GEOLOGY AND GROUND WATER

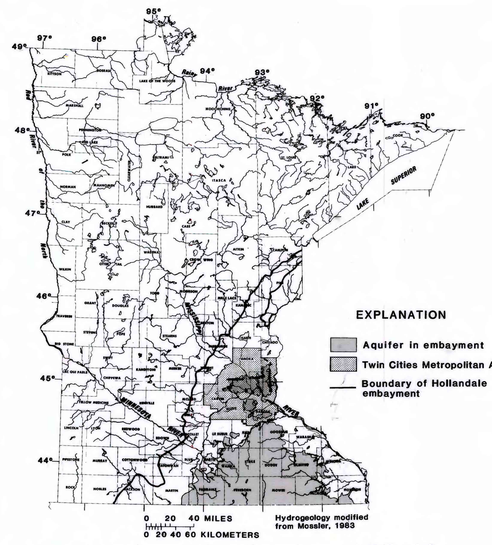

Figure 1.--Areal extent of aquifer and area of Hollandale embayment in southeast Minnesota

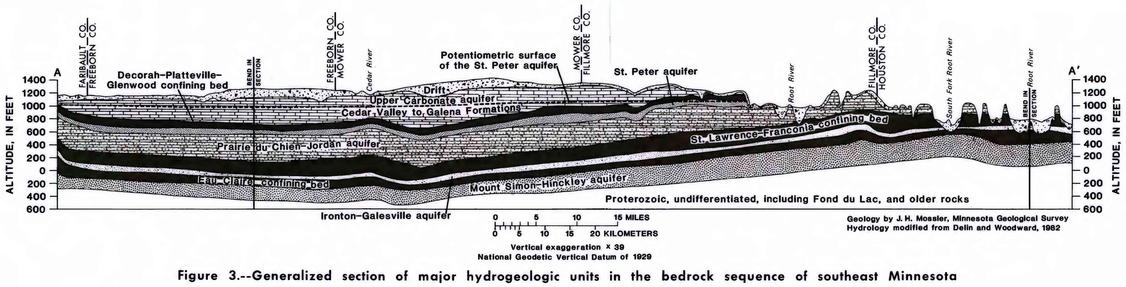

Figure 3.--Generalized section of major hydrogeologic units in the bedrock sequence of southeast Minnesota

