GROUND-WATER FLOW AND QUALITY NEAR THE UPPER GREAT LAKES CONNECTING CHANNELS, MICHIGAN

by J.L. Gillespie and D.H. Dumouchelle

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CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who may prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
foot per second (ft/s)	0.3048	meter per second (m/s)
foot per day (ft/d)	0.3048	meter per day (m/d)
cubic foot per second (ft^3/s)	28.32	liter per second (L/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	10.93	liter per second per square kilometer [$(L/s)/km^2$]
gallon per day per square foot [$(gal/d)/ft^2$]	40.7	liter per day per square meter
ton per day (ton/d)	907.2	kilogram per day (kg/d)

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

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ABSTRACT

The Upper Great Lakes connecting channels are the St. Marys, St. Clair and Detroit Rivers, and Lake St. Clair. The effect of ground water on the connecting channels is largely unknown, and the controls on its movement and quality are undefined. Geologic, hydrologic, and environmental conditions near the channels have been examined for this investigation. Included in the study area is a 50-mile reach of channel beginning at Whitefish Bay and extending to Neebish Island, and a 90-mile reach of channel between Port Huron and Pointe Mouillee in Lake Erie.

Glacial deposits, which transmit most ground water to the channels, range from less than 100 feet in thickness in the southern part of the St. Clair-Detroit River area to more than 250 feet in thickness in the northern part. Marine seismic surveys were used at some locations to determine the thickness of deposits. Glacial deposits in the St. Marys River area range from less than 10 feet to more than 300 feet in thickness. Permeable bedrock in the southern reach of the Detroit River area and throughout most of the St. Marys River area may contribute substantial amounts of water to the channels. Total ground-water discharge to the channels, by area, is estimated as follows: St. Marys area, 76 cubic feet per second; St. Clair area, 11 cubic feet per second; Lake St. Clair area, 46 cubic feet per second; and Detroit area, 54 cubic feet per second.

Analyses of water from 31 wells, 25 of which were installed by the U.S. Geological Survey, were made for organic compounds, trace metals, and other substances. Volatile hydrocarbons, and base neutral, acid extractable, and chlorinated neutral compounds were not detectable in water at most locations. Concentrations of trace metals, however, were higher than common in natural waters at some locations.

INTRODUCTION

The Upper Great Lakes Connecting Channels (UGLCC) are the St. Marys, St. Clair and Detroit Rivers, and Lake St. Clair. These bodies of water function as conduits for the waters of the upper lakes (Superior, Michigan, and Huron) to drain into the lower lakes (Erie and Ontario).

The channels provide water for public supply in the southeastern corner of Michigan's Lower Peninsula and for the city of Sault Ste. Marie in the Upper Peninsula. Water is also withdrawn for a variety of other uses, the largest of which are industrial use and thermoelectric power generation. Serious degradation of water of the channels, if it occurred, could have a detrimental effect on public health, the regional economy, and the biota of the channels. Protection of the water of the connecting channels is, therefore, of major importance to citizens of both the United States and Canada.

This investigation was undertaken as part of a larger study by United States and Canadian government agencies to determine existing environmental conditions, to assess problems, and to recommend remedial measures and corrective actions where appropriate. Early in the planning stages of the study it was recognized that such a comprehensive evaluation needs to take into account the role of ground water. Information on its movement and on its transport of contaminants and other dissolved substances was inadequate. Factors that affect ground-water quality had not been adequately assessed. A main factor is the presence of more than 200 waste sites near the connecting channels. The upward movement of chemical substances from deep geologic strata, either from natural sources or from areas where deep injection of wastes has occurred, also was recognized as a possibility.

Purpose and Scope

This report summarizes information collected by the U.S. Geological Survey from April 1985 through September 1987 in areas bordering the Great Lakes connecting channels in Michigan. Information on geology and hydrology is used to delineate areas where ground water discharges to the connecting channels, and to estimate the rate of ground-water flow from each area. Water-quality data collected by U.S. Geological Survey and similar data from other sources are summarized.

Description of Study Areas

Figure 1 shows the two major areas of investigation in this study. These areas comprise zones extending 12 mi (miles) inland along the St. Marys River, and along a reach of the St. Clair River, Lake St. Clair, and Detroit River between Port Huron and Lake Erie. At places in this report, the major study areas are referred to as "the St. Marys area" and as the "St. Clair-Detroit area". To distinguish more precisely, the terms "St. Clair area" and "Detroit area" are also used.

The St. Marys River begins at Whitefish Bay at an altitude of 602 ft (feet) above sea level and flows to the Soo Locks. Downstream from the Locks, the elevation of the river at Neebish Island is 582 ft. The Waiska and Charlotte Rivers are the principal tributaries to the St. Marys River on the United States side. The drainage basin for the river is about 350 mi^2 (square miles). Elevation of the land surface ranges from about 580 ft above sea level at Neebish Island to 1,045 ft at Mission Hill; in most of the area, the elevation of the land surface ranges from 600 to 750 ft. About 22,000 people reside in the study area; 14,500 reside in Sault Ste. Marie, the area's largest community.

The St. Clair-Detroit area, which begins at the northern edge of Port Huron and extends generally southwestward to Pointe Mouillee, is about 90 mi long. The elevation of the St. Clair River at Port Huron is 580 ft; the elevation of the Detroit River at Point Mouillee is 572 ft. The St. Clair River is about 35 mi long; the Detroit River is about 30 mi long. Principal tributaries in the St. Clair-Detroit area in the United States are the Black, Pine, Belle, Clinton, and Huron Rivers, and River Rouge. Elevation of the land surface ranges from about 575 ft near Pointe Mouillee to about 660 ft just west of Port Huron. In most of the area the elevation of land surface

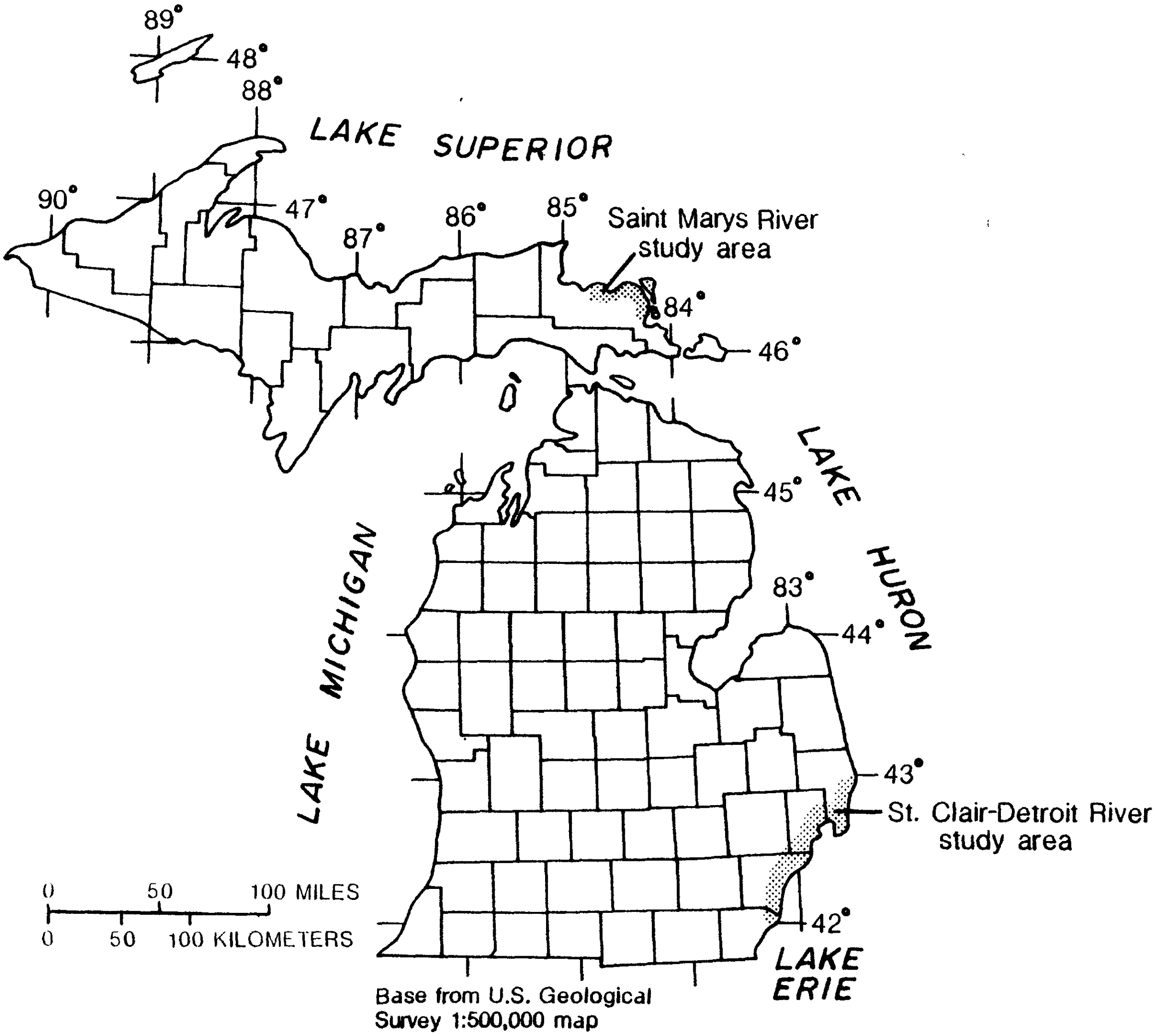


Figure 1.--Location of Upper Great Lakes connecting channels study areas.

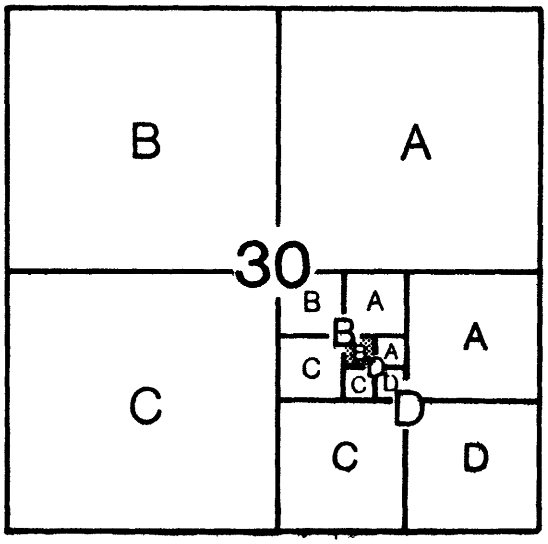
ranges from 580 to 625 ft. The study area includes parts of Macomb, Monroe, Oakland, St. Clair, and Wayne Counties. About 2.5 million people reside in the 900-mi^2 area; it is the most populated and heavily industrialized in Michigan.

Methods of Data Collection and Analysis

The study of ground water near the Upper Great Lakes connecting channels is part of the larger joint United States-Canadian effort to evaluate environmental conditions in channel areas. Methods and procedures were established before initiating work to ensure that investigators in both countries obtained comparable and high-quality data. Quality-assurance and quality-control procedures were determined by an international technical committee. For ground-water investigations conducted by the U.S. Geological Survey, the Survey and the U.S. Environmental Protection Agency prepared a quality assurance/quality control plan. The plan covered all aspects of sample collection and analysis, and well-drilling techniques.

Site-Location System

The site-location number indicates the location of sites within the rectangular subdivision of land with reference to the Michigan meridian and base line. The first two segments of the site number designate township and range, the third designates successively smaller subdivisions of the section as shown below. Thus, a well designated as 4S10E30DBDB would be located within a 2.5-acre tract, as indicated by the shaded area in section 30. The number following the section subdivision identifies the wells in sequence.



Acknowledgements

The Michigan Department of Natural Resources, in particular Frank Belobraidich, Groundwater Quality Division, assisted in assembling much of the geologic and hydrologic data. County Health Departments also provided file information. Canadian investigators, who jointly conducted similar studies at the same time near the connecting channels, made available the results of their work.

GEOLOGIC SETTING

Geology in the UGLCC study area consists of sedimentary rocks of Precambrian and Paleozoic age overlain by unconsolidated Quaternary deposits. Sedimentary rocks include sandstone, shale, limestone, and dolomite. These rocks are part of the Michigan structural basin in which all beds dip toward the structural center. The St. Marys area is located on the northern rim of the basin, and thus bedrock formations dip toward the south. In the St. Clair-Detroit area, on the southeastern rim of the basin, the rocks dip to the northwest. Unconsolidated Quaternary deposits are till, glaciolacustrine and glaciofluvial deposits; alluvium occurs near streams. These deposits are the result of continental glaciation and subsequent high water stages of the Great Lakes. Although similar geological processes have operated in both study areas, the stratigraphic relationship between bedrock and glacial deposits is different between and within the two study areas.

Stratigraphy

St. Clair-Detroit River Study Area

The St. Clair-Detroit area has two general lithologic sequences that are recognizable in the Paleozoic rocks (fig. 2). Rocks of Silurian to Late Devonian age lie beneath glacial deposits from Pointe Mouillee to just north of Belle Isle. These rocks are primarily an evaporite-carbonate sequence that include, in ascending order, the Bass Islands Dolomite, Detroit River Group, Dundee Formation and the Traverse Group; (table 1). These geologic units consist of limestone, dolomite, and minor beds of gypsum and salt. In the Detroit River Group, sandstone is present.

Bedrock beneath the St. Clair area is of Devonian and Mississippian age. These rocks are a clastic sequence that includes the Antrim Shale, Bedford Shale, Berea Sandstone, Sunbury Shale, and Coldwater Shale; they consist mostly of shale (table 1). The most extensive unit in the St. Clair area is the Antrim Shale.

The relation between geologic units beneath channels is shown in a section from Lake Erie to Lake Huron (fig. 3). The dip of beds to the north is about 10 ft/mi (feet per mile). Pleistocene glacial deposits are overlain by Holocene lacustrine deposits in Lake St. Clair.

Bedrock topography slopes gently eastward toward the connecting channels. The bedrock surface is dissected by erosional valleys that generally trend east-west. There is no surface expression of these valleys because they are filled with glacial deposits.

The surficial features of glacial deposits are shown in figure 4. These features generally parallel present shorelines, indicating source direction of deposits. Glacial deposits range in thickness from less than 100 ft in the southern part of the area to nearly 250 ft at places in the northern part. Deposits are usually till or glaciolacustrine and consist of fine-grained sand, silt, and clay. Glaciofluvial deposits are absent at the surface in the study area.

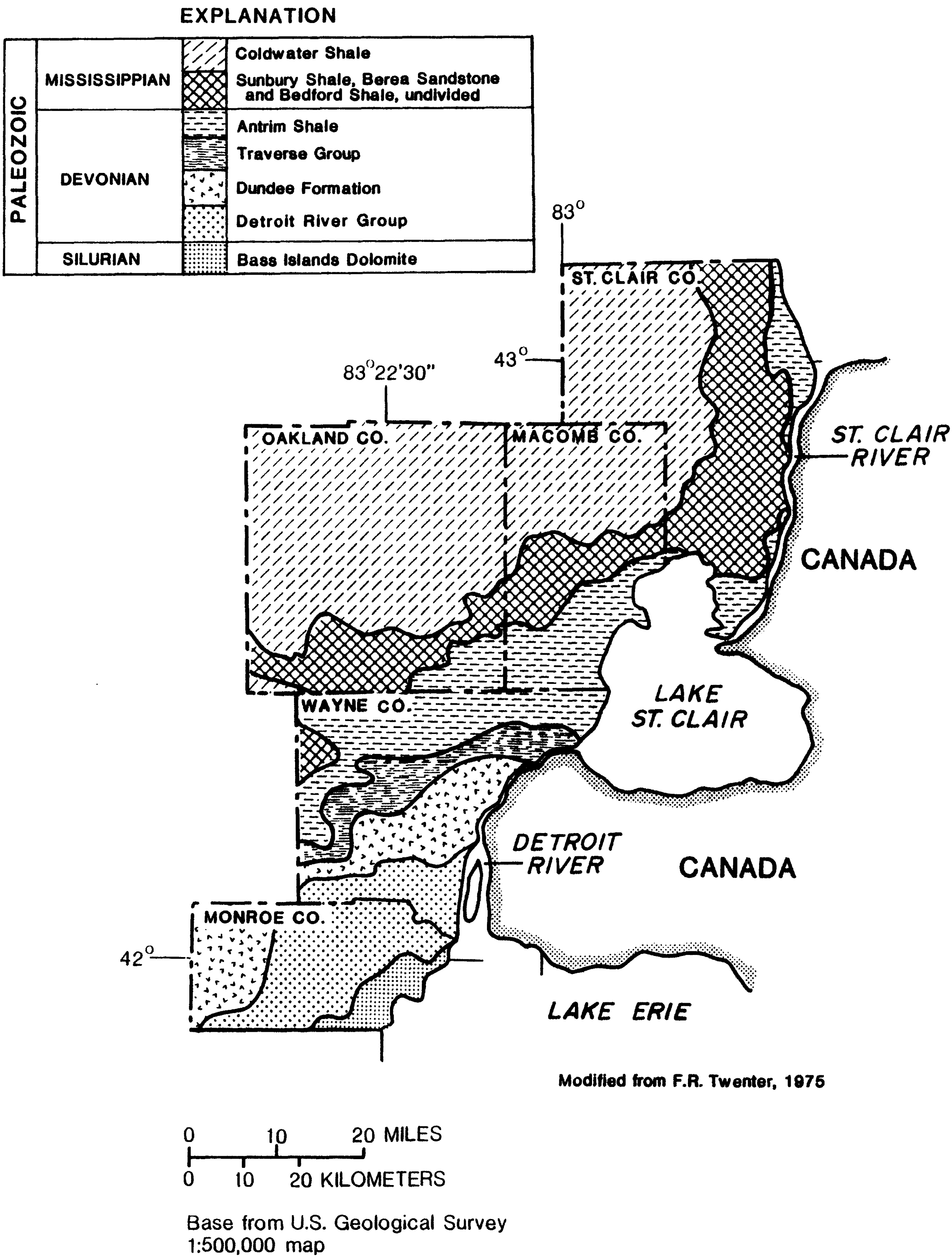


Figure 2.--Bedrock geology of St. Clair-Detroit River study area.

Table 1.--Description of geologic units in St. Clair-Detroit River study area

Geologic unit (age)	Lithology
Coldwater Shale (Early Mississippian)	Primarily a micaceous, blue, blue-gray to green-gray shale but locally is reddish and sandy in the upper part. The weathered upper surface at the base of the glacial deposits can be mistaken for glacial clays. Thin lenses of limestone, dolomite, sandstone, and siltstone are interspersed with the shale.
Sunbury Shale (Early Mississippian)	A dark brown, gray, or black, hard shale that locally is dolomitic. Usually less than 50 ft thick; absent at some locations.
Berea Sandstone (Early Mississippian)	White to gray or brown, fine to coarse grained, micaceous sandstone, 50 to 120 ft thick. Gray to blue-gray calcareous shales are locally interbedded with the sandstone. Contact between the Berea Sandstone and Bedford shale is difficult to delineate, and they are commonly treated as one unit.
Bedford Shale (Early Mississippian and Late Devonian)	Light gray, calcareous or sandy shale with sporadic lenses of sandstone, limestone and/or dolomite. Where the formation is distinguishable, its thickness is as great as 300 ft.
Antrim Shale (Late Devonian)	Gray to black, thin bedded to fissile carbonaceous shale, with pyritic nodules and large bituminous concretions; the formation ranges from about 125 to 170 ft in thickness.
Traverse Group (Late to Middle Devonian)	Varicolored interbedded shales, limestones, and dolomites. Bedding varies from thin to massive. Total thickness of the group ranges from 200 to 350 ft. Shales commonly are calcareous, limestones and dolomites cherty, and some limestones are highly fossiliferous.
Dundee Formation (Middle Devonian)	Primarily a gray, fossiliferous brown- to buff- limestone and dolomite. It is 150 to 250 ft thick.

Table 1.--Description of geologic units in St. Clair-Detroit River study area--Continued

Geologic unit (age)	Lithology
Detroit River Group (Middle Devonian)	The Detroit River Group underlies the drift in southern Wayne and northeastern Monroe County. The formation consists of gray to buff, thin-bedded dolomite, with some limestone, anhydrite, salt and sandstone.
Bass Islands Dolomite (Late Silurian)	Consists of light gray, brown- to buff-, dense, finely crystalline dolomites, and some shaly dolomites. Gypsum and anhydrite are common.

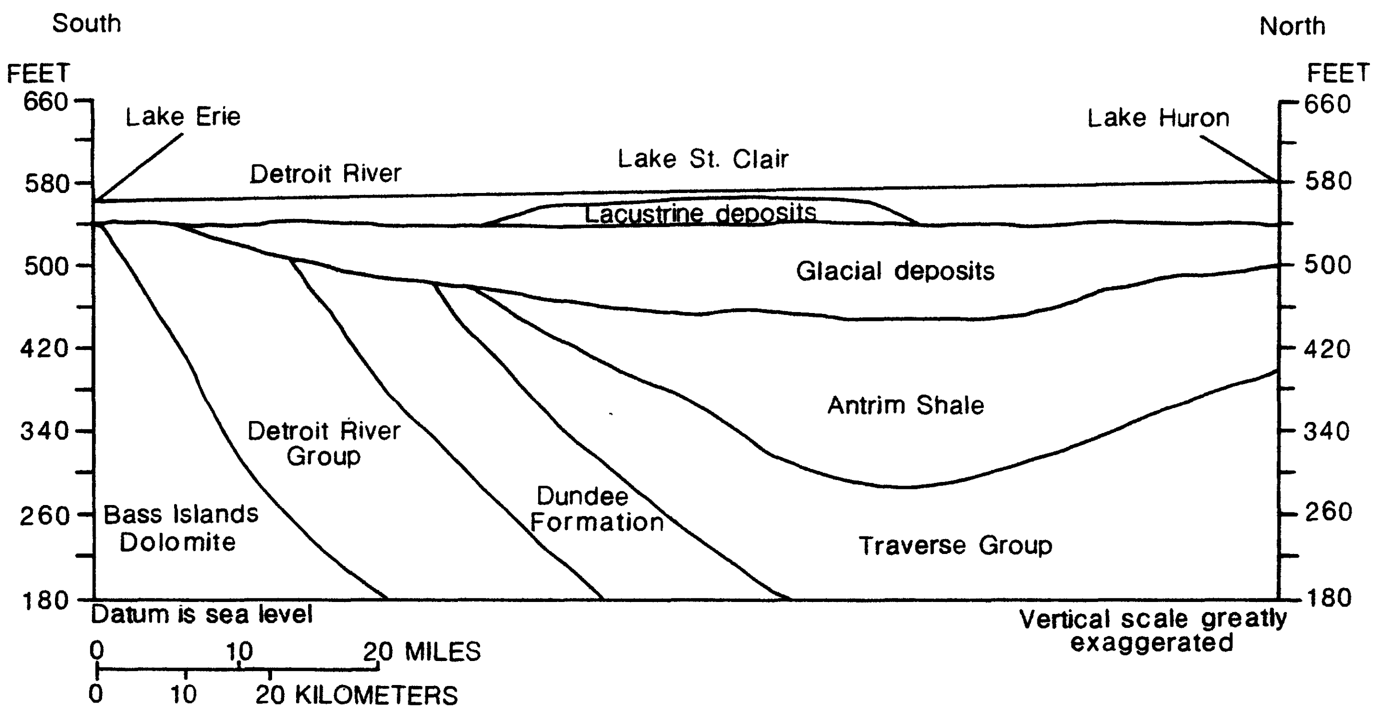


Figure 3.--Generalized geologic section showing dip of bedrock and relation of bedrock and glacial deposits from Lake Erie to Lake Huron.

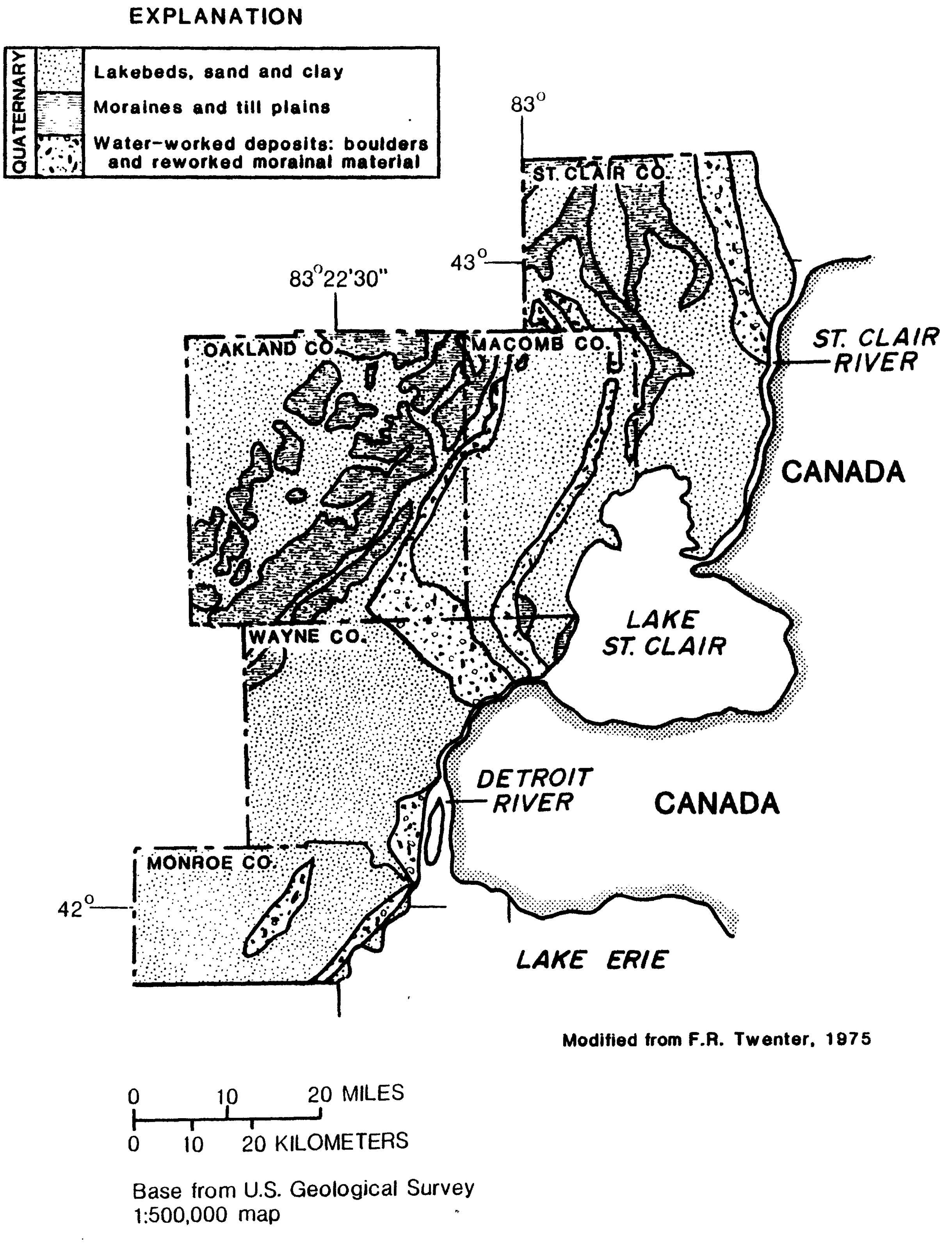


Figure 4.--Surficial glacial features of St. Clair-Detroit River study area.

