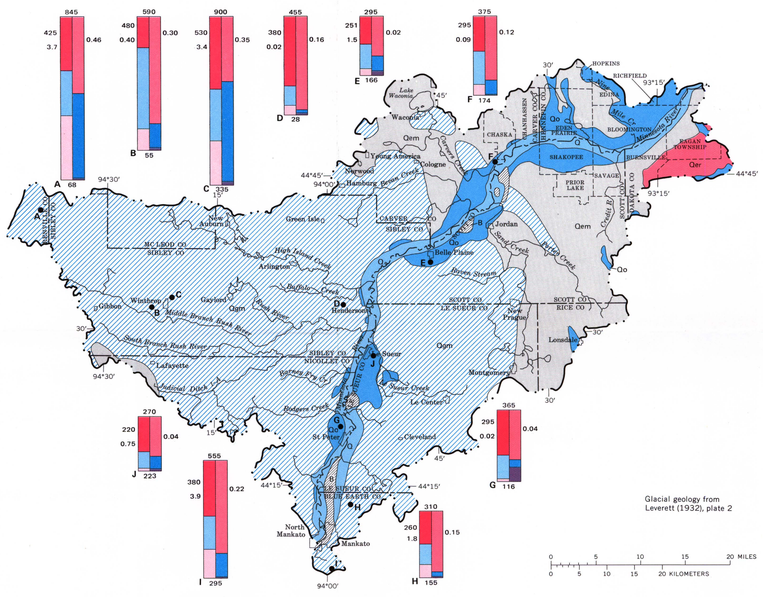
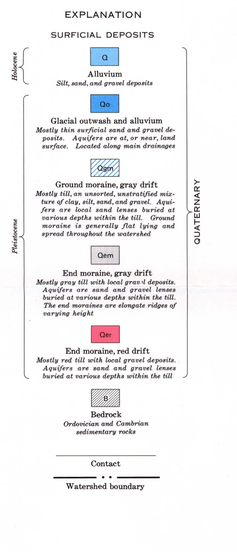
PREPARED IN COOPERATION WITH THE
MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS, SOILS, AND MINERALS

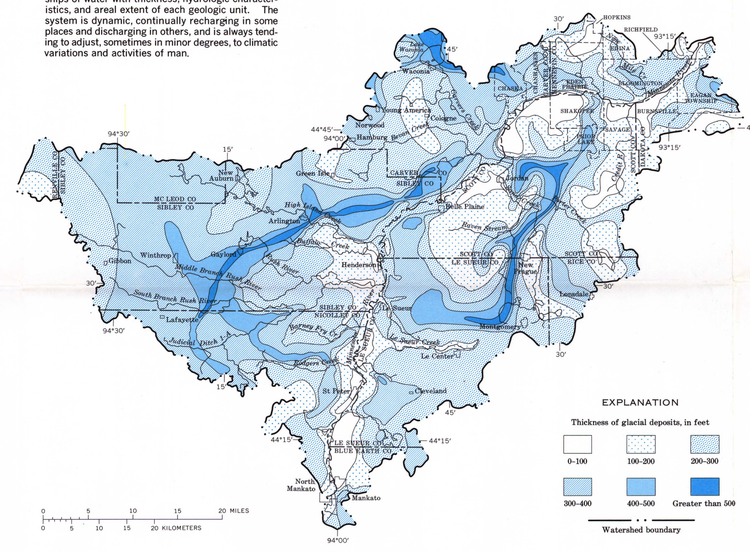
GROUND WATER

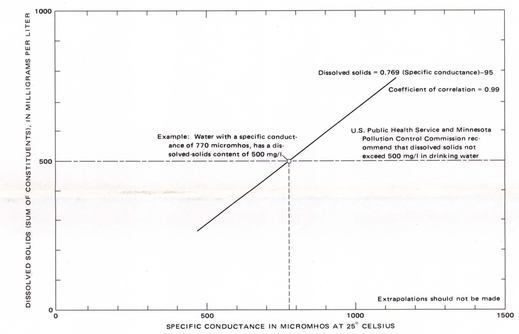
GLACIAL DEPOSITS

The ground-water system involves the interrelationships of water with thickness, hydrologic characteristics, and areal extent of each geologic unit. The system is dynamic, continually recharging in some places and discharging in others, and is always tending to adjust, sometimes in minor degrees, to climatic variations and activities of man.









