Geology and Ground-Water Resources of Portage County, Ohio

By JOHN D. WINSLOW *and* GEORGE W. WHITE

GEOLOGICAL SURVEY PROFESSIONAL PAPER 511

Prepared in cooperation with the Ohio Department of Natural Resources, Division of Water

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1966

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

Library of Congress catalog-card No. GS 66-310

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

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By JOHN D. WINSLOW and GEORGE W. WHITE

ABSTRACT

Portage County, Ohio, which has a population of 91,798 (1960 census), comprises an area of 504 square miles in the center of the industrial area of northeastern Ohio. The large manufacturing cities in adjoining counties include Cleveland, Akron, Youngstown, Canton, Warren, and Niles. At Hiram the average annual precipitation is 38.25 inches and the average annual temperature is 48.6°F. The average monthly temperatures in Portage County range from 26.3°F in January to 71.3°F in July.

The rocks of Portage County related to the availability of potable ground water comprise sandstone and shale units of Mississippian and Pennsylvanian age and glacial tills and outwash deposits that were deposited during two or more of the four major glacial stages. The consolidated rocks beneath the Cussewago and Berea Sandstones are principally shales, which are poor sources of ground water. The Cussewago Sandstone is present only in the eastern part of the county where it is likely to contain brine or brackish water. The Berea Sandstone contains brine in the southern part of the county, but in the northern part may contain potable water, as in Nelson Township, where wells at Garrettsville yielding as much as 50 gpm (gallons per minute) provide the water supply for the village. The best consolidated-rock aquifers are the sandstone members of the Pottsville Formation of Pennsylvanian age, namely the Sharon, the Connoquenessing, and the Homewood Members. Of these three, the Sharon Member generally is the best aquifer because its areal extent, thickness, and permeability are greatest. Wells in the Sharon yield as much as 200 gpm. The Connoquenessing Member of the Pottsville Formation is principally sandstone, but in some areas the unit contains considerable shale. The permeability of the Connoquenessing Sandstone Member generally is less than that of the Sharon Member. Where the Connoquenessing Sandstone Member is thick and coarse grained, it yields as much as 200 gpm to wells. One exceptionally good well in the consolidated rocks, an irrigation well on the Chadwick farm in Mantua Township, which penetrates both the Sharon and the Connoquenessing Members, yields 850 gpm. The Homewood Sandstone Member is the uppermost bedrock unit in the county, stratigraphically, and its distribution is limited to upland areas in the eastern part of the county. The Homewood Sandstone Member generally is a coarse-grained rock, and where its areal extent and thickness are favorable, principally in the southeastern part of the county, it yields as much as 200 gpm to wells.

The rugged topography of the bedrock surface of the county is, to a large extent, concealed by the mantle of glacial drift. Deep valleys cut by pre-Pleistocene and Pleistocene streams form a complex pattern. These valleys, in places deepened by glacial scour, subsequently were buried beneath the glacial drift. Where the drift filling the buried valleys is coarse sand and gravel, as in western Franklin, Brimfield, and Suffield Townships and in the buried valley that approximately underlies the Cuyahoga Valley in Streetsboro, Shalersville, and Mantua Townships, wells have yielded as much as 1,200 gpm. In other buried-valley areas, where the glacial deposits principally are fine sand, silt, and clay, the yields of wells are poor. Groundwater supplies in those areas are usually taken from thin, narrow, and discontinuous sand and gravel lenses that occur in the finer grained deposits. Unfortunately, the occurrence of such sand and gravel lenses ordinarily cannot be predicted in advance of drilling.

The chemical quality of water from the Pennsylvanian sandstones and the glacial drift in Portage County is satisfactory for most purposes. The quality of water from the Berea Sandstone is satisfactory for most purposes in the northern part of the county, although the water usually is saltier than that in the overlying aquifers. All potable ground water in the county is hard to very hard and contains moderate to excessive amounts of dissolved mineral constituents. The total hardness of the ground-water samples analyzed ranged from 82 to 740 ppm (parts per million); the bicarbonate ranged from 10 to 522 ppm, fluoride from 0.1 to 0.6 ppm and silica from 6.2 to 16 ppm. Manganese, as much as 0.66 ppm, was present. Sodium and chloride generally were low, but concentrations of as much as 468 and 508 ppm, respectively, were noted. Sulfate ranged from 0.6 to 505 ppm. The pH ranged from 5.9 to 7.9.

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESTIGATION

This report is based on field investigations of the geology and ground-water resources of Portage County, Ohio, begun in 1950 and continued intermittently until 1956. The purpose of the report is to describe the bedrock and glacial geology in relation to the ground-water resources of the county, and the availability and quality of ground water in the various parts of the county, such information being useful as a guide in the development of domestic, public, agricultural, and industrial supplies.

For this purpose it has been necessary to investigate and map the Devonian, Mississippian, and Pennsylvanian rocks that constitute the bedrock in the county, and to map the glacial and alluvial deposits of Pleistocene and Recent age, respectively. The data upon which this report is based are from field investigations of the geology, from seismic profiles made to determine the configuration of the rock surface beneath the glacial drift, and from the records of several thousand water wells, oil-and-gas wells, and test holes which give the general lithology and thickness of the stratigraphic units.

The report is one of a series of county water-resources reports prepared as part of the program to investigate the water resources of Ohio; the program is being conducted by the U.S. Geological Survey in cooperation with the Division of Water, Ohio Department of Natural Resources.

ACKNOWLEDGMENTS

Most of the basic data upon which this report is based were collected and interpreted by John D. Winslow, U.S. Geological Survey geologist. George W. White, U.S. Geological Survey geologist and head of the University of Illinois Department of Geology, investigated the surficial and glacial deposits of the county. Chemical analyses of 10 samples of ground water were made by personnel of the U.S. Geological Survey Quality of Water Branch. Personnel of the U.S. Geological Survey Geophysics Branch made shallow reflection and refraction investigations in several areas of the county to determine the thickness of the unconsolidated deposits.

The Ohio Department of Natural Resources is represented in this investigation by the director, H. B. Eagon, and by C. V. Youngquist, chief of the Division of Water. The U.S. Geological Survey Ground Water Branch is represented by O. M. Hackett, chief, and S. E. Norris, district geologist.

R. E. Warrick, U.S. Geological Survey geophysicist, directed the seismic investigation and computed the depth to bedrock in areas where other data were not available. The authors are indebted to the well drillers in Portage County who furnished many of the well records in the report.

Sedimentary and clay-mineral analyses of the tills were made in the laboratories of the University of Illinois Geology Department with the aid of two research grants from the National Science Foundation and of grants from the University of Illinois Research Board.

PREVIOUS WORK AND SOURCES OF INFORMATION

Early geologists in northeastern Ohio were interested mainly in identifying and mapping the coal units of the Pottsville Formation. Whittlesey (1838, p. 41–71) described the geology of Portage County, particularly the Sharon coal. Newberry (1871, p. 21–24; 1873, p. 72–79, 184–190) described the Carboniferous System in Ohio, and made numerous references to the Devonian, Mississippian, and Pennsylvanian rocks in northeastern Ohio. Later Newberry (1878, p. 133–150) in his report on the geology of Portage County discussed the glacial deposits and their history and described the Paleozoic rocks from surface exposures and from the records of wells. Orton (1884, p. 227) described the coal field in Palmyra Township, Portage County, in his report on the economic geology of Ohio. Lamb (1911, p. 104–109) traced the Mississippian-Pennsylvanian contact through northeastern Ohio, and described the relief on the Mississippian surface upon which the conglomerate unit of the Sharon Member was deposited in the Portage County area. Scranton and Lamb (1932) investigated the possible courses of the buried valleys in Portage County and vicinity. More recently, Stout, Ver Steeg, and Lamb (1943) discussed the buried valleys in Portage County and ground-water supplies of the larger communities.

Lamborn (1951, p. 303–304), in his report on the limestones of eastern Ohio, described the Lower Mercer Limestone in Portage County. Fuller (1947, p. 48–55; 1955, p. 159–176) studied the Sharon Conglomerate and discussed its further development as a source of silica refractory and ferrosilicon material. Fuller (1965) has compiled a report on the geology of the Garrettsville, Ohio, quadrangle, which includes part of northeastern Portage County.

The description of the geology and ground-water resources in this report are based on field investigations, records of wells and test holes, and aerial photographs. The records of exploratory borings and of wells drilled for water, oil, and gas and the results of seismic investigations are the basis of the subsurface information. Most of the water-well records were obtained from the files of the Ohio Division of Water and the wells were subsequently located in the field. Records of other wells were obtained from the files of the Ohio Division of Geological Survey (Dept. Nat. Resources), the Ohio Bureau of Mines, and the East Ohio Gas Co. The Wheeling and Lake Erie Railroad Co. furnished the log of the deep test hole in southwestern Aurora Township. A number of well records from the northern part of the county were furnished by J. O. Fuller. The aerial photographs were obtained from the Production and Marketing Authority, U.S. Department of Agriculture.

LOCATION

Portage County includes 504 square miles in northeastern Ohio, between lat 40°56′ and 41°21′ N. and between long 81°00′ and 81°24′ W. Ravenna, the county seat, is 34 miles southeast of Cleveland, 16 miles east of Akron, 27 miles north of Canton, and 27 miles west of Youngstown, Ohio. The county is bordered by Geauga County on the north, Trumbull County and part of Mahoning County on the east, part of Mahoning and Stark Counties on the south, and Summit County on the west (fig. 1). On the topographic maps of the U.S.

Geological Survey, Portage County occupies parts of the Chagrin Falls, Garrettsville, Kent, Ravenna, Canton, and Alliance quadrangles.

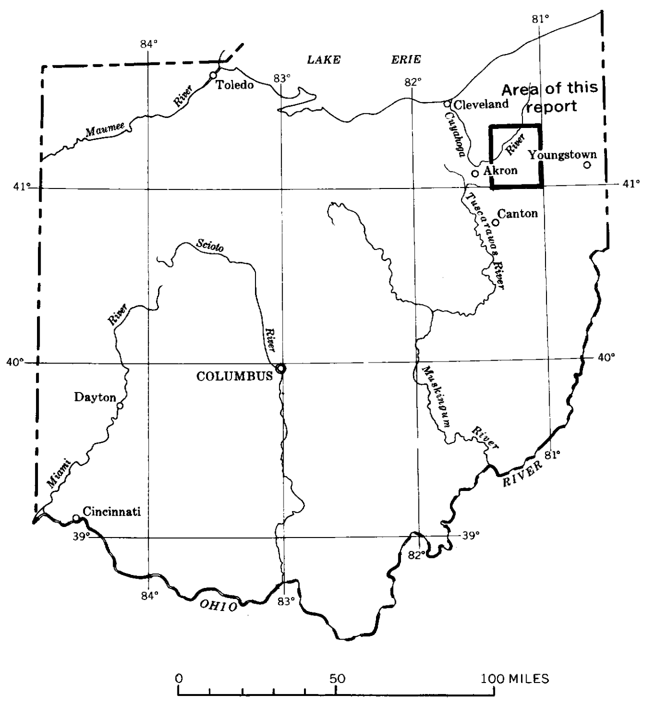

FIGURE 1.—Index map of Ohio showing Portage County.

CLIMATE

On the basis of data from the U.S. Weather Bureau (1957), the climate of Portage County is humid and the precipitation is fairly evenly distributed throughout the year. The average annual precipitation is 38.25 inches on the basis of a 71-year record, and the average annual temperature is 48.6°F on the basis of a 67-year record at Hiram, in northeastern Portage County. Sanderson (1950) tabulated U.S. Weather Bureau data for the 25-year period, 1921–46, for Ohio. His tables are given by hydrologic year, October 1 to September 30. The hydrologic year is used because October usually is the month of the lowest average streamflow and minimum ground-water storage. Also, by use of the hydrologic year, the snow season is not split as it would be if the records were tabulated by the calendar year.

For the 25-year period of record, 1921–46, the average annual precipitation was 37.70 inches with the annual precipitation ranging from a low of 28.99 inches in 1923 to a high of 49.67 inches in 1924. The month of lowest average precipitation was February, with 2.24 inches; and the months of highest average precipitation were June and July, each with 3.93 inches. The first 5 months of the hydrologic year had an average precipitation of 2.64 inches as compared with an average of 3.50 inches for the last 7 months of the hydrologic year. The average annual snowfall, as measured at Hiram, was 37.3 inches.

The average annual temperature in Portage County for the period 1921–46 was 49.0°F, and the range was from 46.9°F in 1924 to 51.6°F in 1932. January, the coldest month, had an average temperature of 26.3°F for the 25-year period of record; and July, the warmest month, had an average temperature of 71.3°F. The average dates of the last killing frost in the spring and of the first killing frost in autumn were May 1 and October 16, respectively. The average length of the growing season at Hiram was 168 days. The length of the growing season, as well as the dates of the first and last frost of the season, varies from place to place, depending upon the altitude and other factors.

The climate of Portage County is moderated by the effect of Lake Erie to the north and west and the Allegheny Plateau to the east. The climatic modification caused by the lake and by the difference in altitude between the Central Lowland and the Allegheny Plateau is shown by the fact that Portage County has a higher average annual precipitation and a lower average annual temperature than the areas immediately surrounding the county. Despite the fact that its average annual temperature is lower, Portage County has a longer growing season than the neighboring counties.

ECONOMIC DEVELOPMENT

The population of Portage County was 91,798 in 1960, the population density being 182.1 persons per square mile (18th Federal Census for Ohio). Since 1950 the population has increased markedly in the western part of the county because of the suburban extension of Cleveland and Akron. In 1960 Ravenna, the county seat, had a population of 10,918.

The industries of the county are primarily concentrated in Ravenna and Kent, where rubber and plastic products, transport and construction equipment, cast metal, machine tools, and other metal products and textiles are manufactured. The largest single industry in the county is the Ravenna Arsenal, Inc., which employs about 1,800 people. Industrially, Portage County ranks 26th among Ohio counties in the number of employees, and 22d in the number of manufacturing establishments (Ohio Department of Industrial Relations, 1956).

The agricultural value of all Portage County farm products of 1954 was $7,354,643, of which $2,360,045 was from field crops and $4,970,115 was from livestock or livestock products. The county has a total of 3,494 farms on a combined total of 244,060 acres (U.S. Bureau of Census, 1956).

The mineral industries in Portage County produced 1,346,835 short tons of sand and gravel, 488,474 short tons of crushed sandstone, and 135,034 short tons of coal in 1956 (Ohio Department of Industrial Relations, 1957). The sand and gravel is produced principally from glacial deposits in the western part of the county, and it is used primarily for paving and construction work. Quarries in the Connoquenessing Sandstone Member of the Pottsville Formation, in Aurora Township, and in the Sharon Member, in Nelson and Windham Townships, produce crushed sandstone that is highly valued for ferrosilicon and silica refractory use. Shale is mined in Palmyra Township, where it is used for the manufacture of sewer tile and allied clay products. The Bedford coal is strip mined in Atwater Township, southeastern Portage County.

The transportation facilities in Portage County include five railroads and an excellent system of highways, including the Ohio Turnpike, which connect the county with the surrounding industrial cities in northeastern Ohio, and with the rest of the nation.

GROUND-WATER UTILIZATION

In 1956, an average of about 9 mgd (million gallons per day) was pumped from wells in Portage County for other than irrigation use. Of this amount, 2 mgd was pumped by six municipalities: Kent, Mantua, Windham, Garrettsville, Aurora, and Hiram. Surface water from Muzzy Lake, Rootstown Township, supplied the municipalities of Ravenna and Rootstown. The approximate average daily use of surface and ground water, in million gallons per day, by the eight municipalities was as follows: Aurora, 0.06; Garrettsville, 0.15; Hiram, 0.06; Kent, 1.6; Mantua, 0.07; Windham, 0.12; Ravenna, 1.5; and Rootstown, 0.05. The remaining communities in the county obtain water from common wells. Domestic and stock wells in the county yielded about 3 mgd in 1956. The amount of ground water used by industry is about 4 mgd.

The number of farms in Portage County that are irrigated during dry periods is increasing rapidly. The average yearly amount of water used for irrigation is not known because it is related directly to the amount and distribution of rainfall. The capacity of all irrigation wells in the county in 1956 was about 5 mgd.

NUMBERING SYSTEM OF WELLS AND SEISMIC SITES

In the well-numbering system used in this report, blocks of 99 numbers have been assigned to each of the 20 townships to designate the wells. Table 1 shows the numbering system for each township. Where reference is made in the report to a particular well, the number of the well is placed in parentheses. Information on the wells is given in table 1 and on plate 1. The locations of the wells are shown on plate 2.

TABLE 1.—*Numbers used to designate wells, and prefixes used to designate seismic-determination sites in Portage County*

Well	Township	Prefix for seismic-site designation
101–199	Atwater	(1)
201–299	Aurora	Sp
301–399	Brimfield	Br
401–499	Charlestown	(1)
501–599	Deerfield	(1)
601–699	Edinburg	(1)
701–799	Franklin	Fr
801–899	Freedom	(1)
901–999	Hiram	H
1001–1099	Mantua	(1)
1101–1199	Nelson	N
1201–1299	Palmyra	(1)
1301–1399	Paris	Sp
1401–1499	Randolph	Ra
1501–1599	Ravenna	Rv
1601–1699	Rootstown	Ro
1701–1799	Shalersville	(1)
1801–1899	Streetsboro	St
1901–1999	Suffield	(1)
2001–2099	Windham	(1)

[1] No seismic investigations were made.

The drillers' logs of most of the oil-and-gas wells in the county are given in table 2. The logs of these wells show the lithology of the Mississippian, Pennsylvanian, and Quaternary rocks. Consecutive numbers prefixed by the letter "P" are used to designate the oil-and-gas wells.

The depth to bedrock (thickness of unconsolidated materials), determined by seismic methods at many places in the county, is tabulated in table 3. The locations of the sites where seismic determinations were made are shown on plate 2; the sites are prefixed in different townships as shown in table 1.

TOPOGRAPHY AND DRAINAGE

The boundary between the Eastern Lake section of the Central Lowland province and the glaciated Allegheny Plateau section of the Appalachian Plateaus province is the Portage escarpment, which crosses parts of Cuyahoga and Geauga Counties that adjoin Portage County on the north. Northern Portage County, in the northwestern part of the glaciated Allegheny Plateau section, has been deeply dissected by streams that drain through the escarpment into the Lake Erie basin. The Grand River lowland in central Ashtabula and Trumbull Counties and eastern Portage County was described by Fenneman (1938, p. 309) as a "sag in the upland" of the Allegheny Plateau, in effect a southern extension of the Central Lowlands province. Modification of the pre-Pleistocene surface by glacial erosion and the deposition of glacial drift have resulted in the present topography. Remains of the preglacial topography occur in the northern part of the county, in Hiram, Nelson, Freedom, and Windham Townships, where the sandstone highlands of the Pottsville Formation were resistant to ice erosion. The local relief in this part of the county is more than 300 feet (from less than 1,000 feet to more than 1,300 feet above sea level) and the topography generally is more rugged than in the remainder of the county. The western edge of the Grand River lowland is marked by a low north-south escarpment which separates it from the central part of the county. The escarpment is more pronounced in the northeast part of the county, where it is formed on the lower sandstones of the Pottsville Formation, than in the southeastern part of the county, where the bedrock is composed of the less resistant shales of the upper part of the Pottsville Formation. The escarpment is broken in southwestern Paris Township by the valley of the West Branch of the Mahoning River which has been cut in glacial drift filling a preglacial valley.

Cole (1934, p. 292–293) recognized three regional erosion surfaces in eastern Ohio and western Pennsylvania: the Allegheny, Worthington, and Parker Strath surfaces. Cole believed these erosion surfaces are correlative with the Harrisburg, Lexington, and Sommerville surfaces, respectively, of the eastern Appalachian region.

In the Portage County area, the Allegheny surface is represented by upland areas above the altitude of 1,300 feet. The Worthington erosion surface is represented by the general upland area in the north-central, central, and south-central parts of the county, where the altitude ranges from 1,100 to about 1,200 feet. The Parker Strath is represented by the bedrock surface in the eastern part of the county, in Palmyra, Paris, and Windham Townships, where its general level is about 950 feet above sea level. The smoothness of this surface is well illustrated by the bedrock contours in Windham and Paris Townships and by the level rock surface shown on the east end of section *C*. (See pl. 3.) Many of the extensive benches in the bedrock surface in northern Summit County (Smith and White, 1953, pl. 11) and in Cuyahoga County (Winslow and others, 1953, pl. 1) between 900 and 950 feet above sea level are probably correlative with Parker Strath benches and were formed by the lateral cutting of Teays-stage streams.

The bedrock topography is almost completely obscured in the western and southern parts of Portage County by kame moraine deposits. Kame and kettle topography is especially well developed in Suffield and Randolph Townships.

The drainage divide between the Lake Erie basin and the Ohio River basin extends from Randolph Township in the southern part of Portage County to Hiram Township in the northern part of the county. Drainage west of the divide is primarily by the Cuyahoga River and the Little Cuyahoga River to Lake Erie. East of the divide, drainage in Portage County is to the Ohio River, primarily by Eagle Creek and the West Branch of the Mahoning River.

TOPOGRAPHY OF THE BEDROCK SURFACE

Deposits of glacial drift and alluvium almost completely mantle the bedrock surface in Portage County. On the geologic map (pl. 3), contour lines are shown both on the present land surface (20-ft contour interval) and on the surface of the bedrock (100-ft contour interval). The approximate thickness of the unconsolidated deposits at any given place is readily computed by subtracting the altitude of the contour line on the rock surface from the altitude of the contour line on the land surface. The topography of the rock surface is shown by the contour lines to have a striking pattern of troughs. These troughs are valley systems cut by streams before or during the Pleistocene Epoch and further deepened in places by ice scour. Generally these troughs are wholly or partly filled by glacial or lacustrine deposits and are called "burried valleys."

The present streams generally follow the buried depressions in the rock surface, flowing in linear depressions in the land surface caused by the compaction of the unconsolidated materials that fill the buried valleys. In some places moraine, outwash, and other deposits have filled these linear depressions and the modern streams, in reestablishing drainage, have cut new channels into the rock surface. An example of this is at Kent, Franklin Township, where the Cuyahoga River is cutting its channel into the Sharon Member of the Pottsville Formation, although a buried valley lies only about 1 mile to the west. If another glacial stage occurs, this modern rock channel will be added to the buried-valley system of the county.

The bedrock geology of a glaciated area can best be described on a base map which also shows the topography of the rock surface. The first use of this type of map in Ohio was by Norris (Norris and others, 1948) in a report on the water resources of Montgomery County, Ohio. By use of such a map, a rock aquifer beneath the glacial drift can be shown, and the depth that a well must be drilled to penetrate the rock aquifer can be computed.

METHODS OF INVESTIGATION

WELL RECORDS, PHOTOGEOLOGY, AND FIELDWORK

Most of the data used in contouring the bedrock surface are from the records of several thousand wells drilled in the county. Sufficient data were available to construct the contour lines fairly accurately in areas where the bedrock is within 100 feet of the surface. In other areas the data sufficed to reveal only the general configuration of the rock surface, as most of the water wells are not drilled into the bedrock. The records of the few oil and gas wells drilled in areas of thick drift provided additional information. To these data were added the information obtained from field investigations of rock exposures and the results of a study of aerial photographs. The aerial photographs revealed linear depressions that suggested the presence of buried valleys in Aurora and Atwater Townships.

SEISMIC PROFILES

A program of seismic work, directed in the field by R. E. Warrick, geophysicist in the U.S. Geological Survey Geophysics Branch, was conducted in areas where the writers expected the major buried valleys to be present. The seismic work consisted of making a series of long profiles across the deeply buried valley in Aurora, Streetsboro, and Franklin Townships, and in the area of thick drift in Brimfield and Rootstown Townships. Shorter profiles were run in other areas. The equipment used was an experimental model of the high-frequency shallow reflection and refraction type which required only a small explosive charge to determine the thickness of the unconsolidated materials overlying bedrock. This use of a small charge permitted the seismic operations to be conducted safely along public roads and near dwellings. Detailed technical descriptions of the methods and results of the seismic operations in Portage County have been published in scientific journals (Pakiser and Warrick, 1956; and Warrick and Winslow, 1960) and, except for the tabulation of the results in table 3, are not presented here. These investigations provided most of the data used to construct the contour lines on the bedrock surface in the areas of thick drift in the western half of the county.

STREAMFLOW RECORDS

Streamflow records collected by the U.S. Geological Survey Surface Water Branch were examined to see whether surface streams in some areas have had relatively high sustained flow during the dry periods; such flow would reflect areas of thick glacial drift. The investigation was inconclusive, partly because data were not available from closely spaced measuring sites.

BURIED VALLEYS AND VALLEY FILLS

A knowledge of the history of buried valleys is necessary in the investigation of the ground-water resources of an area. Portage County is on the divide between the Ohio River basin and the St. Lawrence River basin. As ice advanced into Portage County the streams draining northward into the St. Lawrence drainage basin were dammed and lakes were formed in the valleys which were filled chiefly with fine-grained deposits. Sand and gravel lenses also were deposited by streams carrying melt water from the ice, the location and size of these sand and gravel lenses being dependent upon local drainage conditions at the ice front. When the ice advanced over these deposits, glacial till was deposited over them. The streams in the Ohio River drainage basin were unaffected by the ice advance until the ponded waters north of the divide found outlets through low points along the divide betwen the two basins. Then the flow of the south-draining streams was augmented by drainage from the ice sheet. This additional flow increased the capacity of a stream to erode and deepen its channel. As the ice front advanced over the drainage divide, coarse sand and gravel outwash material was deposited in the valleys. With further advance of the ice, the outwash deposits were buried by till. As the ice front retreated, valley trains were again deposited. Thus, in the divide area, the valleys that formerly drained to the south are partly filled with coarse sand and gravel outwash deposits, and some till; the valleys that formerly drained to the north are filled with clay, silt, and sand, plus some till and sand and gravel lenses. Along the divide, as in all upland areas overriden by ice, the topography of the rock ridges was smoothed and rounded by ice erosion.

The fill in the formerly south-draining valleys is coarse and permeable and provides an excellent source of ground water. The fill in the formerly north-draining valleys is fine-grained material and constitutes a relatively poor source of ground-water supply, except where a well penetrates one or more of the narrow, thin, and discontinuous sand and gravel lenses, from which perhaps 20 to 30 gpm (gallons per minute) may be obtained.

The buried valley that enters the northwestern part of Portage County trends southeastward across western Aurora, central Streetsboro, and northeastern Franklin Townships, and thence trends eastward across the southern parts of Ravenna, Charlestown, and Paris Townships. This buried valley and its tributary in

Rootstown Township predominantly are filled with sand, silt, and clay. Fine-grained material also predominates in the buried valley in Nelson, Windham, and Hiram Townships. These valleys, which were part of the St. Lawrence River system, drained most of Portage County and the surrounding area during Teays time when the Parker Strath erosion surface was developing. When the St. Lawrence drainage outlet was dammed and the waters ponded, the resulting proglacial lake was filled with fluvial and lacustrine clay, silt, and sand.

In places the advancing ice scoured out these deposits, deepened the valleys, and smoothed the valley walls. Examples of ice scour in buried valleys occur in Nelson Township, between Nelson and Kennedy Ledges, and in eastern Aurora, Streetsboro, and Franklin Townships. In Teays time, the bottom of the valley was slightly more than 700 feet in altitude. The rock floor of the buried valley now has an altitude of slightly more than 300 feet. Most of the erosion of the buried-valley floor is due to ice scour. Stream erosion could account for only a small part of the valley cutting, because the valley floor has a minimum altitude of about 450 feet to the north in Cuyahoga County (Winslow and others, 1953, pl. 1) and more than 700 feet to the southeast in Ravenna Township. The ice scour is believed to have occurred either during, or prior to, the advance of Illinoian ice because G. W. White (1953b, p. 36–39) reported drift of Illinoian age in the extension of this buried-valley system in Cuyahoga County. Had the ice scour occurred during Wisconsin time, the Illinoian deposits probably would have been removed.

In late Wisconsin time, ice tongues pushed down the Chagrin Valley from the north and into the valleys of Eagle Creek and of the West Branch of the Mahoning River from the east. Melt water from these ice tongues drained south to the ancestral Ohio River either through preexisting valleys or by cutting new valleys. Coarse outwash material was eventually deposited in these drainageways, of which one generally underlies the course of the Cuyahoga River below Mantua, in Mantua, Shalersville, and Streetsboro Townships, and another is the north-south buried valley in western Franklin, Brimfield, and Suffield Townships. Most of the other buried valleys in the southern part of Portage County also contain some sand and gravel, but the deposits are not extensive.

The buried-valley systems in Portage County are not necessarily associated with any one glaciation. Sufficient data are as yet not available to discuss the history of the Pleistocene drainage in the county in greater detail.

STRATIGRAPHY OF THE BEDROCK FORMATIONS

GENERAL

The consolidated rocks in Portage County that were studied in this investigation range from the Chagrin Shale of Devonian age through the Pottsville Formation of Pennsylvanian age. (See table 2.) The Devonian and Mississippian rocks, which generally lie below the present drainage level of the county, are marine sediments with the exception of the Bedford and Berea Formations, which are, in part, brackish-water deltaic deposits (Pepper and others, 1954).

The Pottsville Formation of Pennsylvanian age, composed of sandstones, shales, coals, and limestones, unconformably overlies the Mississippian formations. The Pennsylvanian units vary from coarse-grained crossbedded sandstones, such as the Sharon, Connoquenessing, and Homewood Members that were deposited in delta and valley environments, to the lower limestone unit of the Mercer Member that contains numerous marine fossils.

TABLE 2.—*Generalized geologic section of the consolidated rocks in Portage County*

	Thickness (feet)
Pennsylvanian:	
Pottsville Formation:	
Homewood Sandstone Member	0–100
Mercer Member	0– 90
Tionesta coal.	
Upper limestone unit.	
Bedford coal.	
Lower limestone unit.	
Middle Mercer coal.	
Lower Mercer coal.	
Connoquenessing Sandstone Member	0–140
Sharon Member:	
Shale unit	0– 90
Quakertown coal.	
Sharon coal.	
Conglomerate unit	0–250
Mississippian:	
Cuyahoga Group	5–250
Meadville Shale.	
Sharpsville Sandstone.	
Orangeville Shale.	
Berea Sandstone	0– 75
Mississippian and Devonian	600+
Bedford Shale.	
Cussewago Sandstone.	
Ohio Shale (Cleveland Member).	
Chagrin Shale.	

The Devonian and Mississippian sequence in the county is similar to that in other areas in northeastern Ohio, but the Pennsylvanian sequence differs in that many of the units are missing or very poorly developed. To the south of the county, the sandstone units have a greater thickness and are less uniform than was reported by Stout (Stout and others, 1943, facing p. 108). This may indicate that the deposits coarsen toward the margin of the Pennsylvanian basin but thin within the basin proper. If so it would explain why many of the units found farther out in the basin are missing in the Portage County area where the environment of deposition was different.

The regional dip of the sedimentary strata in Portage County is between 5 and 10 feet per mile to the south. Locally the dip is greater or less than this because of slight flexures in the beds. The lower limestone unit of the Mercer Member at Limestone Ridge, in southwestern Freedom Township, dips to the south about 45 feet per mile. In Deerfield Township the lower limestone unit dips southeast about 25 feet per mile.

During construction of the Ohio Turnpike, many cuts were made into the bedrock in the eastern part of the county. In three of these roadcuts, units of the shale members of the Pottsville Formation were observed to be complexly folded and faulted. In a cut on a side road that crosses the turnpike 1 mile east of Shalersville, the dip of two coal beds in the Mercer Member of the Pottsville Formation is nearly vertical. The thick sandstone units below the contorted zone do not appear to be disturbed, and the folding and faulting therefore are not considered a major structural feature. In this section the Homewood sandstone truncates the steeply dipping Mercer unit.

The principal aquifers in the consolidated rocks are the thick Pennsylvanian sandstones. The amount of water that these units can yield depends in part upon the thickness and the lithologic character of the sandstones in a given area. The Mississippian Cussewago and Berea Sandstones have been reported to contain brackish water or brine in the southern part of the county, and the Cussewago Sandstone may contain brine in the northeastern part of the county. The Berea Sandstone may be expected to yield potable water in the northern half of the county.

PRE-BEREA UNITS

The part of the rock sequence below the Berea Sandstone that is included in the present investigation consists of the Chagrin and Ohio (Cleveland Member) Formations of Devonian age and the Cussewago and Bedford Formations of Mississippian age. For the purpose of this report, the four units have been grouped together because they are seldom penetrated by wells and are not generally a source of potable water. Three of the formations, the Chagrin, Ohio, and Bedford, are predominantly shales. The fourth, the Cussewago, is a sandstone and occurs only in the eastern part of the county, according to Pepper, de Witt, and Demarest (1954, pl. 4). The four formations generally contain brine or brackish water, but at places wells have struck small amounts of oil and gas. These formations are not exposed at the surface in Portage County, but they are present beneath the glacial drift along the sides and bottoms of several of the buried valleys as shown on the geologic map (pl. 3).

CHAGRIN SHALE

The Chagrin Shale was first described by Prosser (1903, p. 521) from exposures along the Chagrin River, south of Willoughby, Lake County, Ohio. In Cuyahoga County the shale is unconformably overlain by the Cleveland Member of the Ohio Shale. Eastward, along the western margin of Trumbull County, the upper part of the Chagrin Shale grades into the Cleveland Member (de Witt, 1951, p. 1352). The Chagrin Shale has a thickness of about 500 feet near Cleveland and thickens to about 1,200 feet near the Pennsylvania State line in Ashtabula and Trumbull Counties (de Witt, 1951, p. 1349).

The Chagrin in Cuyahoga County, where it is exposed at the surface, consists of blue-gray to dark-gray silty shale with sporadic light-blue-gray iron carbonate concretions and thin calcareous sandstone and siltstone beds. De Witt (1951, p. 1352) reported that in central and eastern Ashtabula County and in northern Trumbull County, the upper beds of the Chagrin are predominantly massively bedded siltstones and silty mudstone. In Portage County the Chagrin Shale is known only from the records of a few oil-and-gas wells, in which it is described simply as shale.

OHIO SHALE (CLEVELAND MEMBER)

The Cleveland Member of the Ohio Shale derives its name from exposures at Cleveland, Cuyahoga County, Ohio. Newberry (1871, p. 19; 1873, p. 187) initially described the black carbonaceous shale as the Cleveland Formation, and he placed it at the base of the Carboniferous System. De Witt (1951, p. 1352) considered the Cleveland Shale a member of the Ohio Shale because of its genetic relationship to the Ohio Shale. The Cleveland Member is the uppermost unit of Devonian age in the Portage County area.

The Cleveland Member consists of about 60 feet of massive carbonaceous shale containing pyrite concretions. The shale is fissile upon weathering, but where freshly exposed it is usually more massive and blocky and has a blue-black color and vitreous luster. Fragments of the Cleveland Member are common in the glacial till in Cuyahoga County.

CUSSEWAGO SANDSTONE

The Cussewago Sandstone was described by de Witt (1946) from the section in the Bartholomew Quarry, Mayfield Township, Crawford County, Pennsylvania. De Witt's designation was a restriction of I. C. White's (1881, p. 91) Cussewago Group, which included a shale and a local limestone. Pepper, de Witt, and Demarest (1954, pl. 1) showed that the unit thins westward and lenses out in the eastern part of Portage County. The maximum thickness is about 60 feet in Deerfield Township.

De Witt (1951, p. 1353) described the Cussewago Sandstone as consisting of poorly cemented medium- to coarse-sized quartz grains. The lower part of the unit is generally massive, whereas the upper part contains some thin ripple-marked beds. The Cussewago Sandstone is the oldest unit of Mississippian age in Portage County, and it is known only from the records of wells.

BEDFORD SHALE

The Bedford Shale receives its name from the location of the type section in the gorge of Tinkers Creek, southwest of Bedford, Cuyahoga County, Ohio (Newberry, 1871, p. 21; 1873, p. 188). There the formation is composed of shale and local thin interbedded sandstones and limy siltstones. Two lenticular siltstones, the Euclid and Sagamore Members, occur in Cuyahoga County. These are believed by de Witt (oral commun.) to be bar deposits of limited areal extent and are not believed to be present in the Portage County area. The upper part of the Bedford Shale generally consists of soft blue-gray clay shale with flagstone layers and thin sandstone lenses occurring locally. The flagstone is generally fine grained and is well indurated by calcareous cement. The brownish-red clay shale at the top of the Bedford Shale in central Cuyahoga County is not recorded in the logs of wells in Portage County.

The Bedford Shale conformably overlies the Cleveland Member of the Ohio Shale and is uncomformably overlain by the Berea Sandstone. The thickness of the Bedford Shale in Cuyahoga County ranges from 40 to nearly 90 feet, the variation in thickness being due to local erosion prior to the deposition of the Berea Sandstone.

BEREA SANDSTONE

The Berea Sandstone is named from extensive quarries at Berea, Cuyahoga County, Ohio (Newberry, 1871, p. 21). In the area of the type section, the Berea Sandstone occupies an erosion channel in the Bedford Shale and has a thickness of about 150 feet. Elsewhere in Cuyahoga County, the average thickness is about 60 feet.

The Berea Sandstone in Portage County is known only from the records of a few oil-and-gas and water wells, but it is exposed at the surface a few miles north of the county in Bainbridge and Parkman Townships, Geauga County. The formation occurs beneath the glacial drift along the walls of the buried valleys in the central and northern parts of Portage County. The thickness of the Berea Sandstone according to the few well records available in the county, has a considerable range due to the unconformity at its base. In northeastern Edinburg Township its thickness is about 80 feet, and in southern Atwater Township its thickness is at least 80 feet and may be as much as 180 feet. Generally, however, the sandstone has a range of 10 to 30 feet. Some of the logs of oil-and-gas wells do not record the presence of the Berea Sandstone either because it is not present or is too thin to note or because the well records are not sufficiently detailed.