Geologic sections in the study area are given in Appendix A, and are shown on figure 5. Sections A-A' through J-J', with the exception of section E-E', suggest the lack of significant sand and gravel bodies at depth. Section E-E' shows a sand and gravel body at depth near the city of Fraser; this sand and gravel could be of glaciofluvial origin. All other significant coarse-grained materials occur at the interface of glacial deposits and bedrock, and they are usually discontinuous.

St. Marys River Study Area

Bedrock geology of the St. Marys area consist of a clastic-carbonate sequence that ranges from Precambrian to Ordovician age (fig. 6). These rocks include the Jacobsville Sandstone and Munising Formation (table 2). The Jacobsville Sandstone underlies glacial deposits in the St. Marys River from Whitefish Bay to the southern end of Sugar Island. At Sault Ste. Marie, the Jacobsville Sandstone underlies the river channel which creates the rapids in the St. Marys River. South of Sugar Island, limestones and dolomites of the Black River and Trenton Limestones (table 2) underlie the St. Marys River. These rocks are of Ordovician age and are the youngest rocks in this study area.

Bedrock topography of this area has higher relief than that in the St. Clair-Detroit area. This high relief is shown in geologic sections K-K' and L-L' (Appendix A), the locations of these sections are shown on figure 7. The resistant limestone beds form a bedrock high in the southern part of the study area, which also forms the southern boundary of a major buried valley system that trends east-west. Another major buried valley trends north-south in the vicinity of the Waiska River.

Glacial features are less pronounced in this area than in the St. Clair-Detroit area. Thickness of glacial deposits ranges from less than 10 ft at Sugar Island to more than 300 ft in bedrock valleys. Deposits are largely fine-grained lacustrine deposits, coarser-grained tills (due to the underlying bedrock) and glaciofluvial deposits. Geologic section K-K' shows that significant deposits of sand and gravel are present at depth.

Table 2.--Description of geologic units in St. Marys River study area

Geologic unit (age)	Lithology
Trenton-Black River Limestones (Middle Ordovician)	Composed predominantly of buff to brown and gray fossiliferous, finely crystalline to medium-crystalline limestone. Shale layers are common near the base of the Trenton Limestone.
Munising Formation (Late Cambrian)	A medium-grain, competent sandstone and poorly sorted, friable sandstone.
Jacobsville Sandstone (Precambrian)	Mottled red to reddish-brown feldspathic sandstone containing lenses of red or gray conglomerate and some red shale.

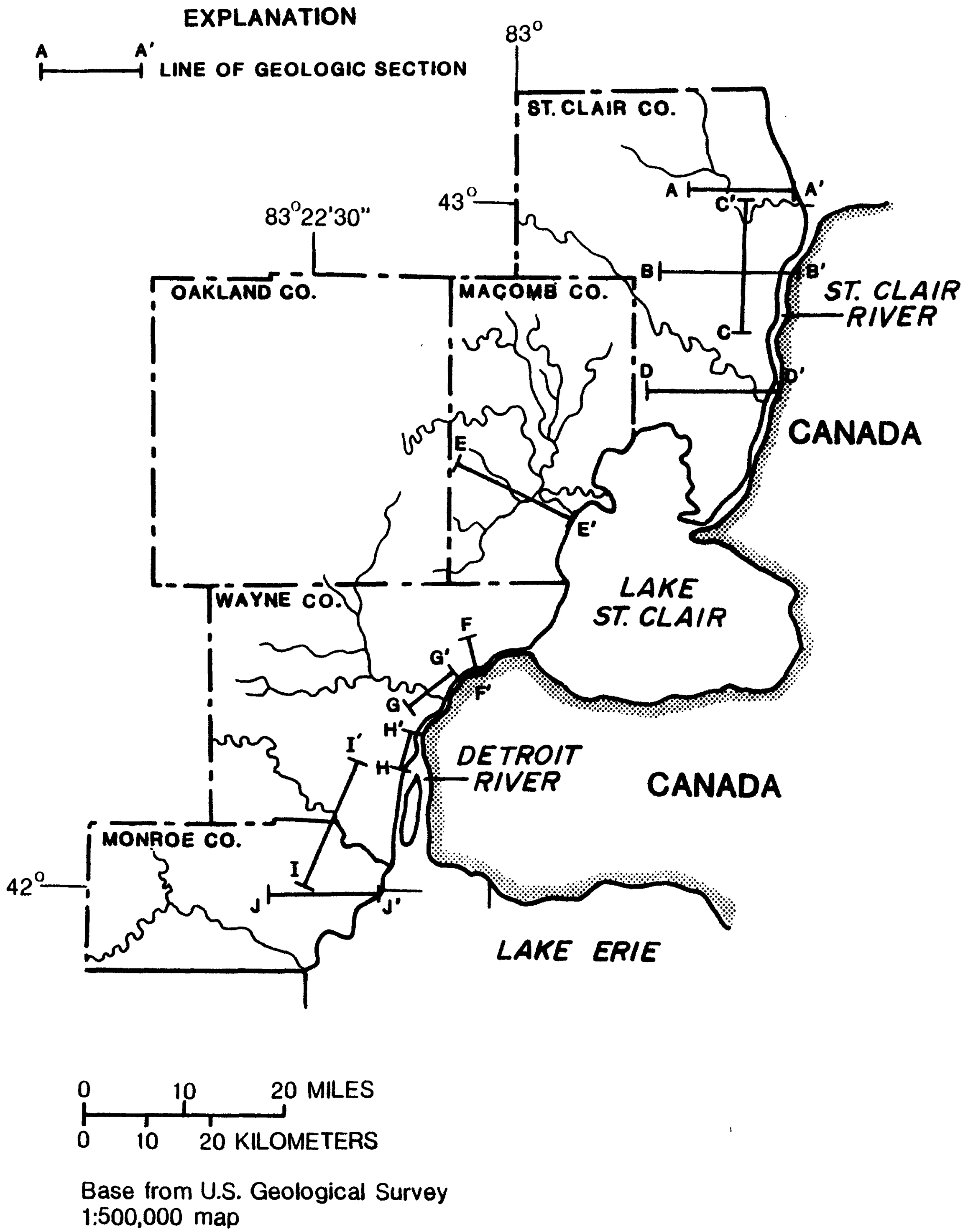


Figure 5.--Locations of geologic sections in the St. Clair-Detroit River study area.

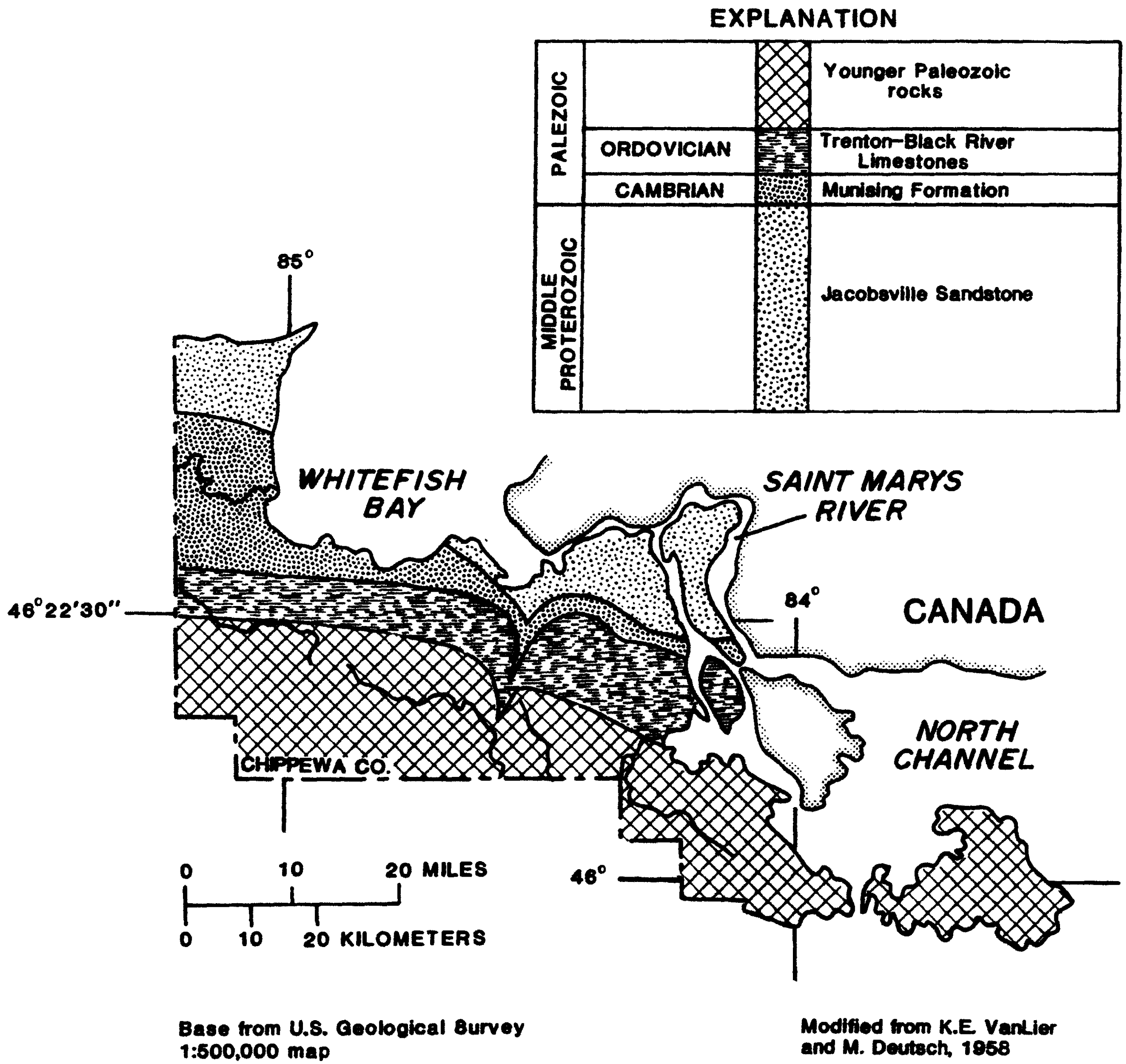


Figure 6.--Bedrock geology of St. Marys River study area.

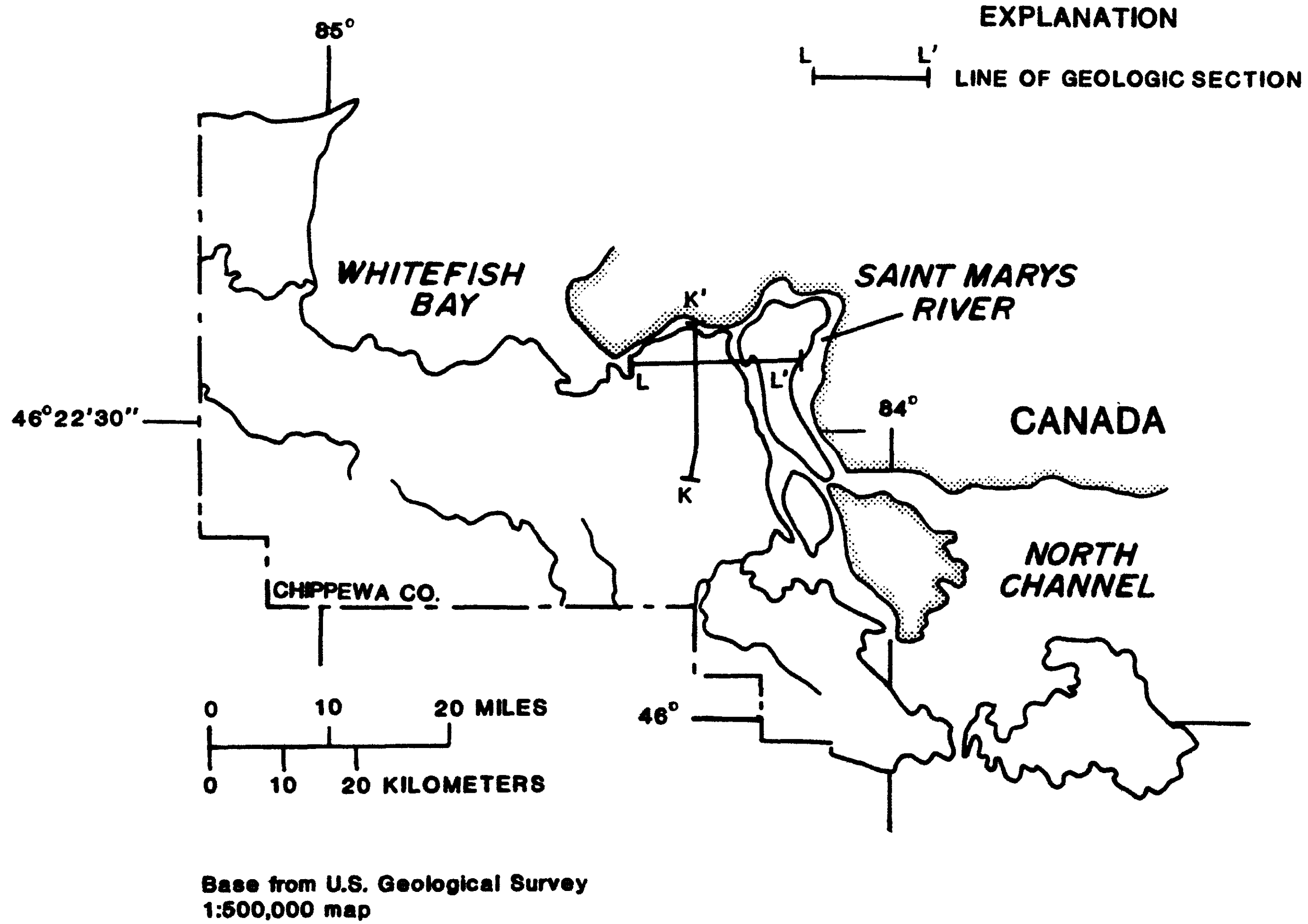


Figure 7.--Locations of geologic sections in the St. Marys River study area.

Stratigraphic Relations from Seismic Studies

A high-resolution marine seismic survey[1] was conducted to improve the definition of the geologic framework of the connecting channels in southeastern Michigan. Bedrock geology, bedrock topography, and drift thickness maps are available for only the Detroit River area (Mozola, 1969). In other parts of the study area, the depth to bedrock and thickness and characteristics of glacial deposits in the channel areas were unknown. The seismic profiles helped define the stratigraphy of the channels and delineate the hydrogeologic boundaries.

Interpretation of seismic records for the St. Clair River indicate that glacial deposits range from 50 to 100 ft in thickness, depending on channel depth. The bedrock surface is relatively flat, although minor undulations occur. Figure 8 is a continuous seismic-reflection profile typical of the St. Clair River. (Figure 8 corresponds to USGS line 20 C-C' on Figure 9.) Water well and oil and gas well logs close to the St. Clair River were used to confirm interpretations. Bedrock beneath the channel are the Bedford Shale and the Antrim Shale of Mississippian and Devonian age. In the seismic profile, the Antrim Shale, which is harder than the Bedford Shale, is indicated by the strong seismic reflection it produced. The Bedford Shale is defined on the basis of oil and gas logs which identify it as a semi-consolidated shale. Well G2 near Port Huron is the only well installed by the U.S. Geological Survey for the UGLCC study in the St. Clair study area that reached bedrock. (Data for U.S. Geological Survey wells are given in Appendix B.) Some surficial sand deposits, 5 to 10 ft thick, and at least 50 ft of silty-clay glacial deposits, were found when wells were installed. During drilling of well G2, silty-clay glacial deposits extending to bedrock were encountered. Till and lacustrine deposits could not be differentiated. Contacts or sedimentary structures within deposits are not visible in the seismic section because they are either poor reflectors or they are obscured by acoustical interference.

In Lake St. Clair, glacial deposits, including Holocene lacustrine deposits, range from 75 to more than 150 ft in thickness. Interpretations of the seismic profiles are difficult because of the lack of borehole data within Lake St. Clair. Shallow borings made by the U.S. Army Corps of Engineers for navigational light placement, a study by Brigham (1971), and logs of oil and gas wells located on shore, provide generalized information.

Figure 10 shows a continuous seismic reflection profile in the southern half of Lake St. Clair where lacustrine deposits overlie till. (Figure 10 corresponds to USGS line 14 B-B'on Figure 11.) Bedrock of this area in Lake St. Clair is the Traverse Group which consists of limestones and shales. The lack of sedimentary structures visible in the seismic section as well as the glacial history of the area, suggest that till underlies the lacustrine unit. The till also may contain some intercalated lacustrine deposits laid down in the subaqueous depositional environment postulated by Leverett and Taylor

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[1] Theories, techniques, and methods used in the survey are outlined by Hanei and Melvin (1984) and by Hanei (1986).

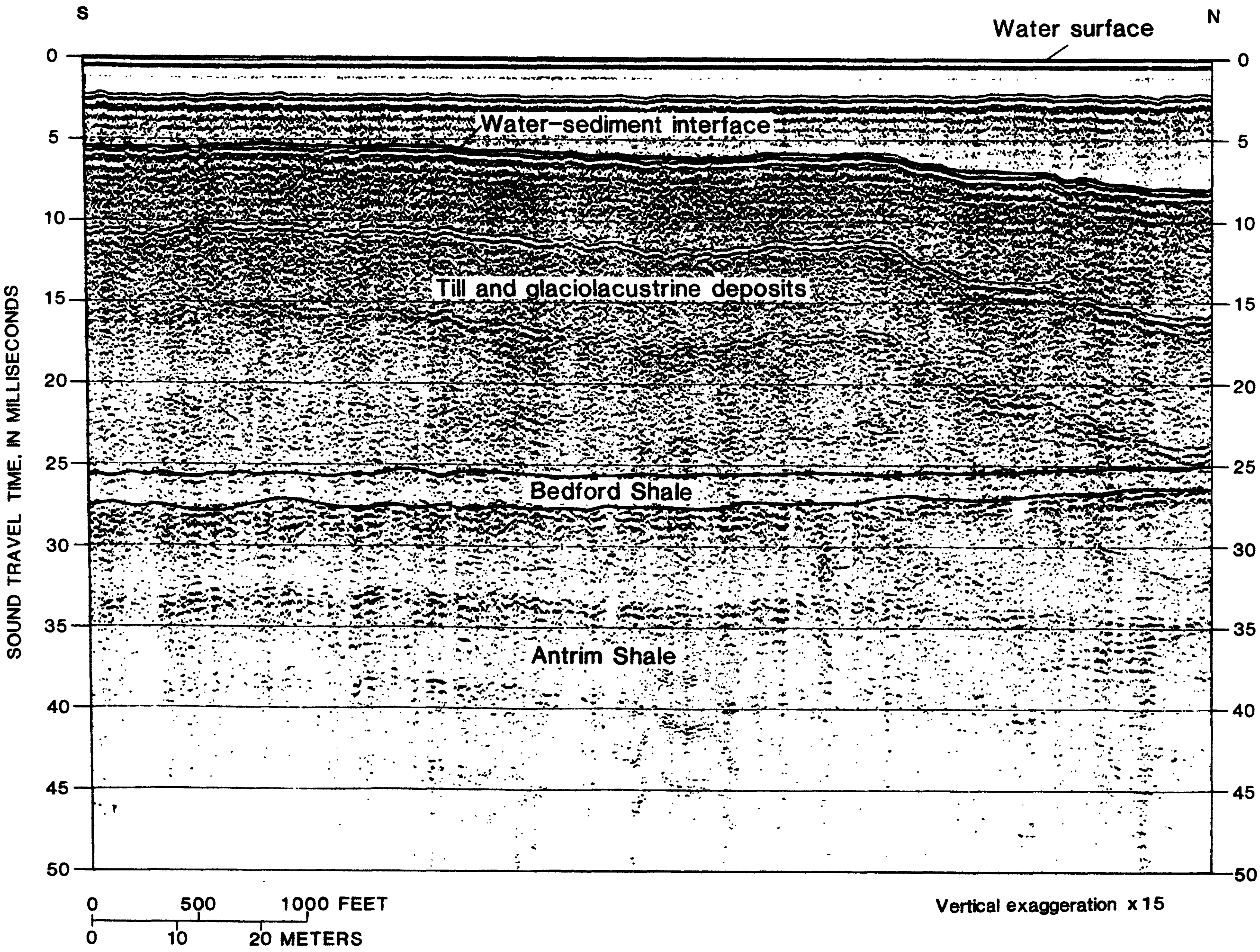


Figure 8.--Continuous seismic-reflection profile in the St. Clair River near Marine City (see figure 9 for line of section).

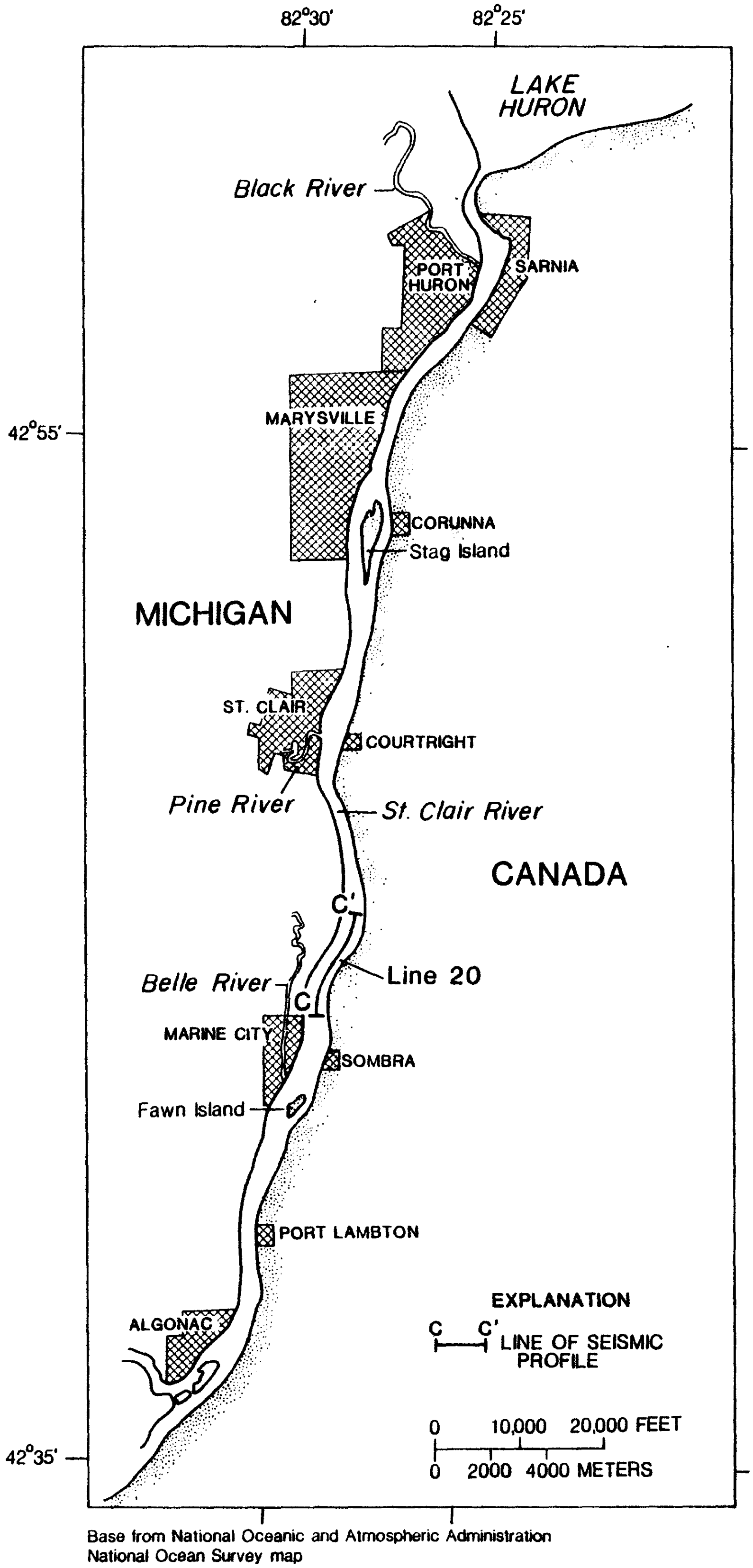


Figure 9.--Location of U.S. Geological Survey seismic profile in the St. Clair River.