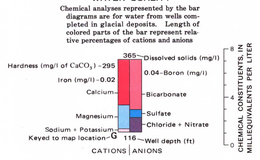
ESTIMATES OF DISSOLVED SOLIDS IN GROUND WATER FROM THE BASIN CAN BE MADE BY MEASURING SPECIFIC CONDUCTANCE.—*Measured specific conductance applied to the equation, or to the graph, will yield dissolved solids accurate to ±10 percent.*

PLEISTOCENE GLACIAL DEPOSITS, WHICH COVER ALMOST THE ENTIRE WATERSHED, CONTAIN THE MOST WIDELY USED AQUIFERS FOR DOMESTIC WATER SUPPLIES—*Although glacial aquifers are widespread, less than a third of the wells in the watershed obtain water from them. The glacial deposits are predominantly till, an unsorted, unstratified mixture of clay, silt, sand, and gravel. Beds of sand and gravel within the till are the most widely accessible and widely used shallow aquifers. These buried beds are commonly thin and discontinuous, but generally provide water adequate for domestic use. In the western and northwestern parts of the watershed, few wells fully penetrate the glacial deposits. Eastward, there is an increasing number of wells that extend below the glacial deposits and obtain water from bedrock.*

The quality of water in glacial aquifers depends on location, depth of well, permeability of underlying bedrock, and sources of pollution. Leaching of gray till by percolating water results in higher dissolved solids and sulfate concentration in deep wells than in shallow wells in the western part of the watershed. (See samples B and C.) Dissolved solids and sulfate decrease generally from west to east. Removal of dissolved solids from the gray till by leaching is more effective in the east, where glacial deposits are underlain by permeable sedimentary rocks, than in the west, where glacial deposits are underlain by nearly impermeable crystalline bedrock. Water containing the lowest dissolved solids (less than 100 mg/l) is found in outwash along the Minnesota River and in sand and gravel associated with red till. Nitrate pollution from barnyards and cattle feedlots is common locally in outwash, thin till, and bedrock underlying these deposits. Carbonate (temporary) hardness dominates the eastern part of the watershed, whereas, noncarbonate (permanent) hardness is more common in the western part. Iron generally exceeds the level 0.3 mg/l recommended by the U.S. Public Health Service (1962); its magnitude depends on availability of iron minerals and reducing potentials. Boron diminishes from west to east with the decrease of both Cretaceous rocks and thickness of gray till. Plant tolerances to boron range from less than 0.33 mg/l for sensitive crops to more than 3.75 mg/l for tolerant crops.

