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 province I (south part)—SHEET 2 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 I (south part)

GEOLOGY

PRECAMBRIAN ROCKS

Precambrian rocks that underlie the southern part of province I are crystalline rocks of the basement complex. The Precambrian surface is covered by Paleozoic sedimentary rocks except where scattered Precambrian inliers are present and along the boundary between provinces I and III. The quartzite bluffs near Baraboo (section G–G') form the largest and most well known of the Precambrian inliers. All the Precambrian rocks are dense and impermeable and yield water only where fractures have created secondary permeability.

Several major faults have been described. A fault described by Chamberlin (1877, p. 289) extends from Wonewoc (Lafayette County) to Milton (Rock County); it intersects section A–A' near Evansville and section E–E' near Milton Junction. P.R. Wright (University of Wisconsin, unpub. B.A. thesis, 1930) and Thwaites (1931, p. 736) reported a fault that extends from east of Dodgeville (Iowa County) to Waukesha (Waukesha County) and intersects section A–A' near Oregon (Dane County) and section E–E' near Jefferson (Jefferson County). Dutton and Bradley (1970) described a short fault that intersects section G–G' near Dodgeville. Section B–B' intersects a complex system of faults east of Madison in Dane County (Olcott, 1968). Section A–A' intersects a fault south of Arlington; the extent of this fault is not known. Other short faults that do not intersect sections have been identified in the mining district of Grant, Iowa, and Lafayette Counties (Heyl and others, 1970) and in Marquette County (Ekern and Thwaites, 1930).

PALEOZOIC ROCKS

The Precambrian rocks are overlain by Paleozoic sedimentary rocks that form the sandstone aquifer; these rocks include the Mount Simon, the Eau Claire, and the Wonewoc Sandstones; the Tunnel City Group; the St. Lawrence formation; the Jordan Sandstone; and the Prairie du Chien, the Ancell, and the Sinnipee Groups. The Maquoketa Formation and Silurian rocks are found in scattered small areas in the south.

Because of its depth and the large water-yielding capacity of aquifers nearer the surface, the Mount Simon Sandstone usually is not full penetrated by wells except where it is the uppermost bedrock or near the bedrock surface. Geologic logs from wells at Madison (section A–A') and south of Baraboo (section G–G') indicate that the Mount Simon Sandstone contains shale and silt layers similar to those found in the upper part of the Eau Claire Sandstone. Nevertheless, the Mount Simon Sandstone is a highly productive aquifer within most of the province. It is medium- to coarse-grained sandstone that is poorly cemented by dolomite in most places and by silica locally (M.E. Ostrom, Wisconsin Geological and Natural History Survey, written commun., 1982). The Mount Simon Sandstone is thickest (800–1,000 feet) in the south along the Illinois state line.

The Eau Claire Sandstone generally is poorly cemented, but locally well cemented, by dolomite (M.E. Ostrom, Wisconsin Geological and Natural History Survey, written commun., 1982). In the northeastern part of the province, it is thin or absent, as can be seen at the northern end of sections A–A' and G–G' and the eastern end of section D–D'. The Eau Claire Sandstone generally can be divided into a lower sandy unit and upper shaly unit where its thickness exceeds 100 feet. Where it is shaly, the Eau Claire Sandstone yields only moderate quantities of water and is a confining between the overlying and underlying sandstones.

The Wonewoc Sandstone differs considerably in thickness areally because it was deposited on an irregular erosion surface. The sandstone generally is medium- to coarse-grained and poorly cemented by dolomite in most places and by silica locally (M.E. Ostrom, Wisconsin Geological and Natural History Survey, written commun., 1982). It yields large quantities of water to wells in many areas.

The Tunnel City Group is a well-cemented dolomitic sandstone that consists of two facies distinguished by the presence or absence of the mineral glauconite (Odom, 1978). The nonglauconitic facies is a southwestward-extending "tongue" within the glauconitic facies. This tongue is present west of Melvina (section D–D') north of West Lima (section H–H'), north of Dodgeville (section G–G'), north of Brooklyn (section A–A'), and north of Watertown (section E–E'). The glauconitic facies is a fine- to medium-grained, but commonly fine-grained feldspathic sandstone. The nonglauconitic facies is a fine- to medium-grained feldspathic sandstone or, locally, a sandy dolomite. The two facies are identifiable in outcrops, but generally are not distinguishable in well cuttings (M.E. Ostrom, Wisconsin Geological and Natural History Survey, written commun., 1982). The Tunnel City Group thickens gradually to the northwest. The Tunnel City Group yields water to wells locally, but it is commonly a confining unit in concert with the overlying St. Lawrence Formation where both are present.