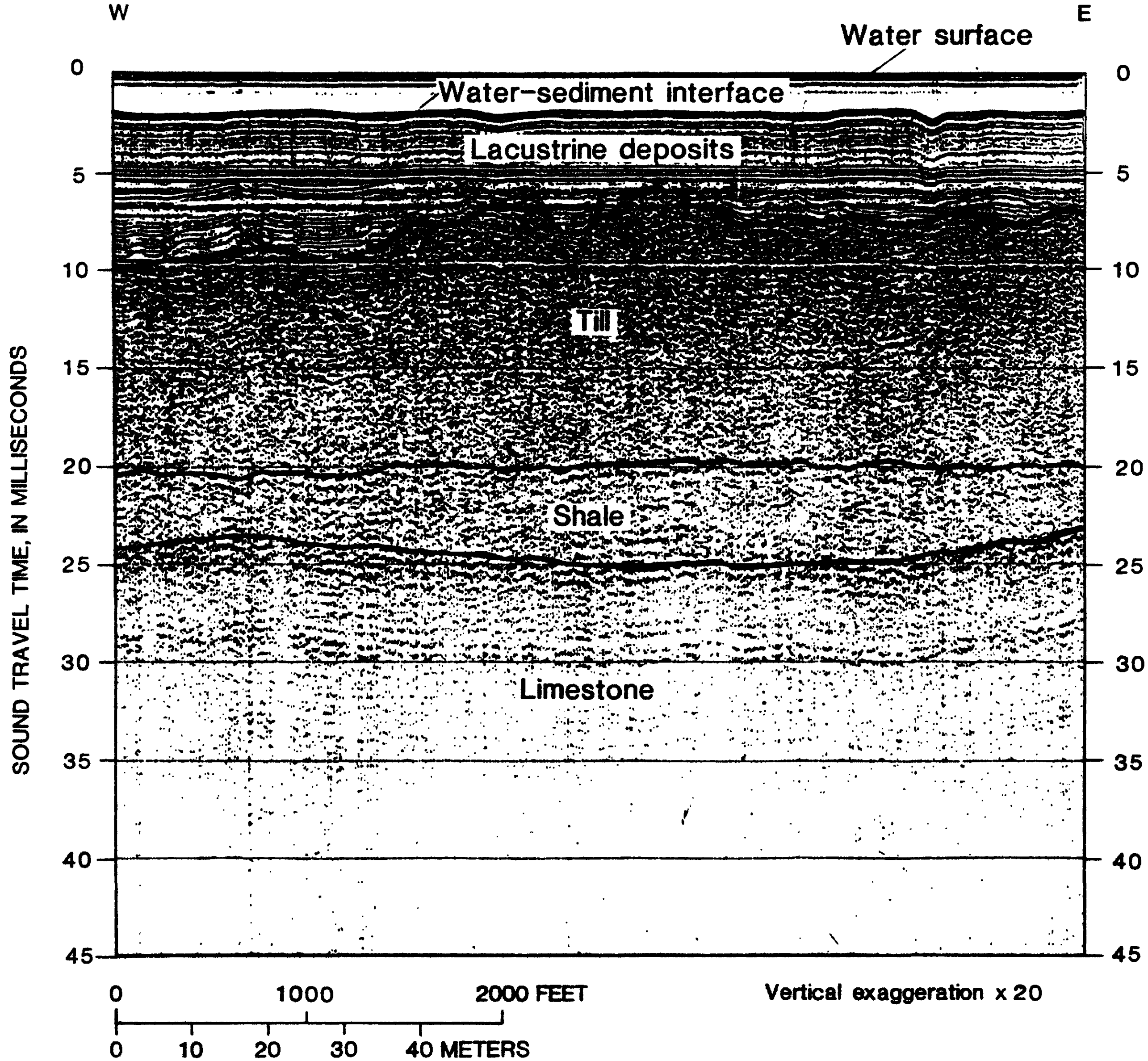


Figure 10.--Continuous seismic-reflection profile in southern Lake St. Clair showing lacustrine deposits overlying till (see figure 11 for line of section).

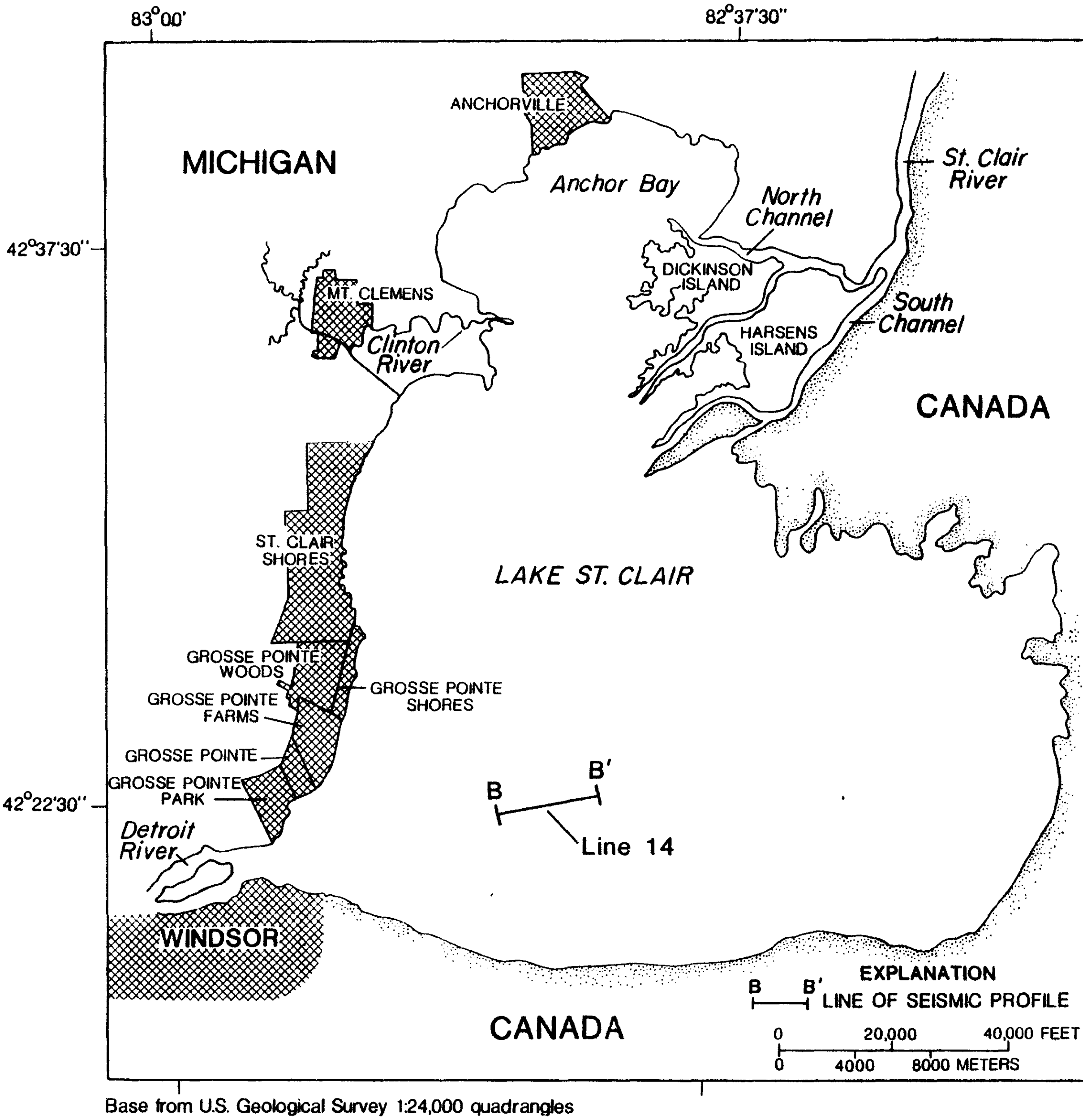


Figure 11.--Location of U.S. Geological Survey seismic profile on Lake St. Clair.

Glacial deposits beneath the Detroit River range from less than 10 to 70 ft in thickness. In the southern reach of the Detroit River, glacial deposits are absent; bedrock forms the channel bottom.

Figure 12, a continuous seismic-reflection profile in northern reach of the Detroit River, shows that Pleistocene lacustrine deposits overlie glacial till. (Figure 12 corresponds to USGS line 22 B-B' on figure 13.) Interpretation of the seismic profile is based on borings, on a study by VanWyckhouse (1966), and on the sedimentary structures and nature of the contacts shown in the seismic section. In this area, bedrock is the Dundee Formation of middle Devonian age (Mozola, 1969).

The presence of till is suggested by strong reflectors forming the basal unit of the glacial deposits. VanWyckhouse (1966) refers to this unit as the "hardpan" or "lower drift unit"; it is distinguished by its hardness. Records of borings and wells in the Detroit area describe the unit, although it is discontinuous and only 5 to 20 ft thick. The origin of the unit is uncertain. The basal till may have formed from till that has been overridden by glacial ice or by leaching of carbonate ions from the underlying bedrock.

The basal till unit is overlain by a second unit lacking internal structure or bedforms. The nature of the contact with the overlying lacustrine deposits suggests that it is a till. This unit also was recognized by VanWyckhouse (1966), who described it as a gray, medium-hard till. He reported a thickness of 35 to 40 ft.

A lacustrine unit also can be identified on the basis of seismic and borehole information (fig. 12). The sedimentary structures are quite evident in the seismic record; the contact with the underlying till is unconformable.

The hydraulic significance of these glacial units is uncertain because the data are sparse. These units are fine grained; significant sand deposits seem to be absent. However, the heterogenous nature of the deposits suggest that coarse-grained materials may be present at some locations.

GROUND-WATER FLOW

Altitude of Water Table and Direction of Ground-Water Flow

The water table in the UGLCC study areas is shown on plates 1-5. Water-table maps were constructed from well driller's records obtained from the Michigan Department of Natural Resources, Geological Survey Division, and from files of the U.S. Geological Survey. Well-record coverage for St. Clair, Macomb, Monroe, and Chippewa Counties is adequate, except in areas close to the channels. In Wayne County, coverage is very sparse within the study area, and limited mostly to historical data. In areas where data are not available, streams and other surface-water features were used to estimate the altitude of the water table.

In southeastern Michigan, ground water flows eastward to the St. Clair River, Lake St. Clair and Detroit River (plates 1-4). In Chippewa County, in the Upper Peninsula, ground water flows radially toward St. Marys River (plate 5). The direction of ground-water flow in the study areas is

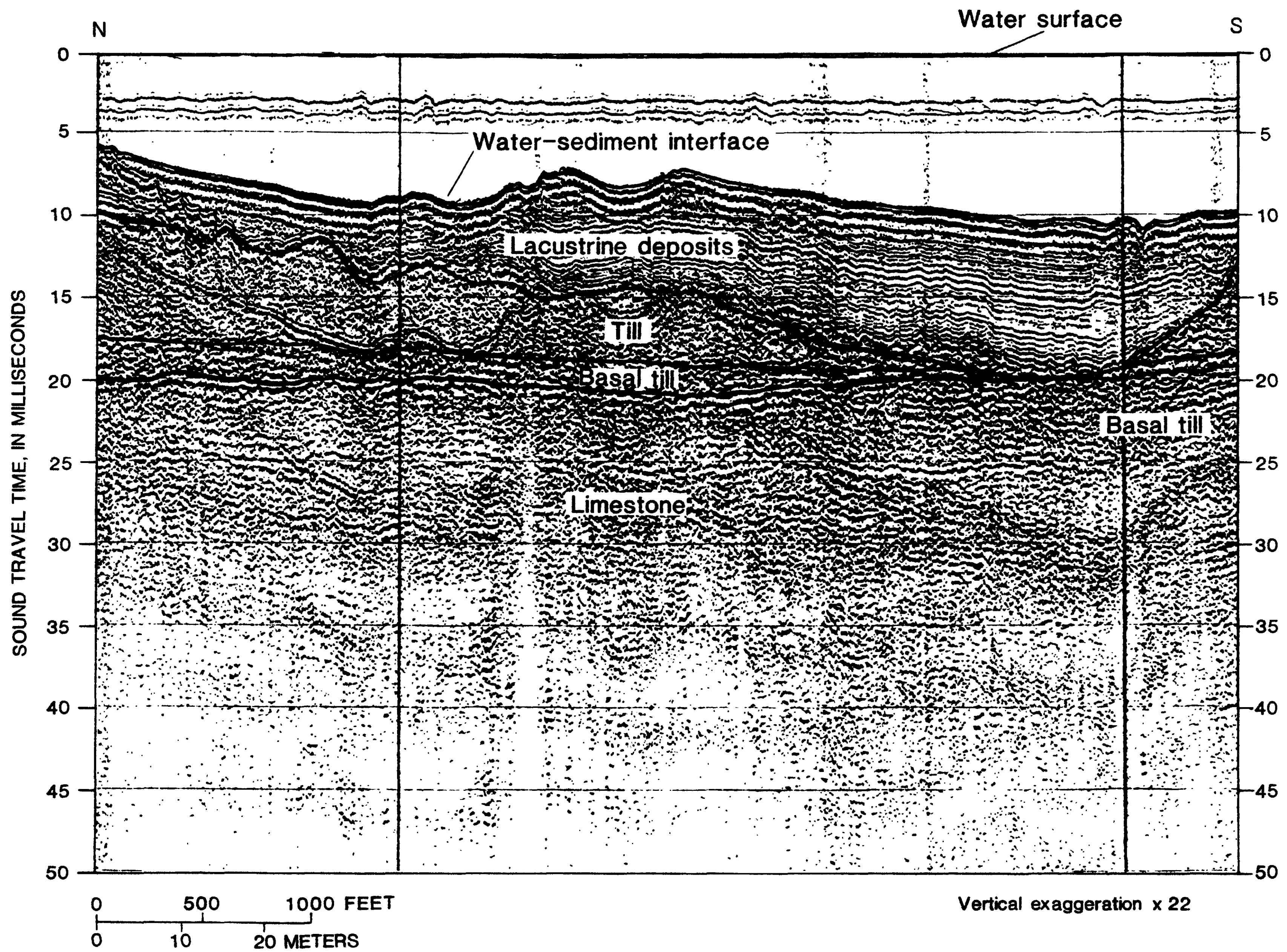
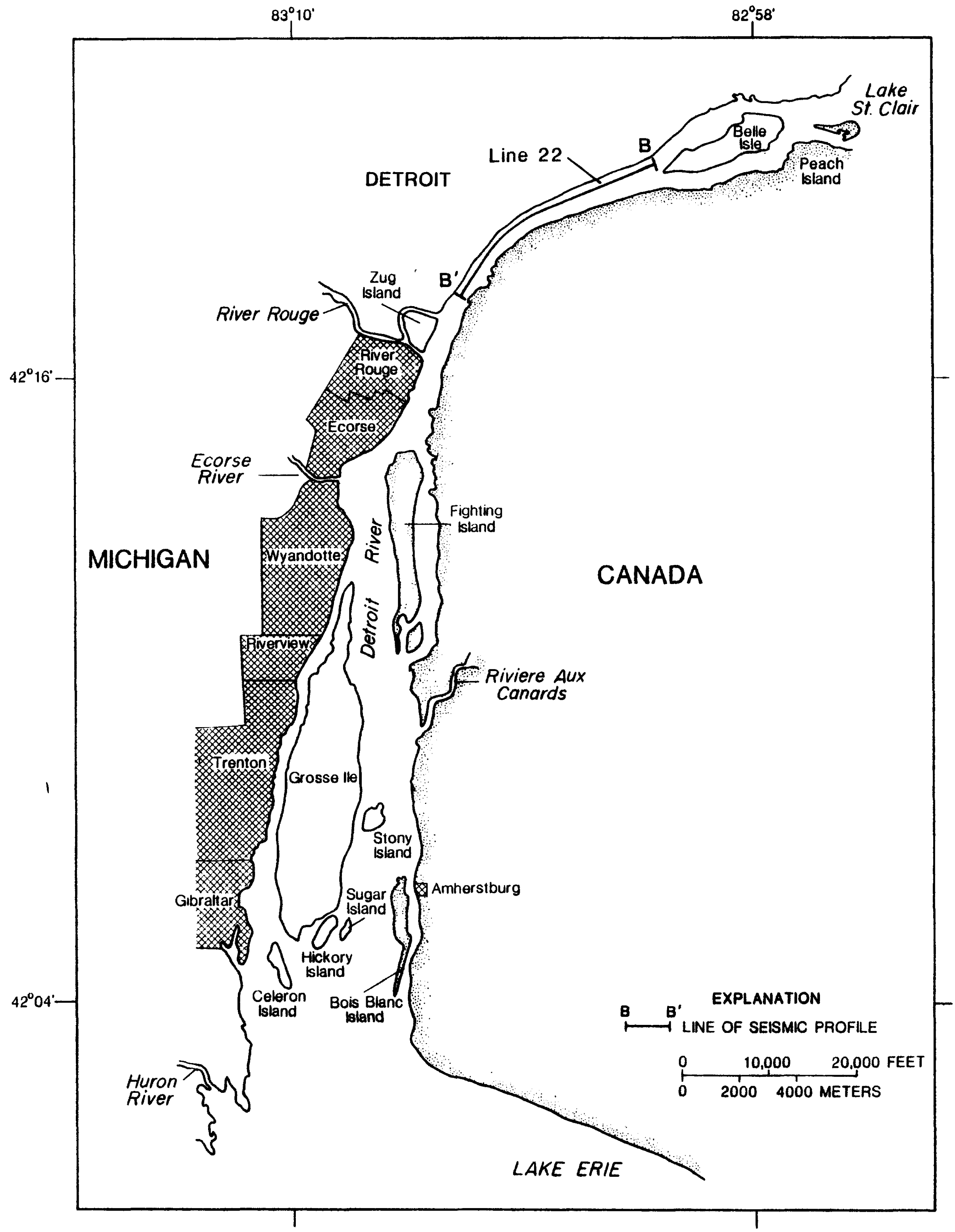


Figure 12.--Continuous seismic-reflection profile in the Detroit River near Belle Isle showing Pleistocene lacustrine deposits overlying glacial till.



Base from National Oceanic and Atmospheric Administration
National Ocean Survey map

Figure 13.--Location of U.S. Geological Survey seismic profile on the Detroit River.

influenced by surface-water drainage, dewatering projects, and glacial landforms. These factors, in conjunction with water-level measurements, are the basis for differentiating ground-water discharge areas also shown on plates 1-5. Ground water within these areas discharges directly to connecting channels; at places outside of discharge areas, ground water discharges to tributaries of the connecting channels.

Dewatering projects create cones of depression which may be extensive. In Wayne County, dewatering of Sibley Quarry has created a cone with an area of about 4 mi^2 (plate 4). Other quarry dewatering projects have a pronounced effect near the cities of Rockwood and Flatrock (plate 4). Glacial landforms, such as end moraines, also control water-table configuration (plate 2). The Mount Clemens moraine, which trends northeast-southwest, causes a number of streams to flow into the main branch of the Clinton River near Mount Clemens. The Emmet moraine near New Baltimore increases the altitude of the water table. These end moraines form subtle topographic highs. They are composed of fine-grained material characteristic of the water-laid till in the area.

Generalized subsurface ground-water flow paths to connecting channels are shown in figure 14. In the St. Clair area, where the bedrock is predominantly shales, most discharge to the streambed would be from the glacial deposits (fig. 14a). In the southern reaches of the Detroit River, and parts of the St. Marys area where the silty-clay glacial materials are thin or absent, the discharge to the rivers from the more permeable underlying bedrock increases (fig. 14b).

Ground-Water Discharge

Ground water discharges to the connecting channels from glacial deposits and bedrock formations that form and underly channels. The unique geologic settings and environmental problems associated with the different reaches of the channels required the identification of each significant hydrogeologic unit. For this study the units are shallow glacial deposits, glacial-bedrock interface, and bedrock units. Separate estimates of flow from each unit have been made.

Hydrogeologic Units

Shallow glacial unit.--The shallow glacial unit consists entirely of Pleistocene age glacial deposits. In southeastern Michigan these are mostly silty-clay till and glaciolacustrine deposits that contain discontinuous stringers of sand and gravel. In the Upper Peninsula, significant deposits of sand and gravel are at land surface and are also within the underlying till and glaciolacustrine deposits. These sand and gravel deposits have significantly higher ground-water runoff rates and, thus, discharge a greater volume of ground water to the connecting channels.

Glacial-bedrock interface unit.--The glacial-bedrock interface unit separates the shallow glacial unit and the bedrock unit. The discontinuous interface unit is usually 5 to 20 ft of unconsolidated silty sand, gravel, and weathered or fractured bedrock surface. The unit is only of significance in the St. Clair River and possibly the Lake St. Clair part of the study area where the Antrim and Bedford Shales are the principal bedrock units. The

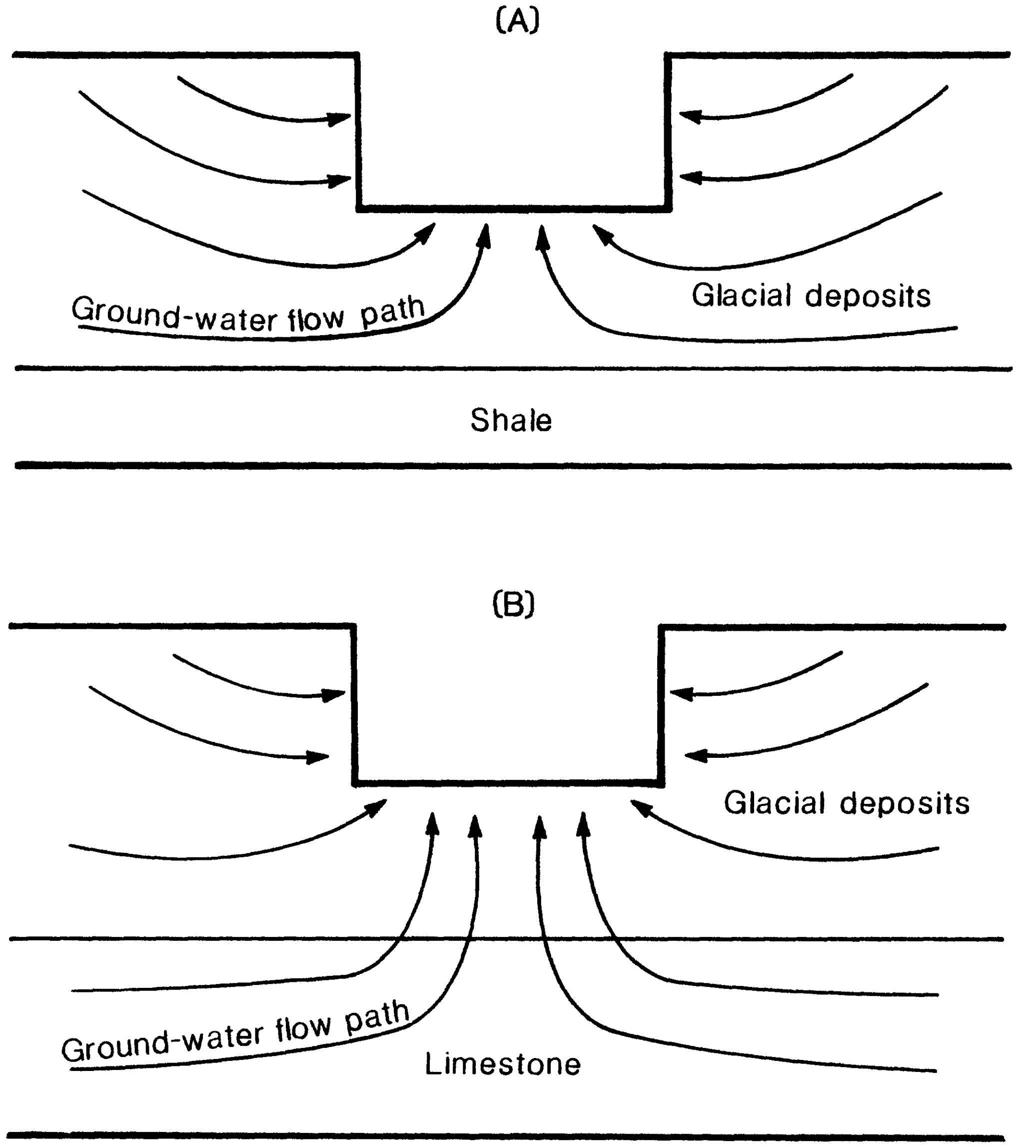


Figure 14.--Generalized ground-water-flow paths to connecting channels.

interface unit is assumed to be continuous for the purpose of estimating flow to the St. Clair River and Lake St. Clair because of the unique role it may play as an avenue of contaminant transport. For example, in the St. Clair River area, past deep injection of wastes into shallow horizons in the Detroit River Group near Sarnia, Ontario, caused overpressurization of the reservoir rock. During the injection process, the pressure front forced oil, gas, and water up through unplugged oil and gas wells. An environmental concern is that high heads in the Detroit River Group resulting from the injection process could cause waste fluids to migrate through fractures or more permeable horizons in the rock. The glacial-bedrock interface unit could, therefore, be one pathway through which waste fluids could reach the channels or contaminate adjacent ground water. No evidence exists that this has occurred in Michigan. Water from well G2, drilled to a depth of 112 ft near Port Huron, did not contain chemical substances in concentrations higher than common in natural waters; this suggests that no modification of water quality by wastes has occurred at that depth. Analyses of water from greater depths have not been made. In general, the glacial-bedrock interface unit discharges less water to the connecting channels than does the shallow glacial unit.

Bedrock unit.--For this study, the bedrock unit is defined as the first bedrock aquifer lying directly beneath the connecting channels. From Port Huron to southern Lake St. Clair, the bedrock unit includes all carbonate rocks of the Traverse Group at depths of 100 to 300 ft beneath the Antrim Shale. From Lake St. Clair to near Fighting Island in the Detroit River, the bedrock unit includes the carbonate rocks of the Traverse Group and Dundee Formation that underlie at least 50 ft of glacial deposits. South of Fighting Island, the bedrock unit is composed of limestone, dolomite, and sandstone of the Detroit River Group, which lies beneath about 25 ft of fine-grained glacial deposits. In an area near the mouth of the river, however, the Detroit River Group forms the river channel. In the St. Marys area, the bedrock unit is Jacobsville Sandstone. At some locations, it is exposed at the surface; at other locations, it is beneath as much as 300 ft of glacial deposits. At most places in both northern and southeastern Michigan, bedrock units discharge less water to the connecting channels than do either the shallow or glacial-bedrock interface units. In the lower reach of the Detroit River, however, discharge from the bedrock unit is substantially greater than at other locations.

