U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
WISCONSIN DEPARTMENT OF NATURAL RESOURCES

HYDROLOGIC INVESTIGATIONS ATLAS HA–731
Hydrogeologic sections, ground-water provinces III and IV—SHEET 4 OF 4
Kammerer, P.A., and others, 1998, Geology, ground-water flow, and dissolved-solids concentrations in ground water along hydrogeologic sections through Wisconsin aquifers

GROUND-WATER PROVINCE III

GEOLOGY

Bedrock

The bedrock surface in this province comprises the Precambrian crystalline rocks of the basement complex except for a small area of Cambrian sandstone along the southern border. The Precambrian rocks are primarily metasedimentary and metavolcanic rocks, granite, and gneiss. Precambrian rocks shown on the map and hydrogeologic sections are undivided, but the lithology of the rocks at the bedrock surface is shown on the sections. The geology of the Precambrian rocks has been described in detail by Dutton and Bradley (1970), Sims (1976), Van Schmus (1976), Mudrey and others (1982), and Greenberg and Brown (1984).

All the Precambrian rocks are dense and impermeable and yield water only where fractures and weathering have created secondary permeability. These rocks generally are used for water supplies only where adequate quantities of water cannot be obtained from overlying glacial deposits.

Unconsolidated Deposits

Unconsolidated deposits in this province consist of Pleistocene glacial deposits. The glacial deposits range in thickness from less than 50 feet to greater than 200 feet (Trotta and Cotter, 1973). Glacial deposits generally are thinnest in the southern part of the province.

Permeable glacial outwash deposits in buried bedrock valleys and outwash plains are important sources of ground-water supplies. Outwash in buried valleys is especially important in the south where glacial deposits generally are thin. An outwash plain north and east of Antigo (sections H–H' and J–J') yields large quantities of water to irrigation wells.

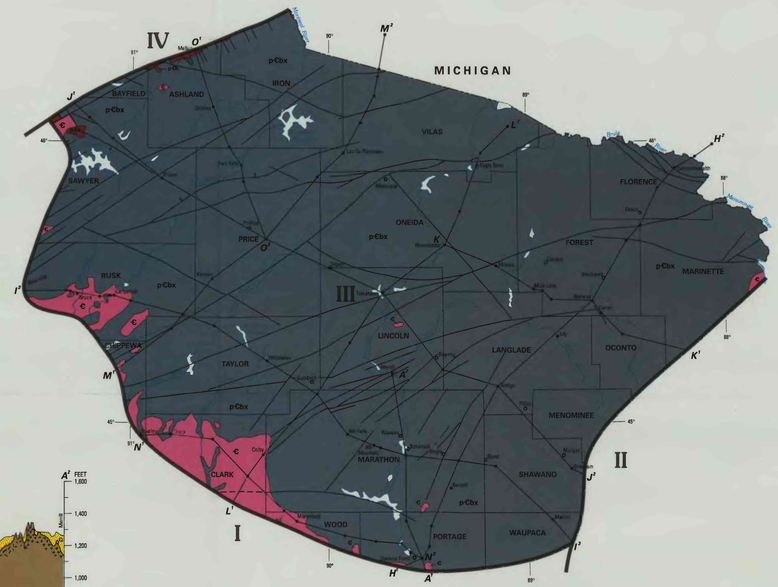
Vertical Ground-Water Flow

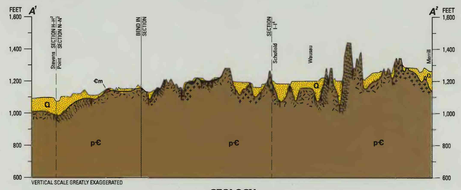
No regional confining units are in this province. Ground-water flow is affected by local confining units, but consideration of these local effects is beyond the scope of this atlas.

