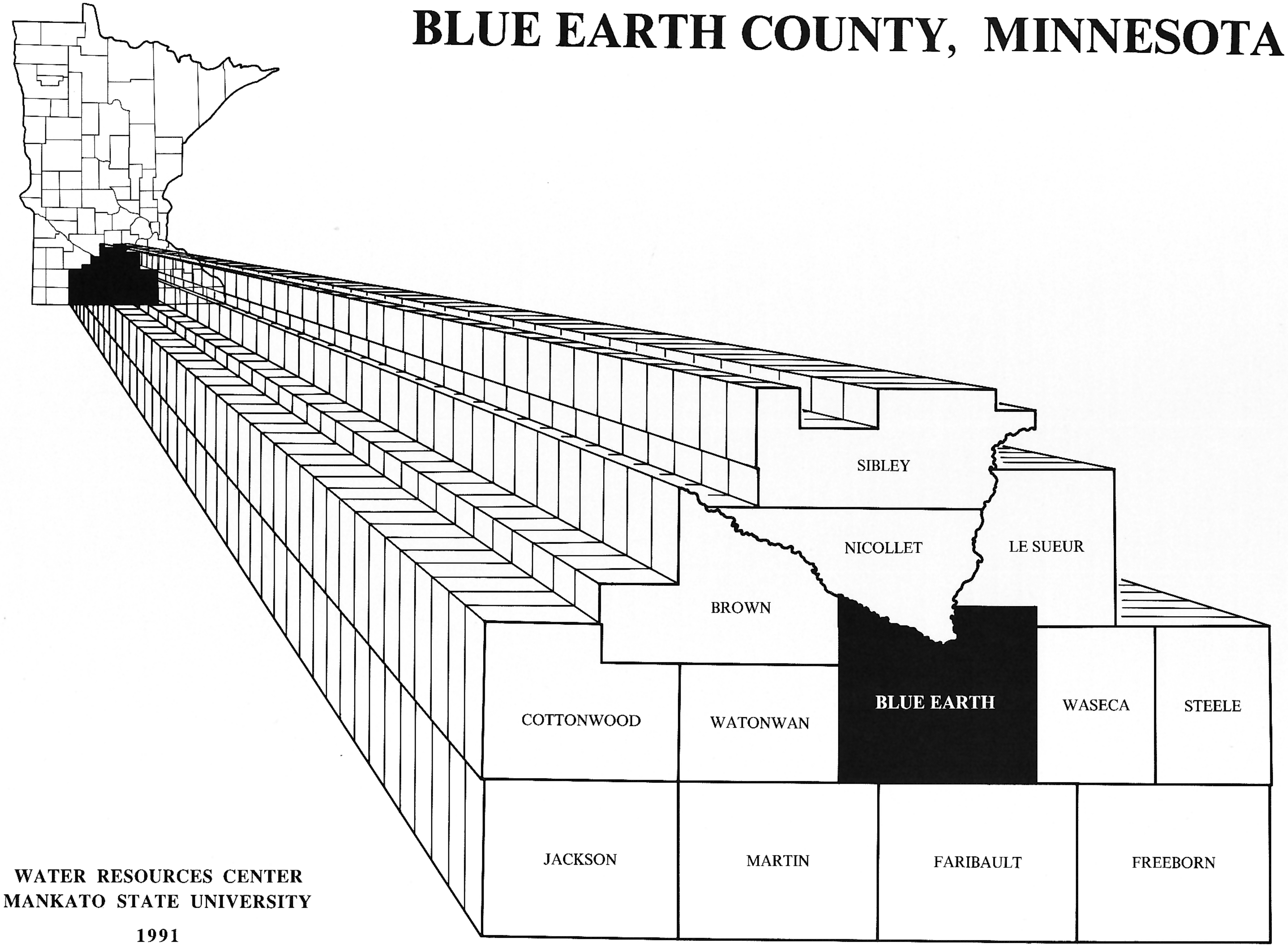
GEOLOGIC ATLAS

BLUE EARTH COUNTY, MINNESOTA



WATER RESOURCES CENTER
MANKATO STATE UNIVERSITY
1991

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JULY, 1991

The Blue Earth County Geologic Atlas was prepared and published with the support of a grant from the Legislative Commission on Minnesota Resources and the Blue Earth County Board of Commissioners. The project involves the production of county geologic atlases for each of the 13 counties of south central Minnesota and a computerized data base of available water well and groundwater data. Principal investigators for the project are Henry Quade and John Rongstad.

The following people and agencies have provided valuable assistance to this project by providing information, reviewing or contributing to the content, or by making helpful comments. While their contributions are acknowledged, the responsibility for errors or omissions rests with the principal authors.

The Minnesota Geological Survey for providing water well records and other subsurface geophysical data. Particular thanks to Bruce Olsen, Bruce Bloomgren, and Roman Kanivetsky for their guidance and support.

Mankato State University for providing work space and a variety of needed services. Personal thanks to James Zimmer for his guidance and encouraging remarks, and to the Biology Department for its close support. Special mention should be made of Phil Kelley and the Geography Department for use of its camera and darkroom facilities where most of the map reproduction and picture processing was done. Special thanks goes to Jean Spellacy, the secretary at the Water Resources Center.

The building of this atlas involved the contributions of a significant number of students at Mankato State University. The maps in this atlas are, in large part, the result of their loyal support.

Fieldwork: Paul Vogel, Kristen Vogel, Bruce Anderson, Chuck Peterson, and Charles Wohler.

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BLUE EARTH COUNTY GEOLOGIC ATLAS

INTRODUCTION

This is one of thirteen geologic atlases that were prepared for the South Central Minnesota Comprehensive County Water Planning Project consisting of Blue Earth, Brown, Cottonwood, Faribault, Freeborn, Jackson, LeSueur, Martin, Sibley, Steele, Waseca, and Watonwan Counties. The basic subsurface data for these atlases have been gathered over a period of years by the Minnesota Department of Health and the Minnesota State Geological Survey. Additional data pertaining to well location and elevation were gathered by the Water Resources Center at Mankato State University during preparation of the geologic mapping project. The subsurface geologic atlases are the first of two reports on the water resources of southcentral Minnesota. Surface water resources are the subject of a 13 county atlas series that is now in preparation.

The Blue Earth County Geologic Atlas presents available subsurface geologic and hydrologic data in a descriptive form. The maps in this atlas present an interpretation of the subsurface data on a county wide scale. The scale (1:150,000), and hence the size of the atlas maps, was chosen because it shows both geologic and hydrogeologic interpretation at a manageable level, and it represents the size at which the atlas can be printed economically. Detailed, site specific, information cannot be shown on the maps presented in this atlas. The accompanying text is designed to present only general concepts.

The subsurface maps and cross sections that are presented in this atlas show both the vertical relationship and areal distribution of important water-yielding bedrock units in Blue Earth County. The atlas is intended to be used as a guide to the subsurface geologic conditions and groundwater resources in Blue Earth County. The amount of geologic information that is required for decision making will vary considerably. For this reason, more detailed site-specific information is available in readily accessible electronic files at the Water Resources Center, Mankato State University.

ATLAS MAPS

Preparation of the maps presented in this atlas required the evaluation of information concerning the present land surface and subsurface. The Bedrock Topography Map and Bedrock Structure Maps were constructed independently; they were directly created from the data itself. These maps provided the necessary reference lines from which all succeeding geologic boundary lines were drawn. All other geologic maps in the atlas were derived through combinations of the Surface Topography, Bedrock Topography, and Bedrock Structure Maps. This sequence of atlas map construction is designed to present a consistent picture of the bedrock geology on a county wide scale.

SURFACE TOPOGRAPHY MAP was produced for each of 13 counties included in the South Central Minnesota Comprehensive County Water Planning Project. These maps were compiled from US Geological Survey 7.5 Minute Topographic Quadrangles. The USGS quadrangle maps were photographically reduced in scale from 1:24,000 to 1:62,500, and a photo mosaic was constructed to provide a county base surface topography map for each county. These maps provided a standard base from which the maps for all 13 county geologic atlases were developed.

DATA BASE MAP (Page 3) shows the location, distribution, and type of subsurface data used to develop this atlas. The Data Base Map is designed to be used as a guide to interpreting the accuracy of atlas maps.

BEDROCK TOPOGRAPHY MAP (Page 8) was directly created from the data contained in water well drillers' logs. The map provides a means by which the top of the bedrock can be traced continuously over the entire county.

BEDROCK STRUCTURE MAPS (Page 16 and 17) were directly created from geophysical logs. These maps show the structural configuration of key bedrock units and provide a means by which these bedrock units may be traced continuously over wide areas.

DEPTH TO BEDROCK MAP (Page 9) combines the Surface Topography Map and Bedrock Topography Map to show variations in the thickness of sediments that cover the bedrock surface.

BEDROCK GEOLOGY MAP (Page 7) combines the Bedrock Topography Map and Bedrock Structure Maps to show the distribution of bedrock units, as they would appear, if the overlying sediments were removed and the bedrock exposed at the surface.

GEOLOGIC CROSS SECTIONS (page 11 thru 14) combine the Surface Topography, Bedrock Topography, and Bedrock Structure Maps to construct cross sectional profiles for Blue Earth County. The cross section profiles are arranged as a grid system to provide county wide cross section coverage.

BEDROCK AQUIFER MAPS (page 20 and 21) were developed directly from the data contained in the hydrologic portions of water well drillers' logs, including static water level and casing length.

GLACIAL DRIFT AQUIFER MAP (page 23) was developed directly from the data contained in the hydrologic portions of water well drillers' logs, including static water level, casing length, and pumpage test.

GENERAL GEOLOGY

The characteristics of the present land surface in Blue Earth County, including the topography and nature of surficial materials, are the result of the action of glacial ice and flowing water. The surficial materials are chiefly glacial deposits, collectively called drift, of the continental glaciers that covered Blue Earth County during the last million years. The continental glaciers were centered over southern Canada and extended into southern Minnesota. These continental glaciers expanded and contracted several times and the interval between glacial episodes may have been sufficient to allow deep erosion and weathering of the drift and bedrock surfaces.

The glacial drift is composed mainly of glacial till, which is characterized by a matrix of sand, silt, and clay with scattered pebbles, cobbles, and some boulders. The drift deposits overlie the bedrock surface and range in thickness from slightly less than 150 feet to over 300 feet except along the Minnesota, Blue Earth, and LeSueur River Valleys where the drift has been removed and the bedrock is exposed at the surface. Before glaciation, erosion of the bedrock surface produced deep valleys, most of which are now filled with glacial drift. The nature of thickening and thinning of the glacial deposits is largely influenced by buried bedrock valley cuts.

The bedrock that underlies Blue Earth County is part of a sequence of Late Cambrian to Middle Ordovician sedimentary rock which consists of three major rock types: sandstone, shale, and carbonates. The bedrock was deposited under tectonically stable geologic conditions in shallow marine waters that flooded southern Minnesota about 500 million years ago. The lithology of individual bedrock units is nearly uniform throughout Blue Earth County due to the continuous nature of the geological processes that formed them.

In the southeastern quarter of Blue Earth County the St. Peter sandstone forms the bedrock surface beneath the glacial drift. The St. Peter sandstone is the youngest bedrock unit and gives way to progressively older dolomites, sandstones, and shales to the north and west. This pattern reflects the general dip of the bedrock structure toward the southeast. Deep erosion of the bedrock surface, prior to glaciation, also influence this pattern.

Structural faulting and uplift is known to have occurred in Minnesota during Precambrian time. The tectonic activity that contributed to the Precambrian faulting is thought to have ceased before Cambrian time. This interpretation suggests that the Cambrian and Ordovician aged bedrock sediments were deposited on top of inactive Precambrian aged fault blocks, and assumes that individual bedrock formations are not deformed internally. For the purpose of this study, each bedrock unit is treated as a continuous layer and mapped accordingly.

WELL CONSTRUCTION PRACTICES

WATER WELL PRACTICES

In Blue Earth County, water well drilling and water well construction will vary from place to place, due to variations in bedrock geologic conditions. In 1974, implementation of the Minnesota water well code standardized water well construction practices. Since 1974, all water well drillers are required to be licensed by the Minnesota Department of Health. Licenses are issued on the basis of one's knowledge of the regulations governing well construction and proof of drilling experience. All water wells drilled since 1974 may use from only one aquifer, and each well must meet minimum standards of depth, minimum distances from possible sources of contamination, and have had a water sample analysis that confirms potability.

Before the Minnesota water well code was implemented in 1974, well construction practices were used that are no longer allowed. Water well casings were often not seated firmly into the bedrock and few were properly sealed to prevent the downward movement of groundwater between the well casing and the borehole. High-capacity wells were often cased only to the uppermost bedrock unit and left as an open borehole between two or more bedrock aquifers, sometimes crossing a confining bed. These wells interconnect aquifers and aquifer systems, allowing the movement of groundwater and serve as conduits for spreading pollution into otherwise unspoiled groundwater supplies.

Since 1974, all newly constructed wells must use standardized well construction materials and installation procedures. Each well casing should extend at least 15 feet into the bedrock aquifer being used with the casing grouted and seated firmly into the bedrock. Water wells that penetrate more than one bedrock aquifer or that penetrate a confining bed must have the entire casing grouted. If multiple strings of casings are used, the inner casing must be separated from the outer casing by at least two inches of space to accommodate cement grout between them. Grouting of the well casing is done to insure that the well does not interconnect aquifers along the space between two casings or between the well casing and the borehole into which it is set.

WATER WELL DRILLERS' LOGS

The largest source of information used to develop the geologic and hydrogeologic maps in this atlas are drillers' logs from water wells. The preparation of water well data, for mapping, was a two step process; first to verify the location and determine the elevation of each water well, and second to evaluate the geologic data contained in each water well drillers' log. The location of each water well was determined by visiting the well site and marking its position onto a USGS 7.5 minute topographic map. The position of each water well has been described by Public Land Survey coordinates to an accuracy of half an acre. The elevation at the top of each water well was determined, from USGS topographic maps, to an accuracy of five feet.

The two most difficult tasks a well driller performs during drilling operations are to record the physical characteristics of the penetrated rock and the depth at which these characteristics change significantly. Most of the geologic portions of well drillers' logs are only tolerably accurate; however, many can be re-evaluated by comparing them with more dependable subsurface data. The geologic portion of each well drillers' log was re-evaluated and adjusted by comparing them against the information contained in geophysical logs. The geophysical logs provided standardized data against which all well driller data was compared.

Information contained in each well drillers' log should include the following: a description of the main rock types encountered during drilling, their thickness and depth; a description of the well casing including diameter, length, and screened zones; hydrologic data, such as the static water level in a well after drilling is completed and a report of a production test; and the direction and distance to the nearest sources of possible contamination. In actuality, many of the drillers' logs have only a portion of the above information. An example of the information contained in a typical well drillers' log is given in FIGURE 1, together with interpretation.

RECORD OF WATER WELL CONSTRUCTION

WELL NO.	: 209835	CASING	: 012 INCH TO 156 FEET
			: 010 INCH TO 305 FEET
* COUNTY	: BLUE EARTH	WATER LEVEL	: 97 FT. (EL. 908 FT.)
* TOWNSHIP	: 108 NORTH	DATE	: 05/29/71
* RANGE	: 27 WEST	AQUIFER (S)	: ST. LAWRENCE-IRONTON-GALESVILLE
* SECTION	: 16/DBDACB		
* QUADRANGLE	: MANKATO WEST		
COMPLETED	: 05/29/71		
DEPTH	: 550 FT.		
* ELEVATION	: 1005 FT.		
* WELL USE	: PUBLIC		

PUMPAGE TEST		TEST 1	TEST 2
HOURS	:	24 HRS.	—
RATE (GPM)	:	335 GPM	—
PUMPING LEVEL	:	187 FT.	—

GEOLOGIC LOG

WELL DRILLER'S DESCRIPTION					INTERPRETATION
DEPTH (FEET) FROM	TO	LITHOLOGY	COLOR	HARDNESS	STRATIGRAPHIC UNIT
0	3	SOIL	BLACK	SOFT	RECENT
3	9	CLAY	YELLOW	SOFT	PLEISTOCENE
9	16	SAND	BROWN	SOFT	PLEISTOCENE
16	30	CLAY	YELLOW	SOFT	PLEISTOCENE
30	42	CLAY	BLUE	SOFT	PLEISTOCENE
42	43	BOULDER	BLACK	HARD	PLEISTOCENE
43	55	CLAY	BLUE	SOFT	PLEISTOCENE
55	65	GRAVEL	BROWN	MED	PLEISTOCENE
65	100	SANDY CLAY	BLUE	SOFT	PLEISTOCENE
100	126	COARSE SAND	BROWN	SOFT	PLEISTOCENE
126	132	SAND & GRAVEL	BROWN	SOFT	PLEISTOCENE
132	156	GRAVEL	BROWN	MED	PLEISTOCENE
156	166	BROKEN LIMEROCK	BROWN	-----	PRAIRIE DU CHIEN
166	210	LIMEROCK	BROWN	HARD	PRAIRIE DU CHIEN
210	213	QUARTZ LAYER	-----	HARD	JORDAN
213	220	SAND	WHITE	SOFT	JORDAN
220	223	QUARTZ LAYER	-----	HARD	JORDAN
223	290	SANDSTONE	WHITE	SOFT	JORDAN
290	305	SHALE	BLUE	SOFT	ST. LAWRENCE
305	313	LIMEROCK	RED	HARD	ST. LAWRENCE
313	370	LIMEROCK & SHALE	RED/BLUE	-----	ST. LAWRENCE
370	380	ROCK	GREEN	HARD	FRANCONIA
380	405	SANDSTONE & SHALE	GREEN	HARD	FRANCONIA
405	430	LIMEROCK & SHALE	PINK	HARD	FRANCONIA
430	465	SANDSTONE & SHALE	BLACK	HARD	FRANCONIA
465	470	SHALEY SANDROCK	-----	-----	IRONTON-GALESVILLE
470	540	SANDSTONE	WHITE	FIRM	IRONTON-GALESVILLE
540	545	SHALEY SANDROCK	-----	-----	EAU CLAIRE
545	550	LIMEROCK & SHALE	-----	-----	EAU CLAIRE

* Information that was verified or obtained from a field investigation at the well site.

Figure 1. The sample water well record shows information that was provided by the well contractor and information that was verified or obtained from a field investigation at the well site. The geologic portion of the water well record illustrates the sequence of paleozoic bedrock deposits and the unconsolidated nature of the overlying glacial deposits.

DATA BASE

DATA BASE MAP

The Data Base Map shows the location, distribution, and type of subsurface data used to develop this atlas. For the preparation of atlas maps every data point represents an area. This area is usually a circle, whose radius depends on the density of the data. When estimating the range of validity for individual atlas maps, it is important to take into account the uneven distribution of the data. The data quality and the depth penetrated by each control point will also affect the accuracy of each map. The Data Base Map is designed to be used as a guide to interpreting the accuracy of atlas maps.

The location of all points on the Data Base Map have been recorded onto USGS 7.5 minute quadrangle maps. The data for each point is stored in both manual and electronic files at the Water Resources Center, Mankato State University. Individual files can be accessed by Unique Well ID Number or by the Public Land Survey coordinates that correspond to individual well data points.

DATA

The subsurface data used to develop this atlas is a compilation of all water well drillers' logs, geophysical logs, and cutting sample logs that are currently available in the files of the Minnesota State Geological Survey. The water well drillers' logs contain the water well contractor's description of the geologic and hydrologic conditions encountered at a specific well site, and a description of the materials used to complete the well. A geophysical log can be an electrical log or gamma-ray log. An electric log records differences in the electrical resistance that is measured along the length of an open borehole. A gamma-ray log records the amounts of natural gamma radiation occurring in the strata of the earth. Cutting sample logs consist of drilling samples that were collected from selected well sites. Cutting samples provide physical examples of subsurface materials.

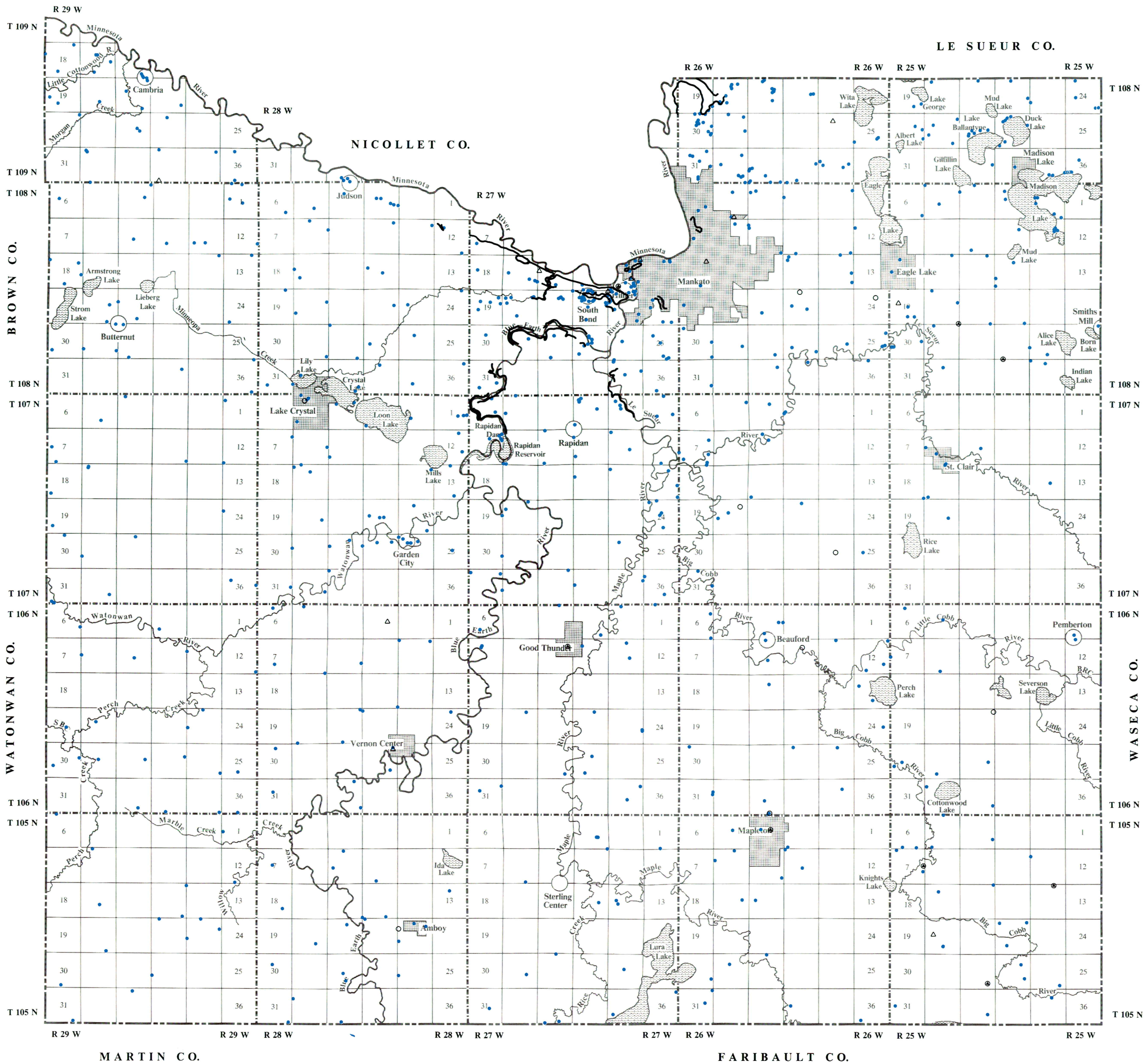
Information from each water well drillers' log should include the following: a physical description of the main rock types that are encountered during drilling along with their thickness and depth; a description of the well casing, including diameter and length; hydrologic data, such as the static water level and a report of a production test. In actuality, many logs have only a portion of the above information.