In Cuyahoga County, where surface exposures have been studied by the writers (Winslow and others, 1953, p. 47), the Berea Sandstone can be divided into three separate units, the lowest being in the channels in the Bedford Shale. The channel unit consists of profusely crossbedded tan to red-brown well-indurated coarse-grained sandstone. The middle unit of the Berea Sandstone is a massive moderately hard medium- to coarse-grained sandstone that is light gray on a fresh surface and tan to light brown when weathered. The upper unit is a thinly bedded gray to tan fine-grained sandstone having shale partings. De Witt (1951, p. 1358) referred to the upper unit as a marine phase, 5 to 20 feet thick, that is thinnest in western Cuyahoga County and thickens eastward. He believed that the oscillation and interference ripples reflect deposition in protected bays and estuaries adjacent to the retreating shoreline of the Berea delta. The Berea Sandstone in Portage County probably has the character of the middle and upper units except possibly in the central and southeastern parts of the county where it may include the channel sandstone unit.

Potable-water supplies are obtained from the Berea Sandstone in Aurora, Nelson, and Paris Townships. The largest supply is in Nelson Township, where the city of Garrettsville pumps from several wells in the Berea Sandstone. This aquifer is distinctive in that the water has a lower carbonate hardness and higher chloride content than the other aquifers in the county. South of the Teays-age buried valley that lies in a general east-west line across the central part of the county, the water in the Berea Sandstone may be expected to range from saline to brackish, as the connate water in the unit has never been flushed out. North of the buried valley, the Berea Sandstone was above drainage when those valleys were cut by normal streams; and the normal ground-water movement has had sufficient time to flush the connate water at least partially, so that the water now in the formation is probably potable.

CUYAHOGA GROUP

The Cuyahoga Group was initially described by Newberry in northeastern Ohio (1871, p. 21) as the shale and interbedded sandstone lying between the Berea Sandstone and the Pottsville Formation. I. C. White (1881, p. 83–90) described a similar section at Meadville, Crawford County, Pa., naming it the Meadville Group. The two groups were eventually correlated as being the same and designated as the Cuyahoga Formation, including the Orangeville Shale, the Sharpsville Sandstone, and the Meadville Shale Members. The members have been given formation status and form the Cuyahoga Group, the uppermost unit of the Mississippian System in northeastern Ohio.

The three units in the Cuyahoga Group are generally similar in their water-bearing and lithologic characteristics and, except for the following descriptions, are not referred to separately in this report.

In Portage County the formations of the Cuyahoga Group are exposed at the surface in Aurora, Nelson, and Windham Townships; they occur beneath the glacial drift along the walls of many of the buried valleys in the county. Although the Cuyahoga Group may contribute some water to a few wells in Nelson Township, most wells are drilled through it into the underlying Berea Sandstone.

The thickness of the Cuyahoga Group varies considerably. In Aurora Township, the thickness is about 200 feet. At Nelson Ledges State Park in Nelson Township, the thickness is about 75 feet. At other places where the overlying Sharon Member of the Pottsville Formation is especially thick, the Cuyahoga Group may be only 30 feet thick, or less.

ORANGEVILLE SHALE

The Orangeville Shale was described from the type section near the town of the same name in Mercer County, Pa. (White, I. C., 1880, p. 63). The Orangeville Shale includes at its base the Sunbury Shale Member, which in central Ohio is a unit of considerable thickness. The Sunbury is reported in the records of some oil-and-gas wells in Portage County as 7 to 14 feet of black shale, immediately overlying the Berea Sandstone. In Cuyahoga County the Aurora Siltstone Member of the Orangeville Shale overlies the Sunbury Shale Member. The Aurora has a thickness of about 5 feet and consists of thin light-blue-gray fine-grained siltstone layers interbedded with shale at the Independence Quarry Park, in Solon Township, Cuyahoga County. In Portage County this member is not reported in any well record probably because it is too thin to note.

The remainder of the Orangeville Shale in Cuyahoga County consists of a uniform gray shale, but eastward the unit is sandier and contains siltstone and clay-ironstone zones. The only surface exposure of the Orangeville Shale in Portage County is in "Old Maid's Kitchen" at the Nelson Ledges State Park, Nelson Township. Here the shale, exposed under a ledge of the Sharon Member of the Pottsville Formation, is a sandy and micaceous shale and some thin clay-ironstone concretions.

SHARPSVILLE SANDSTONE

The type section of the Sharpsville Sandstone is found near Sharpsville, Mercer County, Pa. I. C. White (1880, p. 61–62) first described it as a persistent sequence of alternating layers of sandstone and shale in beds 1 to 5 feet thick. The limy sandstone is generally medium to fine grained and distinctive gray brown, and the shale has the typical blue-gray color of other Mississippian shales in Ohio, excepting the Sunbury Member of the Orangeville Shale. The thickness of the Sharpsville Sandstone in Pennsylvania is 50 to 60 feet, and in Cuyahoga County it has an average thickness of about 45 feet.

In Portage County the Sharpsville Sandstone is not reported in the records of wells and is known only from exposures along the low escarpment that occurs immediately north of Nelson Ledges State Park, Nelson Township. The Sharpsville Sandstone is believed to occur in the east wall of the deeply buried valley in southwestern Aurora Township, where a break in the slope was recorded by seismic profiles at an altitude of about 950 feet.

MEADVILLE SHALE

The Meadville Shale is the uppermost unit of the Cuyahoga Group and of the Mississippian System in northeastern Ohio. It derives its name from the location of the type section at Meadville, Crawford County, Pa. (White, I. C., 1881, p. 83–90).

The Meadville Shale consists of a micaceous blue-gray sandy shale containing numerous flagstone and clay-ironstone layers. In Portage County the unit can be observed only at two places, beneath a ledge of the Sharon Member of the Pottsville Formation at the northeastern corner of Kennedy Ledge in Nelson Township, and along a tributary of the Aurora Branch of the Chagrin River in Aurora Township, just south of the Portage-Geauga County line.

POTTSVILLE FORMATION

Most of the local correlation of the members of the Pottsville Formation is based upon the records of oil-and-gas and water wells. Other than where rock sections have been exposed by road construction and mining operations, the thick mantle of glacial drift in the county is broken only where stream valleys have been cut through the drift into the underlying bedrock and where the thinner drift that once covered the resistant sandstones which cap the upland areas has been removed by Recent erosion. The geologic sections that have been observed in these areas are rarely complete, but do serve to provide information that supplements the well data. Such sections are given in table 14 and reference is made to them by township in the discussion of the stratigraphy.

The Pottsville Formation of Pennsylvanian age is the youngest consolidated formation in the area of investigation. The Pottsville was described by I. C. White (1880, p. 33; 1881, p. 55–56) as the Conglomerate Measures lying between the base of the Sharon Member and the upper surface of the Homewood Sandstone Member. The Pottsville rocks lie unconformably upon the Mississippian formations because prior to the deposition of the Pennsylvanian rocks an erosion surface was formed on the Cuyahoga Group in northeastern Ohio.

The Pottsville Formation is divided, in accordance with usage of the U.S. Geological Survey, into the Sharon, the Connoquenessing Sandstone, the Mercer, and the Homewood Sandstone Members. The Sharon, Connoquenessing, and Homewood Members are mostly sandstones containing a few discontinuous shale lenses. In much of the southern part of the county, Connoquenessing Member consists of two sandstone units separated by shale. In some places the shale is 40 feet thick. The shale in the Pottsville Formation contains thin coals, underclays, and limestone units. Unconformities at the bases of the two upper sandstones represent time breaks. Wanless (1944, pl. 1) divided the Pottsville Formation into three sedimentary sequences which he designated as Morrowan, Lampasan, and Desmoinesian in age. In this classification the Sharon Member is Morrowan, the Connoquenessing Sandstone and the Mercer are Lampasan, and the Homewood Sandstone is the basal part of the Desmoinesian.

Before deposition of each of the upper two sandstone members of the Pottsville Formation, the shale members stratigraphically below them were partly or wholly removed. The areas in which this occurred is described in the discussion of the geology by townships.

SHARON MEMBER

CONGLOMERATE UNIT

The Sharon Member is a sandstone at the base of the Pottsville Formation and lies unconformably on an erosion surface formed on the Cuyahoga Group early in Pennsylvanian time. The unconformity has a relief of as much as 200 feet in Portage County, and this is reflected in the variation in thickness of the Sharon. The conglomerate unit of the Sharon has a thickness of as much as 250 feet where it was deposited in a broad channel cut into the Mississippian rocks. The channel enters the county from the north, in Hiram Township, and deepens gradually as it passes southwestward across the county. The orientation of the channel and the direction of dip of the crossbeds, ranging from southeast to southwest, indicate a source for the unit to the north or northeast, as pointed out by Fuller (1947, p. 51; 1955, p. 160–164). In the marginal areas of the channel, in the southeastern part of the county, the conglomerate unit thins to about 20 feet and in places may be missing, owing to nondeposition on the uplands of the early Pennsylvanian erosion surface. The lower boundary of the conglomerate unit is sharp because generally the unit rests directly on the blue-gray shales and sandstones of the Mississippian Cuyahoga Group. In southwestern Nelson Township, in the quarry of the Industrial Silica Corp. at the southern end of Newels Ledge, the Sharon lies on a micaceous sandy shale that contains numerous plant fragments. This shale is distinctly different from the shales of the Cuyahoga Group and has been assumed to be of Pennsylvanian age. J. O. Fuller (oral commun.), of the Ohio Division of Geological Survey, who has seen this sub-Sharon unit, agrees with the interpretation that these shales were deposited contemporaneously with the coarser conglomerate unit of the Sharon Member.

In Portage County the Sharon Member consists of a thick sandstone having a basal quartz-pebble conglomerate in the channel areas. The sandstone is a porous, coarse- to medium-grained, gray-white to light-tan-brown orthoquartzite (fig. 2). The rock is friable because the grains are weakly cemented by silica and iron oxide. The conglomerate consists of a mass of well-rounded quartz pebbles and granules, commonly having little sand-sized matrix or cementing material. The conglomerate unit of the Sharon is quarried in Nelson and Windham Townships as a source of silica for the manufacture of silica refractory brick. Chemical analyses of the rock show it to be as much as 99 percent silica dioxide (SiO_2), the impurities being principally iron oxide (Fuller, 1947, p. 51–52).

Here and there within the upper part of the conglomerate unit, thin shale lenses occur. At the exposure of one of these shale lenses in south central Windham Township, the shale is a fissile clay shale, gray to gray black in color.

The conglomerate unit generally is an excellent aquifer and yields from 5 to 200 gpm to wells. Locally,

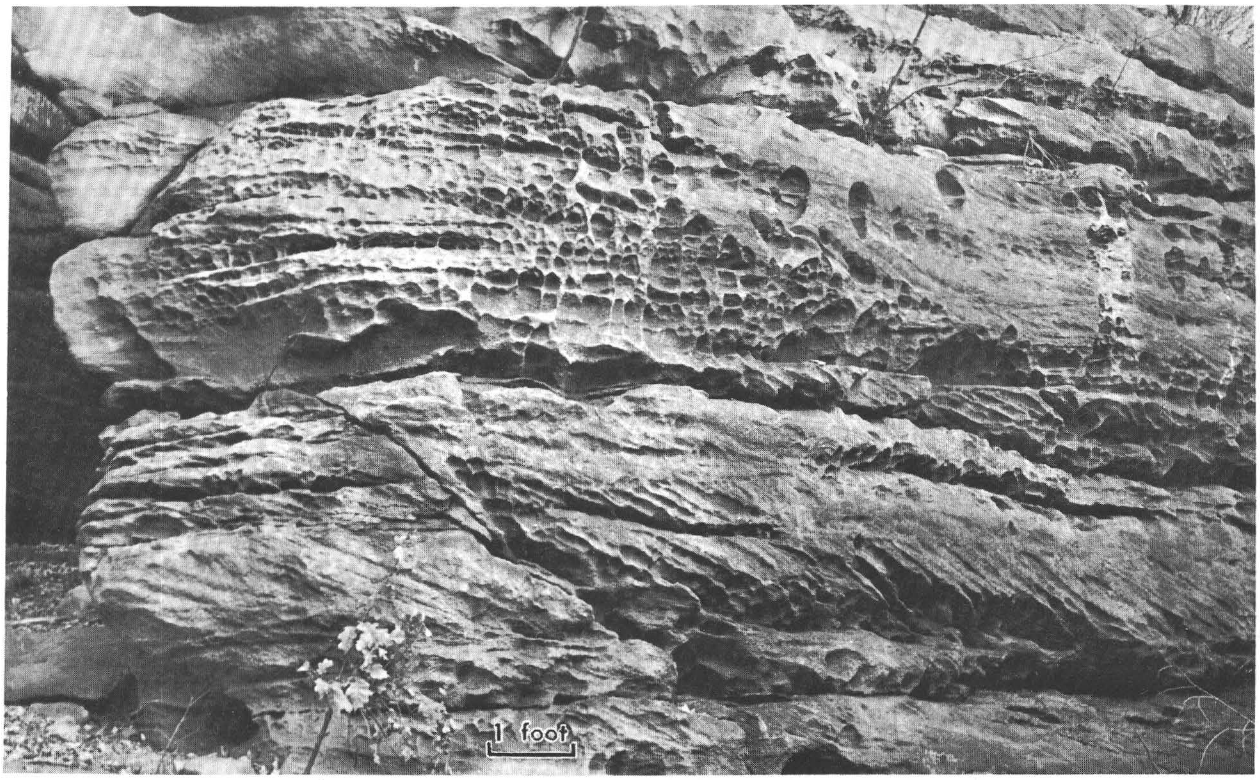

FIGURE 2.—The conglomerate unit of the Sharon Member of the Pottsville Formation at Kennedy Ledge, Nelson Township. Differential weathering has emphasized the crossbedding of the sandstone, especially in the lower part of the photograph.

where the unit is thin or is relatively impermeable owing to an abundance of cementing material, yields of wells are small.

SHALE UNIT

The shale unit of the Sharon Member overlies the conglomerate unit and underlies the Connoquenessing Sandstone Member of the Pottsville Formation. The shale unit ranges in thickness from 0 to 90 feet. In places in the northwestern part of the county, the shale unit was completely eroded prior to the deposition of the Connoquenessing Sandstone Member, and the latter directly overlies the conglomerate unit. In the remainder of the county the shale unit has greater thickness. The full section is present in Palmyra Township, where the member has a thickness of about 90 feet. The sandy shale contains some plant fragments, and it is generally fissile. The unit is gray to gray black. Sporadic ironstone-concretion zones and thin flagstone beds occur in the shale. At one exposure of the shale unit, in Freedom Township, along the tributary of Eagle Creek that lies immediately south of Hiram Station, a thin shaly conglomerate occurs. The conglomerate contains angular pieces of coal and underclay.

Two coal units occur within the shale unit, the Sharon coal and the Quakertown coal. Discussion of these units is warranted because their character, especially that of the Sharon coal, yields information on the depositional environment of the Pottsville Formation in the county.

SHARON COAL

The Sharon, or No. 1, coal occurs near the bottom of the shale unit of the Sharon Member (Stout and others, 1943, facing p. 108). The coal usually occurs as a 1- and 3-inch band, or may be represented by a smut streak or a thin zone of carbonaceous shale. The underclay beneath the coal is generally thin. A minable deposit of the Sharon coal occurred in Palmyra Township (Bownocker and Dean, p. 9), where the coal (now mined out) had a thickness of as much as 4 feet and occurred in a series of crooked basins, probably formed in the abandoned meanders of a Pennsylvanian river valley. The valley-flat environment of the coal deposit is indicated by the following quotation from Orton (1884, p. 227), who discussed the coal mines in Portage County:

* * * The Palmyra coal lies in narrow troughs or swamps, the length of which is considerable in proportion to the breadth. In this field the troughs are often very narrow and never exceed 200 yards in breadth. They are very sinuous, but the general direc-

tion is northeast and southwest. Mr. E. T. Bowen, intelligent manager of the Palmyra Coal Company, has observed that whenever a sharp deflection in the course of the swamp occurs, there is a good body of coal to be found in the concavity of the curve.

Further evidence of the variable lithology of the Sharon coal is shown by two sections within one-quarter of a mile of one another, along a tributary of Eagle Creek in Freedom Township immediately south of Hiram Station. Both sections start at the same point; one is in a tributary valley, the other in a side valley to the tributary. In the section along the main tributary valley, about 20 feet above the conglomerate unit of the Sharon, two thin coal beds occur. The lower of the coal beds is 2 inches thick and overlies 2½ feet of underclay. The upper coal bed is 1 foot thick and overlies about 1 inch of underclay. The two beds are separated by 2½ feet of sediments that include a black silty carbonaceous shale and a blue-gray silty sandstone and that contain numerous plant fragments. Some of the plant fragments are parts of logs that either became coal where they fell or were washed into a swamp of the valley-flat environment. The section exposed in the side valley of the tributary includes not these beds, but instead a sequence of thin shale, siltstone, and sandstone units. The shale unit of the Sharon Member is exposed in another section nearby, 1.2 miles east of the common corner of Freedom, Hiram, Mantua, and Shalersville Townships, where thin sandstone and shale units constitute the member. The Sharon coal unit, a 3-inch-thick bed, occurs with a thin underclay in the shale member at an altitude of about 980 feet above sea level. This section is exposed along Silver Creek, in the northeastern corner of Edinburg Township. The record of one oil-and-gas well in the south-central part of Edinburg Township notes a thin coal, believed to be the Sharon coal, directly overlying the Cuyahoga Group at at altitude of about 960 feet above sea level.

QUAKERTOWN COAL

In the upper part of the shale unit of the Sharon Member (Ohio Geol. Survey classn.), the Quakertown, or No. 2, coal was exposed in a small strip mine immediately north of State Route 18, and half a mile east of Palmyra Station. The coal is about 2 feet thick and overlies 2 or 3 feet of clay. The coal, designated as Quakertown by Orton (1884, p. 226), lies below the Connoquenessing Sandstone Member, which crops out at the same altitude at Palmyra, 1½ miles west.

CONNOQUENESSING SANDSTONE MEMBER

The Connoquenessing Sandstone unconformably overlies the shale unit of the Sharon Member and underlines the Mercer Member of the Pottsville Formation. In Portage County the Connoquenessing Sandstone Member ranges in thickness from 0 to 140 feet and is present in most of the county, though not in Charlestown Township. It occurs either as a massive sandstone or as two sandstone units separated by as much as 50 feet of shale. An example of the massive phase may be found along the northern boundary of the county. In the southern part of the county, the other form is more prevalent.

The Connoquenessing Sandstone Member consists of a sequence of thin sandstones and shale in the valley of a tributary to Silver Creek, locally called Big Hollow, immediately south of Hiram. On the basis of the proportion of shale to sandstone, many drillers report this phase of the Connoquenessing either as sandstone, shale, or simply "shale and shell." Such practice leads to some confusion and ambiguity in interpreting the geology on the basis of drillers' logs. Another phase of the Connoquenessing Sandstone Member that is only slightly different from the one just mentioned occurs in the roadcut on the Ohio Turnpike (fig. 3), 1 mile east of the Cuyahoga River, in Shalersville Township. Here about 60 feet of the sandstone is exposed in crossbedded layers 10 to 15 feet thick that are separated by sandy shale beds about 5 feet thick. Both units have the same light-yellow-brown color, and the drill cuttings would be very similar to the eye. Doubtless most drillers would record the entire sequence as sandstone; however, the sandy shale partings make the vertical permeability of the unit much less than the horizontal permeability.

In the central part of the county, principally in Charlestown Township, the Connoquenessing Sandstone Member is not reported in the records of wells except for sporadic thin channel sandstone. In this area the erosion surface on the shale unit of the Sharon assumedly lay above the level of Connoquenessing deposition, and thus the Mercer Member directly overlies the shale unit of the Sharon. The contact between the two shale units, as shown on plate 3 on the geologic map and in section *C*, is arbitrarily placed at the top of the zone of the thin discontinuous sandstone lenses that occur at the horizon of the Connoquenessing Sandstone Member.

Lithologically the Connoquenessing is a coarse- to medium-grained sandstone. Generally the member is micaceous and contains considerably more feldspar and clay than does the conglomerate unit of the Sharon Member. Commonly the unit is crossbedded, and the dip of the crossbeds ranges from southwest to northwest. The direction of the dip of the crossbeds corresponds to the general westerly direction of the sandstone channel in the northern part of the county and is indicative of an eastern source area. In some

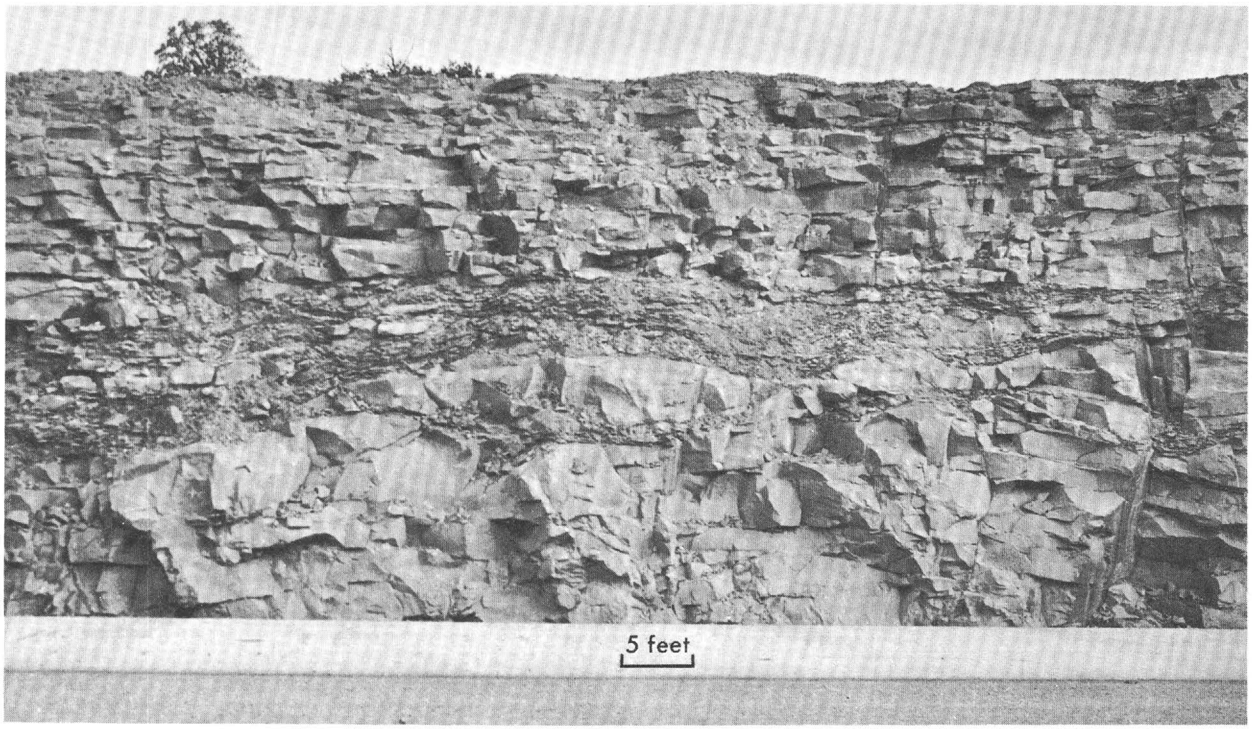

FIGURE 3.—The Connoquenessing Sandstone Member of the Pottsville Formation along the Ohio Turnpike, Shalersville Township. The 5-foot-thick shale lens in the sandstone unit restricts the vertical movement of ground water.

areas in the county, the sandstone contains numerous rounded granules and pebbles of quartz, but these beds are never as extensive or as thick as the conglomerate beds in the conglomerate unit of the Sharon Member. At Geauga Lake Quarry of the Industrial Silica Corp., in Aurora Township, the Connoquenessing Sandstone Member is quarried for the manufacture of silica brick, as its silica content there is comparable to that of the conglomerate unit of the Sharon Member in Nelson and Windham Townships. In areas where the Connoquenessing Member consists of two units of sandstone, separated by as much as 40 feet of shale, the intervening shale ranges from silty to sandy and contains many plant fragments and sporadic thin (1- to 4-in.) ironstone concretion zones.

The Connoquenessing Sandstone Member is a good aquifer, but it is not as good as the conglomerate unit of the Sharon because it contains a greater amount of clay and cementing materials which reduce the permeability. The water in the sandstone generally has a lower iron content than that in the conglomerate unit of the Sharon. Well drillers sometimes report the Connoquenessing Sandstone Member as limestone because the great amount of cementing material makes is more difficult to drill. Where the member occurs as a sequence of sandstone and shale, it will probably yield less than 50 gpm to wells. In the northern part of the county where the sandstone is thick and coarse grained, it may yield as much as 200 gpm to properly constructed wells.

MERCER MEMBER

The Mercer Member of the Pottsville Formation includes the shale, thin coal, underclay, limestone, and sandstone units that lie above the Connoquenessing Sandstone Member and below the Homewood Sandstone Member. Where the Connoquenessing is missing, principally in Charlestown Township, and where only well-record data are available, the base of the Mercer Member is arbitrarily placed at the top of the zone of thin discontinuous sandstone lenses that commonly replace the Connoquenessing Sandstone Member in the section.

In the Pennsylvanian basin, south of Portage County, the units in the Mercer Member are persistent. In Portage County some of these units are missing and others are discontinuous, but the following have been observed: The lower Mercer coal and clay, the middle Mercer coal and clay, the lower limestone unit, the Bedford coal and clay, the upper limestone unit, and the Tionesta coal and clay. Recognition of some units has been made on the basis of a single surface exposure, and good correlation with the Mercer section south of the county would require considerable core drilling. Several of the Mercer units are probably present over a larger area of the county than is presently known, but identifying them is difficult because few surface exposures exist and the units are seldom reported in the records of wells in a recognizable manner. In attempting to map the Mercer Member on the basis of the records of wells, the most anomalous feature is the occurrence, in places, of numerous thin discontinuous coarse- to medium-grained sandstones. These micaceous sandstones often have a high clay content which detracts from their value as aquifers. Moreover, it is impossible to predict their presence in advance of drilling. In areas where these sandstone lenses have a thickness of 20 feet or more, their lithology resembles that of the Homewood Sandstone Member; and where they occur high in the Mercer section, they may have been included, inadvertently, within the Homewood Sandstone Member in this report.

The occurrence and lithology of the Mercer units in the county are briefly described below.

LOWER AND MIDDLE MERCER COALS

The lower Mercer coal is known in the county only in the section exposed in Willow Creek, three-quarters of a mile north of U.S. Route 224, on the boundary line between Atwater and Deerfield Townships. The coal lies about 10 feet below the lower limestone unit, is 1 to 2 inches thick, and is underlain by about 3 feet of underclay. Immediately below the lower limestone unit is about 1 foot of black carbonaceous shale which is underlain by about 2 inches of underclay. The carbonaceous shale is believed to represent the middle Mercer coal. The silty shale zone that lies between the two coals is gray to dark gray and contains plant fragments.

One of these coals, probably the lower Mercer coal, reportedly occurs in eastern Edinburg Township, where it is 2½ feet thick (Newberry, 1878, p. 145); and in southwestern Freedom Township, where it was evidently explored, but not mined, along the north-south road, 300 yards south of State Route 88, about 2½ miles southwest of Freedom. Both sections are now covered and further information is not available.

In Deerfield Township, north of the road leading to the Berlin Dam, 1½ miles north of U.S. Route 224 and 2½ miles east of Deerfield, a coal below the lower limestone unit has been strip mined. This is probably the lower Mercer coal, but could not be determined at the time of the present investigation as the strip mine was abandoned and flooded.

LOWER LIMESTONE UNIT

The lower limestone unit, unless missing from the section, is the key stratigraphic unit in the county. It consists of a 2½- to 3½-foot-thick bed of dense fossiliferous blue-gray to dark-grayish-black limestone. The rock is usually massive except for the lower 6 inches, which is somewhat platy. The limestone crops out at the surface in many of the small stream valleys along the western boundary of Deerfield Township. It occurs just above high water level at many places along the shore of Berlin Reservoir in the southeastern part of the township. It is also found as an outlier in the northeastern part of the township, 1½ miles north of U.S. Route 224 and about 2½ miles east of Deerfield, where it is poorly exposed in an abandoned strip mine. Newberry (1878, p. 145) reported both the upper and the lower limestone units in eastern Edinburg Township, but the writers were unable to find them exposed there. In Shalersville Township, in the north-south roadcut through the hill 1 mile east of Shalersville, the lower limestone unit is observed to change from its characteristic lithology to a 2-foot-thick siderite ore within the distance of about 5 feet.

Limestone Ridge, in Freedom Township, is named from exposures of the lower limestone unit along the north-south road, half a mile east of the west boundary of the township, between State Routes 88 and 303. The dip of the limestone is about 40 feet per mile and is related to the flexure shown on section *F* (pl. 3).

In northeastern Hiram Township, exposed in a bank at the north side of the road, 1¼ miles southwest of Hiram Rapids, is a fossiliferous siderite ore about 1 foot thick, which probably represents the lower limestone unit. The lower limestone unit cropped out on the east side of Hiram in foundation excavations for the new (1958) Hiram College fieldhouse.

In areas where the lower limestone unit is not present or is represented by the siderite ore, it is missing from the section owing either to its passing into a shale facies or to its having been eroded prior to the deposition of the Homewood Sandstone Member. White, G. W. (1949, p. 107), observed that the lower limestone unit in Holmes County weathers rapidly at the surface and is not likely to be exposed except in steep gullies. The weathering probably accounts for the lack of surface exposures of the unit in southeastern Portage County where it likely occurs over large areas.

BEDFORD COAL

The Bedford coal is 3 to 6 feet thick in eastern Atwater Township, where a considerable area has been strip mined. The coal is underlain by 3 feet of underclay, and it lies stratigraphically about 30 feet above the lower limestone unit. The Bedford coal is about 3 feet thick and overlies about 4 feet of clay in the steep eastern valley wall of Silver Creek, in the northeastern corner of Edinburg Township. The Bedford coal may also be the coal in the hill 1 mile east of Shalersville, but the section there is too contorted to allow good correlation. The Bedford coal, where seen in the strip mines or surface exposures, is usually a moderately hard bright banded bituminous coal, but in places the coal is bony to dull and contains some bands that are rich in pyrite.

UPPER LIMESTONE UNIT

Stratigraphically the upper limestone unit is just above the Bedford coal, but the limestone is not known to occur in Portage County, other than as reported by Newberry (1878, p. 145). In the strip mine of the Petersen Coal Co., in southeastern Atwater Township, a black carbonaceous shale, just above the Bedford coal, has a sufficiently large calcium carbonate content in places that it reacts weakly to a dilute solution of hydrochloric acid, and this shale is presumed to represent the upper limestone unit. The shale has not been recognized outside of the mined area.

TIONESTA COAL

The Tionesta coal may be represented in Portage County by the thin (0- to 6-in.) coal bed overlying 3 feet of underclay that occurs about 25 feet above the Bedford coal in the southern end of the strip mine of the Petersen Coal Co. It has not been observed or reported elsewhere in the county.

HOMEWOOD SANDSTONE MEMBER

In Portage County the Homewood Sandstone Member is the youngest consolidated unit, and it is also the uppermost unit of the Pottsville Formation, as described by I. C. White (1880, p. 33; 1881, p. 55–56). The Homewood Sandstone Member unconformably overlies the Mercer Member. The erosion surface that existed prior to the deposition of the Homewood Sandstone Member was in places cut deeply into the Mercer Member, as illustrated in section *F* (pl. 3). The unconformity represents a significant time break in that the units of the Mercer Member were consolidated prior to the full development of the unconformity. This fact is clearly shown by the section, now covered, exposed in the north-south roadcut made during the construction of the Ohio Turnpike, 1 mile east of Shalersville. The section, which was mentioned previously in the discussion of the Mercer Member, had a stratigraphic thickness of about 75 feet, and included one recognizable unit of the Mercer Member, the lower limestone unit. The beds have been complexly faulted and contorted, and their dip ranges from 15° N. to overturned beds that dip 80° S. The cause of the structural movement is not clear, but the records of wells in the area indicate that the conglomerate unit of the Sharon and the Connoquenessing Sandstone Member apparently were not involved. Significantly, however, the beds were consolidated prior to the structural movement. The cleat of the two 1½-foot-thick coal beds in the section is perpendicular to the bedding planes, indicating that consolidation occurred when the coal beds were essentially horizontal. At some time following consolidation, structural movement occurred that brought the beds into their present position and then sufficient time elapsed to allow subaerial weathering to alter the upper limestone unit of the Mercer to a siderite ore within the soil zone. The soil formed on these beds was partly removed by channel currents before the deposition of the Homewood Sandstone Member. The basal few inches of the Homewood Sandstone Member in the section is a conglomerate, consisting of nodular ironstone concretions and angular fragments of coal and shale eroded from the underlying Mercer Member.

The distribution of the Homewood Sandstone Member is confined principally to the north-central, central, and south-central parts of Portage County, where it crops out in the upland areas beneath glacial drift. The Homewood Sandstone Member is at a lower altitude in central and southern Deerfield Township, owing to the increased southeasterly regional dip in the southeastern part of the county.

Surface exposures of the Homewood Sandstone Member are not numerous, and those that have been observed are principally in the beds of streams, in roadcuts, and in the strip mines in eastern Atwater Township. In places on the northern slopes of upland areas where glacial scour predominated over deposition, slump and erosion have partly exposed benches of the sandstone (fig. 4). The lithology ranges from a well-sorted coarse-grained white quartzose sandstone, as observed on Sugar Loaf Hill in eastern Troy Township, Geauga County, to a tan, poorly sorted, clay-bonded micaceous medium- to fine-grained sandstone, as observed in the strip mine of the Petersen Coal Co. in southeastern Atwater Township. The thickness of the sandstone ranges from 0 to about 80 feet in the county. The full section is nowhere present, owing to erosion in late Tertiary time and glacial scour during the Pleistocene. In the south-central part of the county, in Randolph and Rootstown Townships, a thin discontinuous shale unit is reported in the sandstone by drillers. The shale lens has a maximum thickness of about 30 feet.

The crossbedding has a considerable range in the general direction of the dip. Generally the dip of the crossbedding is southwestward with variations from northwest to southeast; however, in the broad ridge in northwestern Palmyra Township, the crossbedding dips predominantly to the north and northeast. The course of the channels in the Homewood Sandstone Member has not been observed in Portage County; but partly because the source area of the sandstone would not be expected to be in the Pennsylvanian basin to

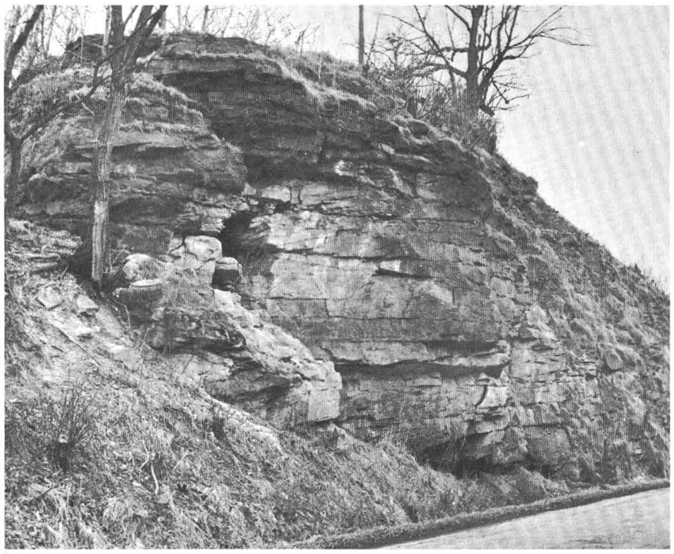

FIGURE 4.—The Homewood Sandstone Member of the Pottsville Formation in Edinburg Township. Many springs issue from the base of this resistant sandstone ledge.

the south and west of the county, an easterly source area is presumed.

The Homewood Sandstone Member has proved, generally, to be a good aquifer for domestic and stock wells, and it warrants investigation for irrigation and industrial use in the areas where it has sufficient thickness. One irrigation well in southeastern Rootstown Township (well 1645) has a yield of 200 gpm. The performance of this well indicates the potential yield of the sandstone where it is coarse grained and permeable.

GLACIAL DEPOSITS OF PORTAGE COUNTY

The material overlying the bedrock in Portage County is of glacial origin and consists of boulder clay and sand and gravel. Boulder clay, or glacial till, is an unsorted, unstratified mixture of varying amounts of sand, silt, and clay, containing pebbles, cobbles, and boulders. These materials were deposited by ice sheets which covered a large part of Ohio, including all Portage County, several times in the Pleistocene Epoch.

The ice sheets advanced into Ohio from a major center in Labrador. Each ice sheet invaded the Erie basin and then spread out from it in a series of lobes controlled by the position of lowland and highland areas. The limit of ice advance over Ohio and the position of the lobes are shown in figure 5. The ice that invaded Portage County was part of the Grand River lobe, except the ice in the northwestern part of the county which was part of the Killbuck lobe (fig. 6).

The glacial features of Portage County were described by Hildreth (1837), Whittlesey (1938, p. 56; 1866), Newberry (1874, 1878), and Leverett (1902). The stria-

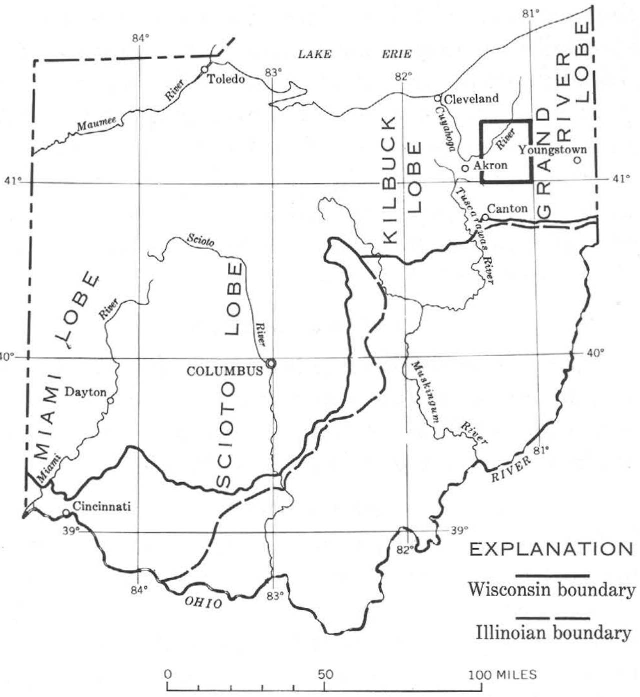

FIGURE 5.—Map of Ohio showing margins of glacial lobes.