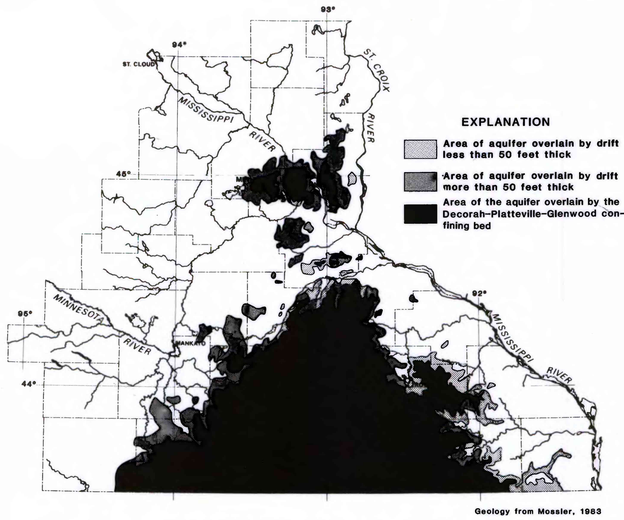

Figure 6.--Deposits overlying the aquifer

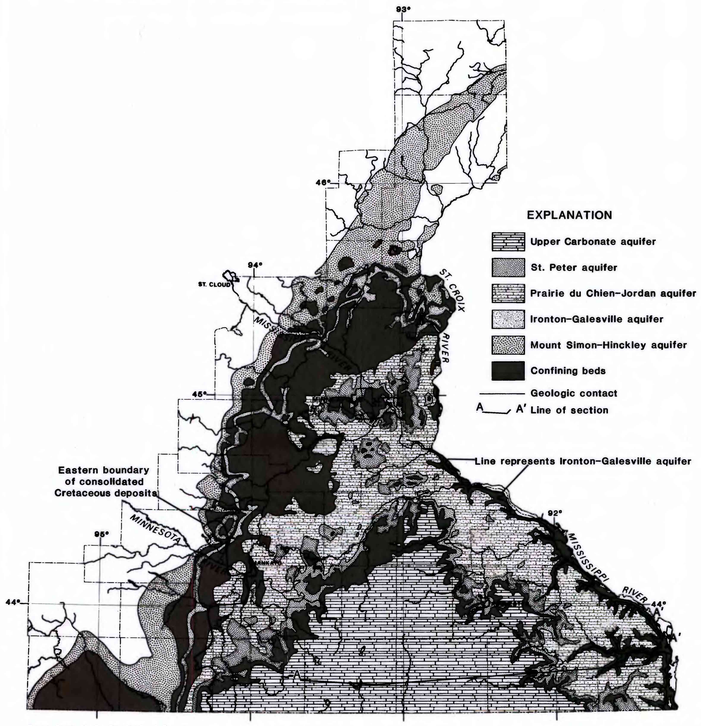

Figure 2.--Bedrock hydrogeology in southeast Minnesota

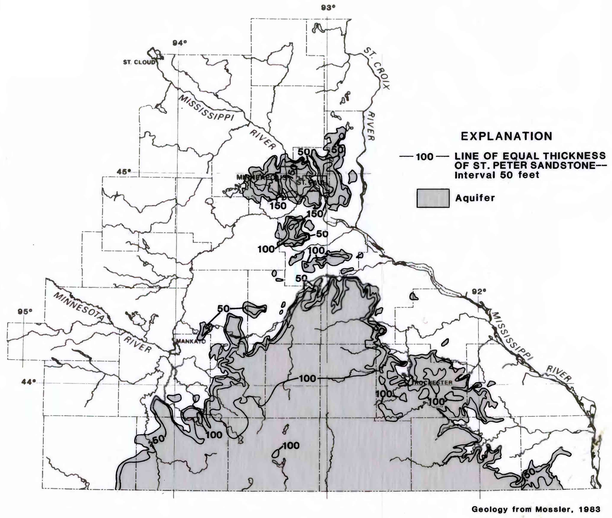

Figure 4.--Thickness of the aquifer

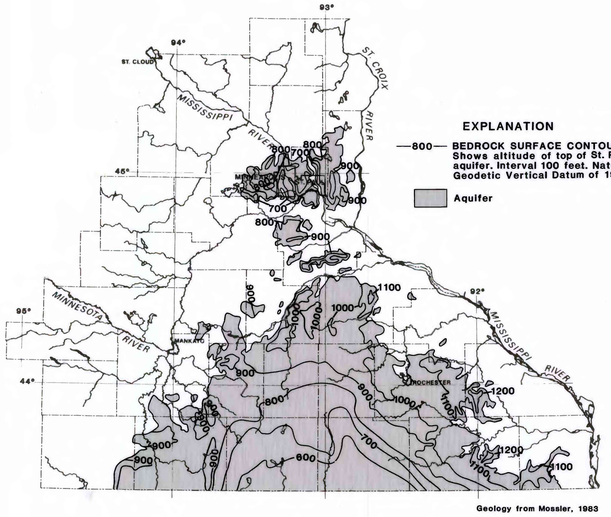

Figure 5.--Contours of the top of the aquifer

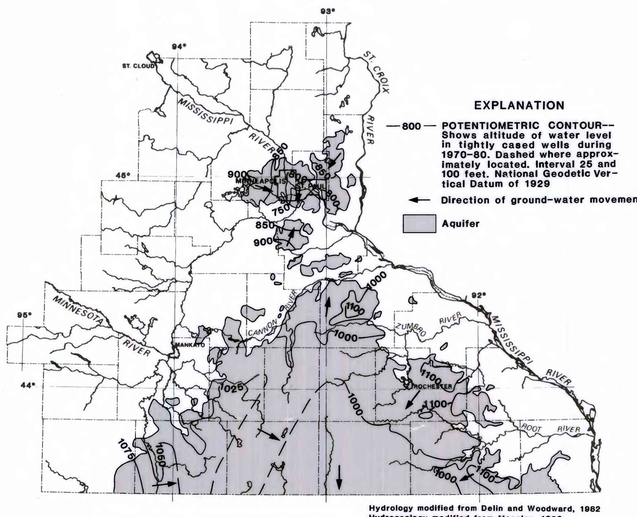

Figure 7.--Flow directions and potentiometric surface of the aquifer, 1970-80

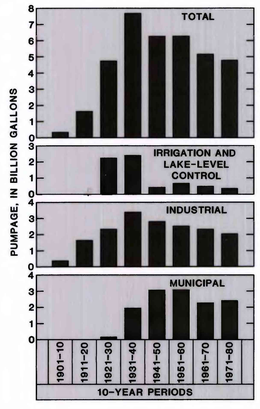

Figure 8.--Pumpage from the aquifer by major use category in the Twin Cities metropolitan area for 10-year periods from 1900 to 1980

ABSTRACT

Quality of water in the St. Peter aquifer is generally acceptable for most uses. Sulfate concentrations increase toward the southwestern part of the aquifer because of highly mineralized leakage from overlying Cretaceous deposits. Concentrations of sodium, magnesium, and sulfate generally increase to the west, and those of calcium, bicarbonate, and chloride generally increase toward the margins of the aquifer. Calcium magnesium bicarbonate water is the most common type in the aquifer. The aquifer is well protected from surface sources of contaminants by the overlying Decorah-Platteville-Glenwood confining bed, which overlies about 80 percent of the St. Peter aquifer. Thin drift, which overlies the east side of the aquifer, provides much less protection than the confining bed. Water in the aquifer generally flows toward the Mississippi River and its tributaries. Some water flows southward into Iowa from a ground-water divide in Dodge and Steele Counties. Well yields from the aquifer, which are generally between 100 and 250 gallons per minute, are generally adequate for most uses.