The St. Lawrence Formation consists of interfingering facies of the dolomite and sandy dolomite of the Black Earth Member and the dolomite-cemented siltstone and the very fine-grained shaly sandstone of the Lodi Shale Member (M.E. Ostrom, Wisconsin Geological and Natural History Survey, written commun., 1982). Its thickness is variable areally because of pre-Jordan erosion. In the south, the Black Earth Member can rest directly on the Tunnel City Group as it does in the western half of section C–C'. The Black Earth Member extends northward to Melvina (section D–D') as a wedge about 100 feet thick. The maximum known thickness of the St. Lawrence Formation (120 feet) is near Cassville (section C–C'). The St. Lawrence Formation is a confining unit and is an unproductive source of water.

The Jordan Sandstone is a very fine- to medium-grained white to orange sandstone. The upper part of the formation, the Coon Valley Member, is a sandy dolomite (Odom and Ostrom, 1978). The Jordan Sandstone thins to the east from Prairie du Chien where it is about 140 feet thick (section B–B'); it has been identified only at isolated locations east of a line between Argyle (section C–C') and Baraboo (section G–G'). This apparent absence of the Jordan Sandstone in the east may be due to the difficulty in distinguishing between dolomites of the Coon Valley Member and those of the overlying Prairie du Chien Group in areas where the Coon Valley Member is the only unit of the Jordan Sandstone present. Well yields from the Jordan Sandstone are variable areally but are highest along the western border of the State where the formation generally is a well-sorted sandstone. Whether the Jordan Sandstone is poorly cemented by dolomite, well cemented by calcite, or very well cemented by silica depends on location (M.E. Ostrom, Wisconsin Geological and Natural History Survey, written commun., 1982).

Rocks of the Prairie du Chien Group differ in thickness areally because erosion preceded deposition of the rocks of the Ancell Group. Rocks of the Prairie du Chien Group generally are thickest (270–290 feet) in the west (western parts of sections B–B' and C–C') and generally thinnest (less than 100 feet) in the east. The Prairie du Chien Group consists of dolomite, sandstone, chert, and oolite (M.R. Thomasson, University of Wisconsin, unpub. data, 1959). The rocks of the Prairie du Chien Group are not a major source of water in the southern part of province I, but they are used locally for domestic supplies where they are the uppermost aquifer.

Rocks of the Ancell Group were deposited on an irregular erosion surface. The Ancell Group consists of medium- to coarse-grained sandstone that is poorly cemented by dolomite in most places and by limonite locally (M.E. Ostrom, Wisconsin Geological and Natural History Survey, written commun., 1982). It generally is shaly at the bottom of deep channels. The maximum thickness of the Ancell Group in this part of province I is more than 400 feet near Shullsburg (section G–G'). The Ancell Group is used for water supplies south of the Wisconsin River.

The dolomites of the Sinnipee Group are most common in the south. The Sinnipee Group generally is the uppermost bedrock unit in this part of province I. The maximum thickness of these rocks is about 300 feet. The Sinnipee Group yields sufficient quantities of water to wells for domestic water supplies; its permeability is due to fractures and solution cavities.

The Maquoketa Formation is found in scattered areas in the south. It is as thick as 150 feet at Shullsburg (section G–G') and about 100 feet thick at Blue Mounds (section B–B'). Silurian dolomite caps a few ridges in the south (section B–B' at Blue Mounds) where it has been eroded to less than its original thickness and is unsaturated.

UNCONSOLIDATED DEPOSITS

Unconsolidated deposits in this part of province I consist of Pleistocene glacial deposits and valley alluvium. Glacial deposits are absent in the Driftless Area in the west. Unconsolidated deposits in the Driftless Area consist of alluvium in river valleys. Examples of these alluvium-filled valleys can be seen where hydrogeologic sections intersect the Mississippi River (sections B–B' and D–D') and the Wisconsin River (sections A–A' and G–G'). The alluvial deposits in these valleys commonly range from 100 to 200 feet in thickness (Trotta and Cotter, 1973), and they are used extensively for water supplies.

The thickest unconsolidated deposits outside the Driftless Area consist of permeable glacial outwash in the central sand plain (parts of Portage, Adams, Wood, and Waushara Counties) and in the Rock River valley (Rock County). These deposits commonly range from 100 to 300 feet in thickness (Trotta and Cotter, 1973) and yield large quantities of water to wells. The northern ends of sections A–A' and H–H' cross the central sand plain, sections B–B' and C–C' cross the Rock River, and part of the southern end of section E–E' is within the Rock River Valley.