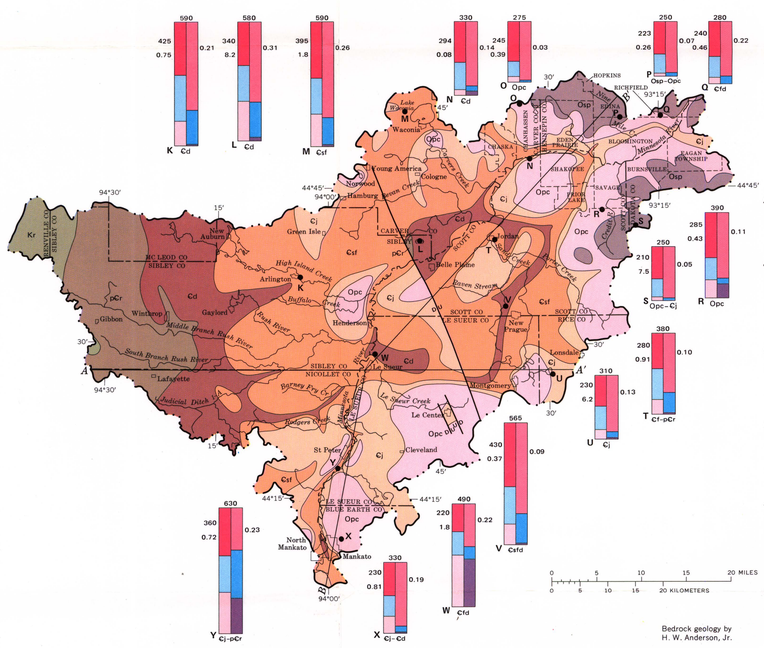
WATER QUALITY

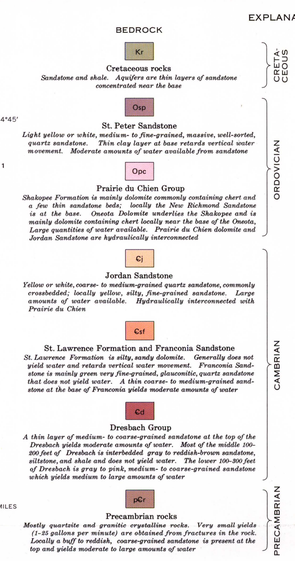
Chemical analyses represented by the bar diagrams are for water from wells completed in glacial deposits. Length of colored parts of the bar represent relative percentages of cations and anions

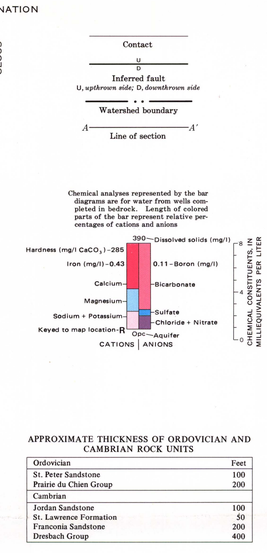


GLACIAL DEPOSITS RANGE IN THICKNESS FROM ZERO TO SLIGHTLY MORE THAN 500 FEET.—*The greatest drift thickness is localized in two deeply buried bedrock valleys, one east and one west of the Minnesota River. The greater the saturated thickness, the greater likelihood of penetrating a water-yielding sand lens and obtaining a water supply. Only part of the available ground water has been developed. However, because water availability varies locally, detailed hydrologic studies can aid resource development, especially where large supplies are needed.*

BEDROCK







APPROXIMATE THICKNESS OF ORDOVICIAN AND CAMBRIAN ROCK UNITS

Ordovician	Feet
St. Peter Sandstone	100
Prairie du Chien Group	200
Cambrian	
Jordan Sandstone	100
St. Lawrence Formation	50
Franconia Sandstone	200
Dresbach Group	400

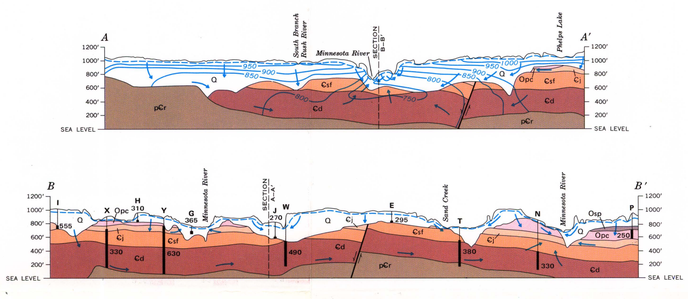
THE MOST RELIABLE BEDROCK AQUIFERS ARE ST. PETER SANDSTONE, THE PRAIRIE DU CHIEN GROUP, IN AREAS WHERE IT IS BURIED DEEPLY ENOUGH TO PROTECT IT FROM POLLUTION, JORDAN SANDSTONE, AND BASAL SANDSTONE IN THE DRESBACH GROUP—*The Ordovician New Richmond Sandstone, occurring locally in the Prairie du Chien Group, yields water to some wells. Cretaceous sandstone yields some water. In drilling for water, a particular bedrock aquifer may be penetrated where its presence or that of any younger formation (other than Cretaceous) is indicated on the map. Depth to the aquifer can be estimated by adding the thicknesses of overlying drift and bedrock formations.*

The bedrock formations directly below the glacial deposits are progressively older from east to west; from Ordovician sandstone, dolomite, and limestone in the east through Cambrian sedimentary rocks to Precambrian crystalline rocks in the west. Exceptions to this are scattered deposits of Cretaceous sandstone and shale directly overlying various older rocks (a large Cretaceous area is outlined at the western tip of the watershed).