Estimated Rates

Ground-water discharge from the shallow glacial unit to the connecting channels was estimated by analyzing base flow at gaging stations on streams in southeastern Michigan. Ground-water discharge from the glacial-bedrock interface and bedrock units was estimated by using Darcy's Law of ground-water flow and information on the hydraulic properties of glacial and bedrock deposits beneath the channels.

Shallow glacial unit.--Base flow of perennial streams, which is largely ground-water runoff, was used to estimate the ground-water discharge to the connecting channels from the shallow glacial unit. Flow records collected at the U.S. Geological Survey streamflow-gaging stations (table 3) were used to determine base flow. In previous studies by the U.S. Geological Survey, the 55th to 60th percentile of annual flow duration (amount of time that flow in

Table 3.--Characteristics of stream basins

[mi^2, square mile; ft^3/s, cubic feet per second; $(ft^3/s)/mi^2$, cubic feet per second per square mile]

River basin	Station number and name	Period of record	Drainage area (mi^2)	Discharge at 60-percent duration (ft^3/s)	Discharge rate [$(ft^3/s)/mi^2$]
Black River	04160050 Black River near Port Huron	1933-43	684	34.3	0.05
	04159500 Black River near Fargo	1945-85	480	39.3	.08
	04159900 Mill Creek near Avoca	1964-75	169	15.2	.09
Belle River	04160600 Belle River at Memphis	1963-85	151	20.1	.13
Clinton River	04165500 Clinton River at Mount Clemens	1935-85	734	241	.33
	04164500 North Branch Clinton River near Mount Clemens	1948-85	199	26.2	.13
	04164000 Clinton River near Fraser	1948-85	444	218	.49
River Rouge	04168500 Lower River Rouge at South Brady Road near Dearborn	1931-33	91.9	6.0	.07
	04168000 Lower River Rouge at Inkster	1948-85	83.2	9.3	.11
	04167000 Middle River Rouge near Garden City	1931-85	99.9	27.4	.27
	04166100 River Rouge at Southfield	1959-85	87.9	24.6	.28
	04166500 River Rouge at Detroit	1931-85	187	40.6	.22

Table 3.--Characteristics of stream basins--Continued

River basin	Station number and name	Period of record	Drainage area (mi^2)	Discharge at 60-percent duration (ft^3/s)	Discharge rate [$(ft^3/s)/mi^2$]
River Raisin	04176500 River Raisin near Monroe	1938-85	1,042	247	0.24
Pine River	04127918 Pine River near Rudyard	1973-85	184	112	.61

an average year is equaled or exceeded) has been considered a representative value for average annual ground-water runoff (U.S. Geological Survey, 1968; Cummings and others, 1984). For this study, the 60th percentile of annual flow duration was used to estimate base flow. With the exception of the Pine River near Rudyard, which is in the St. Marys area, gaging stations locations are shown on figure 15.

Ground-water discharge per square mile was then calculated for the gaged basins, and a rate of discharge was determined. Stream basins that have higher discharge rates are in areas where surficial sand deposits overlie fine-grained till and lacustrine deposits intercalated with deposits of sand and gravel. Discharge rates are lower in stream basins underlain predominantly by fine-grained till and lacustrine deposits.

Rates of ground-water discharge determined for gaged basins were used to estimate rates in the ground-water discharge areas shown on plates 1-5. Because the geological settings of discharge areas and gaged stream basins are similar, the following rates were considered appropriate: 0.10 $(ft^3/s)/mi^2$ (cubic feet per second per square mile) for fine-grained lacustrine deposits; 0.13 $(ft^3/s)/mi^2$ for areas of fine-grained till and lacustrine deposits; 0.18 $(ft^3/s)/mi^2$ for areas of some surficial sand overlying fine-grained till and lacustrine deposits; 0.25 $(ft^3/s)/mi^2$ where the area is mostly covered with surficial sands overlying fine-grained till and lacustrine deposits; 0.35 $(ft^3/s)/mi^2$ where surficial sands overlie till and lacustrine deposits that contain intercalated sand and gravel deposits; and 0.50 $(ft^3/s)/mi^2$ where thick surficial sand deposits are found in parts of the basin.

Rates of ground-water discharge per unit area are higher near the St. Marys River than in southeastern Michigan because of the presence of coarse-grained materials. The estimated total ground-water discharge to the connecting channel in the St. Marys area and the St. Clair-Detroit area from the shallow glacial unit is given in table 4.

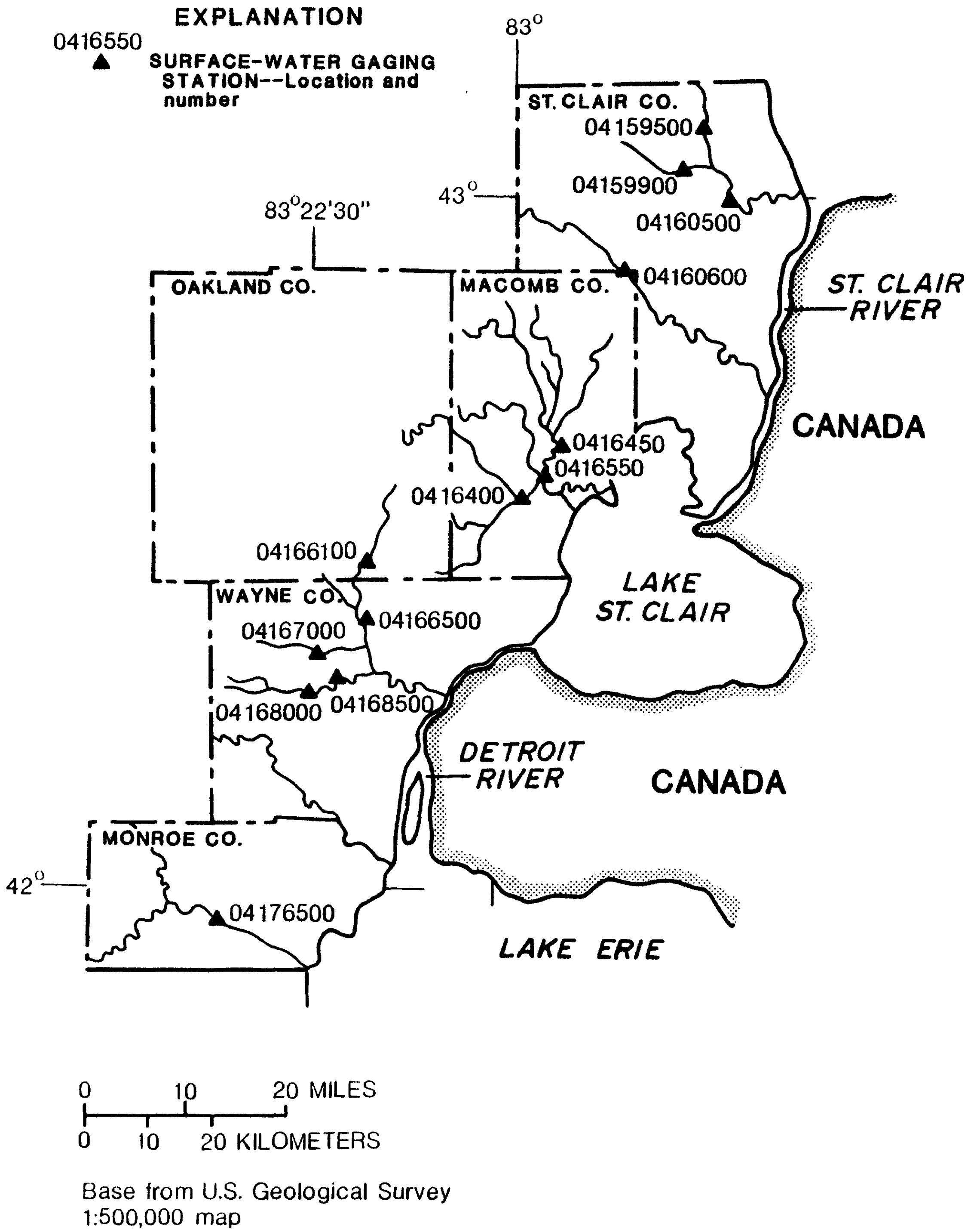


Figure 15.--Location of surface-water gaging stations in southeastern Michigan.

Table 4.--Ground-water contribution to connecting channels

[mi^2, square mile; mi, mile; $(ft^3/s)/mi^2$, cubic feet per second per square mile; ft^3/s, cubic feet per second]

Location	Area number[1]	Area[2] (mi^2)	Shorelength (mi)	Discharge rate for shallow glacial unit [$(ft^3/s)/mi^2$]	Discharge from hydro-geologic units (ft^3/s)	Total discharge from area (ft^3/s)
St. Clair River	1	S 1.9	1.98	0.25	0.48	0.52
		G .43			.047	
		B .43			.001	
	2	S 32.3	11.69	.18	5.81	6.15
		G 3.05			.33	
		B 3.05			.007	
	3	S 11.4	8.41	.13	1.48	1.70
		G 1.96			.21	
		B 1.96			.005	
	4a	S 18.8	6.67	.13	2.44	2.62
		G 1.69			.18	
		B 1.69			.004	
Lake St. Clair	4b	S 27.5	13.26	.10	2.75	6.37
		G 32.41			3.54	
		B 32.41			.080	
	5	S 80.4	15.78	.13	10.45	13.79
		G 32.58			3.56	
		B 32.58			.080	
	6	S 4.7	7.37	.13	.61	4.14
		G 31.60			3.46	
		B 31.60			.070	
	7a	S 103.9	16.36	.13	13.51	22.18
		G 77.61			8.49	
		B 77.61			.18	
Detroit River	7b	S 79.4	10.84	.13	11.62	12.74
		B 4.34			1.12	
	8	S .50	.92	.25	.13	.25
		B .29			.12	

Table 4.--Ground-water contribution to connecting channels--Continued

Location	Area[1] number	Area[2] (mi^2)	Shorelength (mi)	Discharge rate for shallow glacial unit [(ft^3/s)/mi^2]	Discharge from hydro-geologic units (ft^3/s)	Total discharge from area (ft^3/s)
Detroit River (continued)	9	S 4.60	3.53	0.13	0.60	1.05
		B 1.13			.46	
	10	S 6.0	5.37	.13	.78	3.13
		B 5.72			2.35	
	11	S 26.5	11.54	.13	3.45	36.85
		B [3]5.37			2.20	
		B [3]9.67			31.20	
St. Marys River	12	S 21.4	9.95	.50	10.70	14.05
		B 10.37			3.35	
	13	S 65.8	32.18	.35	23.03	30.71
		B 23.81			7.68	
	14	S 7.8	7.46	.35	2.73	3.17
		B 1.35			.44	
	15	S 52.1	37.45	.25	13.03	22.44
		B 29.17			9.41	
	16	S 22.0	20.12	.25	5.50	5.75
		B 4.63			1.50	

[1]See plates 1-5 for location of area.
[2]S is area contributing flow to the channels from the shallow glacial unit in till and lacustrine deposits; G is flow to the channels from the interface of glacial deposits and bedrock; and B is flow to channels from the bedrock unit.
[3]Area 11 is divided on basis of channel geology changing from glacial deposits to limestone.

Glacial-bedrock interface and bedrock units.--Discharge of ground water from the glacial-bedrock interface and bedrock units to the connecting channels was calculated by estimating vertical hydraulic conductivity, hydraulic gradient, and the thickness of fine-grained glacial deposits and bedrock beneath the channels. Generalized sections showing the vertical hydraulic conductivity and relative thickness of deposits are shown in figure 16. Discharge rates from the glacial-bedrock interface and bedrock units in table 4 were derived by using the highest hydraulic conductivities thought possible for geologic materials in the study area. The following equations (Freeze and Cherry, 1979) were used to make estimates of discharge rates:

$$K_z = \frac{d}{\sum_{i=1}^{n} \frac{d_i}{K_i}} \qquad (1)$$

and

$$Q_z = K_z \frac{\partial h}{\partial z} A, \qquad (2)$$

where K_z = equivalent vertical hydraulic conductivity of system of n layers (L/T),
d = total thickness of geologic units (L),
d_i = thickness of layer i (L),
K_i = vertical hydraulic conductivity of layer i (L/T),
n = number of layers (dimensionless),
$\frac{\partial h}{\partial z}$ = vertical hydraulic gradient (dimensionless),
A = area in which vertical flow occurs (L^2), and
Q_z = vertical flow rate (L^3/T).

Calculations using these equations indicate that deposits with the lowest vertical hydraulic conductivity control the vertical movement of ground water to the connecting channels. Hydrogeologic units with the lowest vertical hydraulic conductivity are fine-grained glacial deposits, glacial till and glaciolacustrine deposits, and shale. Sand and gravel, limestone, and sandstone have the highest vertical hydraulic conductivity.

Estimates of vertical hydraulic conductivity for fine-grained glacial deposits were based on work by Desaulniers and others (1981) and on Mason and others (1986). Desaulniers and others (1981) determined the vertical hydraulic conductivity of glacial till and glaciolacustrine deposits of southwestern Ontario to range from 0.00003 ft/d to 0.0003 ft/d (foot per day). Seepage-meter studies by Mason and others (1986) suggested that the streambed hydraulic conductivity of the St. Clair River was at least two orders of magnitude higher than values determined by Desaulniers and others (1981). Based on these data, a vertical hydraulic conductivity of 0.03 ft/d for till is used in calculations for this study.

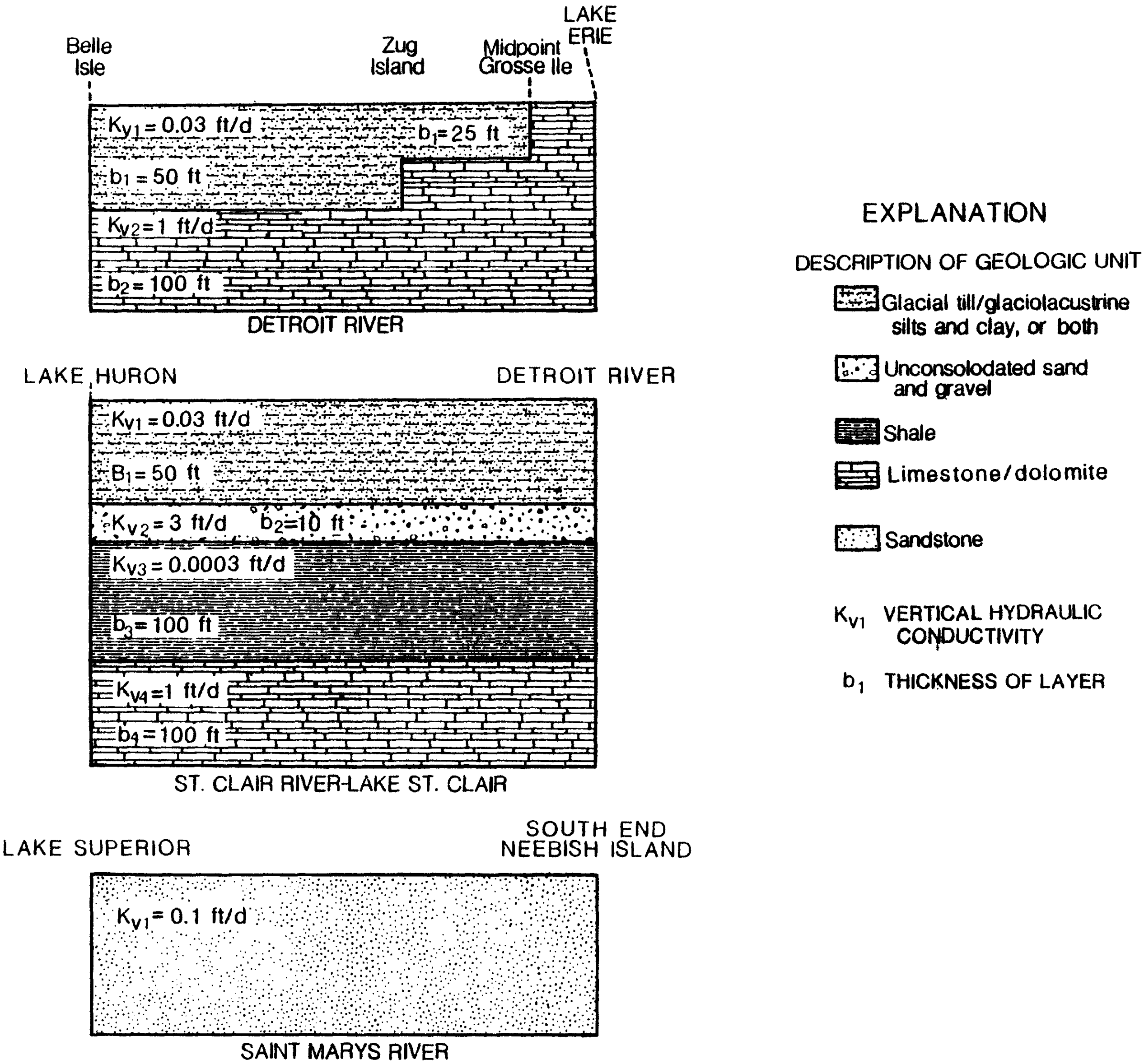


Figure 16.--Generalized geologic sections underlying connecting channels.

Vertical hydraulic conductivities of the shale were estimated by reviewing published values for other shale units. Bredeheoft and others (1983) reported vertical hydraulic conductivities for South Dakota shales ranging from $3x10^{-6}$ ft/d to $3x10^{-8}$ ft/d. Because some evidence exists that shales in the connecting channels study area have been fractured, a vertical hydraulic conductivity of 0.0003 ft/d is used in ground-water discharge calculations.

In calculating ground-water discharge, a vertical hydraulic gradient of 0.01 has been assumed. This assumption is based on historical head data of the Detroit area (Sherzer, 1913) and on a report by Jackson (1987) on the St. Clair River Valley.

One well (G2), installed in the bedrock-glacial deposit interface near Port Huron, has an upward gradient. This is consistent with wells installed by Canadian investigators on the eastern side of the St. Clair River at similar distances from the river (Jackson, 1987).

Estimates of the thickness of geologic units beneath channels in the St. Clair-Detroit area were based on the seismic-reflection survey conducted by the U.S. Geological Survey. (See section "Stratigraphic Relations from Seismic Studies.")

Discharge to Connecting Channels

Total ground-water discharge to the connecting channels in the St. Clair-Detroit area from Port Huron to Pointe Mouillee is about 112 ft^3/s (table 4). Discharge rates increase southward because the fine-grained glacial deposits become thin, and because hydraulic conductivity of the bedrock increases. The highest discharge rate is in Area 11 south of Detroit (plate 4). In this area, glacial deposits are thin or absent; bedrock is limestone, dolomite, and sandstone. Discharge rates are lowest near the St. Clair River where glacial deposits are thick, fine grained, and underlain by shales.

Total ground-water discharge in the St. Marys area is about 76 ft^3/s (table 4). Although ground-water discharge to the connecting channel is about the same as in southeastern Michigan, discharge per square mile is much higher in the St. Marys area because of the extensive deposits of sand and gravel in the shallow glacial unit. Discharge from bedrock also is greater in the St. Marys area principally because permeable sandstones and limestones comprise a significant part of the bedrock.

GROUND-WATER QUALITY

Although substantial amounts of water-quality data are available in the UGLCC study areas, little information has been obtained in Michigan on the concentrations of many of the metals and organic compounds identified by UGLCC study planners as necessary for adequate assessment of water-quality conditions. In an attempt to increase the data base, 25 observation wells were installed during the project (Appendix B). An effort was made to install one to three wells in most of the 16 ground-water discharge areas (plates 1-5). The actual locations of the wells depended on the size of the ground-water discharge area and on permission for drilling from land owners.

Samples for analyses were collected from the 25 wells installed by the U.S. Geological Survey and from six private wells. Analyses were made for volatile, base-neutral, acid-extractable, and chlorinated neutral-extractable hydrocarbons, trace metals, and other chemical substances. These analyses are given in Appendix B.

Concentrations of trace metals, in a number of instances, are unusually high. Analyses of water were made for the total amount present in a sample in accordance with methods agreed on by UGLCC study participants. The deposits in many areas, even after lengthy periods of well pumping, yielded water containing finely divided particulate matter. It is believed that this particulate matter may have contributed significantly to the measured concentrations, and if so, concentrations of trace metals in ground water discharged to the connecting channels could be much lower than analyses indicate.

For this study, analyses by county Health Departments also were assembled and reviewed. However, only a few of the most common constituents found in ground water are determined by Health Departments, and the number of domestic wells located near the connecting channels are comparatively few. As a result, the usefulness of these analyses in this study was minimal.

Study Areas

St. Marys River Study Area

Chemical analyses of water from seven wells in three ground-water discharge areas in the St. Marys study area were made by the U.S. Geological Survey. (These wells are numbered G22 to G25, and P4 to P6, in Appendix B; the locations are shown on plate 5.)

Analyses of water from each of the seven wells indicated that concentrations of the volatile hydrocarbons, if present, did not exceed the detection limit of 3.0 µg/L (micrograms per liter). Base neutral compounds and chlorinated neutral extractable compounds were also less than the detection limit, with exception of water from wells G23 and G24, which contained phthalates. Water of well G23 had the highest concentration--95 µg/L bis (2-ethyl hexyl) phthalate. Analyses made by laboratories other than that of the U.S. Geological Survey did not provide data on organic compounds in ground water.

Trace-metal analyses of water from the seven wells sampled by the U.S. Geological Survey indicated concentrations exceeding USEPA (1986a,b) drinking water standards[2] in only one sample. Water from well G23 contained 320 µg/L

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[2] USEPA maximum contaminant levels for trace metals in drinking water are: arsenic, 50 µg/L; barium, 1,000 µg/L; cadmium, 10 µg/L; chromium, 50 µg/L; lead, 50 µg/L; mercury, 2 µg/L; selenium, 10 µg/L; and silver, 50 µg/L. Secondary maximum contaminant levels are: copper, 1 mg/L; iron, 300 µg/L; manganese, 50 µg/L; and zinc, 5 mg/L.

of chromium and 8.4 mg/L of zinc. Analyses of trace metals by other laboratories showed considerably higher concentrations in ground water at some locations. Maximum concentrations of 300 µg/L arsenic, 410,000 µg/L aluminum, 440,000 µg/L chromium, 2,400 µg/L lead, 570 µg/L nickel are reported.

St. Clair River Study Area

Chemical analyses of water from eight wells in four discharge areas in the St. Clair River study area were made by the U.S. Geological Survey. (These wells are numbered G1 to G8 in Appendix B; the locations are shown on plates 1 and 2.)

Analyses of water from each of the eight wells indicated that concentrations of volatile hydrocarbons were less than the detection limit. Base neutral compounds and chlorinated neutral extractable compounds were detected in water from five of the wells. Well G3 contained 1,500 µg/L of bis (2-ethyl hexyl) phthalate--the highest concentration of an organic compound detected in the study (Appendix B). Analyses of soil and water by laboratories other than that of the U.S. Geological Survey detected chlorinated hydrocarbons, phenols, and aroclor 1260 at one location. Organic compounds are reported in ground water at another location, but concentrations are unknown.

Analyses of water for trace metals by the U.S. Geological Survey showed unusually high concentrations of trace metals in ground water. Maximum concentrations were 6,300 µg/L lead, 390,000 µg/L zinc, 2,100 µg/L barium, 500,000 µg/L iron. It is believed that these high concentrations are due, in part, to the finely divided particulate matter in the samples. Analyses made by other laboratories provide no data on trace metals.

Lake St. Clair Study Area

Chemical analyses of water from eight wells in four ground-water discharge areas in the Lake St. Clair study area were made by the U.S. Geological Survey. (These wells are numbered G9 through G16 in Appendix B; the locations are shown on plates 2 and 3.)

Analyses of water from each of the eight wells indicated that concentrations of volatile hydrocarbons, if present, are consistently less than the detection limit. Benzene, however, was detected in well G14 (3.1 µg/L). Base neutral compounds and chlorinated neutral extractables generally were absent. Phthalates were in water from all but well G10. The highest concentration found was that of bis (2-ethyl hexyl) phthalate, 560 µg/L, in water from well G11. Traces of DDT and lindane were detected in water from wells G9, G11, and G15. Analyses of water by laboratories other than that of the U.S. Geological Survey for organic compounds indicate that petroleum hydrocarbons, chlorinated hydrocarbons, and phenols are in ground water at some locations in the study area. Benzene, toluene, methylene chloride, trichloroethylene, dichloroethylene, and ethyl benzene are reported in concentrations generally less than 100 µg/L. A vinyl chloride concentration of 45 µg/L has been reported. Di-n-octylphthalate was found at a concentration of 650 µg/L.

Analyses of water for trace metals by the U.S. Geological Survey indicated high concentrations at some locations. Maximum concentrations included 4,000 µg/L barium, 580,000 µg/L iron, 600 µg/L lead, and 74,000 µg/L zinc. All of these values are well in excess of USEPA drinking-water regulations. A pH greater than 11 was measured at one location. It is believed that the high trace metal concentrations were caused, in part, by finely divided particulate matter in the samples. Trace metals are frequently adsorbed on particulate matter. Other laboratories also report high concentrations of trace metals in water. At one site, a copper concentration of 1,900 µg/L was found in ground water.

Detroit River Study Area

Chemical analyses of water from eight wells in the Detroit River study area were made by the U.S. Geological Survey. (These wells are numbered G17 to G21, and P1 to P3, in Appendix B; the locations are shown on plates 3 and 4.) Analyses of water from well G17 show significant concentrations of base neutral compounds (Appendix B). Concentrations of inorganic substances are also significantly higher than those found at most other locations.

Analyses of water from each of the eight wells indicated that concentrations of volatile hydrocarbons are less than the detection limit, with the exception of water from well P1 that contained concentrations of 270 µg/L benzene, 410 µg/L ethyl benzene, and 740 µg/L xylenes. Base neutral and chlorinated extractable compounds were more frequently detected in the Detroit area than in the other three study areas. Eighteen organic compounds were detected in water of well P2; the highest concentration was that of bis (2-ethyl hexyl) phthalate (150 µg/L). Analyses of water by other laboratories at several locations in the Detroit area showed even higher concentrations of organic compounds. Maximum concentrations of some of the organic compounds include benzene, 23,000 µg/L; xylenes, 42,340 µg/L; trichloroethylene, 2,785 µg/L; chloroform, 8,500 µg/L; naphthalene, 810,000 µg/L; acenaphthylene, 360,000 µg/L; and benzo (a) pyrene, 820,000 µg/L.