Dissolved-Solids Concentration in Ground Water

Dissolved-solids concentrations in water from the glacial deposits generally range from about 200 milligrams per liter to greater than 300 milligrams per liter in the southeastern part of the province and from less than 100 milligrams per liter to about 200 milligrams per liter in the remainder of the province (Kammerer, 1995). Dissolved-solids concentrations in water from Precambrian rocks are similar to those in water from overlying glacial deposits. The area in the southeastern part of the province where ground water has high dissolved-solids concentrations roughly coincides with an area where the glacial deposits contain more calcareous material than those in the remainder of the province. Simpkins (1980) found that in Forest County, dissolved-solids concentrations were significantly higher in water from calcareous glacial deposits than from glacial deposits with less calcareous material.

Local differences in dissolved-solids concentrations in water from the glacial deposits preclude showing lines of equal dissolved-solids concentrations on many of the hydrogeologic sections. Ranges of dissolved-solids concentrations are given where lines of equal concentration cannot be shown.





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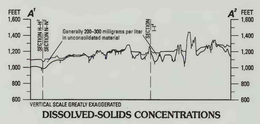
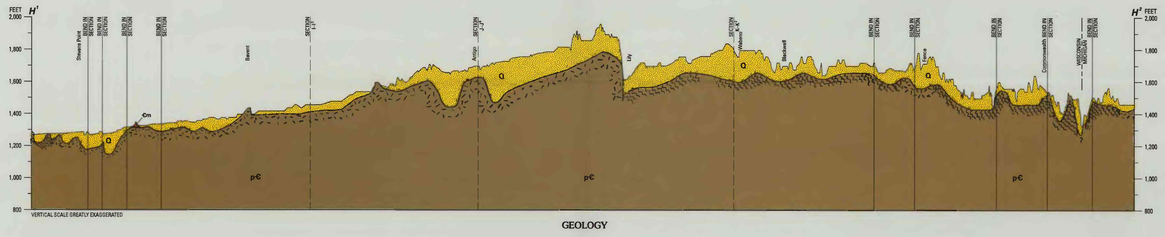


DISSOLVED-SOLIDS CONCENTRATIONS



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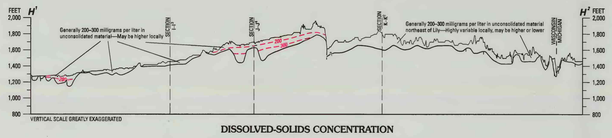

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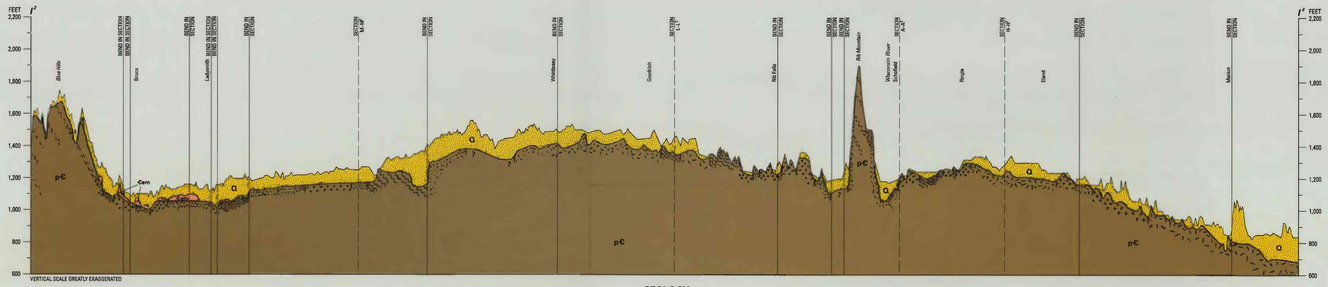

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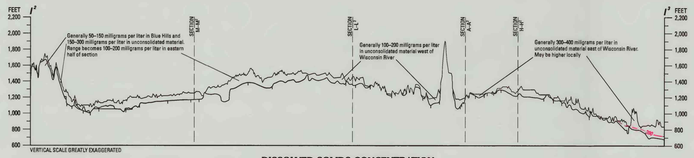