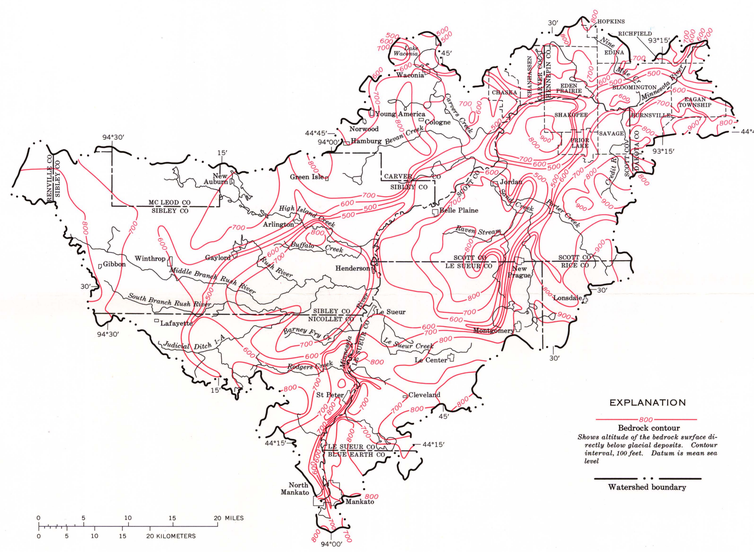
Water analyses from wells completed in sedimentary bedrock formations indicate properties related to recharge through surface deposits, mixing of water from deep and shallow formations, and solution of carbonate rocks. Cambrian sandstones in the northwestern part of the watershed and in bedrock valleys contain water with dissolved solids (565-590 mg/l) and sulfate percentages (greater than 20) representative of leachate from a significant thickness of gray till. Water from Ordovician and Cambrian rocks in the eastern part of the watershed contain dissolved solids (250-390 mg/l) and bicarbonate percentages (greater than 85 percent) representative of recharge through thin gray till, red till, and carbonate rocks. Wells at Saint Peter (Y), Le Sueur (W), and Belle Plaine (L), which penetrate Cambrian sandstones, contain water that represents a mixture from both shallow and deep bedrock aquifers.