Analyses of water by the U.S. Geological Survey indicate that concentrations of trace metals commonly are high in ground water. For example, a copper concentration of 2,500 µg/L (well G17), a lead concentration of 4,700 µg/L (well G17), and a nickel concentration of 1,500 µg/L (well P2) were found. A pH greater than 11 was measured. Analyses by other laboratories indicate even higher concentrations at some locations. Maximum concentrations in ground water as great as the following have been found: chromium, 26,600 µg/L; lead, 62,400 µg/L; mercury, 4,900 µg/L; and zinc, 67,500 µg/L. High concentrations of chloride (54,400 µg/L), cyanide (58,800 µg/L), and dissolved solids (197,000 mg/L) were also reported in ground water.

Relation of Land Use to the Chemical Characteristics of Ground Water

U.S. Geological Survey land-use and land-cover maps (1979, 1984) were used to determine land use in each of the ground-water discharge areas. The results are summarized in table 5. Urban or built-up land includes residential, commercial, industrial, transportation and other urban land. Agricultural land is mostly cropland or pasture. Forests are deciduous,

Table 5.--Land use in the ground-water discharge areas

[Unit is square mile. -- means that land of that category is not present. Data from U.S. Geological Survey, 1979 and 1984]

Area number	Urban or built-up land	Agricultural land	Forest land	Wetland	Barren land	Water	Total area
1	1.8	--	0.1	--	--	--	1.9
2	9.3	21.7	6.7	--	--	3.3	41.0
3	1.3	8.2	1.6	--	0.3	--	11.4
4a	1.0	13.7	3.8	0.3	--	--	18.8
4b	2.2	16.5	5.2	3.6	--	--	27.5
5	13.7	62.1	3.7	--	.6	.3	80.4
6	2.5	.8	.4	.9	--	.1	4.7
7a	100.3	2.5	.7	--	.4	--	103.9
7b	79	--	--	--	.4	--	79.4
8	.5	--	--	--	--	--	.5
9	4.6	--	--	--	--	--	4.6
10	6.0	--	--	--	--	--	6.0
11	9.4	14.9	1.7	.3	.2	--	26.5
12	1.0	.8	18.5	.9	--	.2	21.4
13	7.4	31.1	23.7	2.2	1.4	--	65.8
14	--	.6	6.4	.8	--	--	7.8
15	.2	6.3	42.2	3.4	--	--	52.1
16	--	1.8	18.4	1.6	.2	--	22.0

evergreen, or a mixture of both types. Wetlands consist of both forested and nonforested land. Barren lands in the study area are quarries, gravel pits, or transitional areas. Land use designated as water in table 5 is either a reservoir or a lake; surface streams and the connecting channels are not included.

Partial chemical analyses made by county Health Departments commonly report concentrations of iron, chloride, nitrate, sodium, and fluoride, and values of hardness and specific conductance. These chemical characteristics of ground water were found to be unrelated to land use in all discharge areas. Similarly, results of analyses of water from U.S. Geological Survey wells did not indicate a relation. Nitrogen and phosphorous concentrations were higher in the Detroit area, probably because of the urban and industrial environment rather than any specific use of land. Additional data will be necessary to establish, for example, the effect of agricultural chemicals on ground water and, ultimately, their effect on the connecting channels.

SUMMARY

The Upper Great Lakes Connecting Channels are the St. Marys, St. Clair and Detroit Rivers, and Lake St. Clair. These bodies of water function as conduits for the waters of the upper lakes (Superior, Michigan, and Huron) to drain into the lower lakes (Erie and Ontario).

Bedrock of the St. Clair-Detroit area consists predominantly of shales and limestones. Sandstone is the dominant bedrock type in the St. Marys area. Glacial deposits range from less than 100 ft in thickness in the southern part of the St. Clair-Detroit River area to more than 250 ft in thickness in the northern part. A high-resolution seismic survey showed that the thickness of the glacial deposits directly beneath the channels range from about 50 to 100 ft in the St. Clair River, from about 70 to over 150 ft in Lake St. Clair, and from less than 10 to about 70 ft in the Detroit River. Seismic surveys also show variability in types of deposits. Glacial deposits consist predominantly of silty clay tills and lacustrine deposits containing minor beds of sand and gravel.

Wells were installed at 25 locations throughout the four study areas. Three of these were in bedrock: one was in shale near Port Huron, and two were in limestone deposits south of Detroit. All others were installed in glacial deposits. Lithologic data obtained during drilling confirmed and added detail to existing rock descriptions.

Water-level data indicate that ground-water movement is toward the connecting channels in all areas. Ground water discharges directly to connecting channels from 16 areas. Five of these are in the St. Marys River area, four are in the St. Clair River area, four are in the Lake St. Clair area, and five are in the Detroit River area.

Base flow of perennial streams and Darcy's Law are the basis for ground-water discharge estimates. Discharge to the channels is higher where more permeable bedrock forms the channel, such as in the southern reach of the Detroit River and in most of the St. Marys River. The following ground-water flow rates have been estimated for each study area: St. Marys River area, 76 ft^3/s; St. Clair River area, 11 ft^3/s; Lake St. Clair area, 46 ft^3/s; and Detroit River area, 54 ft^3/s.

Analyses of organic compounds, trace metals, and other dissolved substances were made on water from 31 wells to determine the chemical characteristics of ground water. Concentrations of volatile hydrocarbons generally were less than the detection limit and, therefore, estimates of transport to connecting channels was impractical. Base neutral and chlorinated neutral extractable compounds were detected more frequently than were volatile hydrocarbons, but information also is insufficient to make valid estimates of amounts entering the connecting channels. Estimates of the amounts of trace metals and other dissolved substances transported by ground water were not made because of the finely divided particulate matter in the water. Trace metals may have been adsorbed on the particulate matter, and thus, contributed significantly to the measured concentrations. If so, concentrations of trace metals in ground water discharged to the connecting channels could be much lower than analyses indicate. No relation between water quality and land use was evident.

REFERENCES

Bredehoeft, J. D., Neuzil, C. E., and Milly, C. D., 1983, Regional flow in the Dakota aquifer: A study of the role of confining layers: U.S. Geological Survey Water-Supply Paper 2237, 45 p.

Brigham, R. J., 1971, Structural Geology of Southwestern Ontario and Southeastern Michigan: Paper 71-2, Ontario Department of Mines and Northern Affairs, Petroleum Resources Section, 112 p.

Cummings, T. R., Twenter, F. R., and Holtschlag, D. J., 1984, Hydrology and land use in Van Buren County, Michigan: U.S. Geological Survey Water-Resources Investigations Report 84-4112, 124 p.

Desaulniers, D. E., Cherry, J. A. and Fritz, P. 1981, Origin, Age and Movement of Pore Water in Argillaceous Quaternary Deposits at Four Sites in Southwestern Ontario: Journal of Hydrology, 50, p. 231-257.

Freeze, R. A., and Cherry, J. A., 1979, Groundwater: Prentice-Hall, Inc., Englewood Cliffs, NJ, 604 p.

Haeni, F. P., and Melvin, R. L., 1984, High resolution continuous seismic reflection study of a stratified drift deposit in Connecticut: In Proceedings of Surface and Borehole Geophysical Methods in Ground-Water Investigations, San Antonio, Texas, p. 237-256.

Haeni, F. P., 1986, Application of continuous seismic reflection methods to hydrologic studies: Ground Water, v. 24, no. 1, p. 23-31.

Jackson, R. E., 1987, Environment Canada's Studies of Hydrogeology of the St. Clair River Valley: National Water Research Institute, Environment Canada, unpublished report, 9 p.

Leverett, F. and Taylor, F. B., 1915, The Pleistocene of Indiana and Michigan and history of the Great Lakes: U.S. Geological Survey, Monograph 53, 529 p.

Martin, H. M., compiler, 1936, The centennial geological map of the northern peninsula of Michigan (and) The centennial geological map of the southern peninsula of Michigan: Michigan Deptartment of Conservation, Geological Survey Division Publication 39, Geology ser. 33, 2 sheets.

Martin, H. M., 1955, Map of the surface formations of the southern peninsula of Michigan: Michigan Geological Survey, Deptartment of Conservation, Publication 49, 2 sheets.

Mason, S., M. G. Sklash, S. Scott and C. Pugsley, 1986, An assessment of seepage of ground water into the St. Clair River near Sarnia, Ontario, Canada: Final report for Environment Canada, Great Lakes Inst. of the University of Windsor, 175 p.

Mozola, A. J., 1969, Geology for land and ground water development in Wayne County, Michigan: Michigan Geological Survey Investigations, no. 3, 25 p.

Sherzer, W. H., 1913, Geological report on Wayne County: Michigan Geological and Biological Survey, Publication 12, Geological Survey 9, 388 p.

Twenter, F. R., 1975, Ground water and geology--southeastern Michigan: U.S. Army Corps of Engineers, Detroit, Michigan, 143 p.

U.S. Environmental Protection Agency, 1986a, Maximum contaminant levels (subpart B of Part 141, national interim primary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised as of July 1, 1986, p. 524-528.

-----1986b, Secondary maximum contaminant levels (section 143.3 of part 143, national secondary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised as of July 1, 1986, p. 587-590.

U.S. Geological Survey, 1968, North Atlantic coast regional water-resources study: Geological Survey Research 1968, U.S. Geological Survey Professional Paper 600-A, p. A49-A50.

-----1979, Land use and land cover, 1975-76, Detroit, Mich.; Ontario, Can. (U.S. part only): U.S. Geological Survey Open-File Report 79-425-1, 1 sheet.

-----1984, Land use and land cover, 1980, Sault Sainte Marie, Mich., U.S.; Ontario, Can. (U.S. part only): U.S. Geological Survey Open-File Report 84-035-1, 1 sheet.

VanLier, K. E., and Deutsch, Morris, 1958, Reconnaissance of the ground-water resources of Chippewa County, Michigan: Michigan Geological Survey Progress Report 17, 56 p.

VanWyckhouse, R. J., 1966, A Study of test borings from the Pleistocene of the southeastern Michigan glacial lake plain, Wayne County, Michigan: Unpublished M.S. thesis, Department of Geology, Wayne State University, 85 p.

DEFINITION OF TERMS

Altitude. Vertical distance of a point or line above or below sea level. In this report, all altitudes are above sea level.

Altitude contour. An imaginary line connecting points of equal altitude, whether the points are on the land surface or on a potentiometric or water-table surface.

Aquifer. A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs. It is also called a ground-water reservoir.

Base flow. The discharge entering stream channels as inflow from ground water or other delayed sources; sustained or fair weather flow of streams.

Bedrock. Designates consolidated rocks underlying glacial deposits.

Concentration. The weight of dissolved solids or sediment per unit volume of water expressed in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Connecting channels. In this report, these bodies of water serve as conduits for the waters of the Upper Great Lakes (Superior, Michigan, and Huron) to drain into the lower Lakes (Erie and Ontario). The channels are the St. Marys, St. Clair and Detroit Rivers, and Lake St. Clair.

Discharge. The rate of flow of a stream; reported in cubic feet per second (ft^3/s). Also, in this report, the rate of flow of ground water to surface water bodies; reported in cubic feet per second per square mile [$(ft^3/s)/mi^2$].

Elevation.--Vertical distance of a point on land or surface-water surface above or below sea level.

Grain size. The classification range for the diameter of particles, in millimeters, is as follows:

Gravel	greater than 2.0
Sand, very coarse	1.0 - 2.0
Sand, coarse	0.5 - 1.0
Sand, medium	0.25 - 0.5
Sand, fine	0.125 - 0.25
Sand, very fine	0.0625 - 0.125
Silt and clay	less than 0.0625

Ground water. Water that is in the saturated zone from which wells, springs, and ground-water runoff are supplied.

Ground-water runoff. Ground water that has discharged into stream channels by seepage from saturated earth materials.

Head. The height of the surface of a water column above a standard datum that can be supported by the static pressure at a given point.

Hydraulic conductivity. The volume of water at the prevailing kinematic viscosity that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. In general terms, hydraulic conductivity is the ability of a porous medium to transmit water.

Hydraulic gradient. The change in static head per unit distance in a given direction. If not specified, the direction is generally understood to be that of the maximum rate of decrease in head.

Permeability. A measure of the relative ease with which a porous medium can transmit a liquid under a potential gradient. It is a property of the medium alone, and is independent of the nature of the fluid and of the force field.

Potentiometric surface. In aquifers, the levels to which water will rise in tightly cased wells. More than one potentiometric surface is required to describe the distribution of head. The water table is a particular potentiometric surface.

Recharge. The process by which water is infiltrated and is added to the zone of saturation. It is also the quantity of water added to the zone of saturation.

Runoff. That part of precipitation that appears in streams; the water draining from an area. When expressed in inches, it is the depth to which an area would be covered if all the water draining from it in a given period were uniformly distributed on its surface.

Specific conductance. A measure of the ability of water to conduct an electric current, expressed in microsiemens per centimeter at 25 degrees Celsius (µS/cm). Because the specific conductance is related to amount and type of dissolved material, it is used for approximating the dissolved-solids concentration of water. For most natural waters, the ratio of dissolved- solids concentration (in milligrams per liter) to specific conductance (in µS/cm) is in the range of 0.5 to 0.8.

Water table. That surface in an unconfined water body at which the pressure is atmospheric. It is defined by levels at which water stands in properly constructed wells.

APPENDIXES

APPENDIX A: GEOLOGIC SECTIONS

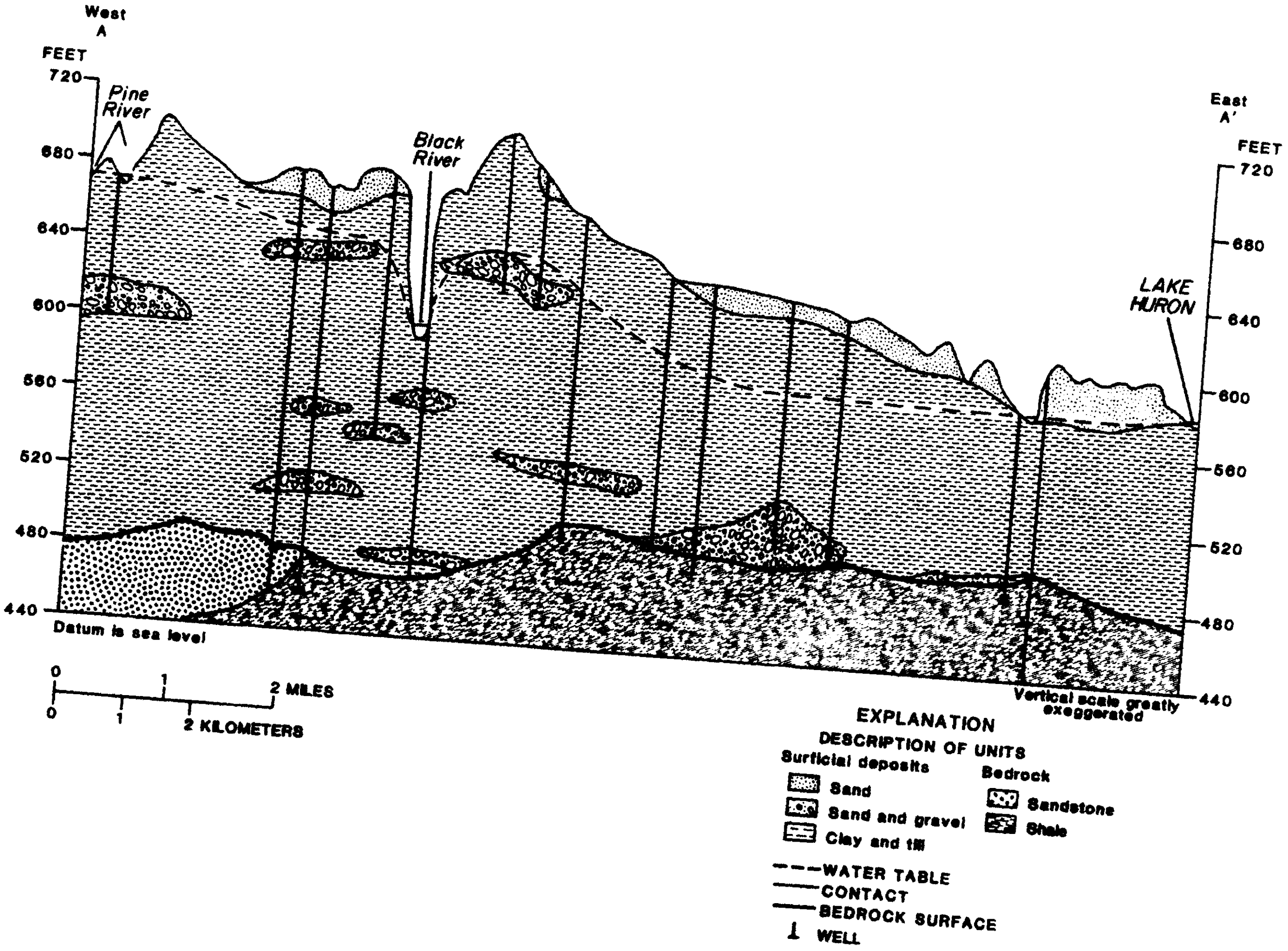

Figure 17.--Geologic section A-A', near Port Huron, Michigan.

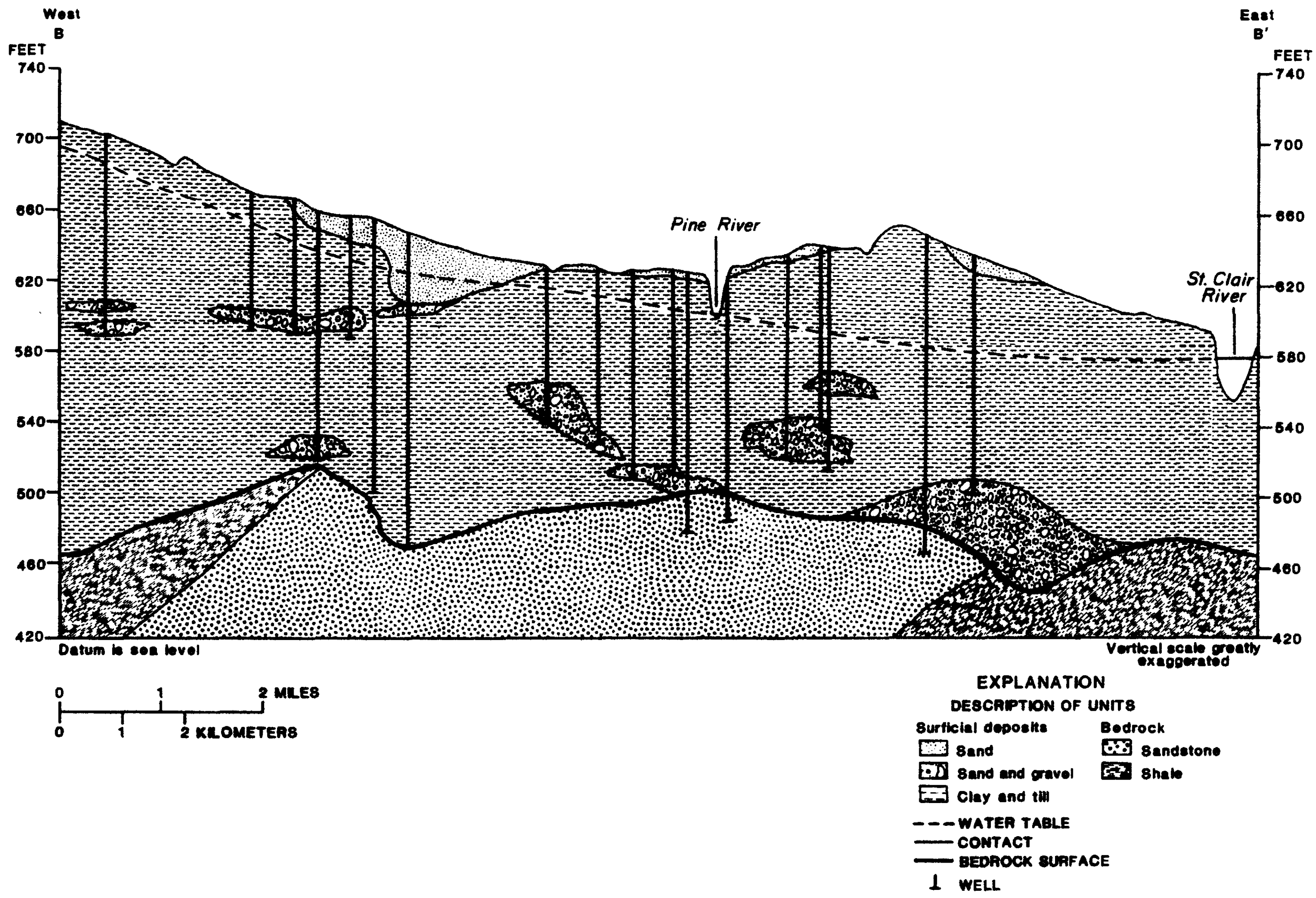

Figure 18.--Geologic section B-B', near Marysville, Michigan.

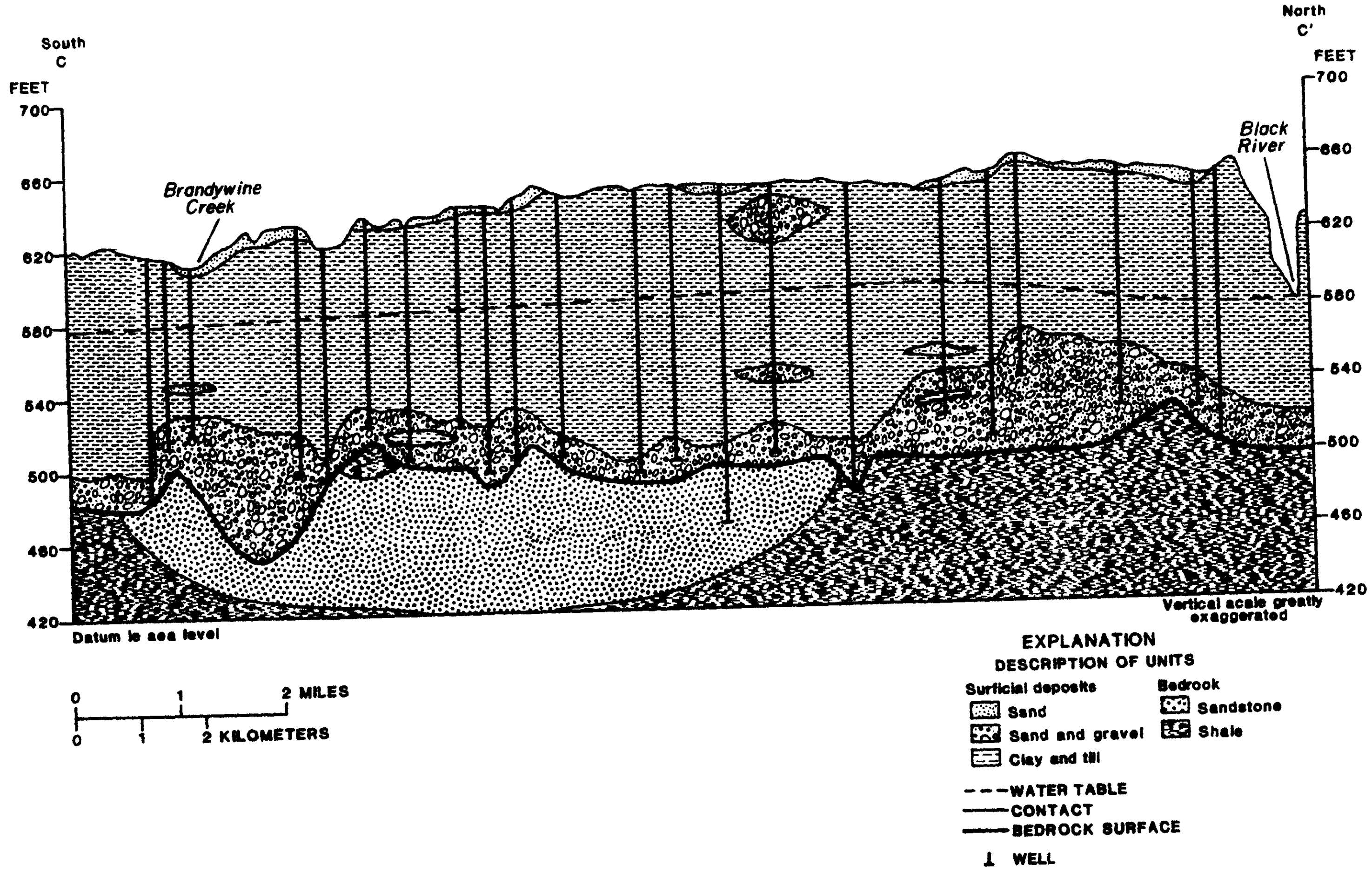

Figure 19.--Geologic section C-C', near Port Huron, Michigan.