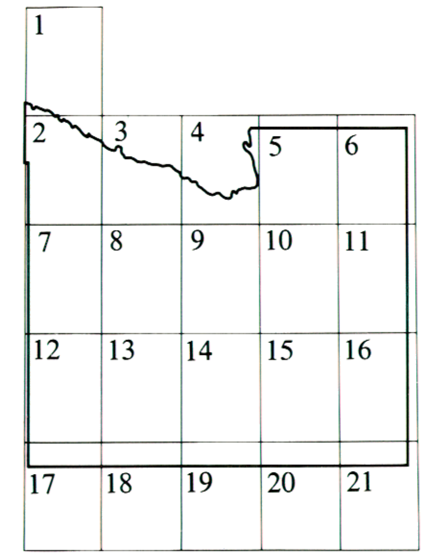
The gamma-ray logs are records of the measured amount of natural gamma radiation that is emitted by various rocks. The intensity of gamma radiation in sandstone, limestone, and dolomite is relatively low while clay, shale, and siltstone have the highest values. Probably the most important application of gamma-ray logs is to identify the amount of shale content in the bedrock sediments. Consequently, the upper and lower boundaries of shale units are identified and marked at the highest gamma-ray value, the shaley sandstone and carbonate units occupy positions of intermediate values, while the clean sandstone and carbonate units occupy areas of lowest gamma-ray values.

An electric log records differences in the electrical resistance that is measured along the length of an open bore hole. Similar to the gamma-ray log, the electric log is used to detect changes in the bedrock lithology for the purpose of determining the boundaries of bedrock units.

DATA BASE MAP

1991





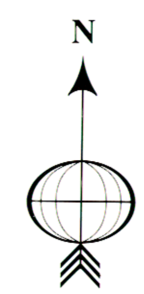
INDEX TO U.S. GEOLOGICAL SURVEY
1 : 24 000 - SCALE TOPOGRAPHIC MAPS

1. Courtland
2. Cambria
3. Judson
4. Mankato West
5. Mankato East
6. Madison Lake
7. Perth
8. Lake Crystal
9. Good Thunder
10. Beauford
11. St. Clair
12. Willow Creek
13. Amboy
14. Sterling Center
15. Mapleton
16. Mapleton NE
17. Truman SE
18. Winnebago
19. Delavan
20. Easton
21. Minnesota Lake

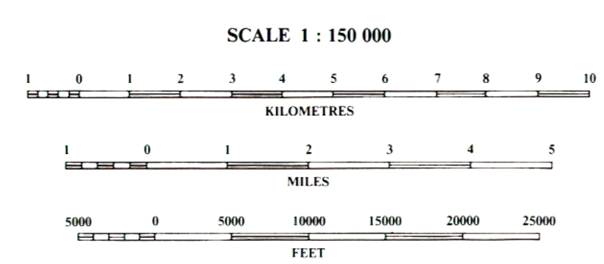
EXPLANATION

- • Record of water-well construction
- ○ Borehole (geophysical log)
- △ Cutting samples
- ⊛ Cutting samples and geophysical log

Bedrock exposure (outcropping)



LOCATION DIAGRAM



BEDROCK GEOLOGY

GEOLOGIC HISTORY

The bedrock that underlies Blue Earth County is part of a sequence of Late Cambrian to Early Ordovician sedimentary rock which consists of three major rock types: sandstone, shale, and carbonates. The bedrock was deposited layer upon layer in shallow marine waters that flooded southern Minnesota about 500 million years ago. The ancient intruding sea followed a shallow depressional lowland, now called the Hollandale Embayment, that extended into southern Minnesota from a larger basin to the south.

In a shallow marine environment, the material that is transported by water is sorted according to the weight and size of the individual particles. Because of different settling rates, coarse (heavy) materials are deposited in turbulent water while the finer (light weight) materials are transported by waves, currents, or winds and deposited in quiet waters.

The relationship between sandstone, shale, and carbonate deposits correspond to a seaward gradation of sediment size. Sand is deposited along the turbulent shoreline environment, where it becomes cemented into sandstone over time. Clay and silt are transported by wave and current action to a deeper, lower energy environment where they are deposited to form shale. Still farther off shore, where sand and clay are not transported by wave and current action, calcite is precipitated to form limestone.

The rise of sea level, during Late Cambrian time, resulted in a progressive overlap of sediment types. As the sea advanced landward, sandy beach deposits were overlain by offshore muds which were in turn overlain by carbonates. Thus, the advancing sea is recorded in bedrock layers by the sequence: sandstone overlain by shale overlain by carbonates. The lithologic character of the bedrock varies with such factors as sediment source, distance from the shore line, depth of the water, and the transporting agent (waves, currents, and winds).

The Cretaceous time period saw the rise of sea level from the west, which resulted in a different kind of progressive overlap. Sediments resulting from this overlap may be lacustrine and alluvial fan deposits as well as marine sediments. The western border of Blue Earth County is thought to represent the eastern shoreline of the advancing sea while the central and eastern portions of the county are viewed as being a coastal plane that was crisscrossed by rivers and streams. In Blue Earth County the Cretaceous age sediments overlie the much older Cambrian and Ordovician age bedrock units and are limited to isolated patches of loosely consolidated clays and sands that were primarily derived from the weathering of the underlying bedrock surface.

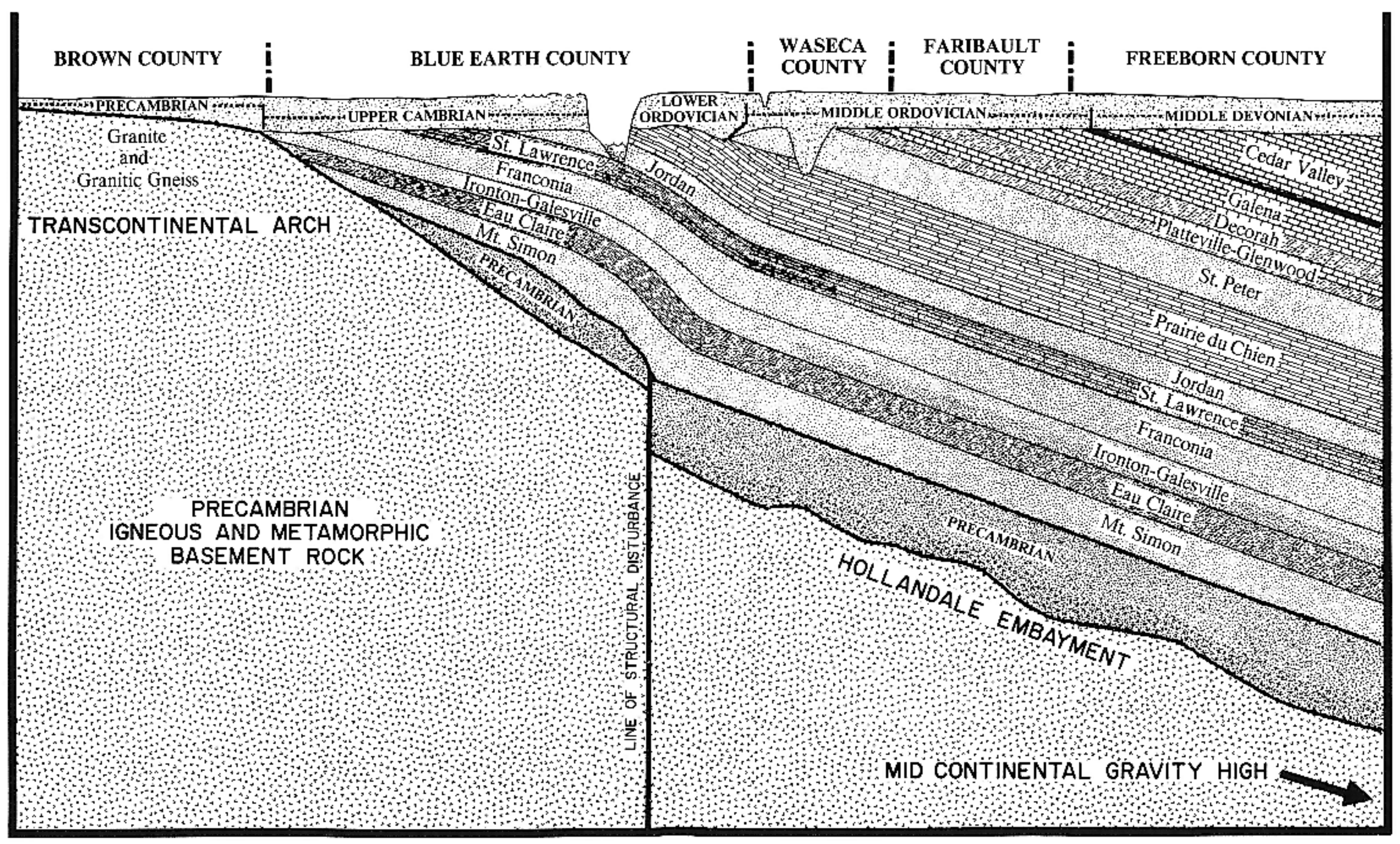


FIGURE 2. Highly generalized cross section showing the variation of subsurface conditions along a line extending from Brown County to Freeborn County Minnesota. The above diagram illustrates the lateral variations and distribution of sediments in the Hollandale Embayment. The geologic structure is much more complex than shown here. Note: the vertical scale is grossly exaggerated; if drawn at true scale the thickest part of the sedimentary basin would be 0.05 inches thick.

BEDROCK UNITS

The following descriptions of the bedrock units that underlie Blue Earth County are primarily derived from water well drillers' logs but supplemented by more detailed descriptions presented by Mossler (1987). For the purpose of this study, some of the stratigraphic units currently recognized as individual geologic units are combined.

MT. SIMON FORMATION-- is the lowest mapped unit of bedrock, several hundred feet thick. The Mt. Simon is generally characterized as a medium to coarse-grained quartzose sandstone. The upper parts of the Mt. Simon contain varying amounts of siltstone and shale while the middle part is primarily quartzose sandstone. Its base marks a major erosional surface with the underlying Precambrian age Hinckley sandstone. The Mt. Simon sandstone marks the advance of the Late Cambrian sea into southern Minnesota.

EAU CLAIRE FORMATION-- is between 80 and 120 feet thick. The Eau Claire consists primarily of shale and siltstone with minor amounts of fine-grained, glauconitic sandstone. Its contact with the underlying Mt.Simon sandstone is transitional. The fine-grained sediments of the Eau Claire Formation suggest a low energy environment of sedimentation, either relatively deep and quiet water or shallow water tidal flats.

IRONTON-GALESVILLE GROUP-- generally 60 to 80 feet thick, is a medium to coarse-grained quartz sandstone with some glauconite and minor amounts of silt. The Ironton and Galesville sandstones are normally classified as separate bedrock formations; however, the two sandstone units are difficult to separate in driller's logs and both are sources of groundwater. For the purpose of this study, the Ironton and Galesville sandstones are treated as a single geologic unit and for convenience called the Ironton-Galesville sandstone. The Ironton-Galesville sandstone may indicate the return to a higher energy nearshore or beach environment of sedimentation.

FRANCONIA FORMATION-- is generally about 80 to 120 feet thick. The Franconia is commonly characterized as a fine-grained, glauconitic sandstone. The upper part of the Franconia Formation may contain substantial amounts of shale and dolomitic layers that are similar to those found in the overlying St.Lawrence Formation. The similarity of rock type makes it difficult to distinguish the Franconia from the overlying St. Lawrence Formation in well drillers' logs. The fine-grained glauconitic sandstone suggests a low-energy sedimentary environment. Glauconite forms on the sea floor in oxygen-poor water where the rate of sedimentation is vary slow.

ST. LAWRENCE FORMATION-- is generally between 60 and 100 feet thick. The St. Lawrence contains several rock types including dolomite, siltstone, shale, sandstone, and glauconite. It is usually characterized by layers of shale, siltstone, and dolomite. Its transition with the underlying Franconia rock is gradational. The dolomitic units of the St. Lawrence Formation would signify a low energy depositional environment; however, the interbedded clay, silt, and sand indicates an environment with fluctuating conditions.

JORDAN FORMATION-- varies between 70 to 90 feet in thickness. The Jordan Formation is characterized as a medium to coarse-grained quartzose sandstone. The top of the Jordan sandstone may contain hard-cemented layers and its base may contain minor amounts of shale. The Jordan sandstone is exposed at the surface as bedrock outcrops along the Minnesota, Blue Earth, and LeSueur River Valleys in northcentral Blue Earth County. The Jordan sandstone indicates the return to a high-energy, nearshore sedimentary environment, perhaps a beach.

PRAIRIE DU CHIEN GROUP-- will vary greatly in thickness, from a feather edge at its erosional limits to as thick as 230 feet. The Prairie du Chien consists primarily of dolomite and sandy dolomite with some thin shale layers and a few units of quartz sandstone. The Prairie du Chien dolomite is exposed at the surface along the Minnesota River Valley where it is quarried extensively from the city of Mankato north to the town of Kasota. The massive nature of the Prairie du Chien dolomite indicates a low-energy sedimentary environment where carbonate deposition was the dominant rock forming process. Carbonate deposits were terminated by the retreat of the shallow sea from the continent. The retreat of the shallow sea exposed the Prairie du Chien dolomite to the forces of erosion. Consequently, the top of the Prairie du Chien Group represents a major erosional surface and its thickness may vary greatly from place to place.

ST. PETER FORMATION-- measured as thick as 100 feet, its presence is limited to the southern margin of Blue Earth County. The St. Peter Formation is primarily a medium-grained pure quartz sandstone. The lower part of the St. Peter may contain beds with varying amounts of silt or shale. The St. Peter sandstone marks the advance of the Middle Ordovician sea into southern Minnesota. The sandstone was deposited along the turbulent shoreline of the advancing sea. The St. Peter sandstone was deposited on top of the Prairie du Chien dolomite and its base marks a major erosional unconformity.

PLATTEVILLE-GLENWOOD FORMATIONS-- limited to erosional remnants in the southeastern corner of Blue Earth County. For convenience, the Platteville and Glenwood Formations are treated as a single geologic unit. The Glenwood Formation is a thin shaley unit that directly overlies the St. Peter sandstone. The Glenwood shale represents a low energy sedimentary environment, offshore from the beaches where the St. Peter sandstone was being deposited. The Platteville Formation is a thin bed of limestone that contains thin shale partings at its top and base. The Platteville limestone represents a more seaward sedimentary environment of the Glenwood shale.

DECORAH FORMATION-- limited to erosional remnants in the extreme southeast corner of the county. Its presence in Blue Earth County is only inferred from maps prepared for the Waseca County Geologic Atlas. The Decorah Formation is primarily a uniform bed of green shale.

CRETACEOUS ROCK-- generally composed of white, red, or brown clay that may represent the weathering of the underlying bedrock. White Cretaceous sand may be reworked St. Peter or Jordan sandstone that was deposited along the advancing shoreline of the Cretaceous Sea.

AQUIFER CHARACTERISTICS OF SEDIMENTARY ROCK TYPES

INTRODUCTION

The most favorable geological structure for groundwater accumulation is found in stratified sedimentary rock like that underlying Blue Earth County. Sedimentary aquifers range from loose, coarse-grained deposits such as sandstone to hard fractured sedimentary rocks such as limestone or dolomite. A water bearing rock unit may vary locally in texture or composition, either vertically because of bedding planes or horizontally because of changes in sediment type. The lithology of the individual sedimentary bedrock units is nearly uniform throughout Blue Earth County due to the continuous nature of the geological processes that formed them.

SANDSTONE AQUIFERS

The sandstone bedrock units transmit water from between individual grains. The ability of sandstone to transmit water depends upon the size and amount of pore space between individual sand grains. Pore space is mostly a function of the amount of cementation that is holding the sand grains together. The cementing material consist of very small particles that partly or entirely fill the voids between sand grains. The most common cementing materials are clay minerals, calcite, and quartz. The hydraulic properties of any sandstone, as a whole, can be variable because the cementation may be localized.

CARBONATE AQUIFERS

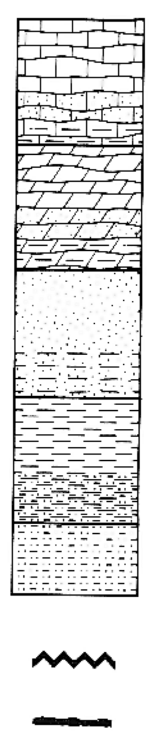
The carbonate aquifers are mostly composed of crystalline limestone and dolomite with some quartz sand and shaley units. In carbonate rock, fractures along bedding planes and pores within the rock provide the primary routes for groundwater flow. The permeability of carbonate rocks depends upon their porosity, which is primarily due to the enlargement of fractures and other openings by erosion through water circulation.

The ability of dolomite to transmit water is usually lower than that of most limestone. The openings between the crystals in dolomite are small and the rate of erosion by solution is less than in limestone. Dolomite is a hard and very brittle rock and may have wide zones of fracturing that result in increased permeability. Limestone has a higher solubility than dolomite, which leads to more spacious fractures and much wider solution channels. Observations in quarries that are excavated in limestone or dolomite show that openings along bedding planes tend to remain open and transport water.

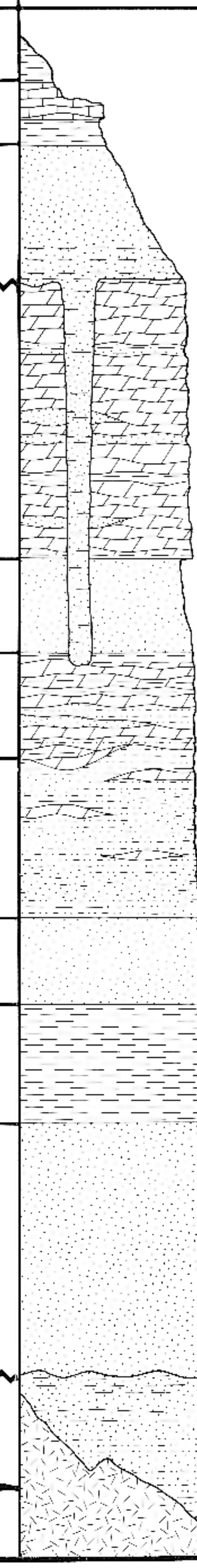
SHALE & SILTSTONE AQUITARDS

Shale and siltstone are composed of fine-grained particles that constitute the finest of the clastic sedimentary materials. The effective porosity of shale and siltstone result in a much more reduced permeability than that found in sandstone and carbonate bedrock units. Consequently, siltstone and shale yield little groundwater and function as aquitards in the sequence of bedrock sedimentary deposits. Although an aquitard may not yield water in usable quantities, it can hold appreciable amounts of water.

EXPLANATION



BEDROCK GEOLOGIC COLUMN



STRATIGRAPHIC CLASSIFICATION			DESCRIPTION OF ROCK UNITS		DESCRIPTION OF AQUIFERS		
SYSTEM / SERIES	GROUP OR FORMATION NAME	MAP SYMBOL	THICKNESS	DOMINANT ROCK TYPES	AQUIFER SYSTEM	AQUIFER	AQUIFER CHARACTERISTICS
MIDDLE ORDOVICIAN	DECORAH FORMATION	Odc	Uncertain; presence is inferred	Shale; greenish gray; limited to erosional remnants	CONFINING LAYER	DECORAH SHALE	Limited to erosional remnants in extreme southeastern part of the county. Its presence is only inferred.
MIDDLE ORDOVICIAN	PLATTEVILLE & GLENWOOD FORMATIONS	Opg	Limited to erosional remnants	Carbonate rock over shale; limited to erosional remnants.	NOT AN AQUIFER	PLATTEVILLE & GLENWOOD	Limited to erosional remnants in the southeastern corner of the county.
MIDDLE ORDOVICIAN	ST. PETER FORMATION	Osp	90 to 100 feet	Quartzose sandstone; white or yellow; may be thin shale or siltstone beds in lower part of formation. Basal contact with Prairie du Chien is unconformal.	ST. PETER - PRAIRIE DU CHIEN - JORDAN AQUIFER SYSTEM	ST. PETER SANDSTONE	Highly permeable quartzose sandstone; has direct hydrogeologic contact with surficial glacial deposits. Used primarily as a source for domestic wells that require moderate water supplies.
LOWER ORDOVICIAN	PRAIRIE DU CHIEN GROUP	Opc	Upper contact is unconformal; ranges from feather edge at erosional limits to as thick as 230 feet	Dolomite and sandy dolmite with beds of quartzose sandstone; may contain thin beds of soft shale or sediment filled crevaces. The top of the Prairie du Chien marks a major erosional unconformity; it disappears as an erosional edge in extreme southwestern part of the county.	ST. PETER - PRAIRIE DU CHIEN - JORDAN AQUIFER SYSTEM	PRAIRIE DU CHIEN DOLOMITE	Carbonate rock, dolomite; has direct hydrogeologic connection with surface and shallow groundwater systems. Wide zones of fractures and crevices generally yield moderate quantities of water. Well-creviced dolomite is partly responsible for local high water yields. Limited shaly layers may form localized confining conditions. The top of the Prairie du Chien marks a major erosional unconformity; it may vary greatly in thickness.
UPPER CAMBRIAN	JORDAN FORMATION	Cj	70 to 90 feet	Quartzose sandstone; white, yellow or brown. In outcrop the Jordan is fine to coarse grained, soft-poorly cemented sandstone.	ST. PETER - PRAIRIE DU CHIEN - JORDAN AQUIFER SYSTEM	JORDAN SANDSTONE	Highly permeable quartzose sandstone; has direct hydrogeologic contact with surficial water. Provides moderate supplies where the Jordan forms the bedrock surface; contains negligible water supplies where the sandstone crops out and perennial rivers at as drains.
UPPER CAMBRIAN	ST. LAWRENCE FORMATION	Csl	60 to 100 feet	Interbedded dolomite, siltstone and shale; may contain thin beds of sandstone. Transition with the underlying Franconia is gradational	CONFINING LAYER	ST. LAWRENCE DOLOMITE & SILT STONE	Rocks of low permeability; act as confining bed at the base of the St. Peter-Prairie du Chien-Jordan aquifer system.
UPPER CAMBRIAN	FRANCONIA FORMATION	Cfn	80 to 120 feet	Fine-grained quartzose sandstone; greenish gray, glauconitic; may contain thin beds of dolomite, siltstone, or shale. Transition with overlying St. Lawrence is gradational.	FRANCONIA - IRONTON - GALESVILLE AQUIFER SYSTEM	FRANCONIA SANDSTONE	Glauconitic sandstone; comes in direct hydrogeologic contact with surficial glacial deposits. Used primarily as a source for domestic wells that require moderate water supplies. Yields artesian flow where land surface elevations are low.
UPPER CAMBRIAN	IRONTON & GALESVILLE FORMATIONS	Cig	60 to 80 feet	Quartzose sandstone; white, buff, or pink.	FRANCONIA - IRONTON - GALESVILLE AQUIFER SYSTEM	IRONTON & GALESVILLE SANDSTONE	Highly permeable quartzose sandstone; has direct hydrogeologic connection with surface and shallow groundwater systems. Yields large volumes of water for domestic, commercial, municipal, and industrial use.
UPPER CAMBRIAN	EAU CLAIRE FORMATION	Cec	80 to 120 feet	Mainly shale and siltstone with some beds of sandstone; transition with the underlying Mt. Simon is gradational.	CONFINING LAYER	EAU CLAIRE SHALE	Shales are generally not water yielding; act as confining bed at the base of the Franconia-Ironton-Galesville aquifer system.
UPPER CAMBRIAN	MT. SIMON FORMATION	Cmt	100 feet to several hundred feet	Quartzose sandstone; may contain shale and siltstone. Transition with the overlying Eau Claire is gradational; its base marks a major erosional unconformity.	MT. SIMON - HINCKLEY AQUIFER SYSTEM	MT. SIMON SANDSTONE	Permeable quartzose sandstone; has no direct hydrogeologic connection with surface and shallow groundwater systems. Yields large volumes of water for public, municipal, and industrial use.
PRECAMBRIAN	HINCKLEY & FOND DU LAC FORMATIONS	Pc	Unknown; may exceed 1000 feet	Data sparse; mainly quartzose sandstone and shale. Its base marks a major disconformity.	MT. SIMON - HINCKLEY AQUIFER SYSTEM	HINCKLEY SANDSTONE	Data absent; water contribution for aquifer use is unknown.
PRECAMBRIAN	METAMORPHIC IGNEOUS	Pc	Unknown; several miles	Igneous and metamorphic rocks; undifferentiated.	BASEMENT ROCK	NOT AN AQUIFER	Not water bearing rock; represents the base of all aquifers and aquifer systems.

