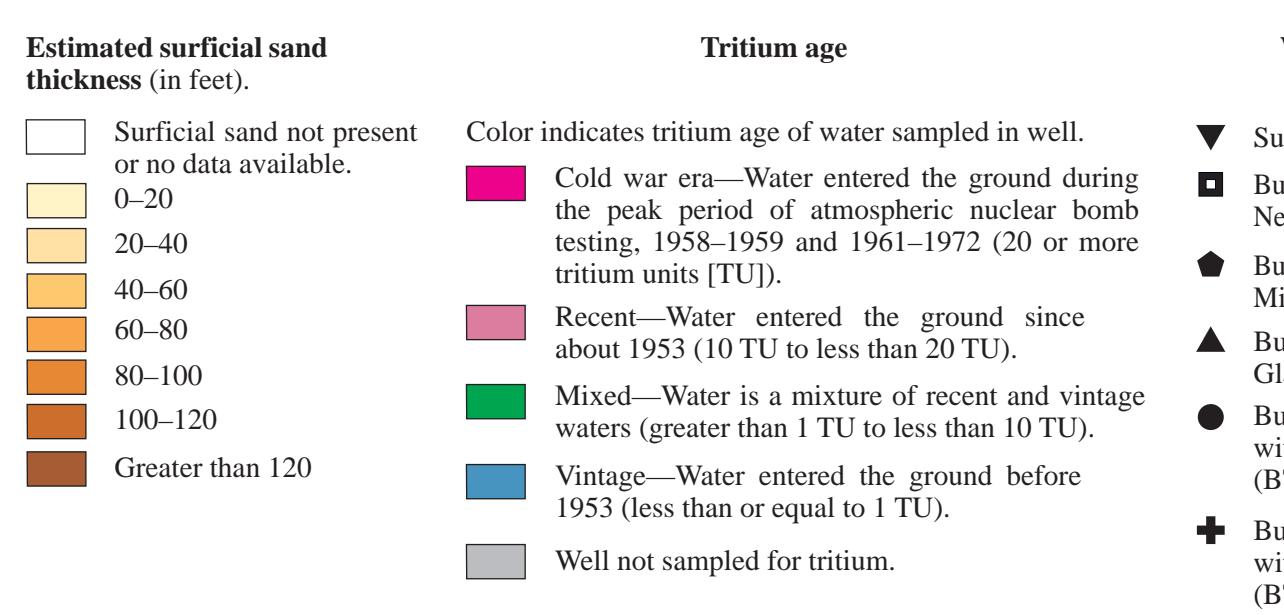


FIGURE 2. Surficial sand thickness, water-table elevation contours, and chemistry data from all aquifers. The thickness of the surficial sand ranges from a few feet to greater than 120 feet, but 80 percent of the surficial sand is less than 55 feet thick. The water table has low relief and is drained by the major rivers (Pine, Mississippi, and Nokomiss) in the county. The locations of all wells sampled for general chemistry and isotopes for this project are shown for convenience.



Estimated surficial sand thickness (in feet).

Surficial sand not present or no data available.

0-20

20-40

40-60

60-80

80-100

100-120

Greater than 120

#### MAP EXPLANATION

- Color indicates tritium age of water sampled in well.
- Cold war era—Water entered the ground during the peak period of atmospheric nuclear bomb testing, 1958–1959 and 1961–1972 (20 or more tritium units [TU]).
- Recent—Water entered the ground since about 1953 (10 TU to less than 10 TU).
- Mixed—Water is a mixture of recent and vintage waters (greater than 1 TU to less than 10 TU).
- Vintage—Water entered the ground before 1953 (less than or equal to 1 TU).
- Well not sampled for tritium.

#### MAP EXPLANATION

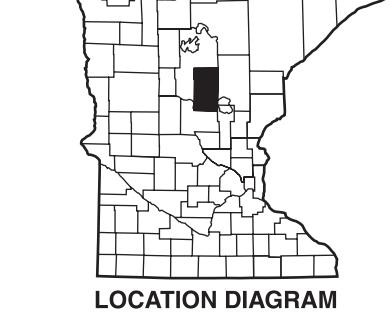
- Surficial sand aquifer.
- Buried sand aquifer beneath the Nelson Lake till (S1AT).
- Buried sand aquifer beneath the Mille Lacs deposits (S1MT).
- Buried sand aquifer associated with Glacial Lake Brainerd (BGLS).
- Buried sand aquifer associated with Brainerd assemblage, north (BTN1, BTN2, BTN3).
- Buried sand aquifer associated with Brainerd assemblage, south (BTS1, BTS2, BTS3).
- Older Quaternary aquifer.
- Bedrock aquifer.