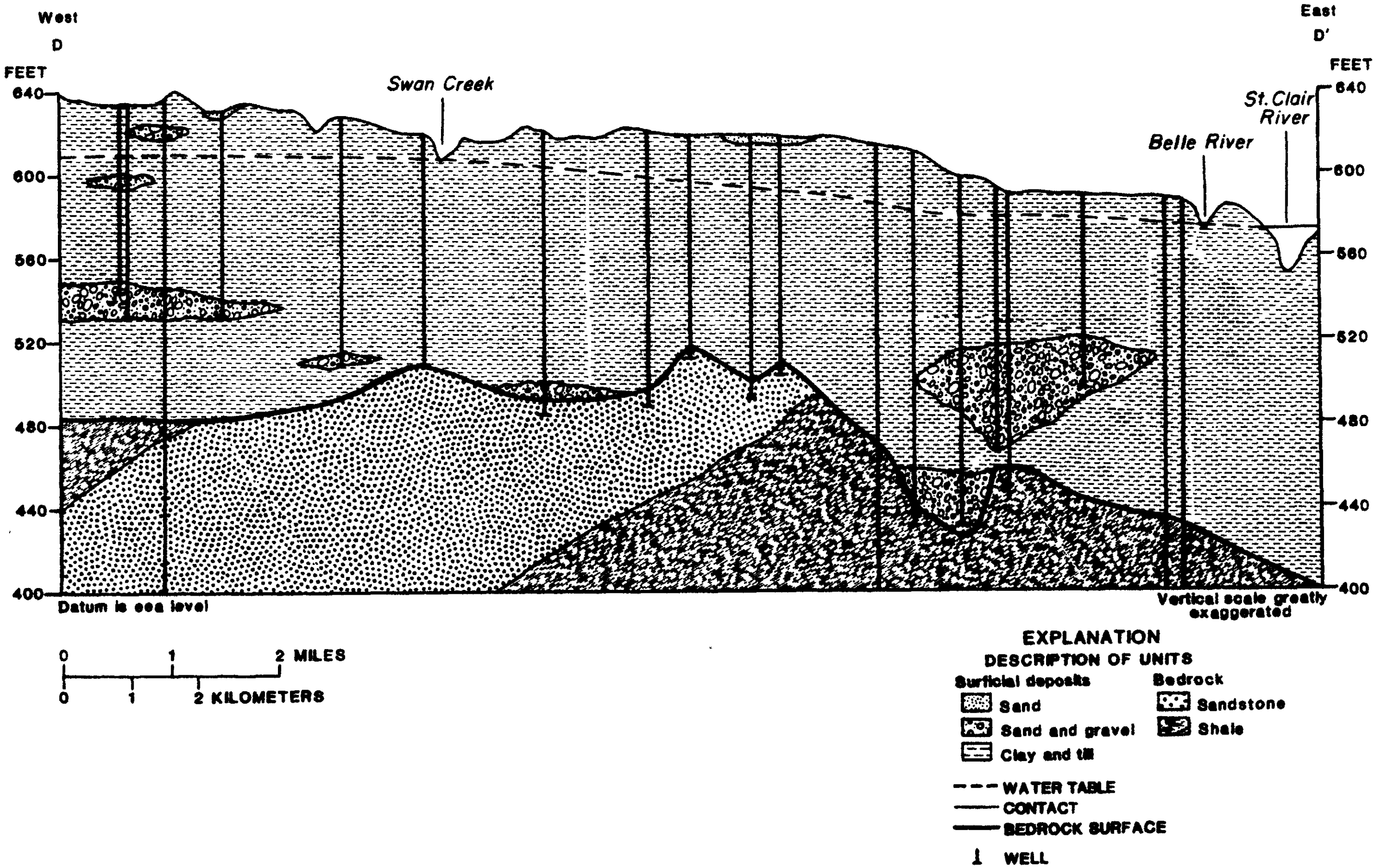

Figure 20.--Geologic section D-D', near Marine City, Michigan.

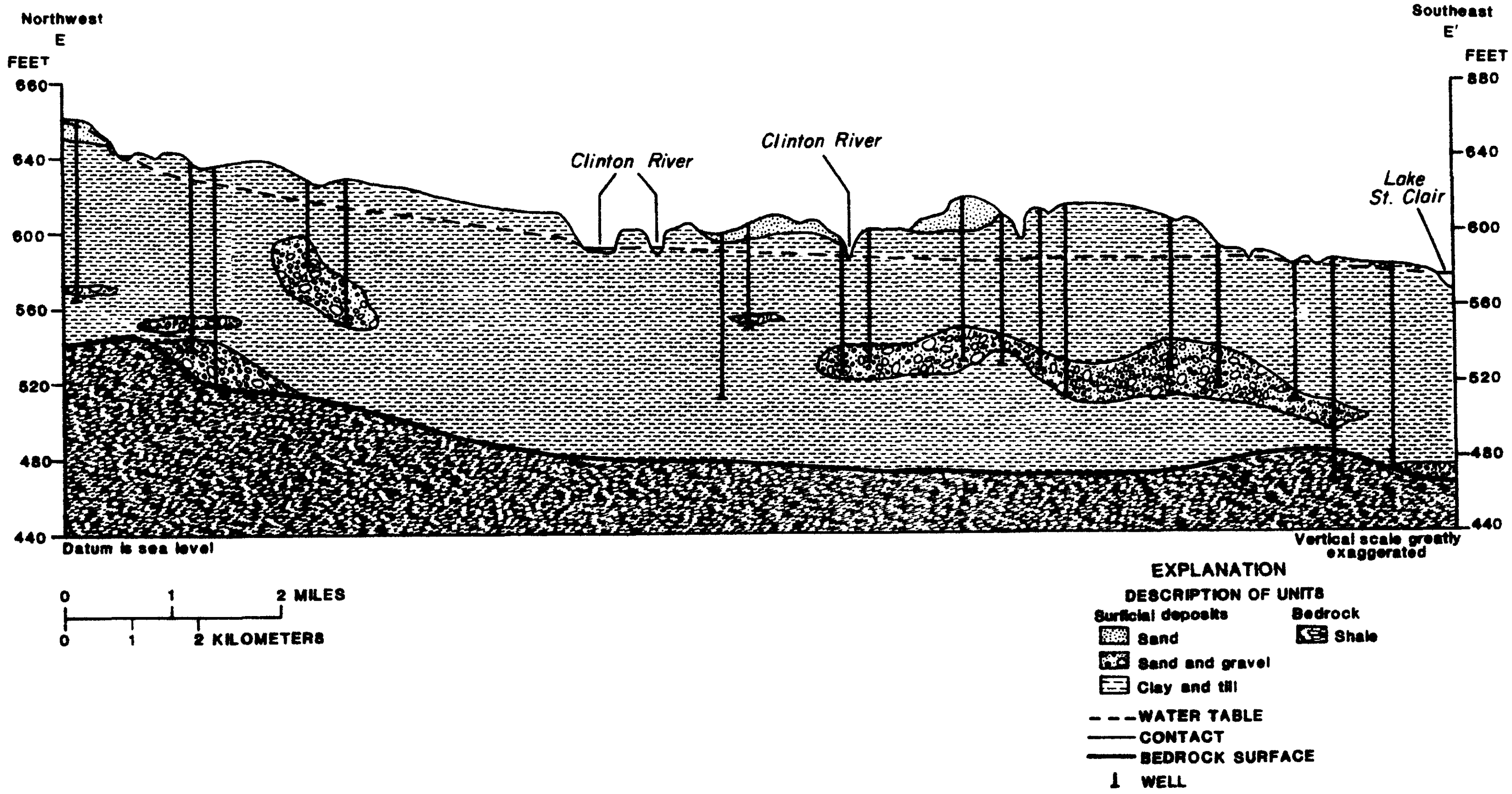

Figure 21.--Geologic section E-E', near Fraser, Michigan.

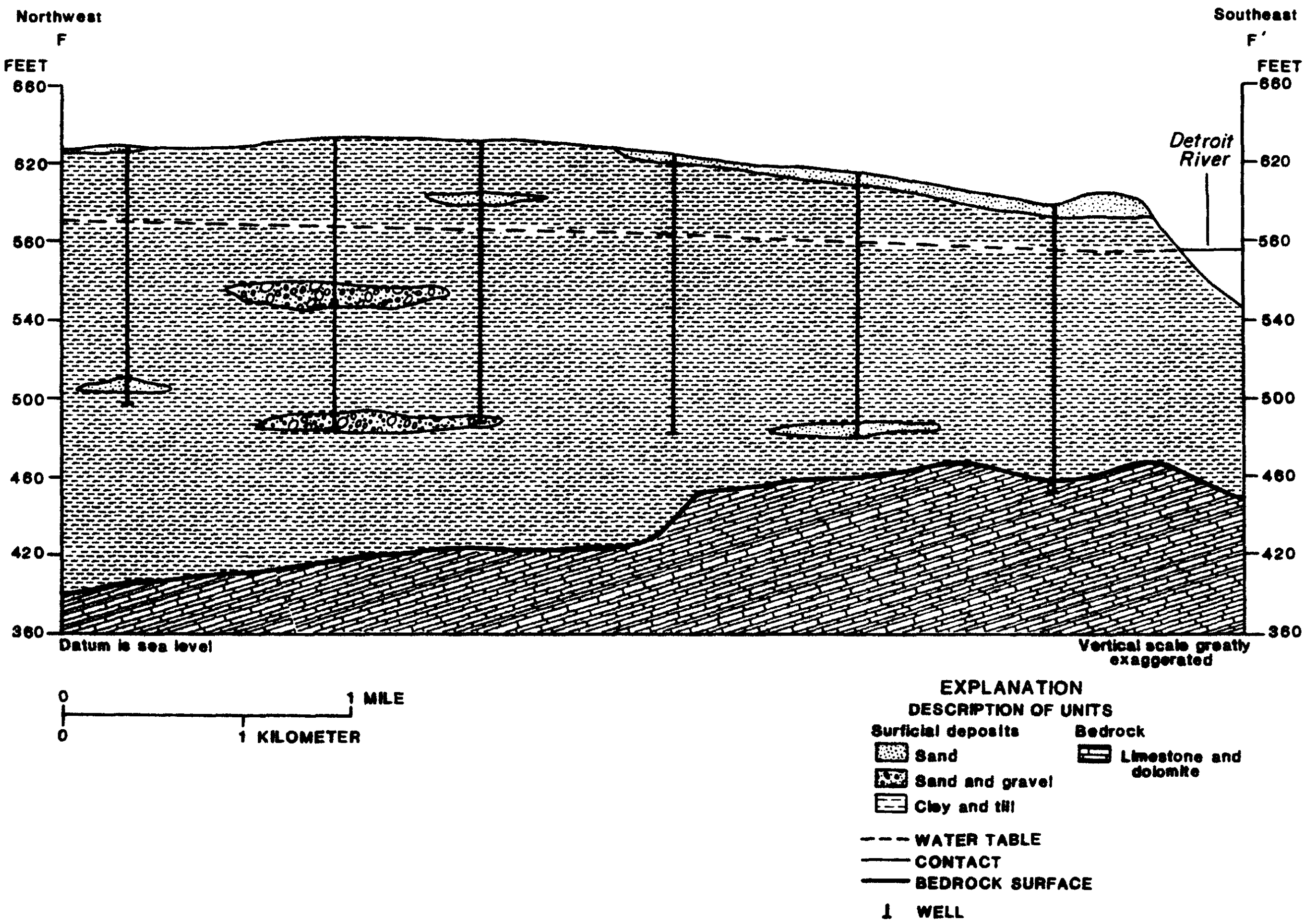

Figure 22.--Geologic section F-F', in Detroit, Michigan.

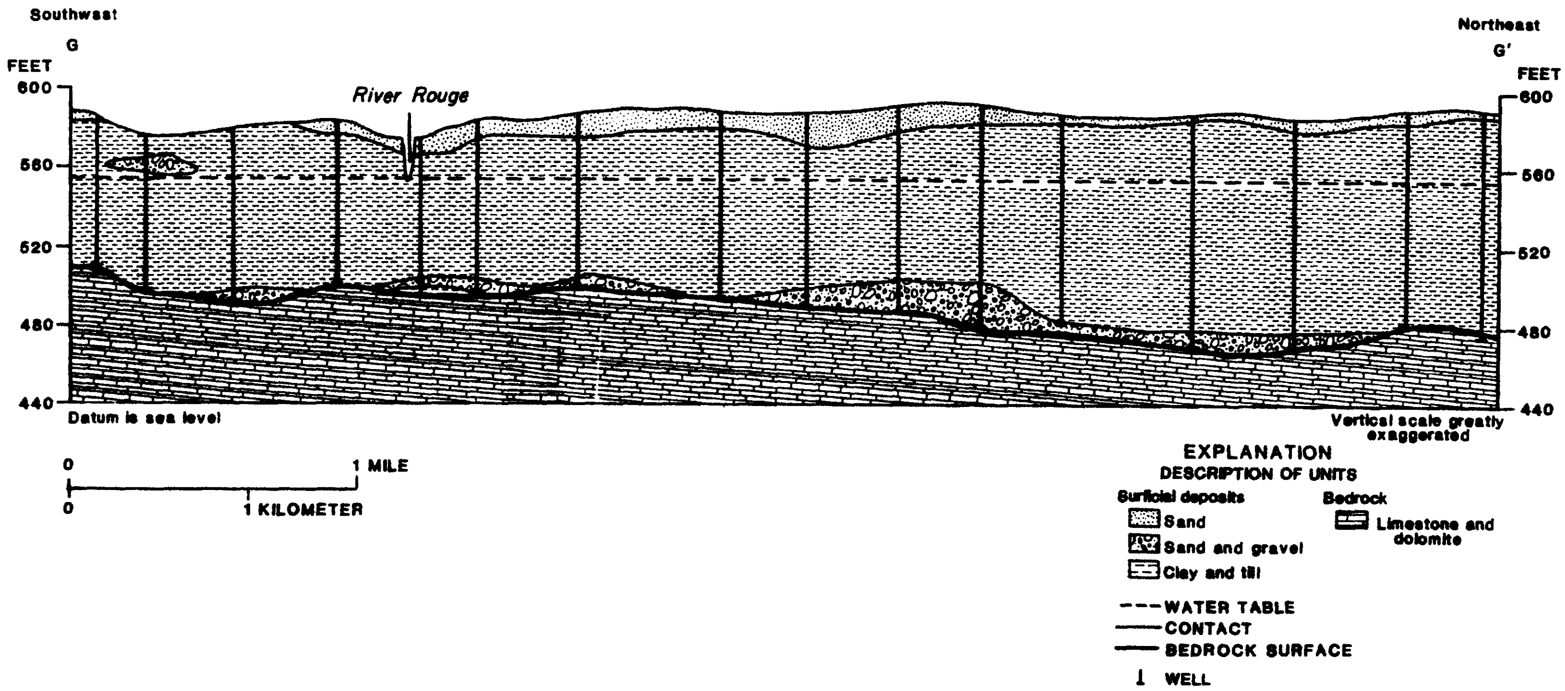

Figure 23.--Geologic section G-G', in Detroit, Michigan.

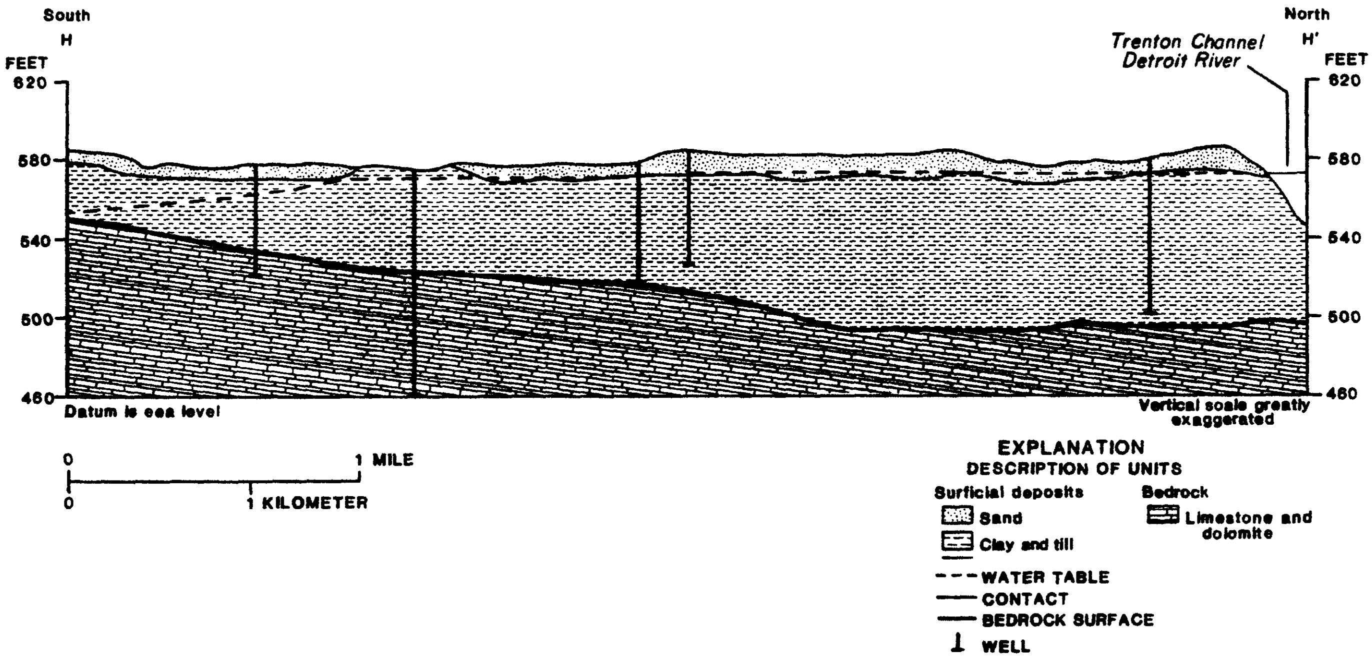

Figure 24.--Geologic section H-H', near Wyandotte, Michigan.

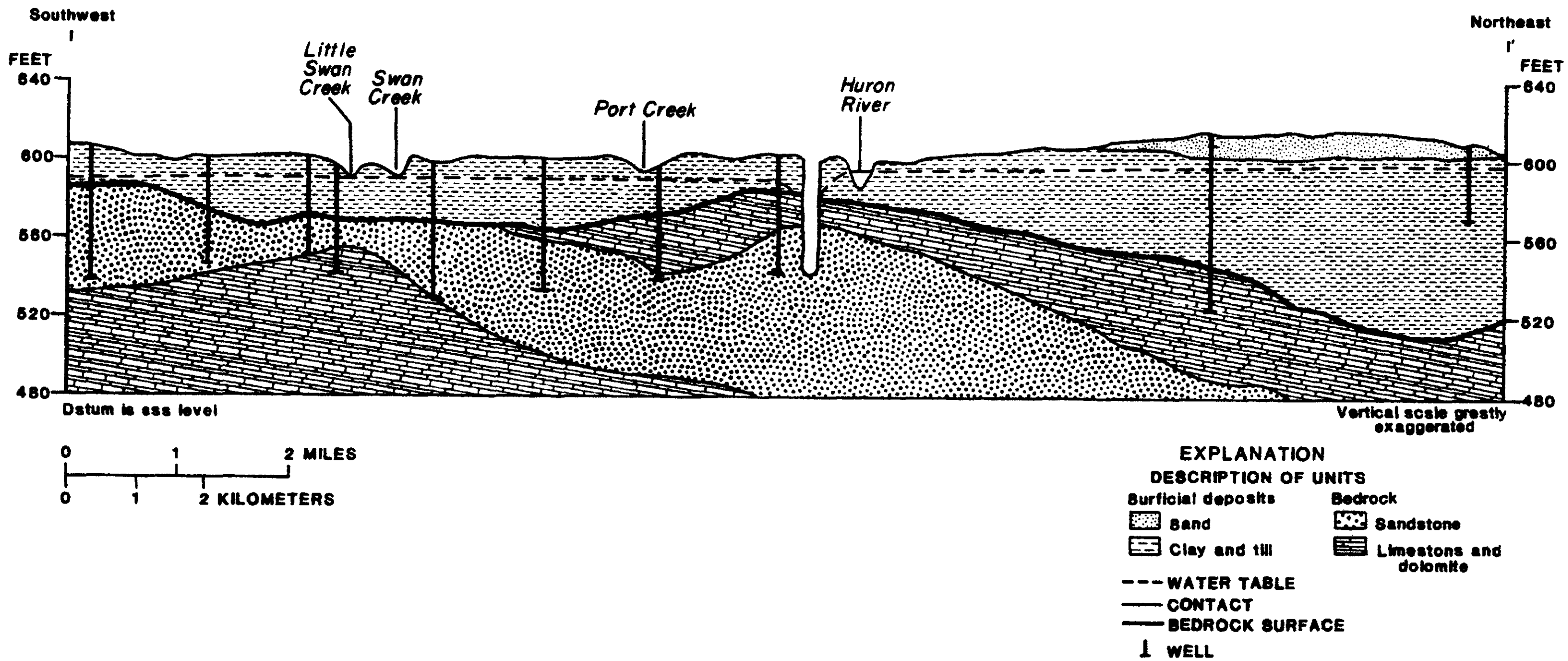

Figure 25.--Geologic section I-I', near Flat Rock, Michigan.

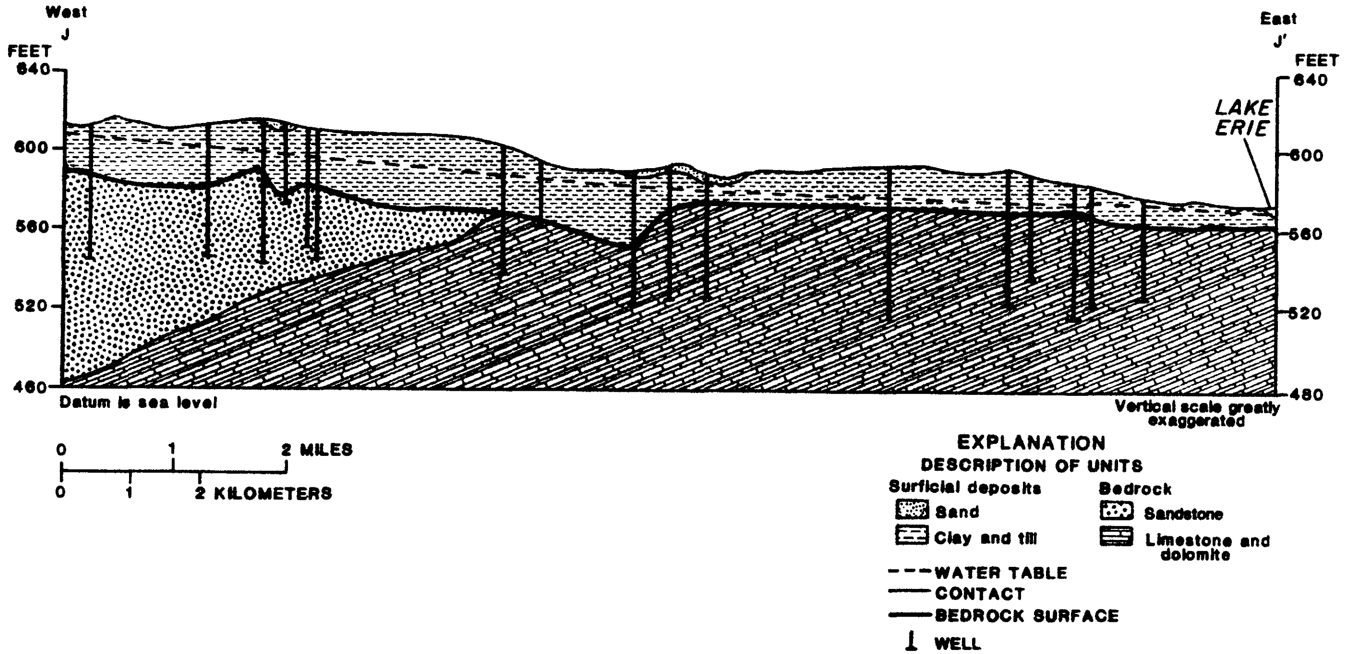

Figure 26.--Geologic section J-J', south of Rockwood, Michigan.

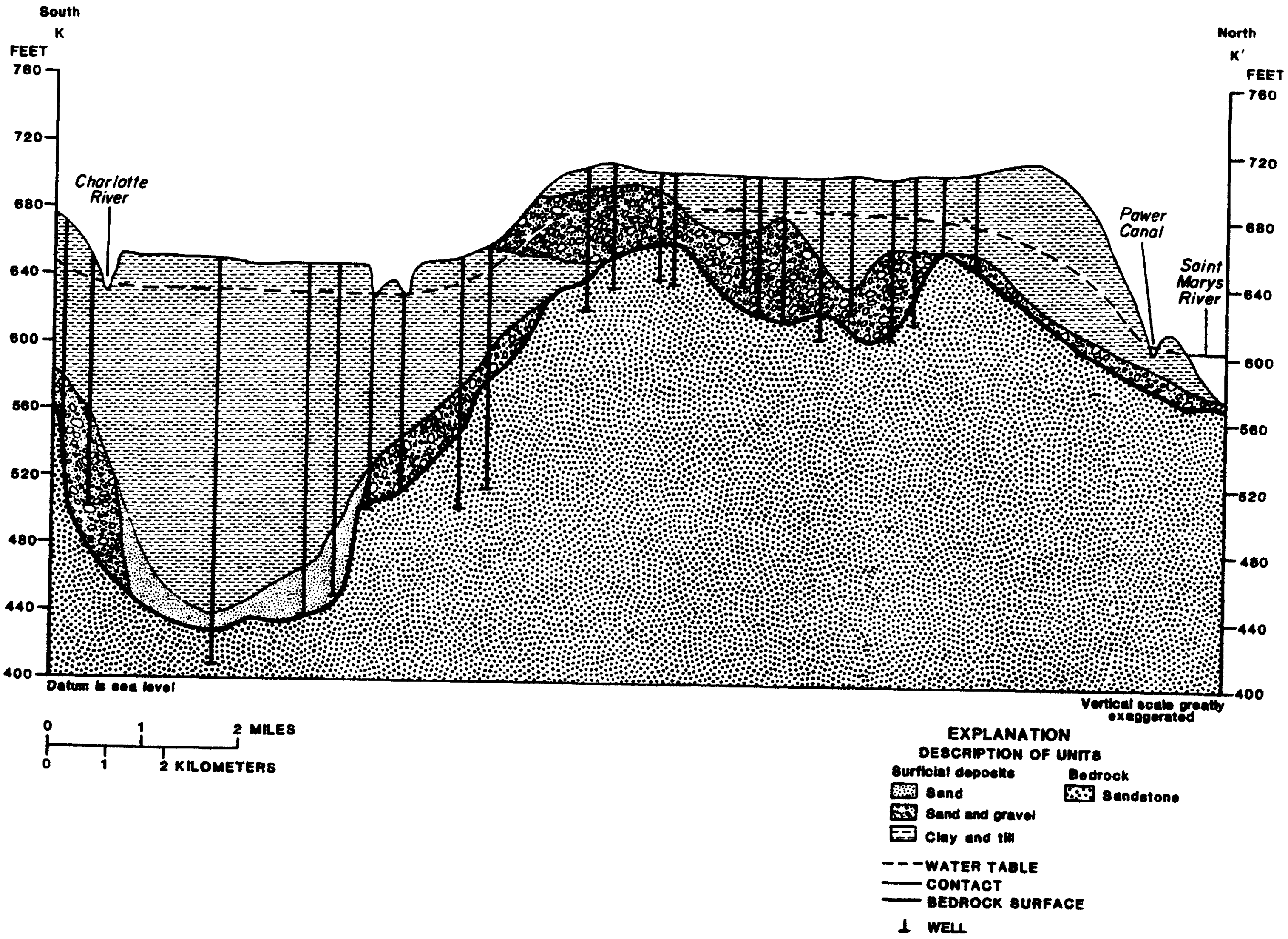

Figure 27.--Geologic section K-K', in Sault Ste. Marie, Michigan.