AQUIFER AND WATER-QUALITY DATA FROM MUNICIPAL WELLS

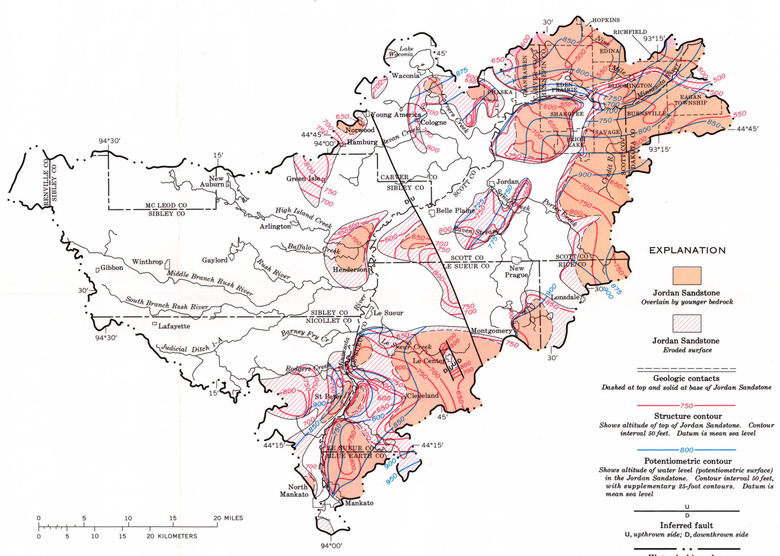
Aquifer	Average thickness open to wells (feet)	Towns using aquifer	Municipal wells in aquifer	Well Depth (feet)		Usual pumping rate (gpm)		Specific capacity (gpm/ft)		Iron (mg/l)		Sulfate (mg/l)		Chloride (mg/l)		Dissolved solids, residue (mg/l)		Hardness as $CaCO_3$ (mg/l)	
				Range	Average	Range	Average	Range	Average	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median
Glacial sand and gravel	30	11	24	76-425	279	135-700	427	15-30	25	0.1-12.0	2.1	5-500	120	1.0-25	4.0	290-1300	530	220-700	380
Jordan Sandstone	80	8	30	81-500	388	350-2300	938	25-118	53	0.24-4.2	.52	1-89	7.8	.5-8	2.0	280-640	300	260-460	290
Franconia	94	1	1	344	------	155	------	6.7	------	1.8	------	130	------	1.5	------	---------	------	540	------
Multiple aquifers Jordan through Dresbach	425	14	25	400-923	684	83-1200	483	3.1-71	15	0.02-3.2	.68	5-200	104	1-54	1.8	290-650	510	260-560	395
Dresbach sandstone	325	3	6	550-802	697	100-710	320	15-33	26	0.60-8.2	.91	30-149	33	1.0-6.6	1.0	381-580	490	280-430	410
Precambrian sandstone	112	1	3	1000	------	1000	------	12	------	.44	------	15	------	16	------	250	------	190	------



REGIONALLY, GROUND WATER MOVES TOWARD THE MINNESOTA RIVER; HOWEVER, COMPLEX LOCAL FLOW PATTERNS INDICATE SHALLOW MOVEMENT TOWARD LOCAL SURFACE DRAINAGE, WHERE DISCHARGE TO STREAMS AND EVAPOTRANSPIRATION OCCURS.—*Along section A-A', ground water moves downward and toward the Minnesota River; along B-B', ground water moves vertically downward through the uplands, but at depth (in Dresbach Group), toward the outlet of the basin, down a gradient with a head of more than 800 feet in the south to less than 700 feet in the northeast.*



BURIED BEDROCK VALLEYS ARE PROMISING AREAS TO EXPLORE FOR WATER-BEARING SAND AND GRAVEL DEPOSITS.—*The contours indicate the general location of buried bedrock valleys whose drainage patterns differ from present surface drainage. These valleys have been filled with glacial till and outwash sand and gravel. The distribution of the outwash is poorly defined by present data, but exploratory drilling may define buried outwash sand and gravel that could provide new water supplies.*



THE JORDAN SANDSTONE IS FAULTED, DISSECTED BY EROSION, AND DIPS GENERALLY TOWARD THE NORTHEAST. GROUND-WATER MOVEMENT IN THE SANDSTONE IS PARTLY CONTROLLED BY AND IS DIRECTED TOWARD THE MINNESOTA RIVER.—*The sandstone is exposed locally along the Minnesota River between Mankato and Le Sueur and between Jordan and Chaska. In Hopkins it dips to more than 400 feet below the surface. Ground water moves perpendicular to the potentiometric contours, from the watershed boundary toward the Minnesota River. It moves northwestward from Rice County through glacial deposits in a buried bedrock valley at New Prague, through more Jordan Sandstone, and discharges in the Minnesota River valley as evapotranspiration and stream base flow.*

Base from U.S. Geological Survey 1:250,000:
St. Paul and New Ulm, 1953

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA.—1974

WATER RESOURCES OF THE LOWER MINNESOTA RIVER WATERSHED, SOUTH-CENTRAL MINNESOTA

By
H. W. Anderson, Jr., D. F. Farrell, and W. L. Broussard

1974