#### Well and aquifer symbols

- Water-table elevation (in feet above mean sea level). Contour interval is 25 feet. Dashed contour indicates estimated elevation.
- Inferred water-table elevation (in feet above mean sea level) in nonaqueous sediments. Contour interval is 25 feet.
- General direction of ground-water movement.
- If shown, arsenic concentration equals or exceeds 5 parts per billion.
- If shown, chloride concentration equals or exceeds 5 parts per million.
- If shown, ground-water age in years, estimated by carbon-14 isotope analysis.
- Well log listed in County Well Index database.
- Surface watershed boundary.
- Line of cross section.
- Body of water.

#### Map symbols and labels

- Estimated depth to water table in surficial sand aquifer (in feet below land surface).
  - Surficial sand aquifer not present or no data available.
  - 0-25
  - 25-50
  - 50-75
  - Greater than 75
- Map symbols and labels
  - \* Static (nonpumping) water-level data from County Well Index database.
  - Line of cross section.
  - Body of water.



## HYDROGEOLOGY OF THE BURIED AND SURFICIAL AQUIFERS

By

Todd A. Petersen

2007

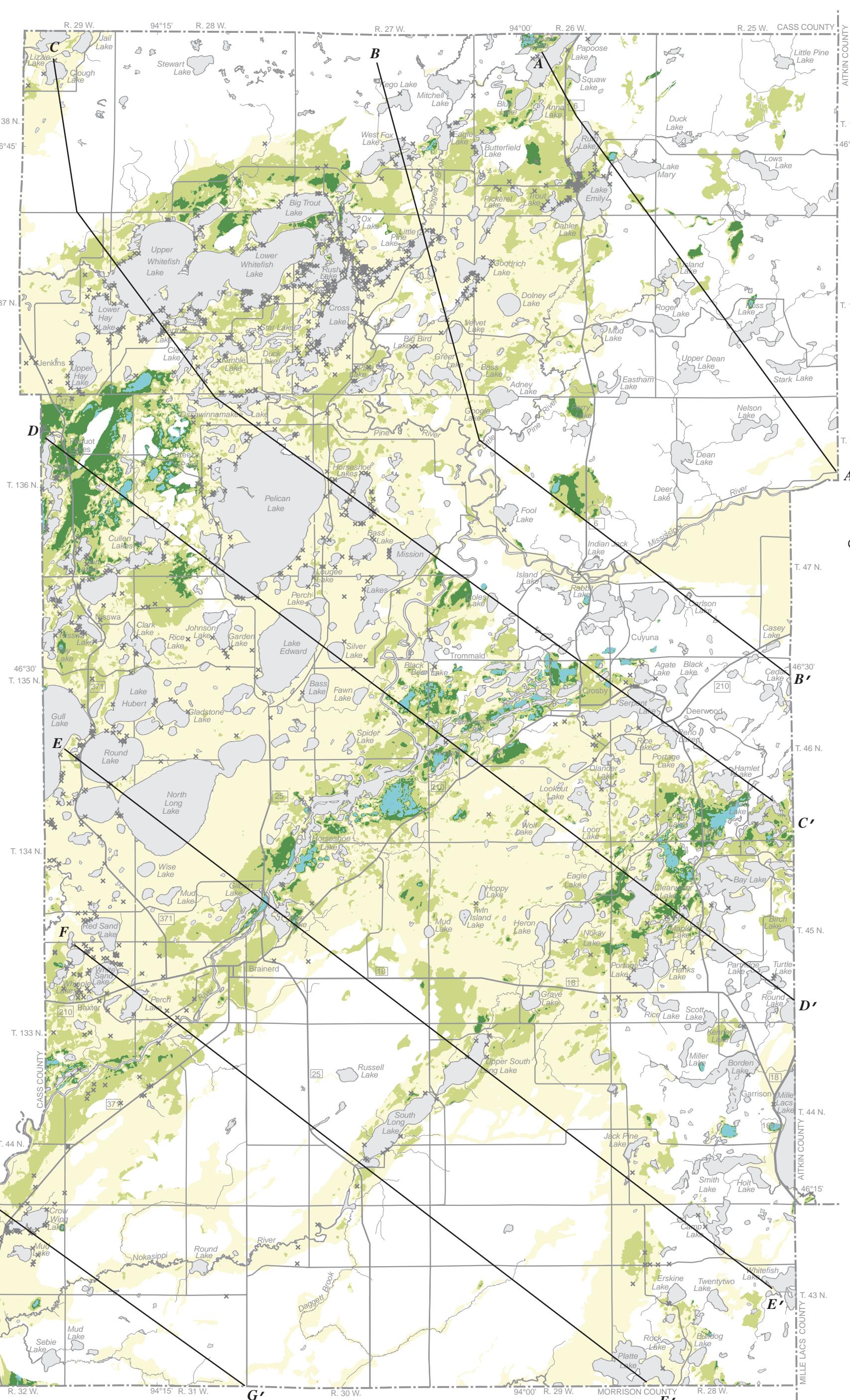


FIGURE 3. Depth to water table from the land surface in the surficial sand aquifer. The depth to the water table is generally less than 25 feet. Because the water table is relatively flat, its depth is greater in areas with locally high topographic relief. Good data on water-table elevations are available where the surficial sand aquifer is widely used, including the western part of Crow Wing County, especially around many of the large lakes, and near Upper South Long Lake and South Long Lake. Limited data on water-table elevations exist elsewhere.

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#### MAP EXPLANATION

- Estimated depth to water table in surficial sand aquifer (in feet below land surface).
  - Surficial sand aquifer not present or no data available.
  - 0-25
  - 25-50
  - 50-75
  - Greater than 75
- Map symbols and labels
  - \* Static (nonpumping) water-level data from County Well Index database.
  - Line of cross section.
  - Body of water.

#### Map symbols and labels

- Estimated depth to water table in surficial sand aquifer (in feet below land surface).
  - Surficial sand aquifer not present or no data available.
  - 0-25
  - 25-50
  - 50-75
  - Greater than 75
- Map symbols and labels
  - \* Static (nonpumping) water-level data from County Well Index database.
  - Line of cross section.
  - Body of water.