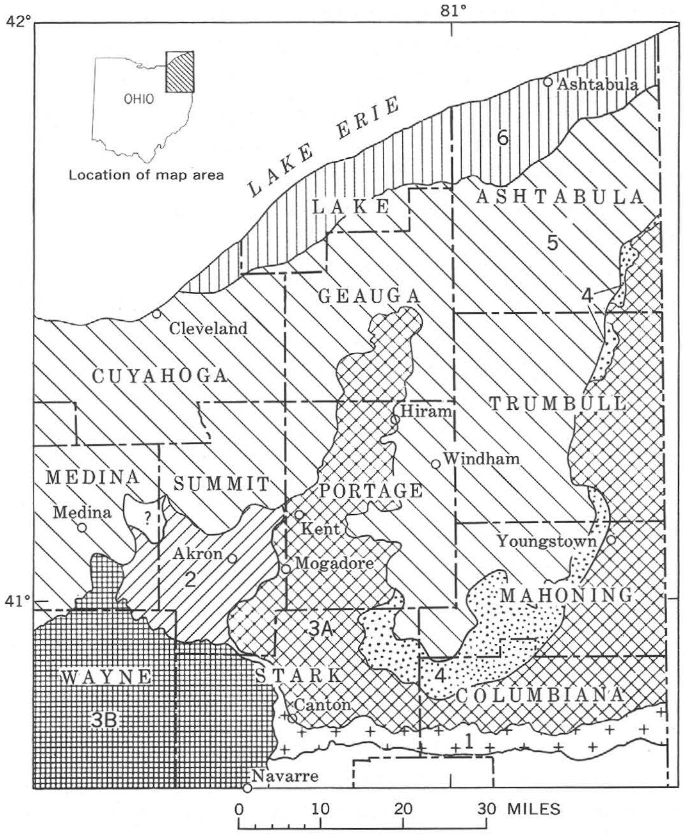

FIGURE 6.—Surface extent of Illinoian drift and Wisconsin rock-stratigraphic units in northeastern Ohio. 1, Illinoian drift; 2, Mogadore Till; 3A, Kent Till; 3B, pre-Hiram Till of Killbuck lobe; 4, Lavery Till; 5, Hiram Till; 6, Ashtabula Till. Modified from G. W. White (1960, fig. 1).

tions on the bedrock surface, the gravel and till, and especially the conspicuous moraine topography of the western part of the county attracted the notice of early geologists. None of them, however, mapped the different kinds of topography in detail or described and classified the deposits as stratigraphic units. Portage County was included on a generalized map of the glacial deposits of northeastern Ohio based on earlier studies (White, G. W., 1953b, pl. 26; 1953c, pl. 8).

GLACIAL EROSION

The ice sheets eroded the bedrock in Portage County. The amount of erosion was variable; in some areas tens and even hundreds of feet of material were removed, while in other areas erosion was negligible.

STRIATIONS

Strip mines and quarries provide views of freshly exposed rock surfaces upon which scratches and striations are at places preserved. Striations have been observed only on sandstone because shale is too soft for the striations to be preserved and limestone is almost lacking in Portage County. In the northwest part of the county, which was invaded from the northwest by ice of the Killbuck lobe, the orientation of striations and shallow ice-cut grooves ranges from S. 28° E. to S. 35° E. on sandstone ledges at and near the Industrial Silica Co. quarry, one-quarter of a mile southeast of Geauga Lake in Aurora Township. Similarly oriented striations are found on sandstone ledges in adjacent Twinsburg Township, Summit County (White, G. W., 1953c, pl. 6).

In the eastern part of Portage County, ice of the west side of the Grand River lobe engraved striations having a general southwest trend. Good striations on sandstone along Dean Street in Hiram trend S. 45° W.; at Kennedy Ledge in Nelson Township, they trend S. 15° W.; at the Sharon sandstone quarries in northeast Windham Township and southeast Nelson Township, they trend S. 30° W. to S. 40° W.; at the Palmyra Center Cemetery the trend is S. 33° W. At an abondoned quarry five-eights of a mile north of the south line and three-eighths of a mile west of the east line of Windham Township, striations trending S. 35° W. appear to cross fainter ones that trend S. 6° E.

ROCK HILLS

Some hills in which sandstone ledges are prominent have been partially streamlined by the ice. Ledges at or near the surface are marked on the glacial map (pl. 4). The rock hills in the northwestern part of the county, and in adjacent Summit County, are elongated in a northwest-southeast direction parallel to the striations, whereas the rock hills in eastern Portage County have a northeast-southwest elongation, parallel to striations and ice movements there. The ridge acquired its orientation in part during pre-Pleistocene time, because the valleys were oriented toward the major lowlands.

VALLEYS

The orientation and character of the major bedrock valleys are shown by the bedrock-surface map (pl. 3). This map shows, as do the bedrock-surface maps of Summit County (Smith and White, 1953, pl. 1) and Cuyahoga County (Winslow and others, 1953, pl. 1), that valleys parallel to the direction of ice advance are wider and have smoother walls and more sharply truncated spurs than valleys alined transverse to the direction of ice movement.

Valley deepening by glacial scour has been extensive in some areas. The bedrock Cuyahoga valley is deeper in Cuyahoga County than in Summit County, probably owing in part to greater ice erosion in Cuyahoga County. The most conspicuous example of glacial valley-deepening in Portage County is the buried valley in northwestern Streetsboro and western Aurora Townships (see section *A–A′*, pl. 3). This valley was deepened at least 300 feet by glacial scour. The buried valley in eastern Nelson Township also appears to have been glacially deepened. Because ice erosion has deepened some valleys more than others, the interpretation of former drainage systems is difficult.

STRATIGRAPHIC CLASSIFICATION

At least four times during the Pleistocene Epoch, glacial ice formed in Canada, moved into the United States, fluctuated over longer or shorter distances, and then melted away; each melting period was followed by a considerable time of milder climate, marked by flourishing vegetation and the formation of deep, mature soils. The advances are termed glaciations and the warmer times between these stages are called interglaciations.

Although details of fluctuations during the earlier glaciations are lacking, the deposits of the latest glaciation, the Wisconsin, exhibit abundant evidence of several major retreats and readvances during which a succession of drift sheets were laid down. It is thus possible to divide the latest glaciation, the Wisconsin Glaciation, into a number of stades. During each stade the advances and retreats of the ice front were on the order of tens to scores of miles. During each advance in a stade a sheet of drift was deposited upon the earlier material. Each drift sheet is usually sufficiently distinct in texture or composition to enable it to be differentiated from other units. In northeastern Ohio the drift sheets have been mapped on the basis of data obtained from surface exposures (fig. 7) or subsurface information. For convenience in describing and dis-

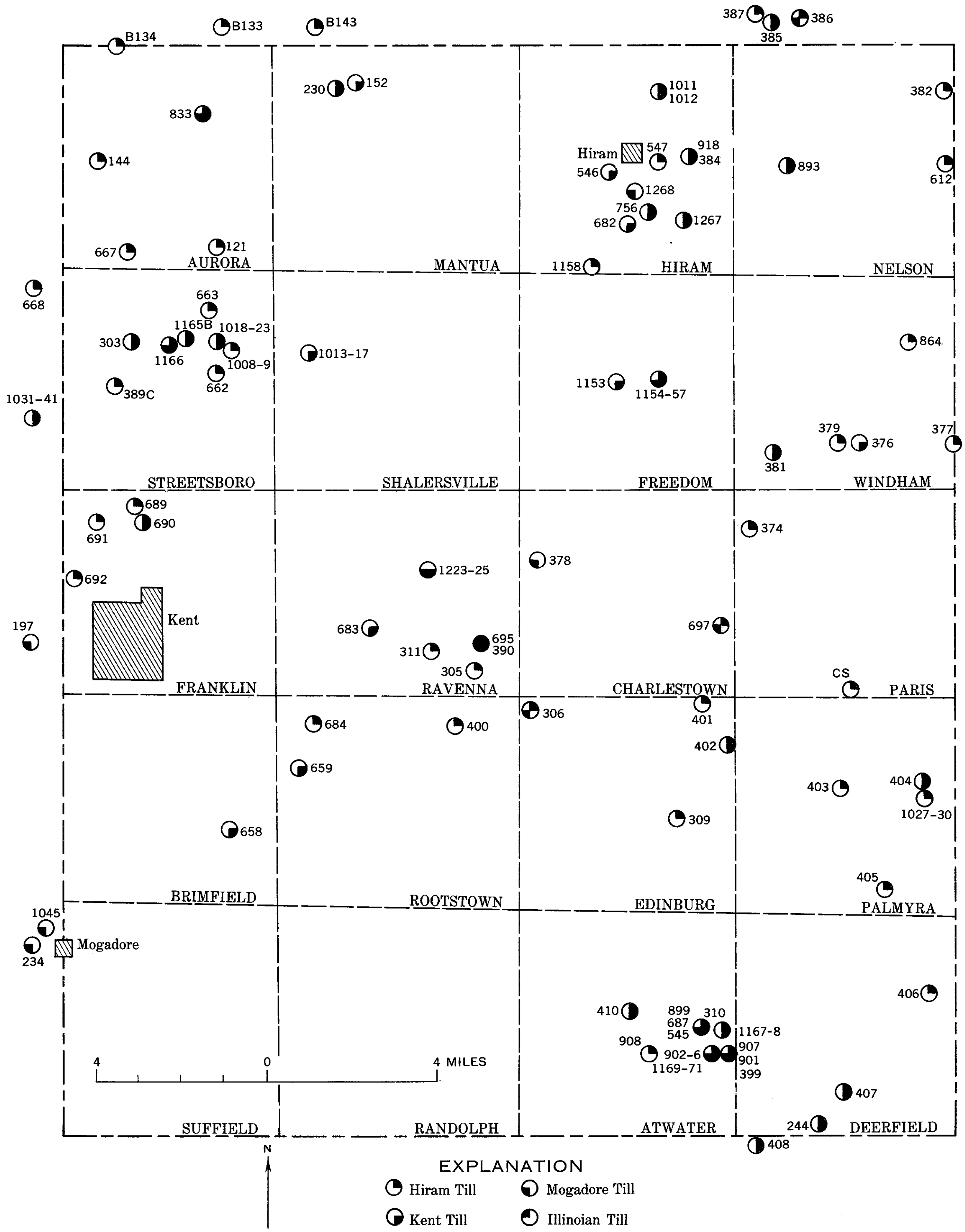

FIGURE 7.—Location of petrographic samples and measured sections. Some symbols are combined on map.

cussing these rock-stratigraphic units, they are given separate names and are regarded as formations (G. W. White, 1960). The deposits are discussed in the usual stratigraphic order—that is, from the oldest to the youngest. The classification of the glacial deposits thus far identified in Portage County is given in table 3.

TABLE 3.—*Quaternary deposits in Portage County*

Epoch	Glaciation	Stade	Division
Recent			Flood-plain deposits along major streams; muck and peat in undrained depressions, especially on Kent moraine.
Pleistocene	Wisconsin	Valders and Port Huron (Mankato)	Not represented in Portage County.
		Cary	Hiram Till: Silty clay-till of Grand River lobe in eastern part of county, and of Cuyahoga sublobe in northwestern part. (late Cary of White, G. W., 1953b.)
			Lavery Till: Silty till of Grand River lobe; underlies Windham Sand or Hiram Till.
			Windham Sand: Thin discontinuous sand deposits in Nelson, Windham, and Paris Townships; outwash modified by wind action; mainly underlies Hiram Till.
			Kent Till: Silty sand-till of Grand River lobe; at surface in western part of county, underlies Hiram Till or Windham Sand in eastern part. Forms ground moraine and Kent end moraine. In the western part of the county the Kent Till is more sandy and includes much kame gravel. (early Cary of White, G. W., 1953b.)
		Uncertain	Mogadore Till: Sandy till underlying Kent Till; lies at the surface west of the county line in southern Summit County.
	Sangamon Interglaciation		Truncated weathered zone or buried soil; poorly known from a few exposures.
	Illinoian		Very discontinuous buried till deposits; distinctive buried gravel deposits at Ravenna.
	Kansan and Nebraskan		Not known in Portage County; lower drift in deeper buried valleys may be related to one or both of these glaciations.

PRE-ILLINOIAN GLACIATION

Drift older than Illinoian has not been identified in northeastern Ohio. That earlier ice sheets invaded northern Ohio is inferred from indirect evidence.

The several systems of buried valleys in northern Ohio give evidence of Wisconsin, Illinoian, and pre-Illinoian episodes of stream diversion, valley cutting and filling, and partial filling (G. W. White, 1934). In Cuyahoga County, early Pleistocene valleys are filled with Illinoian drift. These valleys are parts of a still earlier mature and integrated drainage system that probably was modified in Kansan and (or) Nebraskan time (Winslow and others, 1953, p. 42).

Other indication of one or more pre-Illinoian ice advances into northeastern Ohio are the remnants of older outwash terraces in the Ohio River valley. These fragments of once continuous valley trains have deeply weathered soils and lie well above the younger Pleistocene terraces (Lessig, 1959).

Subsurface information for the deeper buried valleys in Portage County is not sufficiently detailed to aid in determining the age of the deposits. Deposits in the deeper parts of the valleys in northwestern Streetsboro and western Aurora Townships may be pre-Illinoian in age, as may the deposits in the deeper parts of other deeply buried valleys such as those shown in sections *B–B′*, *C–C′*, *D–D′*, and *E–E′* of plate 3. Buried soil zones, proglacial loess, and peat deposits, which may indicate older deposits, have not been reported thus far in the records of wells.

ILLINOIAN GLACIATION

The line of farthest advance of the Grand River lobe of the Illinoian glacier extends generally east-west across central Stark and Columbiana Counties, some 2 to 5 miles further south than the limit of late Wisconsin Glaciation (White, G. W., 1951). Portage County was completely covered by this ice sheet, but because these deposits were covered later by Wisconsin deposits, the Illinoian (and earlier) drift is exposed only in excavations or eroded valleys. Small patches of Illinoian drift may occur at the surface on uplands but have not been identified with certainty. Most of the Illinoian drift in Portage County probably occurs in deeply buried valleys covered by Wisconsin drift. Exposures of extensive Illinoian deposits near Cleveland (Winslow and others, 1953, p. 36; White, G. W., 1953a), at Swine Creek in Geauga County, 5 miles north of Portage County (Baker, 1957), and at Ravenna, make it reasonable to assume that many more Illinoian deposits will be discovered when detailed samples from wells drilled in the deeper buried valleys are available for study. Illinoian gravel generally contains less fine-grained material and more crystalline rock fragments than does Wisconsin gravel.

Illinoian drift is exposed in the pit of the Ravenna Sand and Gravel Co. on New Milford Road a quarter of a mile south of State Route 5 and 1⅛ miles east-southeast of the courthouse in Ravenna. Exposed in the pit are 25 to 30 feet of gray gravel, overlain by a complex sequence of several thin and discontinuous till sheets that have an aggregate thickness of 10 to 15 feet. As stripping of the tills and excavation of the gravel proceeds, other relationships no doubt will be observed, but the general sequence of units is shown in figure 8. The Illinoian age of the gravel is indicated by the occurrence, at some places, of highly weathered material underlying the less weathered Wisconsin deposits and by the high proportion of crystalline and limestone pebbles in the gravel (table 4), which is characteristic of Illinoian deposits elsewhere in northeastern Ohio (Winslow and others, 1953, p. 37).

At one place in the pit a discontinuous layer of gray till was observed about 25 feet below the top of the gravel. At the east end of the pit as much as 12 feet of brown calcareous till was exposed at the same horizon. These till deposits may indicate an episode of ice readvance within the Illinoian Glaciation.

The Illinoian gravel is conspicuously crossbedded in cut and fill structure. The pebble composition, given in table 4, is 63 percent calcareous and crystalline rock material. This percentage is far higher than for Wisconsin age gravel, and is comparable to other Illinoian gravel deposits at Cleveland, Cuyahoga County, and at Swine Creek, Geauga County, and to Illinoian till at Brecksville and Chagrin Falls, Cuyahoga County.

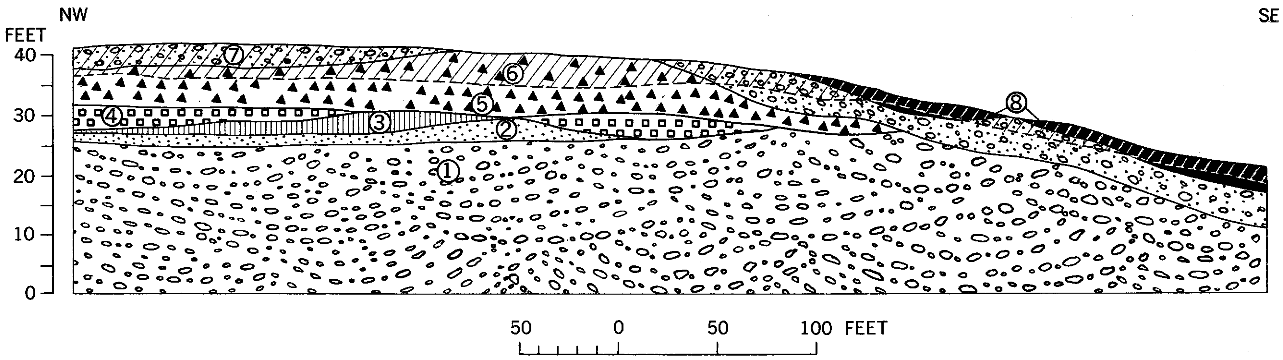

FIGURE 8.—Geologic section of Ravenna Sand and Gravel Co. pit, southeast of Ravenna. 1, Gravel, gray, Illinoian; 2, sand, brown; 3, till, brown, weathered, Illinoian; 4, till, coarse, calcareous, gray, Mogadore; 5, till, coarse, brown, calcareous, Mogadore; 6, till, coarse, brown, leached, Mogadore; 7, till, silty, sandy, brown, leached above dashed line, Kent; 8, till, clayey, brown, leached above dashed line, Hiram.

TABLE 4.—*Composition of 1- to 2-inch-diameter pebbles in glacial deposits in Portage and adjacent counties*

Glaciation	Division	Location	Pebble composition (percent)								
			Limestone and dolomite	Siltstone	Shale, black	Sandstone	Crystalline	Shale, gray	Clay ironstone	Quartz	Chert
Wisconsin	Hiram (late Cary)	Glenwillow, Cuyahoga County	22	7	41	11	9	6	3	----	1
		Solon, Cuyahoga County	25	7	28	5	18	10	7	----	----
		West Aurora, Portage County	15	34	10	16	16	4	5	----	----
		Mantua, Portage County	32	30	16	12	8	----	----	2	2
		Northampton, Summit County	40	12	21	6	18	3	----	----	----
		Average	27	18	23	10	14	5	3	----	----
	Kent (early Cary)	Henry, Cuyahoga County	10	31	31	10	7	4	3	----	----
		North Solon, Cuyahoga County	9	29	11	21	9	9	9	2	1
		Mantua, Portage County	24	28	2	20	8	2	6	6	4
			28	32	----	16	4	4	6	16	----
		Average	16	33	14	16	6	5	4	5	1
Illinoian		Chagrin Falls, Cuyahoga County	44	17	----	23	9	----	1	2	3
		Chippewa Creek, Cuyahoga County	32	32	11	4	15	4	----	3	----
		Griswold Creek, Cuyahoga County	43	18	2	16	11	1	1	5	----
			36	17	10	11	3	19	1	2	1
		Mill Creek, Cuyahoga County	59	----	3	9	22	----	----	----	7
		Swine Creek, Geauga County	32	32	----	4	15	----	13	2	2
		Ravenna, Portage County	32	18	----	13	23	----	----	6	8
		Average	40	19	4	11	14	3	3	3	3

The Illinoian gravel is probably the remnant of a terrace deposit on the north side of the east-west buried valley (map and section *F–F′*, pl. 3), which is now concealed by Wisconsin drift. Extensive continuation of this or other remnants may be preserved under cover of Wisconsin drift. An abandoned and much slumped gravel pit southeast of the new public school in southeast Ravenna, half a mile west of the Ravenna Sand and Gravel Co. pit, has a high proportion of limestone pebbles. This deposit may be a continuation of the Illinoian gravel described above.

A lense of oxidized Illinoian till as much as 3 feet thick and about 50 yards long formerly was exposed beneath gray Wisconsin till in the Ravenna Sand and Gravel Co. pit, as shown in figure 8. The Illinoian till lens was brown, moderately pebbly, and calcareous in the lower part. It was silty to sandy in texture, and a sample contained 33 percent sand, 42 percent silt, and 25 percent clay. The upper part of the till was leached and appeared to represent the lowest part of a weathered zone from which all overlying weathered material was removed by the Wisconsin ice.

SANGAMON INTERGLACIATION

At the close of the Illinoian Glaciation, the ice retreated from North America, marking the beginning of the Sangamon Interglaciation which lasted several tens of thousands of years and during which the climate was as warm, or warmer, than now. This was a period of erosion and of the formation of soil in the Illinoian drift. Erosion by Wisconsin ice removed much of the Sangamon soil, except in a few protected places where it has been preserved. A complete Sangamon soil profile, several feet thick, in Illinoian gravel is preserved beneath Wisconsin loess, lacustrine silt and clay, and till in the Mill Creek valley near Cleveland (White, G. W., 1953a; Winslow, 1958). In most of the Ravenna Sand and Gravel Co. pit in the southeastern part of Ravenna, Wisconsin till rests on unweathered Illinoian drift; however, pockets of weathered material also have been found in the excavation, as shown in figure 9. In such pockets only the lowest part of the weathered zones are preserved. Perhaps, as excavation continues in the pit, other pockets of weathered material may be found, as at Cleveland, which will present a more complete soil profile. Exposures are generally similar in the Illinoian gravel pits along the Mill Creek Valley near Cleveland. The complete weathering profile there is preserved at very few places, but many pockets occur in which the lowest weathered horizons are preserved.

Wisconsin glacial erosion generally removed the Sangamon soil from the uplands in Portage County. Scores of exposures in roadcuts, stream valleys, and strip mines on the uplands of the county reveal unweathered Wisconsin drift resting on unweathered, or only slightly weathered, bedrock. In a few places, however, weathered bedrock underlies unweathered Wisconsin drift, and this weathered bedrock is taken to be the remnant of a pre-Wisconsin soil.

A basement excavation 1 mile south of the Kent corporation line in northern Brimfield Township revealed a mass of weathered till, having the appearance of gumbotil, 4 feet below the surface in leached, but otherwise unweathered, Wisconsin till. The mass, 10 inches in diameter, was of sooty gray clay, having green mottling. It contained a few small sandstone pebbles. The mass was interpreted as being from the B horizon of a Sangamon soil. It could not have been transported far; from observation elsewhere in northeastern Ohio, it is known that a mass of unconsolidated material incorporated in the till becomes unidentifiable within 50 to 200 feet of its original position.

Not enough samples of Sangamon soil have been found in northeastern Ohio to classify it on the basis of mineral and clay-mineral composition, as has been done in northwestern Pennsylvania (Droste and Tharin, 1958). Mogadore Till contains some kaolinite, and Kent Till rarely contains kaolinite. Hiram Till contains no kaolinite. The kaolinite of the earlier Wisconsin tills may be derived from Sangamon soil.

WISCONSIN GLACIATION

The Wisconsin ice advanced into the Erie basin and spread out in lobes or sublobes into lowland areas (fig. 5). The extensive lowland in western Ohio, west of the Bellefontaine highland, was occupied by the Miami lobe; the lowland between the Bellefontaine highland and the Allegheny plateau was occupied by the Scioto lobe. Both lobes extended far southward in Ohio. In the Allegheny plateau a much shorter lobe, the Killbuck, spread over the lower land between Mansfield and Akron, and extended as far south as Holmes County. The Grand River lobe occupied the lowland that lies between the highlands of Geauga and Summit Counties and the higher part of the Allegheny plateau in Pennsylvania, 20 to 35 miles east of the Ohio-Pennsylvania line. Ice from the western part of the Grand River lobe advanced southwestward over Portage County.

In late Wisconsin Cary time the ice advanced again (symbol 5, fig. 8). The most extensive lobe at this time was the Grand River lobe which extended as far south as Alliance in Stark County. Only the eastern part of Portage County was covered by this advance. A much smaller sublobe of the Erie lobe, the Cuyahoga (Shepps, 1953), extended across Medina and northern Summit

Counties and the northwest corner of Portage County to the Cuyahoga River. At this time the Cuyahoga River in Portage County established its present course as an ice marginal stream.

MOGADORE TILL (EARLY WISCONSIN)

The surface drift in southern Summit County and in small parts of adjacent southeastern Medina and northeastern Wayne Counties is believed to be early Wisconsin (fig. 6). The drift is less weathered and must therefore be younger than the Illinoian drift south of Stark and Columbiana Counties; it is more weathered than the later Wisconsin drift which surrounds it. The early Wisconsin drift can be traced beneath the later drift surrounding or overlying it, which is correlated with the Cary drift of the Mississippi Valley. The early Wisconsin drift was interpreted as Tazewell in age (White, G. W., 1953c, pls. 6, 18), but as the early Wisconsin drift in southern Summit County cannot be traced directly into the Tazewell drift of the type locality in Illinois, it is now preferably regarded as early Wisconsin until more definite correlation can be made. The early Wisconsin drift has been named the Mogadore Till, from exposures just west of the village of Mogadore in Summit County (White, G. W., 1960). The type section of the Mogadore Till is in the south wall of the shale pit of the Universal Clay Products Co., 1 mile west of the center of Mogadore, in Springfield Township, Summit County. (See section 1043, fig. 9.) The type section of the Mogadore Till overlies Pennsylvanian shale. Droste (1956a) studied the clay minerals of the unaltered till exposed in this section as well as

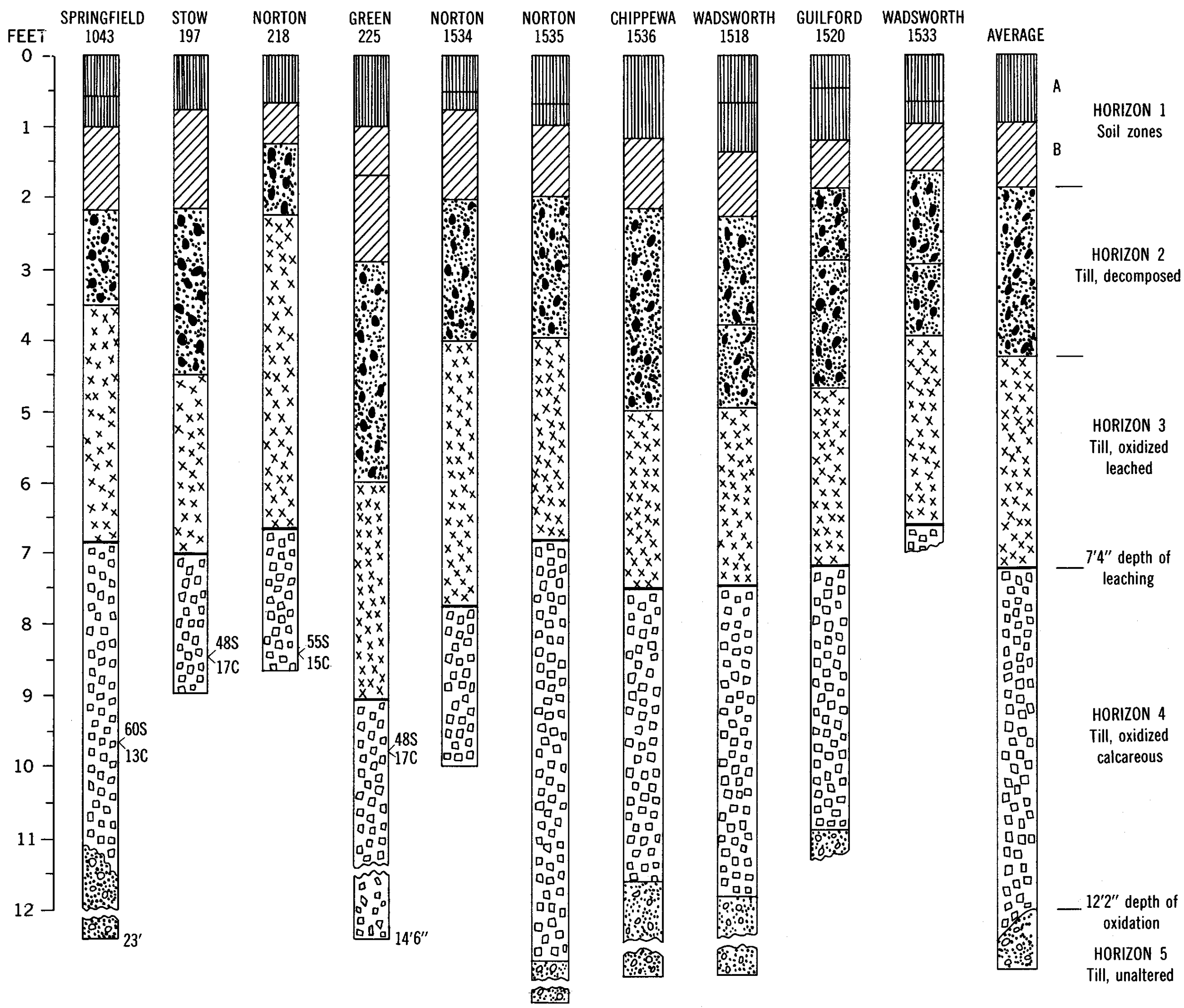

FIGURE 9.—Columnar sections of weathering horizons of Mogadore Till measured in Summit County, west of Portage County. Percentage of sand (S) and clay (C) shown for samples collected at indicated points; silt content, 100—(S+C), not shown.

the weathering zones in it (Droste, 1956b, loc. 1, fig. 1, p. 918). At the type locality the oxidized calcareous till contains 60 percent sand, 27 percent silt, and 13 percent clay.

Portage County was covered by post-Mogadore ice, and no Mogadore Till occurs at the surface, except for very small areas from which later drift was eroded or upon which no post-Mogadore drift was deposited (White, G. W., 1952). Mogadore Till is found beneath later drift at many exposures in the county. The similarity of the buried till to that exposed at the surface near Mogadore, and the fact that the buried till can be traced westward to the type section, leaves little doubt that the buried Mogadore Till of Portage County is an extension of that exposed at the surface in Summit County.

The Mogadore Till is coarse and pebbly. Table 5 shows the sedimentary analyses of 11 samples from various places in the county, the locations of which are shown in figure 7. (See also Shepps, 1953, fig. 2, p. 41.) The clay minerals in typical Mogadore Till determined by X-ray diffraction are mainly chlorite and illite, and a minor amount of kaolinite (Droste, 1956a, p. 189). Electron micrographic study confirms this clay-mineral composition (Droste and others, 1958, fig. 2).

At the time of its deposition, at some places, the Mogadore Till was washed, and some of the fine-grained material was removed by glacial melt water (table 5). Gravel is often associated with the till, as in nearby southern Summit County, where the Tazewell drift is at the surface.

The thickness of the Mogadore Till in Portage County is considerably variable. At many places it is

TABLE 5.—*Composition of Mogadore Till by particle size*

Sample	Township	Percent		
		Sand	Silt	Clay
Portage County				
905	Atwater	40.67	38.63	20.70
1167	do	41.30	38.60	20.10
1171	do	40.30	38.80	20.90
833A	Aurora	37.40	44.79	17.81
697A	Charleston	48.87	39.38	11.76
378	do	51.00	33.00	16.00
197	Franklin	58.00	31.00	11.00
1156	Freedom	50.99	38.66	10.35
1268	Hiram	18.23	46.90	34.81
1224	Ravenna	44.11	41.56	14.33
1225	do	49.40	32.43	18.17
234	Suffield	60.00	27.00	13.00
Average		44.48	37.98	17.54
Summit (S), Medina (M), and Wayne (W) Counties				
197	Stow (S)	58.00	31.00	11.00
225	Green (S)	48.00	35.00	17.00
218	Norton (S)	55.00	30.00	15.00
1534	do	47.50	34.40	18.10
1535	do	44.60	35.80	19.60
1518	Wadsworth (M)	29.60	48.30	22.10
1519	do	34.60	43.40	22.00
1533	do	45.50	37.20	17.30
1520	Guilford (M)	30.80	44.60	24.60
1536	Chippewa (W)	39.70	42.10	18.20
Average		43.33	38.18	18.49

absent and post-Mogadore till directly overlies the bedrock. At other places, as in the Petersen strip mine in Atwater Township, as much as 20 feet of Mogadore Till is preserved in depressions and valleys (fig. 10). At the Ravenna Sand and Gravel Co. pit, as much as 10 feet of Mogadore Till lies between the Illinoian drift and the overlying Kent Till (fig. 8). In the now landscaped excavation for the drainage cutoff at the Streetsboro (State Route 14) interchange of the Ohio Turnpike (just south of the tollhouse), as much as 20 feet of gravelly Mogadore drift, of unknown total

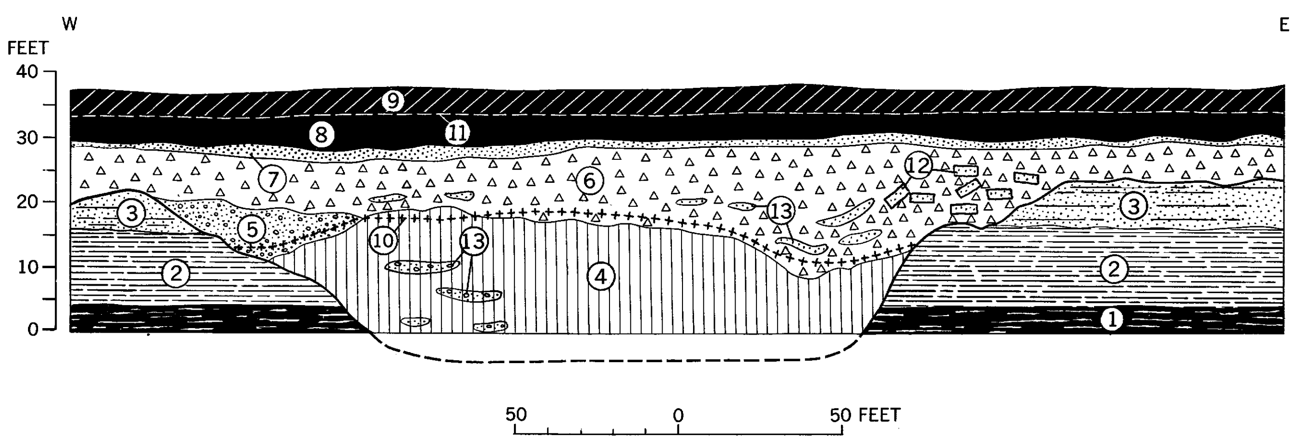

FIGURE 10.—Geologic section in the Petersen mine, eastern Atwater Township. 1, Coal; 2, shale; 3, sandstone; 4, till, coarse, sandy, calcareous, gray (sample 1171, 40 percent sand, 21 percent clay), Mogadore; 5, gravel; 6, till, silty, sandy, calcareous, brown, but gray at base (sample 1170, 23 percent sand, 37 percent clay), Kent; 7, silt, yellow, having streaks of brown and red calcareous till; 8, till, silty, clayey, calcareous, brown (sample 1169, 19 percent sand, 40 percent clay), Hiram; 9, till, similar to 8, leached and weathered; 10, depth of oxidization; 11, depth of leaching; 12, sandstone blocks; 13, gravel lenses.

thickness, was exposed in the base of the excavation (fig. 11). The thickest exposure of Mogadore Till near Portage County is along the south bank of the Grand River, half a mile southeast of Parkman, Geauga County, and about 2 miles north of Portage County. The basal 90 feet of drift in the section is Mogadore drift, mostly till. The overlying material, comprising an aggregate thickness of 45 feet, is post-Mogadore till in several layers. Another exposure of Mogadore Till underlying younger drift may be observed in Aurora Township, associated with more than 30 feet of gravel in an abandoned pit, 1 mile northwest of Aurora Station (pl. 4; section 833, fig. 12). Mogadore Till occurs below later drift in Streetsboro, Hiram, Nelson, Freedom, Charlestown, Atwater, and Suffield Townships, as shown in figure 13. The stratigraphic relationships in longitudinal sections are shown in figures 10, 11, 14, 15, and 16.

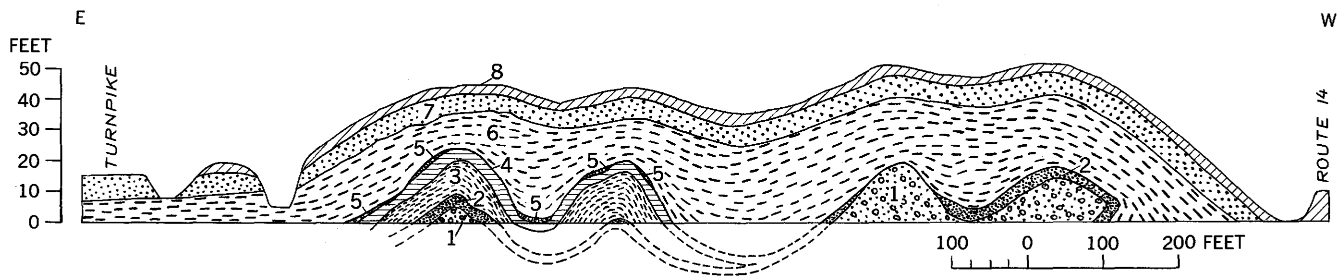

Figure 11.—Geologic section in cut for drainage diversion, Ohio Turnpike interchange, Streetsboro. 1, Till, coarse, sandy, mixed with sandy gravel, calcareous, gray, Mogadore; 2, silt, calcareous, gray; 3, till, sandy, calcareous, gray, Kent; 4, till, similar to 3, slightly oxidized to olive gray; 5, gravel, sandy; 6, till, silty, clayey, calcareous, gray with faint pinkish cast, Hiram; 7, till, similar to 6, brown; 8, till, leached, and soil.

