HYDROGEOLOGY OF SHALLOW GROUNDWATER RESOURCES IN THE VICINITY OF ST. CHARLES, KANE COUNTY, ILLINOIS

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ABSTRACT

The St. Charles aquifer, consisting of sand and gravel deposits in bedrock valleys buried 100 to 150 feet deep beneath the earth's surface, may be the most promising source for alternative water supplies for the City of St. Charles. Between the surface and 100 feet deep, the even shallower sand and gravel deposits of the Kaneville aquifer member of the Elburn aquiformation lie above these bedrock valleys or bedrock uplands. Some of these deposits may yield sufficient water for development, especially where they directly overlie the St. Charles aquifer or Upper Bedrock aquifers.

The city is seeking alternative sources for a municipal water supply because of declining water levels and an unacceptably high radium content in the deep (400 to 2,000 ft) Basal Bedrock and Midwest Bedrock Aquigroup aquifers currently in use. The search is focused on shallower aquifers in the glacial sediments (Prairie Aquigroup) and the Upper Bedrock Aquigroup.

INTRODUCTION

Sandstone aquifers of the Basal Bedrock and Midwest Bedrock Aquigroups have supplied most of the water for St. Charles in the past. Declining water levels and the discovery of unacceptably high concentrations of radium in these aquifers have created a need for new or supplemental sources of municipal drinking water. The decline in water levels is a regional phenomenon in northeastern Illinois and has been caused by widespread overpumping (Sasman et al. 1982). The naturally occurring radium concentrations in the Basal and Midwest Bedrock Aquigroup aquifers exceed the standards set by the U.S. Environmental Protection Agency for safe drinking water (Gilkeson et al. 1984).

This study evaluates the shallow groundwater resources (Prairie Aquigroup and Upper Bedrock Aquigroup) in the southern two-thirds of T40N, R8E, Kane County (fig. 1). The Illinois State Geological Survey has mapped the distribution of the shallow groundwater aquifers. In a separate study, the Illinois State Water Survey, is evaluating the hydraulic properties of the shallow aquifers. Aquifer tests will determine well yield, well spacing, potential aquifer yield, and shallow groundwater chemistry.

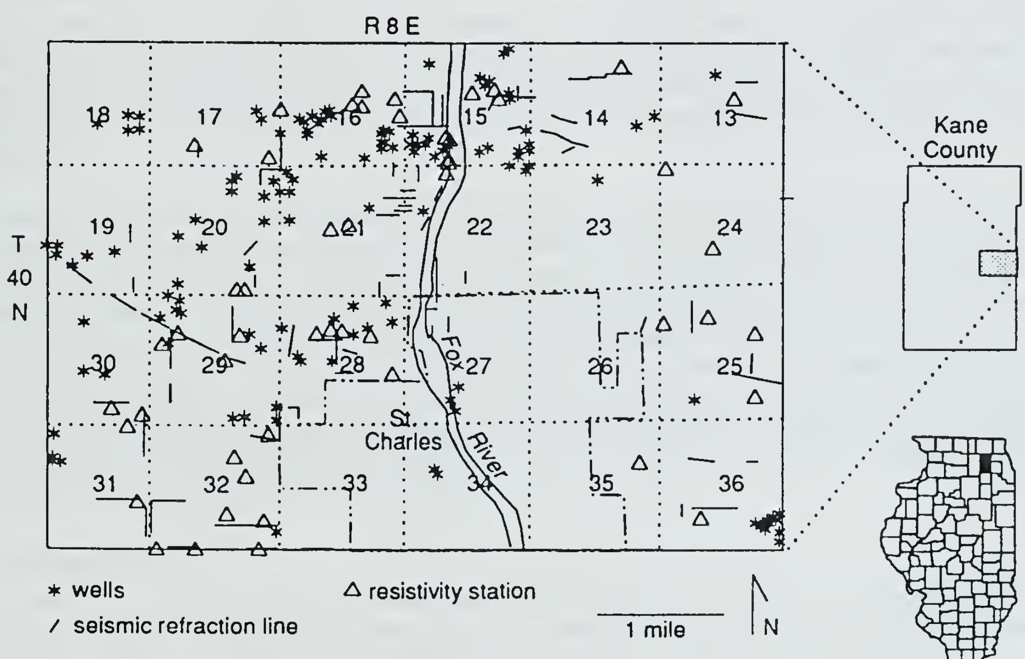


Figure 1 Location of the study area in Kane County.

