



HYDROGEOLOGIC CROSS SECTIONS

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INTRODUCTION

The seven hydrogeologic cross sections on this plate illustrate the horizontal and vertical extent of aquifer and nonaquifer units in Carver County. They also show groundwater residence time and general direction of groundwater flow. The water table is typically within 10 feet of the land surface in most of Carver County and slightly deeper in the surficial sand aquifer (Figure 1, Plate 6). However, because of the large surface-elevation change near the Minnesota River, the water table can locally be more than 120 feet below land surface. This deep water-table condition is shown on the eastern side of cross sections E-E', F-F', and G-G' in the bluffs near the broad valley now occupied by the Minnesota River.

Figure 1 shows the location of the seven hydrogeologic cross sections shown on this plate. These were selected from the 39 geologic cross sections created for Part A because the trace of the cross section lines include the deepest water wells in the county. Selected wells along these cross sections were sampled and analyzed for most of the groundwater chemistry data, which include major cations and anions, trace elements, stable isotopes, tritium, and carbon-14. The cross sections illustrate both shallow and deep hydrologic conditions across the county.

RELATIVE HYDRAULIC CONDUCTIVITY

This report identifies a surficial sand aquifer, 6 Quaternary buried sand and gravel aquifers, and 8 bedrock aquifers in Carver County. The Quaternary buried sand and gravel aquifers are adequate for domestic wells, but their extent and thickness vary greatly and are not always adequate for municipal or industrial supply wells that require higher pumping capacities. Many wells that require higher pumping capacities are constructed in the bedrock aquifers. The amount of water the Quaternary sand and gravel aquifers are able to transmit, calculated from aquifer transmissivity tests, varies from 89,800 to 273,000 gallons per day per foot (gpd/ft). The transmissivity in bedrock aquifers varies from 4,700 to 52,700 gpd/ft. The hydraulic properties of these aquifers are discussed in more detail on Plate 8.

The correlation of Quaternary aquifers and nonaquifers is shown in Figure 2, Plate 6. The Quaternary till units have limited permeability and are considered to be nonaquifer units; these units are shown in shades of gray. The relative hydraulic conductivity of these units is estimated using the average sand percentage of the matrix texture of the till units (the less than 2 millimeter grain size fraction), as shown in Table 1, Plate 4, Part A. It is assumed that as the sand content of the till increases, hydraulic conductivity also increases, and with greater hydraulic conductivity there is more potential for water movement. Lighter grays represent relatively higher hydraulic conductivities; darker grays represent lower hydraulic conductivities. The rt till with 56 percent sand and the dtv till with 51 percent sand have the highest relative hydraulic conductivities of the Carver County till units and are represented by the lightest gray. The gt till, which has 42 percent sand, has an intermediate relative hydraulic conductivity. The dth till and the bt till have 39 percent and 36 percent sand respectively, and have a lower relative hydraulic conductivity; they are represented by a darker gray. The xt till has 25 percent sand, the lowest relative hydraulic conductivity, and is represented by the darkest gray. No textural information is available for the undifferentiated Pleistocene sediment (ups); therefore, no inference of hydraulic conductivity should be made.

The sequence of bedrock geologic units, hydrogeologic units, and hydrogeologic properties is shown in Figure 1, Plate 8. The bedrock aquifers generally have good horizontal and vertical permeabilities. The confining units generally have low vertical permeability but may have relatively high horizontal permeability along bedding fractures. The St. Peter, Wonevoc, Mt. Simon, and Hinckley aquifers are sandstones in which groundwater moves primarily through intergranular flow. Groundwater in the Prairie du Chien and Upper Tunnel City aquifers mainly moves through fractures. Groundwater in the Jordan aquifer moves through a combination of intergranular and fracture flow. An enhanced-permeability zone is generally found in the uppermost 50 feet of all Proterozoic and Paleozoic sedimentary bedrock units that are either exposed at the land surface or directly covered by glacial sediment (Runkel and others, 2006). This enhanced permeability is attributed to the presence of fractures developed or enlarged during weathering when the top of the bedrock surface was the land surface. The fractures in this enhanced-permeability zone generally increase the yield from units that are typically aquifers. In addition, these fractures will usually increase the permeability of units that are typically not aquifers, which may allow nonaquifer units to be used as a water source. The enhanced-permeability fractures in nonaquifer units may also compromise the confining character of those units. Enhanced permeability zones in the Ka aquifer or bedrock units directly beneath the Ka aquifer may exist locally, but this has not been confirmed.