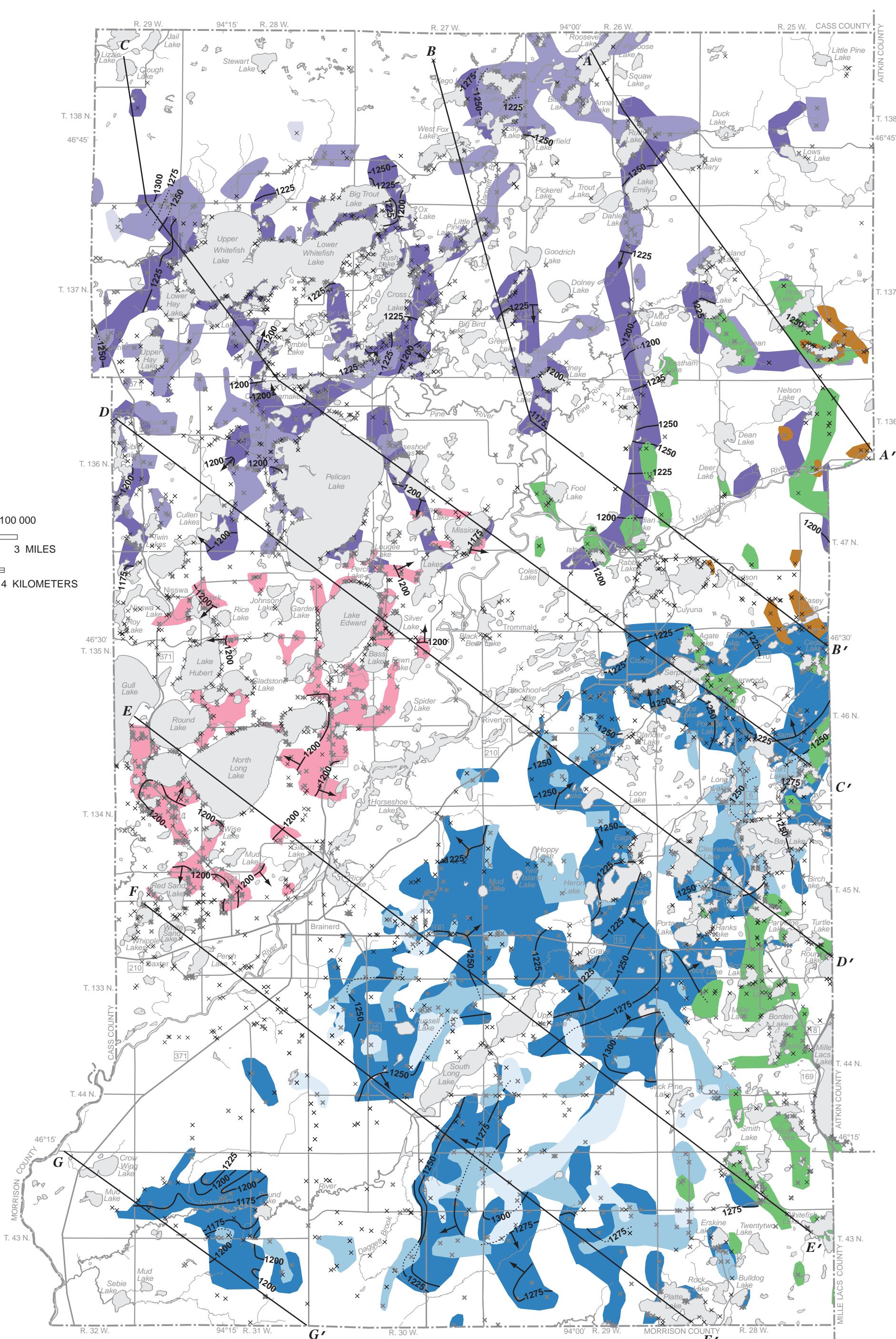


FIGURE 4. Extent and distribution of nine buried sand aquifers in Crow Wing County. Most of these aquifers are discontinuous and of limited geographic extent. Three of the aquifers (BGLS, BTN3, and

BTS3) had sufficient extent and adequate static water-level data to construct potentiometric surface contours.

#### MAP EXPLANATION

- Buried sand aquifers—Color indicates aquifer.
  - Beneath the Nelson Lake till, Aitkin assemblage (S1AT).
  - Beneath the Mille Lacs deposits (S1MT).
  - Associated with Glacial Lake Brainerd (BGLS).
  - Associated with the Brainerd assemblage.
    - North, uppermost (BTN1).
    - North, middle (BTN2).
    - North, lowest (BTN3).
  - South, uppermost (BTS1).