FIGURE 3. Generalized stratigraphic column showing the relationship between individual bedrock units and corresponding water producing intervals. The descriptions of bedrock units, including thickness and rock type, were compiled from the geologic portions of water well drillers' logs and supplemented by more detailed descriptions presented by Mossler (1987). The descriptions of aquifer characteristics for the various bedrock units were derived from the hydrologic portions of well drillers' logs.

BEDROCK GEOLOGY MAP

INTRODUCTION

In Blue Earth County glacial deposits almost completely conceal the bedrock surface; thus, the nature of the bedrock surface is known primarily from subsurface data. The Bedrock Geology Map shows the distribution of bedrock units, as they would appear, if the bedrock were exposed throughout Blue Earth County. The Bedrock Geology Map presents a picture of the bedrock surface that supports a close relationship to the Bedrock Topography Map and Bedrock Structure Maps that were prepared for this atlas. This method of geologic map construction is designed to present a consistent picture of the bedrock on a county wide scale.

Erosion of the bedrock surface before glaciation produced deep valley cuts in the bedrock surface. Because of past erosion, the thickness of the upper bedrock unit may change abruptly over short distances. The patterns displayed on the Bedrock Geology Map range from narrow bands to extended areas. The steep slopes of deeply eroded bedrock valleys are often expressed as narrow bands of bedrock formations that follow along the edges of the valleys; narrow bands that follow along the bottom of these valleys will usually point up stream. In places where a single bedrock formation occupies an extended area, the character of the bedrock surface will be flat and featureless if the formation is thin, but may be deeply eroded if the formation is thick.

METHOD OF CONSTRUCTION

Several structural considerations controlled the construction of the geologic map. Among these were the character of the eroded bedrock surface, the relative thickness of individual bedrock units, and the direction, rate, and degree of dip of the bedrock units. The positioning of geologic boundary lines was accomplished by directly comparing the Bedrock Topography Map (Page 8) with each of the Bedrock Structure Maps (Page 16 & 17). On the Bedrock Geology Map, the geologic boundaries were located by interpolating between points where bedrock topographic contours and bedrock structure contours of equal value intersect.

The boundary lines separating the St. Peter Formation and overlying Platteville-Glenwood Formations were located with information contained in water well drillers' logs and supplemented with information from maps prepared for the Faribault and Waseca County Geologic Atlases. The geologic boundary lines that separate the Jordan Formation from the overlying Prairie du Chien Group were located by interpolating between points where Jordan structure contours intersect bedrock topography contours of equal value. Likewise, the boundary lines that separate the St. Lawrence and the overlying Jordan Formation were located by interpolating between points where St. Lawrence structure contours intersect bedrock topographic contours of equal value. The boundary lines that separate the St. Lawrence, Franconia, Ironton-Galesville, Eau Claire, and Mt. Simon formations were located by projecting the accumulative thickness of the various formations below the top of the St. Lawrence Formation, using the St. Lawrence Structure Map and the Bedrock Topography Map as guides for positioning the lines.

In the southeastern corner of Blue Earth County, the Platteville limestone and St. Peter sandstone form the bedrock surface beneath the glacial drift. These limestones and sandstones are the youngest bedrock units and give way to progressively older dolomites, sandstones, and shales to the north and west. This pattern reflects the general dip of the bedrock structure toward the southeast.

BEDROCK TOPOGRAPHY MAP

INTRODUCTION

The bedrock topography map presents a three-dimensional picture of the bedrock surface by means of contour lines that connect points of equal elevation. The topographic rendition of the bedrock surface was designed to describe an ancient landscape characterized by broad uplands that are cut by a sinuous pattern of river and stream valleys. In Blue Earth County the bedrock surface is completely covered by glacial deposits except along the Minnesota River Valley and the lower portions of the Blue Earth and LeSueur Rivers, where the bedrock is exposed at the surface. Thus, the nature of the bedrock surface is known primarily from subsurface data.

The configuration of the bedrock surface is a product of preglacial, glacial, interglacial, and postglacial erosion of the bedrock strata. Preglacial erosion produced deep valley cuts that were excavated by river and stream erosion prior to continental glaciation, which began about 2 million years ago. Glacial erosion of the bedrock surface may have widened or deepened the bedrock valleys by ice scouring from advancing glaciers or by meltwater flows from retreating glaciers. Interglacial erosion may have modified the bedrock surface slightly; however, repeated ice advances gradually filled the bedrock valleys and covered the bedrock surface with glacial debris. Postglacial erosion of the bedrock surface occurred along the Minnesota, Blue Earth, and LeSueur Rivers with minor erosion by tributaries such as the Watonwan River and Minneopa Creek. In Blue Earth County the majority of the bedrock channels are interpreted to have been eroded prior to glaciation of the region.

METHOD OF CONSTRUCTION

The Bedrock Topography Map is a compilation of all available data from wells that penetrated the glacial drift and reached bedrock. The location and distribution of these data points are shown on the Bedrock Topography Map. Wells that were drilled abnormally deep into the glacial drift, without reaching bedrock, influenced the positioning of the contours. Bedrock exposures along the Minnesota, Blue Earth, and LeSueur River Valleys were used to guide the contours drawn in those areas. Where the bedrock data is dense, the Bedrock Topography Map is more detailed; where the data is sparse, the map is more generalized.

The elevation of the bedrock surface was calculated for each well drillers' log and the data plotted onto a map sheet. The map sheet was contoured to agree with the plotted elevations and to develop any distinctive landforms resulting from geomorphic processes that were wearing down the bedrock surface prior to recent continental glaciation. The placing of contours is intended to reveal a pattern of erosion much like that produced by present day river valleys and their tributaries. The map illustrates that only large valleys and tributaries are identifiable from existing data. In most instances, the valleys and their tributaries are probably not as straight nor wide as indicated.

On the Bedrock Topography Map, the closely spaced contours indicate steep slopes while widely spaced contours indicate flat or gently sloping areas. The spacing of contour lines and the nature of connecting or guiding each contour through elevation points is based upon factors concerning the type of bedrock sediments that underwent erosion. Resistant rock types such as limestone or dolomite tend to form plateaus while softer rock such as shale and sandstone form gently sloping areas. The soft shales or sandstones may contribute to steep valley walls where overlain by more resistant limestones or dolomites.

DEPTH TO BEDROCK MAP

INTRODUCTION

The characteristics of the present land surface in Blue Earth County, including the topography and nature of surficial materials, is the result of the action of glacial ice and flowing water. The surficial materials are chiefly glacial deposits, collectively called drift, of the continental glaciers that covered Blue Earth County during the last million years. The glacial deposits overlie the bedrock surface and range in thickness from less than 150 feet to over 300 feet except along the Minnesota River Valley and the lower portions of the Blue Earth and LeSueur Rivers, where the drift has been removed and the bedrock is at or near the surface. Along the upper Blue Earth and lower Watonwan Rivers the drift cover has been reduced to less than 50 feet in thickness. In Blue Earth County the nature of thickening and thinning of the glacial drift is largely influenced by buried bedrock valley cuts and present day river valley cuts.

The glacial drift is composed mainly of glacial till, which is characterized by a matrix of sand, silt, and clay with scattered pebbles, cobbles and boulders. The glacial till is interbedded with sand and gravel that was released by the melting glaciers. These sand and gravel units are scattered and discontinuous in the shallow drift; but thick deposits of sand and gravel can occur where the drift is thick.

The Depth to Bedrock Map, by means of isopach contours, shows variations in the thickness of glacial deposits. The topography of the bedrock surface has a direct bearing on the thickness of the drift deposits. Where the elevation of the bedrock surface is low, as within major buried bedrock valleys, the glacial deposits are thick. Where the bedrock surface is high, the drift deposits are generally thin. In the vicinity of buried bedrock valleys, the thickness of the glacial deposits may change abruptly over short distances. Valleys on the present land surface present irregularities in drift thickness.

METHOD OF CONSTRUCTION

The thickness of glacial deposits is shown on the Depth to Bedrock Map by isopach lines that connect points of equal thickness. The Depth to Bedrock Map was constructed by combining the Surface Topography Map and the Bedrock Topography Map. The Surface Topography Map was compiled from USGS 7.5 Minute Topographic Quadrangles. The Bedrock Topography Map was produced for this atlas and is shown on page 8. The Bedrock Topography Map is somewhat generalized and therefore limits the accuracy of the depth to bedrock mapping.

Construction of the Depth to Bedrock Map was accomplished by superimposing the Surface Topography Map onto the Bedrock Topography Map in order that the two could be directly compared. The isopach lines were drawn to agree with the difference in elevation between the two maps. The drift thickness was determined at any contour intersection by subtracting the lower value (bedrock elevation) from the higher value (surface elevation). The bedrock should be at or near the surface where the bedrock elevation and the surface elevation are equal.

The method of depth to bedrock map construction was designed to present a picture of drift thickness that is consistent with that suggested by the Surface Topography Map and Bedrock Topography Map prepared for this atlas. On the Depth to Bedrock Map, narrow bands of thick glacial deposits follow the deep bedrock valleys presented on the Bedrock Topography Map. This pattern illustrates the close relationship between drift thickness and the topography of the bedrock surface.

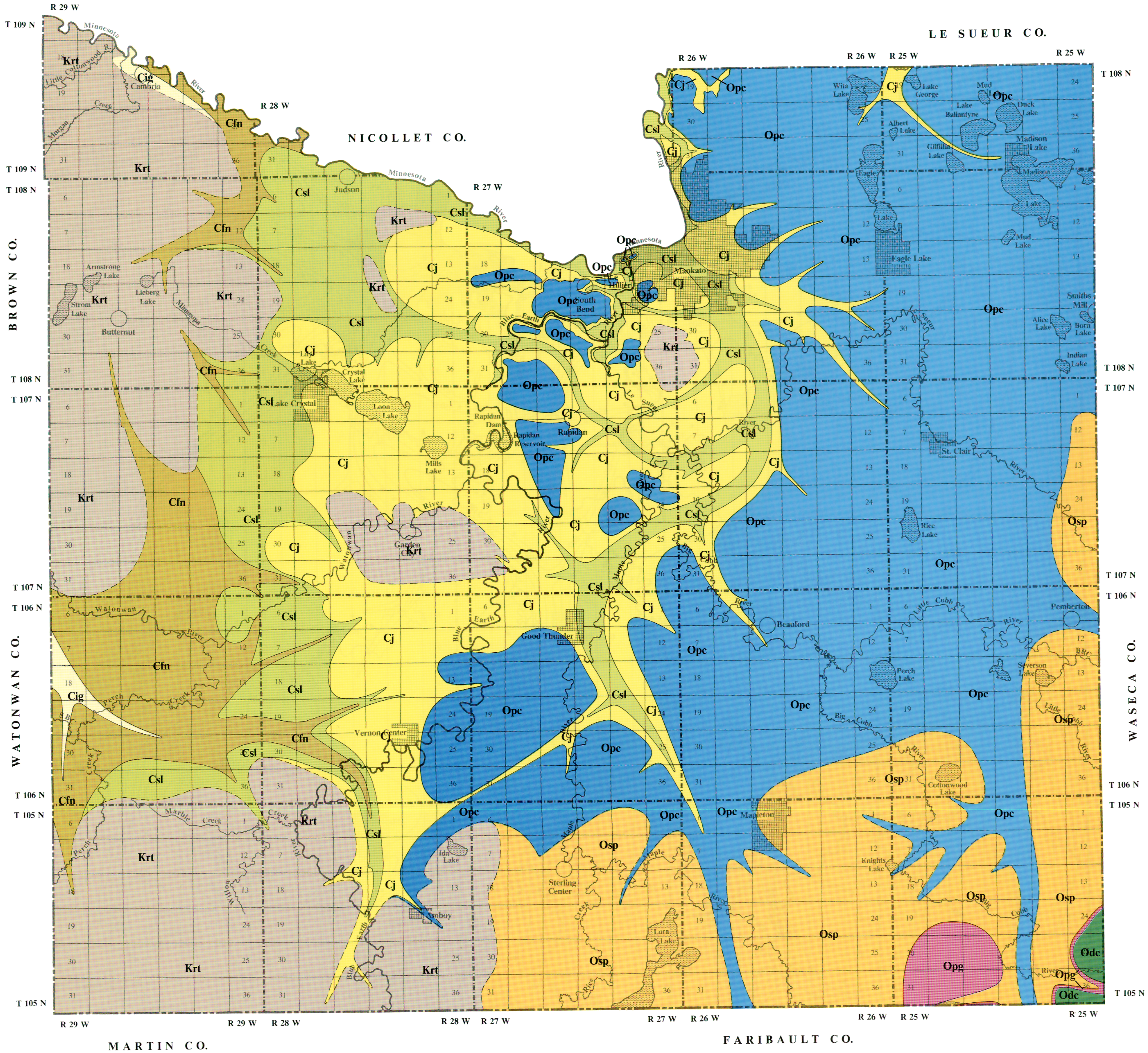
The scale of atlas maps and the generalized nature of the Bedrock Topography Map limits the amount of detail that can be shown on the Depth to Bedrock Map. When determining the nature of drift thickness for a small area at large scale, the original data base and staff at the Water Resources Center, Mankato State University, should be utilized.

BEDROCK GEOLOGY

By

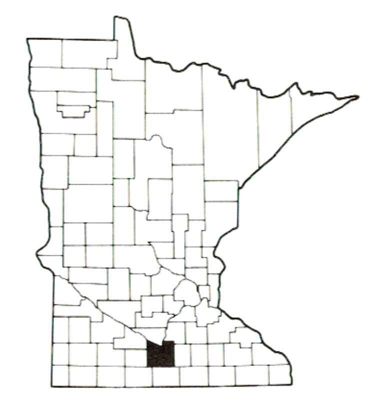
John M. Rongstad and Jesse D. Wohlfeil

1991



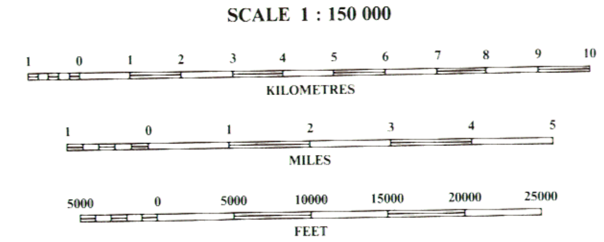
CRETACEOUS SYSTEM	Krt	The Cretaceous sediments are generally composed of white, red, or brown clay that may represent the weathering of the underlying bedrock. White Cretaceous sand may be reworked St. Peter or Jordan sandstone that was deposited along the advancing shoreline of the Cretaceous Sea.

STRATIGRAPHIC CLASSIFICATION				DESCRIPTION OF ROCK UNITS	
SYSTEM / SERIES	GROUP OR FORMATION NAME	MAP SYMBOL	GRAPHIC COLUMN	THICKNESS	DOMINANT ROCK TYPES
MIDDLE ORDOVICIAN	DECORAH FORMATION	Odc		Uncertain; presence is inferred	Shale; greenish gray; limited to erosional remnants
	PLATTEVILLE & GLENWOOD FORMATIONS	Opg		Limited to erosional remnants	Carbonate rock over shale; limited to erosional remnants.
	ST. PETER FORMATION	Osp		90 to 100 feet	Quartzose sandstone; white or yellow; may be thin shale or siltstone beds in lower part of formation. Basal contact with Prairie du Chien is unconformal.
LOWER ORDOVICIAN	PRAIRIE DU CHIEN GROUP	Opc		Upper contact is unconformal; ranges from feather edge at erosional limits to as thick as 230 feet	Dolomite and sandy dolmite with beds of quartzose sandstone; may contain thin beds of soft shale or sediment filled crevaces. The top of the Prairie du Chien marks a major erosional unconformity; it disappears as an erosional edge in extreme southwestern part of the county.
UPPER CAMBRIAN	JORDAN FORMATION	Cj		70 to 90 feet	Quartzose sandstone; white, yellow or brown. In outcrop the Jordan is fine to coarse grained, soft-poorly cemented sandstone.
	ST. LAWRENCE FORMATION	Csl		60 to 100 feet	Interbedded dolomite, siltstone and shale; may contain thin beds of sandstone. Transition with the underlying Franconia is gradational
	FRANCONIA FORMATION	Cfn		80 to 120 feet	Fine-grained quartzose sandstone; greenish gray, glauconitic; may contain thin beds of dolomite, siltstone, or shale. Transition with overlying St. Lawrence is gradational.
	IRONTON & GALESVILLE FORMATIONS	Cig		60 to 80 feet	Quartzose sandstone; white, buff, or pink.



LOCATION DIAGRAM

SCALE 1 : 150 000



BEDROCK TOPOGRAPHY

By

John M. Rongstad and Jesse D. Wohlfeil

1991

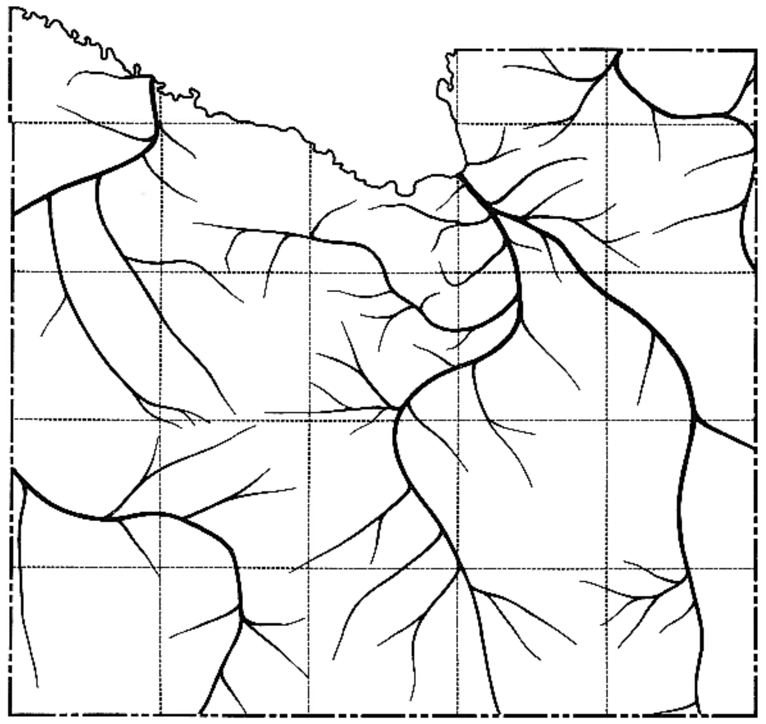


FIGURE 4. The sinuous system of buried bedrock valleys is shown in solid black. This pattern is suggested by the contours on the Bedrock Topography Map.

EXPLANATION

BEDROCK TOPOGRAPHY

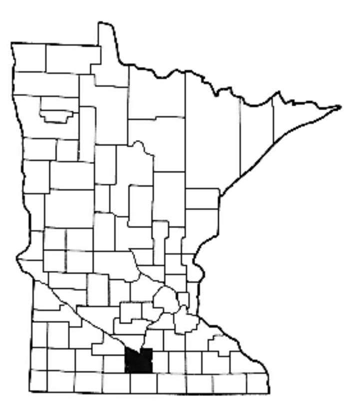
Topographic contours in feet above sea level.