A recent, countywide study found that conditions are favorable for the development of shallow groundwater resources (Curry and Seaber 1990). Significant shallow aquifers were defined and mapped on regional scale. Now, we apply those definitions to the St. Charles area. Much of the technical information in the Curry and Seaber (1990) report provides background for this study and will be referenced but not necessarily repeated in this report.

Kane County was also part of an extensive geotechnical study for siting the proposed Superconducting Super Collider (SSC) in Illinois. Graese et al. (1988) summarized the SSC-related investigations.

The most significant regional shallow aquifer, the St. Charles aquifer (Curry and Seaber 1990), occurs where sand and gravel that was deposited several thousand years ago by melting glaciers has filled the ancient St. Charles valley cut into the bedrock. This bedrock valley, now buried by glacial sediments, passes beneath the St. Charles area. There are other sand and gravel aquifers in the glacial deposits, but they are not as important as the St. Charles unless they also happen to overlie the buried bedrock valley and thus combine the two resources. Similarly, fractured dolomite beneath the bedrock surface is not considered an important aquifer in this area except where the St. Charles aquifer lies immediately above it or where it is highly fractured. Therefore, determining the location of the St. Charles bedrock valley was the most important task in our investigation.

METHODOLOGY

Well records, existing reports and maps, and new test borings and surficial geophysical surveys provided information on the composition of the glacial sediments, bedrock surface and lithology, aquifer properties, and groundwater quality. Test wells drilled for this project, the regional Kane County project, and the SSC siting project were other sources of detailed data. The maps and general conclusions in this report are derived from Graese et al. (1988) and Curry and Seaber (1990). We have included specific, recent information relevant to St. Charles and revised the maps accordingly.

Well Records

Well records on file at the Illinois State Geological and Water Surveys were used in the study. (Well locations are shown on fig. 1.) Well logs, recorded at the time of drilling, document the locations of wells and the geologic materials encountered during drilling. These records provide information on the thickness and lithology of the glacial deposits and on the depth and lithology of bedrock.

Types of well records include those from privately drilled wells, municipal and industrial wells, and test wells. Frequently, well locations described in the logs from private wells are inaccurate or very general. Private well locations were verified at the Kane County Permit Office. In most cases, the reliability of glacial drift descriptions was adequate to poor, but that of the depth to bedrock was generally considered good. Records of wells with unverified locations were used in areas of sparse data coverage and provided general information on geologic trends. Records of public water-supply wells for the municipalities in Kane County provided detailed and reliable data on the geologic materials. Published sources of well records in Kane County include Lund (1965), Reed (1975), Woller and Sanderson (1978), Kempton et al. (1985, 1987a, 1987b), Curry et al. (1988), and Vaiden et al. (1988).

Geophysical Methods

The seismic refraction method provides useful information for mapping the bedrock surface. Seismic energy traveling through the ground is refracted back to ground surface from the interface between the glacial sediments and the bedrock. Recordings of the energy returning to the ground surface are used to calculate the depth to the refracting interface. Reversed profile

seismic data were gathered using a 24-channel signal enhancement seismograph. (Seismic line locations are shown in fig. 1.) A seismic signal was created with either a buried explosive charge or a mechanical weight-drop system. A 50-foot geophone spacing was used for work in the St. Charles area. Data were processed with a ray tracing program, SIPT-1 (Scott et al. 1972). The SIPT-1 program corrects for irregular surface terrain along the seismic profile and calculates the depth to bedrock beneath each geophone.

Anomalously great depths to bedrock are calculated from the seismic refraction method in areas where thick sand and gravel deposits are overlain by thick, clay-rich glacial till (Zohdy et al. 1974). This occurs because the sand and gravel layer has a lower seismic velocity than both the overlying till and underlying bedrock. The error in calculated depth is proportional to the thickness of the sand layer and always results in greater calculated depths to bedrock than actually exist. Because the anomalies are caused by buried sand and gravel, the anomalies are potential targets for further groundwater resource evaluation.

A second surficial geophysical method, electrical earth resistivity, was used to determine the texture of the glacial sediments. (Resistivity station locations are shown in fig. 1.) In freshwater environments, deposits of sand and gravel have a higher resistance to electrical conduction than deposits with a greater clay content. The results of the electrical earth resistivity surveys made in the St. Charles area were limited in value because of interference from cultural features.