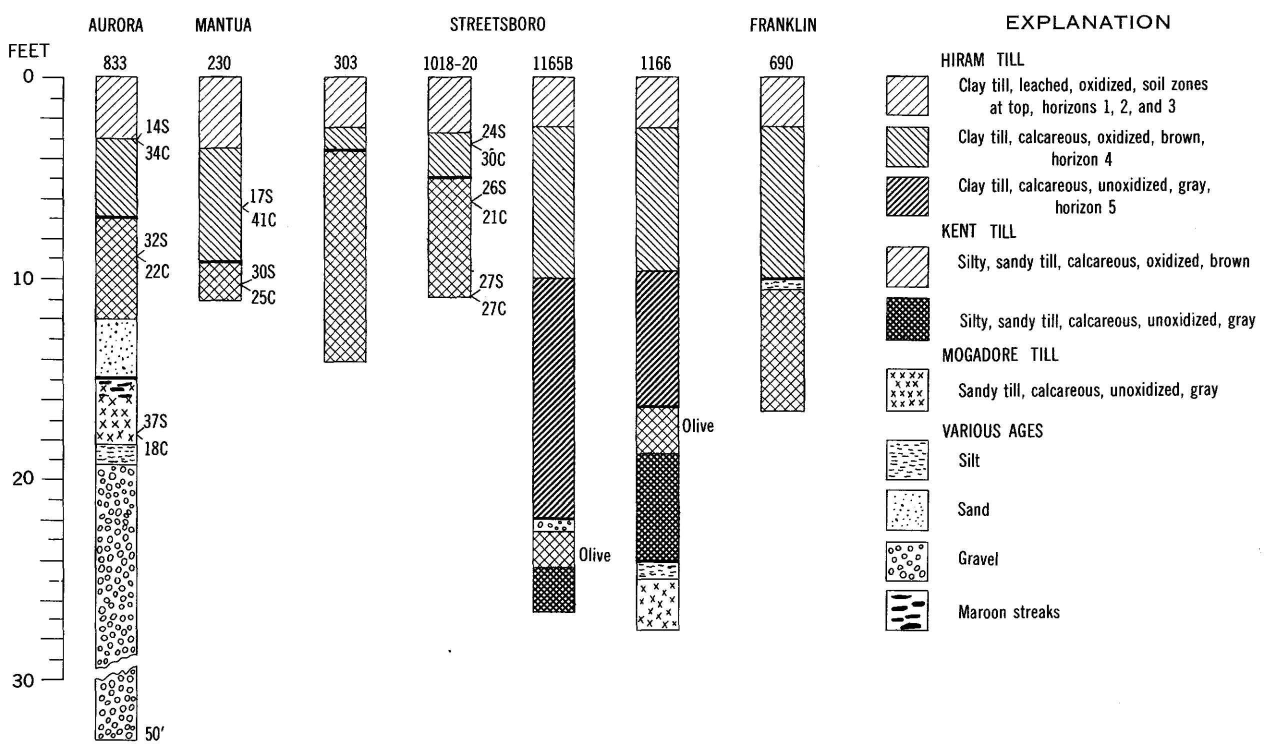

Figure 12.—Columnar sections of tills and other drift of more than one age in Cuyahoga lobe, northwestern Portage County. Percentage of sand (S) and clay (C) shown for till samples collected at indicated points; silt content, 100—(S+C), not shown.

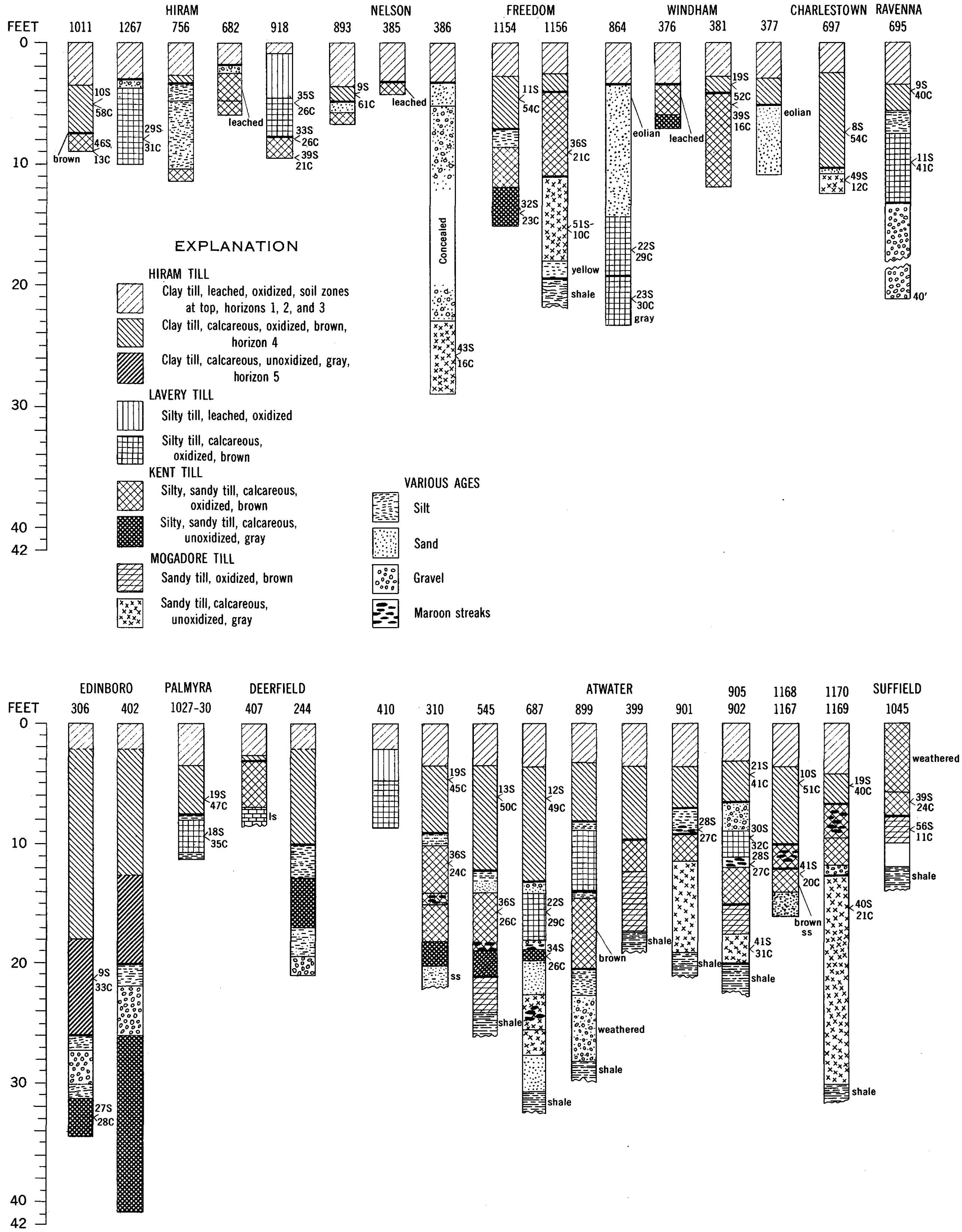

FIGURE 13.—Columnar sections of tills and other drift of more than one age in area of Grand River lobe, eastern, central, and southern Portage County. Percentage of sand (S) and clay (C) shown for till samples collected at indicated points; silt content, 100—(S+C), not shown. Sample 1045 from section half a mile west of Suffield Township, Portage County, and half a mile northwest of Mogadore, Summit County.

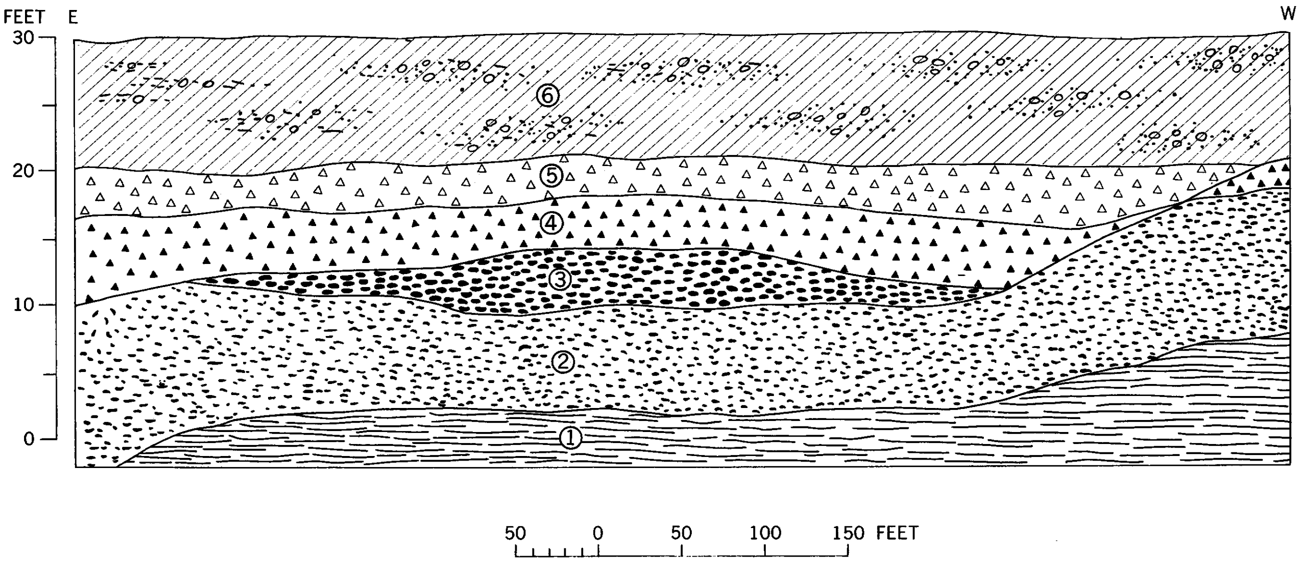

FIGURE 14.—Geologic section of cut in highway 14, in the northern part of Ravenna, 200 yards west of highway 82. 1, Shale; 2, till, coarse, sandy, calcareous, gray (sample 1225, 49 percent sand, 18 percent clay), fresh chlorite and illite, Mogadore; 3, till, coarse, sandy, calcareous, brown (sample 1224, 44 percent sand, 14 percent clay), partly degraded chlorite and illite, slightly weathered; 4, till, sandy to silty-sandy, calcareous, gray (sample 1223, 34 percent sand, 19 percent clay), fresh chlorite and illite, Kent; 5, till, similar to 4, brown, Kent; 6, till, leached, has sand and gravel streaks, possibly includes thin Kent Till in soil and weathered zone at top.

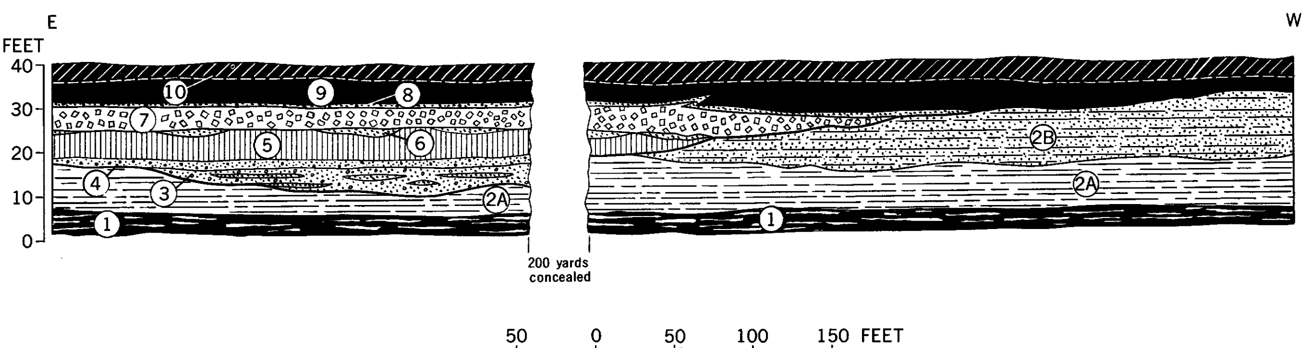

FIGURE 15.—Geologic section of cut at Keller Mines, eastern Atwater Township. 1, Coal; 2a, shale, carbonaceous; 2b, sandstone, thin-bedded, weathered at top; 3, sand and gravel, noncalcareous but not much weathered; 4, silt, yellow, noncalcareous; 5, till, coarse, sandy, brown, calcareous, Mogadore; 6, sand; 7, till, silty, sandy, brown, calcareous, Kent; 8, silt; 9, till, clayey, brown, calcareous, Hiram; 10, till, leached, and soil.

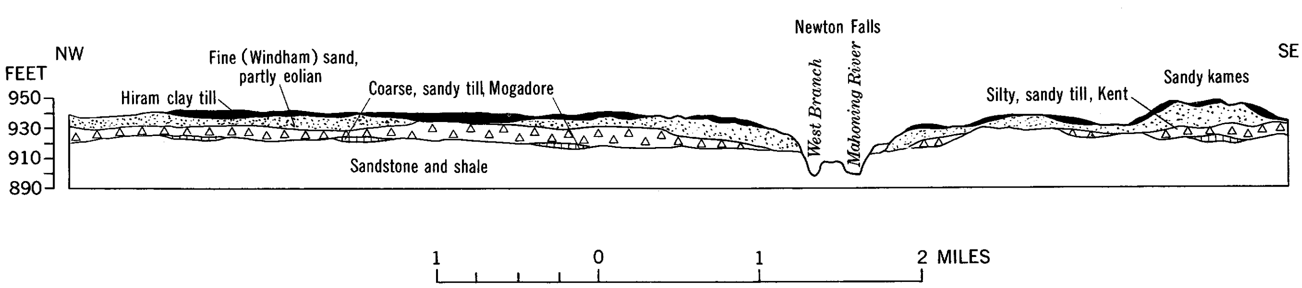

FIGURE 16.—Geologic section from Windham, Portage County, through Newton Falls, Trumbull County.

Coarse gravelly till, mixed with some gravel, was exposed during construction of State Route 82, three-quarters of a mile south of the main crossroads in Hiram, both north and south of a deep ravine that is tributary to Silver Creek valley. This till may be Mogadore and may represent a considerable body of buried coarse Mogadore drift.

Gravel and sand more than 50 feet thick is exposed at the pit of the Charlestown Sand and Gravel Co., about 2 miles east of Charlestown. The sand and gravel is overlain by 8 feet of coarse till which resembles Mogadore. The till is overlain, on lower slopes of the pit, by poorly exposed younger tills. The lower till is interpreted as Mogadore, and the gravel and sand that underlie it is believed to be the same age.

A considerable part of the drift in some of the deeply buried valleys in the county, shown in the cross sections on plate 3, may be of Mogadore age. A great thickness of Mogadore Till occurs in the partly reexcavated valley at Parkman. Careful study of well cuttings might lead to the identification of Mogadore drift in subsurface materials because it has a lower content of limestone and crystalline rock pebbles than the Illinoian drift. Mineralogic studies of sand-sized particles are in progress, and it is not yet known whether the mineral content of the sand from till of different ages will provide means of identification.

POST-MOGADORE INTERVAL

After the deposition of the Mogadore Till, the ice retreated from Portage County. The ice is believed to have retreated a considerable distance north of the county, as Mogadore Till has been found unconformably beneath later till in Geauga County (Baker, 1957), in western Pennsylvania within 30 miles of Lake Erie (Shepps, 1955), and in Cuyahoga County. The time involved in the retreat and readvance must have been appreciable because the Mogadore Till shows evidence of considerable weathering at several places where it underlies later deposits, although at many exposures it shows little weathering because the upper part has been removed. A remnant of a buried zone of oxidation was seen in an excavation for the State Route 15 bypass in the northern part of Ravenna. Here a lens of brown Mogadore Till, having a maximum thickness of 3 feet, overlies gray Mogadore Till and is overlain by gray Kent Till, as illustrated in figure 14. The chlorite and illite in the brown Mogadore Till are slightly weathered, the degree of weathering corresponding to that usually found in the lower part of soil horizon 4 (fig. 14), rather than that characteristic of more weathered till or of soil (Droste, J. B., oral commun., Apr. 1958). This degree of weathering is in accord with the presence of calcite, also characteristic of soil horizon 4.

CARY STADE

After the retreat of the early Wisconsin ice to an unknown position north of Portage County, ice readvanced in all the several lobes in Ohio. The drift deposited in the post-Tazewell readvance has been named Cary (Leighton, 1933) from deposits in northern Illinois. The readvance of the ice in Ohio is correlated with the readvance in the Lake Michigan basin which deposited the Cary drift in Illinois. The boundary of maximum advance of the Cary ice in the Grand River lobe extended through the eastern part of Summit County, south of Canton in Stark County (White, G. W., 1951), thence eastward across Stark and Columbiana Counties into western Pennsylvania, and thence northeastward to Warren, Pa. During Cary time, several ice advances and retreats occurred, two of which are recorded for Portage County.

KENT TILL

The Cary ice during its earliest advance into northeastern Ohio built a prominent end moraine, the Kent moraine, along the margin of the Grand River lobe (White, G. W., and others, 1957; White, G. W., 1957). This end moraine and the ground moraine associated with it has been called early Cary (White, G. W., 1953b). However, this drift sheet cannot be directly traced to earliest Cary drift at the type locality in northern Illinois or to early Cary drift of the Scioto and Miami lobes farther west in Ohio (Goldthwait, 1953). The term Kent Till has been given (White, G. W., 1960) as a stratigraphic designation for this formation.

COMPOSITION

The Kent Till is predominantly a silty, sandy boulder clay. It is moderately pebbly and contains a few cobbles and sporadic boulders. (See table 6 for analyses.) The till is somewhat more sandy in the Kent moraine, the western part of which is a kame moraine. The clay matrix of the till is predominantly chlorite and illite, but a small amount of kaolinite is present (Droste, 1956a).

KENT MORAINE

The existence of the morainic topography in this area has been known for almost 100 years. Newberry described (1878, p. 133) and illustrated (1874, p. 42) high kames in Randolph Township which are a part of the Kent moraine. Chamberlin (1883, p. 341, pl. 31) noted the moraine marking the western margin of the Grand River lobe but interpreted that part of the moraine in Stark, Summit, Portage, and Geauga Counties (p. 339, 341) as interlobate moraine between the Scioto (now called Killbuck) lobe on the west and the Grand River

TABLE 6.—*Composition of Kent (early Cary) Till by particle size*

Sample	Township	Percent			Sample	Township	Percent		
		Sand	Silt	Clay			Sand	Silt	Clay
410	Atwater	26.00	46.00	28.00	152	Mantua	37.00	45.00	18.00
545A	do	36.00	38.00	26.00	230B	do	30.00	45.00	25.00
687A	do	33.62	40.89	25.49	683	Ravenna	29.29	50.36	20.35
713A	do	53.88	33.18	12.94	695A	do	32.74	42.38	24.88
901	do	28.15	44.91	26.94	1223	do	34.06	47.14	18.80
1170	do	22.90	40.10	37.00	659	Rootstown	26.74	50.40	22.86
310A	do	35.50	37.00	23.50	1013	Shalersville	31.48	62.07	6.45
833A	Aurora	32.20	46.25	21.55	1014	do	33.21	55.38	11.41
658	Brimfield	11.41	52.90	35.69	1018	Streetsboro	27.00	46.00	27.00
408	Deerfield	29.00	39.00	22.00	1019	do	26.00	53.00	21.00
306A	Edinburg	27.00	39.00	27.00	1022	do	19.50	46.00	34.50
1153	Freedom	26.20	53.19	20.61	1023	do	20.00	49.00	31.00
1155	do	31.55	45.35	23.56	1041	do	29.82	43.85	26.33
384	Hiram	39.00	40.00	21.00	381A	Windham	39.00	45.00	16.00
1011	do	45.60	41.02	13.38	Average		31.84	46.96	23.89

lobe on the east. Leverett (1902, p. 438, pl. 12) traced the moraine in more detail and further interpreted as interlobate the moraine from Canton to Geauga County. However, the drift in central and southern Summit County (now called Mogadore) is older than the Kent moraine, and the Kent moraine in eastern Summit and western Portage Counties is a marginal end moraine (G. W. White, in Winslow and others, 1953, pl. 26) and not interlobate as stated by Chamberlin and Leverett.

The Kent moraine extends southward from central Geauga County to near Canton in Stark County and thence eastward across Ohio to Pennsylvania. The moraine ranges in width from about 6 miles in Geauga County to about 12 miles in southwestern Portage County, southeastern Summit County, and Stark County. In northwestern Portage County the topographic form of the Kent moraine prevails despite a thin covering of later drift.

The Kent moraine can be divided into two nearly parallel belts on the basis of composition. The western belt, 4 to 8 miles wide (in part covered by later till in northwestern Portage County), is a kame moraine composed of a high proportion of gravel. The eastern belt, 2 to 5 miles wide, is principally till. These two belts are differentiated on the map (pl. 4).

In the western belt the drift is aggregated in gravel knolls and hills (kames). The highest kames, about 1 mile northwest of St. Joseph, in northeastern Suffield Township, rise 160 feet above their bases. Elsewhere in Suffield Township and in western Randolph and Brimfield Townships, kames more than 100 feet high are common. Within the kame moraine belt the hills are arranged in a random pattern.

Depressions, called kettle holes, are common within the morainic belt. These kettle holes range in size from less than 1 acre to more than 1 square mile. The deepest kettle holes are the sites of ponds and lakes, the largest of which are Fritch (Wingfoot) Lake, Brady Lake, Lake Pippen, and Twin Lakes. The larger kettle holes are shown on the map (pl. 4). Some of the kettle holes are above the water table and are dry; others are not far below the water table and are occupied by swamps in which peat and some marl have accumulated. The extensive areas of peat and muck, clearly shown on the soil map of the county (Mooney and others, 1919), are the sites of intensive truck farming. The largest single area in Portage County is about 2 miles long and 1 mile wide, just north of Mantua Center. In the morainic area many streams flow from one kettle hole to another, rather than in regular valleys. Congress Lake Outlet, a stream which rises at Congress Lake, just south of Portage County, flows almost entirely through kettle holes, northward across Randolph, Rootstown, and southwestern Ravenna Townships to join the Cuyahoga River at Kent.

The eastern belt of the Kent moraine, shown by a separate pattern on the map (pl. 4), is composed principally of till knolls, arranged in a random pattern. This belt extends from northeastern Mantua Township, where it is about 2 miles wide, southward across Shalersville, western Ravenna, southeastern Franklin, eastern Brimfield, western Rootstown, and western Randolph Townships. The width of the belt increases southward to as much as 5 miles in Brimfield and Rootstown Townships and then decreases to about 1 mile in width at the Portage-Stark County line. In Mantua Township bedrock hills, thinly till veneered, protrude through the moraine, as does an elongate north-south ridge 3½ miles long in Shalersville and Ravenna Township (see pl. 4).

Associated with the till of the moraine are sand and gravel lenses, some of which are large enough for gravel-pit operation. At some of these gravel pits, in the part of the moraine that is mostly till, the till is associated with the sand and gravel deposits in such a way as to suggest oscillation of the ice front at the time of deposition of the moraine. At the large Sober pit, 2 miles west of Rootstown, well-sorted evenly bedded medium-sized gravel (with a few poorly sorted beds) is an ice-contact deposit related to the large kettle hole to the north. The beds dip generally south about 25°. Till, ranging from less than 1 foot to more than 8 feet in thickness, overlies the gravel. Possibly the Kent moraine was deposited as a kame moraine in the area where till predominates at the surface. A readvance of the Kent ice may have overridden the eastern part of the moraine, depositing a sheet of till of variable thickness upon it.

KENT GROUND MORAINE

The Kent ground moraine forms the surface material in a belt 3 to 6 miles wide, extending from western Hiram Township southward through western Freedom, eastern Shalersville, northwestern Charlestown, northeastern Ravenna, southeastern Rootstown, southwestern Edinburg, eastern Randolph, and western Atwater Townships. East of this belt the Kent ground moraine underlies younger drift. The belt of ground moraine is separated into two parts southeast of Ravenna where younger drift overlies it in the wide ancient valley which extends east-west through Campbellsport.

The Kent ground moraine forms an undulating surface, masking the underlying bedrock topography to a large extent. The thickness of the drift is clearly shown in section *F–F′* (pl. 3), which is drawn from south to north across the county along this belt of ground moraine. North of the valley of the West Branch of the Mahoning River the drift is from 0 to 25 feet thick, whereas south of the valley the drift is over 100 feet thick in places. The total section of drift is not everywhere entirely Kent; in some Ohio Turnpike cuts in Freedom Township two tills, the lower one Mogadore, were exposed.

SUBSURFACE KENT TILL

The Kent ground moraine underlies the later Lavery and Hiram Tills of the Grand River lobe in eastern Portage County and underlies the Hiram Till of the Cuyahoga sublobe in the northwestern part of the county. The Hiram Till is distinctively finer in texture and much more clay-rich in composition than the Kent Till. Samples from deep hand-auger borings and exposures in strip mines, highway excavations, and stream cuts usually show Kent Till to underlie the upper tills which generally are not more than 10 to 12 feet thick. The Hiram-Lavery-Kent drift relationship is shown in some of the columnar sections of figure 13 and in longitudinal sections in figures 8, 10, 15, and 17. The base of the Kent Till is exposed in some strip mines and in a few other exposures. Where the base of the Kent Till is exposed, usually it is seen to overlie either Mogadore Till or bedrock. Kent Till overlies Illinoian gravel in the Ravenna Sand and Gravel Co. pit (fig. 8). Commonly, the upper part of the buried Kent Till is oxidized because the overlying tills are so thin that oxidation has occurred throughout their entire thickness and has progressed into the underlying Kent Till. Where the overlying tills are thick enough to possess a lower unoxidized zone, the underlying Kent Till is usually also unoxidized, indicating that very little time elapsed between the deposition of the Kent Till and the readvance of the ice which deposited the Lavery Till.

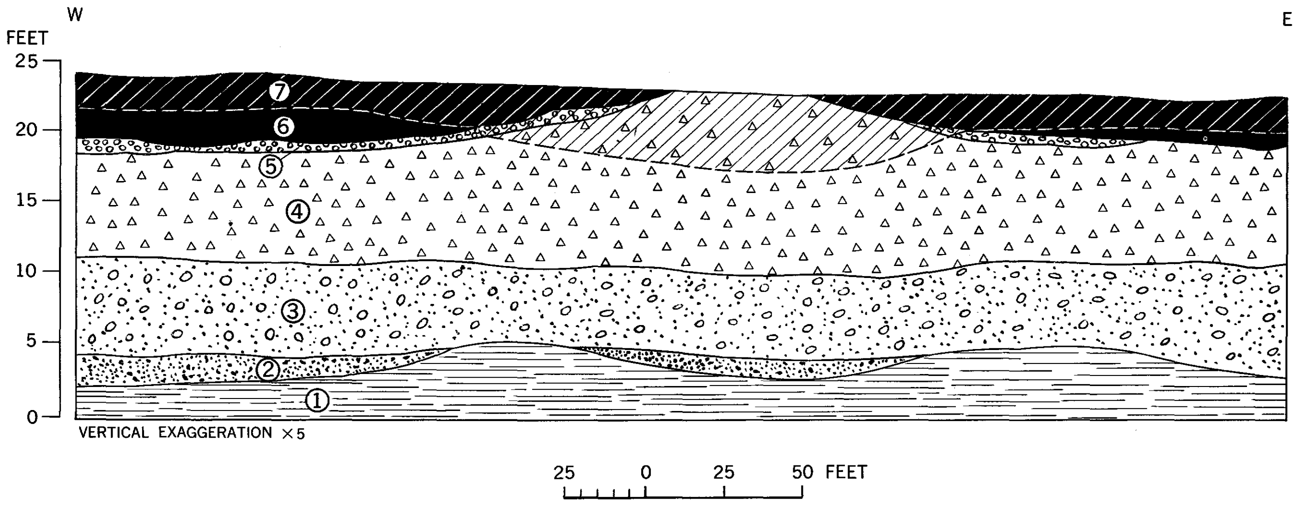

FIGURE 17.—Geologic section of Ohio Turnpike cut, 1 mile northeast of Freedom, Portage County. 1, Shale; 2, silt, yellow; 3, till, coarse, sandy, calcareous, brown and gray (sample 1156, 51 percent sand, 10 percent clay), Mogadore; 4, till, silty, sandy, calcareous, brown but some gray at base (sample 1157, 36 percent sand, 21 percent clay), Kent; 5, gravel; 6, till, silty, clayey, calcareous, brown (sample 1154, 11 percent sand, 54 percent clay), Hiram; 7, till, similar to 6, leached and weathered. Dashed line shows depth of leaching, which is greater in Kent Till where exposed.

In Aurora, western Mantua, and most of Streetsboro Townships, in northwestern Portage County, Kent Till (of the Grand River lobe) underlies the younger clayey Hiram Till of the Cuyahoga sublobe. The stratigraphic relations are shown in the columnar sections of figure 14 and in the longitudinal sections of figures 11 and 18. Figure 18 shows the depths of weathering in the two till sheets along the western margin of the Hiram Till, near Streetsboro, Portage County. The depth of leaching is greater in the sandier Kent Till (fig. 19).

Much of the Kent Till in the northwestern part of the county is in the buried Kent moraine. The till of the Kent moraine is sandy and gravelly, and part of the moraine is composed of kame gravel. The overlying Hiram Till generally is thin, and at several places Kent Till, particularly the gravelly phase, protrudes through the Hiram Till as kame islands in a sea of clay till. At several exposures the base of the Kent Till was observed either lying directly on Mogadore Till or separated from it by a few feet of sand (section 833, fig. 12).

At the drainage-diversion cut at the State Route 14-Ohio Turnpike interchange, in Streetsboro Township, the Kent Till is about 20 feet thick at the east end of the cut and pinches out toward the western end where the Hiram Till lies directly upon gravelly Mogadore Till (fig. 11). In this cut was observed the only indication of weathering on the upper surface of the Kent Till, where it is overlain by unweathered Hiram Till. The upper 2 feet of the Kent Till is very slightly oxidized, to a brownish-gray, indicating a very brief period of weathering before the readvance of the ice to deposit the Hiram Till. In this exposure the Kent Till appears to have been deposited upon an irregular surface of Mogadore Till that had a relief of 25 or more feet. Some displacement of the lower till to the west is evident, although no evidence of ice shove of the Kent Till was observed. The upper surface of the Kent Till also is irregular, having a relief of about 25 feet. The surface of the overlying Hiram Till also is irregular with a relief of about 25 feet over most of the section, but the relief is greater to the east of the section. It appears that the Kent Till was deposited upon a moraine of Mogadore Till, forming the Kent moraine. The Hiram Till was in turn deposited upon the Kent moraine to form the present surface. The present morainic surface of the Hiram Till thus is inherited from the underlying Kent moraine which, at this place, appears to have inherited at least part of its topography from a still earlier moraine.

The buried Kent drift in Portage County is economically important. Large volumes of kame gravel in places underlie a generally thin cover of Hiram Till and these deposits are the source of much sand and gravel in the northwestern part of the county. Where Hiram Till is very thin, the underlying coarser, more permeable, Kent Till induces better soil drainage and permits more rapid infiltration of precipitation. It is probable that many dug wells and shallow drilled wells derive their water from the underlying Kent drift and not from the surface stratum of Hiram Till.

RETREAT OF KENT ICE

How far the Kent ice retreated before the ice moved forward again is conjectural. That Kent Till underlies later tills is known from many exposures in eastern Portage County (figs. 10, 13, 15, 17), Trumbull County (fig. 16), and Mahoning County. Exposures studied in northern Trumbull and southern Ashtabula Counties indicate the presence in those places of Kent Till; therefore, the Kent ice retreated at least as far as this. The overlying till is much more clayey, which indicates that after the deposition of the more sandy Kent Till the ice retreated to a position from which it could pick up clay-rich material during its readvance. Extensive lacustrine deposits may have been the source of the clay and fine silt in the later till. If so, the ice probably retreated into the Erie basin before readvancing into Portage County.

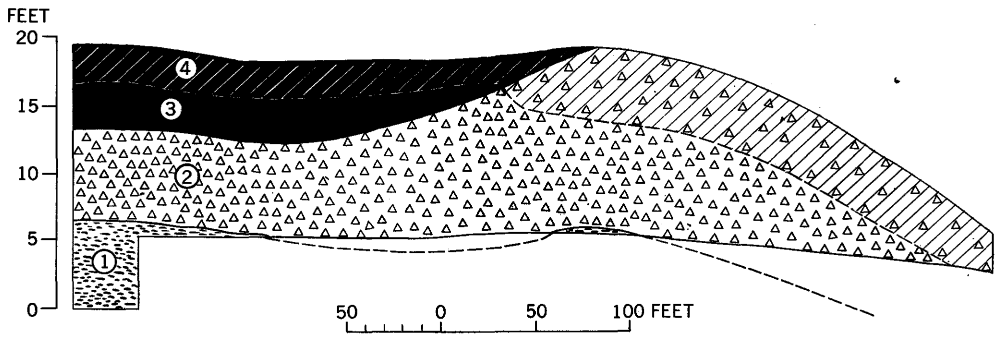

FIGURE 18.—Geologic section of Ohio Turnpike cut, 1 mile northeast of Streetsboro, Portage County. 1, Till, silty, sandy, calcareous, gray, Kent; 2, till, same as 1, brown; 3, till, silty, clayey, calcareous, brown, Hiram; 4, till, same as 3, leached and weathered. Dashed line shows depth of leaching, which is noticeably greater in Kent Till.

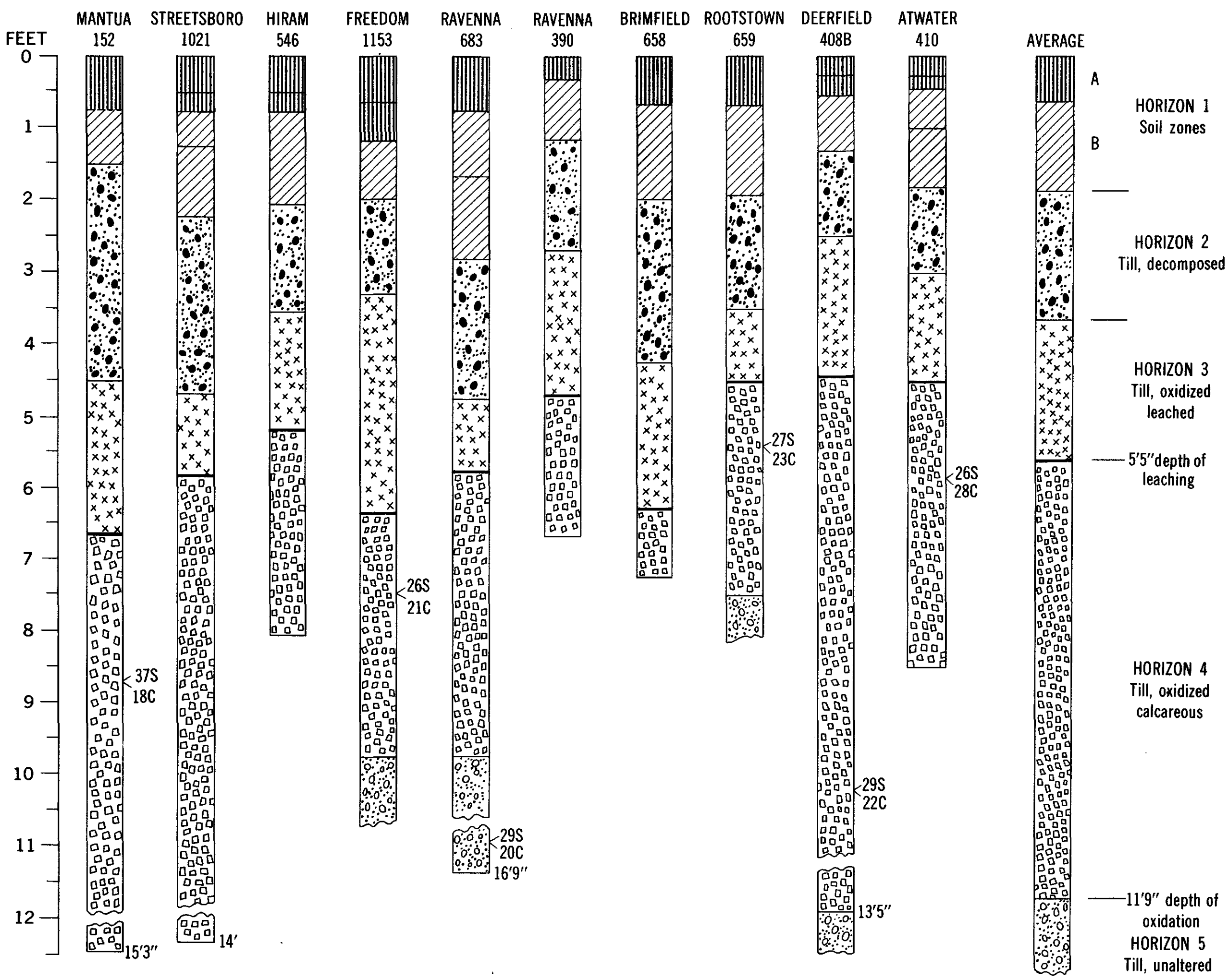

FIGURE 19.—Measured columnar sections of weathering horizons in Kent Till, Portage County. Percentage of sand (S) and clay (C) shown for samples collected at indicated points; silt content, 100—(S+C), not shown. Subdivisions of A and B soil zones of horizon 1 shown by horizontal lines in some sections.

LAVERY TILL

After the retreat of the ice that deposited the Kent Till the ice readvanced and deposited the Lavery Till. This till has been traced from its type locality at Lavery crossroad in northwestern Pennsylvania (Shepps and others, 1959, p. 38) into Ohio (White, G. W., 1960, p. 7). It is exposed at the surface in eastern Ashtabula and Trumbull Counties and lies below the later Hiram Till in the central and western parts of these counties and in eastern Geauga County. In Portage County the Lavery Till is covered by Windham Sand or by Hiram Till, except in a few places where the overlying material is so thin that the Lavery is the surface drift, and in a very small area in the central southern part of Atwater Township where the Lavery Till extends westward for about 1 mile beyond the Hiram Till. To the south, in northeastern Stark and in the northwestern Columbiana Counties and to the east in central Mahoning County, the Lavery Till is at the surface in a belt several miles in width (fig. 6).

The Lavery Till crops out at the road fork 1 mile east of Hiram, where the overlying Hiram Till is so thin it is incorporated in the present soil (section 918, fig. 13). It crops out at the base of the Dutter-Miller sandpit seven-eighths of a mile west of the east line and 1½ miles south of the north line of Windham Township (section 864, fig. 13). Lavery Till has been exposed from time to time in strip mines both north and south of the Atwater-Deerfield highway in eastern and central Atwater Township. In these excavations it occurs as a discontinuous thin sheet between Hiram Till and Kent Till (fig. 13).