VERTICAL GROUND-WATER FLOW

Flow simulations by Mandle and Kontis (1992) indicate vertical recharge to deep aquifers in Paleozoic rocks in this part of province I except along the Mississippi River and along parts of the Wisconsin River. Near the Mississippi and the Wisconsin Rivers, hydraulic heads increase with depth, as indicated by the upward arrows across confining units in hydrogeologic sections where the sections cross these rivers. The upward hydraulic gradients across the Eau Claire and the St. Lawrence–Tunnel City confining units near the Mississippi River (sections B–B', C–C', D–D', and H–H') indicate upward leakage of water from the Mount Simon and Wonewoc aquifers; however, most of the water in these aquifers probably flows to the south, parallel to the Mississippi River.

DISSOLVED-SOLIDS CONCENTRATION IN GROUND WATER

Previous summaries of dissolved-solids concentrations in ground water, by geologic unit, for province I (Kammerer, 1984, p. 14–15) indicate that concentrations are highest in water from Ordovician aquifers and lowest in Cambrian aquifers. The data included in these summaries represent conditions in areas where the geologic unit being characterized is the bedrock aquifer nearest the land surface. Dissolved-solids concentration data for water from Ordovician aquifers are representative of water-quality conditions within the entire areal extent of the aquifer because these aquifers are part of the shallow aquifer system that commonly is tapped for water supplies. The data for the Cambrian aquifers generally are adequate to characterize water quality only in areas where the Ordovician aquifers are thin or absent.

In areas where Ordovician aquifers provide adequate quantities of water for water supplies (south of the Wisconsin River, for example), few wells are open only to the underlying Cambrian aquifers, and fewer still draw water from the deepest aquifers. Because of this, very few water-quality analyses are available for water from deep Cambrian aquifers.

The only available data on water-quality differences with depth in the western part of the province where the total thickness of Ordovician and Cambrian aquifers is greatest are from test wells drilled as part of the Regional Aquifer-System Analysis program (Young, 1992). Two wells were drilled in western Vernon County, and one well was drilled near Bagley in Grant County. The wells were drilled through the entire thickness of Paleozoic rocks to the Precambrian basement complex. The locations of these wells are shown on a map on sheet 1 of this atlas.

Packer tests were done on these wells to measure hydraulic heads in individual geologic units and to collect water samples for chemical analysis. Analyses of water samples from the wells in Vernon County indicated no readily apparent differences in water quality with depth. Water analyses for the well near Bagley indicated considerable differences in water quality with depth, especially in deep Cambrian aquifers.

Dissolved-solids concentrations in water from the Bagley test well ranged from 251 to 1,080 milligrams per liter. The highest concentration was measured in water from near the base of the Mount Simon Sandstone. Dissolved-solids concentrations decrease with decreasing depth through the full thickness of the Mount Simon and Eau Claire Sandstones to 251 milligrams per liter in water from the Wonewoc Sandstone. The Tunnel City–St. Lawrence confining unit separates these deep aquifers from overlying Cambrian and Ordovician aquifers that yield water with dissolved-solids concentrations that generally are within the range of 450 to 550 milligrams per liter.

The hydraulic head in the Bagley test well was highest (57 feet above the land surface) in the Mount Simon Sandstone and lower in each successive overlying unit. The composite head for all aquifers that overlie the Mount Simon Sandstone was below the land surface. Consequently, water from any aquifer that overlies the Mount Simon aquifer probably consists of a mixture of water from that aquifer and water from underlying aquifers.

Dissolved-solids concentrations in the range of 2,000 to 3,000 milligrams per liter in water from Cambrian aquifers at Prairie du Chien, which is about 10 miles north of the Bagley test well, have been reported (Weidman and Schultz, 1915; Holt and Skinner, 1973). The extent of saline water (water with a dissolved-solids concentration of greater than 1,000 milligrams per liter) in Cambrian aquifers cannot be determined from available data.