GEOLOGIC FRAMEWORK

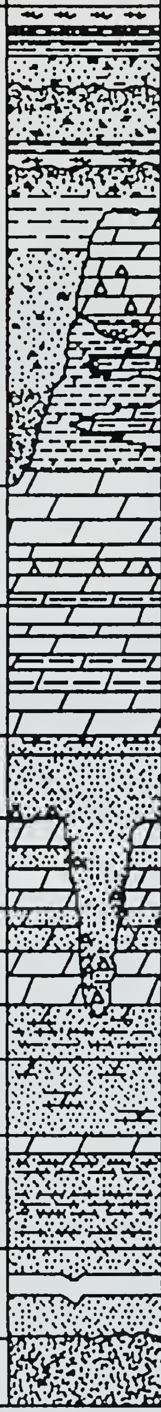
Stratigraphy

The geology of the area includes Precambrian crystalline basement rocks, Paleozoic sedimentary rocks, and Quaternary uncemented sediments. In northern Illinois, the Paleozoic history from 600 million to 245 million years ago is represented by rocks of marine origin (fig. 2) with a maximum thickness of 4,000 feet (Kempton et al. 1985). The Paleozoic rocks are overlain by Quaternary sediments as much as 200 feet thick in the St. Charles area.

Bedrock The Paleozoic rocks most significant to the shallow groundwater resources in the area are the Ordovician Maquoketa Group and the Silurian Kankakee and Elwood Formations (Willman et al. 1975) (fig. 3). (Deeper aquifers are beyond the scope of this study, but are discussed in Visocky et al. [1985].) The Maquoketa Group is composed of shale, argillaceous dolomite and limestone, and interbeds of shale and dolomite; it is present at the bedrock surface in buried bedrock valleys beneath the study area. The regionally important formations of the Maquoketa include, in ascending order, the Scales Shale, Ft. Atkinson Limestone, Brainard Formation, and Neda Formation (Kolata and Graese 1983); but these cannot be readily differentiated in Kane County (Graese et al. 1988). Here, the Maquoketa consists of two sequences of basal shales that become increasingly enriched in carbonate. In the St. Charles area, the carbonate is more dominant where the Maquoketa occurs at the upland bedrock surface; whereas the shale is present along the slopes of the buried bedrock valleys.

The Elwood and Kankakee Formations are composed of thin to medium-thick beds of dolomite; the Kankakee also contains abundant nodules and interbeds of chert. Because the lithology of these units is similar (Curry and Seaber 1990), they are not differentiated in this report. The distribution of these Silurian dolomites (fig. 3) is determined chiefly by the buried bedrock topography. The total thickness of dolomite, including parts of the Maquoketa Group, approaches 100 feet east of the Fox River and thins toward the west.

Quaternary deposits The local stratigraphic classification of Quaternary deposits is illustrated in figure 4a. Quaternary sediments consist of glacial till, glacial outwash, glacial lakebed materials, windblown sediments, and recent deposits along steep slopes and floodplains (Curry and Seaber 1990). The distribution of the surficial units is shown in figure 4b. These deposits



ERA	SYSTEM	Group	FORMATION (thickness in feet)	DESCRIPTION	Aqui-group
CENOZOIC	QUATERNARY		(0-200)	silt and loess peat and muck sand and gravel diamicton (clay, silt, sand, gravel, and boulders; commonly till)	Prairie
PALEOZOIC	SILURIAN		Joliet-Kankakee (0-50)	dolomite, fine-grained, cherty	Upper Bedrock
			Elwood (0-30)		
			Wilhelmi (0-20)		
	ORDOVICIAN	Maquoketa	(0-210)	shale, argillaceous dolomite and limestone	Upper Bedrock
		Galena	(155-185)	dolomite, some limestone, fine- to medium-grained, slightly cherty	Midwest Bedrock
		Platteville	(140-150)		
		Ancell	Glenwood-St. Peter (60-520)	sandstone, white, fine- to medium-grained,sandy	
		Prairie du Chien	(0-400)	dolomite, sandstone	
	CAMBRIAN		Eminence (20-150)	dolomite, fine to medium grained, sandy	
			Potosi (90-225)	dolomite, fine grained, trace sand and glauconite	
			Franconia (75-150)	sandstone, fine-grained, glauconitic; green and red shale	
			Ironton-Galesville (155-220)	sandstone, fine- to medium-grained, dolomitic	
			Eau Claire (350-450)	sandstone, fine grained, glauconitic; siltstone, shale, and dolomite	Basal Bedrock
			Mt. Simon (1400-2600)	sandstone, white, coarse grained, poorly sorted	
PRECAMBRIAN (13,000+)				granite	Crystal-line

Figure 2 Stratigraphy of rocks underlying the St. Charles area.