This report is one of a series on the hydrogeology and water quality of the 14 principal aquifers in Minnesota prepared by the U.S. Geological Survey. The U.S. Environmental Protection Agency requested these studies because of the need for information to develop its Underground Injection Control Program.

INTRODUCTION

The U.S. Geological Survey began a study in 1980 of the quality of water in the principal aquifers of Minnesota. The U.S. Environmental Protection Agency funded the study as part of the Underground Injection Control Program, which deals with disposal of liquid wastes beneath land surface. The initial report designated 14 aquifers in the State and provided general information about their geologic, hydrologic, and water-quality characteristics (Adolphson and others, 1981). This report, one in a series that describes individual aquifers in more detail, concerns the St. Peter aquifer.

HYDROGEOLOGY

The St. Peter aquifer is part of a sequence of sedimentary rocks consisting predominantly of sandstone, limestone, dolomite, and shale. Most of these rocks were deposited during the Paleozoic Era in seas that occupied the Hollandale embayment, a shallow depression that extended northward from Iowa into southeastern Minnesota (Austin, 1972). Figure 1 shows the areal extent of the St. Peter aquifer and the embayment.

The Paleozoic sedimentary rocks and the underlying Proterozoic Hinckley Sandstone in southeast Minnesota comprise five major bedrock aquifers and four major confining beds (Lindholm and Norvitch, 1976; Delin and Woodward, 1984). Table 1 shows this aquifer classification scheme and schematically represents the vertical position of these hydrogeologic units, including Cretaceous deposits and drift. Kanivetsky and Walton (1979) and Adolphson and others (1981) have proposed classifications that are slightly different because they include the Franconia Formation as part of the Ironton-Galesville aquifer and the Fond du Lac Formation as part of the Mount Simon-Hinckley aquifer. Figure 2 shows the areal extent of the aquifers and confining beds listed in table 1 for southeast Minnesota. Figure 3 is a generalized section of the hydrogeologic units along an east-west line through southeast Minnesota.

Geologic Framework

The St. Peter Sandstone of Ordovician age in Minnesota consists primarily of light yellow or white, fine- to medium-grained, well-sorted, massive and friable, quartzose sandstone (Kanivetsky and Walton, 1979). However, it also includes basal beds of siltstone and shale in the Twin Cities basin. The St. Peter and other underlying bedrock units dip toward the interior of the Hollandale embayment (fig. 4), forming a southerly plunging synclinorium.

Hydrologic Characteristics

The St. Peter aquifer comprises the water-bearing sandstone of the St. Peter Sandstone. The thickness of the aquifer averages about 100 feet throughout southeast Minnesota (Woodward, 1983). The basal layer of the St. Peter Sandstone forms a confining bed in the Twin Cities basin and has a maximum known thickness of 80 feet (fig. 5). Woodward (1983) determined the basal St. Peter confining bed is absent in the southern part of the Hollandale embayment in Minnesota, however, the existence of this unit is unknown in the central part of the study area. The thickness map of the aquifer, therefore, also represents the confining unit because its areal extent and thickness are unknown in some areas.

The Decorah-Platteville-Glenwood confining bed, which overlies approximately 80 percent of the aquifer, retards vertical flow and protects the St. Peter aquifer from surface sources of contamination. Drift overlies the remainder except for the extreme southwestern corner and other scattered patches where Cretaceous deposits are present (fig. 6). The absence of the Decorah-Platteville-Glenwood confining bed and thinness of overlying drift in the southeastern part of the St. Peter aquifer facilitate downward percolation of precipitation and potential contaminants (Delin and Woodward, 1984). Ground-water mounds in the southeast indicate relatively high rates of recharge to the aquifer (fig. 7). The St. Peter aquifer is underlain by a confining bed that retards vertical flow through the bottom of the aquifer.

Ground-water flow in the eastern part of the aquifer is mainly toward tributaries of the Mississippi River, such as the Root and Zumbro Rivers (fig. 7). A ground-water divide in northern Dodge and Steele Counties separates flow to the north into the Cannon River and to the south into Iowa (Delin and Woodward, 1984). Ground water moves toward the Mississippi and Minnesota Rivers in the Twin Cities basin (Norvitch and others, 1974).