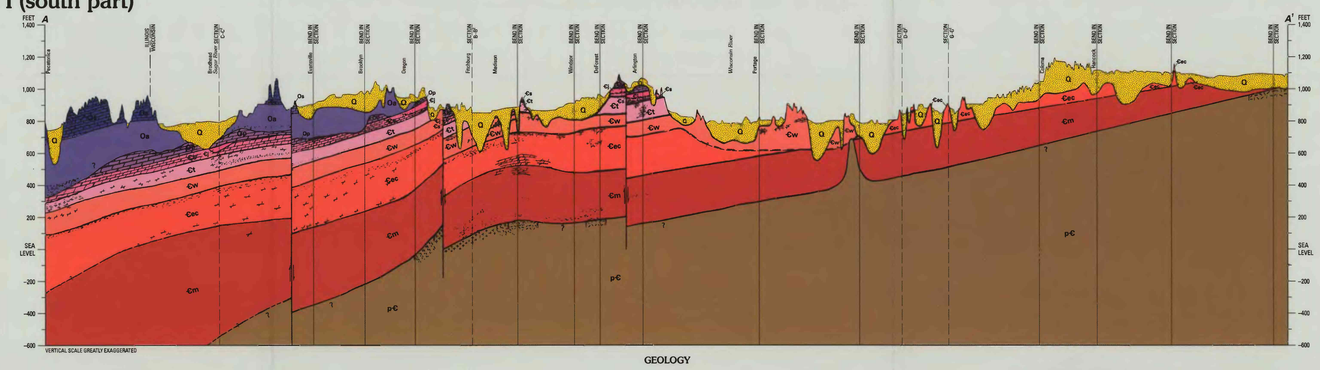
Dissolved-solids concentrations in this part of province I generally are lowest in the north in water from glacial deposits and Cambrian sandstones (sections A–A' and H–H') and highest in the southwest in water from the shallow aquifers commonly tapped for water supplies and from deep Cambrian aquifers. Dissolved-solids concentrations in water from alluvium in the Mississippi River Valley are similar to those in water from adjoining bedrock aquifers because the water in the alluvium generally is from the bedrock aquifers.

Placement of lines of equal dissolved-solids concentration in sections that traverse deep aquifers in the west and south is conjectural because of the scarcity of water quality and hydrologic data. In areas where the Tunnel City–St. Lawrence confining unit is present, dissolved-solids concentrations generally are higher in water from aquifers that overlie the confining unit than in water from the aquifer that underlies the confining unit. Available data indicate that dissolved-solids concentrations in water in deep, confined Cambrian aquifers in the west increase with depth and in the direction of regional ground-water flow.

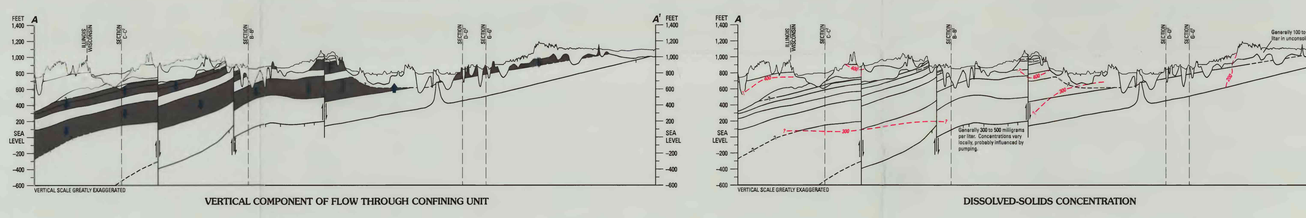
CONVERSION FACTORS

To obtain measurements in meters, multiply feet by 0.3048.

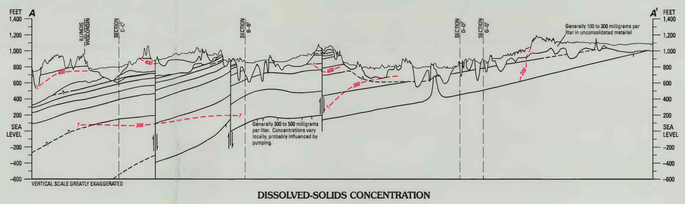
Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NVGD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.