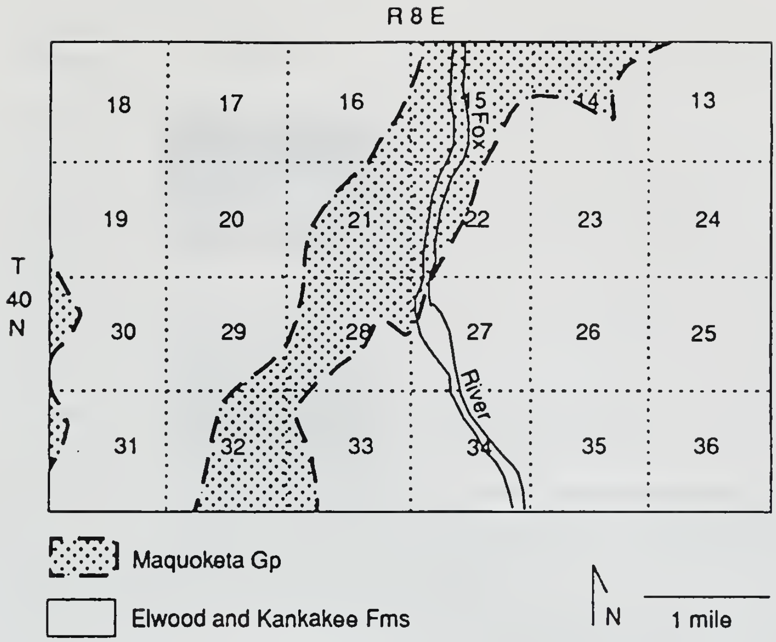


Figure 3 Areal geology of the bedrock surface.

are the product of a variety of depositional environments associated with major glacial advances and retreats during approximately 1.6 million to 14,000 years ago. Successive glacial advances modified the sediments deposited by earlier events and further complicated the geometry of the various units. Finally, since the retreat of the most recent glaciers, the modification of glacial deposits has occurred predominantly in fluvial environments such as the present Fox River Valley.

The oldest glacial sediments identified in Kane County are Illinoian and may correlate to the Glasford Formation near Rockford in Boone and Winnebago Counties (Berg et al. 1985). Illinoian deposits are covered by Sangamonian and early to middle Wisconsinan colluvium composed of organic carbon-rich, silty deposits that have been modified by soil formation; these include the Berry Clay and the Robein Silt (Curry 1989) (fig. 4a). These sediments may be as much as 25 feet thick in Kane County, but more commonly, they are thin or absent (Curry and Seaber 1990).

The late Wisconsinan Wedron Formation, Henry Formation, and related formations (Willman and Frye 1970) cover the Robein Silt. The bulk of the late Wisconsinan deposits belong to the Wedron Formation; its representative members in Kane County are, in ascending order, the Tiskilwa, Malden, Yorkville, and Haegar Till Members (fig. 4a). Till members consist of diamicton (poorly sorted sediment deposited directly or indirectly by glacial ice) interlayered with outwash (well sorted sand and gravel deposited in or near glacial environments). The Yorkville Till Member is the predominant surficial deposit in the St. Charles area; the Malden is present at the surface in the western parts of the area; the Tiskilwa is present in the subsurface within the buried bedrock valleys; and the Haeger has not been identified in the area. The Henry Formation consists of sand and gravel; its distribution is relatively well known because of its importance as an aggregate resource (Masters 1978). The Equality Formation is composed of stratified to massive sand, silt, and clay associated with sedimentation in lakes; it is a common surficial deposit in the southwest portion of the area. Richland Loess (fine-grained eolian sediment) mantles the upland landscape, but it is generally less than 2 feet thick and has not been mapped in this report.