850

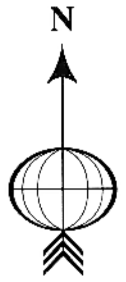
Contour interval 50 feet

•

Datum Point



LOCATION DIAGRAM

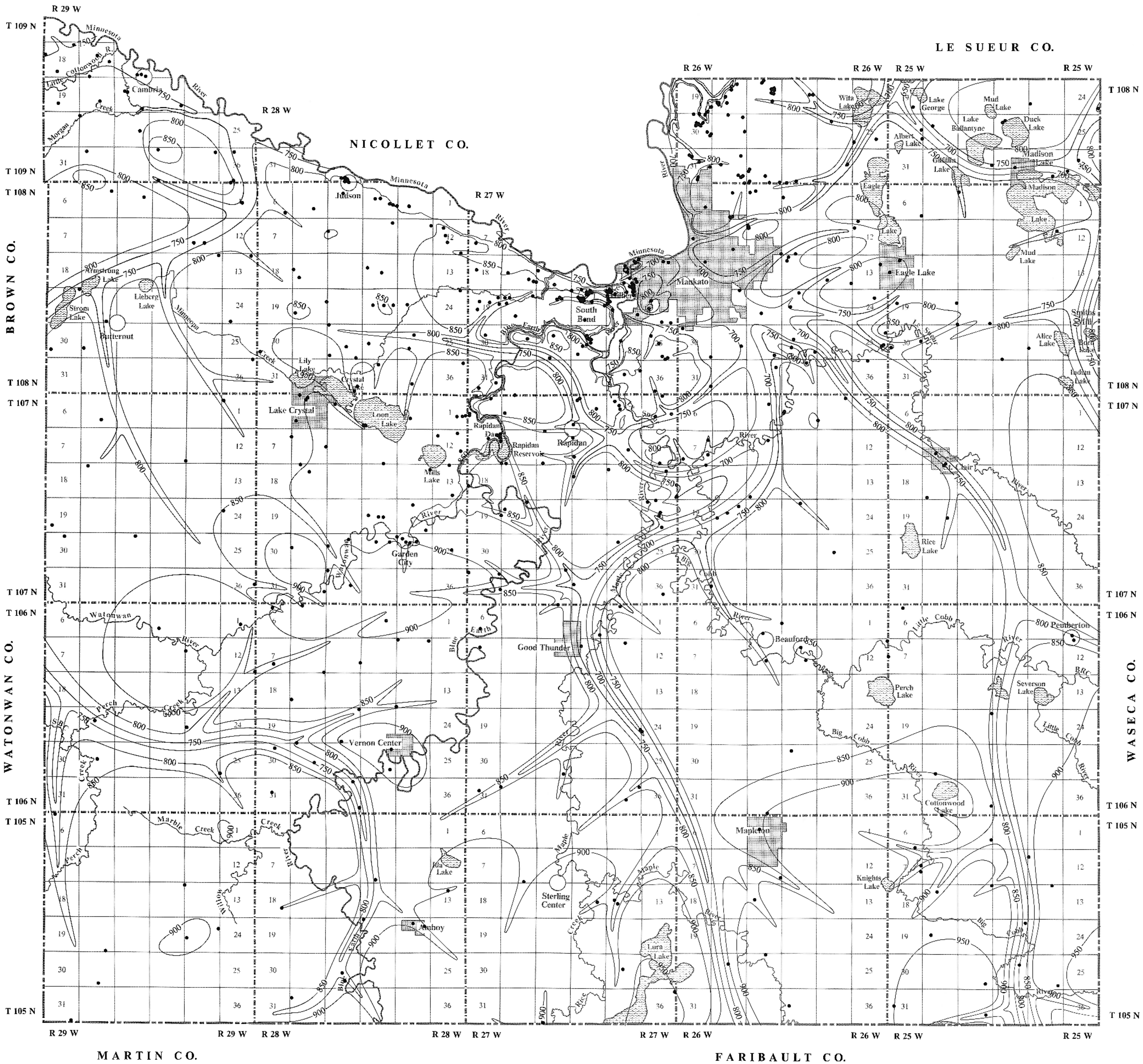


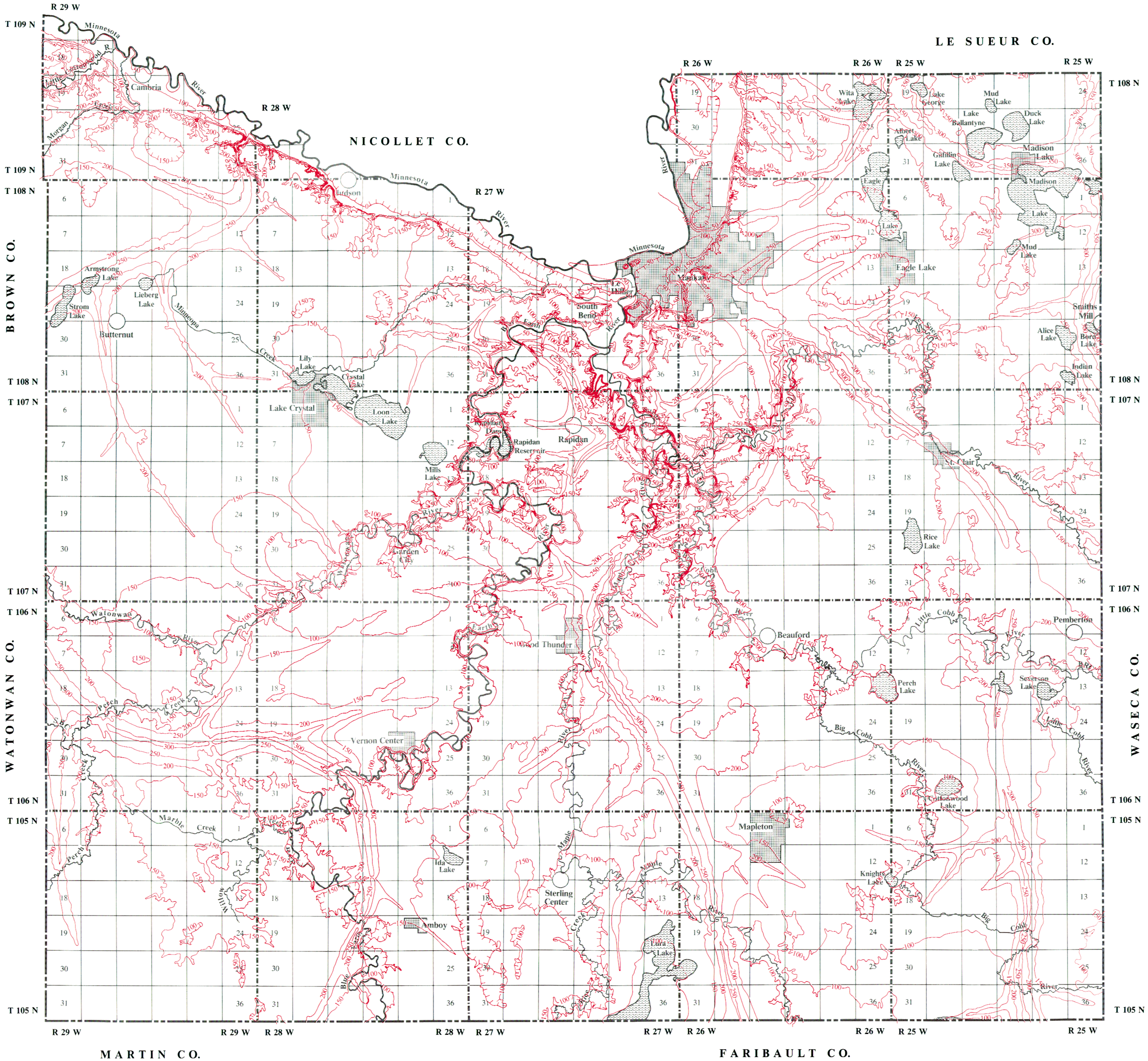
SCALE 1 : 150 000

1 0 1 2 3 4 5 6 7 8 9 10 KILOMETRES

1 0 1 2 3 4 5 MILES

5000 0 5000 10000 15000 20000 25000 FEET





DEPTH TO BEDROCK

By

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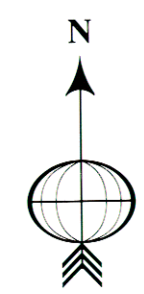
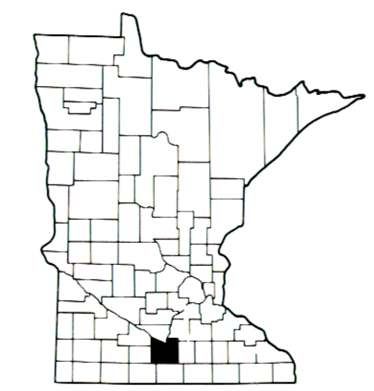
1991

EXPLANATION

Isopach lines connect points of equal thickness
Contour interval 50 feet

Hachures show closed areas of less thickness





LOCATION DIAGRAM

SCALE 1 : 150 000

KILOMETRES

MILES

FEET

GEOLOGIC CROSS SECTIONS

INTRODUCTION

The Geologic Cross Sections in this atlas combine the Surface Topography Map, Bedrock Topography Map, and the Bedrock Structure Maps to develop cross section profiles of Blue Earth County. The cross section profiles were prepared at three mile intervals; one set trending west-east and a second set trending north-south. The cross sections were constructed along each Township and Range line, and along section lines that pass through the center of each township (FIGURE 5). The cross section profiles are arranged as a grid system to provide county wide cross section coverage.

The cross section profiles of Blue Earth County are arranged in stacks on pages 11 through 14 in this atlas. Those cross sections that trend from west to east are stacked and labeled from north to south (A-A to J-J'). Those cross sections that trend from north to south, are stacked and labeled from east to west (K-K' to U-U'). On each cross section the location of intersecting cross sections and natural features such as rivers, streams, and lakes are labeled; the approximate location for cities and towns are also shown for reference. The individual bedrock units are separated by solid or dashed boundary lines and labeled with their respective names.

INDEX TO GEOLOGIC CROSS SECTIONS

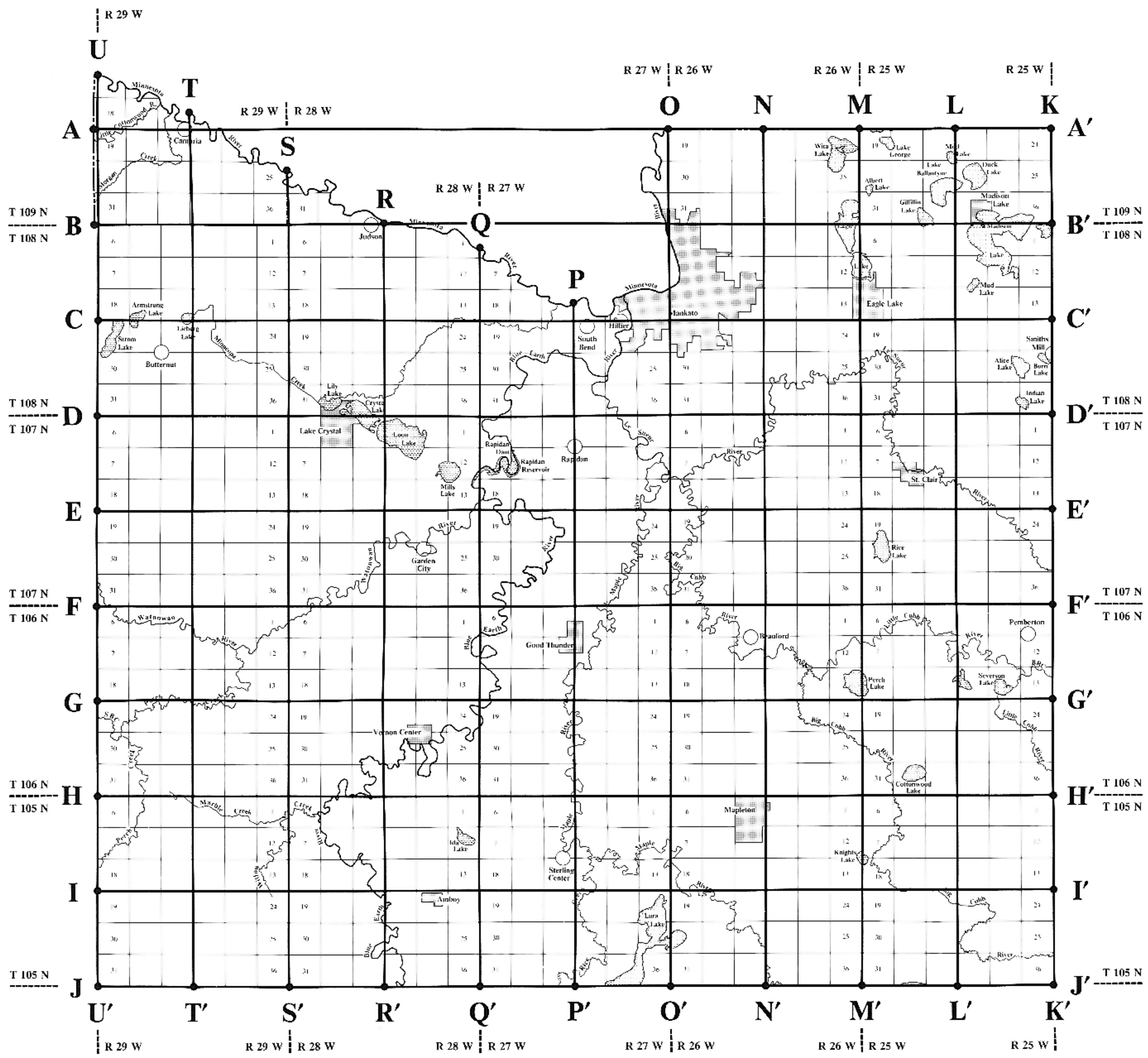


FIGURE 5. The above diagram describes the pattern of cross section profiles that were prepared for the atlas. The cross sections were prepared along Public Land Survey boundary lines: Township, Range, and Section lines.

The cross sections graphically illustrate the close relationship between the thickness of glacial deposits and the location of buried bedrock valleys and valleys on the land surface. The cross sections show that thicker glacial deposits are associated with deep bedrock valleys while the thinnest glacial deposits occur over bedrock uplands or below surface river valley cuts.

The cross sections illustrate the relationship between individual bedrock units and bedrock aquifer systems. The three major bedrock aquifer systems and the individual bedrock aquifers that combine to form them are shown on the cross sections. The regional confining layers that separate bedrock aquifer systems have been filled with a distinguishing pattern to make them easy to recognize; the individual bedrock aquifers have been left clear or white.

METHOD OF CONSTRUCTION

The positioning of boundary lines on each cross section was accomplished by transferring the elevation contour data from the Surface Topography Map, Bedrock Topography Map, and Bedrock Structure Maps. The boundary lines that divide individual bedrock units may describe a gradual change over a few feet or tens of feet, from one rock type to another. Solid lines were used where the contact between bedrock units is usually abrupt. Dashed lines were used where the contact between bedrock units represents an erosional unconformity or where the contact is gradational.

The surface profile for each cross section was constructed by using the Surface Topography Map as a guide. The profile for the top of the bedrock was constructed using the Bedrock Topography Map as a guide. The Bedrock Structure Maps were used as guides to plot profiles for the top of the Jordan and St. Lawrence formations onto each of the cross sections. Wherever present the upper boundary of the St. Peter Formation is the top of the bedrock. The boundary lines that define the Decorah and Platteville-Glenwood were positioned through inferences made from maps prepared for the Waseca and Faribault County Geologic Atlases. The top of the Prairie du Chien Group was located by plotting the apparent thickness of the St. Peter Formation below its upper boundary. The boundaries of all other bedrock units were located by projecting the average thicknesses (accumulative) for each of the underlying bedrock units below the top of the St. Lawrence Formation.

The cross sections show bedrock structural conditions more accurately above the St. Lawrence Formation than below it. Above the St. Lawrence Formation the structure map for the Jordan Formation controls the accuracy of the cross sections. The St. Lawrence Formation is the lowest bedrock unit for which a bedrock structure map was constructed. Thus, as the depth increases below the St.Lawrence Formation, information about the structural nature of individual bedrock units decreases. Eventually, depths are reached below which little or no information is available. At these depths the accuracy of the cross sections is limited.

GROUNDWATER

The cross sections show the relationship between water producing intervals and bedrock formations. The sandstones and limestones function as aquifers while the shales and siltstones function as aquitards in the sequence of bedrock sedimentary deposits. The bedrock aquifers are shown to extend continuously and uniformly over extended areas beneath Blue Earth County.

The direction of groundwater movement cannot be shown on the cross sections in this atlas. Groundwater does not flow in a straight line and the direction of groundwater flow can change significantly over very short distances. For groundwater work, study area boundaries should be established and cross sections developed that are parallel and perpendicular to the direction of inferred groundwater flow.

The cross sections indicate the vertical extent of bedrock aquifer materials and their connection with bedrock structure, bedrock topography, bedrock confining layers, and other factors that may control the movement of groundwater. In the vicinity of buried bedrock valleys, the emergence and subsequent termination of bedrock units may be abrupt. In these areas, bedrock aquifers may change from confined conditions to unconfined conditions over very short distances.

SCALE

The horizontal scale of each cross section is identical to the horizontal scale on all other atlas maps (1:150,000). However, the vertical scale of each cross section has been exaggerated twenty times the horizontal scale. The vertical scale was magnified so that the thin bedrock units would have adequate dimension for mapping. Exaggeration of the vertical scale affects primarily the vertical dimensions of a bedrock formation but it also affects, in a certain way, the horizontal dimensions of a bedrock formation. In the vertical direction the bedrock formation is actually expanded; in the horizontal direction it is apparently contracted. Persons not accustomed to exaggerated cross sections are apt to forget the fact of exaggeration and will gain a mental picture of acute structural relief when, in fact, the structural relief may be very mild.

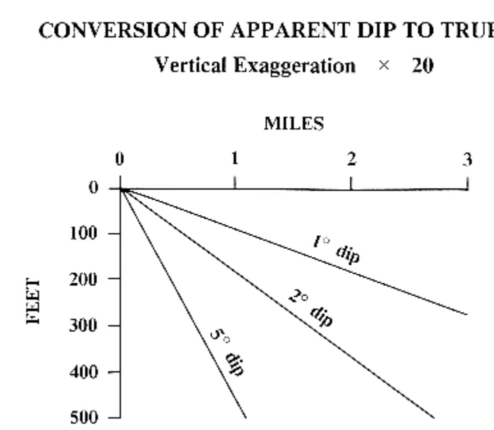


FIGURE 6. The above diagram illustrates the conversion of apparent dip to true dip. One is provided on each page of cross sections. The dip conversion diagram is designed to give the user a mental picture of the relief distortion that is caused by the vertical exaggeration.

GEOLOGIC CROSS SECTIONS
A-A′ TO E-E′

EXPLANATION

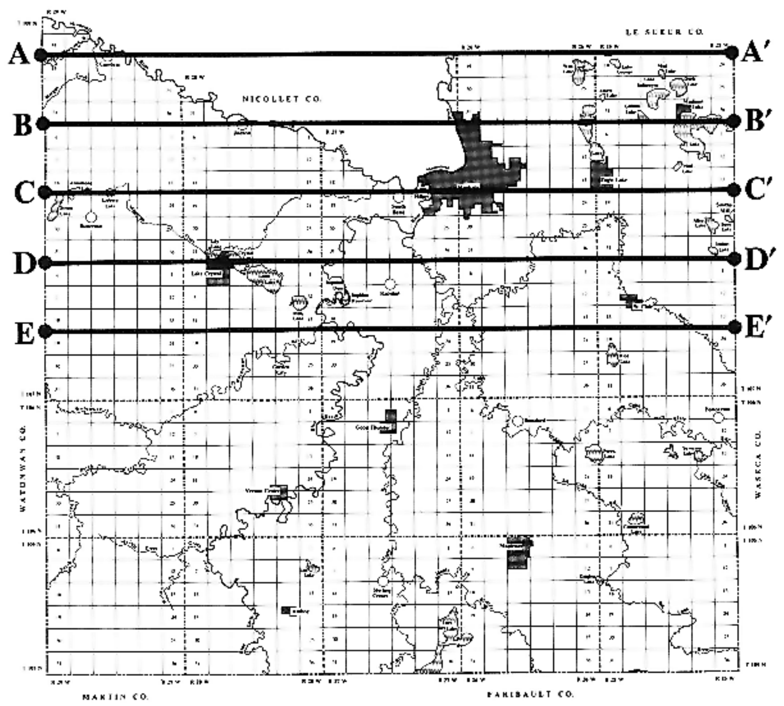
Unconsolidated surficial deposits, chiefly glacial drift; alluvial silts, sands, and gravels commonly present along streams.

Confining layer, chiefly shale and siltstone; separates bedrock aquifer systems.

Bedrock aquifer, chiefly sandstone, limestone, and dolomite; water yielding unit of an aquifer system.

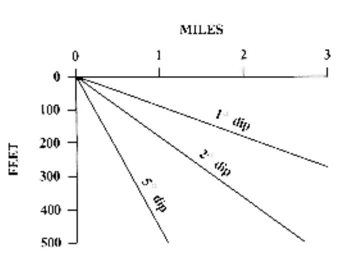
Contact between bedrock units is approximately located; dashed where inferred between lithologically similar units, erosional unconformities, or where contact is gradational.

INDEX TO GEOLOGIC CROSS SECTIONS



CONVERSION OF APPARENT DIP TO TRUE DIP

Vertical Exaggeration × 20



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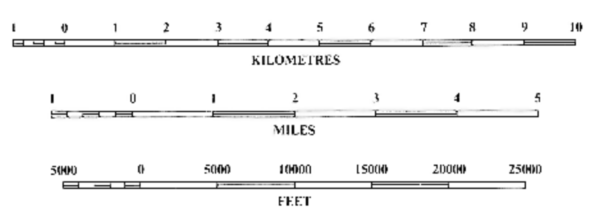
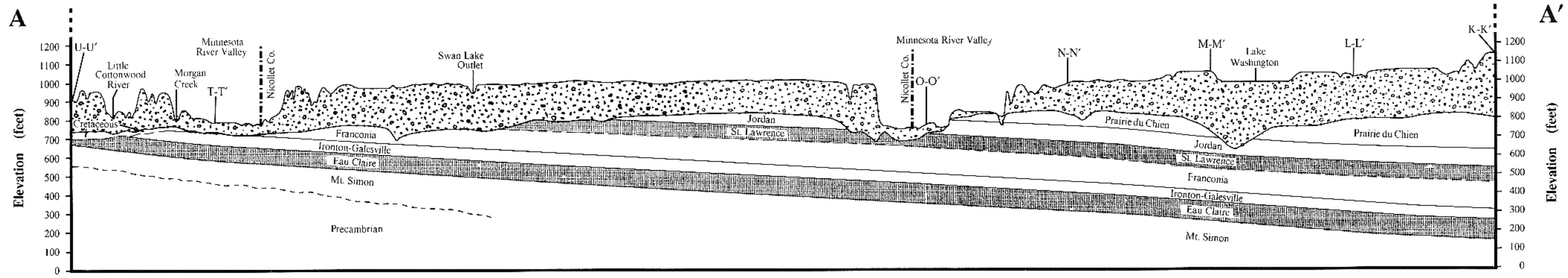
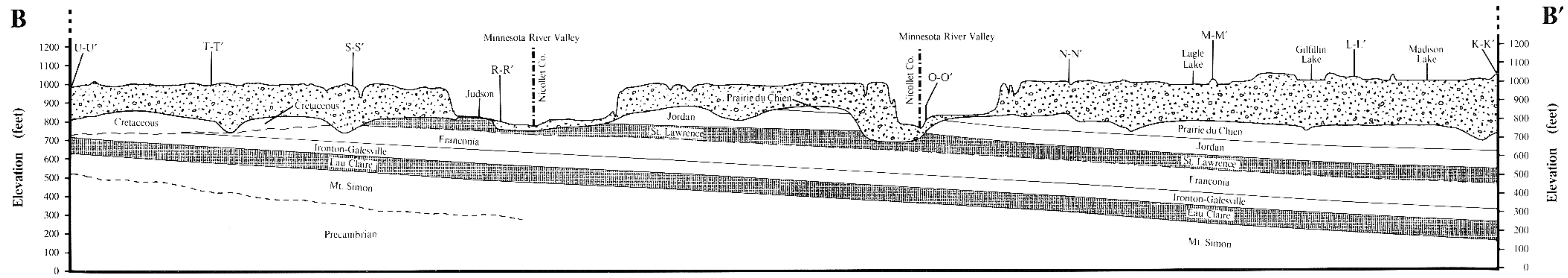
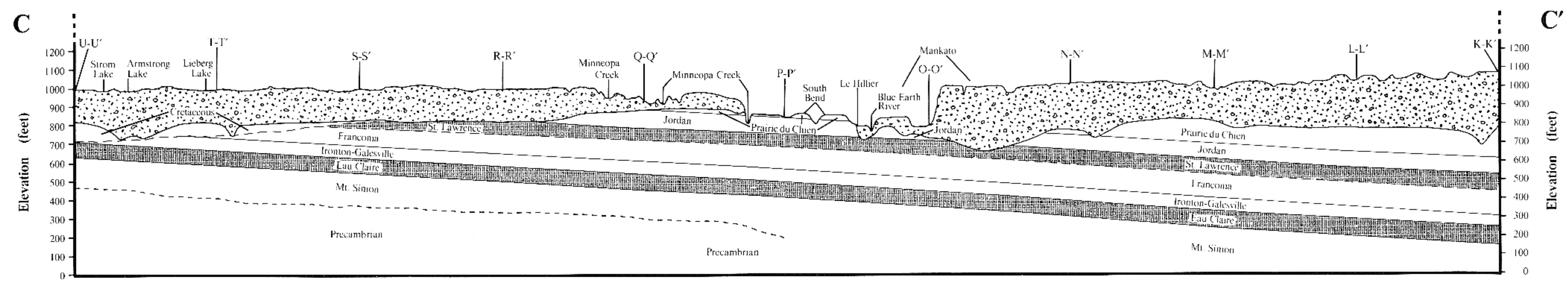
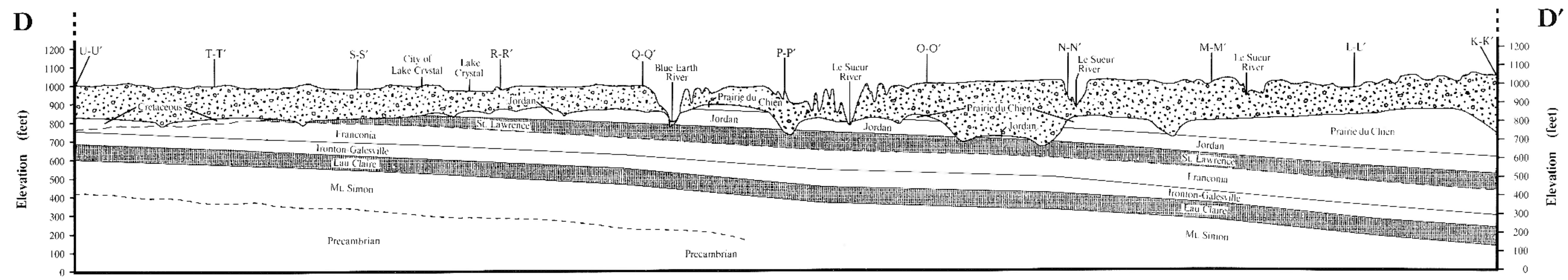
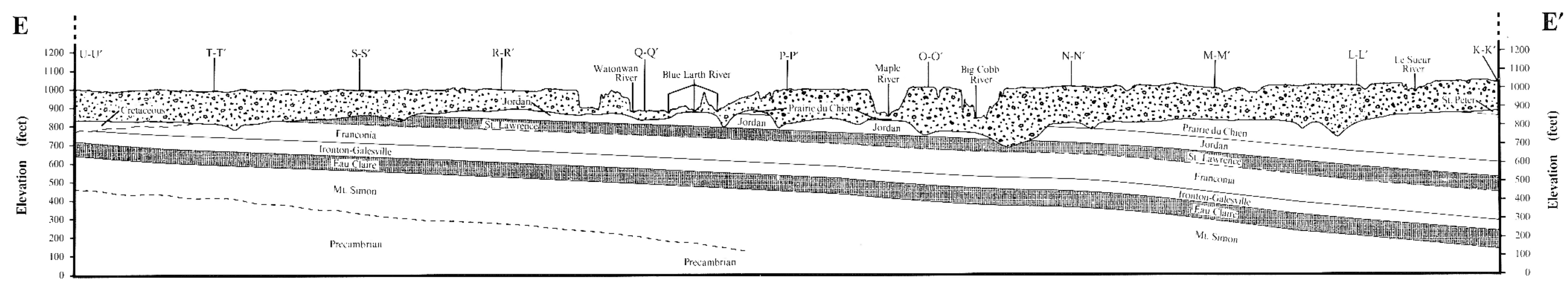