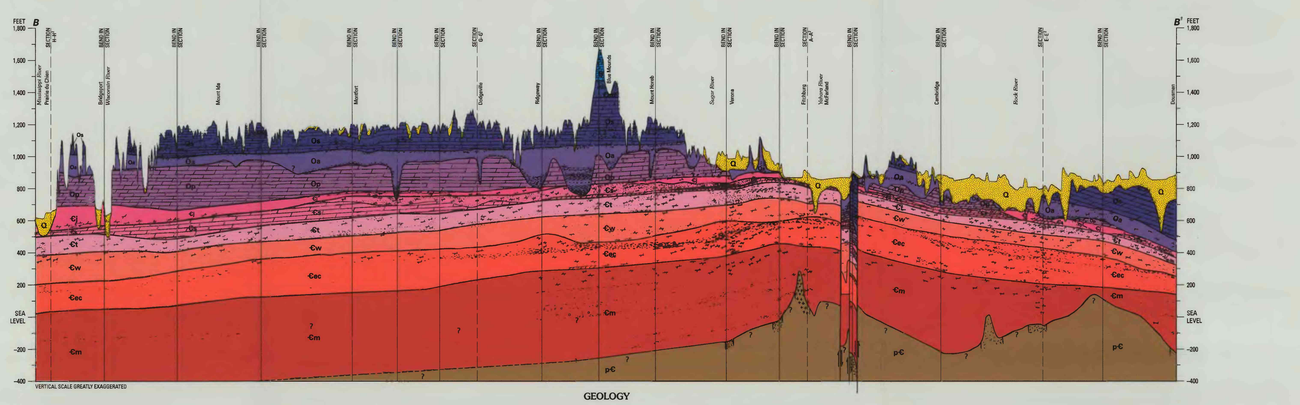
GEOLOGY



VERTICAL COMPONENT OF FLOW THROUGH CONFINING UNIT



DISSOLVED-SOLIDS CONCENTRATION



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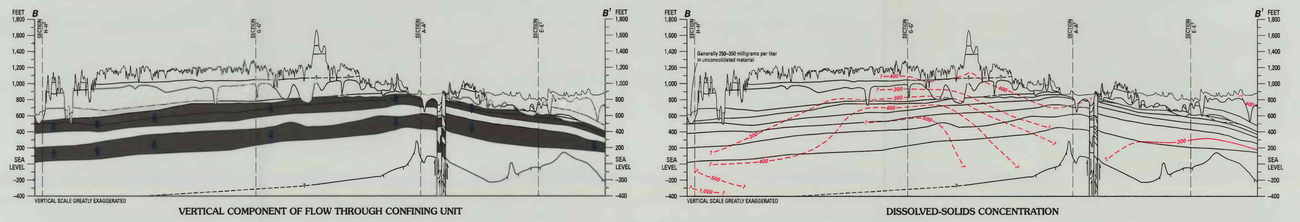

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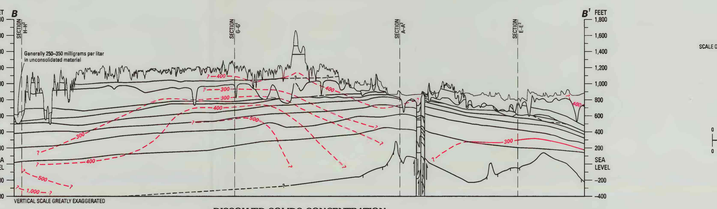

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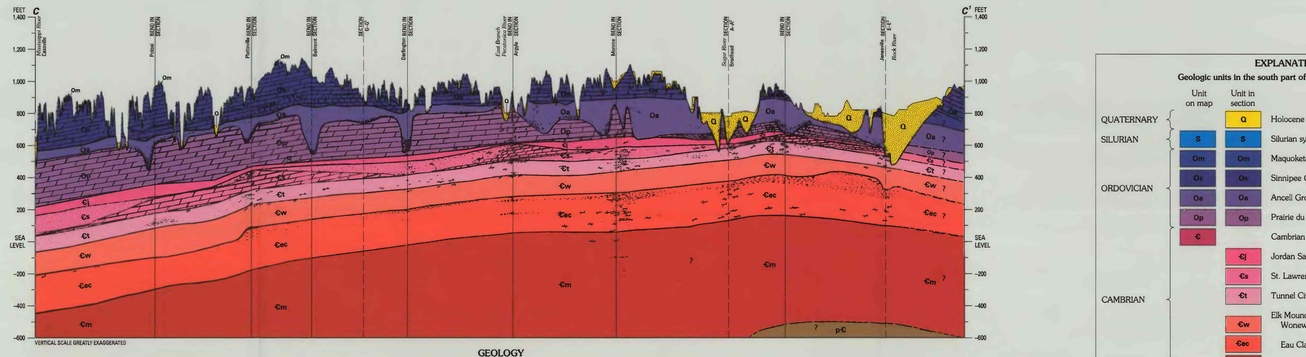