System	Series	Stage	Formation / Member	Graphic Column	Genetic Interpretation of Materials and Description
QUATERNARY	HOLOCENE		Cahokia Alluvium		Alluvium — sand, silt and clay deposited by streams
QUATERNARY	HOLOCENE		Grayslake Peat		Peat and muck, often interbedded with silt and clay
QUATERNARY	PLEISTOCENE	WISCONSINAN	Equality Fm		Lake deposits — stratified silty clay and sand
QUATERNARY	PLEISTOCENE	WISCONSINAN	Henry Fm		Outwash — sand and gravel
QUATERNARY	PLEISTOCENE	WISCONSINAN	Wedron Fm: Haeger		Till — yellowish brown loam; extensive, thick basal sand and gravel
QUATERNARY	PLEISTOCENE	WISCONSINAN	Wedron Fm: Yorkville		Till — yellowish brown to gray silty clay loam*
QUATERNARY	PLEISTOCENE	WISCONSINAN	Wedron Fm: Malden		Till — yellowish brown to brownish gray loam to clay; extensive basal sand and gravel west of the Fox River*
QUATERNARY	PLEISTOCENE	WISCONSINAN	Wedron Fm: Tiskilwa	Not Exposed At Ground Surface	Till — pinkish brown to grayish brown clay loam*
QUATERNARY	PLEISTOCENE	WISCONSINAN / SANGAMONIAN	Robein Silt	Not Exposed At Ground Surface	Buried soil developed into alluvium, colluvium or bog deposits — organic rich silt, sand and clay.
QUATERNARY	PLEISTOCENE	SANGAMONIAN	Berry Clay	Not Exposed At Ground Surface	Accretion-gley — colluvium
QUATERNARY	PLEISTOCENE	SANGAMONIAN / ILLINOIAN	Pearl Fm	Not Exposed At Ground Surface	Outwash — sand and gravel
QUATERNARY	PLEISTOCENE	ILLINOIAN	Glasford Fm: Esmond	Not Exposed At Ground Surface	Till — gray silty loam
QUATERNARY	PLEISTOCENE	ILLINOIAN	Glasford Fm: Herbert	Not Exposed At Ground Surface	Till — pink sandy loam; extensive basal sand and gravel

d — disturbed (quarries, sand and gravel pits)

• — till interbedded with sand and gravel

Figure 4a *above* Stratigraphy of glacial drift (Prairie Aquigroup) underlying the St. Charles area.

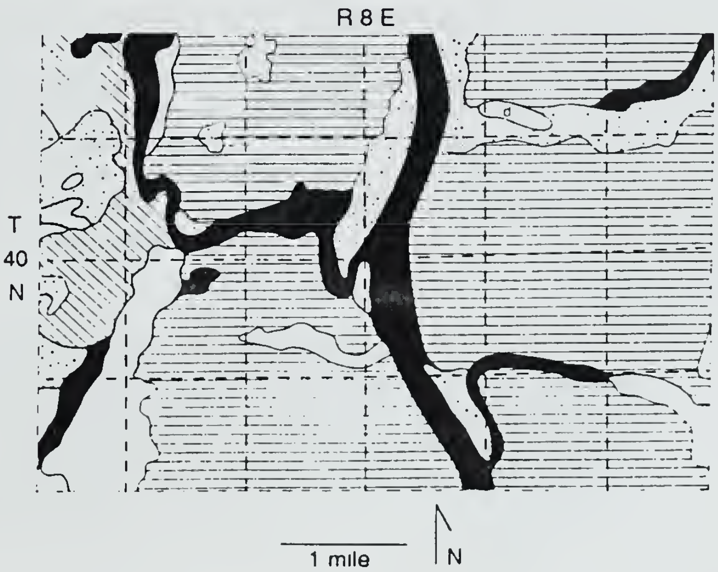


Figure 4b *right* Surficial drift map of the St. Charles area.