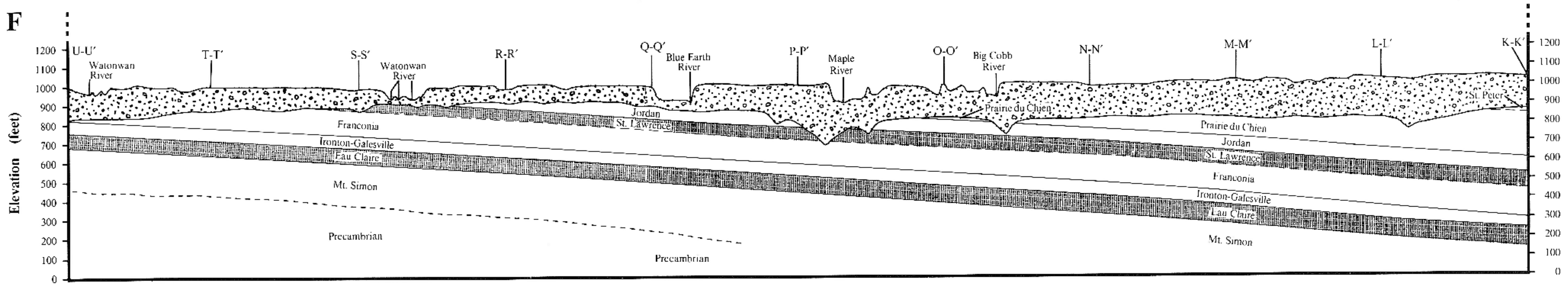


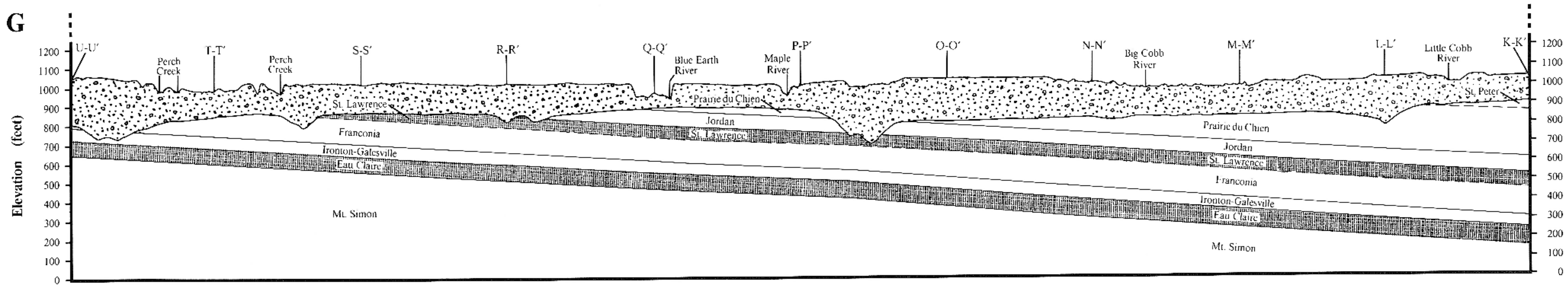


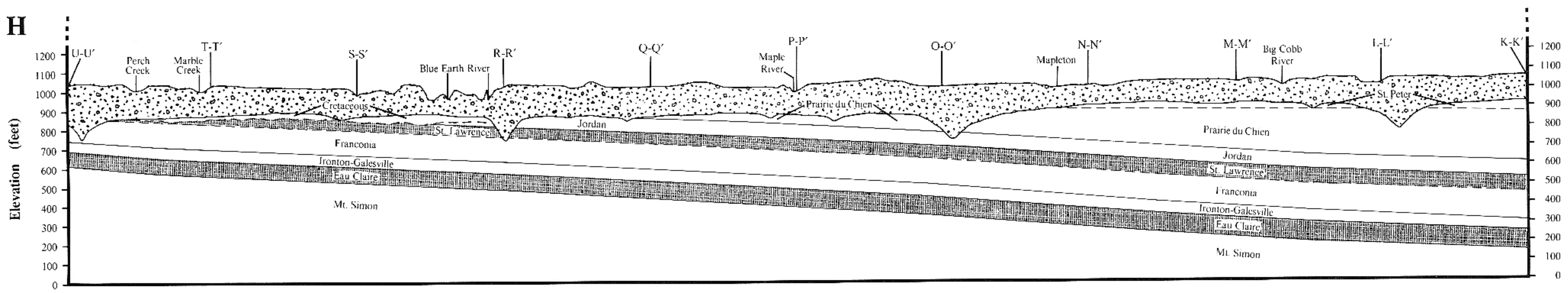


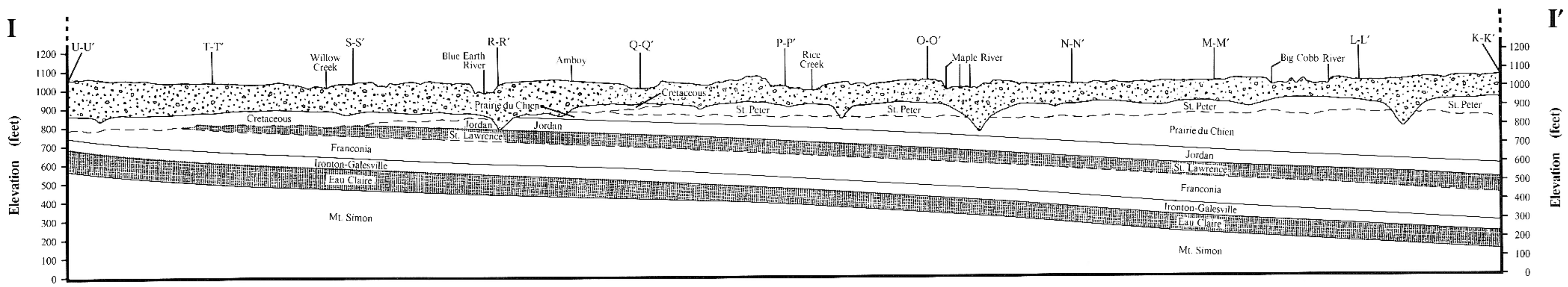


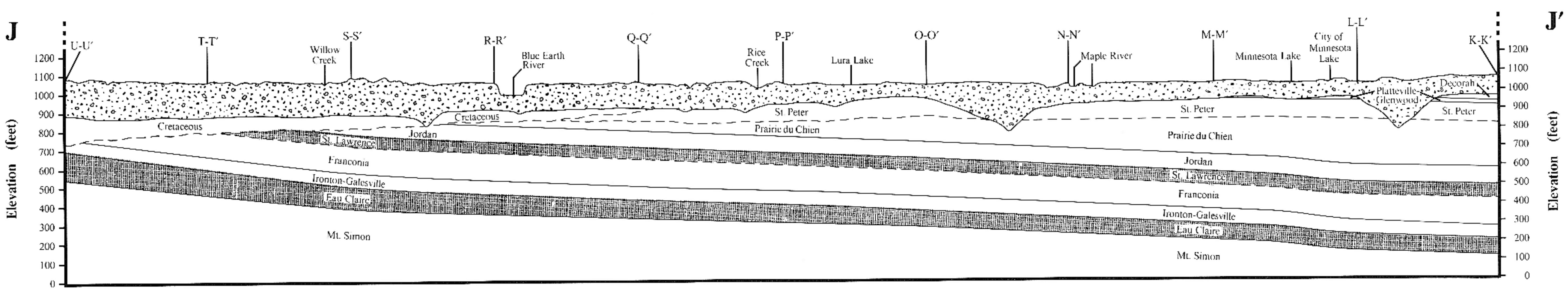












GEOLOGIC CROSS SECTIONS F-F′ TO J-J′

EXPLANATION

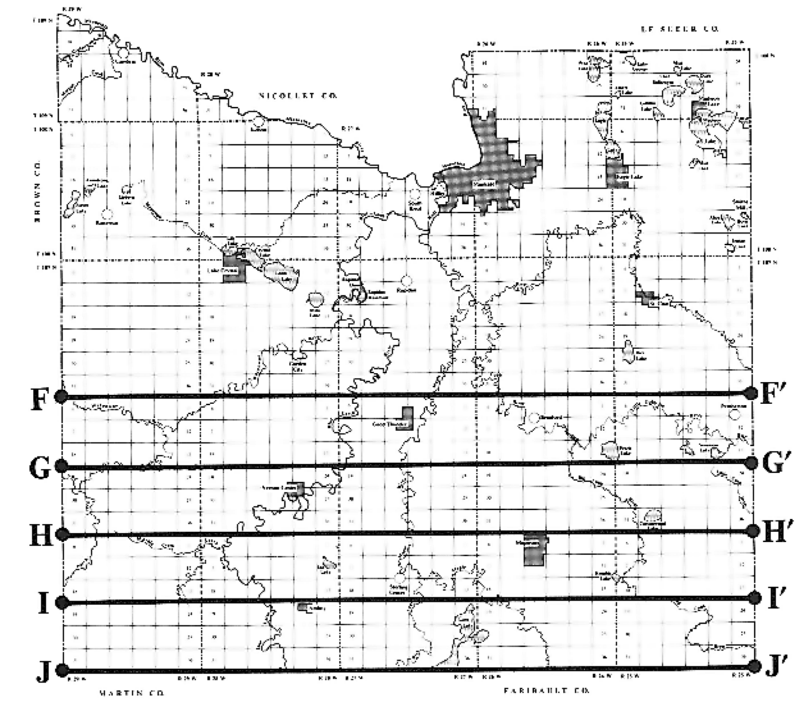
Unconsolidated surficial deposits, chiefly glacial drift; alluvial silts, sands, and gravels commonly present along streams.

Confining layer, chiefly shale and siltstone; separates bedrock aquifer systems.

Bedrock aquifer, chiefly sandstone, limestone, and dolomite; water yielding unit of an aquifer system.

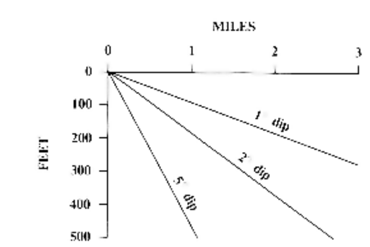
Contact between bedrock units is approximately located; dashed where inferred between lithologically similar units, erosional unconformities, or where contact is gradational.

INDEX TO GEOLOGIC CROSS SECTIONS



CONVERSION OF APPARENT DIP TO TRUE DIP

Vertical Exaggeration × 20



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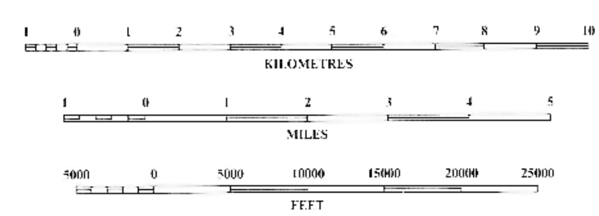


GEOLOGIC CROSS SECTIONS K-K′ TO O-O′

EXPLANATION

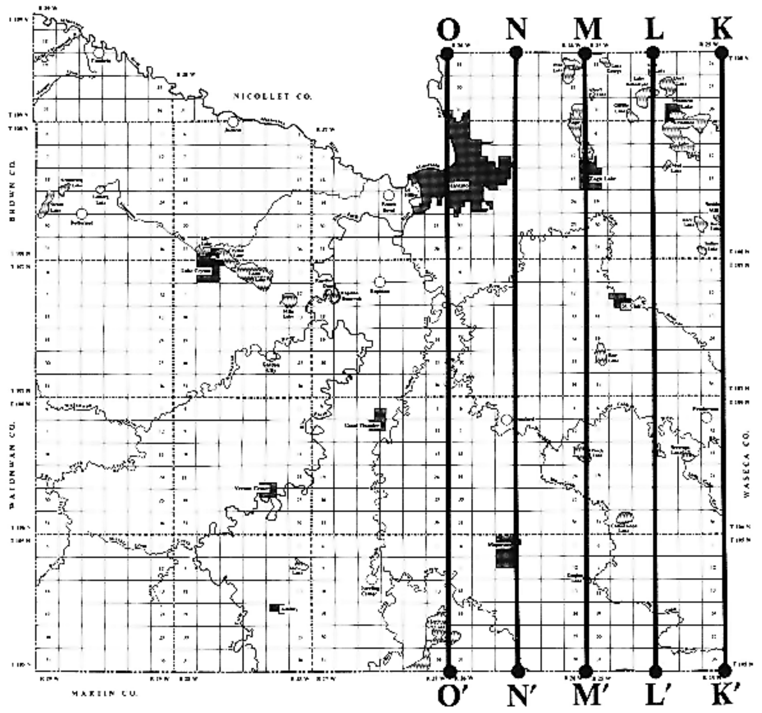
Unconsolidated surficial deposits, chiefly glacial drift; alluvial silts, sands, and gravels commonly present along streams.

Confining layer, chiefly shale and siltstone; separates bedrock aquifer systems.

Bedrock aquifer, chiefly sandstone, limestone, and dolomite; water yielding unit of an aquifer system.

Contact between bedrock units is approximately located; dashed where inferred between lithologically similar units, erosional unconformities, or where contact is gradational.

INDEX TO GEOLOGIC CROSS SECTIONS



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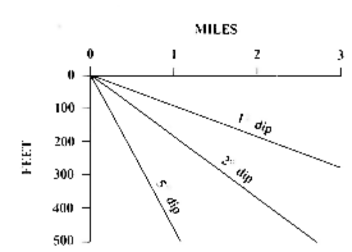
Vertical Exaggeration × 20



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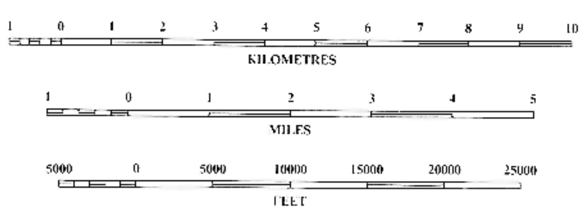
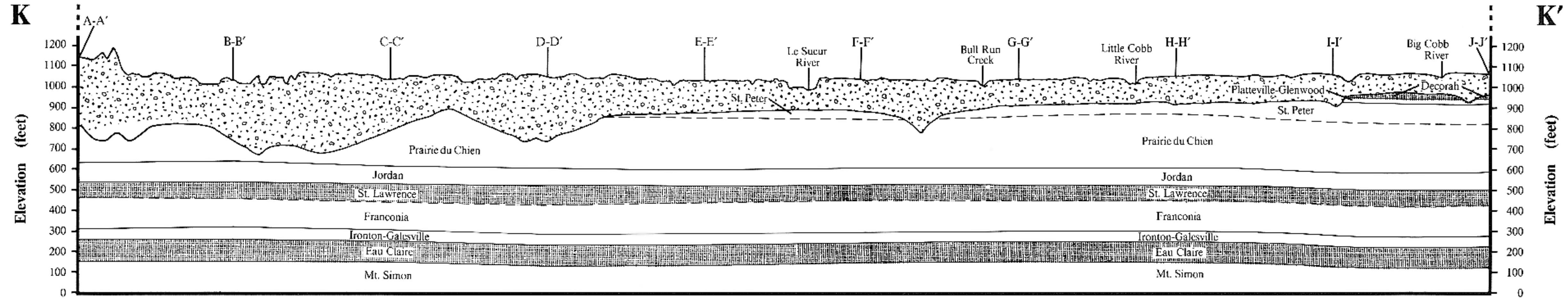
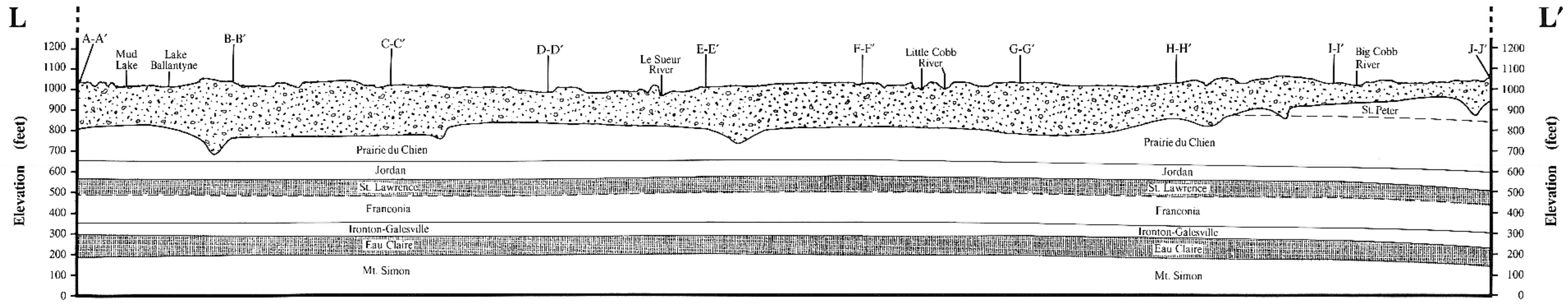
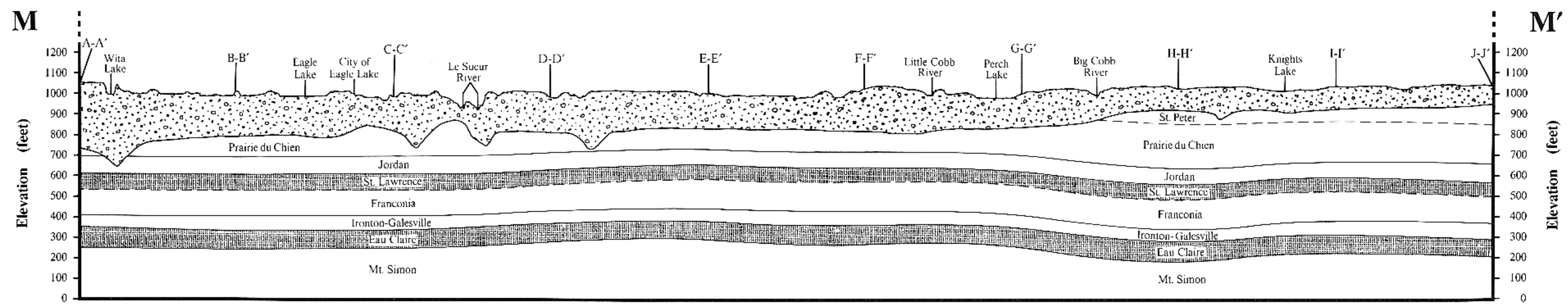
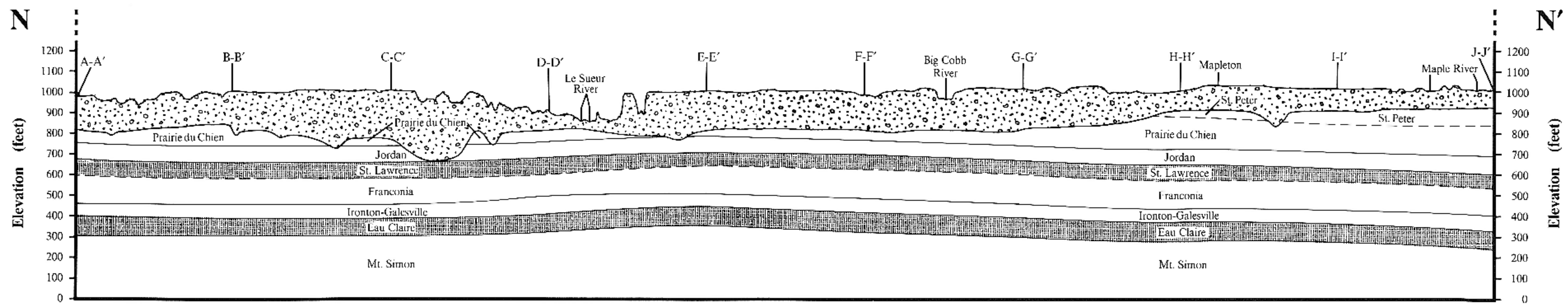
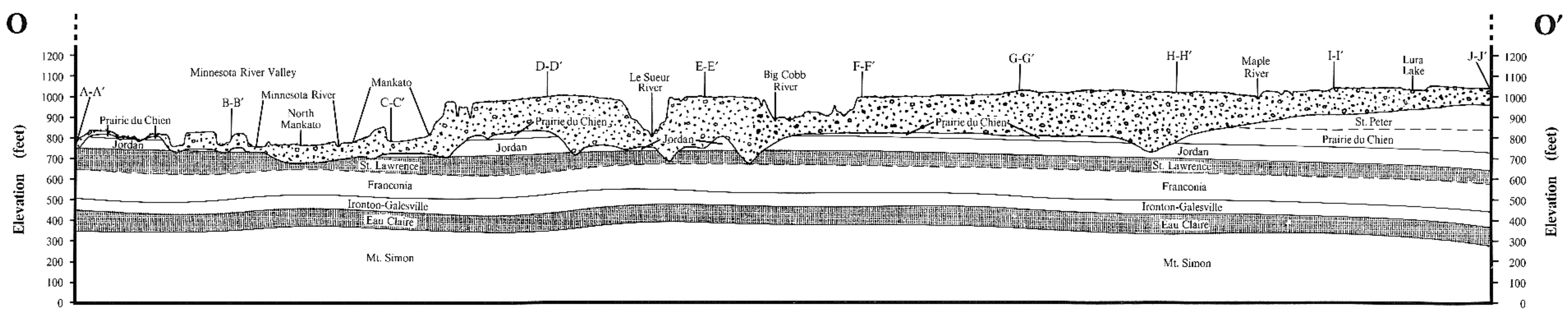