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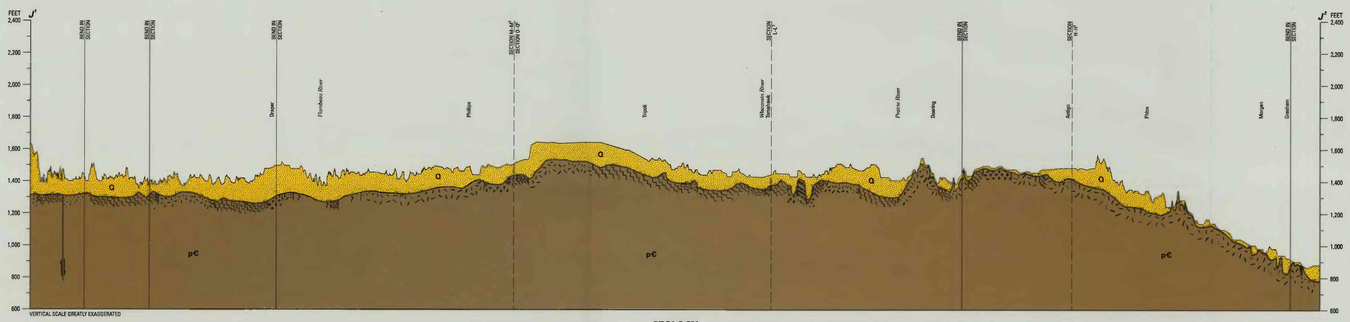

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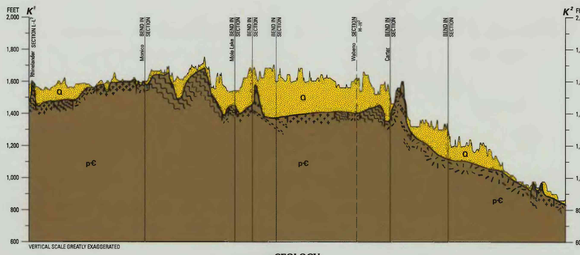

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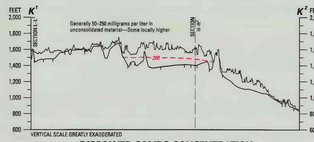

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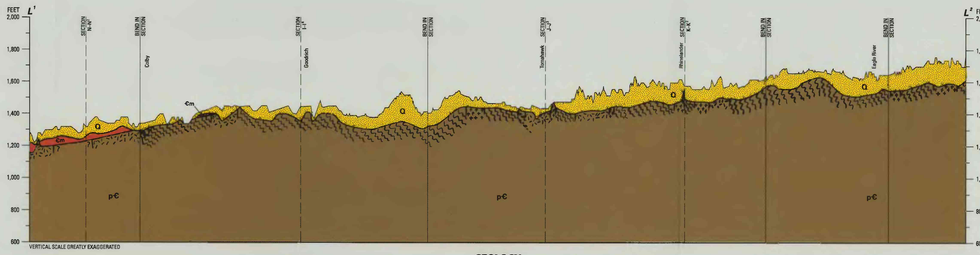

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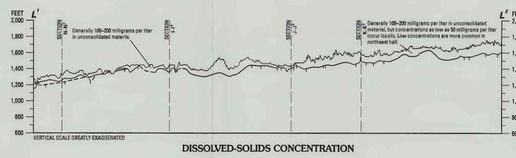

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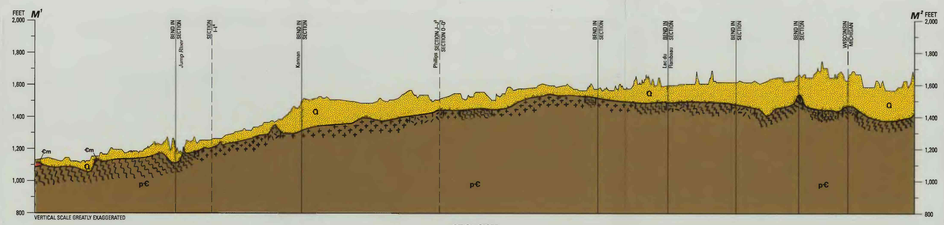