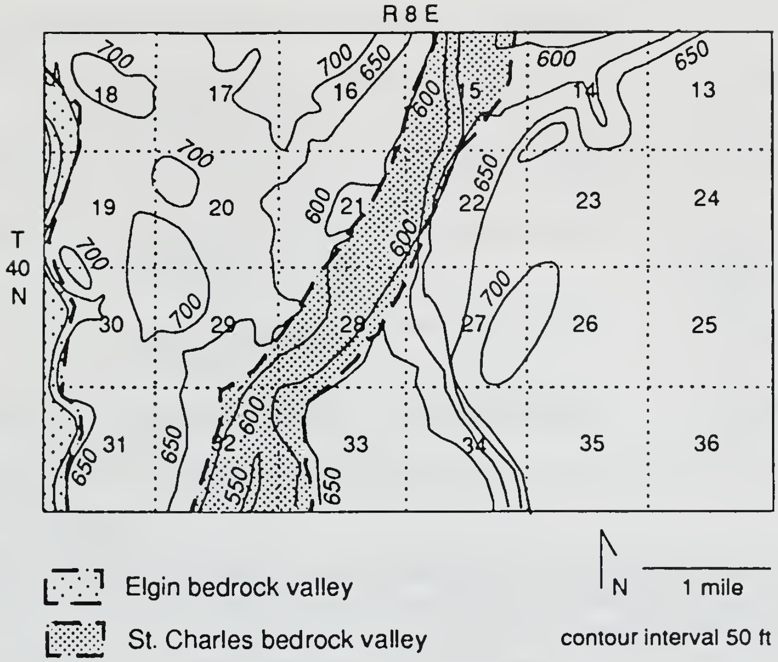


Figure 5 Elevation of the bedrock surface.

Sediments deposited since the last glaciers melted away from the area are thin and occur along drainage ways (Cahokia Alluvium) and in shallow or drained wetlands (Greyslake Peat; fig 4b).

Bedrock Surface Topography

The bedrock topography of Illinois was mapped by Horberg (1950). More recently, bedrock topography maps have been published for all or part of Kane County by Graese et al. (1988) and Curry and Seaber (1990). The elevation of the bedrock surface in the St. Charles area is shown on figure 5. This map is modified from the map provided by Curry and Seaber (1990).

The dominant local feature of the bedrock topography is the St. Charles bedrock valley (called the Newark bedrock valley in some previous reports) that lies beneath the central part of the area in a northeast-southwest orientation. Data collected for this study indicate that the bedrock valley is narrow and sinuous. The Elgin bedrock valley, a north-south-oriented tributary of the St. Charles bedrock valley, is located at the western edge of the area. The elevation of the bedrock surface along the axis of the St. Charles bedrock valley is between 525 and 550 feet above mean sea level. The rest of the area consists of bedrock uplands with elevations approximately 650 to 700 feet above mean sea level.

HYDROGEOLOGY

The Prairie and Upper Bedrock Aquigroups (Visocky et al. 1985) provide the shallow groundwater resources for Kane County. Curry and Seaber (1990) informally subdivided the Prairie Aquigroup in Kane County. For consistency, we will use their terminology as a working model of the local hydrostratigraphy. Many older reports use different names for the same aquifers. Table 1 describes how the hydrostratigraphic units used in this report compare with the terminology used previously for drift aquifers.

Table 1 Informal classifications of drift aquifers compared with hydrostratigraphic units in the Prairie Aquigroup, as used in this report

Information classifications			Prairie Aquigroup
McFadden et al. (1989)	Schicht et al. (1976)	Graese et al. (1988)	Curry and Seaber (1990) and this report
Upper sand and gravel aquifer	Surficial sand and gravel aquifer	Surficial drift aquifer	Valparaiso aquifer Kaneville aquifer, Elburn aquiformation
	Interbedded sand and gravel aquifer	Basal drift aquifer	Bloomington aquifer
Lower sand and gravel aquifer	Basal sand and gravel aquifer	Buried drift aquifer	St. Charles aquifer

Upper Bedrock Aquigroup

The Upper Bedrock Aquigroup consists of local and intermediate flow systems in sedimentary rock that directly underlie the glacial sediments constituting the Prairie Aquigroup. The Upper Bedrock Aquigroup may have open interconnections with the overlying Prairie Aquigroup (Visocky et al. 1985). In Kane County the aquigroup consists of the Ordovician Maquoketa Group and the Silurian Elwood and Kankakee Formations.

The most significant and productive aquifer is the Silurian dolomite aquifer or shallow dolomite aquifer (figs. 2 and 3), which sustains pumping rates as great as 100 to 200 gallons per minute (gpm) (Visocky et al. 1985). The Silurian rocks thin westward and are replaced at the bedrock surface by rocks of the Maquoketa Group. Where the Maquoketa Group rocks are dominated by shale, the Upper Bedrock Aquigroup becomes much less productive. The hydrogeology and yields of these units are discussed by Csallany and Walton (1963). Packer test data for these units are presented in Kempton et al. (1987a, 1987b) and summarized in Curry et al. (1988).