Water supplies from the St. Peter aquifer are generally adequate, although yields to wells are small in some places because of the fineness of the sand (Anderson and others, 1974a; Broussard and others, 1975). The aquifer generally is undeveloped in the interior of the Hollandale embayment where it is overlain by the more productive upper carbonate aquifer (table 1). The St. Peter aquifer is of secondary importance as a source of water supply to other Paleozoic aquifers, particularly the Prairie du Chien-Jordan.

Table 1.--Stratigraphic nomenclature for southeast Minnesota and general descriptions of the corresponding aquifers and confining beds

Stratigraphic nomenclature			Hydrogeology	
Erathem	Period or system	Geologic unit (group, formation, or bed)	Hydrogeologic unit (aquifer or confining beds)	Water-bearing characteristics and dominant lithology
Cenozoic	Quaternary	Drift	Surficial sand and gravel aquifer	Largly outwash, but includes alluvium along major streams and local ice-contact deposits. Slightly used, with additional development of supplies possible. High potential for contamination because the water table is at or near land surface. Yields as much as 1,000 gal/min in places.
			Confining beds	Till and clay of low permeability. Not a source of water to wells.
			Buried sand and gravel aquifers	Outwash and ice-contact deposits confined by till of low permeability. Slightly to moderately developed for water supplies with potential for additional development, especially in buried valleys. Yields range from 100 to 1,000 gal/min.
Mesozoic	Cretaceous	Cretaceous beds	Cretaceous confining beds	Shale beds of low permeability. Not a source of water.
			Cretaceous aquifer	Sandstone lenses near base of predominantly shale section. Slightly developed, may yield additional small supplies. Typical yields to wells are 5 to 50 gal/min, but may be as much as 250 gal/min. Water is highly mineralized, particularly in the basal units along the western border of the State.
Paleozoic	Devonian	Cedar Valley Limestone	Upper Carbonate aquifer	Limestone, dolomite, and dolomitic limestone. Major aquifer in the south-central part of embayment. Wells generally yield 200 to 500 gal/min from solution channels, joints, and fissures.
		Wapsipinicon Formation		
		Coralville Formation		
		Lithograph City Dolomite		
	Ordovician	Decorah Shale	Confining bed	Relatively impermeable shale, dolomitic limestone, and limestone.
		Platteville Limestone		Platteville yields about 25 gal/min from local fractures and solution channels.
		Glenwood Shale		
		St. Peter Sandstone	St. Peter aquifer	Mainly fine- to medium-grained sandstone. A major aquifer, but seldom used for public supply because larger yields are available in wells in other aquifers. Typical yields range from 100 to 250 gal/min.
			St. Peter confining bed	Contains siltstone and shale that restrict vertical flow. Areal extent unknown. Not a source of water to wells.
		Prairie du Chien Group	Prairie du Chien-Jordan aquifer	Mainly dolomite and sandstone. The major aquifer in the area. Commonly yields 500 to 1,000 gal/min. Supplies 75 percent of water in Twin Cities metropolitan area. Karstic conditions are common in extreme southeast.
		Jordan Sandstone		
	Cambrian	St. Lawrence Formation	Confining bed	Silty, sandy dolomite interbedded with layers of fine-grained sandstone and siltstone. Generally a poor source of water to wells; however, yields from the Franconia in the northwest part of the area are adequate for domestic use.
		Franconia Formation		
		Ironton Sandstone	Ironton-Galesville aquifer	Very fine to coarse-grained sandstone interbedded with shale, siltstone, and dolomite; an important aquifer outside the limits of other major aquifers. Yields range from 250 to 500 gal/min.
		Galesville Sandstone		
		Eau Claire Sandstone	Confining bed	Sandstone, siltstone and shale, gray to reddish brown. Normally not a source of water; however, sandstone beds may yield small quantities to wells in the south.
		Mount Simon Sandstone	Mount Simon-Hinckley aquifer	White to red beds of sandstone, siltstone, and shale. The secondary aquifer in Twin Cities area and only bedrock aquifer used in the northern part of the Hollandale embayment. Little used for water supply in extreme southeast. Wells generally yield from 400 to 700 gal/min, but may be as much as 2,000 gal/min.
Precambrian	Proterozoic	Hinckley Sandstone		
		Fond du Lac Formation	Hydrologic properties little known	Fond du Lac Formation, in combination with Hinckley Sandstone, yields water north of the Twin Cities metropolitan area where the Mount Simon is absent. Elsewhere, the Fond du Lac is deeply buried and undeveloped as a source of water supply.
		Sedimentary, metamorphic, and igneous rocks	Hydrologic properties unknown	Lack of detailed subsurface information precludes evaluation of hydraulic characteristics.

HYDROGEOLOGIC AND WATER-QUALITY CHARACTERISTICS OF THE ST. PETER AQUIFER, SOUTHEAST MINNESOTA

BY
J. F. RUHL AND R. J. WOLF, 1983