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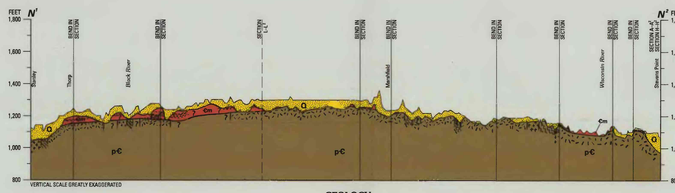

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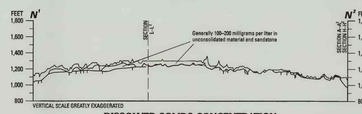

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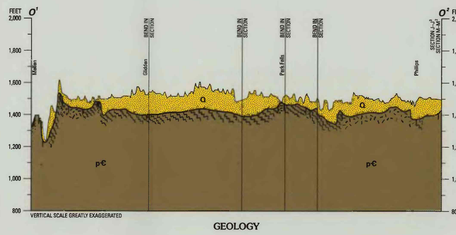

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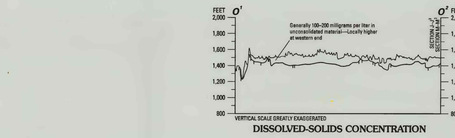


DISSOLVED-SOLIDS CONCENTRATION

EXPLANATION

Geologic units in ground-water provinces III and IV

	Unit on map	Unit in section	
QUATERNARY	Q	Q	Holocene alluvial and Pleistocene glacial deposits
CAMBRIAN	€	€	Cambrian system, undivided
	€j	€j	Jordan Sandstone
	€s	€s	St. Lawrence Formation
	€t	€t	Tunnel City Group
	€em	€em	Elk Mound Group
	€w	€w	Wonewoc Sandstone
	€ec	€ec	Eau Claire Sandstone
	€m	€m	Mt. Simon Sandstone
	p€	p€	Precambrian rocks, undivided
PRECAMBRIAN	p€k		Keweenawan Super Group Bayfield Group
	p€o		Oronto Group
	p€v		Keweenawan Volcanic Sequence
	p€bx		Basement complex

Lithology

CENOZOIC — Unconsolidated materials composed of clay, silt, sand, gravel, and boulders. Specific lithology not shown

PALEOZOIC AND PRECAMBRIAN — Major rock type / Secondary lithology

- Dolomite / Dolomitic
- Shale / Shaly
- Siltstone / Silty
- Limestone / Cherty
- Sandstone
- Conglomerate
- Saprolite
- Granitic rocks massive to foliated including quartz, monzonite, and syenite
- Quartzite, rhyolite, and conglomerate
- Metavolcanic rocks including diorite and gabbro
- Schist and gneiss including metasedimentary rocks
- Keweenawan volcanic rocks including andesite

PRECAMBRIAN — ? Lithology unknown

Contact—Dashed where approximately located. Queried where inferred

Fault—Dashed where approximately located. On map, ball and bar on downthrown side. On section, arrows indicate direction of vertical movement

III **Ground-water province boundary and province number**

L L' Antigo **Surface trace of hydrogeologic section**—Letters identify end points and intersections with ground-water province boundaries. Solid circles show locations of turning point wells and municipality where turning point is located

?—200— **Line of equal dissolved-solids concentration**—Dashed where approximately located. Queried where inferred. Interval, in milligrams per liter, is variable

Phillips **Municipality located near hydrogeologic section**

GROUND-WATER PROVINCE IV

GEOLOGY

Bedrock

The uppermost bedrock in this province is Precambrian volcanic and sedimentary rocks of the Keweenawan Supergroup; a small area of Paleozoic sandstones, however, is in the south. The Keweenawan Supergroup is underlain by the older Precambrian crystalline rocks of the basement complex (Dutton and Bradley, 1970). The volcanic rocks are lava flows of basalt and andesite that are possibly as thick as 30,000 feet and contain as many as 700 separate sheet flows (White, 1966, p. 2). The younger sedimentary rocks of the Oronto and the Bayfield Groups of the Keweenawan Supergroup overlie the volcanic rocks along the northern and southern boundaries of the province. The Oronto Group is 60 percent shale and 40 percent arkosic sandstone, and the Bayfield Group is 99 percent quartzose sandstone (Thiel, 1956, p. 1088). Estimates of the maximum thickness of the sedimentary rocks range from 13,000 to greater than 25,000 feet; although the thickness is uncertain, it is greatest north of the Douglas Thrust Fault (Young and Skinner, 1974).