Table 2 Informal hydrostratigraphic hierarchy in Kane County (modified from Curry and Seaber 1990)

Aquigroup	Aquiformation	Aquimember
Prairie	Valparaiso aquifer	
	Elburn aquiformation	Kaneville aquifer member
	Bloomington aquifer	
	Pingree Grove aquiformation	
	Marengo aquitard	
	St. Charles aquifer	

Prairie Aquigroup

In Kane County, the Prairie Aquigroup has local and intermediate flow systems in noncemented geologic materials, including glacial deposits, alluvium, and other recent sediments. The aquifers are confined locally by fine-grained sediments. Recharge to the system is mainly from local precipitation. Of the six hydrostratigraphic units informally recognized by Curry and Seaber (1990) in Kane County (table 2), three are important in the St. Charles area: the St. Charles aquifer, the Marengo aquitard, and the Kaneville aquifer member of the Elburn aquiformation.

St. Charles aquifer Composed chiefly of sand and gravel of the Wedron and Glasford Formations, the St. Charles aquifer occurs primarily within the buried St. Charles and Elgin bedrock valleys. Its thickness exceeds 100 feet in the southwest corner of the study area. The

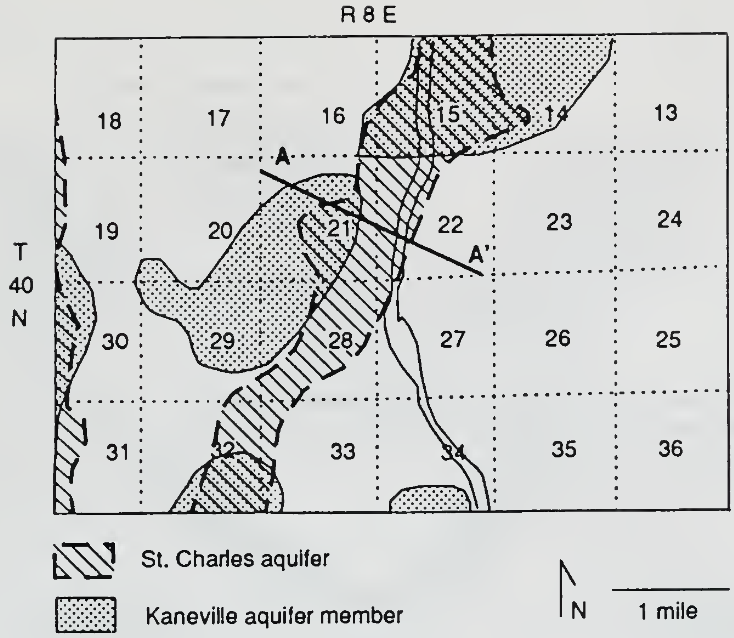


Figure 6 Major aquifers of the Prairie Aquigroup within the St. Charles area.

distribution of the St. Charles aquifer is shown in figure 6. Here, the aquifer is composed of proglacial outwash of the Tiskilwa Till Member of the Wedron Formation. Because of the complex relationship between diamicton and outwash, the area mapped as St. Charles aquifer on figure 6 may include some diamicton.

Marengo aquitard Covering the St. Charles aquifer in the southwestern parts of the study area is the Marengo aquitard. It is chiefly composed of diamicton of the Tiskilwa Till Member of the Wedron Formation (Wickham et al. 1988). The unit thins eastward, covering only a small part of the St. Charles aquifer in the center of the study area; it is not present in the northeast part of the area.

The Marengo aquitard has a field-measured hydraulic conductivity on the order of 0.2 to 0.002 gal/day/ft^2 (10^{-6} to 10^{-8} cm/sec) (Jennings 1985). Materials with such low hydraulic conductivities restrict the flow of water and contaminants. Where the Marengo aquitard occurs above the St. Charles aquifer, well yields within the aquifer may be reduced. However, the presence of the overlying aquitard affords some protection from surface contamination to the underlying aquifer. Scattered occurrences of relatively small bodies of sand and gravel have been found within the Marengo aquitard, but these supply only small amounts of groundwater (Graese et al. 1988).

Kaneville aquifer member, Elburn aquiformation Underlying most of central and south-central Kane County is the Elburn aquiformation, primarily an aquitard (chiefly diamicton, but also lacustrine deposits). It also contains bodies of sand and gravel outwash that can be considered aquifers. In the St. Charles area, the Elburn aquiformation consists of the Malden and Yorkville Till Members of the Wedron Formation. The Kaneville aquifer member of the Elburn aquiformation represents the ice-contact and outwash sand and gravel sequences of these units (fig. 6). In places, the Kaneville aquifer member is in contact with the St. Charles aquifer, forming a vertically continuous aquifer.