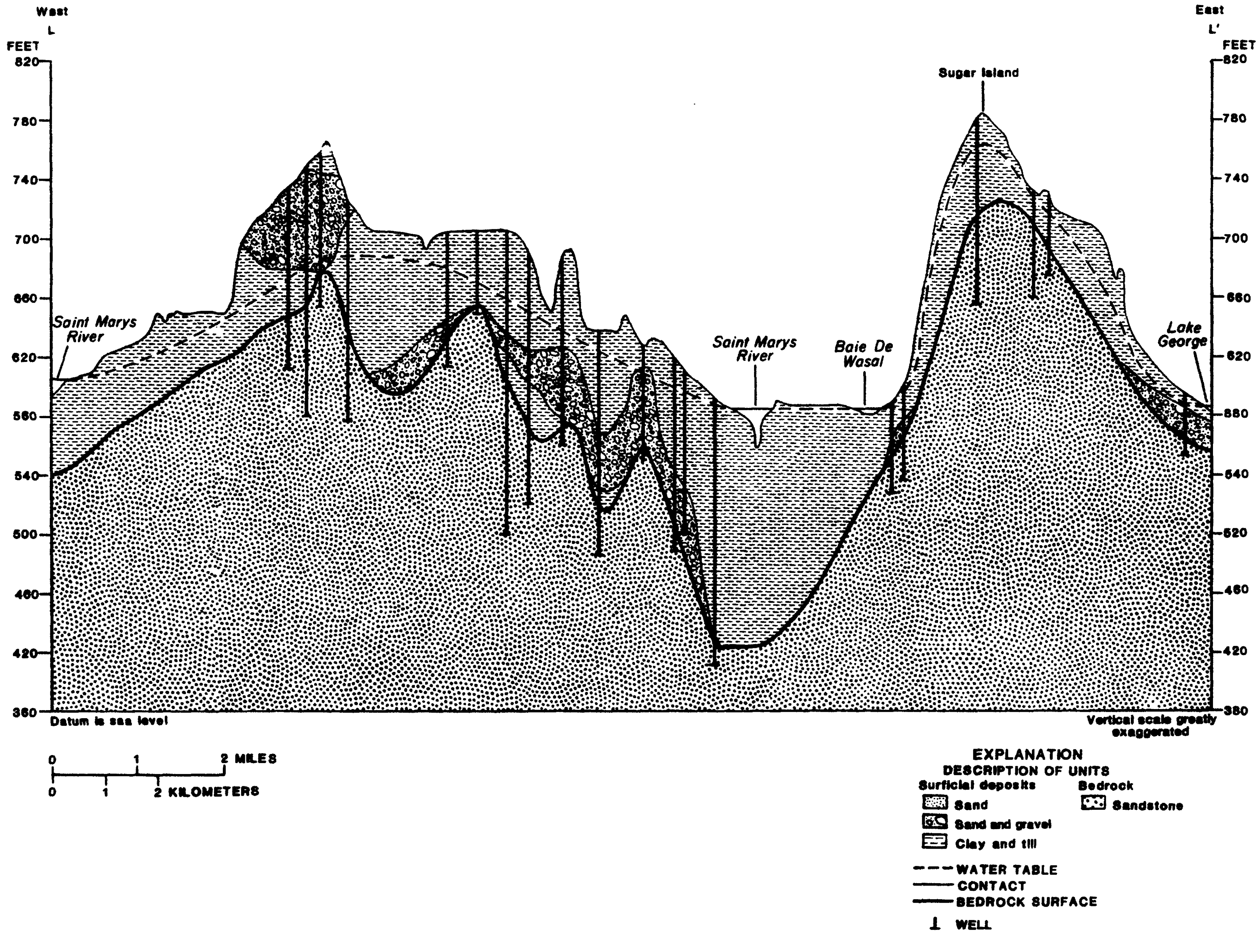

Figure 28.--Geologic section L-L', near Sault Ste. Marie, Michigan.

APPENDIX B. TABLES OF DATA

Table 6.--Selected data for wells installed by the U.S. Geological Survey

[in., inches; ft, feet]

Well number	Location	Ground water discharge area	Well diameter (in.)	Depth, total/screen (ft)	Geologic characterization: Depth (ft)	Geologic characterization: Description
G1	7N 17E 35BDD	1	2	34/27-31	0-6	Sand, gray, silty; damp
					6-27	Clay, gray, silty, includes black shale clast; damp
					27-30	Sand, gravel; wet
					30-34	Clay, gray, silty; damp
G2	6N 17E 15BDD	2	4	112/107-111	0-5	Fill
					5-35	Clay, brown, silty, trace sand; includes rock clast
					35-100	Clay, gray, silty; includes black shale clast; damp
					100-107	Clay, gray, silty; damp
					107-108	Round black shale fragments with coarse grain sand
					108-112	Black shale
G3	6N 17E 21CCB	2	2	50/41-45	0-12	Sand, brown-gray; dry
					12-21	Clay, gray, silty; damp
					21-22	Sand, gray, silty; damp
					22-41	Clay, gray, silty; damp
					41-44	Sand, gray, silty; damp
					45-50	Clay, gray, silty; damp
G4	5N 17E 7ADD	2	2	65/52-63	0-21	Clay, brown, silty, small shale clast; dry
					21-65	Clay, gray, silty; damp
G5	4N 17E 7DCD	3	2	48/44-48	0-10	Clay, brown, silty; dry
					0-48	Clay, gray, silty; damp
G6	4N 17E 30AAC	3	2	24/19-24	0-1	Clay, brown, silty; dry
					1-7	Clay, brown, silty; damp
					7-9	Organic material; clay; damp
					9-24	Sand, gray, fine; clay; wet

Table 6.--Selected data for wells installed by the U.S. Geological Survey--Continued

Well number	Location	Ground water discharge area	Well diameter (in.)	Depth, total/screen (ft)	Geologic characterization: Depth (ft)	Geologic characterization: Description
G7	3N 16E 14DDC	4a	2	52/43-52	0-2.5	Topsoil; gravel
					2.5-6	Sand, brown-tan; clay; dry
					6-16	Clay, brown-green, silty; trace gravel, fine; damp
					16-49	Clay, gray, silty; trace gravel, fine; damp
					49-52	No record
G8	3N 16E 9BCA	4a	2	28/21-28	0-2	Topsoil
					2-17	Clay, gray, silty; trace gravel, fine
					17-26	Clay, gray; trace gravel
					26-28	Clay, gray
G9	2N 16E 9BCA	4b	2	33/20-24	0-1	Topsoil
					1-5	Sand, yellow, fine
					5-26	Sand, gray, fine-medium; trace gravel
					26-28	Sand, gray, clayey
					28-33	Clay, gray
G10	3N 15E 23ADA	4b	2	52/43-52	0-.5	Topsoil
					.5-3.5	Fill, clay, rocks, brick
					3.5-9	Clay, brown-gray, silty; dry
					9-13	Clay, brown, silty; damp
					13-49	Clay, gray, silty; trace gravel, fine; damp
					49-52	No record
G11	3N 15E 17AAC	5	2	48/38-48	0-.5	Topsoil
					.5-9	Clay, brown; dry
					9-48	Clay, gray; wet
G12	3N 14E 23DA	5	2	42/35-42	0-1.5	Topsoil
					1.5-5	Clay, brown, sandy-silty; trace gravel; damp
					5-6	Clay, gray, sandy
					6-28	Clay, brown-gray, silty; damp
					28-39	Clay, gray; wet
					39-42	No record

Table 6.--Selected data for wells installed by the U.S. Geological Survey--Continued

Well number	Location	Ground water discharge area	Well diameter (in.)	Depth, total/screen (ft)	Geologic characterization: Depth (ft)	Geologic characterization: Description
G13	2N 14E 5DB	5	2	33/23-33	0-2.5	Topsoil
					2.5-6	Clay, brown; dry
					6-9	Clay, brown-gray; damp
					9-29.5	Clay, gray; wet
					29.5-33	Sand, tan-gray, fine, clayey; dry
G14	2N 14E 29AC	6	2	49/45-49	0-5	Sand
					5-49	Clay, gray, silty; trace gravel; wet
G15	1N 13E 14BAA	7a	2	49/45-49	0-4	Sand, tan, silty; fill; clay
					4-12	Clay, brown, silty; trace gravel
					12-22	Clay, gray, silty; damp
					22-49	Clay, gray; wet
G16	1S 13E 22DD	7a	2	48/44-48	0-2	Topsoil
					2-12	Clay, brown; trace gravel, fine; dry
					12-48	Clay, gray; trace gravel, fine; slightly damp
G17	2S 12E 1AAD	7b	2	30.5/15.5-	0-8.5	Fill, dirt, sand, clay, gravel, metal, bricks; damp
					8.5-12	Fill; wet
					12-30	Sand, clayey; gravel; wet
G18	3S 11E 5ADA	9	2	47/33-47	0-7	Topsoil, fill
					7-12	Clay, brown, silty; dry
					12-17	Clay, brown, silty; damp
					17-43	Clay, gray, silty; trace gravel, fine; damp
					43-47	No record
G19	3S 11E 9CDA	9	2	50/41-50	0-3	Fill, dirt, brick
					3-7	Clay, dark gray; dirt; dry
					7-14	Clay, brown-tan, silty; damp
					14-18	Clay, brown, silty; wet
					18-50	Clay, dull gray, silty; trace gravel; wet

Table 6.--Selected data for wells installed by the U.S. Geological Survey--Continued

Well number	Location	Ground water discharge area	Well diameter (in.)	Depth, total/screen (ft)	Geologic characterization: Depth (ft)	Geologic characterization: Description
G20	5S 10E 1A	11	2	27/ -- (open hole 19.5-27)	0-2	Topsoil
					2-4	Clay, brown, silty; dry
					4-11	Clay, brown, silty; gravel, fine; dry
					11-19.5	Clay, gray, silty; trace gravel; dry
					19.5-22	Clay, gravel, dry
					22-27	Limestone
G21	5S 10E 12DC	11	2	33.5/26-30 (open hole	0-13	Clay, brown, silty; dry
					13-15	Clay, light gray, silty; trace gravel, fine medium; dry
					15-25	Clay, dark gray, silty; trace gravel,small-medium; dry
					25-26	Clay, dark gray, silty; gravel, fine; wet
					26-28	Clay, gray; gravel; wet
					28-33.5	Limestone
G22	47N 1W 31BB	12	4	44/40-44	0-1	Topsoil
					1-2	Sand, tan
					2-36	Clay, red-brown
					36-40	Clay, red-brown; trace gravel
					40-44	Sand, tan, very fine; clay, red-brown
G23	47N 1W 11BA	13	4	21/17-21	0-3	Leather waste; dry
					3-7	Leather waste; wet
					7-11	Sand, red-brown, very fine, silty; wet
					11-15	Sand, gray-red, very fine, silty; clay, light brown, wet
					15-21	Sand, tan, very fine, silty; clay, light brown, wet

Table 6.--Selected data for wells installed by the U.S. Geological Survey--Continued

Well number	Location	Ground water discharge area	Well diameter (in.)	Depth, total/screen (ft)	Geologic characterization: Depth (ft)	Geologic characterization: Description
G24	47N 1E 5DD	13	4	53/49-53	0-1.5	Topsoil, trace gravel
					1.5-2.5	Topsoil; sand; gravel
					2.5-42	Clay, brown; trace sand, fine
					42-48	Clay, brown; sand, tan, fine; trace gravel
					48-53	Sand, tan, fine; clay, brown
G25	45N 2E 19AA	14	4	22/17-21	0-.5	Topsoil
					.5-2	Fill, dirt, clay, gravel
					2-17	Clay, gray, silty
					17-22	Sand, fine-coarse

Table 7.--Concentrations of volatile hydrocarbons in ground water discharging to the Upper Great Lakes connecting channels

[Analyses by the U.S. Geological Survey. Concentrations are in µg/L (micrograms per liter). Values underlined are greater than the detection limit. < means less than]

Compound	Location and well number							
	St. Clair River area							
	G1[1]	G2	G3	G4	G5	G6	G7	G8
Benzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Bromoform	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Carbon Tetrachloride	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chlorobenzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chlorodibromomethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
2-Chloroethylvinylether	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chloromethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chloroform	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
m-Dichlorobenzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
o-Dichlorobenzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
p-Dichlorobenzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Dichlorobromomethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Dichlorodifluoromethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1-Dichloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-Dichloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1-Dichloroethylene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-(trans)Dichloroethylene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-Dichloropropane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,3-Dichloropropene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Ethyl benzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-Dibromoethylene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Methylbromide	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Methylene chloride	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Styrene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1,2,2-Tetrachloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Tetrachloroethylene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Toluene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1,1-Trichloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1,2-Trichloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Trichloroethlyene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Trichlorofluoromethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Vinyl Chloride	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Xylenes	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

[1] Wells designated as "G" wells are those installed by the U.S. Geological Survey

Table 7.--Concentrations of volatile hydrocarbons in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number									
	Lake St. Clair area									
	G9	G10	G11	G11[1]	G12	G13	G14	G15	G15[1]	G16
Benzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<u>3.1</u>	<3.0	<3.0	<3.0
Bromoform	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Carbon Tetrachloride	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chlorobenzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chlorodibromomethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
2-Chloroethylvinylether	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chloromethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chloroform	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
m-Dichlorobenzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
o-Dichlorobenzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
p-Dichlorobenzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Dichlorobromomethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Dichlorodifluoromethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1-Dichloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-Dichloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1-Dichloroethylene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-(trans)Dichloroethylene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-Dichloropropane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,3-Dichloropropene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Ethyl benzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-Dibromoethylene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Methylbromide	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Methylene chloride	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Styrene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1,2,2-Tetrachloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Tetrachloroethylene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Toluene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1,1-Trichloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1,2-Trichloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Trichloroethlyene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Trichlorofluoromethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Vinyl Chloride	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Xylenes	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

[1] Duplicate sample collected for quality assurance/quality control

Table 7.--Concentrations of volatile hydrocarbons in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number								
	Detroit River area								
	G17	P1[1/]	G18	G19	P2	G20	P3	P3[2/]	G21
Benzene	<3.0	270	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Bromoform	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Carbon Tetrachloride	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chlorobenzene	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chlorodibromomethane	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chloroethane	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
2-Chloroethylvinylether	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chloromethane	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chloroform	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
m-Dichlorobenzene	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
o-Dichlorobenzene	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
p-Dichlorobenzene	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Dichlorobromomethane	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Dichlorodifluoromethane	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1-Dichloroethane	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-Dichloroethane	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1-Dichloroethylene	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-(trans)Dichloroethylene	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-Dichloropropane	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,3-Dichloropropene	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Ethyl benzene	<3.0	410	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-Dibromoethylene	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Methylbromide	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Methylene chloride	<3.0	<20	<3.0	<3.0	5.9	<3.0	<3.0	<3.0	<3.0
Styrene	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1,2,2-Tetrachloroethane	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Tetrachloroethylene	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Toluene	<3.0	24	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1,1-Trichloroethane	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1,2-Trichloroethane	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Trichloroethlyene	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Trichlorofluoromethane	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Vinyl Chloride	<3.0	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Xylenes	<3.0	740	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

[1] Wells designated as "P" wells are private wells

[2] Duplicate sample collected for quality assurance/quality control

Table 7.--Concentrations of volatile hydrocarbons in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number							
	St. Marys River area							
	G22	P4	G23	G24	P5	P6	G25	G25[1]
Benzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Bromoform	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Carbon Tetrachloride	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chlorobenzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chlorodibromomethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
2-Chloroethylvinylether	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chloromethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chloroform	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
m-Dichlorobenzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
o-Dichlorobenzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
p-Dichlorobenzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Dichlorobromomethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Dichlorodifluoromethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1-Dichloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-Dichloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1-Dichloroethylene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-(trans)Dichloroethylene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-Dichloropropane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,3-Dichloropropene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Ethyl benzene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,2-Dibromoethylene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Methylbromide	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Methylene chloride	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Styrene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1,2,2-Tetrachloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Tetrachloroethylene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Toluene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1,1-Trichloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
1,1,2-Trichloroethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Trichloroethlyene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Trichlorofluoromethane	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Vinyl Chloride	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Xylenes	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

[1] Duplicate sample collected for quality assurance/quality control

Table 8.--Concentrations of base neutral, acid extractable, and chlorinated neutral extractable compounds in ground water discharging to the Upper Great Lakes connecting channels

[Analyses by the U.S. Geological Survey. Concentrations are in µg/L (micrograms per liter). Values underlined are greater than the detection limit. < means less than]

Compound	Location and well number							
	St. Clair River area							
	G1[1]	G2	G3	G4	G5	G6	G7	G8
Acenaphthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Acenaphthylene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Aldrin	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Anthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo (a) anthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo (b) fluoranthene	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Benzo (k) fluoranthene	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Benzo (g,h,i) perylene	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Benzo (a) pyrene	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Bis (2-chloroethoxy) methane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Bis (2-chloroethyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Bis (2-chloroisopropyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Bis (2-ethyl hexyl) phthalate	80.0	<5.0	1,500	<5.0	<5.0	<5.0	6.0	<5.0
4-Bromophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Butyl benzyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	6.0	6.0
Chlordane	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
2-Chlorophenol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2-Chloronapthalene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
4-Chlorophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
4-Chloro-3-methylphenol	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0
Chrysene	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
DDD	<.010	<.010	<.010	<.010	<.010	<.010	<.010	<.010
DDE	<.010	<.010	<.010	<.010	<.010	<.010	<.010	<.010
DDT	<.010	<.010	<.010	<.010	<.010	<.010	<.010	<.010
Dibenzo (a,h) anthracene	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
1,2-Dichlorobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,3-Dichlorobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,4-Dichlorobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2,4-Dichlorophenol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Dieldrin	<.010	<.010	<.010	<.010	<.010	<.010	<.010	<.010
Diethyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2,4-Dimethylphenol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Dimethyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Di-n-butyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
4,6-Dinitro-2-methylphenol	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0
2,4-Dinitrophenol	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
2,4-Dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

[1] Wells designated as "G" wells are those installed by the U.S. Geological Survey

Table 8.--Concentrations of base neutral, acid extractable, and chlorinated neutral extractable compounds in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number							
	St. Clair River area							
	G1	G2	G3	G4	G5	G6	G7	G8
2,6-Dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Di-n-octylphthalate	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Endosulfan	<.010	<.010	<.010	<.010	<.010	.080	<.010	<.010
Endrin	<.010	<.010	<.010	<.010	<.010	<.010	<.010	<.010
Fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Fluorene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Gross polychlorinated biphenyls	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
Gross polychlorinated naphthalenes	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Heptachlor	<.010	<.010	<.010	<.010	<.010	<.010	<.010	<.010
Heptachlor epoxide	<.010	<.010	<.010	<.010	<.010	<.010	<.010	<.010
Hexachlorobenzene	0	0	0	0	0	0	0	0
Hexachlorobutadiene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hexachlorocyclopentadiene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hexachloroethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Indeno (1,2,3-cd) pyrene	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Isophorone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Lindane	<.010	<.010	<.010	<.010	<.010	<.010	<.010	<.010
Methoxychlor	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Mirex	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Naphthalene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Nitrobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2-Nitrophenol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
4-Nitrophenol	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0
n-Nitrosodimethylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
n-Nitrosodi-n-propylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
n-Nitrosodiphenylamine	<5.0	<5.0	10.0	<5.0	<5.0	<5.0	<5.0	<5.0
Octachlorostyrene	0	0	0	0	0	0	0	0
Pentachlorophenol	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0
Perthane	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
Phenanthrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Phenol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Toxaphene	<1	<1	<1	<1	<1	<1	<1	<1
1,2,4-Trichlorobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2,4,6-Trichlorophenol	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0

Table 8.--Concentrations of base neutral, acid extractable, and chlorinated neutral extractable compounds in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number							
	Lake St. Clair area							
	G9	G10	G11	G11[1/]	G11[2/] RPD	G12	G13	G14
Acenaphthene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Acenaphthylene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Aldrin	<.01	<.01	<.050	<.050	0	<.01	<.01	<.050
Anthracene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Benzo (a) anthracene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Benzo (b) fluoranthene	<10.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
Benzo (k) fluoranthene	<10.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
Benzo (g,h,i) perylene	<10.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
Benzo (a) pyrene	<10.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
Bis (2-chloroethoxy) methane	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Bis (2-chloroethyl) ether	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Bis (2-chloroisopropyl) ether	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Bis (2-ethyl hexyl) phthalate	100	<5.0	170	560	107	<5.0	51.0	38.0
4-Bromophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Butyl benzyl phthalate	9.0	<5.0	25.0	37	39	12.0	16.0	<5.0
Chlordane	<.1	<.1	<.5	<.5	0	<.1	<.1	<.5
2-Chlorophenol	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
2-Chloronapthalene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
4-Chlorophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
4-Chloro-3-methylphenol	<30.0	<30.0	<30.0	<30.0	0	<30.0	<30.0	<30.0
Chrysene	<10.0	<10.0	<10.0	<5.0	0	<10.0	<10.0	<10.0
DDD	<.010	<.010	<.050	<.050	0	<.010	<.010	<.050
DDE	<.010	<.010	<.050	<.050	0	<.010	<.010	<.050
DDT	.080	<.010	.41	<.050	--	<.010	<.010	<.050
Dibenzo (a,h) anthracene	<10.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
1,2-Dichlorobenzene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
1,3-Dichlorobenzene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
1,4-Dichlorobenzene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
2,4-Dichlorophenol	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Dieldrin	<.010	<.010	<.050	<.050	0	<.010	<.010	<.050
Diethyl phthalate	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
2,4-Dimethylphenol	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Dimethyl phthalate	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Di-n-butyl phthalate	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
4,6-Dinitro-2-methylphenol	<30.0	<30.0	<30.0	<30.0	0	<30.0	<30.0	<30.0
2,4-Dinitrophenol	<20.0	<20.0	<20.0	<20.0	0	<20.0	<20.0	<20.0
2,4-Dinitrotoluene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0

[1] Duplicate sample collected for quality assurance/quality control
[2] RPD (relative percent difference) is the difference between the two sample values, divided by the mean of the values, multiplied by 100. RPD is not calculated if one of the values is reported as less than (<).

Table 8.--Concentrations of base neutral, acid extractable, and chlorinated neutral extractable compounds in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number							
	Lake St. Clair area							
	G9	G10	G11	G11[1]	G11[2] RPD	G12	G13	G14
2,6-Dinitrotoluene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Di-n-octylphthalate	<10.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
Endosulfan	<.010	<.010	<.050	<.050	0	<.010	<.010	<.050
Endrin	<.010	<.010	<.050	<.050	0	<.010	<.010	<.050
Fluoranthene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Fluorene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Gross polychlorinated biphenyls	<.1	<.1	<.5	<.5	0	<.1	<.1	<.5
Gross polychlorinated naphthalenes	<.10	<.10	<.50	<.50	0	<.10	<.10	<.50
Heptachlor	<.010	<.010	<.050	.05	--	<.010	.14	<.050
Heptachlor epoxide	<.010	<.010	<.050	<.050	0	<.010	<.010	<.050
Hexachlorobenzene	0	0	0	0	0	0	0	0
Hexachlorobutadiene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Hexachlorocyclopentadiene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Hexachloroethane	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Indeno (1,2,3-cd) pyrene	<10.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
Isophorone	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Lindane	.030	<.01	<.050	<.050	0	<.010	<.010	<.050
Methoxychlor	<.01	<.01	<.05	<.05	0	<.01	<.01	<.05
Mirex	<.01	<.01	<.05	<.05	0	<.01	<.01	<.05
Naphthalene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Nitrobenzene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
2-Nitrophenol	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
4-Nitrophenol	<30.0	<30.0	<30.0	<30.0	0	<30.0	<30.0	<30.0
n-Nitrosodimethylamine	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
n-Nitrosodi-n-propylamine	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
n-Nitrosodiphenylamine	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Octachlorostyrene	0	0	0	0	0	0	0	0
Pentachlorophenol	<30.0	<30.0	<30.0	<30.0	0	<30.0	<30.0	<30.0
Perthane	<.1	<.1	<.5	<.5	0	<.1	<.1	<.5
Phenanthrene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Phenol	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Pyrene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Toxaphene	<1	<1	<5	<5	0	<1	<1	<5
1,2,4-Trichlorobenzene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
2,4,6-Trichlorophenol	<20.0	<20.0	<20.0	<20.0	0	<20.0	<20.0	<20.0

[1] Duplicate sample collected for quality assurance/quality control
[2] RPD (relative percent difference) is the difference between the two sample values, divided by the mean of the values, multiplied by 100. RPD is not calculated if one of the values is reported as less than (<).