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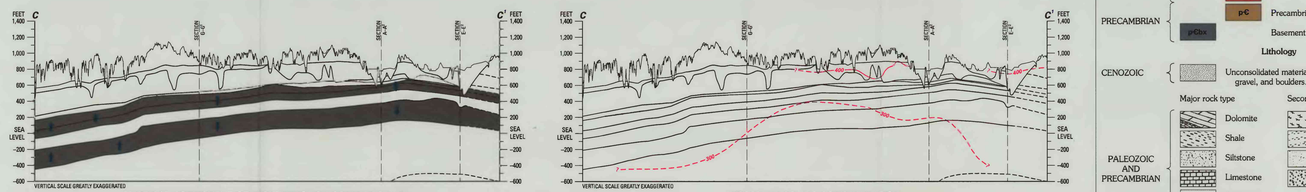

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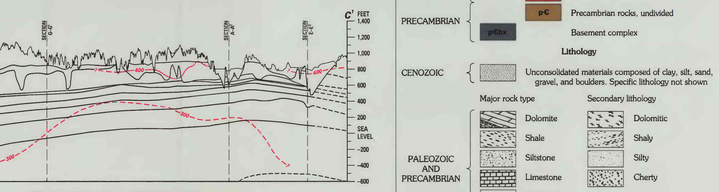

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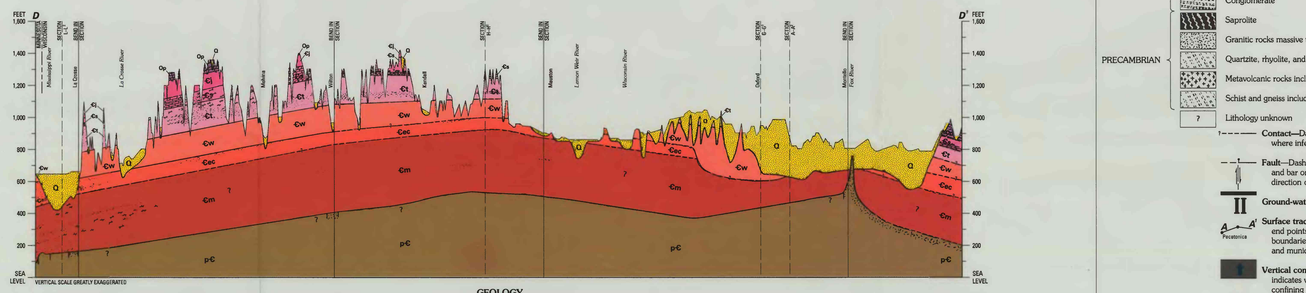

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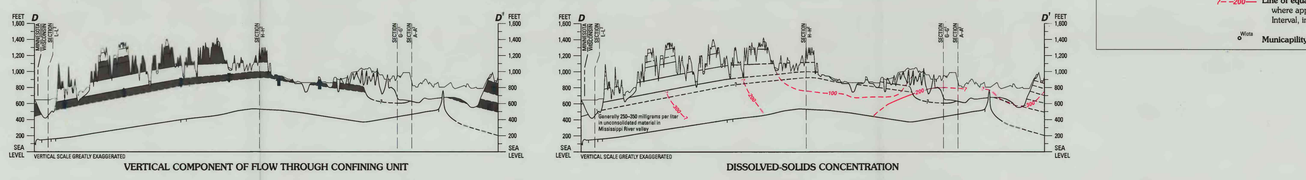

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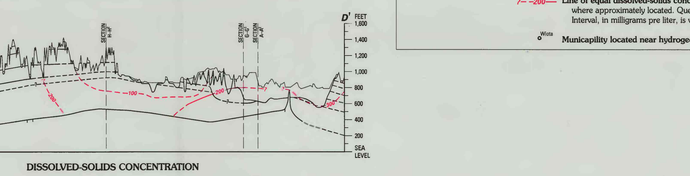