In the pit of the National Fireproofing Co. half a mile northeast of Diamond, eastern Palmyra Township, 3 feet of Lavery Till lies upon shale or silt, and is overlain by 7½ feet of Hiram Till (sections 1027–30, fig. 13). The Lavery Till is included with the underlying shale in the raw material for ceramic ware, but the upper till is discarded.

The Lavery Till is a silt till, in which the matrix contains only a litle more clay than sand. The composition is shown in table 7. It is sparingly to very moderately pebbly.

Sections showing weathering horizons occur only in that very small area in Portage County where the Lavery Till is at the surface. In southern Atwater Township, 1½ miles south of Atwater Center and ¼ mile east of the north-south highway, Lavery Till is leached 4 feet 4 inches. The oxidized calcareous till is dark brown to dark yellowish brown, somewhat darker than the more yellow-brown Kent Till. This depth of leaching and this color are characteristic of the Lavery Till in its greater surface extent in Stark County.

TABLE 7.—*Composition of Lavery Till in Portage County by particle size*

Sample	Township	Percent		
		Sand	Silt	Clay
687B	Atwater	21.92	50.46	27.62
903	do	29.52	38.80	31.68
908	do	28.60	41.32	30.06
918	Hiram	35.12	38.69	26.19
1267	do	29.17	39.64	31.19
1027	Palmyra	17.50	47.50	35.00
695B	Ravenna	10.98	48.41	40.64
864A	Windham	22.17	49.23	28.60
864B	do	22.95	46.83	30.22
Average		24.20	44.60	31.20

WINDHAM SAND

A sheetlike deposit of sand overlies the Lavery Till and underlies the Hiram Till in eastern Nelson, eastern Windham, and eastern Paris Townships, Portage County, and in adjacent Newton and Braceville Townships, Trumbull County. This formation is called the Windham Sand from the township of that name (White, G. W., 1960). The Windham Sand is an outwash deposit laid down in an irregular sheet when the Lavery ice was retreating. In the retreat it may have stood for a time along a line extending from east-central Nelson Township to southern Southington and northern Braceville Townships. Immediately northeast of the sand deposit, a buried till ridge confirms the position of the ice.

The Windham Sand generally overlies the Lavery Till, but at a few places it lies on Kent Till or on bedrock. The Windham Sand is generally overlain by younger Hiram Till whose thickness ranges from as much as 10 feet to a sheet so thin that it is incorporated in the modern soil. At places the Hiram Till is absent, and the Windham Sand forms the surface material as is shown on the map (pl. 4).

The Windham Sand ranges in thickness from a few inches to 10 or more feet. In the type section at the sandpit of the Dutter-Miller Sand and Gravel Co. in northeastern Windham Township, half a mile south of the Erie Railroad and 1 mile west of the county line, the Windham Sand ranges from 11 to 18 feet in thickness. It lies upon Lavery Till and is overlain by 3½ feet of Hiram Till (section 864, fig. 13). The sand probably is much thicker in the buried-valley area in southern Nelson Township, but all the sand penetrated in wells in that area may not be of this age.

The Windham Sand generally is fine grained. It is coarser to the northwest, containing pockets of fine gravel in Nelson Township, and becomes finer to the east where, in Trumbull County, it is a fine-grained silty sand that may be well sorted and may lack silt in the upper part.

The bedding of the Windham Sand ranges from evenly thin bedded (or even laminated in Trumbull County) in the lower part where the sand is thickest, to irregularly crossbedded in the upper part of the formation. At many places the upper few feet are very markedly crossbedded in a manner common to sand dunes.

The Windham Sand is the surface material in parts of Nelson and Windham Townships, in the Eagle Creek drainage basin, and in Paris Township southeast of the West Branch of the Mahoning River (pl. 4). The sand has a few low knolls on its surface, especially in Paris Township; these may be small, low dunes now covered by vegetation. The Windham Sand was deposited as an irregular sheet, in ponds and low areas and on wide flat areas over which melt-water streams shifted rapidly. After deposition ceased, or in dry areas during deposition, wind shifted the upper material, even building low dunes in favorable places. Subsequently the Hiram ice advanced over the sand, covering it with a thin discontinuous sheet of clay-till.

The Windham Sand is penetrated in drilling, but even in the buried valleys where the sand is thickest, the material generally is so fine grained that few wells are developed in it.

HIRAM TILL

After the Lavery ice retreated an unknown distance from Portage County, it readvanced as a fairly thin sheet. Its margin, except in southern Atwater Township, was just beyond that of the Lavery ice. That the ice was thin is shown by the fact that its margins were rather delicately controlled by topography. The readvance was in a series of sublobes of the main Erie lobe (fig. 6). The short Cuyahoga sublobe extended into northern Summit, northwestern Portage, and western Geauga Counties. A much longer sublobe advanced into the Grand River lowland, but it did not reach the limit of the earlier Grand River lobe of Kent time. It covered most of the eastern half of Portage County, the eastern part of Geauga County, extreme northeastern Stark County, northwestern Mahoning County, western and central Trumbull County, and most of Ashtabula County.

The till of this readvance has been named the Hiram Till from exposures just east of Hiram in Portage County (White, G. W., 1960). This till was earlier called late Cary (White, G. W., 1953b, c; Shepps, 1953). The Hiram Till of the Grand River lobe has been traced from Portage County northward around the highlands of Geauga County and observed to be continuous with the till of the Cuyahoga lobe (fig. 6; White, G. W., 1953b, pl. 26). Therefore, the same stratigraphic term is applied to this till in both lobes in Portage and adjacent counties. The minor differences between the Hiram Till of the two lobes are only facies differences of the same rock-stratigraphic unit.

COMPOSITION

The Hiram Till is clay rich and generally has sparse pebbles, a few cobbles, and a very few boulders. The unoxidized till is blue gray, and the oxidized calcareous material is dark brown. The composition of the till in the Grand River lobe in eastern Portage County and in the Cuyahoga lobe in the northwestern part of the county is shown in table 8. Baker (1957) studied in detail the relation and transition of these two facies in Geauga County. Sand or gravel lenses are rarely found in the Hiram Till in the eastern part of the county, but in the northwestern part a few sand or gravel streaks do occur.

TABLE 8.—*Composition of Hiram (late Cary) Till by particle size*

Sample	Township	Percent		
		Sand	Silt	Clay
Grand River lobe				
310B	Atwater	18.50	47.00	44.50
545B	do	13.00	37.00	50.00
687C	do	11.76	39.58	48.66
713B	do	14.04	45.73	40.23
902	do	21.26	37.42	41.32
1168	do	10.20	38.40	51.40
1169	do	18.90	41.50	39.60
697B	Charleston	7.54	38.78	53.68
406	Deerfield	10.00	39.00	51.00
306B	Edinburg	9.00	54.50	32.50
309	do	18.00	58.50	45.00
401	do	12.00	38.00	50.00
1154	Freedom	11.09	45.35	53.56
547	Hiram	12.01	38.21	49.78
1012	do	10.28	37.80	57.92
1158	do	5.63	39.24	55.13
382	Nelson	8.63	41.19	50.18
612	do	11.00	47.75	41.25
893	do	9.30	30.09	60.61
405	Palmyra	4.00	34.00	62.00
1027	do	17.50	47.50	35.00
1028	do	18.50	35.00	46.50
311	Ravenna	8.00	47.00	45.00
695B	do	10.98	48.41	40.64
695C	do	8.59	51.23	40.18
381B	Windham	19.00	29.00	51.50
Average		12.26	41.40	47.58
Cuyahoga lobe				
144	Aurora	20.00	37.00	42.00
833C	do	13.55	52.79	32.66
689	Franklin	23.96	42.61	33.43
690B	do	23.46	52.95	23.59
230A	Mantua	17.00	42.00	41.00
1008	Streetsboro	15.04	39.56	45.40
1009	do	18.60	41.56	39.84
1020	do	24.00	46.50	29.50
Average		19.45	44.37	35.93

The clay minerals in the Hiram Till are entirely illite and chlorite, kaolinite being absent (Droste, 1956a; Droste and others, 1958). The sequence of weathering of clay minerals in Hiram Till at Streetsboro was reported by Droste (1956b). The composition of the pebbles in the Hiram Till is shown in table 2. Black shale pebbles make up almost one-fourth of all the pebbles less than 2 inches in diameter.

Sections showing the weathering zones in the till are illustrated in figures 20 and 21. The average depth of leaching in the Grand River lobe is 3 feet $2\frac{1}{2}$ inches, and in the Cuyahoga lobe, 2 feet $8\frac{1}{2}$ inches. The Hiram Till is leached to a shallower depth than any of the other tills in Portage County (fig. 22).

SURFACE EXPRESSION

As shown on the map (pl. 4), the surface of the Hiram Till in the northwestern part of Portage County is irregular and at places strongly hummocky, having conspicuous kettle holes. Such topography is that of an end moraine. Mainly it is inherited from the underlying Kent moraine and is due only in minor part to the Hiram advance.

The Hiram Till in the eastern part of Portage County generally has a flat to gently undulating ground-moraine surface which generally is poorly drained. Small areas of constructional topography are shown on the map as end-moraine areas. These areas are of more than one type. Those in Palmyra, Paris, and Edinburg Townships are underlain by somewhat thicker Hiram Till than that in the ground moraine, and their surfaces are more undulating than the surface of the ground moraine. These areas of undulating topography are not alined and so do not indicate a true end moraine as would be formed along a stationary ice margin.

A tract near the margin of the Hiram Till in Ravenna and Rootstown Townships, just south of Ravenna, contains areas of moderately undulating constructional topography, the knolls being 15 to 20 feet high and the kettle holes including the basins of Muzzy Lake and Crystal Lake. This morainic tract may be due in part to the Hiram Till overlying the Kent moraine, and thus inherited a morainic surface; in part, however, it is an end moraine of thicker Hiram Till having its own constructional topography and being related to the westward advance of the ice into the lowland now occupied by the valley of the West Branch of the Mahoning River.

In Silver Creek and Camp Creek valleys in Hiram, northern Freedom, and western Nelson Townships, the Silver Creek valley being along the margin of the Hiram drift area, the Hiram Till has a constructional surface of pronounced undulations, or low hummocks and swales. A few kettle holes exist. In Camp Creek valley in western Nelson Township, masses of silt, sand, and sandy gravel are associated with the till.

In northeastern Nelson Township a tract of 3 or 4 square miles is a part of the Defiance moraine which has been traced around the southern part of the Erie basin, from Michigan across Ohio to Pennsylvania (Leverett, 1931, fig. 8). The Hiram Till of the Defiance moraine varies in thickness; in nearby Trumbull County, where it rests on lower coarser Lavery Till, it is only a few feet thick. The moraine consists of Hiram Till draped over an earlier end moraine. The part of the moraine in Portage County is so small that its history must be interpreted from other areas.

THICKNESS AND STRATIGRAPHIC RELATION

The Hiram Till is thin in most of Portage County. The columnar sections in figures 12 and 13 and the Ohio Turnpike and strip-mine sections in figures 10, 11, 15, 16, and 17 show that the till is not more than 10 feet thick at most places. A thickness of over 20 feet is unusual, although not unknown (fig. 11). The till is so thin that at most places the zone of oxidation has penetrated through the unit into underlying earlier material. The Hiram Till at most places lies upon Lavery or Kent Till or Windham Sand, but at a few places the Hiram Till may lie upon Mogadore Till or bedrock. In part of Nelson Township and in much of Windham Township, the Windham Sand lies between the Hiram Till and the Lavery Till.

HIRAM OUTWASH

The Hiram ice left very meager outwash deposits. In northeastern Portage County two small kames of sandy gravel in extreme northeastern Freedom Township are the only ice-contact outwash deposits derived from Hiram ice, aside from very small lenses of sand and fine gravel associated with Hiram Till. Just north of Portage County, between Grove and Parkman in Geauga County, Baker (1957) identified small kames and a kame terrace of Hiram age.

Sand and fine sandy gravel in a lowland tract of about $2\frac{1}{2}$ square miles, now drained by the West Branch of the Mahoning River in northeastern Ravenna Township, is of uncertain origin. It may be outwash from the Hiram ice deposited when the ice lay in the valley of the West Branch of the Mahoning River, to the south. The exposures are poor, and the stratigraphic and genetic relations are not clear.

Faint marginal channels border Hiram Till in Freedom Township, the northern part of Charlestown Township, and the northern part of Atwater Township. The shallow depth of these channels shows that they were operative for only a short time. No outwash was found associated with them, but north of Atwater are deposits of pebbleless clay as much as 5 feet thick which appear to have been deposited in short-lived ponds at the ice front.

Some of the sand of the low outwash terraces along the Cuyahoga River in Shalersville, Streetsboro, and Franklin Townships (pl. 4) may be of Hiram age and consist of sand carried down the Cuyahoga valley by

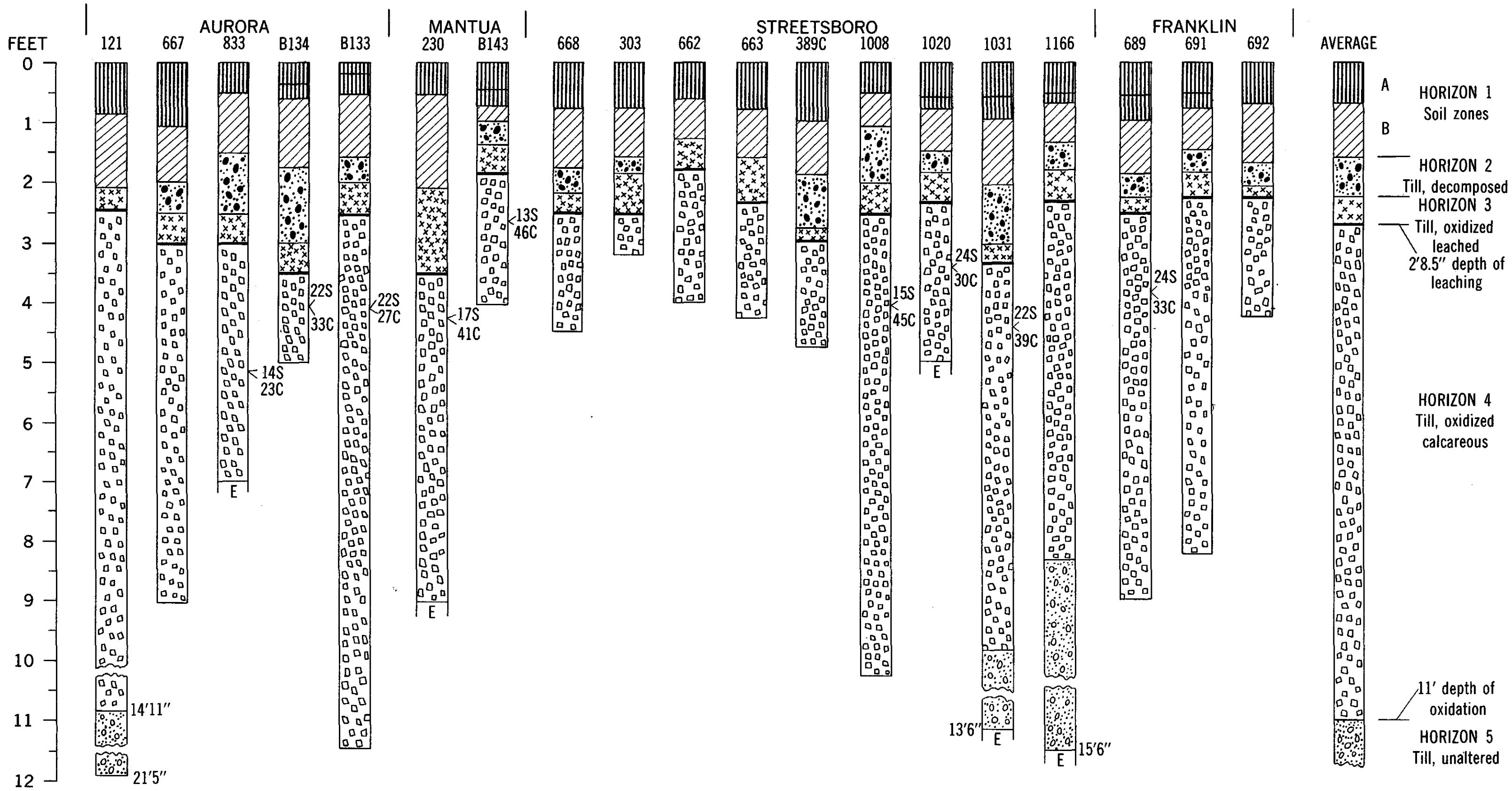

FIGURE 20.—Measured columnar sections of weathering horizons in Hiram Till of Cuyahoga lobe, northwestern Portage County. Percentage of sand (S) and clay (C) shown for samples collected at indicated points; silt content, 100—(S+C), not shown. Subdivisions of A and B soil zones of horizon 1 shown by horizontal lines in some sections; E, earlier drift.

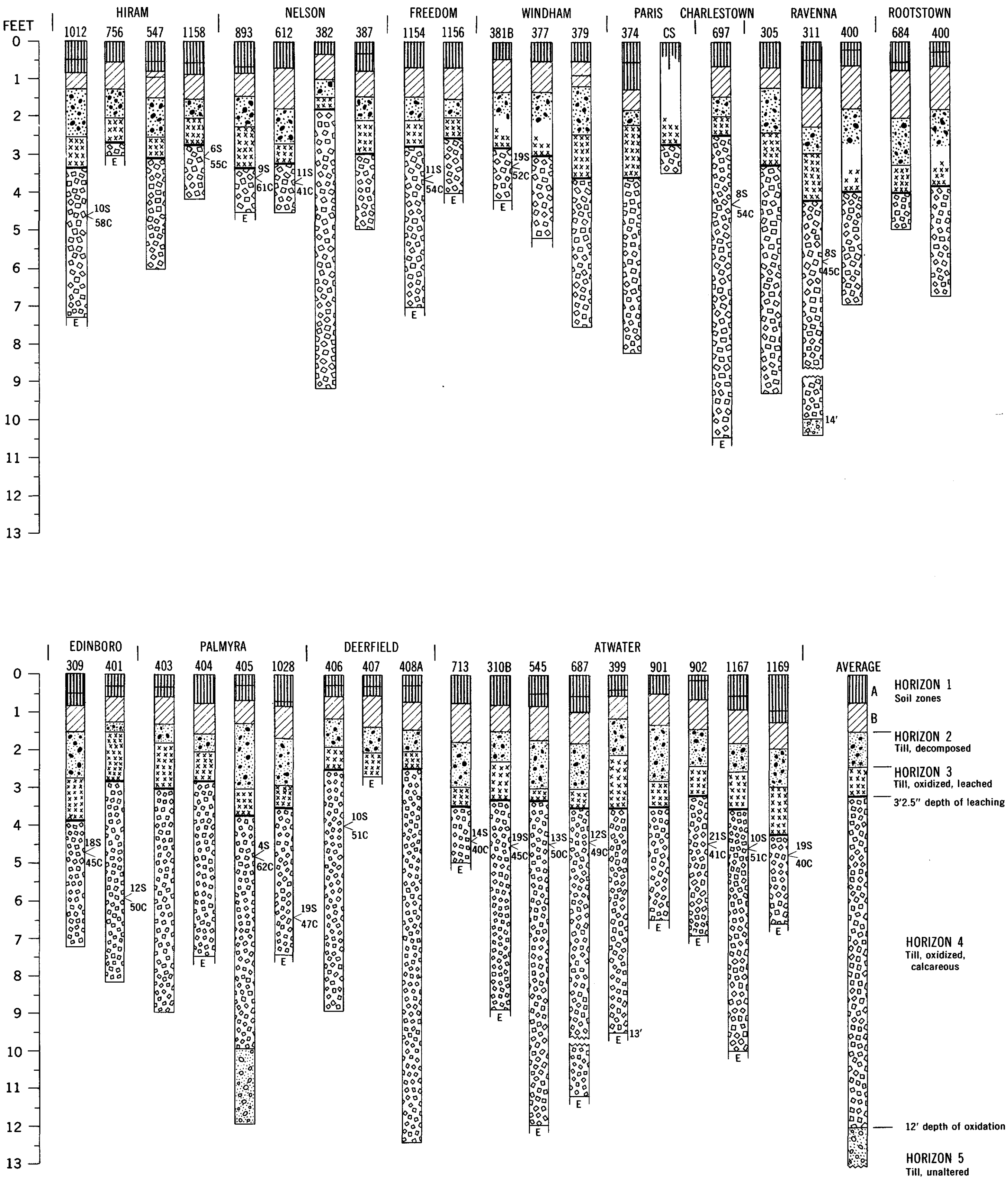

FIGURE 21.—Measured columnar sections of weathering horizons in Hiram Till of Grand River lobe, eastern and central Portage County. Percentage of sand (S) and clay (C) shown for samples collected at indicated points; silt content, 100—(S+C), not shown. Subdivisions of A and B soils zones of horizon 1 shown by horizontal lines in some sections; E, earlier till below Hiram Till.

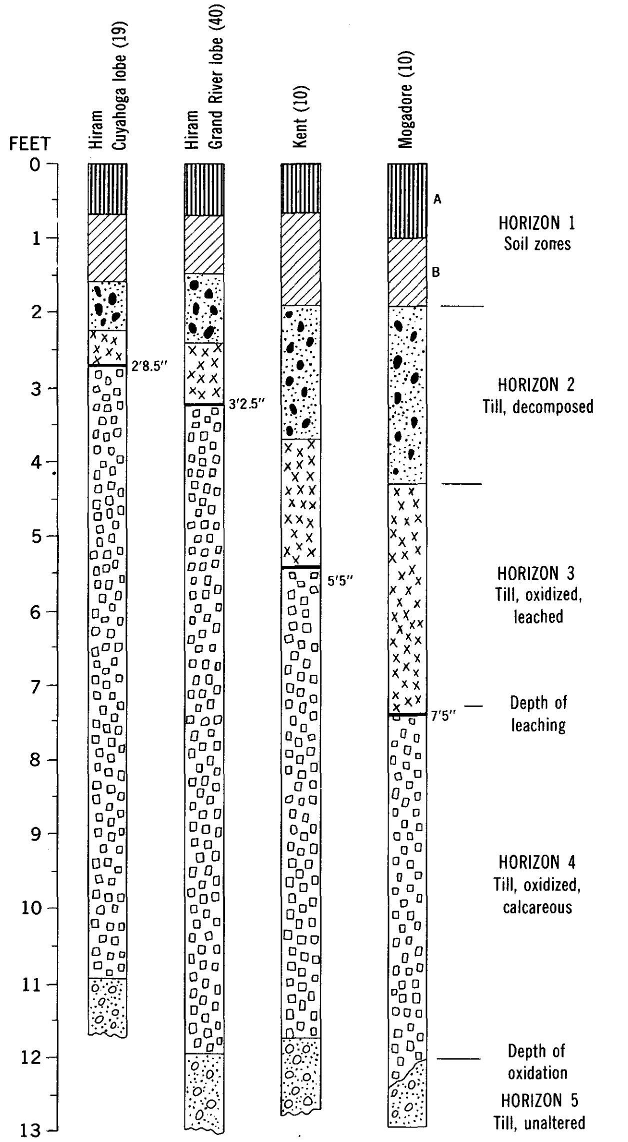

FIGURE 22.—Average columnar sections of weathering horizons in Mogadore, Kent, and Hiram Tills. Number of sections on which average section is based shown in parentheses for each till. Averages derived from sections in figures 9, 19, 20, and 21.

melt water from Hiram ice when it stood near the Cuyahoga River between Burton and Middlefield, Geauga County (White, G. W., 1953b, pl. 26; Baker, 1957). However, most of the material in the terraces is believed to be of Kent age, as already discussed.

RETREAT OF THE HIRAM ICE

No evidence is available to show that the Hiram ice of the Cuyahoga and Grand River lobes did not retreat at the same time. As the ice was thin, the retreat was probably very rapid. The small amount of outwash material associated with the Hiram Till is noteworthy, and it may be attributed to the thinness of the ice sheet, to the fine-grained character of the Hiram drift, or to the short duration of the Hiram ice advance.

GROUND-WATER HYDROLOGY

The source of virtually all the ground water in Portage County is precipitation. About four-fifths of the precipitation in the northeastern Ohio region runs directly off the land surface into surface-water bodies or is returned to the atmosphere by evapotranspiration. The remainder becomes ground water after infiltrating through the zone of aeration and the capillary fringe to the zone of saturation. The water in the zone of saturation slowly moves through the ground to an area of discharge such as a surface-water body or a pumped well. During dry periods the discharge of ground water into a stream sustains the flow of the stream unless the natural hydrologic system has been altered by manmade structures that control the flow of the stream. Over a period of years, the average recharge to an undeveloped aquifer is approximately equal to its average discharge.

The water table is the upper surface of the zone of saturation, below which all the voids in the soil or rock are filled with water under atmospheric pressure. The water table has an undulating surface, the form of which is a subdued modification of the topography of a region. In humid regions, such as Portage County, the lowest part of the water table coincides with stream level; the water table is deepest beneath hills. The average depth to the water table in the county is about 50 feet and the maximum depth rarely exceeds 100 feet.

The movement of ground water is controlled principally by gravity, and the rate of movement in an unconfined aquifer depends upon the gradient of the water table and the permeability of the soil and rocks through which the water flows. The amount of water that can be stored in a soil or rock and the rate at which water can move through it are determined by the size, shape, and arrangement of the constituent rock particles. In a coarse gravel deposit the interstitial voids are relatively large and interconnected; thus porosity is good and flow of water through the material is comparatively free. In finer grained sediments the interstitial voids are smaller, and the flow of water through them is impeded. The porosity of a nearly impermeable clay actually may be greater than that of a coarse water-yielding gravel deposit. The consolidation of sediments by the pressure of overburden or by the addition of cementing material between the individual rock particles reduces both the permeability and the porosity of the rock.

In stratified sediments the size, shape, and arrangement of rock particles in each bed may be different from those characteristics in adjacent beds, and the permeability of the finer grained beds of an aquifer may be much less than that of adjacent coarser grained beds. The vertical movement of water is impeded by the less permeable beds, and water moving laterally moves fastest in the more permeable beds. Within typical sand and gravel aquifers, there may be a considerable difference between the vertical and horizontal permeability of the individual beds.

In a stratified sedimentary sequence of sandstone and shale, or of sand and clay, the shale and clay layers form relatively impermeable beds, called confining beds, which impede the vertical movement of water. If the water level in a well drilled through a confining bed into a permeable bed, or aquifer, is higher than the upper surface of the aquifer, the well is said to be artesian, even though the water level in the well may be about the same as the level of the water table. If the recharge area for the confined aquifer is higher than the ground level in the vicinity of the well, the hydrostatic pressure in the confined aquifer may be sufficient to cause the well to flow at the surface. Many of the wells in Portage County are artesian wells, but only a few of them flow at the surface.

When a well is pumped, a cone of depression is formed about the well. The dimensions of the cone of depression are determined by the amount of water pumped from the well, whether or not artesian conditions exist, and by the physical properties of the aquifer—that is, its permeability, porosity, thickness, and areal extent. The cone of depression expands until it either induces sufficient recharge or reduces sufficiently the natural discharge from the aquifer to equal the discharge of the pumping well. Should the rate of pumping exceed the recharge to the aquifer, the water table within the cone of depression will decline continuously as water is removed from storage in the aquifer.

FLUCTUATIONS OF GROUND-WATER LEVELS

The seasonal fluctuations of the water level in four observation wells in Portage County are shown in figure 23. The seasonal fluctuations that affect most of the water wells in the county show the annual cycle of ground-water recharge and discharge. The amplitude of the fluctuations in any well is related to precipitation, surface runoff, evapotranspiration, the permeability of the water-bearing materials, the proximity of the well to recharge and discharge areas, and the amount of pumping in the vicinity of the well. The hydrographs of wells Po–1, Po–2, Po–3, and Po–4 (from files of Ohio Dept. Nat. Resources, Div. Water; prefix "Po" signifies Portage County) show that most of the recharge occurs early in the year; the period of recharge generally begins when the ground thaws and ends during the early part of the growing season when warm weather and plant growth cause a significant increase in the rate of evapotranspiration.

If a line is drawn to connect the highest (or lowest) annual water levels in a particular well, the line may show a general upward or downward trend over a period of years. Such a decline or rise of the level of the water table is related to the variation in precipitation from year to year and, to some extent, the seasonal distribution of the precipitation. A long-term decline of the water table also may indicate overpumping in the vicinity of the well.

Observation well Po–1 (No. 2037), Windham, is 55 feet deep and penetrates the conglomerate unit of the Sharon Member of the Pottsville Formation. Little pumping is done in the vicinity and the water level in the well is principally related to the amount of recharge derived from precipitation and to the ground-water discharge from the aquifer.

Observation well Po–2 (No. 738), in the well field of the Kent Water Department, near the south city limits, is 65 feet deep and penetrates sand and gravel for its full depth. The fluctuations of the water level in the well are in part due to pumping in nearby wells, one well being only 8 feet distant. The slightly declining trend of the water table is due to the increasing rate of pumping at the well field.

Observation well Po–3 (No. 1349) is near Water Works 2 at the Ravenna Arsenal and penetrates 136 feet of the conglomerate unit of the Sharon Member of the Pottsville Formation. Originally the well yielded 128 gpm with a drawdown of 85 feet. The water level fluctuates in response to the annual recharge and discharge cycle and to pumping from the well field. Precipitation in the latter part of 1952 and in 1953 was substantially below average. As a result the water level declined to a point much lower than usual. Since 1953, annual precipitation has been slightly above average and the water level in the well has risen considerably.

Observation well Po–4 (No. 460) is also at the Ravenna Arsenal, near Water Works 3. The well penetrates both the conglomerate unit of the Sharon Member and the Connoquenessing Sandstone Member of the Pottsville Formation. The fluctuations of the water level are in response to the annual recharge and discharge cycle and to pumping in the well field.

PUMPING TESTS

Controlled pumping tests provide information on the hydraulic properties of an aquifer. These properties are commonly expressed as values of T and S, the coefficients of transmissibility and storage, respectively, which reflect the permeability, thickness, and other char-

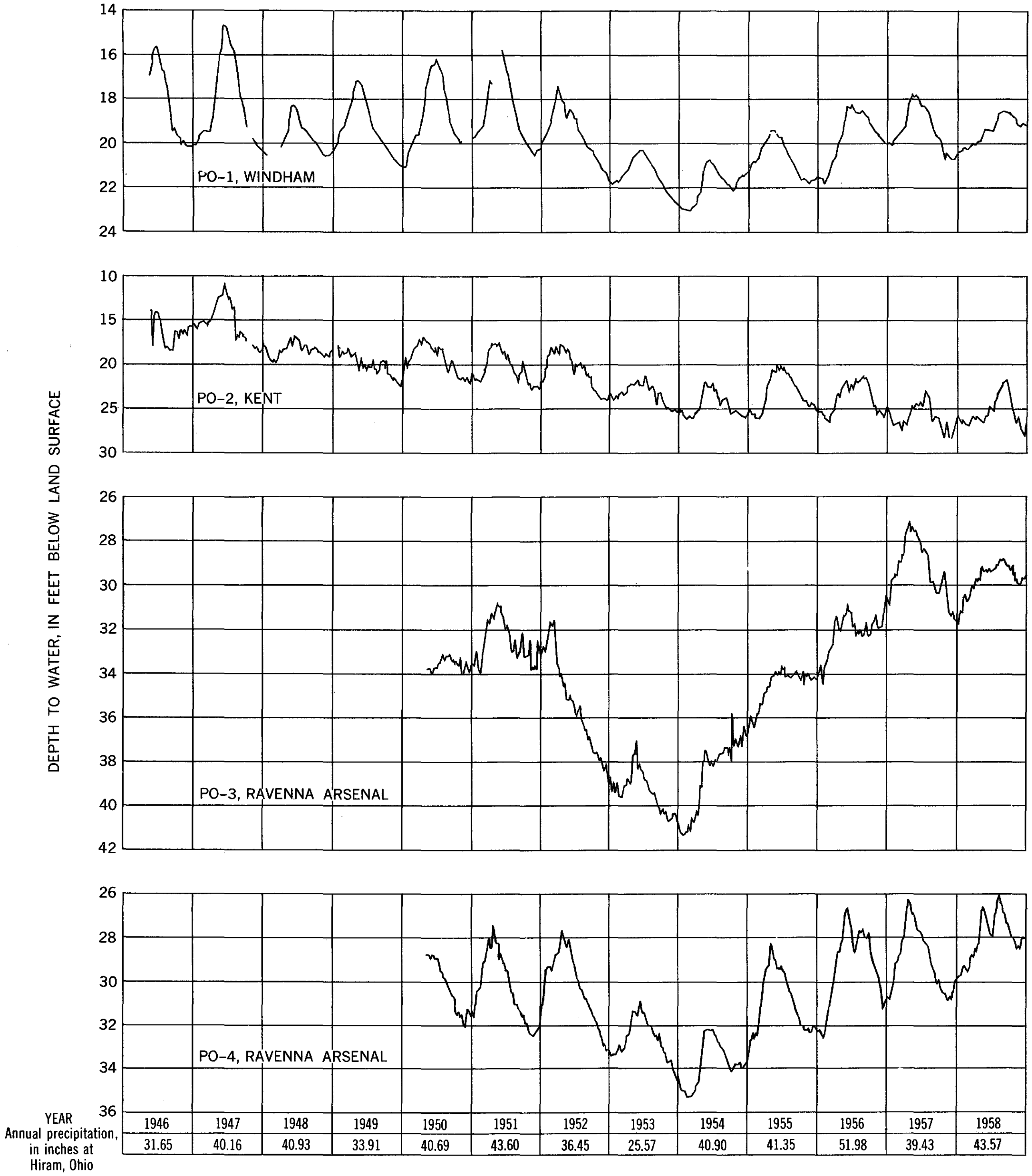

Figure 23.—Fluctuations of water level in observation wells.

acteristics of an aquifer. A pumping test can provide basis for an estimate of the yield of a well, the amount of drawdown that can be expected at a given pumping rate, and the effect of pumping upon water levels in other wells in the vicinity. This information is essential to the proper design of a water-supply installation.

In areas where the aquifers are of large areal extent and have nearly constant thickness, porosity, and permeability, a few pumping tests made at widely spaced intervals may provide sufficient information on which to base an estimate of the performance of a well at any point in the aquifer in advance of drilling. Unfortunately, in Portage County the lithology, thickness, and areal extent of the water-bearing formations change over such short distances that it is very difficult to predict the yield of a well in advance of drilling.

Three pumping tests were made by E. J. Schaefer, formerly U.S. Geological Survey district engineer, to determine the hydraulic characteristics of the sandstone aquifers from which the water supply of the Ravenna Arsenal is obtained. The pumping tests were made on Ravenna Arsenal wells 25, 29, and 68 (wells 1361, 1336, and 447, respectively, in this report). All three wells were drilled through the glacial drift into the sandstone and shale units of the Pottsville Formation. Ravenna Arsenal well 25 is 130 feet deep and penetrates 117 feet of the conglomerate unit of the Sharon Member of the Pottsville Formation. Ravenna Arsenal well 29 is 155 feet deep and penetrates 100 feet of the conglomerate unit of the Sharon Member. Ravenna Arsenal well 68 is 222 feet deep and penetrates 49 feet of the conglomerate unit of the Sharon Member, 12 feet of an unnamed (stray) sandstone unit, and 35 feet of the Connoquenessing Sandstone Member.

The pumping tests conducted on Ravenna Arsenal wells 25 and 29 were inconclusive concerning the hydrologic characteristics of the aquifer because of the hydraulic boundaries close to the pumping wells. In both pumping tests the effect of pumping reached the boundary so rapidly that the effect of the boundary on the water levels in the pumping well and in the observation wells was hidden by the comparatively large initial drop of water levels during the first minutes of the tests. However, is was possible to estimate, from pumping-test data, that for a 6-month period without recharge the yield of Ravenna Arsenal well 25 was 180 gpm for a drawdown of 78 feet, and the yield of Ravenna Arsenal well 29 was 135 gpm for a drawdown of 60 feet.

The pumping test made on Ravenna Arsenal well 68, which was drilled in an area where the hydraulic characteristics of the conglomerate unit of the Sharon Member and the Connoquenessing Sandstone Member are nearly constant, gave values of T and S for both aquifers in combination of about 13,000 gpd per ft (gallons per day per foot) and 0.0002, respectively. The yield of the well for a 6-month period without recharge was estimated to be about 200 gpm for a drawdown of about 130 feet.

GEOLOGY AND GROUND-WATER CONDITIONS IN SPECIFIC TOWNSHIPS

The rocks in Portage County vary considerably in character owing to (1) the complex variety and history of the depositional environments of the consolidated rocks, (2) the local variation in the thickness and character of the glacial drift, and (3) the topographical features of the bedrock surface and of the present land surface. During the course of this investigation, many drillers have inquired about the ground-water geology in areas where they had experienced difficulty in obtaining a good well or in areas unfamiliar to them where they had been requested to drill a well. For answering their questions, the township, each having about 25 square miles in area, has been chosen as the unit for discussion. The geologic section in each township is shown in one or more of the cross sections on plate 3. The geologic map (pl. 3) shows the contours on the land surface and the contours on the rock surface. The approximate thickness of the glacial drift at selected sites can be readily determined by subtracting the altitude of one from the other.

The largest ground-water supplies in the county are available from the glacial sand and gravel in the north-south buried valley that underlies western Franklin, Brimfield, and Suffield Townships and in the buried valley whose course approximately underlies the present Cuyahoga valley in Streetsboro, Shalersville, and Mantua Townships. The sand and gravel in these two buried valleys is favorably situated to receive recharge from surface streams, and wells in them yield as much as 1,600 gpm. The other buried valleys in the county also contain sand and gravel deposits, but these generally are in the form of thin, narrow, and discontinuous lenses interbedded with finer grained, less permeable materials. It is not usually possible to predict the presence of these sand and gravel lenses in advance of drilling. In addition, sustained yields of wells that do penetrate such sand and gravel lenses are considerably less than from wells that receive recharge from stream infiltration.