Table 8.--Concentrations of base neutral, acid extractable, and chlorinated neutral extractable compounds in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number							
	Lake St. Clair area continued				Detroit River Area			
	G15	G15[1/]	G15[2/] RPD	G16	G17	P1[3/]	G18	G19
Acenaphthene	<5.0	<5.0	0	<5.0	<5.0	15.0	<5.0	<5.0
Acenaphthylene	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Aldrin	<.050	<.050	0	<.050	<.01	<.01	<.01	<.01
Anthracene	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo (a) anthracene	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzo (b) fluoranthene	<10.0	<10.0	0	<10.0	10.0	<10.0	<10.0	<10.0
Benzo (k) fluoranthene	<10.0	<10.0	0	<10.0	<10.0	<10.0	<10.0	<10.0
Benzo (g,h,i) perylene	<10.0	<10.0	0	<10.0	10.0	<10.0	<10.0	<10.0
Benzo (a) pyrene	<10.0	<10.0	0	<10.0	12.0	<10.0	<10.0	<10.0
Bis (2-chloroethoxy) methane	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Bis (2-chloroethyl) ether	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Bis (2-chloroisopropyl) ether	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Bis (2-ethyl hexyl) phthalate	75.0	46	48	13.0	350	<5.0	<5.0	<5.0
4-Bromophenyl phenyl ether	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Butyl benzyl phthalate	<5.0	<5.0	0	24.0	14.0	<5.0	27.0	8.0
Chlordane	<.5	<.5	0	<.5	<.1	<.1	<.1	<.1
2-Chlorophenol	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
2-Chloronapthalene	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
4-Chlorophenyl phenyl ether	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
4-Chloro-3-methylphenol	<30.0	<30.0	0	<30.0	<30.0	<30.0	<30.0	<30.0
Chrysene	<10.0	<10.0	0	<10.0	<10.0	<10.0	<10.0	<10.0
DDD	<.050	<.050	0	<.050	<.010	<.010	<.010	<.010
DDE	<.050	<.050	0	<.050	<.010	<.010	<.010	<.010
DDT	.20	.20	0	<.050	<.010	<.010	<.010	<.010
Dibenzo (a,h) anthracene	<10.0	<10.0	0	<10.0	<10.0	<10.0	<10.0	<10.0
1,2-Dichlorobenzene	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
1,3-Dichlorobenzene	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
1,4-Dichlorobenzene	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
2,4-Dichlorophenol	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Dieldrin	<.050	<.050	0	<.050	<.010	<.010	<.010	<.010
Diethyl phthalate	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
2,4-Dimethylphenol	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Dimethyl phthalate	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Di-n-butyl phthalate	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
4,6-Dinitro-2-methylphenol	<30.0	<30.0	0	<30.0	<30.0	<30.0	<30.0	<30.0
2,4-Dinitrophenol	<20.0	<20.0	0	<20.0	<20.0	<20.0	<20.0	<20.0
2,4-Dinitrotoluene	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0

[1] Duplicate sample collected for quality assurance/quality control
[2] RPD (relative percent difference) is the difference between the two sample values, divided by the mean of the values, multiplied by 100. RPD is not calculated if one of the values is reported as less than (<).
[3] Wells designated as "P" wells are private wells

Table 8.--Concentrations of base neutral, acid extractable, and chlorinated neutral extractable compounds in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number							
	Lake St. Clair area continued				Detroit River area			
	G15	G15[1/]	G15[2/] RPD	G16	G17	P1[3/]	G18	G19
2,6-Dinitrotoluene	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Di-n-octylphthalate	<10.0	<10.0	0	<10.0	<10.0	<10.0	<10.0	<10.0
Endosulfan	<.050	<.050	0	<.050	<.010	<.010	<.010	<.010
Endrin	<.050	<.050	0	<.050	<.010	<.010	<.010	<.010
Fluoranthene	<5.0	<5.0	0	<5.0	6.0	<5.0	<5.0	<5.0
Fluorene	<5.0	<5.0	0	<5.0	<5.0	9.0	<5.0	<5.0
Gross polychlorinated biphenyls	<.5	<.5	0	<.5	<.1	<.1	<.1	<.1
Gross polychlorinated naphthalenes	<.50	<.50	0	<.50	<.10	<.10	<.10	<.10
Heptachlor	<.050	.07	--	<.050	<.010	.021	<.010	<.010
Heptachlor epoxide	<.050	<.050	0	<.050	<.010	<.010	<.010	<.010
Hexachlorobenzene	0	0	0	0	0	0	0	0
Hexachlorobutadiene	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Hexachlorocyclopentadiene	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Hexachloroethane	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Indeno (1,2,3-cd) pyrene	<10.0	<10.0	0	<10.0	<10.0	<10.0	<10.0	<10.0
Isophorone	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Lindane	<.050	<.050	0	<.050	<.010	<.010	<.010	<.010
Methoxychlor	<.05	<.05	0	<.05	<.01	<.01	<.01	<.01
Mirex	<.05	<.05	0	<.05	<.01	<.01	<.01	<.01
Naphthalene	<5.0	<5.0	0	<5.0	<5.0	250	<5.0	<5.0
Nitrobenzene	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
2-Nitrophenol	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
4-Nitrophenol	<30.0	<30.0	0	<30.0	<30.0	<30.0	<30.0	<30.0
n-Nitrosodimethylamine	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
n-Nitrosodi-n-propylamine	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
n-Nitrosodiphenylamine	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Octachlorostyrene	0	0	0	0	0	0	0	0
Pentachlorophenol	<30.0	<30.0	0	<30.0	<30.0	<30.0	<30.0	<30.0
Perthane	<.5	<.5	0	<.5	<.1	<.1	<.1	<.1
Phenanthrene	<5.0	<5.0	0	<5.0	11.0	13.0	<5.0	<5.0
Phenol	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
Pyrene	<5.0	<5.0	0	<5.0	9.0	<5.0	<5.0	<5.0
Toxaphene	<5	<5	0	<5	<1	<1	<2	<1
1,2,4-Trichlorobenzene	<5.0	<5.0	0	<5.0	<5.0	<5.0	<5.0	<5.0
2,4,6-Trichlorophenol	<20.0	<20.0	0	<20.0	<20.0	<20.0	<20.0	<20.0

[1] Duplicate sample collected for quality assurance/quality control
[2] RPD (relative percent difference) is the difference between the two sample values, divided by the mean of the values, multiplied by 100. RPD is not calculated if one of the values is reported as less than (<).
[3] Wells designated as "P" wells are private wells

Table 8.--Concentrations of base neutral, acid extractable, and chlorinated neutral extractable compounds in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number							
	Detroit River area continued						St. Marys River area	
	P2	G20	P3	P3[1/]	P3[2/] RPD	G21	G22	P4
Acenaphthene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Acenaphthylene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Aldrin	<1.0	<.010	<.010	<.010	0	<.010	<.010	<.010
Anthracene	11.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Benzo (a) anthracene	17.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Benzo (b) fluoranthene	26.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
Benzo (k) fluoranthene	20.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
Benzo (g,h,i) perylene	23.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
Benzo (a) pyrene	30.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
Bis (2-chloroethoxy) methane	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Bis (2-chloroethyl) ether	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Bis (2-chloroisopropyl) ether	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Bis (2-ethyl hexyl) phthalate	150	76.0	<5.0	<5.0	0	26.0	<5.0	<5.0
4-Bromophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Butyl benzyl phthalate	<5.0	20.0	<5.0	<5.0	0	8.0	<5.0	<5.0
Chlordane	<.1	<.1	<.1	<.1	0	<.1	<.1	<.1
2-Chlorophenol	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
2-Chloronapthalene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
4-Chlorophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
4-Chloro-3-methylphenol	<30.0	<30.0	<30.0	<30.0	0	<30.0	<30.0	<30.0
Chrysene	15.0	<10.0	<10.0	<5.0	--	<10.0	<10.0	<10.0
DDD	<.010	<.010	<.010	<.010	0	<.010	<.010	<.010
DDE	<.010	<.010	<.010	<.010	0	<.010	<.010	<.010
DDT	<.010	<.010	<.010	<.010	0	<.010	<.010	<.010
Dibenzo (a,h) anthracene	16.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
1,2-Dichlorobenzene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
1,3-Dichlorobenzene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
1,4-Dichlorobenzene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
2,4-Dichlorophenol	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Dieldrin	<.010	<.010	<.010	<.010	0	<.010	<.010	<.010
Diethyl phthalate	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
2,4-Dimethylphenol	48.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Dimethyl phthalate	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Di-n-butyl phthalate	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
4,6-Dinitro-2-methylphenol	<30.0	<30.0	<30.0	<30.0	0	<30.0	<30.0	<30.0
2,4-Dinitrophenol	<20.0	<20.0	<20.0	<20.0	0	<20.0	<20.0	<20.0
2,4-Dinitrotoluene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0

[1] Duplicate sample collected for quality assurance/quality control
[2] RPD (relative percent difference) is the difference between the two sample values, divided by the mean of the values, multiplied by 100. RPD is not calculated if one of the values is reported as less than (<).

Table 8.--Concentrations of base neutral, acid extractable, and chlorinated neutral extractable compounds in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number							
	Detroit River area continued						St. Marys River area	
	P2	G20	P3	P3[1/]	P3[2/] RPD	G21	G22	P4
2,6-Dinitrotoluene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Di-n-octylphthalate	<10.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
Endosulfan	<.010	<.010	<.010	<.010	0	<.010	<.010	<.010
Endrin	.021	<.010	<.010	<.010	0	<.010	<.010	<.010
Fluoranthene	21.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Fluorene	10.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Gross polychlorinated biphenyls	<.1	<.1	<.1	<.1	0	<.1	<.1	<.1
Gross polychlorinated naphthalenes	<.10	<.10	<.10	<.10	0	<.10	<.10	<.10
Heptachlor	<.010	<.010	<.010	<.010	0	<.010	<.010	<.010
Heptachlor epoxide	<.010	<.010	<.010	<.010	0	<.010	<.010	<.010
Hexachlorobenzene	0	0	0	0	0	0	0	0
Hexachlorobutadiene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Hexachlorocyclopentadiene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Hexachloroethane	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Indeno (1,2,3-cd) pyrene	21.0	<10.0	<10.0	<10.0	0	<10.0	<10.0	<10.0
Isophorone	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Lindane	<.010	<.010	<.010	<.010	0	<.010	<.010	<.010
Methoxychlor	<.01	<.01	<.01	<.01	0	<.01	<.01	<.01
Mirex	<.01	<.01	<.01	<.01	0	<.01	<.01	<.01
Naphthalene	5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Nitrobenzene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
2-Nitrophenol	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
4-Nitrophenol	<30.0	<30.0	<30.0	<30.0	0	<30.0	<30.0	<30.0
n-Nitrosodimethylamine	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
n-Nitrosodi-n-propylamine	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
n-Nitrosodiphenylamine	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Octachlorostyrene	<5.0	<5.0	0	0	0	<5.0	<5.0	<5.0
Pentachlorophenol	<30.0	<30.0	<30.0	<30.0	0	<30.0	<30.0	<30.0
Perthane	<5.0	<5.0	<.1	<.1	0	<5.0	<5.0	<5.0
Phenanthrene	35.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Phenol	47.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Pyrene	19.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
Toxaphene	0	0	<1	<1	0	0	0	0
1,2,4-Trichlorobenzene	<5.0	<5.0	<5.0	<5.0	0	<5.0	<5.0	<5.0
2,4,6-Trichlorophenol	<20.0	<20.0	<20.0	<20.0	0	<20.0	<20.0	<20.0

[1] Duplicate sample collected for quality assurance/quality control
[2] RPD (relative percent difference) is the difference between the two sample values, divided by the mean of the values, multiplied by 100. RPD is not calculated if one of the values is reported as less than (<).

Table 8.--Concentrations of base neutral, acid extractable, and chlorinated neutral extractable compounds in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number						
	St. Marys River area continued						
	G23	G24	P5	P6	G25	G25[1]	G25[2] RPD
Acenaphthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Acenaphthylene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Aldrin	<.01	<.01	<.01	<.01	<.010	<.010	0
Anthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Benzo (a) anthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Benzo (b) fluoranthene	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	0
Benzo (k) fluoranthene	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	0
Benzo (g,h,i) perylene	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	0
Benzo (a) pyrene	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	0
Bis (2-chloroethoxy) methane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Bis (2-chloroethyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Bis (2-chloroisopropyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Bis (2-ethyl hexyl) phthalate	95.0	11.0	<5.0	<5.0	<5.0	<5.0	0
4-Bromophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Butyl benzyl phthalate	5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Chlordane	<.1	<.1	<.1	<.1	<.1	<.1	0
2-Chlorophenol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
2-Chloronapthalene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
4-Chlorophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
4-Chloro-3-methylphenol	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	0
Chrysene	<10.0	<10.0	<10.0	<10.0	<10.0	<5.0	--
DDD	<.010	<.010	<.010	<.010	<.010	<.010	0
DDE	<.010	<.010	<.010	<.010	<.010	<.010	0
DDT	<.010	<.010	<.010	<.010	<.010	<.010	0
Dibenzo (a,h) anthracene	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	0
1,2-Dichlorobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
1,3-Dichlorobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
1,4-Dichlorobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
2,4-Dichlorophenol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Dieldrin	<.010	<.010	<.010	<.010	<.010	<.010	0
Diethyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
2,4-Dimethylphenol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Dimethyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Di-n-butyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
4,6-Dinitro-2-methylphenol	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	0
2,4-Dinitrophenol	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	0
2,4-Dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0

[1] Duplicate sample collected for quality assurance/quality control
[2] RPD (relative percent difference) is the difference between the two sample values, divided by the mean of the values, multiplied by 100. RPD is not calculated if one of the values is reported as less than (<).

Table 8.--Concentrations of base neutral, acid extractable, and chlorinated neutral extractable compounds in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number						
	St. Marys River area continued						
	G23	G24	P5	P6	G25	G25[1]	G25[2] RPD
2,6-Dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Di-n-octylphthalate	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	0
Endosulfan	<.010	<.010	<.010	<.010	<.010	<.010	0
Endrin	<.010	<.010	<.010	<.010	<.010	<.010	0
Fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Fluorene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Gross polychlorinated biphenyls	<.1	<.1	<.1	<.1	<.1	<.1	0
Gross polychlorinated naphthalenes	<.10	<.10	<.10	<.10	<.10	<.10	0
Heptachlor	<.010	<.010	<.010	<.010	<.010	<.010	0
Heptachlor epoxide	<.010	<.010	<.010	<.010	<.010	<.010	0
Hexachlorobenzene	0	0	0	0	0	0	0
Hexachlorobutadiene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Hexachlorocyclopentadiene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Hexachloroethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Indeno (1,2,3-cd) pyrene	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	0
Isophorone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Lindane	<.010	<.010	<.010	<.010	<.010	<.010	0
Methoxychlor	<.01	<.01	<.01	<.01	<.01	<.01	0
Mirex	<.01	<.01	<.01	<.01	<.01	<.01	0
Naphthalene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Nitrobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
2-Nitrophenol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
4-Nitrophenol	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	0
n-Nitrosodimethylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
n-Nitrosodi-n-propylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
n-Nitrosodiphenylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Octachlorostyrene	<5.0	<5.0	<5.0	<5.0	0	0	0
Pentachlorophenol	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	0
Perthane	<5.0	<5.0	<5.0	<5.0	<.1	<.1	0
Phenanthrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Phenol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
Toxaphene	0	0	0	0	<1	<1	0
1,2,4-Trichlorobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0
2,4,6-Trichlorophenol	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	0

[1] Duplicate sample collected for quality assurance/quality control
[2] RPD (relative percent difference) is the difference between the two sample values, divided by the mean of the values, multiplied by 100. RPD is not calculated if one of the values is reported as less than (<).

Table 9.--Concentrations of trace metals and other dissolved substances in ground water discharging to the Upper Great Lakes connecting channels

[Analyses by the U.S. Geological Survey. -- means no analysis made. < means less than]

Compound	Location and well number					
	St. Clair River area					
	G1[1]	G2	G3	G4	G5	G6
Antimony, total (µg/L)	1	<1	<1	9	1	1
Arsenic, total (µg/L)	4	15	12	9	<1	2
Barium, dissolved (µg/L)	240	300	1,400	60	51	300
Beryllium, dissolved (µg/L)	<.5	<1	4	<1	<1	<1
Cadmium, total (µg/L)	<1	<1	<1	<1	<1	<1
Chromium, total (µg/L)	59	21	<1	18	17	26
Cobalt, total (µg/L)	20	10	200	2	<1	30
Copper, total (µg/L)	38	36	380	11	2	160
Iron, total (mg/L)	48	40	200	9.7	1.2	79
Lead, total (µg/L)	1,600	23	6,300	1,500	36	100
Mercury, total (µg/L)	.40	.50	<.10	.50	<.10	<.10
Nickel, total (µg/L)	52	56	400	6	<1	200
Selenium, total (µg/L)	<1	<1	<1	<1	<1	<1
Zinc, total (mg/L)	70	2.5	390	83	9.9	9.3
Carbon, total organic (mg/L)	28	16	17	30	3.6	18
Chloride (mg/L)	79	210	44	51	250	31
Cyanide, total (mg/L)	<.010	<.010	<.010	<.010	<.010	<.010
Dissolved solids (mg/L)	436	629	246	285	1,560	810
Oil-grease, total (mg/L)	6	5	3	7	4	5
Nitrogen, total (mg/L)	1.2	1.7	2.1	.20	1.8	2.3
pH (units)	10.1	8.4	10.9	11.2	11.0	8.1
Phenols, total (µg/L)	5	4	4	6	4	2
Phosphorus, total (mg/L)	.440	.570	.041	.070	.021	.120
Specific conductance (µS/cm)	[2]838	1,100	[2]427	720	2,380	1,190
Temperature (°C)	14.0	11.5	13.5	16.0	14.5	17.0

1 Wells designated as "G" wells are those installed by the U.S. Geological Survey
2 Laboratory value

Table 9.--Concentrations of trace metals and other dissolved substances in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number						
	St. Clair River area continued		Lake St. Clair area				
	G7	G8	G9	G10	G11	G12	G13
Antimony, total (µg/L)	13	1	3	2	5	1	5
Arsenic, total (µg/L)	13	4	2	2	8	<1	8
Barium, dissolved (µg/L)	96	2,100	78	110	79	4,000	1,000
Beryllium, dissolved (µg/L)	<1.0	21	<.5	<1	2	22	<.5
Cadmium, total (µg/L)	<1	<1	<1	<1	<1	<1	<1
Chromium, total (µg/L)	13	11	41	12	<1	<1	36
Cobalt, total (µg/L)	3	26	1	<1	<1	1	10
Copper, total (µg/L)	8	730	10	11	10	3	19
Iron, total (mg/L)	9.5	500	5.2	5.3	3.7	580	15
Lead, total (µg/L)	400	1,700	71	500	110	34	200
Mercury, total (µg/L)	.1	.3	.10	.20	.20	.30	.30
Nickel, total (µg/L)	11	1,300	11	6	2	<1	29
Selenium, total (µg/L)	<1	<1	<1	<1	<1	<1	<1
Zinc, total (mg/L)	26	78	9.6	21	21	74	16
Carbon, total organic (mg/L)	30	190	15	19	5.0	220	19
Chloride (mg/L)	56	11	14	280	530	5.6	32
Cyanide, total (mg/L)	<.010	<.010	<.010	<.010	<.010	<.010	<.010
Dissolved solids (mg/L)	218	145	230	1,020	1,530	144	3,920
Oil-grease, total (mg/L)	8	18	10	6	10	19	6
Nitrogen, total (mg/L)	2.5	--	1.3	3.0	.6	43	.20
pH (units)	10.9	10.3	8.5	11.4	7.5	10.7	[1]9.3
Phenols, total (µg/L)	4	4	5	4	3	7	8
Phosphorus, total (mg/L)	.16	.10	.008	.330	.090	.110	1.10
Specific conductance (µS/cm)	454	322	411	2,130	2,610	397	5,790
Temperature (°C)	12.5	12.5	14.5	14.0	12.0	18.5	14.0

[1] Laboratory value

Table 9.--Concentrations of trace metals and other dissolved substances in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number						
	Lake St. Clair area continued			Detroit River area			
	G14	G15	G16	G17	P1[1]	G18	G19
Antimony, total (µg/L)	5	1	5	--	--	<1	5
Arsenic, total (µg/L)	2	7	11	<1	58	3	13
Barium, dissolved (µg/L)	1,700	210	680	2,400	2,000	110	99
Beryllium, dissolved (µg/L)	260	14	4	13	<10	<1	<1
Cadmium, total (µg/L)	<1	1	4	<1	40	1	<1
Chromium, total (µg/L)	<1	25	12	<1	120	10	15
Cobalt, total (µg/L)	60	9	60	50	160	<1	<1
Copper, total (µg/L)	350	23	250	2,500	660	16	27
Iron, total (mg/L)	180	15	130	570	960	3.4	9.4
Lead, total (µg/L)	500	110	600	4,700	2,500	400	4,200
Mercury, total (µg/L)	.50	.20	.20	2.2	55	.40	.20
Nickel, total (µg/L)	500	19	400	900	880	7	2
Selenium, total (µg/L)	<1	<1	<1	<1	<1	<1	<1
Zinc, total (mg/L)	24	6.4	34	26	12	16	170
Carbon, total organic (mg/L)	68	7.5	14	330	1,000	9.3	29
Chloride (mg/L)	66	140	130	930	93	220	190
Cyanide, total (mg/L)	<.010	<.010	<.010	<.010	<.010	<.010	<.010
Dissolved solids (mg/L)	395	423	523	2,110	--	2,840	2,210
Oil-grease, total (mg/L)	3	3	2	4	--	4	13
Nitrogen, total (mg/L)	10	1.0	1.5	58	--	3.4	.90
pH (units)	8.8	8.6	10.6	7.0	6.6	9.0	10.1
Phenols, total (µg/L)	4	2	1	4	580	3	4
Phosphorus, total (mg/L)	1.10	.480	.710	3.80	2.2	.070	.830
Specific conductance (µS/cm)	686	776	942	3,620	3,110	3,070	[2]2,590
Temperature (°C)	13.0	10.5	13.0	13.5	14.0	15.0	14.5

1 Wells designated as "P" wells are private wells
2 Laboratory value

Table 9.--Concentrations of trace metals and other dissolved substances in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number					
	Detroit River area continued					
	P2	G20	P3	P3[1]	P3[2] RPD	G21
Antimony, total (µg/L)	4	1	<1	<1	0	1
Arsenic, total (µg/L)	84	2	<1	<1	0	4
Barium, dissolved (µg/L)	130	82	16	15	6	150
Beryllium, dissolved (µg/L)	1	<.5	<1	<1	0	3
Cadmium, total (µg/L)	<1	<1	5	<1	--	7
Chromium, total (µg/L)	3	30	30	26	14	29
Cobalt, total (µg/L)	6	<1	<1	<1	0	10
Copper, total (µg/L)	530	12	18	6	100	36
Iron, total (mg/L)	42	3	.12	.39	106	25
Lead, total (µg/L)	800	600	<5	8	--	300
Mercury, total (µg/L)	1.7	.70	.20	.30	40	<1.0
Nickel, total (µg/L)	1,500	6	4	3	29	42
Selenium, total (µg/L)	<1	<1	<1	<1	0	<1
Zinc, total (mg/L)	.39	12	.18	.63	192	9.6
Carbon, total organic (mg/L)	86	14	3.2	3.4	6	15
Chloride (mg/L)	64,000	32	18	23	24	27
Cyanide, total (mg/L)	<.010	<.010	<.010	<.010	0	<.010
Dissolved solids (mg/L)	114,000	1,390	2,380	2,240	6	2,420
Oil-grease, total (mg/L)	13	10	3	4	29	10
Nitrogen, total (mg/L)	.80	50	1.7	1.7	0	2.9
pH (units)	11.5	7.4	7.5	[3]7.9	52	7.4
Phenols, total (µg/L)	250	2	2	2	0	2
Phosphorus, total (mg/L)	.830	.600	.021	.041	65	.700
Specific conductance (µS/cm)	130,000	1,760	2,430	[3]2,400	1	2,440
Temperature (°C)	16.0	12.0	14.0	14.0	0	14.5

1 Duplicate sample collected for quality assurance/quality control
2 RPD (relative percent difference) is the difference between the two sample values, divided by the mean of the values, multiplied by 100. RPD is not calculated if one of the values is reported as less than (<).
3 Laboratory value

Table 9.--Concentrations of trace metals and other dissolved substances in ground water discharging to the Upper Great Lakes connecting channels--Continued

Compound	Location and well number						
	St. Marys River area						
	G22	P4	G23	G24	P5	P6	G25
Antimony, total (µg/L)	<1	--	1	<1	<1	<1	<1
Arsenic, total (µg/L)	1	2	1	2	1	1	1
Barium, dissolved (µg/L)	32	150	120	66	37	120	21
Beryllium, dissolved (µg/L)	<.5	<.5	<.5	<.5	<.5	<.5	<.5
Cadmium, total (µg/L)	<1	<1	<1	<1	<1	<1	5
Chromium, total (µg/L)	23	<1	320	42	15	<1	25
Cobalt, total (µg/L)	<1	<1	4	70	<1	<1	70
Copper, total (µg/L)	<1	1	19	3	3	1	2
Iron, total (mg/L)	<.01	.04	6.6	.28	.16	.08	3.5
Lead, total (µg/L)	<5	<5	49	12	<5	12	<5
Mercury, total (µg/L)	.30	.10	.1	.30	.30	.30	.10
Nickel, total (µg/L)	<1	2	11	<1	<1	<1	<1
Selenium, total (µg/L)	<1	<1	<1	<1	<1	<1	<1
Zinc, total (mg/L)	.24	.081	8.4	2	.009	.099	.22
Carbon, total organic (mg/L)	.7	.6	56	4.6	2.4	2.2	1.3
Chloride (mg/L)	.70	160	.8	7.3	15	140	.70
Cyanide, total (mg/L)	<.010	<.010	<.010	<.010	<.010	<.010	<.010
Dissolved solids (mg/L)	101	443	385	290	263	487	156
Oil-grease, total (mg/L)	1	2	5	<1	<1	1	<1
Nitrogen, total (mg/L)	.20	.40	.4	1.0	.40	.40	1.2
pH (units)	8.3	8.3	8.2	8.4	7.9	8.2	7.5
Phenols, total (µg/L)	2	2	7	6	2	2	3
Phosphorus, total (mg/L)	.021	.100	.43	.070	.041	.120	.021
Specific conductance (µS/cm)	154	700	639	474	410	876	252
Temperature (°C)	8.0	11.0	9.5	9.0	12.0	12.5	8.0