  - South, middle (BTS2).
  - South, lowest (BTS3).
- Map symbols and labels
  - 1225 — Potentiometric surface contour (in feet above mean sea level) for the BGLS, BTN3, and BTS3 aquifers.
  - 1225 — Potentiometric surface contour (in feet above mean sea level) for the BGLS, BTN3, and BTS3 aquifers obscured by overlying aquifers.
  - ← General direction of ground-water movement in the BGLS, BTN3, and BTS3 aquifers.
  - \* Static (nonpumping) water-level data from County Well Index database.
  - Well log listed in County Well Index database.
  - Line of cross section.
  - Body of water.

#### Correlation of Buried Aquifers

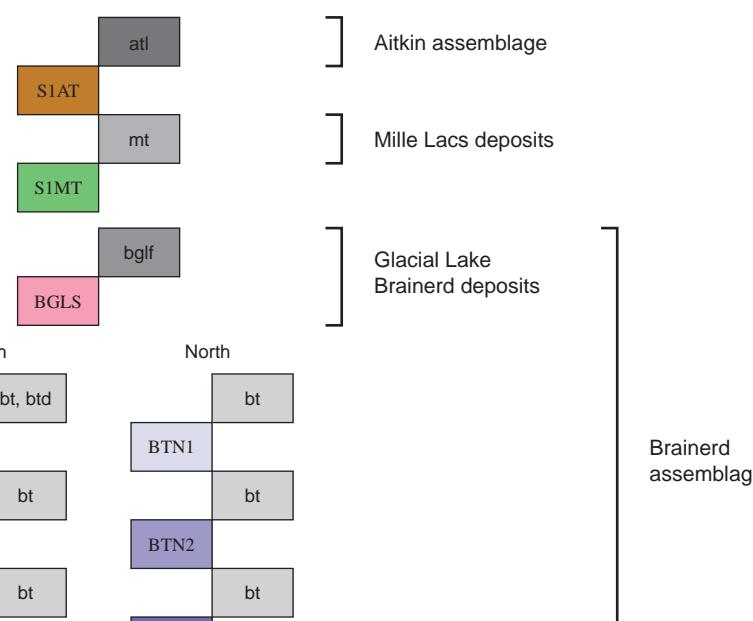
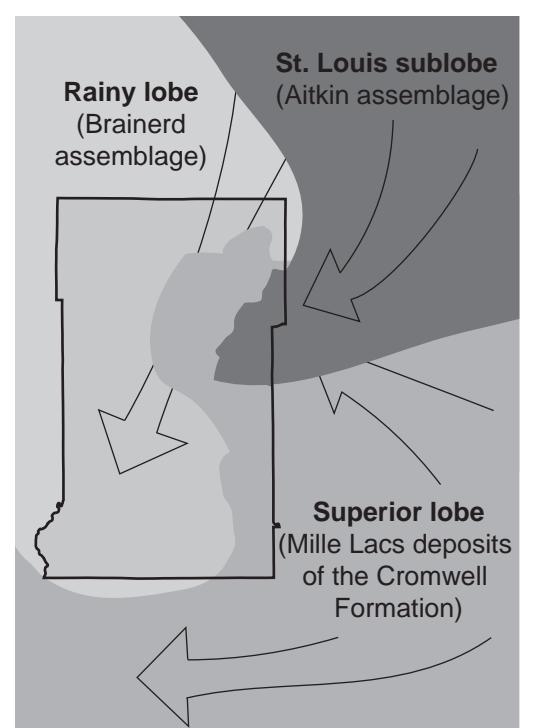