The volcanic rocks generally yield only small quantities of water to wells, but these rocks are used locally for domestic water supplies. The Precambrian sedimentary rocks yield larger quantities of water to wells than do the volcanic rocks. The sedimentary rocks are used for water supplies primarily along the Lake Superior shoreline where the overlying glacial deposits are not suitable for water supplies (Young and Skinner, 1974). Cambrian sandstones along the southern boundary of the province generally yield larger quantities of water to wells than do the Precambrian sedimentary rocks.

Unconsolidated Deposits

Unconsolidated deposits in this province consist of Pleistocene glacial deposits. These deposits range in thickness from less than 50 to greater than 400 feet (Trotta and Cotter, 1973). The glacial deposits are thickest along a southwesterly trending band of pitted outwash that extends from the Bayfield Peninsula through Burnett County and in the St. Louis River Valley near Superior (Trotta and Cotter, 1973; Hadley and Pelham, 1976). Most of the thickness of the deposits in the band of pitted outwash is unsaturated; depths to the water table commonly range from 150 to 250 feet in Bayfield County and are almost 400 feet beneath some hills on the tip of the Bayfield Peninsula (Young and Skinner, 1974).

Most ground-water supplies from glacial deposits are from isolated layers or lenses of sand and gravel. Yields from these deposits generally are higher than those from the bedrock. The glacial deposits are used for ground-water supplies throughout the province.

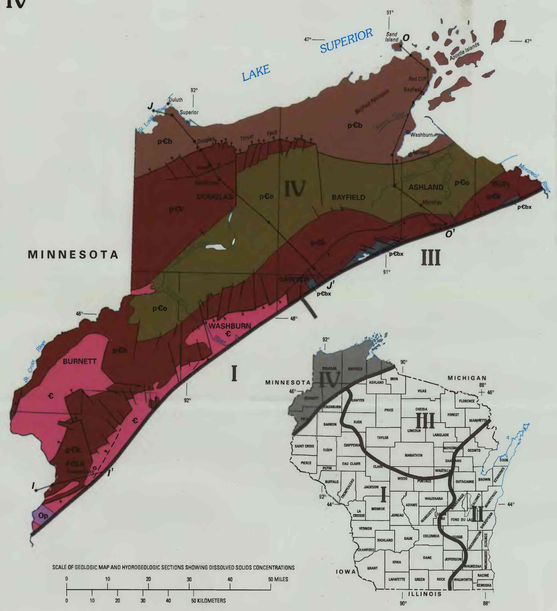
Vertical Ground-Water Flow

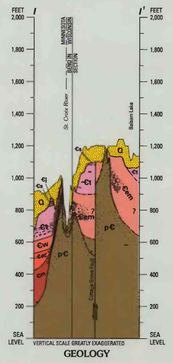
Regional confining units are absent (or unknown) in this province. Ground-water flow is probably affected by local confining units, but consideration of these local effects is beyond the scope of this atlas.

Dissolved-Solids Concentration in Ground Water

Dissolved-solids concentrations generally are lowest in water from glacial deposits in the central and southern parts of the province and highest in water from the aquifers in Precambrian sandstone along the shore of Lake Superior. Dissolved-solids concentrations in water from shallow aquifers (glacial deposits and the uppermost bedrock) commonly range from less than 100 to 200 milligrams per liter within most of the province, but concentrations commonly are greater than 300 milligrams per liter along the shore of Lake Superior (Kammerer, 1995).