The best sources of ground water in the consolidated rocks are the sandstone units. Of these, the Berea Sandstone is likely to contain brine or brackish water in the southern half of the county. In the northern part of the county, where the water from the Berea Sandstone is potable, the yields of wells are generally much less than 50 gpm; the yields usually range from 1 to 5 gpm. The sandstones in the Pennsylvanian Pottsville Formation (namely, the conglomerate unit of the Sharon Member, the Connoquenessing Sandstone Member, and the Homewood Sandstone Member) are the best of the consolidated-rock aquifers. The first and last named are the most dependable because their lithology and thickness are fairly uniform. The yields of wells in these sandstones may be more than 200 gpm and depend largely upon the local thickness and lithology. Many of the thin and discontinuous sandstone lenses that occur in the shale unit of the Pottsville Formation can yield sufficient water to provide good domestic and stock wells. The shale units in Portage County generally have not been used as a source of water because of either the poor quality of the water or its insufficient quantity. However, in places, some wells in the shale units have been satisfactory, especially where the joints are open and the unit thus has greater permeability.

The discussion of ground-water conditions in each of the townships is based principally on drillers' records of wells on file at the Ohio Department of Natural Resources, Division of Water. The approximate locations of the wells were determined in the field, and their altitudes were estimated from the topographic maps.

Most of the wells in Portage County were drilled for domestic and stock use. Wells that yield 5 to 10 gpm are adequate for these purposes, and, consequently, are drilled no deeper than necessary for them to yield this amount. Such domestic and stock wells may penetrate only the upper few feet of a thick sand and gravel or sandstone aquifer. If these wells fully penetrated the aquifer, the yield for a given drawdown would be much larger. Thus, in Portage County an irrigation well that full penetrates an aquifer may yield 250 gpm in an area where the yields of domestic and stock wells, in the same aquifer, are reported to be 5 to 10 gpm.

ATWATER TOWNSHIP

In Atwater Township the sandstone members of the Pottsville Formation and the glacial sand and gravel in the buried valleys are the only sources of potable ground water. The Devonian and Mississippian rocks that unconformably underlie the Pottsville Formation are reported, in the records of oil-and-gas wells, to contain brine. No known water wells tap formations below the Pottsville Formation.

Pepper, de Witt, and Demarest (1954, pl. 1) reported 0 to 20 feet of Cussewago Sandstone and 40 to 60 feet of Berea Sandstone within the township. Both sandstones may be expected to contain brine along with small amounts of oil and gas. The top of the Berea Sandstone is at an altitude of about 700 feet. The overlying Cuyahoga Group has a thicknes as great as 300 feet.

The Pennsylvanian section below the Mercer Member of the Pottsville Formation is known from the records of wells. The conglomerate unit of the Sharon Member is reported to be 0 to 100 feet thick, and the shale unit of the Sharon Member 50 to 60 feet thick. The Connoquenessing Sandstone Member is thin or wanting in the north-central part of the township, but elsewhere the sandstone unit, which includes thin shale lenses, probably has a thickness of as much as 50 feet. The Mercer Member of the Pottsville Formation is as much as 80 feet thick, being thicker in Atwater Township than anywhere else in Portage County. The shale section of the Mercer Member in the eastern and southeastern parts of the township is shown in table 14. The Homewood Sandstone Member, which overlies the shale unit of the Mercer Member, occurs only in the upland areas where it has a maximum thickness of 60 to 70 feet.

Domestic wells in the sandstone of the Pottsville Formation are reported to yield as much as 25 gpm. Wells in the sand and gravel in the buried valleys may yield more than this, the yield depending upon the thickness, areal extent, and permeability of the aquifers and the recharge available. The buried valley south of Atwater Station is reported to contain coarse gravel in considerable thickness and should yield large supplies of ground water.

AURORA TOWNSHIP

Wells drilled into the Sharon and Connoquenessing Members of the Pottsville Formation yield most of the ground water used in Aurora Township. No known water wells are in formations older than the Pottsville, except for one well (well 228) in the Berea Sandstone. Wells in the glacial drift in the buried valleys yield water from thin discontinuous sand and gravel lenses.

The Berea Sandstone is about 30 feet thick in the township and yields potable water. The top of the formation is at an altitude of about 800 feet. The one well (No. 228) reported to be in the Berea Sandstone is near the junction of State Routes 82 and 306, and it yields 8 gpm. The Cuyahoga Group, overlying the Berea Sandstone, ranges in thickness from 150 to 180 feet. The Pottsville Formation is represented in the township by the lower members, the conglomerate, and the shale units of the Sharon Member and the Connoquenessing Sandstone Member. The conglomerate unit of the Sharon has a thickness of between 20 and 100 feet, the variation in thickness being due to the unconformity at its base. The shale unit of the Sharon has a maximum thickness of about 40 feet in the southern part of the township and thins northward to a featheredge in the north-central part of the township, where it was partly or wholly removed by erosion prior to the deposition of the overlying Connoquenessing Sandstone. The Sharon coal unit is reported in the records of two wells drilled in the central and north-central parts of the township, where the shale member is thin. In the southern part of the township, the shale unit of the Sharon contains many thin sandstone lenses. The Connoquenessing Sandstone Member is about 70 feet thick, although there is considerable variation in its thickness owing to the unconformity at the base and to the upper surface having been subjected to glacial erosion and stream dissection. Wells drilled into both the Connoquenessing Sandstone Member and the conglomerate unit of the Sharon, just southwest of the junction of State Routes 14 and 82, provide the public water supply for Aurora. One of these wells is 122 feet deep and yields 100 gpm. Domestic wells in the sandstones of the Pottsville Formation are reported to yield 5 to 30 gpm.

The range in thickness of the glacial drift in the township is considerable, from a few feet to as much as 100 feet in the upland areas, and from 200 to 700 feet in the buried valleys. The drift in the buried valley that underlies the western boundary of the township consists of glacial till, fluvial and lacustrine clay, silt, and fine sand. In addition, there are a few thin discontinuous sand and gravel lenses that may yield as much as 20 gpm to wells. Some wells that have been drilled into one of the sand and gravel lenses have produced as much as 35 gpm, whereas other wells drilled more than 30 feet in the same area have not penetrated sand and gravel. In the buried valley whose course is southeastward from the north-central part of the township, coarse sand and gravel lenses probably occur at depth. This is especially true to the north of Aurora Station where a now abandoned, but once extensive, sand and gravel pit is located. The sand and gravel in this buried valley is thought to have been deposited by melt water from an ice tongue in the Chagrin River, to the north. Another buried valley, which joins the one just discussed in the east-central part of the township, is filled principally by fine-grained material. Many of the better wells penetrate one or more of the thin gravel lenses at depths between 50 and 150 feet, but several wells have been drilled to depths of as much as 250 feet without penetrating material coarse enough for well development.

BRIMFIELD TOWNSHIP

Wells drilled into the lower members of the Pottsville Formation and wells drilled into the glacial drift in the buried valleys provide all the ground-water supplies in Brimfield Township. No water wells are reported in rocks older than the Pottsville Formation. The records of oil and gas wells show the Berea Sandstone to have a thickness of about 60 feet in the township and the top to be at an altitude of about 740 feet. Presumably it contains brine. The Cuyahoga Group ranges in thickness from 50 to 150 feet.

The conglomerate unit of the Sharon Member of the Pottsville Formation ranges in thickness from about 140 to 200 feet depending upon variations in the unconformity at its base. A shale lens as much as 35 feet thick occurs in the conglomerate unit in the north-central part of the township. Domestic and stock wells in the conglomerate unit are reported to yield as much as 15 gpm. The shale unit of the Sharon Member of the Pottsville has a thickness of as much as 60 feet. The few wells in the township that produce water from the shale have a maximum yield of about 10 gpm. The Connoquenessing Member occurs as two sandstone units separated by 40 to 50 feet of shale. The lower sandstone unit ranges in thickness from 10 to 65 feet. The upper sandstone unit, which is present along the western boundary of the county, ranges from 15 to 35 feet in thickness. Each of the sandstone units is reported to yield as much as 15 gpm. Above the Connoquenessing Member, the Mercer Member occurs in the northwestern part of the township.

Two buried valleys occur in the township: the principal one, in the western part, trending north and south; and the other, in the southeastern corner of the township, trending northeast and southwest. Few wells are reported in either of the buried valleys, but both north and south of the township the westernmost buried valley contains deposits of gravel that are the source of water supply for Kent and for the Goodyear Aircraft Co. plant in Suffield Township. Similar gravel may also occur in Brimfield Township.

Sand and gravel is reported in a few records of wells drilled in the buried valley in the southeastern part of the township. The domestic wells in this buried valley range from 82 to 165 feet in depth and are reported to yield about 10 gpm. Larger yields may be available, and investigation is warranted should the need arise for larger supplies.

CHARLESTOWN TOWNSHIP

Most water wells in Charlestown Township tap either the conglomerate unit of the Sharon Member of the Pottsville Formation, the Homewood Sandstone Member, or thin discontinuous sand and gravel lenses in the buried valley that underlies the southern edge of the township.

The presence of the Berea Sandstone is not recorded in the logs of oil and gas wells, but it does occur at an altitude just below 800 feet in adjoining townships and it is probably present at most places in Charlestown Township. For this reason it is shown on the geologic map at its proper place in the section.

The thickness of the Cuyahoga Group in Charlestown Township ranges from 20 to about 180 feet depending upon the configuration of the unconformity of the base of the conglomerate unit of the Sharon Member. The pre-Pottsville erosion surface was relatively high in the eastern part of the township and as a result the conglomerate unit of the Sharon has a thickness there of

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about 80 feet, as compared with a thickness of about 200 feet in the western part of the township. The shale unit of the Sharon Member is presumed to have a thickness of about 50 feet. The Connoquenessing Sandstone Member is either thin or absent except for the thin channel-sandstone unit which trends from east to west across the northern part of the township, and the smaller channel-sandstone unit that occurs in the east-central part of the township. The channel-sandstone units have a maximum thickness of about 40 feet. The shale unit of the Mercer Member is about 60 feet thick and is overlain by the Homewood Sandstone Member, which has a maximum thickness of about 70 feet. Some wells in the Homewood yield as much as 40 gpm. Wells in the conglomerate unit of the Sharon Member yield as much as 150 gpm locally, the yield depending upon the thickness and permeability of the aquifer. Part of the water supply for the Ravenna Arsenal is obtained in Charlestown Township, from wells in the conglomerate unit of the Sharon Member. Some domestic wells obtain water from the Cuyahoga Group and from the Sharon and Mercer shales.

The buried valley in the southern part of the township is filled principally with till, fluvial and lacustrine clay, silt, and fine sand. A few wells in the valley-fill deposits tap thin discontinuous sand and gravel lenses. Some of these aquifers contain water under sufficient pressure so that the wells flow at the surface. Most of the wells in the buried valley tap aquifers composed of fine- to medium-grained sand and yield 5 to 10 gpm. Some of these wells are more than 200 feet deep.

DEERFIELD TOWNSHIP

Most ground-water supplies in Deerfield Township are from wells in the Connoquenessing and Homewood Sandstone Members. Only one water well (No. 524) is reported in the conglomerate unit of the Sharon Member of the Pottsville Formation and none is reported in the Berea Sandstone. A few shallow wells obtain water from sand and gravel lenses in thin glacial drift.

In the western part of Deerfield Township, the Berea Sandstone is about 30 feet thick and occurs between altitudes of 630 and 690 feet according to records of two oil-and-gas wells. The Berea Sandstone is reported to contain brine in Palmyra Township, to the north, and similar conditions probably exist in Deerfield Township. Information on the Cuyahoga Group is available only in the western part of the township where it has a thickness of about 100 feet. The conglomerate unit of the Sharon Member is about 50 feet thick in western Deerfield Township. The conglomerate unit is penetrated by one water well (No. 524) in the eastern part of the township, but the thickness of the member was not reported. The Connoquenessing Sandstone Member is thin, contains sporadic thin shale lenses, and underlies most of the township. It ranges in thickness from about 20 feet in the western part of the township to about 60 feet in the eastern part and is reported to yield as much as 30 gpm to domestic and stock wells. The shale unit of the Mercer Member of the Pottsville Formation, although thin, is fairly persistent in the township except locally where it was removed by erosion prior to the deposition of the Homewood Sandstone Member. The Homewood, which forms the bedrock surface in central and southern Deerfield Township, has a maximum thickness of about 40 feet; but because it was deposited in a channel, its thickness commonly is much less. The Homewood may yield 5 to 10 gpm to domestic wells. If greater yields are desired, wells can be deepened to the Connoquenessing Sandstone Member.

The glacial drift is thin in Deerfield Township, and buried valleys are unknown. For this reason few wells yield water from the glacial drift. Those that tap a sand and gravel lens in the thin drift may yield 5 to 10 gpm.

EDINBURG TOWNSHIP

Ground-water supplies in Edinburg Township are from sandstone members of the Pottsville Formation and the glacial drift in the buried valleys. Formations below the Pottsville are known only from the records of oil and gas wells.

The Berea Sandstone reportedly is about 80 to 125 feet thick in the north-central and northeastern parts of the township and about 20 to 30 feet thick in the south-central part. The altitude of the upper surface of the sandstone is about 800 feet, 750 feet, and 670 to 700 feet in the north-central, northeastern, and south-central parts of the township, respectively. In some of the well records, as much as 10 feet of black Cuyahoga shale (Sunbury Shale Member of the Orangeville Shale) is reported overlying the Berea Sandstone. The Berea Sandstone in Edinburg Township contains brine or brackish water, and some oil and gas. The thickness of the Cuyahoga Group ranges from about 5 to 250 feet, depending upon the configuration of the unconformity at the base of the Pottsville Formation.

The conglomerate unit of the Sharon Member of the Pottsville Formation is reported to be between 130 and 200 feet thick in the northern part of the township and to be thin or absent in the south-central part of the township where the pre-Pennsylvanian erosion surface was above the general level of conglomerate deposition. Domestic and stock wells yield 5 to 10 gpm from the sandstone. Substantially greater yields should be available from properly constructed wells in the areas where the conglomerate unit is fairly thick.

The shale unit of the Sharon Member of the Pottsville Formation ranges in thickness from about 20 feet in the south-central part of the township to as much as 75 feet in the north-central part. The shale unit has yielded as much as 5 gpm to domestic wells.

The Connoquenessing Sandstone Member ranges in thickness from 15 to 20 feet in the northern part of the township to about 100 feet in the south-central part. In places, the sandstone contains shale lenses, the largest of which is about 40 feet thick and is known from the records of wells about 2 miles southeast of Edinburg. Domestic wells yield as much as 15 gpm from the Connoquenessing Member and probably as much as 100 gpm locally under favorable conditions.

The Mercer Member of the Pottsville Formation ranges in thickness from about 20 to 90 feet in the township. The member yields 5 to 10 gpm to domestic and stock wells, but the water may contain objectionable amounts of sulfur and iron.

The Homewood sandstone Member of the Pottsville Formation occurs in areas of bedrock uplands and forms prominent knobs and ridges along the southern edge of the valley of the West Branch of the Mahoning River. A thin shale lens in the Homewood forms bedrock surface in the southeastern corner of the township. The sandstone is quite coarse over most of the township and is as much as 50 feet thick, comprising a good aquifer that will yield as much as 40 gpm to exceptionally good wells. Most of the area underlain by the Homewood is above the level of the perennial streams in the township; therefore, recharge could not be induced from streams.

The ground-water resources of the glacial drift are adequate for domestic use in some areas and are inadequate in others. The drift in the buried valley that underlies the northern edge of the township is principally fine-grained sand, silt, and clay; however, a few wells tap thin and discontinuous sand and gravel lenses in the drift. A better source of ground water is the sand and gravel in the buried valleys that approximately underlie Barrell Run and Silver Creek. Well records indicated that the sand and gravel underlies clay and fine sand at depths between about 90 and 170 feet, and the wells in these gravels yield 10 to 25 gpm.

FRANKLIN TOWNSHIP

In Franklin Township, ground water is from two principal sources, the conglomerate unit of the Sharon Member of the Pottsville Formation and the sand and gravel in the buried valleys. One well reportedly yields water from the shales of the Cuyahoga Group.

No information is available about the Berea Sandstone in the township; but where present, it should be 50 to 60 feet thick, and the altitude of its upper surface should be about 790 feet. It probably contains brackish water or brine. The Cuyahoga Group ranges in thickness from 30 to 100 feet, except in buried-valley areas where it has been removed by erosion. One well (No. 774) in the Cuyahoga Group reportedly yields 8 gpm.

The conglomerate unit of the Sharon Member has a maximum thickness of about 200 feet in the township, and wells tapping this source yield as much as 250 gpm. An irrigation well (No. 760) in the west-central part of the township was finished in both the sandstone and the permeable sand and gravel that overlies it. According to the well record, the water-yielding material consists of 10 feet of gravel and 24 feet of sandstone, and the well yields 850 gpm.

In the buried-valley areas, water is obtained from sand and gravel lenses in the glacial drift. The buried valley in the west-central and southwestern parts of the township contains fairly large amounts of permeable sand and gravel. Wells in sand and gravel at the Kent waterworks yield as much as 800 gpm. The well at the Hugo Sand and Gravel Co. pit, 300 yards west of State Route 43 and 1½ miles north of the center of Kent, is reported to yield 1,250 gpm. Another well (No. 773) in the same area is reported to yield 100 gpm, and a third well in that area was said to be a failure owing to fine sand penetrated at the site.

In the Twin Lakes area, many wells obtain water from sand and gravel lenses within 60 feet of the surface. Other wells in the area have been drilled to depths of more than 300 feet before penetrating a sand and gravel lens. In the Brady Lake area, conditions are similar to those at Twin Lakes. The small buried valley near the northeast corner of the township may contain considerable sand and gravel, but no information is available to confirm this.

FREEDOM TOWNSHIP

Ground water in Freedom Township is derived principally from the sandstone units in the Pottsville Formation. A few wells obtain water from shale units of the Pottsville, and the remainder of the wells are drilled into sand and gravel lenses in the glacial drift that fills the buried valleys.

The Berea Sandstone is about 50 feet thick in the township and occurs at an altitude of about 800 to 850 feet. The water in the Berea Sandstone is probably potable, but no information is available on either the quality or quantity of the water. The Cuyahoga Group is 30 to 50 feet thick, but nothing is known of its water-yielding characteristics in the township.

The conglomerate unit of the Sharon Member of the Pottsville Formation ranges in thickness from about

140 to 200 feet and presumably is a good source of ground water; however, most wells are drilled only to the sandstone units above it. The shale unit of the Sharon Member is about 50 feet thick.

The Connoquenessing Sandstone Member ranges in thickness from about 30 to 100 feet. It is mapped and shown in the cross sections as a single bed of sandstone, but it includes a few thin shale lenses, particularly in the upper part. Wells (No. 833 is representative) drilled into the Connoquenessing Member at the service plaza on the Ohio Turnpike in the west-central part of the township were reported to yield up to 65 gpm.

The shale unit of the Mercer Member of the Pottsville Formation is 40 to 60 feet thick and contains many thin and discontinuous sandstone units in its upper part. Along State Route 88, southwest of Freedom, most wells tap one or more of these thin sandstone units and yield as much as 10 gpm.

The Homewood Sandstone Member is 40 to 60 feet thick and may yield 50 to 100 gpm where areally extensive. Only a few domestic wells have been drilled into the sandstone, and these are reported to yield up to 10 gpm.

A buried valley in Freedom Township approximately underlies Black Creek. The few wells drilled in the buried valley penetrate sand and gravel lenses, and yield up to 30 gpm.

HIRAM TOWNSHIP

Most ground-water supplies in Hiram Township are from the sandstones of the Pottsville Formation or sand and gravel lenses in the buried valleys.

The Berea Sandstone, in the township, should have a thickness between 40 and 60 feet and lie at an altitude of about 850 feet. The water in the sandstone should be potable; however, no water wells are known to have been drilled into the Berea Sandstone because the overlying sandstones of the Pottsville Formation and the sand and gravel lenses in the buried valleys have been adequate for all needs. The Cuyahoga Group probably ranges in thickness from 50 to 100 feet, but no well records are available.

The conglomerate unit of the Sharon Member of the Pottsville Formation is about 120 to 180 feet thick in the township and is a major aquifer. Most of the wells are reported to yield between 10 and 25 gpm. The Hiram water supply is principally from two wells in the conglomerate unit (well 933 is typical), 1 mile west of the village. The wells have a combined yield of about 100 gpm. The thickness of the shale unit of the Sharon Member ranges from 0 to 600 feet because of the unconformity at the base of the overlying Connoquenessing Sandstone Member.

The Connoquenessing Sandstone Member is 30 to 70 feet thick and, locally in an area southwest of Hiram, contains many thin shale beds. Wells in the sandstone yield as much as 30 gpm. The overlying shale unit of the Mercer Member is between 30 and 70 feet thick, and no information is available on the quality or quantity of water in the unit.

The Homewood Sandstone Member has a maximum thickness of about 80 feet in upland areas of the township. The few wells drilled in the sandstone reportedly yield about 5 gpm each. Part of the Hiram water supply is from springs at the base of the Homewood Sandstone Member about 1 mile west of town. Wells yielding 25 to 50 gpm can probably be developed in the sandstone in the central and south-central parts of the township.

The buried valleys in Hiram Township are shown on the geologic map as linear depressions in the rock surface. Most wells in these areas have been drilled through the valley-fill deposits into the conglomerate unit of the Sharon Member. Sand and gravel lenses should exist in all the buried valleys but beneath part of the outwash plain in the southwestern part of the township the glacial drift principally is fine sand. Sand and gravel lenses have yielded as much as 12 gpm to some wells, and larger yields may be available to properly constructed wells.

MANTUA TOWNSHIP

The Sharon and Connoquenessing Members of the Pottsville Formation and the sand and gravel in the buried valleys yield most of the ground-water supplies in Mantua Township. A few wells obtain water from the shale unit of the Sharon Member.

The Berea Sandstone, on the basis of the record of an oil and gas well, is about 20 feet thick and lies at an altitude of about 900 feet. The Berea Sandstone probably contains potable water, but its great depth and the fact that it is thin and therefore capable of small yield to wells, make it a minor aquifer. The Cuyahoga Group is estimated to range in thickness from 50 to 150 feet, being thickest in the western part of the township.

The conglomerate unit of the Sharon Member ranges in thickness from 80 to 160 feet, being thickest in the eastern part of the township. Wells in the sandstone unit of the Sharon have yielded as much as 50 gpm, and wells yielding as much as 250 gpm probably can be developed where the aquifer is sufficiently permeable. The shale unit of the Sharon may be as thick as 40 feet locally, but generally it is thinner. In the northwestern part of the township, the shale is thin or absent, as it was partly or wholly removed by erosion prior to deposition of the Connoquenessing Sandstone Member. Here the Connoquenessing Sandstone Member directly overlies the conglomerate unit of the Sharon Member.

The Connoquenessing Sandstone Member ranges in thickness from 70 to 100 feet. In places it is interbedded with shale lenses 20 to 30 feet thick. Wells in the sandstone are reported to yield as much as 20 gpm. An exceptional irrigation well (No. 1024) is in the north-central part of the township, on the Chadwick farm, 2½ miles north of Mantua Center. The well is 12 inches in diameter and 142 feet deep. The shale unit of the Sharon is missing in this area, and the well penetrates 100 feet of sandstone consisting of both the conglomerate unit of the Sharon Member and the Connoquenessing Sandstone Member. The well is cased above the sandstone. During dry periods in the growing season, the well is pumped almost continuously at a rate of 850 gpm, the drawdown being about 23 feet. The exceptionally large yield of this well is probably due to the presence of open joints in the sandstone which locally would increase the permeability of the rock. In addition, 16 feet of sand and gravel which overlies the sandstone undoubtedly contributes to the yield. Wells of such high yield are rare and cannot be expected generally.

The Mercer and Homewood Members of the Pottsville Formation occur only in the upland areas and are not known to be used as sources of ground water. The Homewood Sandstone Member is of small areal extent; but where the unit is sufficiently thick, domestic and stock wells probably can be developed in it. If the yield of such a well is insufficient, the well can be deepened to the Connoquenessing Sandstone Member.

Wells drilled in the buried valleys in the township obtain water from the coarse-sand and gravel lenses. Coarse glacial outwash fills the buried valley that underlies the Cuyahoga River in the vicinity of Mantua. A well in this outwash yielded 800 gpm at the abandoned gravel pit at the south edge of town. The public water supply at Mantua is from three wells in the outwash material one-quarter of a mile east of town. The demand in 1955 was between 100,000 and 150,000 gpd. The present source should easily meet the water requirements of the town in the near future.

Excellent sources of ground water are the sand and gravel lenses in the buried valley that enters the north-central part of the township and trends southwestward. Wells in the sand and gravel lenses yield as much as 70 gpm in the Black Brook Swamp, north of Mantua Center, and a well (No. 1004) at Round-Up Lake, one-third of a mile east of Silo, is reported to yield 150 gpm.

NELSON TOWNSHIP

In Nelson Township, wells obtain water from the Mississippian and Pennsylvanian formations and the glacial drift in the buried valleys.

The Cussewago Sandstone is the source of water to a well (No. 1107) in the east-central part of the township. It is the only well known to be drilled in this formation in Portage County. The sandstone is reported to be 10 feet thick and to lie at an altitude of 745 feet. The water is said to be soft, though being turbid and having a slightly gassy odor. The yield of the well is 2 to 3 gpm.

The Berea Sandstone is the source of ground water for the public supply of Garrettsville and for domestic and stock wells in that area. The sandstone lies between altitudes of 850 and 900 feet in the township and has a maximum thickness of about 75 feet. The wells (No. 1127 and 1150 have representative logs) at the Garrettsville waterworks yield between 50 and 100 gpm each. The maximum pumpage from the well field is about 150,000 gpd.

The Cuyahoga Group is 70 to 100 feet thick in the township. Wells in the Cuyahoga Group may yield as much as 10 gpm.

The conglomerate unit of the Sharon Member has a maximum thickness of about 100 feet in the township. The well (No. 1148) of the General Refractories Co., at the junction of State Routes 282 and 305, penetrates 42 feet of sandstone and yields 85 gpm. Where the sandstone is permeable and is fairly thick, yields as much as 200 gpm probably are available.

The shale unit of the Sharon Member is about 40 feet thick but is not known to be used as a source of ground water in the township.

The Connoquenessing Sandstone Member has a maximum thickness of about 80 feet. Northeast of Garrettsville a shale lens 20 to 30 feet thick occurs in the middle part of the formation. Wells in the sandstone are reported to yield as much as 12 gpm. Properly constructed wells drilled in the sandstone in the northern part of the township, where the unit is thickest, can probably yield more than 50 gpm.

The glacial deposits in the buried valleys generally are fine-grained, and it is difficult to develop a well in them. Some wells have been drilled to depths of more than 200 feet without penetrating a usable aquifer. However, of the few wells that have penetrated coarse sand and gravel lenses, some yield as much as 30 gpm. Sand and gravel lenses may occur in the buried valley south of the Garrettsville waterworks. Should need arise for a larger water supply for the town, an investigation of the water-bearing characteristics of the buried-valley fill would be warranted.

PALMYRA TOWNSHIP

Most of the ground water in Palmyra Township is from wells in the sandstone members of the Pottsville Formation. The Berea Sandstone is not reported in the record of the one oil-and-gas well (P–14) in the township. If the sandstone is present, it probably contains brine.

The conglomerate unit of the Sharon Member of the Pottsville Formation ranges in thickness from about 10 feet in the eastern part to about 50 feet in the western part of the township. Few wells have been drilled into the unit, but of those that do, most penetrate the sandstone where it is thin and yield little or no water. No information is available on the yield of the conglomerate unit in the northern and western parts of the township.

The shale unit of the Sharon Member is 50 to 60 feet thick in Palmyra Township, and it includes sporadic sandstone lenses that have thicknesses as much as about 20 feet. Wells in the shale unit may produce 5 to 10 gpm from the sandstone lenses.

The Connoquenessing Member consists of a shale and sandstone sequence. The upper part of the member is a massive sandstone 25 to 60 feet thick; the middle part is a shale unit as much as 30 feet thick, containing some thin sandstone lenses; the lower part is a sandstone lens that thins westward from a maximum thickness of about 40 feet in the south-central part of the township. Wells in the Connoquenessing Member yield as much as 30 gpm.

The Mercer Member has a maximum thickness of about 90 feet in the northwestern part of the township, but it may be as thin as 20 feet in places because of the unconformity at the base of the Homewood Sandstone Member.

The Homewood Sandstone Member has a maximum thickness of about 90 feet in the upland areas. Wells in the member are reported to yield as much as 10 gpm, which may be a conservative estimate of the available yield.

A buried valley that enters the township from the northeast contains sand and gravel lenses, but no estimate of their yield to wells is known. Outwash gravel lenses as much as 30 feet thick occur in the drift that covers the surface of the township. One well (No. 1201) in these outwash gravel lenses is reported to yield 25 gpm.

PARIS TOWNSHIP

In Paris Township most wells obtain water from the conglomerate unit of the Sharon Member of the Pottsville Formation. The well at the Paris School, at the geographic center of the township, is in the Berea Sandstone, and the remainder of the water wells are in the glacial deposits that fill the buried valley in the southern part of the township.

The Berea Sandstone intersects the walls of the buried valley at an altitude just below 800 feet. In the well (No. 1304) at the Paris School, the Berea Sandstone is 32 feet thick and yields 25 gpm. The water is potable, but the mineral content is sufficiently high to make the water objectionable to some people. The Cuyahoga Group ranges in thickness from 30 to 100 feet.

The conglomerate unit of the Sharon Member is the principal aquifer in the township. The thickness of the unit ranges from about 70 to 170 feet. Most wells at the Ravenna Arsenal penetrate the entire thickness of the conglomerate unit and are reported to yield between 30 and 260 gpm each. The wide range in yield is probably due to variations in the permeability and thickness of the aquifer at the different well sites.

Most of the fill in the buried valley in the southern part of the township is sand and silt and some clay lenses, but here and there in the glacial deposits are coarse sand and gravel lenses which have been penetrated by wells. The best of these wells (No. 1353) is reported to yield 18 gpm. Some wells in the drift flow at the surface.

RANDOLPH TOWNSHIP

Water wells in Randolph Township tap either the Pottsville Formation or the sand and gravel deposits in the buried valleys. No water well has been drilled to the base of the Pottsville Formation. In the record of an oil-and-gas well, the Berea Sandstone is reported to be 50 feet thick and occur at an altitude of about 700 feet. The Cuyahoga Group is reported to be about 70 feet thick.

The conglomerate unit of the Sharon Member of the Pottsville Formation ranges in thickness from about 60 to 200 feet, the wide range being due to the configuration of the unconformity at its base. A deep irrigation well (No. 1412) on the farm of Steve Nuspil near the southeast corner of the township penetrated only 10 feet of sandstone at the stratigraphic position of the conglomerate unit. The well record indicates an upland in the pre-Pennsylvanian erosion surface in this part of the county. No well is known to yield water from the unit, but in other townships, where the conglomerate unit is more permeable, yields of about 200 gpm have been obtained from wells drilled through 150 to 200 feet of the unit.

The shale unit of the Sharon Member of the Pottsville Formation is 40 to 60 feet thick. The shale unit, reported in the records of two wells, yields sufficient water for domestic requirements.

The Connoquenessing Sandstone Member in the township consists of two persistent beds of sandstone separated by a shale lens that ranges from about 20 to 50 feet in thickness. The lower of the sandstone lenses is about 40 feet thick, and the upper one is as much as 60 feet thick. Wells in the Connoquenessing yield as much as 85 gpm.

The Mercer Member is probably 40 feet thick in some parts of the township and can probably yield as much as 10 gpm. However, if the yield is poor, wells can be deepened to the Connoquenessing Sandstone Member. The Homewood Sandstone Member is as much as 40 feet thick in Randolph Township, and wells in the member yield as much as 35 to 100 gpm.

Coarse sand and gravel is reported in the logs of wells drilled into the glacial deposits in the buried valleys, and the wells yield 5 to 30 gpm. Outwash sand and gravel probably occurs in lower parts of the buried valley that approximately underlies the Congress Lake Outlet, and an investigation of the valley fill there would be warranted should the need arise for a large ground-water supply.

RAVENNA TOWNSHIP

The principal aquifer in Ravenna Township is the conglomerate unit of the Sharon Member of the Pottsville Formation. A few wells also are drilled into the shale unit of the Sharon Member and the Connoquenessing Sandstone Member of the Pottsville Formation, and other wells yield water from sand and gravel deposits in the buried valleys.

The Berea Sandstone is reported in the logs of oil-and-gas wells to lie at an altitude of about 700 feet. The formation may be thin or discontinuous in parts of the township, and its thickness generally ranges from about 5 to 80 feet. The water in the Berea Sandstone is probably potable in the area north of the major east-west buried valley that underlies the southern part of the township.

The Cuyahoga Group probably ranges in thickness from 20 to 150 feet, the wide range being due to the unconformity at the base of the conglomerate unit of the Sharon. It is not utilized as an aquifer in the township.

Wells in the conglomerate unit provide much of the ground water used in the township. The formation is 200 feet or more in thickness and occurs at or near the bedrock surface over most of the area. Wells in the conglomerate unit are reported to yield as much as 30 gpm; in areas where the aquifer has good permeability, larger yields probably are available.

The shale unit of the Sharon Member is generally thin, but may be as thick as 50 feet. No wells are reported to yield water from this member.

The Connoquenessing Sandstone Member is thin and unimportant as an aquifer.

The buried-valley fill consists predominantly of sand and finer grained material. Some coarse sand and gravel occurs at a fairly high altitude along the northern edge of the east-west buried valley in the southern part of the township. Wells penetrating coarse sand and gravel lenses yield as much as 40 gpm, and larger yields probably are available from these lenses.

The municipal water supply at Ravenna is surface water from Crystal and Muzzy Lakes and, by diversion, from the Congress Lake Outlet.

ROOTSTOWN TOWNSHIP

Wells in the sandstone members of the Pottsville Formation and wells in the glacial fill in the buried valleys provide most of the ground water used in the township. The public water supply of Ravenna also serves Rootstown.

The Berea Sandstone is not reported in the records of some oil-and-gas wells and is presumed missing in certain areas. In other areas the formation has a thickness of as much as 70 feet and contains brine or a small amount of oil and gas. The top of the formation occurs at an altitude of about 750 feet. Detailed information on its areal extent is not available.

The Cuyahoga Group ranges from 100 to 150 feet in thickness. No water well is reported to be drilled in the unit.

The conglomerate unit of the Sharon Member of the Pottsville Formation is 50 feet thick in places and is much thinner than this where cut by the buried valleys. Wells in the conglomerate unit are reported to yield as much as 100 gpm. The water-bearing potential of this unit has not been fully realized in the township because most of the wells need to penetrate only a few feet of the sandstone to satisfy domestic requirements. As the use of water for irrigation increases, the conglomerate unit probably will become the principal aquifer in the township.

The shale unit of the Sharon Member is about 50 feet thick. Few wells in the township obtain water from the shale, but those that do so yield from 5 to 10 gpm.

The Connoquenessing Sandstone Member is generally thin in the township, its thickness ranging from 0 to about 50 feet. Domestic wells in the sandstone are reported to yield between 5 and 10 gpm.

The Mercer Member is as much as 60 feet thick and is reported to yield between 2 and 10 gpm.

In areal extent the Homewood Sandstone Member is limited to the east-central and southeastern parts of the township. The maximum thickness of the unit is about 100 feet, and it includes a discontinuous shale lens as much as 30 feet thick. Domestic wells in the sandstone are reported to yield 5 to 15 gpm. An irrigation well (No. 1645) owned by D. M. Buzek, in the southeastern corner of the township, yields 175 gpm.

The glacial deposits in the buried valleys are reported to include few coarse sand and gravel lenses and to consist principally of sand and finer grained materials. Wells in the glacial drift are reported to yield between 3 and 15 gpm.

SHALERSVILLE TOWNSHIP

Wells in Shalersville Township yield water from the Sharon and Connoquenessing Members of the Pottsville Formation, or from coarse outwash gravels in the buried valleys.

The Berea Sandstone, on the basis of the records of oil-and-gas wells, generally occurs at an altitude of about 800 feet, though it is thin or may be missing in the township. The maximum thickness reported is 10 feet. The Cuyahoga shales probably range in thickness from 30 to 80 feet.

The conglomerate unit of the Sharon Member is estimated to range in thickness from 100 to 250 feet. A shale lens as much as 50 feet thick separates the member into an upper and a lower sandstone. Pepper, de Witt, and Demarest (1954, pl. 1) reported the occurrence of more than 100 feet of what they call the Berea Sandstone in the southwestern part of the township, between altitudes of 830 and 940 feet (based on well P–26). Because the top of the Berea Sandstone generally occurs at an altitude of about 800 feet in this part of this county, the writers believe that the sandstone is the conglomerate unit of the Sharon Member and that the Berea Sandstone is missing. Wells in the conglomerate unit are reported to yield as much as 90 gpm.

The shale unit of the Sharon Member has a range in thickness of 20 to 90 feet. Wells in the shale unit yield as much as 10 gpm.

The Connoquenessing Sandstone Member ranges in thickness from about 10 to 100 feet owing to the unconformity at its base. In places a shale member as much as 50 feet thick occurs in the middle of the unit. Wells in the Connoquenessing Sandstone Member yield as much as 55 gpm.

The Mercer Member ranges from 15 to 75 feet in thickness. No well is reported to be drilled in the member.

The Homewood Sandstone Member is of small areal extent, being restricted to upland areas in the eastern part of the township. Where the sandstone is as much as 30 feet thick, it can probably yield water in sufficient quantity to sustain domestic wells.

The glacial deposits that fill the buried valleys in the township consist principally of outwash sand and gravel. Few wells obtain water in the glacial drift in the buried valley in the eastern part of the township, but those that do so yield about 10 gpm. The buried valley that underlies the northwestern part of the township is potentially the best source of ground water in the county. Pumping from wells in the thick outwash sand and gravel should induce recharge from the Cuyahoga River. The yield of one well (No. 1731) is 1,200 gpm.

STREETSBORO TOWNSHIP

The principal bedrock aquifer in Streetsboro Township is the conglomerate unit of the Sharon Member. The Connoquenessing Sandstone Member is a source of water to a few wells in the north-central part of the township, and the remainder of the ground water used is pumped from the glacial deposits in the buried valleys.

The Berea Sandstone is reported in the record of an oil-and-gas well (P–28), to be 5 feet thick and to lie at an altitude of about 820 feet. Although generally thin, and possibly missing in some areas, the Berea Sandstone is present in the neighboring townships and on the geologic map is shown as a continuous unit, cropping out at its expected stratigraphic position along the walls of the buried valleys. The water in the Berea Sandstone is probably potable.