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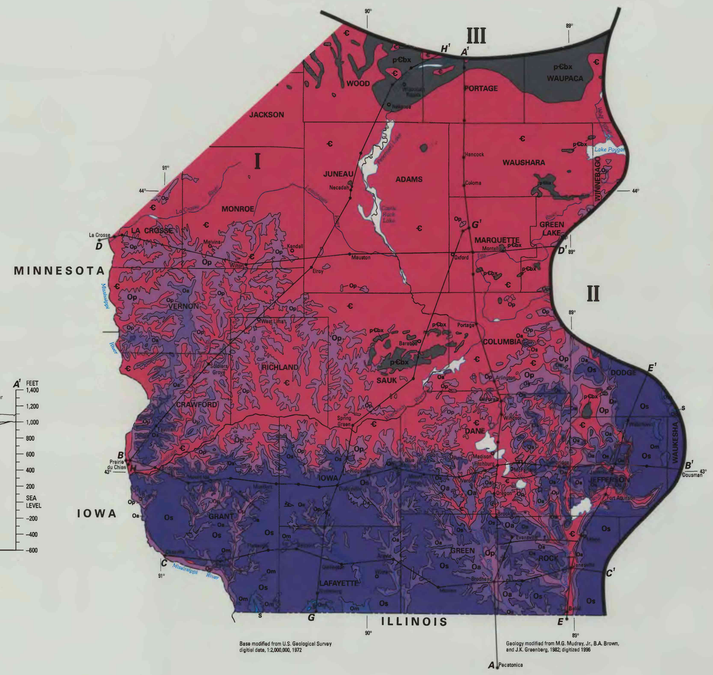

SCALE OF GEOLOGIC MAP AND HYDROGEOLOGIC SECTIONS SHOWING VERTICAL FLOW AND DISSOLVED SOLIDS CONCENTRATIONS

0 10 20 30 40 50 MILES
0 10 20 30 40 50 KILOMETERS

SCALE OF HYDROGEOLOGIC SECTIONS SHOWING GEOLOGY

0 10 20 30 MILES
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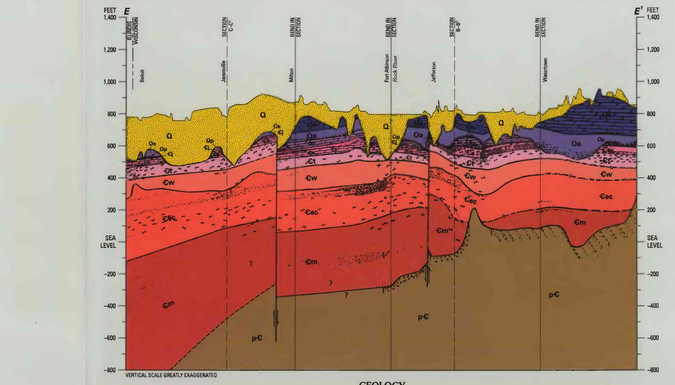

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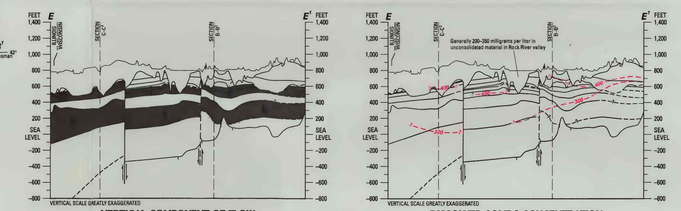
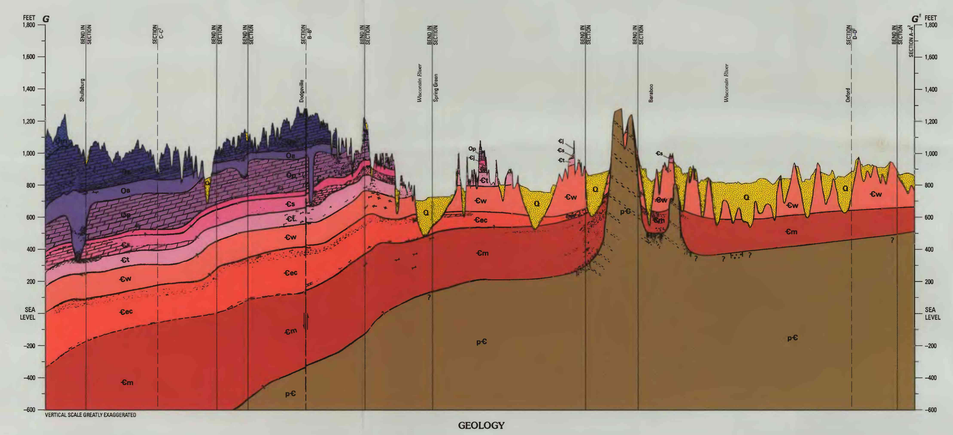