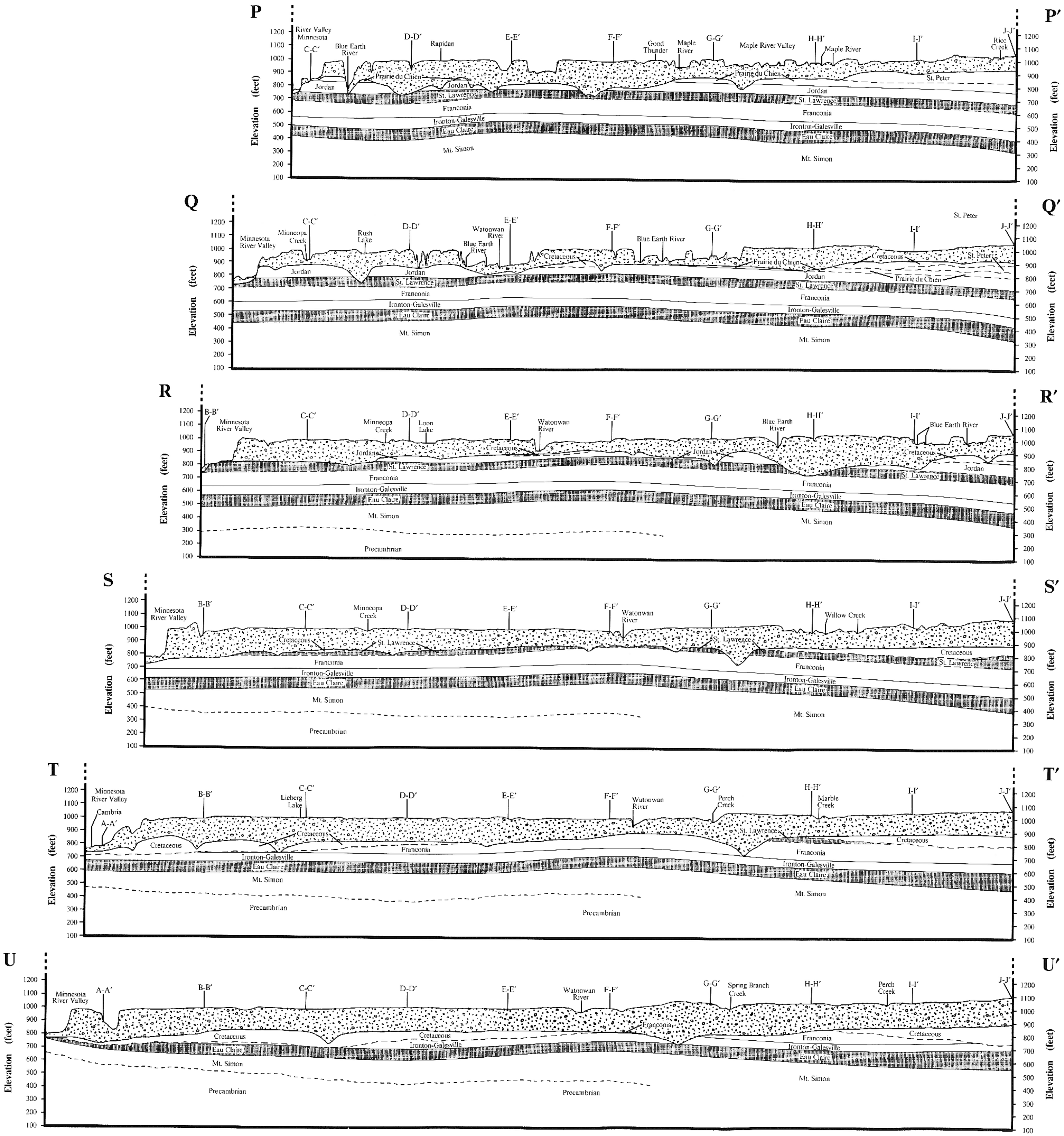












GEOLOGIC CROSS SECTIONS P-P′ TO U-U′

EXPLANATION

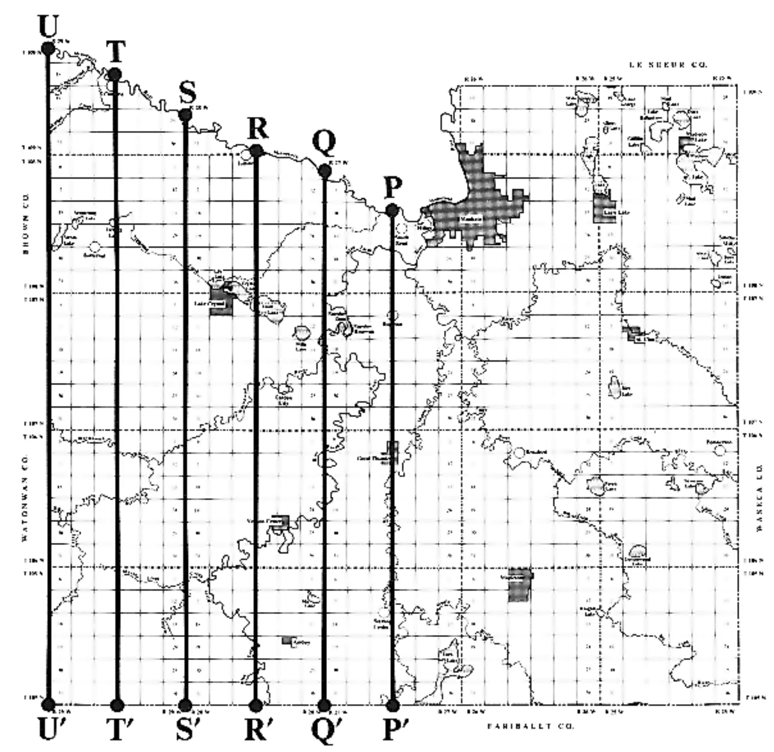
Unconsolidated surficial deposits, chiefly glacial drift; alluvial silts, sands, and gravels commonly present along streams.

Confining layer, chiefly shale and siltstone; separates bedrock aquifer systems.

Bedrock aquifer, chiefly sandstone, limestone, and dolomite; water yielding unit of an aquifer system.

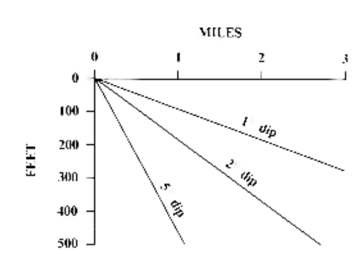
Contact between bedrock units is approximately located; dashed where inferred between lithologically similar units, erosional unconformities, or where contact is gradational.

INDEX TO GEOLOGIC CROSS SECTIONS



CONVERSION OF APPARENT DIP TO TRUE DIP

Vertical Exaggeration × 20



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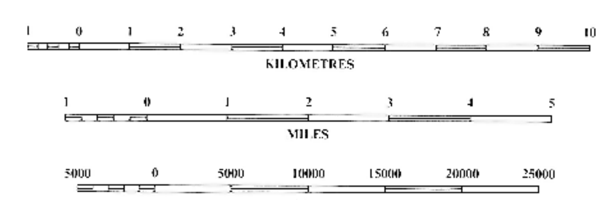


GEOLOGIC CROSS SECTIONS

CROSS SECTIONS A-A' TO E-E'

Cross sections A-A' to E-E' trend from west to east and are stacked from north to south, providing cross section coverage for the northern half of Blue Earth County. On this set of cross sections, the nature of thickening and thinning of the glacial deposits is shown to be largely influenced by buried bedrock valley cuts and present day river valley cuts. On these cross sections the bedrock strata gently dips from west to east. The actual regional dip of the bedrock strata is to the south and east, at about 12 feet per mile. The variation in thickness and subsequent termination of the upper bedrock unit is shown to be largely influenced by the dip of the bedrock strata.

CROSS SECTIONS F-F' TO J-J'

Cross sections F-F' to J-J' trend from west to east and are stacked from north to south, providing cross section coverage for the southern half of Blue Earth County. On this set of cross sections, the surface highs and lows tend to parallel bedrock highs and lows to varying degrees. Thicker glacial deposits are associated with deep bedrock valleys while the thinnest glacial deposits occur over bedrock uplands or beneath present day river valley cuts.

Cross sections I-I' and J-J' show the Prairie du Chien dolomite becoming significantly thinner beneath the St. Peter sandstone near their western limits. The most plausible explanation for the thinning is the erosion of the Prairie du Chien dolomite prior to St. Peter deposition. As the St. Peter sandstone deposits advanced into Minnesota the Prairie du Chien topography may have been low hills and shallow valleys. The St. Peter sandstone was deposited in these low areas.

CROSS SECTIONS K-K' TO O-O'

Cross sections K-K' to O-O' trend from north to south and are stacked from east to west, providing cross section coverage for the eastern half of Blue Earth County. In these cross sections the bedrock strata is nearly flat laying and the emergence and subsequent termination of the upper bedrock units is largely influenced by erosional features on the bedrock surface. The cross sections illustrate that the St. Peter-Prairie du Chien-Jordan aquifer system which is so prominent in K-K' has been subjected to extensive erosion in O-O'.

CROSS SECTIONS P-P' TO U-U'

Cross sections P-P' to U-U' trend from north to south and are stacked from east to west, providing cross section coverage for the western half of Blue Earth County. These cross sections show that the confining conditions of the St.Lawrence Formation, which are present throughout much of Blue Earth County, are completely missing along the western border. In this area the Franconia-Ironton-Galesville aquifer system represents the uppermost bedrock aquifer. The cross sections show that the Mt.Simon-Hinckley aquifer system is protected by the confining conditions of the Eau Claire Formation throughout Blue Earth County. Along the western border of Blue Earth County, precambrian bedrock units are approaching the bedrock surface.

JORDAN STRUCTURE MAP

INTRODUCTION

A structure map was constructed for the top of the Jordan Formation because of the abundance of available data, because of its importance as a regional aquifer, and because the contact between the Jordan sandstone and the overlying Prairie du Chien dolomite is usually abrupt and easily recognized in the geologic portions of water well drillers' logs.

The structure map for the top of the Jordan Formation provides a view of the bedrock structure in Blue Earth County. The bedrock that underlies Blue Earth County was deposited in sheet-like layers under tectonically stable geologic conditions over a wide area in southern Minnesota. In Blue Earth County, the bedrock structure generally dips toward the east-southeast and the center of the basin structure called the Hollandale Embayment. The Hollandale Embayment is the main regional structural feature in which the bedrock layers were deposited. Localized dip discordance occurs in the form of a gentle anticlinal structure. Deviations in the general direction of dip can be mapped only where subsurface information is adequate.

The Jordan sandstone crops out in the northcentral part of Blue Earth County along the Minnesota, Blue Earth, and LeSueur river valleys. The Jordan sandstone can be traced by outcrop along the Minnesota River Valley, from three miles southeast of the city of Judson to the city of Mankato. Jordan sandstone outcrops can be traced along the Blue Earth River as far south as Rapidan Dam. Along these river valleys, hard layers form the caprock of waterfalls that cut narrow gorges through the soft underlying Jordan sandstone.

METHOD OF CONSTRUCTION

The Jordan structure contours were drawn solely on the basis of data contained in the geophysical logs and cutting sample logs shown on the Data Base Map (Page 3). The structure map was contoured to convey the probable forms of any geologic structures that might be suggested by the data.

The Jordan Structure Map was designed to act as a regional mapping horizon for the bedrock in Blue Earth County. The structure map was used as an aid in the interpretation of the geologic portions of water well drillers' logs. The Jordan Structure Map was used in combination with the Bedrock Topography Map to position the geologic boundary line that separates the Jordan Formation from the overlying Prairie du Chien Group on the Bedrock Geology Map. The structure map was also used as a guide from which the top of the Jordan Formation was plotted onto each of the Geologic Cross Sections (Pages 11 - 14).

The Jordan Structure Map describes the present configuration and extent of the Jordan sandstone in Blue Earth County. The structure map defines areas where the absence of overlying bedrock has exposed the sandstone to past erosion. In these areas, the upper boundary of the Jordan sandstone is the top of the bedrock. The structure map marks the erosional limits of the Jordan Formation. Beyond its erosional limits the St.Lawrence Formation forms the upper bedrock unit.

ST. LAWRENCE STRUCTURE MAP

INTRODUCTION

A structure map was constructed for the top of the St. Lawrence Formation because of the abundance of available data, because of its importance as a regional confining layer, and because the contact between the St. Lawrence siltstone and the overlying Jordan sandstone is usually abrupt and easily recognized in the geologic portions of water well drillers' logs. The St. Lawrence forms an aquitard that hydrologically separates the St. Peter-Prairie du Chien-Jordan aquifer system from the underlying Franconia-Ironton-Galesville aquifer system.

The St. Lawrence siltstone was deposited under tectonically stable geologic conditions over a wide area. The thickness of the St. Lawrence ranges from a feather edge at its erosional limits to as much as 100 feet in areas where it is overlain by the Jordan sandstone. Contact between the St. Lawrence and overlying Jordan is usually abrupt; however, the St. Lawrence siltstone grades slowly into the underlying Franconia sandstone. The St. Lawrence and underlying Franconia formations are not easily distinguished in the geologic portions of water well drillers' logs.

The St. Lawrence Structure Map describes the present configuration and extent of the St. Lawrence Formation in Blue Earth County. The structure map defines areas where the absence of overlying bedrock has exposed the St. Lawrence to past erosion. In these areas, the upper boundary of the St. Lawrence is the top of the bedrock. The structure map marks the erosional limits of the St. Lawrence Formation. Beyond its erosional limits the Franconia Formation forms the upper bedrock unit.

METHOD OF CONSTRUCTION

The St. Lawrence structure contours were drawn solely on the basis of data contained in the geophysical logs and cutting sample logs shown on the Data Base Map (Page 3). The structure map was contoured to convey the probable forms of any geologic structures that might be suggested by the data. In areas where the top of the St. Lawrence has been truncated by erosion, the placement of contours is based upon the reconstruction of the original thickness of the St. Lawrence. In areas where the St. Lawrence is absent, the contours are discontinued.

The St. Lawrence Structure Map was designed to act as a regional mapping horizon for the bedrock in Blue Earth County. The structure map was used as an aid in the interpretation of the geologic portions of the water well drillers' logs. The St. Lawrence Structure Map was used in combination with the Bedrock Topography Map (Page 8) to position the boundary line that separates the St.Lawrence siltstone from the overlying Jordan sandstone on the Bedrock Geology Map (Page 7). The structure map was also used as a guide from which the top of the St. Lawrence was plotted onto each of the Geologic Cross Sections (Pages 11 - 14).

BEDROCK STRUCTURE JORDAN FORMATION

By

John M. Rongstad and Paul A. Vogel

1991

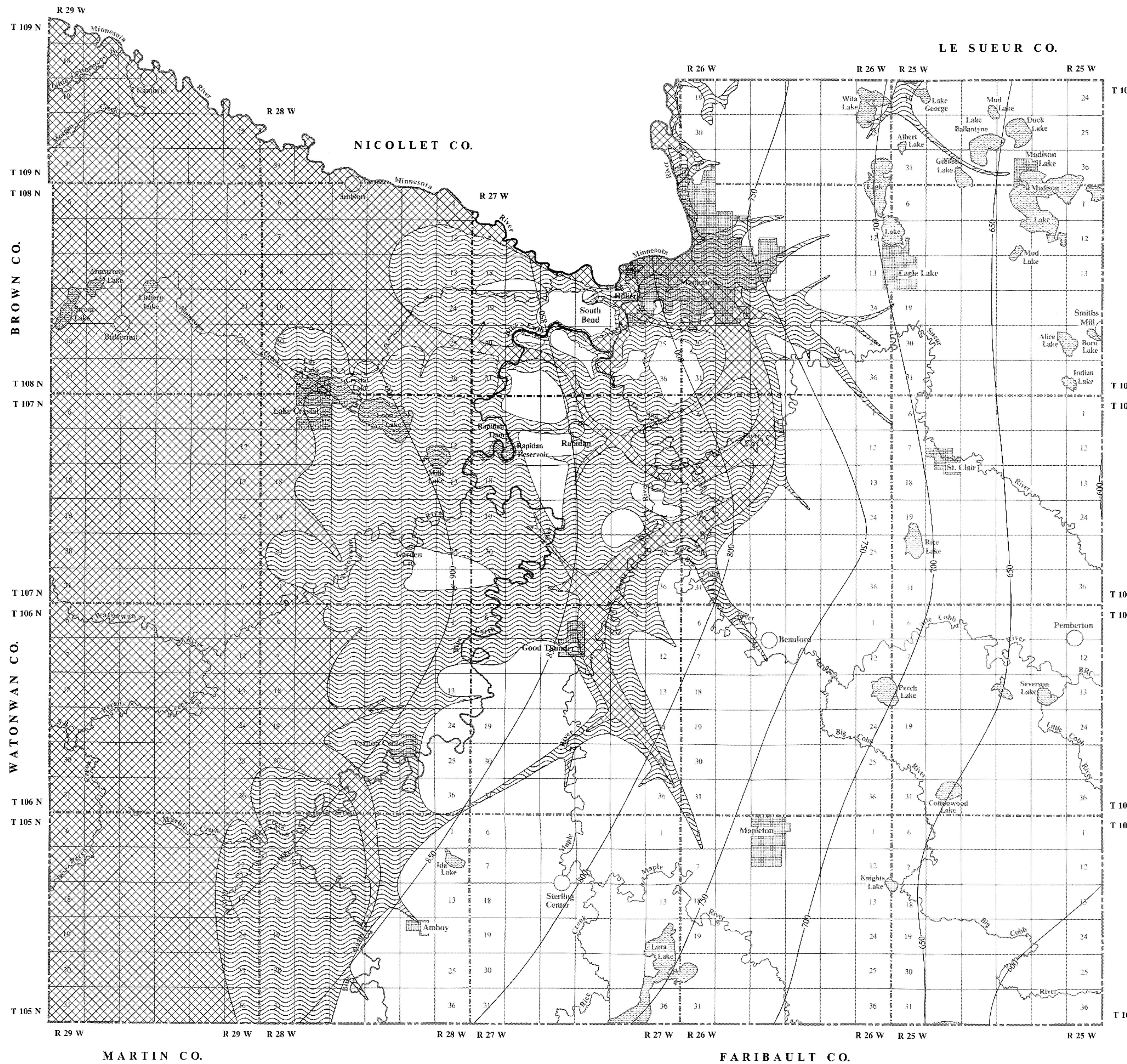
EXPLANATION

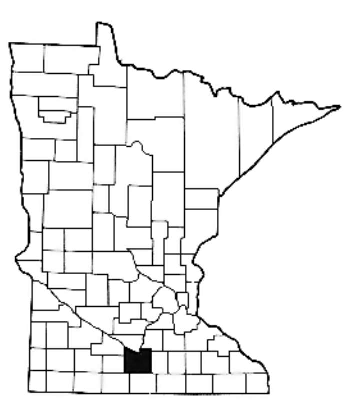
- Area where Jordan Formation is present.
- Area where Jordan Formation is present but top eroded.
- Area where Jordan Formation is not present.

Structure contours in feet above sea level.

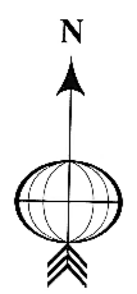
800

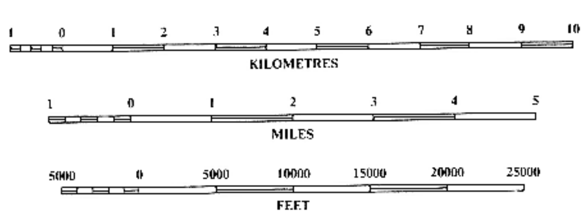
Contour interval 50 feet





LOCATION DIAGRAM





BEDROCK STRUCTURE
ST. LAWRENCE FORMATION

By

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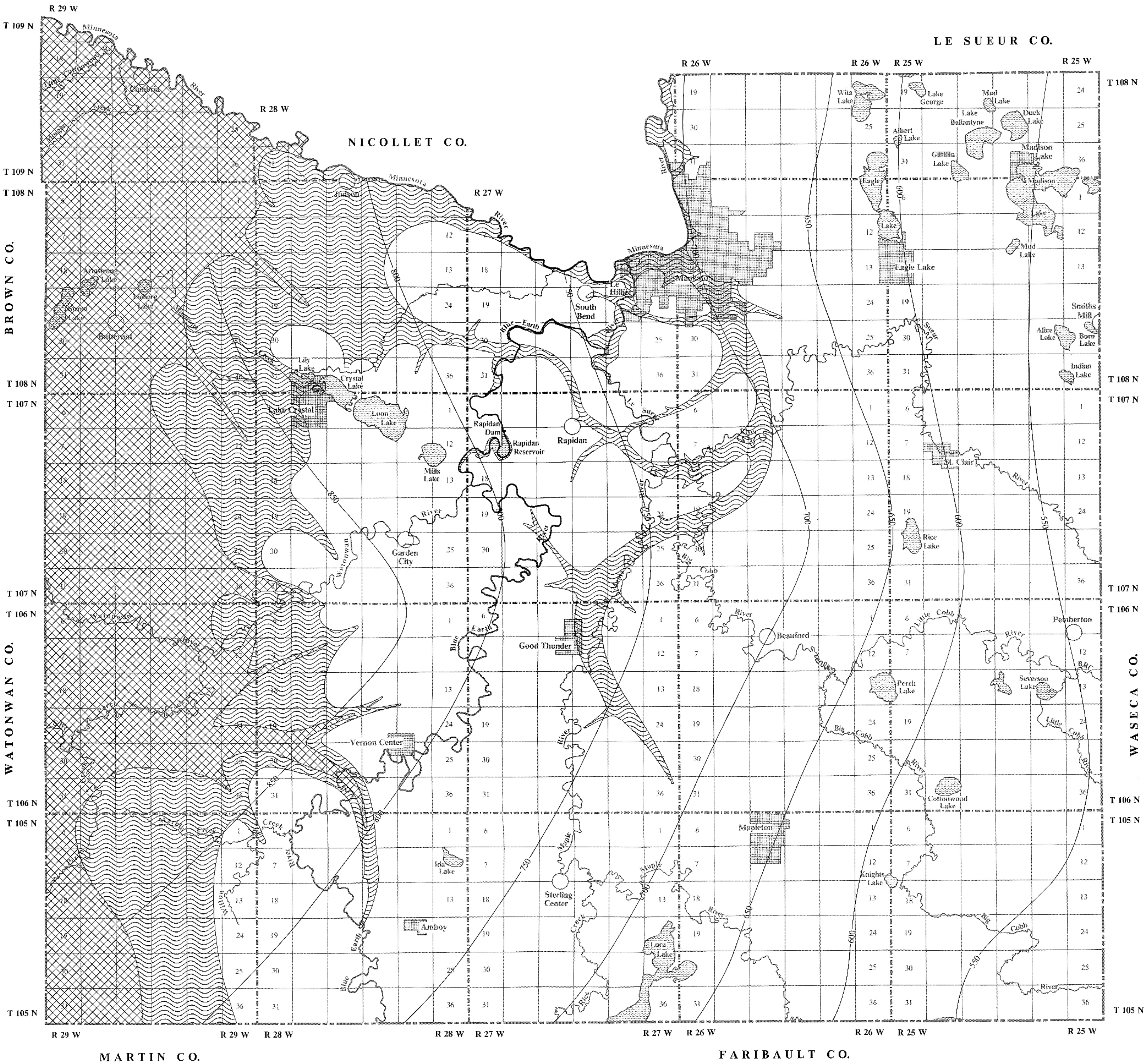
1991



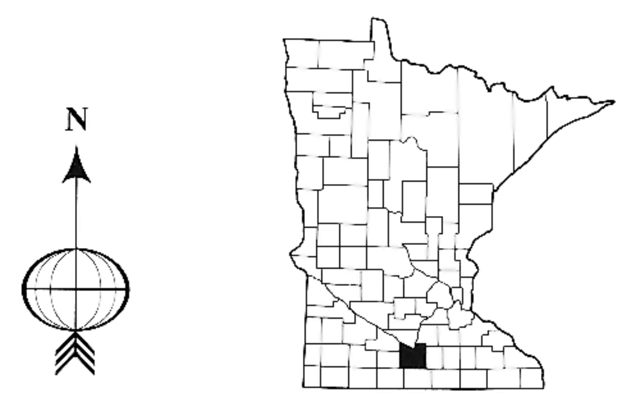
EXPLANATION

- Area where St. Lawrence Formation is present.
- Area where St. Lawrence Formation is present but top eroded.
- Area where St. Lawrence Formation is not present.

Structure contours in feet above sea level.

700

Contour interval 50 feet



LOCATION DIAGRAM

SCALE 1 : 150 000

KILOMETRES

MILES

FEET

BEDROCK HYDROGEOLOGY

BEDROCK AQUIFER SYSTEMS

Three major bedrock aquifer systems, separated on the basis of hydrogeologic properties, are present in Blue Earth County. They are the the St.Peter-Prairie du Chien-Jordan aquifer system, the Franconia-Ironton-Galesville aquifer system, and the Mt.Simon-Hinckley aquifer system.

A bedrock aquifer is a geologic formation that is capable of storing and yielding fresh water in usable quantities. A bedrock aquifer system is a multiaquifer system that is composed of two or more bedrock aquifers that are bound on the top and bottom by aquitards. Individual bedrock aquifers range from coarse-grained deposits such as sandstone to hard fractured sedimentary rocks such as limestone or dolomite. A bedrock aquifer system is a connected set of individual bedrock aquifers that act hydrologically as a single unit. The data suggests that there is good hydraulic connection between the bedrock units within each of the three aquifer systems in Blue Earth County.

The St. Peter-Prairie du Chien-Jordan aquifer system directly underlies the glacial drift and forms the bedrock surface throughout the eastern three-fourths of Blue Earth County. These three bedrock units function as a single aquifer system because all three are sources of groundwater with no regional confining bed separating them. The major bedrock aquifers in this system are the St. Peter and Jordan sandstones, which yield water from between individual grains, and the Prairie du Chien dolomites, which yield water through fractures and crevices. Rock of low permeability of the St.Lawrence Formation underlies the Jordan sandstone and separates the St.Peter-Prairie du Chien-Jordan aquifer system from the underlying Franconia-Ironton-Galesville aquifer system.