The Cuyahoga Group ranges in thickness from 90 to 100 feet. There are no records of wells being drilled in the group in Streetsboro Township.

The conglomerate unit of the Sharon Member has a maximum thickness of about 100 feet. One well (No. 1837) in the unit, drilled where the unit is overlain by coarse sand and gravel, yields 150 gpm. It is probable that wells of similar or greater yield may be obtained elsewhere from the conglomerate unit.

The shale unit of the Sharon Member has a maximum thickness of about 50 feet. No well is reported to yield water from the shale member in the township.

In areal extent the Connoquenessing Sandstone Member is restricted to the north-central part of the township, where it has a maximum thickness of about 30 feet. Wells in the sandstone are reported to yield as much as 18 gpm.

There are two buried valleys in Streetsboro Township. A buried valley in the eastern part of the township is filled principally with coarse glacial-outwash deposits, which yield 800 gpm to an irrigation well (No. 1830) on the Weingart farm, southwest of the junction of State Route 14 and County Highway 155. The other buried valley is in the western part of the township and is mostly filled with fine sand and silt. Thin discontinuous lenses of sand and gravel occur in the valley fill, but it is impossible to predict their presence in advance of drilling. Many wells are failures regardless of the depth to which they are drilled, but other wells which, luckily, have penetrated a sand and gravel lens, yield as much as 35 gpm. The success or failure of a well in this buried valley often rests upon the correct choice of well-screen size and proper well-development procedures. Unfortunately, the valley fill is as much as 700 feet thick, and in much of the area consolidated-rock aquifers do not underlie the glacial drift.

SUFFIELD TOWNSHIP

In Suffield Township, wells yield water from the members of the Pottsville Formation and the glacial drift in the buried valleys.

The Berea Sandstone is not reported in the only available record of an oil-and-gas well drilled in Suffield Township (P–29), but it is 50 feet thick in Randolph Township. The Berea Sandstone is shown on the cross sections at its expected altitude of about 700 feet. The Cuyahoga Group probably has a thickness of 80 feet in the township.

The conglomerate unit of the Sharon Member is the lowest unit in the stratigraphic section used as a source of ground water. The sandstone has a thickness of about 200 feet and yields as much as 90 gpm to wells. Where the conglomerate unit is of good permeability, wells may yield up to 200 gpm.

The shale unit of the Sharon Member ranges in thickness from 20 to 80 feet. Wells in the shale are reported to yield up to 30 gpm.

The Connoquenessing Sandstone Member in Suffield Township occurs in three forms: (1) A single bed of sandstone up to 40 feet thick, (2) two beds of sandstone, each about 30 feet thick, separated by as much as 50 feet of shale, and (3) a sequence of thin sandstone and shale beds. Wells in the Connoquenessing Member yield as much as 20 gpm.

The Mercer Member is limited in areal extent to the southwestern part of the township. Wells in the shale unit are reported to yield as much as 15 gpm.

All the wells drilled into the glacial drift that fills the buried valleys tap sand and gravel deposits. The largest yield of these wells is that of the Goodyear Aircraft Co. well, drilled on the southeastern shore of Wingfoot Lake (formerly known as Fritch Lake). This well (No. 1944) yields 250 gpm, the drawdown being about 10 feet. Other wells in the valley fill yield between 5 and 50 gpm. One well (No. 1958) yields 10 gpm from sand in a kame of the Kent moraine.

WINDHAM TOWNSHIP

The conglomerate unit of the Sharon Member is the principal consolidated-rock aquifer in Windham Township. Two unproductive wells have been drilled into the rocks below the conglomerate unit. One of them (No. 2009) was drilled into shales of the Cuyahoga Group and was reported to be dry except for a small amount of gas. The other well (No. 2027) was drilled into a sandstone lens below the Berea Sandstone, possibly the Cussewago Sandstone, and the water was salty. A few wells have been drilled in the glacial drift that fills the buried valleys.

The Berea Sandstone is not reported in the records of wells in the township but it is believed present and is shown on the geologic map at its expected altitude of about 850 feet. The Berea contains potable water and is up to 75 feet thick in nearby Nelson Township. The Cuyahoga Group is about 40 to 100 feet thick in Windham Township.

The conglomerate unit of the Sharon is about 150 feet thick in the western part of the township where it forms the escarpment on the west side of the Grand River lowland. In the lower areas of the township, the sandstone is 100 feet or less in thickness. Thin shale lenses occur in places in the unit. Wells in the formation yield as much as 50 gpm. The public water supply of Windham is from seven wells in the conglomerate unit. Each well yields 50 gpm and the combined yield of any two of the wells is sufficient to meet the present requirements.

Most wells in the glacial drift that fills the buried valleys are developed in sand. No information is available on the yield of these wells, but wells in a small buried valley in the east-central part of the township yield enough water for domestic and stock use.

CHEMICAL QUALITY OF THE GROUND WATER[1]

The most important chemical properties of water intended for domestic use are generally those related to hardness, taste and odor, and iron and manganese content. The quality of water is even more important to industrial users, for often one undesirable mineral constituent, present in excessive amounts, can result in high costs in maintenance of plant equipment and may, from a practical standpoint, prohibit the manufacture of certain products.

[1] In part from Lamar and Schroeder (1951) and from Winslow, White, and Webber (1953).

TABLE 9.—*Chemical analyses of ground water in Portage County and vicinity*

[Date of collection, May 26, 1953. Character of material: Ss, sandstone: Sh, shale; G, gravel. Chemical constituents, in parts per million. Analyzed by U.S. Geol. Survey Quality of Water Branch]

Well	Principal water-bearing bed		Temperature (°F)	Silica (SiO_2)	Iron (Fe) [1]	Manganese (Mn) [1]	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C)	pH	Color
	Character of material	Geologic age															Ca, Mg	Noncarbonate			
107	Ss	Pennsylvanian	52	12	1.6	0.18	150	89	23	7.0	324	505	10	0.2	1.0	1,070	740	475	1,330	6.9	6
228	Ss	Mississippian	54	6.2	3.7	.05	34	3.4	52	3.0	162	63	17	.1	.8	287	98	0	453	7.2	33
305	Sh	Pennsylvanian	54	9.3	.42	.00	71	16	6.9	9.2	204	68	13	.1	19	323	242	76	522	7.6	1
612	G	Quaternary	54	11	.77	.00	98	31	328	5.6	484	136	380	.2	.0	1,220	374	0	2,150	7.7	2
917	Ss	Pennsylvania	54	11	1.1	.00	19	9.7	6.2	8.5	10	40	12	.1	60	162	88	79	261	5.9	2
1043	Ss	do	54	12	4.2	.27	29	9.2	2.2	.6	108	24	2.4	.1	.4	146	110	22	230	6.9	1
1129	Ss	Mississippian	54	10	3.5	.00	42	14	468	8.4	508	.6	520	.2	.1	1,350	162	0	2,450	7.5	5
1718	G	Quaternary	51	11	1.4	.10	58	14	3.8	1.0	218	29	2.6	.2	.0	236	200	24	397	7.6	2
1833	Ss	Pennsylvanian	52	14	1.2	.25	130	51	12	2.6	522	122	1.5	.1	.6	588	532	106	951	7.2	3
1936	Ss	do	58	16	1.2	.12	60	16	4.8	.6	240	27	2.6	.2	.6	252	216	19	418	7.8	4

[1] Samples for iron and manganese determination filtered at time of sampling.

TABLE 10.—*Chemical analyses of municipal ground-water supplies in Portage County*

[Analyses from Ohio Department of Health (1952). Chemical constituents, in parts per million]

Municipalities	Source of sample	Date of collection	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Bicarbonate (HCO_3)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180° C)	Hardness as $CaCO_3$		pH
													Ca, Mg	Non-carbonate	
Aurora	Connoquenessing and Sharon Members of the Pottsville Formation	11-15-51	8	0.05	0.01	34	6	110	1	0	--------	155	110	20	6 9
Garrettsville	Sandstone of Mississippian age	3-28-51	15	.55	.15	28	3	228	97	.6	--------	430	82	0	7 1
Hiram	Sharon Member of the Pottsville Formation	8-10-51	15	6.8	.45	41	7	156	3	.1	--------	173	130	2	7.2
Kent	Glacial-outwash deposits	4-11-51	13	2.0	.10	64	12	238	6	0	--------	249	208	13	7 9
Mantua	Glacial-outwash deposits	2-19-51	12	.10	.08	62	10	179	6	0	7.1	228	194	47	7.2
Windham	Sharon Member of the Pottsville Formation	1- 7-52	10	6.1	.66	130	34	228	7	.2	.4	675	466	278	6.9

The analyses of water from 10 sources in Portage County are given in table 9. The analyses shown in table 9 also are shown graphically in figure 24 as equivalents per million. These analyses are fairly representative of the chemical character of the ground water found in the county. They show the dissolved-mineral content of the water and do not indicate the sanitary condition of the water. The analyses of water from the six municipal ground-water supplies in Portage County are given in table 10. The locations of the wells given in table 9 are shown on plate 2, and the logs of these wells are shown graphically on plate 1.

The ground water in Portage County has a wide range in chemical quality. The Mississippian and Pennsylvanian rock units generally are thin, and wells drilled into them usually yield water from more than one water-bearing zone. When a well penetrates both shale and sandstone, it can be assumed that most of the water probably is from the sandstone units because of their generally higher permeability. However, be-

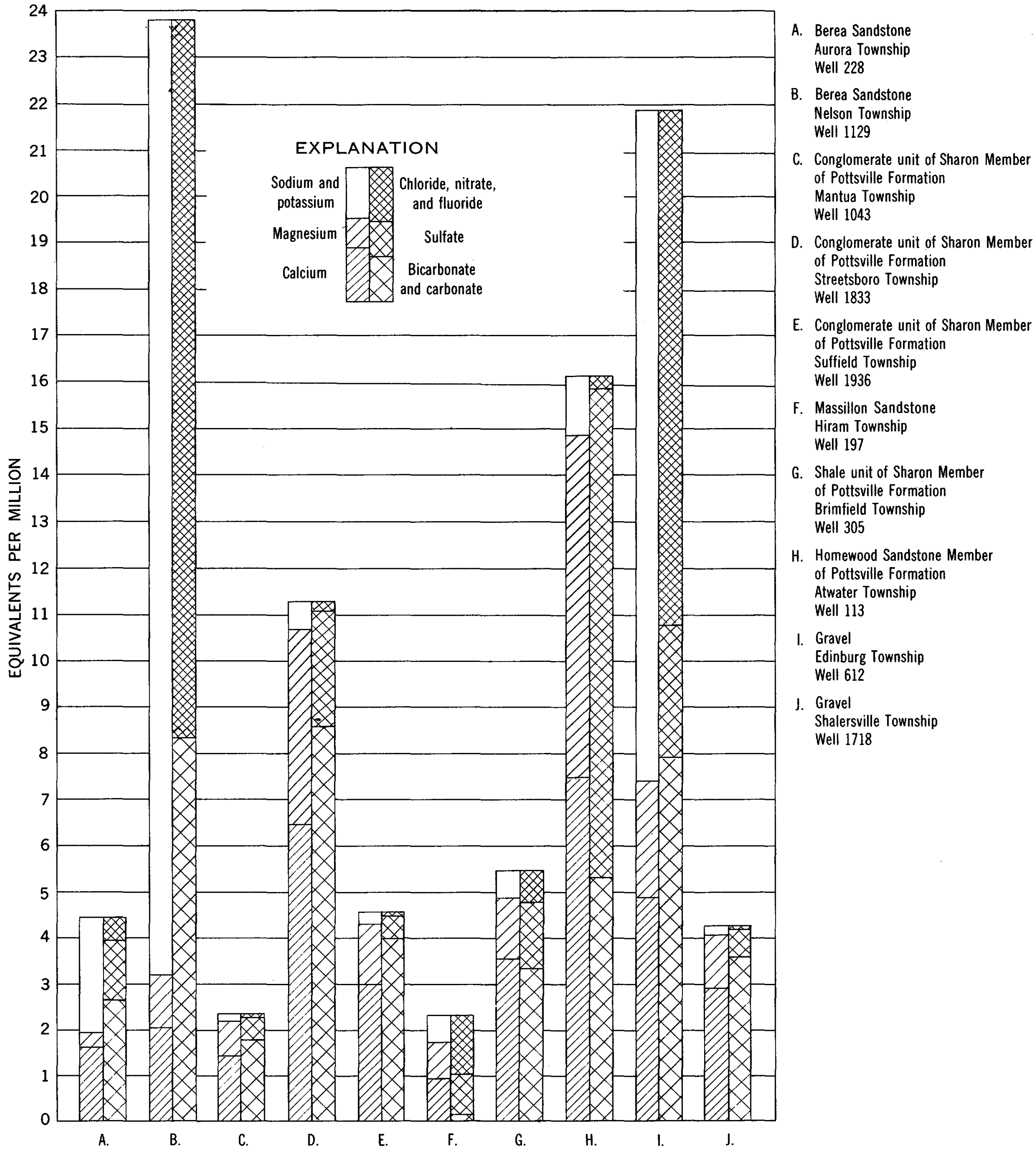

FIGURE 24.—Chemical analyses of ground water in Portage County and vicinity.

cause water from shale generally contains more of the dissolved mineral constituents, the small proportion of water derived from the shale may, in many places, govern the quality of the water obtained from a well.

The ground water in Portage County generally is hard and contains moderate to high amounts of dissolved mineral constituents. The softest water analyzed had a total hardness of 82 ppm (parts per million). It was a sample from one of the Garrettsville municipal-supply wells, drilled in the Berea Sandstone. The hardest water, from a well (No. 113) in the Homewood Sandstone Member of the Pottsville Formation in Atwater Township, had a total hardness of 740 ppm. The ground water of the county generally is the calcium magnesium bicarbonate type, containing various amounts of the other principal ions, such as sodium, potassium, sulfate, chloride, nitrate, and fluoride. Manganese was present in 12 of the samples in amounts up to 0.66 ppm. The sodium content of the samples was low with the exception of samples from two wells, Nos. 612 and 1129, in which it was moderately high, being 328 and 468 ppm, respectively. The chloride content in these two samples was 380 and 520 ppm, respectively, but in the other samples it was relatively low, ranging from 1 to 97 ppm. The bicarbonate content of the samples ranged from 10 to 522 ppm, and sulfate content of the samples given in table 11 ranged from 0.6 ppm, in the sample from well 1129 in the Berea Sandstone, to 505 ppm, in the sample from well 113 in the Homewood Sandstone Member of the Pottsville Formation. The fluoride content in the samples generally was low, ranging from 0.1 to 0.2 ppm, except in the sample from Garrettsville municipal supply, which contained 0.6 ppm. The dissolved solids in the samples ranged from 146 to 1,350 ppm. Iron ranged from 0.05 to 6.8 ppm, and silica ranged from 6.2 to 16 ppm.

QUALITY OF WATER IN THE PRINCIPAL AQUIFERS

The water wells investigated in Portage County range in depth from 22 to 328 feet and average slightly less than 100 feet in depth. The wells are drilled either in glacial drift or in the consolidated rocks of Mississippian and Pennsylvanian age. Few water wells have been drilled deeper than the Berea Sandstone, and for this reason no samples of water were obtained from the formations below the Berea Sandstone. Brine has been reported in records of oil-and-gas wells as being in the deeper formations, and brine may be expected at any depth below the Berea Sandstone in the northern part of the county and at any point below the conglomerate unit of the Sharon Member of the Pottsville Formation in the remainder of the county.

BEREA SANDSTONE

Samples of water collected from three wells drilled into the Berea Sandstone show an average total hardness of 194 ppm as compared with the average total hardness of 247 ppm for all the ground water analyzed. The dissolved solids in the three samples ranged from 287 to 1,350 ppm and consisted principally of calcium and magnesium bicarbonate, and significant amounts of sodium, sulfate, and chloride ions. No noncarbonate hardness was present in any of the three samples.

The chloride content of the water in the Berea Sandstone is shown by the three analyses to range from 17 to 520 ppm, the 520-ppm value being the highest reported in the analyses of ground water in the county. The sodium content of the water is similarly high, the maximum being 468 ppm.

CUYAHOGA GROUP

No analyses were made of water from the rocks of the Cuyahoga Group in Portage County, and only a few wells are reported to yield water from this relatively minor source. In Cuyahoga County, water from the Cuyahoga Group showed wide variation in mineral constituents, on the basis of a few samples. The dissolved solids ranged from 331 to 2,580 ppm, and the total hardness ranged from 44 to 889 ppm (Winslow and others, 1953). The water from the rocks of the Cuyahoga Group in Portage County is probably similar to that in Cuyahoga County. However, the sodium chloride content and that of other mineral constituents may be higher in Portage County, especially in the southern part where the rocks are deeply buried.

PENNSYLVANIAN ROCKS

Most of the wells drilled in rocks of Pennsylvanian age penetrate one or more of the numerous sandstone units of the Pottsville Formation. These sandstone units have considerable local variation in thickness, and all are discontinuous in places. With respect to the quality of the ground waters, the Pennsylvanian rocks may be considered as constituting a single aquifer. The analyses show the total hardness to range from 88 to 740 ppm and the dissolved solids to range from 162 to 1,070 ppm. The chloride content is low, ranging from 1.5 to 13 ppm. The pH of the waters from the Pennsylvanian rocks ranges from 5.9 to 7.9, four of the nine samples having a pH of less than 7.0.

GLACIAL DRIFT

Four samples of water from the glacial drift were analyzed. The total hardness ranged from 194 to 374 ppm and the total solids ranged from 228 to 1,220 ppm. The chloride content in the water from well 612 was 380 ppm, but in the other samples it ranged from 2.6 to 6 ppm.

SIGNIFICANCE OF MINERAL CONSTITUENTS

The dissolved mineral constituents in water are generally reported in parts per million. A part per million is a unit weight of a constituent in a million unit weights of water. Thus, in a water analysis, 1 ppm indicates 1 pound of a particular substance in 1 million pounds of water. Parts per million may be converted into grains per U.S. gallons by dividing parts per million by 17.12. Hardness is reported, in parts per million, as calcium carbonate ($CaCo_3$) equivalent to the calcium and magnesium present. The hardness caused by bicarbonate or carbonate of calcium and magnesium is called carbonate hardness; the hardness in excess of this quantity is called noncarbonate hardness.

Color is expressed in units of the platinum-cobalt scale and can be determined as follows: To a solution of platinic chloride, containing 1 mg of platinum per liter of distilled water, enough cobalt chloride is added to give a color matching the shade of color in the natural water of the sample. In current laboratory practice, colored glass disks, individually calibrated to correspond to the colors on the platinum-cobalt scale, are utilized in direct-reading color comparators to provide color values (Rainwater and Thatcher, 1960, p. 69). Hydrogen-ion concentration is reported as pH, which is the negative logarithm of the number of moles of ionized hydrogen per liter of water. Specific conductance (a measure of the ionized constituents in water) is reported as micromhos at 25°C and is calculated by multiplying 1 million times the reciprocal of the specific resistance of the water, in ohms.

In figure 24 the water analyses are shown graphically in equivalents per million. The equivalents per million for each ionic constituent may be determined by dividing its concentration in parts per million, by its equivalent combining weight. A concentration of 1 epm of a cationic constituent, such as calcium, magnesium, sodium, or potassium, exactly combines with 1 epm of an anionic constituent, such as bicarbonate, sulfate, chloride, fluoride, or nitrate. Thus, in any natural water containing dissolved solids, the sum of the negative ions (anions) equals the sum of the positive ions (cations) in terms of equivalents. These comparisons cannot be made where the constituents are exexpressed in parts per million. Equivalents per million is a useful unit in that samples of water differing widely in concentration but similar in chemical character or percentage composition may be grouped together. Thus, the unit of expression is a helpful guide to the solution of geologic problems involving chemical processes.

TEMPERATURE

The temperature of natural water is related to the atmospheric temperature of the area considered. The temperature of ground water approximates the mean annual air temperature, regardless of season, except near the ground surface, where the water temperature is affected by seasonal temperature variations; at greater depths the water has a higher temperature, corresponding to the higher temperature of the earth's interior. In Portage County, ground-water temperatures, measured when water samples were collected, ranged between 51° and 58°F.

Water having a consistently low temperature is preferred for cooling and air conditioning. In this respect ground water generally is superior to surface water.

COLOR

In water analyses, color refers to the appearance of the water free of suspended solids. The color of natural water is caused primarily by organic matter derived from decaying plants and, in polluted water, from sewage and industrial wastes.

pH

The degree of acidity and alkalinity is expressed as pH. A pH of 7 indicates that the water is neither acid nor alkaline. Values lower than 7 denote increasing acidity and values higher than 7 denote increasing alkalinity. In Portage County the natural ground water is generally alkaline, and its range in pH is from 5.9 to 7.8.

The corrosiveness of water causes the deterioration of water pipes, steam boilers, water heaters, and other metallic equipment. The pH of water indicates its activity on metal surfaces. Some water that does not appreciably corrode cold-water lines will corrode hot-water lines. The principal constituents in water that cause corrosion of metals are free acid, acid-generating salts, and dissolved gases such as oxygen, carbon dioxide, and hydrogen sulfide. Very soft water of low mineral content frequently is more corrosive than water of moderate mineral content and hardness.

SPECIFIC CONDUCTANCE

The specific conductance of water is a measure of its ability to conduct an electrical current. Specific conductance is the reciprocal of the resistance, in ohms, measured between two electrodes (the electrodes are each 1 cm sq and are placed 1 cm apart in the water) at a specified temperature. Simply it is this: water containing chemicals or minerals that ionize in solution can conduct an electric current. The greater the concentration of chemicals and their degree of ionization the greater is the specific conductance. Changes in mineralization of water can be detected quickly by changes in the specific conductance.

SILICA

Silica is dissolved from practically all rocks. Most natural water contains 5 to 30 ppm of silica. Silica affects the usefulness of water in that it contributes to the formation of boiler scale. It is particularly troublesome in high-pressure boilers. The hard silica scale prevents the rapid transfer of heat and thus causes boiler-tube failure. It also forms deposits on the blades of steam turbines. Some silica in water is advantageous when zeolite softening is employed. The silica in the water helps prevent the deterioration of the zeolite materials by inhibiting the solution of silica from the zeolite.

IRON AND MANGANESE

Iron is common in natural water because it is present in practically all rocks. Frequently, it is dissolved from iron pipes through which the water flows. Iron is objectionable in that it makes reddish-brown stains on porcelain or enamelware and on clothing when its concentration exceeds about 0.3 ppm. It is also troublesome in water used for many industrial purposes, including the manufacture of food, carbonated beverages, beer, textiles, dyed fabrics, high-grade paper, and ice. Manganese in water has about the same objectionable characteristics as iron, but its presence is not as widespread. Iron and manganese may be removed by appropriate treatment of the water.

CALCIUM AND MAGNESIUM

Calcium is dissolved from practically all rocks, but especially from limestone, dolomite, and gypsum. Calcium carbonate is only slightly soluble in pure water, but it is appreciably soluble in water containing carbon dioxide. Calcium and magnesium make water hard and are largely responsible for the formation of boiler scale.

SODIUM AND POTASSIUM

All natural water contains sodium and potassium dissolved from rocks and soils, but usually these constituents make up only a small part of the dissolved mineral matter in natural unpolluted water in humid regions. Ground water contains sodium salts ranging from a few parts per million to excessive quantities.

CARBONATE AND BICARBONATE

Bicarbonate occurs in natural water largely through the action of carbon dioxide, which enables the water to dissolve the carbonates of calcium and magnesium. Carbonate is not present, generally, in ground water in the study area. Bicarbonate in water from siliceous rocks and soils may be less than 10 ppm; water from limestone commonly contains as much as 400 ppm; and water in contact with carbonates or bicarbonates of sodium may carry more than 1,000 ppm of bicarbonate. Bicarbonate and carbonate in water increase the pH value and tend to make the water less corrosive for some purposes. However, bicarbonates may break down in steam boilers and hot-water systems and release corrosive carbon dioxide. Bicarbonate or carbonate aids coagulation in the removal of suspended matter from water. In Portage County the bicarbonate content of the ground water generally ranges from 100 to 500 ppm.

SULFATE

Sulfate is dissolved from rocks and soils, and in large quantities from gypsum, anhydrite, and deposits of sodium sulfate. Sulfate in water that contains calcium and magnesium causes the formation of hard scale in steam boilers. It may increase the cost of softening the water or influence the choice of the softening method. In ice manufacture, calcium sulfate may cause the formation of "white butts" in the cores of the ice blocks.

CHLORIDE

Chloride is dissolved from rocks and soils. Ground water may contain chloride derived from connate water (water contained in the rocks at the time of deposition) or from pollution.

Small quantities of chloride have little effect on the use of water. Large quantities, in water that contains considerable calcium or magnesium, increase the corrosiveness of the water. Large quantities of soluble salts, such as sodium chloride, cause foaming and priming in steam boilers. Sodium chloride gives the characteristic salty taste to water that is detectable generally when the sodium chloride content, in terms of chloride, exceeds about 250 ppm.

FLUORIDE

Fluoride has been reported to be present in some rocks in about the same amount as chloride. However, it is present in natural water in much smaller quantities than chloride. Considerable evidence indicates that about 1 ppm of fluoride in water decreases the incidence of dental caries (decay of teeth) when the water is consumed by children during calcification or formation of the teeth. However, fluoride in water exceeding about 1.5 ppm is associated with dental fluorosis, a permanent staining of the teeth, when the water is used for drinking by children (Dean, 1936).

NITRATE

Nitrate in excess of 45 ppm may indicate contamination by sewage or other organic matter. Nitrate is of importance in the inhibiting of the intercrystalline cracking of boiler steel. Because the nitrate is concentrated in the boiler, as little as 2 ppm in the feed water may be sufficient to protect the boiler steel. Wells 305 and 917 yield water very high in nitrate, the concentration being 19 and 60 ppm, respectively.

DISSOLVED SOLIDS

The quantity reported as dissolved solids (the residue after evaporation) consists of the dissolved constituents in the water. It usually consists primarily of the dissolved mineral constituents, but it includes also the organic matter and water of crystallization when dehydration is incomplete. The quantity of dissolved solids is determined by evaporating a given quantity of the clear water and weighing the residue after it has been dried for 1 hour or more at 180°C.

Water containing less than 500 ppm of dissolved solids is used for domestic and many industrial purposes. In industrial processes where chemical quality is critical, much lower concentrations than 500 ppm are necessary. In other processes, such as cooling, the permissible concentration may be higher. Water with more than 1,000 ppm of dissolved solids is likely to be unsuitable for most purposes.

HARDNESS

Hardness of water is recognized by the quantity of soap required to produce a lather. Soap is precipitated by polyvalent metallic ions such as calcium, magnesium, iron, manganese, aluminum, barium, and strontium and by hydrogen ions. However, hardness of water is caused primarily by calcium and magnesium.

The results for hardness given in the tables are reported in parts per million as calcium carbonate ($CaCO_3$) equivalent to the calcium and magnesium. The hardness caused by bicarbonate or carbonate of calcium and magnesium is called carbonate hardness; the balance of the hardness of the water is called noncarbonate hardness.

Among the industries requiring soft water are laundries, powerplants, railroads, textile processing and dyeing concerns, food processing plants, and manufacturers of certain grades of paper. Hardness causes the formation of scale in boilers, water heaters, radiators, and pipes, the results being loss in heat transfer, loss in flow, and the possibility of boiler failure. It is objectionable in the home because it causes more soap to be used.

Water whose hardness is as much as 60 ppm is considered soft and is satisfactory for domestic purposes. Water whose hardness ranges from 61 to 120 ppm is considered moderately hard, but still may be used for many purposes. Water whose hardness ranges from 121 to 180 ppm is considered hard. Such hardness is noticeable in the home, and the water is unsatisfactory without softening for industrial processes in which hardness is of particular significance. Water whose hardness is above 180 ppm is considered very hard. At many places such water is used in the home, but it cannot be considered totally satisfactory. Softening is required for many industrial uses of water. The hardness of ground water in Portage County generally ranges from 100 to 500 ppm, although the analyses indicate that much harder water is found.

SUMMARY

GROUND WATER

Plate 5 is a general guide to the ground-water resources of Portage County. On this map the county is divided into five ground-water provinces, each of which represents the aquifer or aquifers that are the sources of ground water in the respective areas. The aquifers in the five ground-water provinces are: (1) the glacial drift and underlying Pottsville Formation, (2) the Pottsville Formation, (3) the glacial drift and underlying Devonian and Mississippian rocks, (4) the fine-grained glacial drift and underlying Devonian and Mississippian rocks, and (5) the Devonian and Mississippian rocks.

The best ground-water areas are in the western part of the county, in the north-south trending buried valley that lies in western Franklin, Brimfield, and Suffield Townships and in the buried valley which approximately underlies the Cuyahoga River valley in Streetsboro, Shalersville, and Mantua Townships. Recharge to the sand and gravel deposits is available from nearby surface-water bodies in much of these two areas. Properly constructed wells in these areas have yielded as much as 1,200 gpm. The sandstone units of the Pottsville Formation are the source of ground water over large areas of the county, but the yield of wells in these sandstone units is dependent upon local variation in the units' thickness, permeability, and areal extent, as well as in the availability of recharge. One well in the Pottsville sandstones is reported to yield 850 gpm, but generally the yield of wells in these sandstones is somewhat less. The areas of the county underlain by fine-grained glacial drift and Devonian and Mississippian rocks generally are the least productive ground-water provinces. The few thin discontinuous sand and gravel lenses in the drift and the Berea and Cussewago Sandstones are the sources of ground water to most of the wells in these provinces. The Berea sandstone yields as much as 50 gpm to wells at the Garrettsville waterworks in Nelson Township, but this is probably an exceptional rate in that the yield of other wells in the Berea Sandstone, like the yield of wells in the Cussewago Sandstone, is usually about 5 gpm or less. Wells in buried valleys which are predominantly filled with fine-grained glacial drift derive water from the few thin discontinuous sand and gravel lenses interbedded with the fine-grained deposits. The yield of one well drilled in a sand and gravel lens is reported to be about 35 gpm, but usually the yield is considerably less and many wells have been failures.

QUALITY OF WATER

The ground water in Portage County has a wide range in chemical quality and in the concentration of the various mineral constituents. On the basis of 16 analyses, the ground water generally is hard to very hard and contains moderate to excessive amounts of dissolved mineral constituents. Some of the ground water, especially that from the Berea Sandstone, is relatively soft, but this water is not necessarily low in mineral content. The Mississippian and Pennsylvanian rock units generally are thin and many wells penetrate more than one unit so that the water from the consolidated rocks usually is a mixture of water from several water-bearing zones.

The total hardness of the ground water analyzed in Portage County ranged from 82 to 740 ppm. Manganese was present in amounts up to 0.66 ppm. The ionic sodium and chloride content of the ground water generally was low, but the maximum was 468 and 520 ppm, respectively. The bicarbonate content of the ground water ranged from 10 to 522 ppm. The sulfate content ranged from 0.6 to 505 ppm. The fluoride content ranged from 0.1 to 0.2 ppm, except in one sample from the Berea Sandstone which had 0.6 ppm. The dissolved solids in the ground water ranged from 146 to 1,350 ppm. The pH ranged from 5.9 to 7.9. The iron content of the ground water ranged from 0.05 to 6.8 ppm, and silica ranged from 6.2 to 16 ppm.

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TABLES 11–14

TABLE 11.—*Records of water and test wells in Portage County*

Well: The number of the well shown on the well-location map (pl. 2) and above the graphic illustration of the well log (pl. 1).
Owner or tenant: Name of land owner or tenant at the time the well was drilled or at the time of the well inventory.
Altitude at well: Determined approximately from the topographic maps of the U.S. Geological Survey.
Depth to bedrock: Depth to the top of the consolidated rocks; a plus sign indicates that bedrock was not reached.
Depth of well: Depth reported by driller, owner, or tenant.
Character of material: Type of material from which water was obtained or in which the well was terminated; ss, sandstone; sh, shale; ls, limestone; sd, sand; gr, gravel; cl, clay or till.
Geologic unit: Q, Quaternary deposits; Ph, Homewood Sandstone Member of Pottsville Formation; Pm, Mercer Member of Pottsville Formation; Pc, Connoquenessing Sandstone Member of Pottsville Formation; Pss, shale unit of Sharon Member of Pottsville Formation; Psc, conglomerate unit of Sharon Member of Pottsville Formation; Mc, Cuyahoga Group; Mb, Berea Sandstone; M-D, Mississippian and (or) Devonian rocks below the Berea Sandstone. Where two aquifers yield water to a well, the uppermost is the first mentioned (Pc-sc indicates the well yields water principally from the Connoquenessing Sandstone Member and the conglomerate unit of the Sharon Member of the Pottsville Formation).
Water level: Below land surface—Depth to water in the well as reported by the driller, owner, or tenant. Date—Date of measurement of the static water level, yield, or drawdown, or the date the well was completed.
Yield: Rate—Rate at which well was pumped or bailed. Drawdown—Amount of lowering of the water level in the well caused by pumping the well at the rate shown in the yield column.
Diameter of well: Approximate inside diameter of casing.
Use: I, industrial; D, domestic; S, stock; Ir, irrigation; PS, public supply; T, test well; O, observation well.
Remarks: L, graphic representation of well log shown on pl. 1; A, chemical analysis of water from the well is shown in table 9; Du, dug well (all others are drilled wells); T or C, electric or gasoline motor powered turbine or centrifugal pump, respectively (pumps on other wells principally electric powered ejector or submersible types).