VERTICAL COMPONENT OF FLOW THROUGH CONFINING UNIT

DISSOLVED-SOLIDS CONCENTRATION



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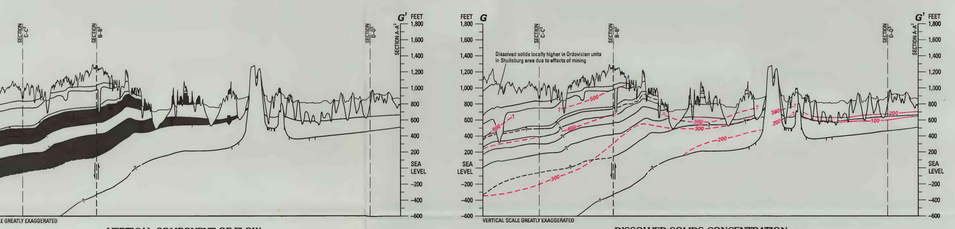

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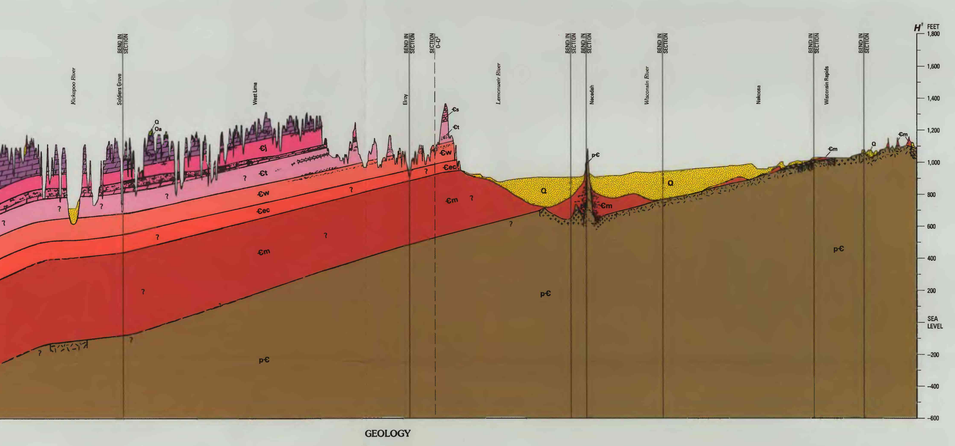

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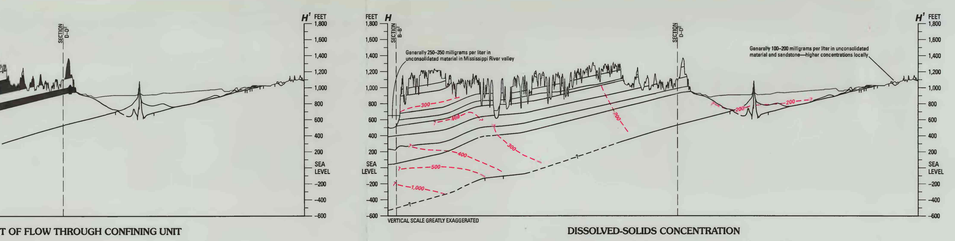

VERTICAL COMPONENT OF FLOW THROUGH CONFINING UNIT

DISSOLVED-SOLIDS CONCENTRATION

EXPLANATION

Geologic units in the south part of ground-water province I

	Unit on map	Unit in section	
QUATERNARY		Q	Holocene alluvial and Pleistocene glacial deposits
SILURIAN	S	S	Silurian system, undivided
ORDOVICIAN	Om	Om	Maquoketa Formation
	Os	Os	Sinnipee Group
	Oa	Oa	Ancell Group
	Op	Op	Prairie du Chien Group
CAMBRIAN	Є	Є	Cambrian system, undivided
	Єj	Єj	Jordan Sandstone
	Єs	Єs	St. Lawrence Formation
	Єt	Єt	Tunnel City Group
	Єw	Єw	Elk Mound Group; Wonewoc Sandstone
	Єec	Єec	Eau Claire Sandstone
	Єm	Єm	Mt. Simon Sandstone
PRECAMBRIAN	p€	p€	Precambrian rocks, undivided
	p€bx	p€bx	Basement complex

Lithology

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

	Major rock type	Secondary lithology
PALEOZOIC AND PRECAMBRIAN	Dolomite	Dolomitic
	Shale	Shaly
	Siltstone	Silty
	Limestone	Cherty
	Sandstone	
	Conglomerate	
PRECAMBRIAN	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	
	? 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

II Ground-water province boundary and province number

A—A' 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

Vertical component of flow through confining unit—Arrow indicates vertical direction of ground-water flow through confining unit (modified from Mandle and Kontis, 1992)

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

Wisconsin Municipality located near hydrogeologic section

Hydrogeologic sections, ground-water province I (south part)

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

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