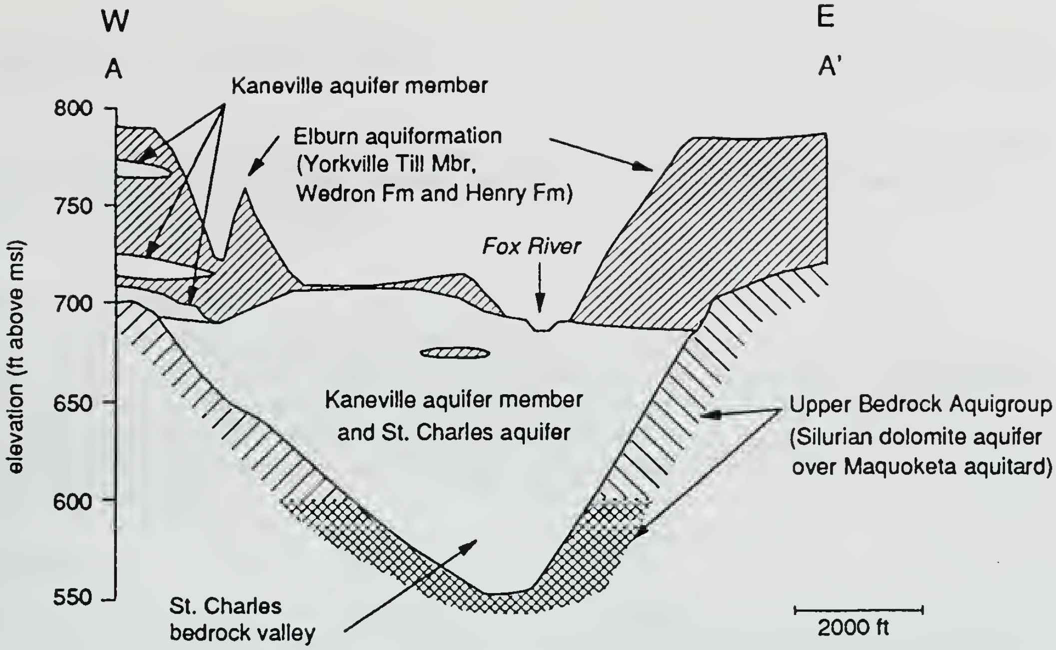


Figure 7 Cross section of the St. Charles bedrock valley northwest of St. Charles.

The vertical relationships between the St. Charles aquifer and other hydrostratigraphic units within the St. Charles bedrock valley were shown in several cross sections by Curry and Seaber (1990, fig. 13). Their cross section D-D′ depicts the aquifer within the St. Charles bedrock valley immediately southwest of the St. Charles area. At this point, the St. Charles aquifer is separated from the Kaneville aquifer member by 30 to 50 feet of the Marengo aquitard. Further northeast, the Marengo aquitard thins, so that the St. Charles aquifer and the Kaneville aquifer member are in direct contact. Although the two aquifers may be distinguishable, at this location they behave as one hydraulic unit and thus are not separated in figure 7. This combined aquifer is potentially very productive. Wells completed within the bedrock valley in this area have yielded more than 1,500 gpm.

SUMMARY

Because of declining water levels, high radium, and high chloride concentrations in the Basal Bedrock and Midwest Bedrock Aquigroups, the City of St. Charles is seeking alternative sources of water for public supply. The Illinois State Geological Survey has mapped the distribution of shallow aquifers lying between the surface and 100 feet deep in the vicinity of St. Charles. A combination of existing records, geophysical surveys, and test drilling was used in the aquifer mapping phase of this study.

A second phase of this study involves aquifer pump testing to determine hydraulic properties, spacing of wells for optimal aquifer development, potential aquifer yield, and groundwater chemistry. This phase of the investigation is being conducted and will be reported by the Illinois State Water Survey.

Results of the geologic mapping of shallow aquifers in the St. Charles area are as follows:

- The St. Charles aquifer in the St. Charles Bedrock Valley is locally extensive. West of St. Charles the aquifer is more than 100 feet thick. The St. Charles aquifer overlies the Upper Bedrock Aquigroup and locally underlies the Kaneville member of the Elburn aquiformation.

Areas in which the aquifers are interconnected are most favorable for development of high-yielding wells.

- The Kaneville aquifer member of the Elburn aquiformation is present at several localities within the area. It is locally interconnected with the St. Charles aquifer but generally is isolated by the Marengo aquitard.

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