The Franconia-Ironton-Galesville aquifer system is overlain by the St. Lawrence confining bed except within the western row of townships in Blue Earth County. The upper bedrock aquifer unit in this system is the Franconia glauconitic sandstone which yields moderate supplies of groundwater. The lower bedrock aquifer unit is the Ironton-Galesville sandstones which are generally a more productive aquifer than the overlying Franconia. Rock of low permeability of the Eau Claire Formation directly underlie the Ironton-Galesville sandstone. The Eau Claire separates the Franconia-Ironton-Galesville aquifer system from the Mt. Simon-Hinckley aquifer system.

The Mt. Simon-Hinckley aquifer system is deepest of the three bedrock aquifer systems in Blue Earth County. These deep sandstone aquifers are overlain by the confining conditions of the Eau Claire formation. Very little information is available on the geology and hydrology of the Mt.Simon-Hinckley aquifer system because it is reached by only a few deep water wells.

SHALLOW BEDROCK AQUIFER SYSTEMS

The shallow bedrock aquifer systems consist of those bedrock units that commonly directly underlie the glacial drift and are recharged locally. The shallow bedrock aquifers are the primary source of groundwater due to their proximity to the land surface. Ease of drilling and lower drilling and operating costs are advantages of using from the shallow bedrock aquifers. The shallow bedrock has the advantage of local and rapid recharge, particularly in areas where the overlying drift is thin, or where there are permeable materials within the drift that are in direct hydrologic connection with the bedrock and will permit the downward movement of water into the bedrock. The disadvantages of the shallow bedrock aquifers include the susceptibility to contamination from waste disposal and other sources. Variability in the quality of the water may limit the use of a shallow bedrock aquifer when the aquifer is near the surface.

The St. Peter sandstone is generally limited to the southeastern quarter of Blue Earth County where it directly underlies the glacial drift. The Prairie du Chien dolomite is present throughout the eastern half of Blue Earth County where it forms the bedrock surface or underlies the St. Peter sandstone. The Jordan sandstone forms the bedrock surface and has been dissected by past and present stream erosion in westcentral Blue Earth County. The bedrock units of the Franconia-Ironton-Galesville aquifer system form the top of the bedrock in western Blue Earth County.

DEEP BEDROCK AQUIFER SYSTEMS

The deep bedrock aquifer systems consist of those bedrock units that are covered by confining bedrock conditions in Blue Earth County. The St. Lawrence confining bed covers the Franconia-Ironton-Galesville aquifer system throughout the eastern three-fourths of the county. Rock of low permeability of the Eau Claire Formation overlays the Mt. Simon-Hinckley aquifer system throughout Blue Earth County. Two major sandstone aquifers are present in the deep bedrock aquifer systems; the Ironton-Galesville and the Mt. Simon sandstones.

STATIC WATER LEVELS

Groundwater is usually held in a bedrock aquifer, at significant pressure, by the presence of a confining bed above the aquifer. High water pressure is sometimes the result of continuous bedrock strata with recharge areas at higher elevations. Water pressure will change in response to varying patterns of recharge, discharge, and pumping. In Blue Earth County, the water pressure in bedrock aquifers is not sufficient to lift the water above land surface except within the Minnesota River Valley and the lower Blue Earth and LeSueur river valleys where the bedrock is at or near the surface.

In water well drillers' logs, groundwater pressure is recorded as static water level measurements that represent the non-pumping water level in a well. These water well records represent data that has been collected over many years through every season. The data is usually a one time measurement of the static water level that was made during well installation.

To precisely map water levels in the bedrock aquifers, static water level data would have to be collected at about the same time of the year from many control points. When data points are few and unequally spaced, only limited confidence can be placed in the resulting map. On the bedrock aquifer maps, static water levels are shown by means of contours. The static water level contours are drawn on the basis of data from water wells for which static water levels have been recorded. The direction of groundwater movement is approximately perpendicular to the static water level contours. In Blue Earth County, current water well driller data are only sufficient to demonstrate the regional groundwater movement is toward the northwest and the Minnesota River Valley.

BEDROCK AQUIFER MAPS

Bedrock aquifer maps were constructed for the St. Peter-Prairie du Chien-Jordan aquifer system and the Franconia-Ironton-Galesville aquifer system because of their importance as a source of groundwater and because of the abundance of available hydrologic data. More water wells are drilled into the upper most bedrock units than into the lower ones. As a bedrock unit becomes covered with more and more overlying units, the available data becomes scarce; consequently the hydrologic conditions of the bedrock are not as well known for the deep aquifer systems.

A bedrock aquifer map for the Mt. Simon-Hinckley aquifer system was not constructed because so little hydrologic data is available for this aquifer system. Little data is available for the Mt. Simon and Hinckley sandstones because few wells need penetrate so deep the find adequate water supplies in Blue Earth County.

WATER WELL CONSTRUCTION

In 1974, implementation of the Minnesota water well code standardized water well construction practices. Before the Minnesota water well code was implemented, well construction practices were used that are no longer allowed.

Prior to 1974, a water well requiring high pumping capacity would often be cased into the uppermost bedrock aquifer and left as an open borehole through the underlying bedrock layers until adequate water supplies were available to support the required yields. When soft sediments were encountered during drilling, pieces of well casing would often be inserted to prevent portions of the well wall from collapsing into the open borehole and plugging the hole. These open boreholes serve as conduits that interconnect individual bedrock aquifers or pierce a confining bed and interconnect separate aquifer systems. These wells serve as conduits for spreading pollution into otherwise unspoiled supplies of groundwater.

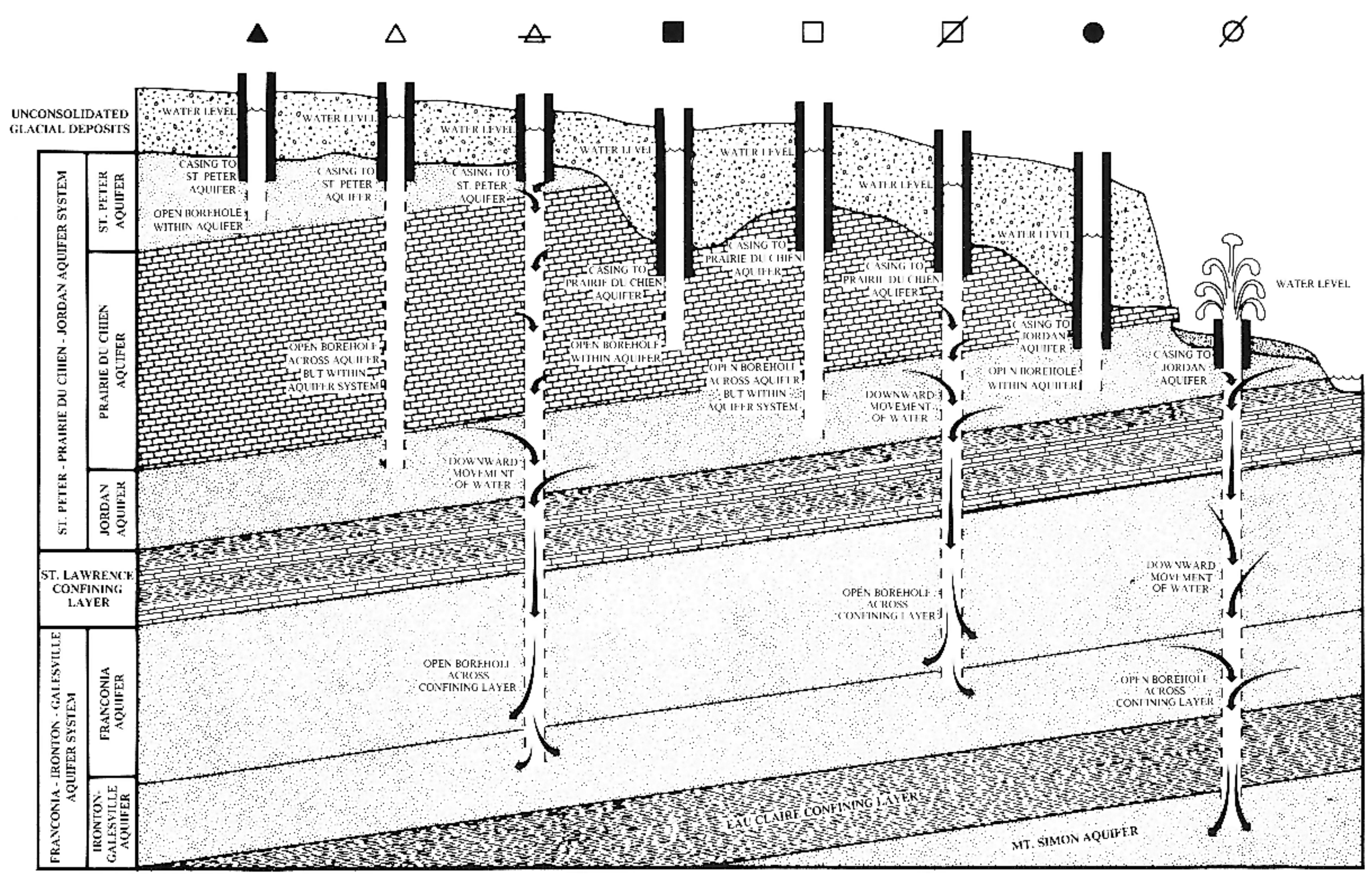


FIGURE 7. The illustration shows various combinations of casing length versus total depth of open borehole for wells finished in the St. Peter-Prairie du Chien-Jordan aquifer system. Triangle shaped symbols are used to represent wells that are cased into the St. Peter sandstone, square shaped symbols represent wells cased into the Prairie du Chien dolomite, and circles represent wells cased into the Jordan sandstone. Solid symbols represent wells for which both well casing and open borehole are finished in the same bedrock aquifer. Open symbols represent wells for which the well casing is finished in one bedrock aquifer but the open borehole penetrates into a lower bedrock aquifer; these wells are still limited to the St.Peter-Prairie du Chien-Jordan aquifer system. Open symbols with a slash through them represent wells for which the well casing is finished in the St.Peter-Prairie du Chien-Jordan bedrock aquifer system but the open borehole extends through the St.Lawrence confining layer and into the underlying Franconia-Ironton-Galesville aquifer system or may even penetrate the Eau Claire confining layer to the Mt.Simon-Hinckley aquifer system.

GROUNDWATER

INTRODUCTION

In Blue Earth County, groundwater exists in unconsolidated glacial deposits and in the underlying bedrock. The possibility of developing small supplies of groundwater for farm and domestic use from the glacial deposits ranges from poor in northcentral Blue Earth County to extremely favorable along the western and southern margins of the county and in the northeastern corner of the county. The bedrock aquifers that underlie the glacial deposits in Blue Earth County are among the highest yielding in the United States. The groundwater supplies that are contained within the bedrock aquifers are adequate for present and foreseeable needs.

An aquifer is any geologic unit that is capable of storing and yielding fresh water in usable quantities. Groundwater is usually held in an aquifer, at significant pressure, by the presence of a confining bed above the aquifer. In most cases confined water is equivalent to artesian water. A flowing artesian well is a well that yields water at the land surface, under its own pressure, without pumping. In a non-flowing artesian well, the pressure is not sufficient to lift the groundwater above the land surface. In the bedrock aquifers that underlie Blue Earth County, high groundwater pressure usually occurs in hydraulically isolated layers that are under high pressure. In bedrock aquifers that form the bedrock surface, high groundwater pressure is sometimes the result of continuous bedrock strata with recharge areas at higher elevations.

GLACIAL DRIFT AQUIFERS

The glacial drift includes all materials deposited directly by glacial ice or by meltwater streams flowing from the ice. Glacial meltwater streams laid down water-sorted sediments, called outwash deposits, along drainage channels that extended beyond the glacier's margins. Glacial outwash deposits are usually coarse-grained sands and gravels which form good aquifers in the drift. Many outwash deposits were laid down during the retreat of various ice sheets and were not destroyed by the advance of subsequent ice sheets. Interglacial erosion may have produced ancient glacial terrain valleys that contained sand and gravel deposits that are now buried and provide productive aquifers. Depending upon their extent, these deposits may be important local aquifers if they are extensive enough and the recharge is large enough. However, glacial outwash deposits form the most important aquifers in the glacial drift.

Materials of low permeability, such as thick clay layers, may suggest confined conditions in the glacial drift. However, clay layers may have a discontinuous areal distribution that make unconfined conditions possible. Confined flow may occur in hydraulically isolated lenses of sand and gravel under sufficiently high pressure. The water pressure in glacial aquifers with unconfined conditions will be influenced by the local topography.

BEDROCK AQUIFERS

Groundwater can be obtained from three bedrock aquifer systems in Blue Earth County. They are the St. Peter-Prairie du Chien-Jordan aquifer system, the Franconia-Ironton-Galesville aquifer system and the Mt.Simon-Hinckley aquifer system. The data suggest that there is good hydraulic connection between the bedrock units within each of the three bedrock aquifer systems.

A bedrock aquifer is a geologic formation that is capable of storing and yielding fresh water in usable quantities. A bedrock aquifer system is a multiaquifer system that is composed of two or more bedrock aquifers that act hydrologically as a single unit and are bound on the top and bottom by aquitards. Individual bedrock aquifers range from coarse-grained deposits such as sandstone to hard fractured sedimentary rocks such as limestone or dolomite.

In Blue Earth County, the uppermost bedrock aquifer supplies water for farm and domestic use. In the eastern three-fourths of Blue Earth County, bedrock units included in the St. Peter-Prairie du Chien-Jordan aquifer system represent the uppermost bedrock aquifers. In the western quarter of the county, the Franconia and Ironton-Galesville sandstones occupy the uppermost bedrock aquifer position. The Mt. Simon sandstone is overlain by the Eau Claire confining bed throughout Blue Earth County. Wells that require high pumping capacity are often drilled through two or more bedrock aquifers.

ST.PETER-PRAIRIE DU CHIEN-JORDAN AQUIFER MAP

INTRODUCTION

The St. Peter-Prairie du Chien-Jordan aquifer system consists of those bedrock units that commonly directly underlie the glacial drift and are recharged locally. The major bedrock units included in this aquifer system are the St.Peter and Jordan sandstones, which yield water from between individual sand grains and the Prairie du Chien dolomites which yield water through fractures and crevices. All three bedrock units are sources of groundwater, and the hydrologic data from water well drillers' logs suggests that there is good hydraulic connection between them.

METHOD OF CONSTRUCTION

The St. Peter-Prairie du Chien-Jordan Aquifer Map was developed directly from data contained in the hydrologic portions of water well drillers' logs. The water level contours were drawn to provide a general description of the top of the static water levels that were recorded in drillers' logs for water wells finished in the St. Peter-Prairie du Chien-Jordan aquifer system. The general direction of groundwater movement through the bedrock aquifer system is approximately perpendicular to the static water level contours in the direction of decreasing elevation.

The static water level data have been collected over many years through every season and the data points are few and unequally spaced. Thus, only limited confidence can be placed in the resulting map. It was not possible to collect sufficient amounts of reliable data to allow the construction of detailed hydrogeologic maps. However, current water well driller data are sufficient to demonstrate that the regional groundwater movement is toward the Minnesota River Valley.

The location and distribution of the data points that were used to construct the aquifer map are shown on the map as point symbols: circles, triangles, or squares. The various point symbols identify the individual aquifer or combination of aquifers that contribute water to the well and describe a relationship between the well casing length and total depth of the borehole. The symbols also indicate if the St. Lawrence confining layer has been penetrated and the borehole left uncased into the underlying Franconia-Ironton-Galesville aquifer system.

FRANCONIA-IRONTON-GALESVILLE AQUIFER MAP

INTRODUCTION

The Franconia-Ironton-Galesville aquifer system is bounded on the top by the St. Lawrence confining bed and on the bottom by the Eau Claire confining bed. The St. Lawrence Formation presents a barrier to the movement of groundwater. However, with sufficient groundwater pumping, down leaking may allow the St. Lawrence to release significant amounts of water into the Franconia-Ironton-Galesville aquifer system. In the western quarter of Blue Earth County, the Franconia and Ironton-Galesville commonly directly underlie the glacial drift and form the bedrock surface.

METHOD OF CONSTRUCTION

The Franconia-Ironton-Galesville Aquifer Map was developed directly from data contained in the hydrologic portions of water well drillers' logs. The static water levels, presented on the map, are based solely on the data recorded in water well drillers' logs and represent the non-pumping water level in a well. The records of well casing length were used to determine the aquifer from which the reported static water levels are derived.

The static water level data was plotted onto the aquifer map by means of elevation contour lines. The water level contours were drawn to provide a general description of the top of the static water levels for water wells finished in the Franconia-Ironton-Galesville aquifer system. The groundwater flow is at right angles to the static water level elevation contours in the direction of decreasing elevation. The location and distribution of the data points that were used to construct the aquifer map are shown on the map. The point symbols describe a relationship between the well casing length and the total depth of the borehole. The symbols indicate if the Eau Claire confining bed has been penetrated by the borehole and left uncased into the underlying Mt. Simon-Hinckley aquifer system.

EXPLANATION

Area where the aquifer system is overlain by a confining bed.

Area where the upper boundary of the aquifer system is the top of the bedrock.

Area where the aquifer system is absent.

950

Contour interval 50 feet.

Shows average elevation in feet above mean sea level of the static water level in water wells that are finished in the St. Peter-Prairie du Chien-Jordan aquifer system.

Arrow points in general direction of groundwater movement.

Possible variations in St. Peter aquifer use.

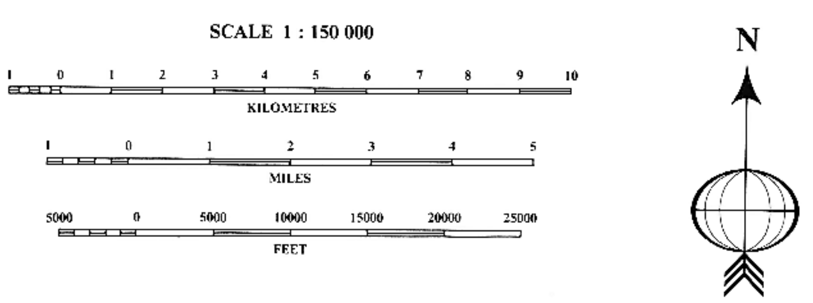
- ▲ Well casing and open hole finished in the St. Peter aquifer.
- △ Well casing finished in the St. Peter aquifer; open hole to Prairie du Chien or Jordan aquifer.
- Well casing finished in the St. Peter aquifer; open hole to underlying aquifer system.

Possible variations in Prairie du Chien aquifer use.

- ■ Well casing and open hole finished in the Prairie du Chien aquifer.
- □ Well casing finished in Prairie du Chien aquifer; open hole to Jordan aquifer.
- Well casing finished in Prairie du Chien aquifer; open hole to underlying aquifer system.

Possible variations in Jordan aquifer use.

- ● Well casing and open hole finished in the Jordan aquifer.
- ⌀ Well casing finished in the Jordan aquifer; open hole to underlying aquifer system.

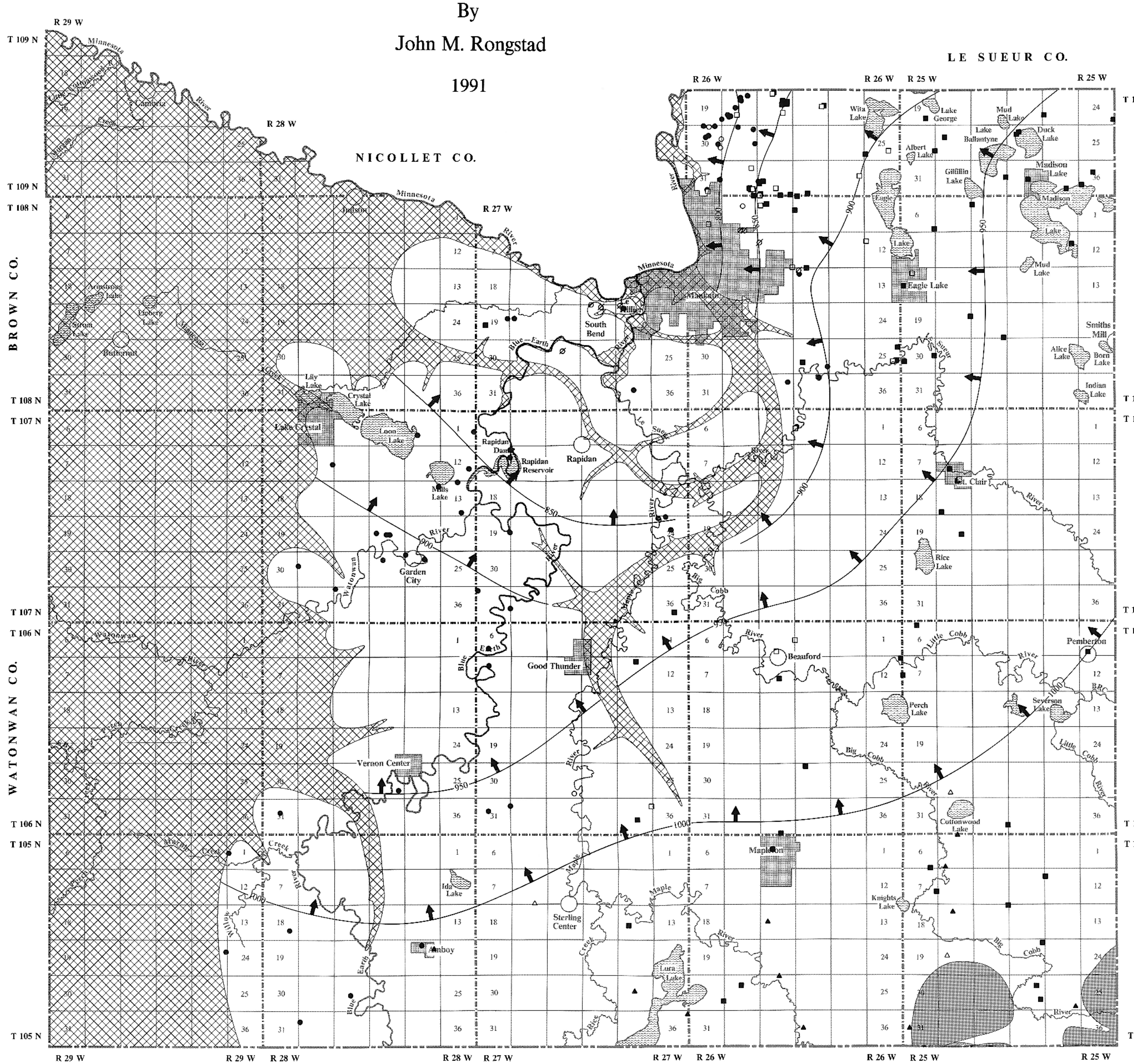


ST. PETER - PRAIRIE DU CHIEN - JORDAN AQUIFER SYSTEM

By

John M. Rongstad

1991

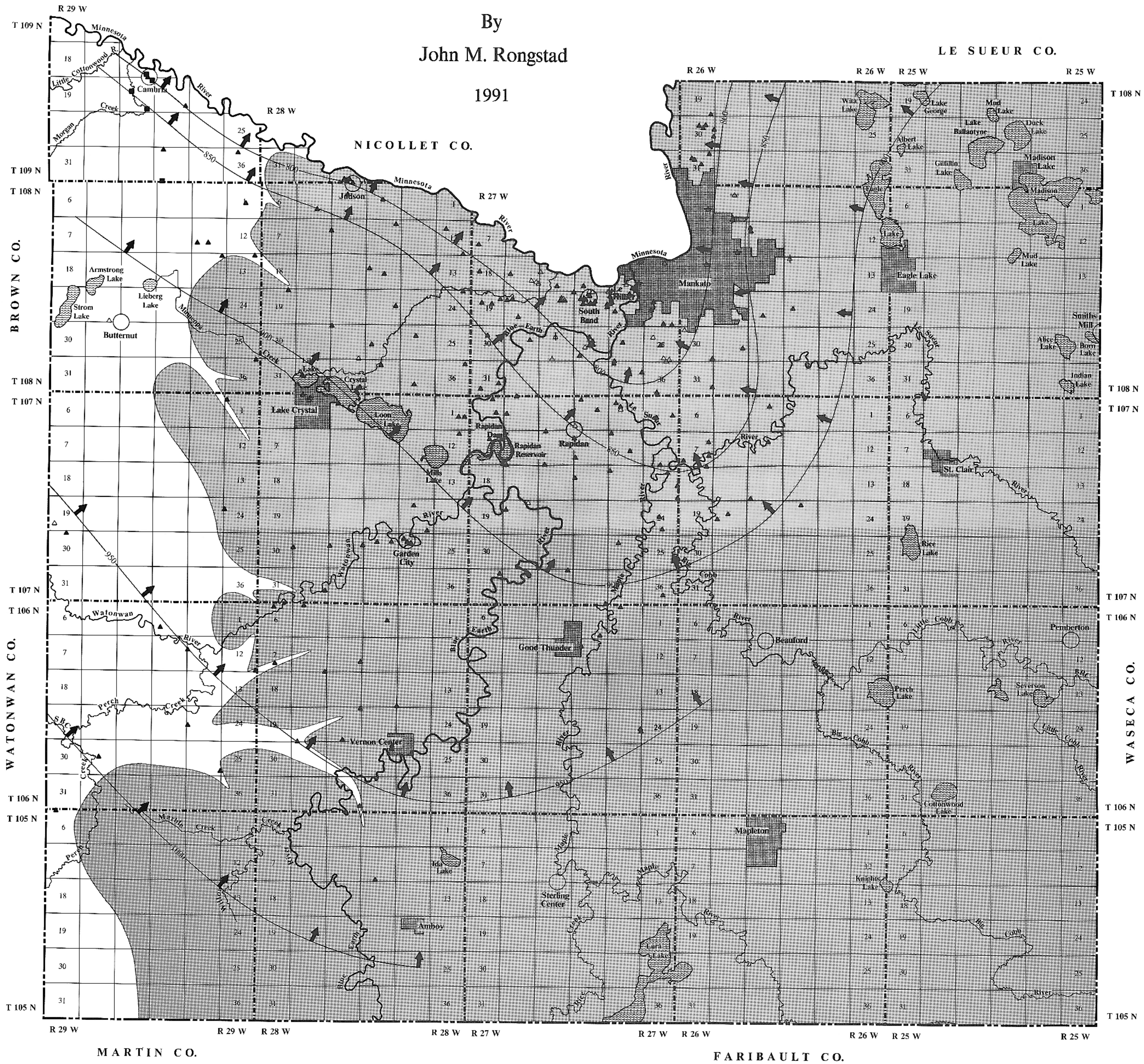


FRANCONIA — IRONTON — GALESVILLE AQUIFER SYSTEM

By

John M. Rongstad

1991



EXPLANATION

Area where the aquifer system is overlain by a confining bed.