FIGURE 5. Correlation of aquifers and till units in Crow Wing County. The till units, as mapped on Plate 3, Part A, are shown in shaded gray in color and labeled in capital letters. The S1AT and S1MT aquifers are correlated with their overlying tills by position only; the stratigraphic relationship could not be determined because data were lacking. The S1AT aquifer is below the Nelson Lake till (at0) and above the Garrison till (mt). The S1MT aquifer is below the Garrison till. The other aquifers are in the Brainerd assemblage. The BGLS aquifer is below fine-grained Glacial Lake Brainerd deposits (bgf). The BTN and BTS aquifers are intertidal sand deposits associated with advances and retreats of the Rainy lobe (see text for complete description).



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Ramsey County boundaries - Minnesota Department of Transportation GIS website: Base Map Composite 1:24,000  
Hydrologic features - U.S. Geological Survey Digital Line Graphs (source scale 1:100,000)

Digital elevation data - Minnesota Geological Survey  
Hydrologic data compiled from 2005 to 2007 from 1:100,000 Universal Transverse Mercator projection, grid zone 18, 1983 North American datum. Vertical datum is mean sea level.

Statewide view of glacial plains - DNR Waters, for a statewide view of glacial plains.

Kiosks and cartography by Todd Petersen and Greg Massier.

FIGURE 6. WATER TABLE AND POTENTIOMETRIC SURFACES OF MAJOR AQUIFERS

#### Surficial Sand Aquifer and Surficial Till

Crow Wing County is topographically fairly flat and is dominated by higher areas where low-permeability till is exposed at the surface in the north, northeast, and south. Most of the central portion of the county has low-lying surficial sand, high relief, and many lakes. The county is drained by the Mississippi River, which has a large drainage area and is the major ground-water system, also greatly influencing the elevation of the water table. The water-table elevation contours (Figure 2) indicate ground-water flow in the surficial aquifer. They are based on static water-level data from water-table wells collected by well drillers immediately after the wells were constructed (from data in the County Well Index) and on lake surface elevation and river elevation data (from topographic maps) in the three river drainages.

In the central surficial sands, the water table has about 150 feet of relief from north to south. It is extremely flat in the north. The Mississippi River has a large drainage area and is the major ground-water system, also greatly influencing the elevation of the water table.

**Buried sand aquifers beneath the Mille Lacs deposits.** Some of these sand units are continuous with and mapped as Brainerd assemblage aquifers (BTN2, BTN3, BTS2, and BTS3). But in extreme southeastern Crow Wing County, they can only be mapped as underlying the Garrison till. The sands were probably deposited during the recession of the glacier that deposited the till, not during the advance of the glacier that deposited the overlying Garrison till. This sand unit is a viable aquifer; at least 91 wells are completed in it. This sand is labeled S1MT because it cannot be stratigraphically correlated to other mapped aquifers; therefore, it is labeled S1MT with a special designation. It lies directly beneath the Garrison till.

**Aitkin assemblage.** A small number of scattered buried sand units of limited extent were mapped beneath the Nelson Lake till (part of the Aitkin assemblage, Part A, Plate 3) in the east-central portion

of the county. Because of the limited number of wells, very little stratigraphic information is available for this unit; those buried sands were labeled S1AT. This indicates that the aquifer lies beneath the Nelson Lake till but may not be directly correlated to it stratigraphically.

#### WATER TABLE AND POTENTIOMETRIC SURFACES OF MAJOR AQUIFERS

##### Surficial Sand Aquifer and Surficial Till

Crow Wing County is topographically fairly flat and is dominated by higher areas where low-permeability till is exposed at the surface in the north, northeast, and south. Most of the central portion of the county has low-lying surficial sand, high relief, and many lakes. The county is drained by the Mississippi River, which has a large drainage area and is the major ground-water system, also greatly influencing the elevation of the water table. The water-table elevation contours (Figure 2) indicate ground-water flow in the surficial aquifer. They are based on static water-level data from water-table wells collected by well drillers immediately after the wells were constructed (from data in the County Well Index) and on lake surface elevation and river elevation data (from topographic maps) in the three river drainages.

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