GROUNDWATER RESIDENCE TIME

The pink, green, and blue areas shown on these cross sections represent the groundwater residence time. This is the approximate length of time that has elapsed since the water infiltrated the land surface to the time it was pumped from the aquifer. Groundwater residence time can be estimated by the amount of tritium (³H) that is present in the groundwater. Tritium is a naturally occurring radioactive isotope of hydrogen whose presence in water samples indicates that the water has infiltrated the land surface since the early 1950s. Concentrations of tritium in the atmosphere were greatly increased between about 1953 and 1963 by above-ground nuclear bomb tests (Alexander and Alexander, 1989). Since tritium decays at a known rate (half-life of 12.32 years), the proportion of recently recharged water in a sample can be estimated by its tritium content. Water samples with tritium concentrations of 8 or more tritium units (TU) are classified as recent water that entered the ground since the early 1950s. Water samples with tritium concentrations of 1 TU or less are classified as vintage water that entered the ground before approximately 1953. Water samples with tritium concentrations greater than 1 TU and less than 8 TU are considered mixed waters because they are a mixture of vintage and recent waters.

Seventy-four out of 87 groundwater samples that were analyzed for tritium had vintage tritium age, 10 samples had mixed tritium age, and 3 samples had recent tritium age. In the Minnesota River valley, much of the area is underlain by high permeability sand and gravel deposits, and recent tritium-age water has penetrated to approximately 200 to 250 feet below land surface. Outside of the Minnesota River valley most of Carver County has relatively low permeability clay-loam and loam glacial sediment at the land surface and recent tritium-age water has only penetrated to about 50 feet below land surface. Recent and mixed tritium-age water has penetrated up to a few hundred feet below land surface in a few select areas: near Watertown on cross section A-A', near Lake Zumbra and Lake Minnetonka on cross section D-D', and in the Jordan aquifer on the east side of cross section D-D'. Most of Carver County is underlain by low permeability, fine-grained glacial sediment. However, a few areas are underlain with near-surface sand and gravel aquifers or deep lakes that connect to buried sand and gravel aquifers, which allows for more local groundwater recharge.

REFERENCES CITED

Alexander, S.C., and Alexander, E.C. Jr., 1989, Residence times of Minnesota groundwaters: Minnesota Academy of Sciences Journal, v. 5, no. 1, p. 48-52.
Runkel, A.C., Tipping, R.G., Alexander, E.C. Jr., and Alexander, S.C., 2006, Hydrostratigraphic characterization of intergranular and secondary porosity in part of the Cambrian sandstone aquifer system of the craton interior of North America—Improving predictability of hydrogeologic properties: Sedimentary Geology, v. 184, p. 281-304.

FIGURE 1. Location of the seven hydrogeologic cross sections shown on this plate (black lines) and the five geologic cross sections shown on Plate 4, Part A (orange lines). The circles indicate the locations of wells displayed on the hydrogeologic cross sections shown on this plate.

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LOCATION DIAGRAM

This map was compiled and generated using geographic information systems (GIS) technology. Digital data products, including chemistry and geophysical data, are available from DNR Ecological and Water Resources at mndnr.gov/groundwatermapping.
This map was prepared from publicly available information only. Every reasonable effort has been made to ensure the accuracy of the factual data on which this map interpretation is based. However, the Department of Natural Resources does not warrant the accuracy, completeness, or any implied uses of these data. Users may wish to verify critical information; sources include both the references here and information on file in the office of the Minnesota Geological Survey and the Minnesota Department of Natural Resources. Every effort has been made to ensure the interpretation shown conforms to source geologic and cartographic practices. This map should be used to establish local title, boundaries, or locations of improvements.
Base modification Minnesota Geological Survey, Carver County Geologic Atlas, Part A, 2009. Project data compiled from 2010 to 2012 at a scale of 1:100,000. Universal Transverse Mercator projection, grid zone 15, 1983 North American datum. Vertical datum is mean sea level. GIS and cartography by Todd Petersen, Shaun Paschal, and Greg Munnings. Edited by Neil Cunningham.