Area where the upper boundary of the aquifer system is the top of the bedrock.

900 — Contour interval 50 feet.

Shows average elevation in feet above mean sea level of the static water level in water wells that are finished in the Franconia-Ironton-Galesville aquifer system.

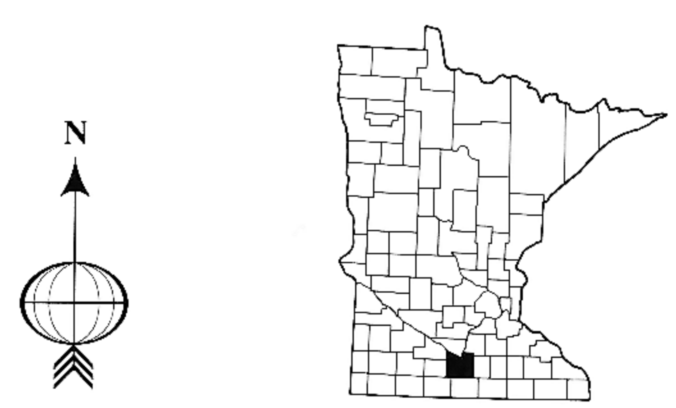
↑ Arrow points in general direction of groundwater movement.

Possible variations in Franconia aquifer use.

- ▲ Well casing and open hole finished in the Franconia aquifer.
- △ Well casing finished in the Franconia aquifer; open hole to Ironton-Galesville aquifer.
- Well casing finished in the Franconia aquifer; open hole to underlying aquifer system.

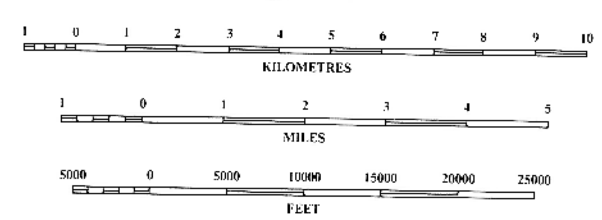
Possible variations in Ironton-Galesville aquifer use.

- ■ Well casing and open hole finished in the Ironton-Galesville aquifer.
- ⌀ Well casing finished in Ironton-Galesville aquifer; open hole to underlying aquifer system.



LOCATION DIAGRAM

SCALE 1 : 150 000



GLACIAL DRIFT AQUIFERS

The possibility of developing small supplies of groundwater for farm and domestic use from wells finished in the glacial drift of Blue Earth County is generally good. The potential for development of moderate to large groundwater supplies from the glacial drift ranges from poor, as in the northcenral part of the county, to favorable in the western and eastern row of townships and in the southern tier of townships in Blue Earth County.

A study of the geologic portions of water well drillers' logs resulted in the recognition of three general hydrostratigraphic units that were used to construct a geologic framework for describing the hydrologic system within the glacial drift. The glacial drift is considered to consist of alternating layers of impermeable, semi-impermeable, and permeable materials, forming a series of aquitards and aquifers. The three hydrostratigraphic units defined here have different properties in relation to the occurrence and movement of groundwater through the glacial drift. Mostly clay and silty clay deposits are fine-grained sediments and considered to be impermeable. A heterogeneous mixture of clay, silt, sand, and gravel are considered to be semi-impermeable. Sand and gravel bodies within the glacial till are considered to be permeable.

Few of the water wells that are finished within the glacial deposits draw water directly from till; most obtain water from sand and gravel bodies within the till. Generally, the glacial tills have low permeabilities and, in many places, the till is sufficiently impermeable that it forms an aquitard between productive sand and gravel aquifers. Groundwater supplies generally occur in sand and gravel deposits under semi-confined or confined conditions within the glacial till. Therefore, the water-yielding deposits are considered to represent an artesian condition and the water level rises above the level at which it was first encountered.

GROUNDWATER

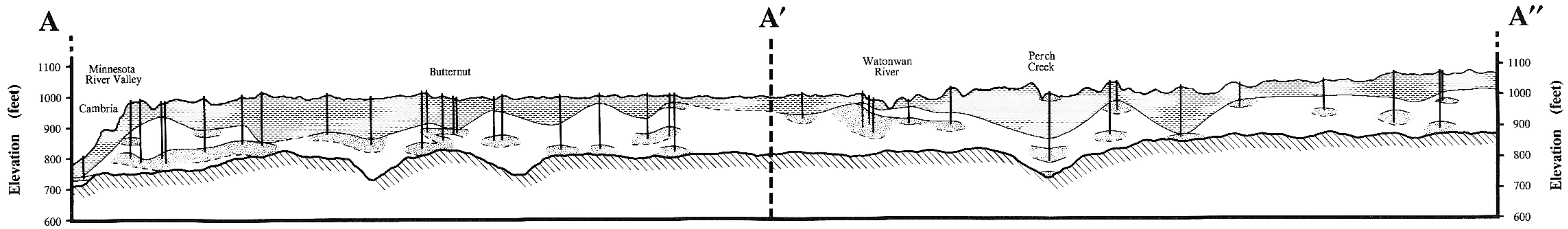
Groundwater in the glacial deposits is derived from precipitation or from underflow into the area through bedrock aquifers. In Blue Earth County, perennial streams and rivers act as drains on the groundwater along most of their distance, with the groundwater gradient toward the river or stream valley. The Blue Earth, LeSueur, and lower Watonwan river valleys drain a particular linear region along their courses and leave a trough of depression that makes the drift permeable deposits not acceptable as an aquifer due to low water content. Water wells drilled within these areas may penetrate large amounts of glacial sand and gravel deposits, however, these deposits are ignored in favor of more productive bedrock aquifers.

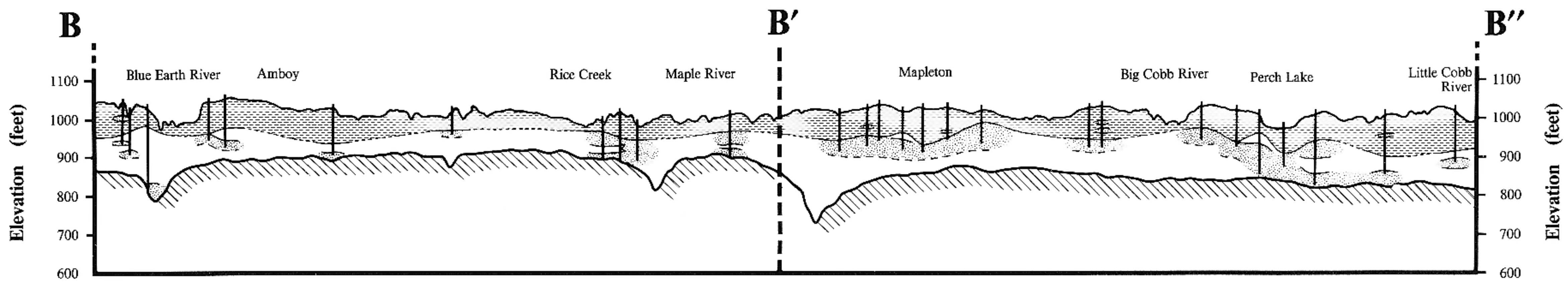
CROSS SECTIONS

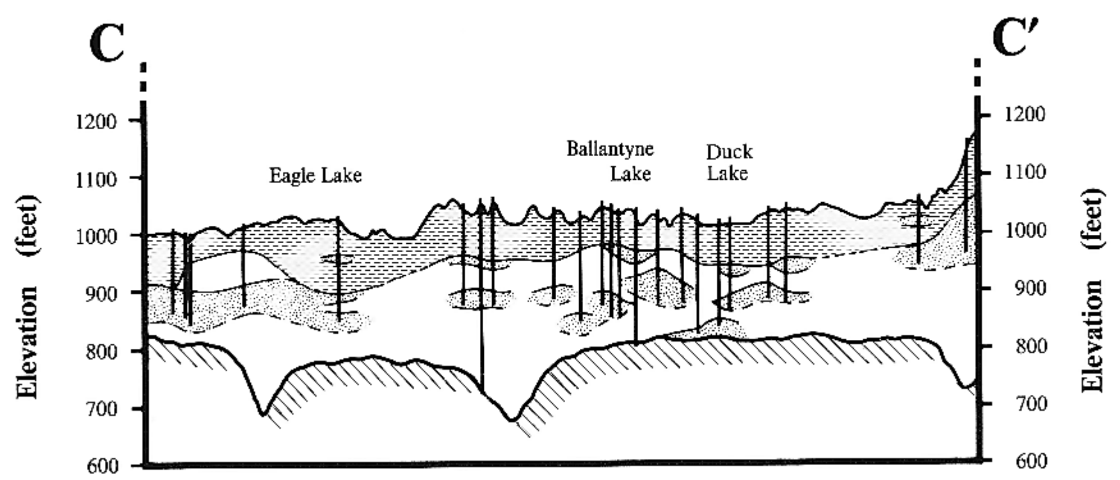
The cross sections illustrate that the uppermost drift zone is composed mostly of clay and silty clay which is neither as permeable nor as productive as the till zone beneath. The lower till zone is composed of a matrix of clay, silt, sand, and gravel. This lower till zone contains thin localized lenses of permeable sand and gravel deposits that may be used for small groundwater supplies. Thick linear deposits of permeable sand and gravel within the till zone may constitute a source of large groundwater supplies.

To identify and define the large permeable deposits within the till zone, it is necessary to determine the three-dimensional distribution of the sand and gravel units. Water well drilling will stop when an adequate supply of groundwater is encountered by the well driller. Therefore, the borehole will seldom penetrate the total thickness of a sand or gravel aquifer and the total thickness of an aquifer with the glacial drift is seldom known.

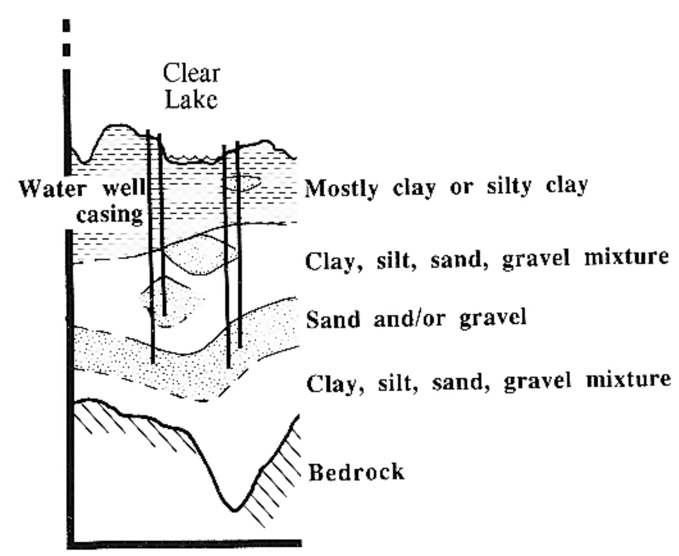
The glacial till will generally yield little water over short time intervals, thus recharge is slow and low pumping rates are associated with sand and gravel aquifers that are interbedded or enclosed by relatively impermeable till material. Where sand and gravel deposits extend to the bedrock surface, recharge rates are commonly fast and the pumping capacity is large. Occasionally, permeable sand deposits are reported by drillers as occurring just above the bedrock and may signify only the presence of weathered bedrock. In Blue Earth County, sand and gravel deposits encountered in the main bedrock channels will provide moderate groundwater supplies. Sand and gravel deposits within the glacial drift are less favorable as aquifers where the bedrock surface elevations are high.



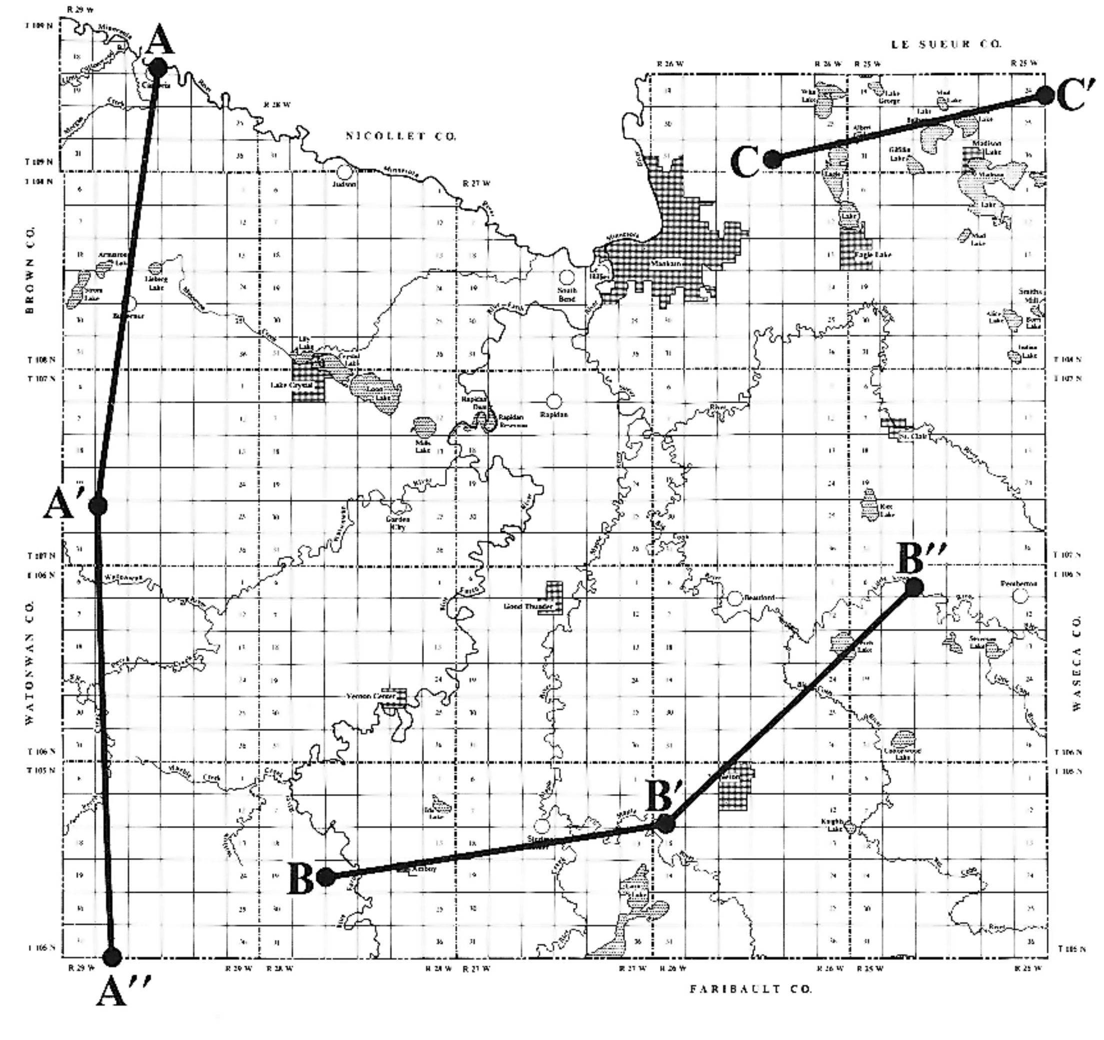




EXPLANATION



INDEX TO CROSS SECTIONS

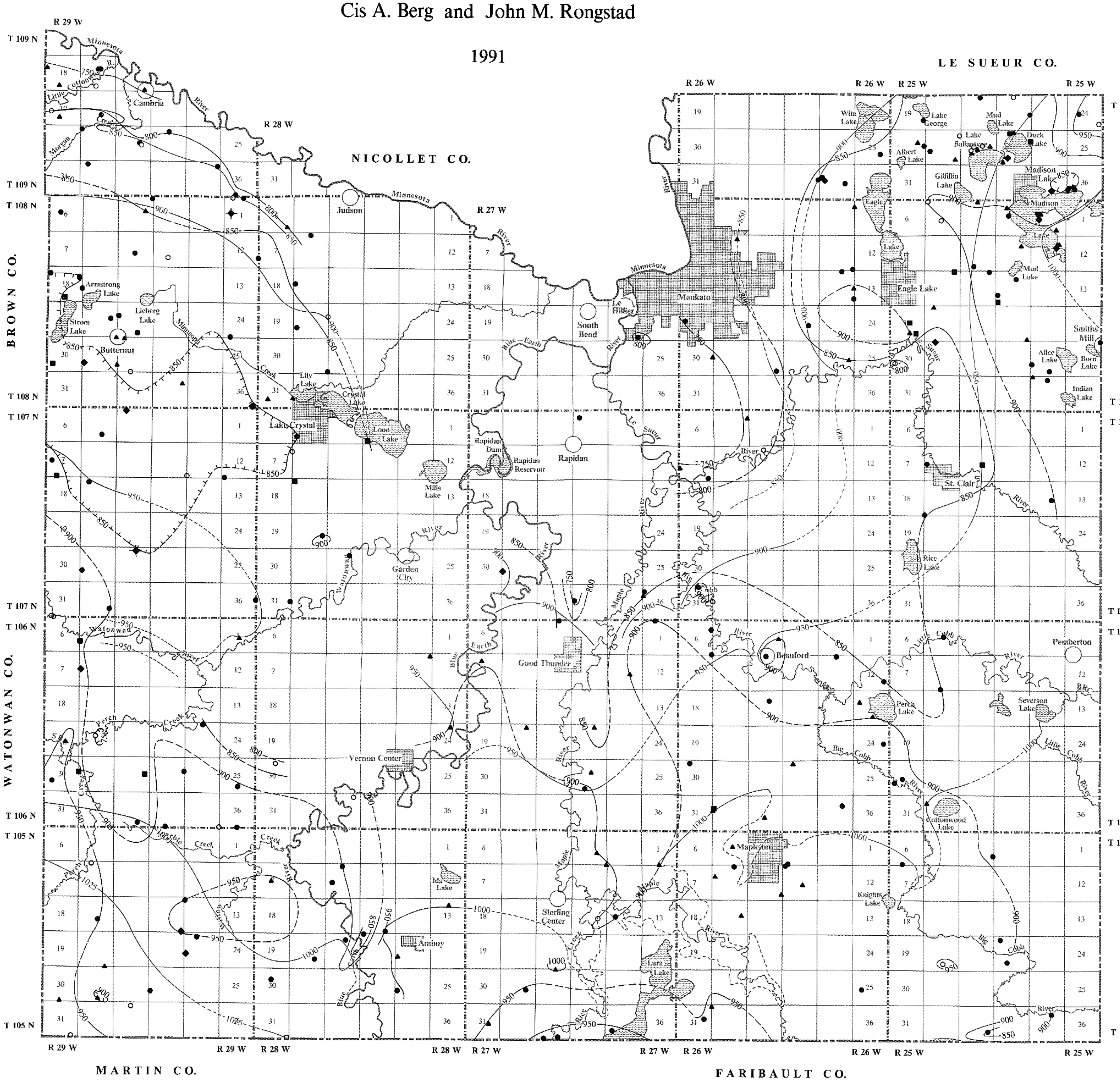


GLACIAL DRIFT AQUIFER MAP

By

Cis A. Berg and John M. Rongstad

1991



GLACIAL DRIFT AQUIFER MAP

The Glacial Drift Aquifer Map defines regions within Blue Earth County that have the greatest potential for the development of groundwater supplies from the glacial drift. The map shows whether a test hole in a given area may encounter favorable conditions for groundwater supplies and at what elevation these conditions might be expected to exist.

The Glacial Drift Aquifer Map was developed directly from the data contained in the hydrologic portions of water well drillers' logs for wells finished in the glacial drift. The static water levels, presented on the map, are based solely on the data recorded in water well drillers' logs and represent the non-pumping levels in a well. The records of well casing were used to determine the elevation from which the reported static water levels are derived.

The static water level data was plotted onto the Glacial Drift Aquifer Map by means of elevation contour lines. The static water level surface is based on elevations to which the confined water rises. The elevation of static water levels may vary as much as 100 feet between neighboring wells whose casings extend to vastly different elevations. Therefore, it is impossible to determine the groundwater flow characteristics from the static water level data reported in water well drillers' logs. Well casings that extend to lower elevations in the glacial drift are usually associated with lower static water levels.

EXPLANATION

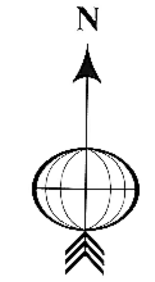
Production Test
Gallons per minute (gpm)

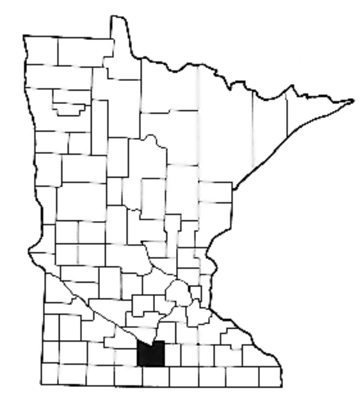
- ○ No record
- ● 1-25 gpm
- ▲ 26-50 gpm
- ■ 51-75 gpm
- ◆ 76-100 gpm
- ✦ Greater than 100 gpm

Elevation at bottom of well casing
Contour interval 50 feet

Elevation of static water level
Contour interval 50 feet

Solid line where correlation between data points is inferred. Dashed line where correlation between data points is interpolated.





LOCATION DIAGRAM

SCALE 1 : 150 000