Extreme local differences in dissolved-solids concentrations are common in water from the Precambrian sandstone aquifers. Kammerer (1984, p. 38–39) reported a range of dissolved-solids concentrations from 67 to 7,620 milligrams per liter for samples from 29 wells. Young and Skinner (1974) reported several wells near Superior and Ashland that yielded water with dissolved-solids concentrations that were greater than 1,000 milligrams per liter. Lines of equal dissolved-solids concentration through bedrock aquifers in the hydrogeologic sections are conjectural because of the unexplained local concentration differences and the lack of hydrologic data for these aquifers.





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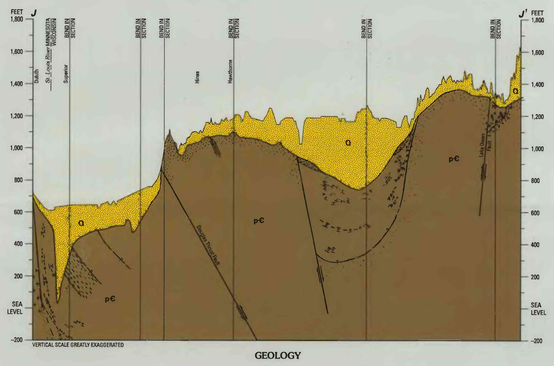

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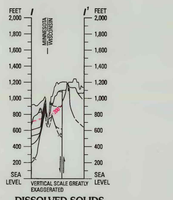

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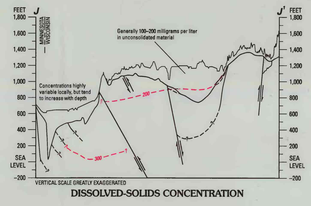

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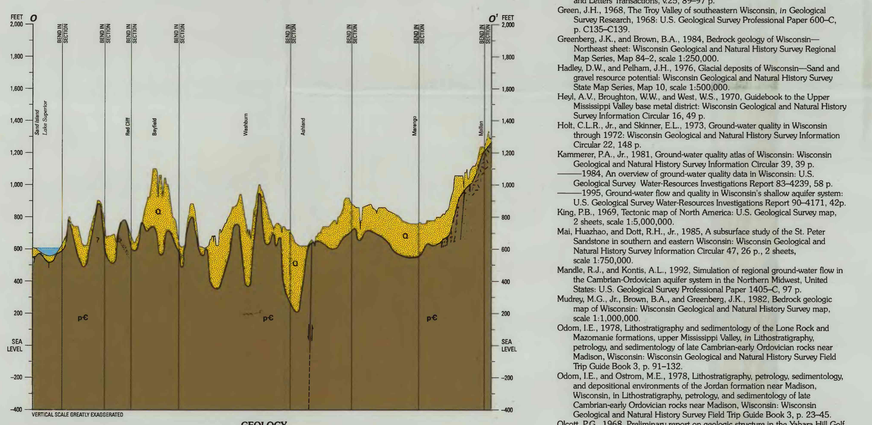

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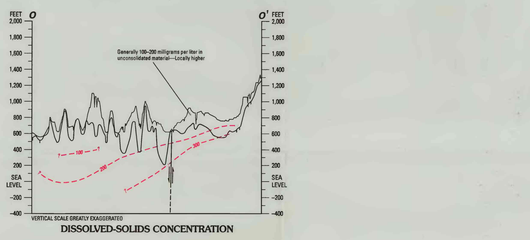

DISSOLVED-SOLIDS CONCENTRATION

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CONVERSION FACTORS

To obtain measurements in meters, multiply feet by 0.3048.

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NVGD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Hydrogeologic sections, ground-water provinces III and IV

GEOLOGY, GROUND-WATER FLOW, AND DISSOLVED-SOLIDS CONCENTRATIONS IN GROUND WATER ALONG HYDROGEOLOGIC SECTIONS THROUGH WISCONSIN AQUIFERS

By
Phil A. Kammerer, Jr., Lee C. Trotta, David P. Krabbenhoft, and R.A. Lidwin
1998

For sale by the U.S. Geological Survey, Branch of Information Services, Box 25286, Federal Center, Denver, CO 80225-0286