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed		Water level		Yield		Diameter of well (inches)	Use	Remarks
					Character of material	Geologic unit	Feet below land surface	Date	Rate (gpm)	Drawdown (feet)			
	Atwater Township												
101	Harry Whittlesey	1120	112	134	ss	Ppc	30	4-20-49	21	----	5	D	L
102	Atwater Methodist Church	1120	220+	220	gr	Q	Flows	6- 7-52	----	----	4	PS	L
103	Andrew Kmetko	1110	40+	40	sd	Q	Flows	9-29-52	15	5	5	D	L
104	Robert D. Roliff	1150	60+	60	sd	Q	27	1-12-51	10	5	6	D	
105	Rice	1140	60+	60	sd	Q	20	2-22-51	10	10	6	D	
106	A. W. Mower	1140	95	133	ss	Ppc	80	4-24-48	7	----	5	D	L
107	O. W. Martin	1165	31	55	ss	Pph	30	5- 7-49	5	20	4	D	L, A
108	P. Libis	1150	47	54	ss	Pph	18	1949	5	5	4	D	L
109	A. R. Carlile	1140	110	122	ss	Ppc	----	----	----	----	4	D	L
110	Fred E. Ewing	1100	29	44	ss	Ppc	13	8-18-49	10	1	4	D	L
112	Pete Karas	1140	10	60	sh	Pph	20	11-16-49	7	35	6	D	L
113	H. H. Smith	1175	146	154	ss	Ppc	55	10-17-51	25	12	4	D	L
114	Carl Pittman	1120	48+	48	sd	Q	22	5- 6-52	25	3	5	D	L
115	Harry Whittlesey	1115	62+	62	gr	Q	20	7-13-53	3	----	5	D	L
116	E. Hamlin	1140	64	83	ss	Pph	36	1- 5-54	----	----	4	D	L
117	W. D. Gay	1180	105+	105	gr	Q	43	10-26-53	----	----	4	D	L
118	Alonzo Jarvis	1200	43	56	ss	Pph	29	9-14-53	----	----	4	D	L
119	McKinley	1147	79	95	sh	Ppm	29	11-20-53	----	----	4	D	L
120	P. L. Frank Co	1160	23	39	ss	Pph	25	10-23-52	12	3	4	D	L
121	Ray Cameron	1140	200	216	sh	Ppss	15	7-31-53	10	50	5	D	L
122	C. L. Strows	1150	47	62	ss	Pph	30	9-27-52	10	10	4	D	L
123	James Cash	1160	61	65	----	----	----	----	----	----	----	D	
124	Paul A. Long	1155	55+	55	gr	Q	----	----	----	----	----	S	
125	Sells	1120	75	130	ss	Ppc	1	7-15-55	25	50	6	D	L
126	A. W. Graham	1140	40	65	ss	Pph	14	9- 3-54	20	22	5	D	L
127	Roy Green	1120	113+	113	gr	Q	Flows	8-13-54	7	30	5	D	L
128	Fred Mortz	1160	48	57	ss	Pph	27	7- 6-54	----	15	4	D	L
129	Souden	1145	69	90	sh	Ppm	15	7- 1-54	----	20	4	D	L
130	A. Kramer	1090	27	77	ss	Ppc	8	5- 1-54	10	55	4	D	L
131	R. B. Hilker	1070	39	74	ss	Ppc	12	5-10-54	22	50	4	D	L
132	James M. White	1120	76	84	ss	Ppc	12	5-18-54	30	15	4	D	L
133	D. Kimble	1060	80	105	ss	Ppc	18	2- 4-56	10	----	4	D	L
134	R. Kays	1105	20	76	ss	Ppc	26	6- 9-56	3	66	6	D	L
135	L. L. Douthitt	1130	45	70	ss	Ppc	3	7-14-54	5	60	4	D	L
136	H. W. Keen	1210	52	71	ss	Pph	----	----	15	25	4	D	L
	Aurora Township												
201	----	1165	10	110	ss	Ppc	----	----	----	----	----	----	
203	----	1130	5	80	ss	Ppc	----	----	----	----	----	----	
204	Hunter	1060	10	70	ss	Ppc-sc	----	----	----	----	----	----	
205	Vaughan	1105	140+	140	gr	Q	----	----	----	----	----	----	
206	----	1100	25	80	sh	Ppss	----	----	----	----	----	----	
207	----	1100	20	80	sh	Ppss	----	----	----	----	----	----	
208	Charles Lowe	1080	20	70	ss	Ppsc	----	----	----	----	----	----	
209	----	1070	30	80	ss	Ppsc	----	----	----	----	----	----	
210	----	1120	100+	100	----	Q	----	----	----	----	----	----	
211	Riley	1140	30	70	ss	Ppc	----	----	----	----	----	----	
212	Polson	1140	20	75	ss	Ppc	----	----	----	----	----	----	
213	----	1100	30	70	ss	Ppc	----	----	----	----	----	----	
214	----	1100	40	80	ss	Ppc-sc	----	----	----	----	----	----	
215	----	1120	20	80	ss	Ppc	----	----	----	----	----	----	
216	----	1140	35	75	ss	Ppc	----	----	----	----	----	----	
217	Papp	1150	40	80	ss	Ppc	----	----	----	----	----	----	
218	Smith	1140	40	80	ss	Ppc	----	----	----	----	----	----	
219	----	1165	20	60	ss	Ppc	----	----	----	----	----	----	
220	----	1140	60+	60	----	Q	----	----	----	----	----	----	
221	Y.M.C.A. camp	1080	16	50	ss	Ppc-sc	----	----	----	----	----	----	
222	----	1080	70	78	ss	Ppsc	----	----	12	----	----	----	L
223	T. Miccio	1120	78+	78	sd	Q	32	8-24-49	5	15	4	D	L
224	Thomson	1120	80+	80	sd	Q	38	4-17-52	10	8	4	D	L
225	Fred Knopf	1100	9	57	ss	Ppc	30	4-22-51	10	12	6	D	L
226	R. O. Harper	1030	39+	39	gr	Q	27	8-30-49	5	8	5	D	L
227	L. A. Botamer	1020	78+	78	sd	Q	15	8-26-52	10	2	4	D	L
228	Aurora Inn	1110	97	318	ss	Mb	40	12-21-48	8	40	6	Ir	L, A
229	Steve Gawrouoki	1090	45+	45	gr	Q	24	6- 1-51	20	4	6	D	L
230	H. Sweet	1190	68	115	ss	Ppc	75	9-19-50	8	10	4	D	L
231	C. C. Raber	1180	79	123	ss	Ppc	93	10- 6-50	5	10	4	D	L
232	Max Du Brava	1180	70	115	ss	Ppc	71	12-16-50	5	14	4	D	

TABLE 11.—*Records of water and test wells in Portage County*—Continued

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic unit	Water level: Feet below land surface	Water level: Date	Yield: Rate (gpm)	Yield: Draw-down (feet)	Diameter of well (inches)	Use	Remarks
	Aurora Township—Continued												
233	Orie Oswald	1160	120+	120	gr	Q	81	11-15-51	7	10	6	D	L
234	Kingsley A. Taft	1160	56+	56	gr	Q					6	D	L
235	W. A. Welch	1180	105	120	ss	Ppc	Flows	8- 9-49	8	10	6	D	L
236	T. Knight	1150	12	85	ss	Ppc	25	10- 2-47	5	25	6	D	L
237	C. J. Charvat	1140	150+	150	gr	Q	37	6-30-49	3	60	6	D	L
238	J. Converse	1120	177+	177	gr	Q	93	11- 1-51	18	31	6	D	L
239	James McCleary	1130	3	70	ss	Ppc	17	9-12-49	20	10	6	D	L
240	S. Vlick	1140	95+	95	gr	Q	38	9- 5-50	5		6	D	L
241	H. Romanoff	1140	52	55	ss	Ppc	24	6-27-51	30	3	6	D	L
242	Arnold Dimick	1130	15	63	ss	Ppc	35	11-24-48	10	15	6	D	L
243	J. Regetz	1160	36	58	ss	Ppc	35	1- 4-52	15	10	6	D	L
244	do	1160	38	60	ss	Ppc	34	5-11-51	10	15	6	D	L
245	J. A. Doepp	1130	93+	93	sd	Q	38	9-12-48	1	18	6	D	L
246	Mahlon D. Boley	1100	35	54	ss	Ppsc	36	9-30-47	10	5	6	D	L
247	Frank Swartz	1150	40	56	ss	Ppc	27	11- 8-50	15	10	4	D	L
248	W. A. Noel	1140	68+	68	gr	Q	20	5- 1-52	8	16	6	D	L
249	Frank Olton	1110	250+	250	gr	Q					5		L, Dry
250	Aurora Lumber Co	1140	8	50	ss	Ppc	20	5-18-52	4	15	6	D	L
251	J. G. Dunneback	1110	105	110	ss	Ppsc			5	2	6	D	L
252	Gordon Stutzman	1200	78	135	ss	Ppc	90	6-24-53	7	Slight	4	D	L
253	Mahlon D. Boley	1140	30	55	ss	Ppc-sc	30	5- 7-53	10	10	6	D	L
254	Mitchokev	1120	10	109	ss	Ppc-sc	55	10- 2-52	8	90	6	D	
255	Ben N. Shaw	1050	12	69	ss	Ppsc	44	9-26-53	16		6	D	L
256	Charles Durning	1200	55	115	ss	Ppc	80	10- 2-52	4	25	6	D	L
257	Mennonite Church	1200	62	122	ss	Ppc	87	5- 1-53	10		6	PS	L
258	Edward Bushnell	1160	20	96	ss	Ppc	50	6-30-53	4	30	6	D	L
259	Charles Martin	1130	30	83	ss	Ppc	58	6-27-53	12		6	D	L
260	Harvey F. Brandt	1120	175+	175	gr	Q	40	6-29-53	10	50	6	D	L
261	A. Demickle	1140	107+	107	gr	Q	30	6-17-53	30	15	6	D	L
262	I. Kittleson	1145	28	110	ss	Ppc-sc	50	5-22-54	12	15	6	D	L
263	O. I. Martin	1090	40	88	ss	Ppsc					6	D	L
264	R. McKinney	1040	154+	154	sd	Q	43	9-19-50	3	30	6	D	L
265	F. Ruzicka	1130	24	107	ss	Ppc	51	3-10-56	18	6	6	D	L
266	E. P. Toler	1145	57	62	ss	Ppsc	26	8-24-55	20	15	6	D	L
267	I. R. Martin	1160	62	82	ss	Ppc	32	12-31-55	18	3	6	D	L
268	F. Bissel	1025	158+	158	sd	Q	28	7-28-54	6	18	4	D	L
269	R. K. Hackett	1100	46	80	sh	Mc	45	7-30-52	10		6	D	L
270	H. Helmuth	1205	68	175	ss	Ppc-sc			10		6	D	L
271	H. W. LaCroix	1170	42	98	ss	Ppc	60	9- 9-55	3		4	D	L
272	O. W. Oswald	1160	98+	98	gr	Q	56	6-19-54	8		6	D	L
273	Erie Railroad	995	656									T	L
274	D. A. Funnell	1115	23	75	ss	Ppc-sc	18	4-30-55	10	4	6	D	L
	Brimfield Township												
301	Alvin Seyler	1110	77	98	sh	Ppss	36	6-10-52	8	45	4	D	L
302	Charles Bunton	1180	55	81	ss	Ppc	51	4-18-50	15	4	4	D	L
303	Charles M. Davis	1140	31	61	ss	Ppss	18	10-15-47	10	22	4	D	L
304	John H. Eiseman	1115	48	67	sh	Ppss	40	10-13-47	15	12	4	D	L
305	A. L. Eversman	1140	47	88	sh	Ppss	35	11-13-51	10		4	D	L, A
306	John A. Scheck	1160	45	60	ss	Ppss	20	8- 3-50	10	18	4	D	
307	Laurence Albergo	1100	43+	43	gr	Q	1	8- 8-50	10	51		D	L
308	E. C. Halloway	1140	35	53	ss	Ppc	24	6-12-52	18	5	4	D	L
309	Leonard Roth	1150	33	41	ss	Ppc					4	D	L
310	Henry Luckhardt	1140	60	97	ss	Ppsc					4	D	L
311	Ionia C. Twitchell	1110	47+	47	gr	Q	18	5-24-50	13	3	4	D	L
312	F. R. Knapp	1120	88+	88	sd	Q					4	D	
313	Harlan H. Laversdorf	1140	177+	177	gr	Q					4	D	L
314	Adaline Shaffer	1180	68	77	ss	Ppc	65	9-12-51	5	5	4	D	
315	Lesley Blanchard	1160	51	87	ss	Ppc	44	9- 8-51	4	40	4	D	
316	F. L. Roliff	1130	49	65	sh	Ppss	24	1- 6-51	5	10	4	D	L
317	Irwin Beal	1120	27	63	ss	Ppsc					5		
318	James Newcome	1110	30	53	ss	Ppsc					4	D	L
319	Norman Robenstine	1120	97	105	ss	Ppsc	40	10-20-50	5	10	4	D	L
320	Nighman	1140	82+	82	sd	Q	49	6- 1-50	7	10	4	D	L
321	Daniel Urban	1110	75	114	ss	Ppsc	40	6- 4-50	5	20	4	D	L
322	Dale Russell	1120	70+	70	gr	Q	24	8-23-50	7		4	D	L
323	L. C. Bowman	1120	75+	75	gr	Q					4	D	L
324	George Sigman	1120	80+	80	sd	Q	13	8- 2-51	8	15	4	D	L
325	Millie Sams	1120	51+	51	gr	Q					4	D	L
326	M. C. Molnar	1180	115+	115	gr	Q	95	7- 7-49	10	2	4	D	L
327	Ken Nash	1120	82+	82	gr	Q	40	4-28-49	15	8	4	D	L
328	Luther Moore	1125	73	90	ss	Ppsc					4	D	L
329	Emil Thyr	1125	52	52	gr	Q					4	D	L
330	Ray Koxielski	1140	60	66	ss	Ppc					4	D	L
331	Earl E. Wortenberger	1100	191+	191	gr	Q	173	8- 8-51	5	5	4	D	L
332	Holly Lakes Motel	1070	83+	83	sd	Q					4	PS	L
333	M. Bisele	1140	63	81	sh	Ppss	56	3-28-50	12	5	4	D	L
334	N. I. Bean	1110	23	36	ss	Ppsc	10	4-18-51	15	11	4	D	L
335	A. W. Woodward	1100	20	72	ss	Ppsc					4	D	L
336	James Puishis	1080	152+	152	gr	Q					4	D	L
337	M. B. Duncan	1060	90	97	ss	Ppsc					4	D	L
338	B. B. Siefert	1105	34	52	ss	Ppc					4	D	L
339	Raymond Smith	1115	40	78	ss	Ppc					4	D	L
340	Leroy Streby	1095	54+	54	gr	Q					4	D	L
341	N. M. Roth	1110	57+	57	gr	Q	19	8-19-50	15	20	4	D	L
342	A. H. Eddington	1140	41+	41	gr	Q	16	9- 5-50	10	6	4	D	L
343	A. Odell Kallbaugh	1090	46	51	ss	Ppsc					4	D	L

TABLE 11.—*Records of water and test wells in Portage County*—Continued

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic unit	Water level: Feet below land surface	Water level: Date	Yield: Rate (gpm)	Yield: Draw-down (feet)	Diameter of well (inches)	Use	Remarks
	Brimfield Township—Continued												
344	Delcie Jacks	1105	71	82	ss	Ppsc					4	D	L
345	Don McNeil	1160	179	183	ss	Ppsc	90	12-16-50		25	4	D	L
346	L. D. Ricker	1090	4	40	sh	Ppc	18	6-12-42			4	D	L
347	C. W. Deis	1160	26	57	ss	Ppc			10	15	4	D	L
348	Emmett S. Roliff	1120	79+	79	gr	Q					4	D	L
349	Wilbur L. Jones	1140	33	67	ss	Ppc	24	2- 9-50	10	11	4	D	L
350	Jess Nelson	1090	74+	74	sd	Q	14	10- 4-49	3	20	4	D	L
351	Joe Prats	1080	140	151	ss	Ppsc	35	9-18-50	10	25	4	D	L
352	O. L. Bailey	1120	64	80	sh	Ppss					4	D	L
353	H. Sherrill	1120	85	110	ss	Ppsc					4	D	L
354	C. Eisman	1110	67	72	ss	Ppsc					4	D	L
355	K. Roth	1100	55	72	ss	Ppsc					4	D	L
356	Roy Giggy	1120	73	110	ss	Ppsc					4	D	L
357	G. A. Curfman	1130	74	110	ss	Ppsc					4	D	L
358	Frank Loomis	1130	44	70	ss	Ppc					4	D	L
359	C. Bragg	1120	165+	165	gr	Q	33	9-19-55	10	6	4	D	L
360	E. Pryce	1170	60	89	sh	Ppss	42	11- 5-55	7	28	4	D	L
361	Harold McCluskey	1130	50	76	sh	Ppss					4	D	L
362	G. H. Klein	1110	46	56	ss	Ppsc					4	D	L
363	Kenneth Sterley	1140	39	74	ss	Ppc	36	11-17-53	12	14	4	D	L
364	Clarence Griffin	1080	65	73	ss	Ppsc					4	D	L
365	Carl L. Bolyard	1120	46	64	sh	Ppc					4	D	L
366	Wilford Fox	1120	36	40	ss	Ppc	14	9- 8-53	15	6	4	D	L
367	Kenneth Knapp	1105	37	57	sh	Ppc	18	9-11-52	12	10	4	D	L
368	D. Snyder	1060	84	86	ss	Ppsc	Flows	3-29-54	7	Flow	4	D	L
369	H. Englehart	1120	74	86	ss	Ppsc					4	D	L
370	McGregor	1050	30	71	ss	Ppsc	14	5-27-50	5	32	4	D	L
371	M. Smith	1160	22	116	ss	Ppc	60	10- 8-54	12	27	4	D	L
372	R. Boosinger	1135	82	100	ss	Ppsc					4	D	L
373	S. Liphum	1130	98	104	ss	Ppsc	55	10-28-55	10		4	D	L
374	J. Polanski	1120	98	105	ss	Ppsc					4	D	L
375	K. McClain	1140	42	80	ss	Ppc	10	8-29-55	10	15	4	D	L
376	H. Kurtz	1120	77	78	ss	Ppc	38	11- 8-55	14	7	4	D	L
377	J. Sibert	1120	105	145	ss	Ppsc	24	2-28-55	10	30	4	D	L
378	R. Kalbaugh	1100	100+	100	gr	Q	5	5- 7-56	10	15	4	D	L
379	N. M. Roth	1160	53	83	ss	Ppc	41	3-10-55	9	29	4	D	L
380	J. Thomas	1160	53	72	ss	Ppc	40	9- 5-55	10		4	D	L
381	I. G. Shafer	1160	39	50	ss	Ppc	20	4- 9-55	10	20	4	D	L
382	J. H. Leway	1120	161	175	ss	Ppsc	35	1-20-55	10	50	4	D	L
	Charlestown Township												
401		1170	20	85	ss	Pph						D	L
403	Moore	1040	100	115	ss	Ppsc						D	L
404	Mark E. Coburn	1120	74+	74	sd	Q	27	9-22-48	3	12	4	D	L
405	H. A. Seyfried	1050	29	50	sh	Ppss	21	8-24-51	10		4	D	L
406	Magnolia Petroleum Co	1060	90+	90	gr	Q						T	L
407	H. O. Hall	980	184	216	sh	Mc	11	10-20-49	4	99	4	D	L
408	Magnolia Petroleum Co	980	105+	105		Q						T	L
409	H. M. Moncrief	1040	143	147	ss	Ppsc	8	9-29-47	6	64	4	D	L
410	E. E. Guend	980	77+	77	sd	Q	38	8-28-51	10		4	D	L
411	A. Galko	970	148	161	ss	Ppsc	Flows	1-27-50	10		4	D	L
412	Magnolia Petroleum Co	1160	95+	95	gr	Q						T	L
413	Earl Lewis	1030	120+	120	sd	Q	60	5-10-52	10	12	4	D	L
414	J. Ferrey	1020	99+	99	sd	Q	84	5-22-48	2	7	4	D	L
415	Bob Everett	960	38+	38	sd	Q	25	5-24-48	5		4	D	L
416	Stanley Kolacz	1080	60+	60	gr	Q	44	2-27-50	5		4	D	L
417	V. G. Sly	1140	28	56	sh	Ppm	36	8- 9-51	6		4	D	L
418	Howard Hoover	1040	29	89	ss	Ppsc	40	11-24-48	5	15	4	D	L
419	Magnolia Petroleum Co	1080	125+	125	gr	Q						T	L
420	do	1165	25	65	ss	Pph						T	L
421	do	1160	17	65	ss	Pph-c						T	L
422	do	1120	36	65	sh	Ppss						T	L
423	do	1180	20	65	ss	Pph						T	L
424	do	1100	37	65	sh	Ppm						T	L
425	do	1160	33	55	sh	Ppm						T	L
426	do	1120	23	40	ss	Ppc						T	L
427	do	1080	95+	95	gr	Q						T	L
428	R. Sanford	1120	15	60	sh	Ppm	Flows	9-15-52	10	4	4	D	L
429	E. P. Babington	1080	30	54	ss	Ppsc						D	L
430	Charles Champaigne	1080	101+	101	gr	Q	30	9-24-52	10	8	4	D	L
431	W. Mowen	1090	114+	114	gr	Q	45	3-20-53	10	30	4	D	L
432	E. Wadyka	1000	54+	54	sd	Q	40	9-26-52	5	5	5	D	L
433	J. Sneda	1020	125	135	ss	Ppsc	Flows	5-28-53	20		4	D	L
434	Ravenna Arsenal	1110	12	183	ss	Ppc-sc	34		40	5	6	T	L
435	do	1100	159	176	ss	Ppsc	61				6	T	L
436	do	1125	24	220	ss	Ppc-sc	10		104	102	6	T	L
437	do	1095	23	214	ss	Ppsc	21		40	100	12	T	L
438	do	1095	16	221	ss	Ppsc	45		100	49	12	T	L
439	do	1175	23	148	ss	Pph-c	22		40	5	6	T	L
440	do	1135	60	150	ss	Ppc	10		15	10	6	T	L
441	do	1130	135	184	sh	Ppss	30		30	90	6	T	L
442	do	1180	18	150	ss	Pph			40	20	6	T	L
443	do	1150	34	131	ss	Ppc	21		34	8	6	T	L
444	do	1190	14	150	ss	Pph	3		40	25	6		L
445	do	1120	11	261	ss	Ppc-sc	22		95	43	8	T	L
446	do	1130	15	223	ss	Ppc-sc	31		104	83	12	I	L
447	do	1130	33	222	ss	Ppc-sc	21		164	100	12	I	L
448	do	1140	31	233	ss	Ppc-sc	34		60	44	12	T	L

TABLE 11.—*Records of water and test wells in Portage County*—Continued

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic unit	Water level: Feet below land surface	Water level: Date	Yield: Rate (gpm)	Yield: Draw-down (feet)	Diameter of well (inches)	Use	Remarks
Charlestown Township—Continued													
449	Ravenna Arsenal	1125	23	230	ss	Ppc-sc	16	------	86	------	12	I	L
450	do	1110	16	78	ss	Ppsc	------	------	------	------	6	D	L
451	do	1110	37	228	ss	Ppsc	50	------	40	25	6	T	L
452	do	1105	22	238	ss	Ppsc	20	------	80	63	6	T	L
453	E. Hartman	1105	153	155	ss	Ppsc	62	6- 1-55	30	4	4	D	L
454	T. J. Naso	1130	55	88	sh	Ppm	58	10-23-53	5	------	4	D	L
455	G. Stetansic	1130	63	71	sh	Ppm	45	9- 5-53	10	------	4	D	L
456	C. Tisdale	1110	97	102	sh	Ppss	21	11-26-56	20	2	4	D	L
457	E. Flynn	1010	190+	190	gr	Q	18	7- 3-54	10	50	7	D	
458	W. E. Ritter	1035	136+	136	sd	Q	65	6- 4-56	10	25	4	D	L
459	D. Boles	1020	199+	199	sd	Q	------	------	------	------	5	D	L
460	Ravenna Arsenal	1140	------	225	ss	Ppc-sc	31	------	------	------	12	O	
Deerfield Township													
501	M. L. Hoffman	1080	29	51	ss	Ppm	15	7-13-49	10	5	6	D	L
502	A. J. Blair	1090	10	75	sh	Ppm	26	9- 6-50	7	10	6	D	L
503	A. H. Hix	1070	56	71	ss	Ppc	30	5-26-49	------	------	6	D	L
504	E. A. Abbuhl	1040	34	57	ss	Ppc	20	10- 2-51	20	10	4	D	L
505	Richard Carver	1040	32	51	ss	Ppc	12	9- 5-48	15	18	4	D	L
507	M. M. Shawl	1070	29	40	sh	Ppm	5	4-19-52	5	------	6	D	L
508	do	1040	40	60	ss	Pph	15	4- 8-52	------	------	6	D	L
509	Paul Cope	1030	10	50	ss	Ppc	26	2-29-52	------	------	6	D	L
510	John Farago	1040	23	80	sh	Ppm	18	11- 2-48	------	------	6	D	L
511	C. T. Brogen	1050	41	96	ss	Ppc	23	5-13-51	------	------	6	D	L
512	Laverne Haident	1020	43	104	ss	Ppc	50	12-22-47	------	------	6	D	L
513	Raymond Austin	1045	30	114	ss	Ppc	25	3-14-49	------	------	6	D	L
514	Harold Oswalt	1040	12	133	ss	Ppc	35	2-11-49	------	------	6	D	L
515	Virgil McCammon	1060	82+	82	gr	Q	30	8-11-51	------	------	6	D	L
516	Roy Kays	1100	15	97	sh	Ppm	------	------	------	------	------	D	L
517	Ohio Oil Co.	1020	22	45	ss	Ppc	------	------	------	------	------	T	L
518	do	1025	13	60	sh	Ppc	------	------	------	------	------	T	L
519	do	1030	0	50	sh	Ppm	------	------	------	------	------	T	L
520	do	1040	0	49	sh	Ppc	------	------	------	------	------	T	L
521	C. J. Blumenstil	1110	27	40	ss	Ppc	18	9-29-53	30	12	7	D	L
522	E. Jenkins	1070	18	98	ss	Ppc	35	9-28-53	2	63	7	D	L
523	R. Jenkins	1050	40	78	ss	Ppc	25	9-21-53	1	53	7	D	L
524	J. Cramer	1020	73	232	sh	Ppsc	------	------	------	------	8	D	L
526	C. B. Smith	1010	68	70	ss	Ppc	15	10- 5-53	10	40	4	D	
527	R. L. McPeck	1040	26	85	ss	Ppc	50	7-28-52	------	------	5	D	L
528	H. Ellison	1050	21	63	ss	Ppc	35	11-18-53	5	28	7	D	L
529	R. Champion	1070	36	82	ss	Ppc	40	4-29-53	8	------	4	D	L
530	B. McIntyre	1085	44	54	ss	Ppc	32	4-26-53	10	8	4	D	L
531	J. Barnes	1020	17	80	ss	Ppc	12	6-17-53	20	40	5	D	L
534	C. Werten-ferger	1030	42	80	ss	Pph	23	6- 3-53	------	------	4	D	L
535	R. Zuber	1020	8	112	ss	Ppc	13	6-10-53	------	------	4	D	L
536	G. Grindley	1110	22	81	sh	Ppm	------	------	------	------	6	D	L
537	Rodlanis	1050	17	50	ss	Pph	24	7-22-53	------	------	4	D	L
538	L. B. Fetherolf	1015	53	110	ss	Ppc	30	6-28-54	10	40	4	D	L
539	H. McSwain	1030	50	124	ss	Ppc	25	8-20-55	4	40	4	D	L
540	E. A. Hunsicker	1100	28	44	ss	Pph	12	9- 5-55	20	30	6	D	L
541	F. Hunsicker	1120	19	31	ss	Pph	7	9-28-54	15	------	4	D	L
542	A. Fordor	1110	23	84	ss	Ppc	14	8-17-54	10	50	4	D	L
543	J. E. Detwiler	1070	45	124	ss	Ppc	50	9-28-54	10	50	4	D	L
544	L. V. Patick	1060	35	84	ss	Ppc	30	8- 9-54	10	50	4	D	L
545	A. Martin	1030	51	75	ss	Ppc	------	------	------	------	5	D	L
546	G. Walters	1060	11	76	ss	Ppc	4	3-17-56	4	------	6	D	L
547	A. Detchon	1070	12	61	ss	Ppc	17	9-22-54	------	------	4	D	L
548	J. Karathanos	1065	10	44	ss	Pph	10	5-26-54	5	------	7	D	L
549	R. D. Thomas	1050	40	126	ss	Ppc	25	8-29-55	10	20	4	D	L
550	F. W. Wearstler	1040	60	99	ss	Pph	45	7- 3-53	------	------	4	D	L
551	L. Bush	1040	45	95	ss	Ppc	30	6-23-54	------	------	6	D	L
552	D. C. Bell	1030	30	82	ss	Ppc	30	4-27-56	10	20	6	D	L
553	J. E. Webber	1070	21	64	ss	Ppc	14	8-31-54	10	40	4	D	L
554	H. J. Duvall	1100	22	50	sh	Ppm	30	5-25-54	------	------	4	D	L
Edinburg Township													
601	E. Needles	1150	19	66	ss	Pph-c	20	5-25-50	8	29	4	D	L
602	A. R. Powers	1140	37	52	sh	Pph	40	10-20-50	6	------	5	D	L
603	George Blasens	1140	51	140	ss	Ppc	21	2-20-49	15	------	4	D	L
604	C. L. Reber	1165	17	24	ss	Pph	21	8-21-50	5	------	4	D	L
605	J. L. Johnson	1145	49+	49	gr	Q	39	8-17-50	6	------	4	D	L
606	Andrew Nutter	1175	17	30	ss	Pph	23	8-17-50	5	------	4	D	L
607	R. W. Whiting	1160	18	42	ss	Pph	20	6- 6-50	6	------	4	D	L
608	P. E. Gibson	1115	24	55	sh	Ppc	18	10- 3-49	5	------	4	D	L
609	T. B. Eatinger	1080	0	48	ss	Ppc	------	------	8	3	4	D	L
610	B. C. Benshoff	1120	152+	152	gr	Q	48	1-27-51	10	5	4	D	L
611	Charles Hupp	1115	17	44	ss	Pph	14	9- 1-51	40	1	5	D	L
612	W. J. Pettengill	1080	175+	175	gr	Q	24	4-24-52	25	12	4	D	L, A
613	T. H. Patton	1100	90+	90	gr	Q	55	12-29-49	8	15	4	D	L
614	Earl W. Forney	1040	16	86	ss	Ppc-sc	40	12-30-48	5	20	------	D	L
615	Samuel C. Janka	1020	35+	35	sd	Q	Flows	8-20-49	10	0	4	D	L
616	D. Staron	1000	132	152	ss	Ppsc	11	9-16-49	5	9	4	D	L
617	Magnolia Petroleum Co.	1030	90	90	gr	Q	------	------	------	------	------	T	L
618	do	1150	95+	95	gr	Q	------	------	------	------	------	T	L
619	do	980	17	55	sh	Ppss	------	------	------	------	------	T	L

TABLE 11.—*Records of water and test wells in Portage County*—Continued

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed		Water level		Yield		Diameter of well (inches)	Use	Remarks
					Character of material	Geologic unit	Feet below land surface	Date	Rate (gpm)	Draw-down (feet)			
					Edinburg Township—Continued								
620	Magnolia Petroleum Co.	1080	11	55	ss	Ppc	----	----	----	----	----	T	L
621	do.	1160	11	55	ss	Pph	----	----	----	----	----	T	L
622	do.	1040	30	55	sh	Ppss	----	----	----	----	----	T	L
623	do.	1080	28	55	sh	Ppm	----	----	----	----	----	T	L
624	C. R. Aldrich	1180	26	62	ss	Pph	25	1-11-54	10	20	4	D	L
625	O. E. Wirble	1130	46	58	ss	Pph	9	7- 3-53	20	10	4	D	L
626	H. L. Pemberton	1145	50	55	ss	Pph	20	9- 4-53	15	15	4	D	L
627	C. C. Phelps	1150	40	44	ss	Pph	18	9-23-53	7	10	4	D	L
628	C. Palomsky	1100	13	95	ss	Ppc	10	3- 1-49	15	----	5	D	L
629	E. J. Brown	1140	75+	75	gr	Q	28	9-30-53	8	22	4	D	L
630	C. L. Reber	1160	15	24	ss	Pph	10	9- 4-53	20	2	4	D	L
631	L. Shilliday	1140	44+	44	gr	Q	18	9-25-53	10	8	6	D	L
632	H. E. Emery	1150	58+	58	gr	Q	35	2-22-54	7	10	4	D	L
634	State of Ohio	1155	44+	44	gr	Q	----	----	----	----	5	P	L
635	E. J. Smolk	1170	29	46	ss	Pph	26	8- 3-54	7	----	4	D	L
636	L. E. Metcalf	1060	2	132	ss	Ppsc	90	3-15-56	5	20	4	D	L
637	L. Stonuey	1020	60	75	ss	Ppsc	40	4-27-54	10	25	6	D	L
638	L. C. Hunter	1135	28	36	sh	Ppm	12	9-21-54	10	----	4	D	L
639	Bishop	1180	17	26	ss	Pph	14	8-12-54	10	4	6	D	L
640	J. H. Hogle	1130	54+	54	sd	Q	8	12-11-54	15	10	6	P	L
641	C. Diehl	1125	21	43	ss	Pph	19	1-26-56	12	----	5	D	L
642	R. W. Bigelow	1115	32	57	ss	Pph	10	12-14-54	15	20	6	D	L
					Franklin Township								
701	R. K. Kilbourne	1060	90+	90	gr	Q	20	8-21-51	10	40	4	D	L
702	K. A. Hoose	1080	120+	120	gr	Q	28	7-13-50	6	22	4	D	L
703	Jay Ferry	1060	59+	59	gr	Q	20	5-18-49	5	10	4	D	L
704	Angie Weaver	1060	139+	139	gr	Q	17	2-25-49	10	1	4	D	L
705	K. M. Anderson	1060	69+	69	gr	Q	25	7- 8-50	10	13	4	D	L
706	Charles H. Grega	1060	83+	83	sd	Q	5	9-10-51	10	20	4	D	L
707	R. E. Muny	1080	328+	328	sd	Q	30	11-30-51	18	25	4	D	L
708	E. H. Kelly	1060	50+	50	gr	Q	30	7-14-50	8	----	4	D	L
709	Krumroy Construction Co.	1060	74+	74	gr	Q	42	11-17-50	18	13	4	D	L
710	Harvey	1090	41+	41	sd	Q	10	5-23-50	5	3	5	D	L
711	Paul Baus	1080	274+	274	gr	Q	28	7- 1-50	4	227	4	D	L
712	Foster Brooks	1120	126+	126	sd	Q	60	3-27-51	10	4	5	D	L
713	Rufi	1070	53+	53	gr	Q	27	3-16-51	10	----	4	D	L
714	J. Kingsbury	1100	103+	103	gr	Q	48	4- 1-49	12	7	4	D	L
715	George Ney	1080	75+	75	gr	Q	42	7-27-49	10	5	4	D	L
716	E. J. Raymond	1060	53+	53	gr	Q	23	5-11-50	10	----	4	D	L
717	J. E. Aurand	1100	90+	90	gr	Q	52	1- 9-52	7	20	4	D	L
718	L. Monaco	1080	46+	46	sd	Q	25	11-26-48	5	3	4	D	L
719	G. M. Cornelius	1100	179+	179	gr	Q	62	2-23-49	7	20	5	D	L
720	A. K. Zimmerman	1080	50+	50	sd	Q	39	5-26-50	5	----	4	D	L
721	James Barber	1050	55+	55	gr	Q	----	----	----	----	4	D	L
722	Charles Smallfield	1120	126+	126	sd	Q	51	11- 2-48	5	26	4	D	L
723	Tinyer Bros	1040	44+	44	gr	Q	27	8-28-50	10	----	4	D	L
724	Don Oberholtzer	1050	61+	61	gr	Q	30	2- 2-52	6	----	4	D	L
725	A. E. Carson	1055	68+	68	gr	Q	8	6-26-48	45	27	6	D	L
726	W. Kirkhart	1040	299+	299	gr	Q	7	1-15-41	7	----	4	D	L
727	G. T. Plum	1040	52+	52	sd	Q	25	9-18-51	10	----	4	D	L
728	J. L. Slates	1195	133+	133	gr	Q	60	9-20-51	15	20	6	D	L
729	C. Vickers	1140	131+	131	sd	Q	60	11-17-48	5	10	6	D	L
730	Dave Longcoy, Jr.	1140	137+	137	gr	Q	90	12-18-50	6	----	4	D	L
731	Mason Tire	1070	35	51	ss	Ppsc	----	----	----	----	6	I	L, Dry.
732	Carl Moledor	1100	74	85	ss	Ppsc	40	7- 9-49	5	----	4	D	L
733	Ed D. Griggy	1100	68+	68	sd	Q	36	6- 3-52	10	3	4	D	L
734	F. Hunsicker	1050	22	49	ss	Ppsc	12	4-20-50	10	5	4	D	L
735	do.	1065	37	62	ss	Ppsc	15	4-18-50	8	30	4	D	L
736	F. W. Wise	1090	100	115	ss	Ppsc	40	9- 8-50	10	25	4	D	L
738	City of Kent	1030	65+	65	gr	Q	20	----	----	----	10	O	
739	R. W. Cook	1100	104+	104	gr	Q	40	4- 2-48	5	10	4	D	L
740	Joe S. Rhodes	1120	86	106	ss	Ppsc	50	5-19-48	5	15	4	D	L
741	L. C. Stulzman	1080	88+	88	sd	Q	45	8-18-49	5	20	4	D	L
742	J. E. McDonald	1080	108+	108	sd	Q	19	11- 8-49	7	24	4	D	L
743	M. Stewart	1040	101	107	ss	Ppsc	25	8-13-49	7	30	4	D	L
744	Alliance Home Inc.	1040	38+	38	sd	Q	10	4-25-52	5	20	4	D	L
745	Mike Gill	1065	67	69	ss	Ppsc	36	12- 8-51	5	30	4	D	L
746	Thomas Shirier	1040	51	64	ss	Ppsc	22	11-30-51	20	6	4	D	L
747	R. M. Johnson	1030	29	39	ss	Ppsc	13	12-10-51	10	20	4	D	L
748	City of Kent	1030	195	195	sd	Q	----	----	----	----	12	PS	L, T, Sandstone at 195 feet.
749	do.	1025	165+	165	gr	Q	Flows	9-28-54	800	14	12	PS	L, T
750	Davenport Corp.	1030	113+	113	gr	Q	35	8-17-51	22	45	6	I	L
751	Frank Schlarb	1060	93	99	ss	Ppsc	39	10-24-47	6	12	4	D	L
752	Tony Missimi	1045	51	81	ss	Ppsc	40	12-10-47	10	51	4	D	L
753	Wm. Bowman	1050	31+	31	sd	Q	31	6-13-51	5	5	4	D	L
754	N. L. Benton	1060	120	131	ss	Ppsc	29	6- 1-51	10	25	4	D	L
755	Albert Deleone	1015	71	80	ss	Ppsc	17	6-17-48	6	23	4	D	L
756	McCourt Gravel Pit	1100	47+	47	gr	Q	10	5-16-51	20	----	5	I	L
757	Fred Schupbach	1040	56	63	ss	Ppsc	45	9- 7-49	6	5	4	D	L
758	H. Krausman	1050	145+	145	sd	Q	75	3-24-52	5	----	4	D	L
759	Ned Kamburoff	1025	134	137	ss	Ppsc	14	11-17-49	10	2	4	D	L
760	Raymond Swartz	1025	56	80	gr ss	Q Ppsc	6	2- 2-48	850	25	12	Ir	L, T
761	O. T. Bradley	1060	165+	165	cl	Q	----	----	----	----	4	D	L
762	M. H. Wagner	1060	47+	47	gr	Q	8	7-28-48	7	7	4	D	L
763	Kent State Univ.	1115	95	148	ss	Ppsc	55	6-15-53	10	51	5	D	L
764	E. O. Jenkins	1075	94	101	ss	Ppsc	35	11- 6-51	8	32	4	D	L

TABLE 11.—*Records of water and test wells in Portage County*—Continued

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic unit	Water level: Feet below land surface	Water level: Date	Yield: Rate (gpm)	Yield: Drawdown (feet)	Diameter of well (inches)	Use	Remarks
	Franklin Township—Continued												
765	Harold Donaldson	1080	42+	42	gr	Q	32	2-25-54	5	1	4	D	L
766	Norman Russell	1100	93+	93	gr	Q	50	5-21-53	6	25	4	D	L
767	C. Fenninger	1080	95+	95	sd	Q	8	10- 1-52	5	32	4	D	L
768	C. Smallfield	1050	44	50	ss	Ppsc	15	10-11-52	7	10	4	D	L
769	Joseph Demara	1060	30+	30	gr	Q	11	3-24-52	6	19	4	D	L
770	H. Lappin	1040	57	108	ss	Ppsc	Flows	10- 1-29	250		10	Ir	L
771	E. Shumacher	1105	210	212	ss	Ppsc	56	11-14-55			5	D	L
772	A. J. Busser	1090	189+	189	sd	Q	60	1-10-55	6	65	6	D	L
773	McCourt Construction Co.	1080	46+	46	gr	Q	26	3-27-53	100	10	8	I	L, T
774	T. Hartley	1100	180	185	sh	Mc	30	7-20-54	8	15	5	D	L
775	W. P. Nelson	1080	171+	171	sd	Q	70	1-13-54	5		4	D	L
776	Portage Plating Co.	1075	19	108	ss	Ppsc	40	7-20-54	30	10	6	I	L
777	R. Knittle	1050	64	74	ss	Ppsc	30	10-31-55	10	7	4	D	L
778	M. Petroff	1040	119	122	ss	Ppsc	3	6- 2-55	8	67	4	D	L
779	E. Crock	1080	119	122	ss	Ppsc	40	10-23-54	15	30	4	D	L
780	P. Brown	1080	91	96	ss	Ppsc	Flows	9- 3-54	7	55	4	D	L
781	C. Smallfield	1075	84	92	ss	Ppsc	13	12-16-54	10	37	4	D	L
782	P. Battaglia	1060	60	105	ss	Ppsc	24	7-30-55	20		4	D	L
	Freedom Township												
801	P. E. Miller	1190	30	65	ss	Pph						D	L
802	H. Kidd	1240	30	65	ss	Pph						D	L
803	F. C. Helmling	1200	20	80	ss	Ppm						D	
804	Magnolia Petroleum Co.	1120	65	85	ss	Ppc						T	L
805	Frank Wagner	1110	12	60	ss	Ppc Pp	6	2-18-49	12	20	6	D	L
806	Herman Ruffing	1105	12	57	sh	Ppss	14	8- 5-52			6	D	L
807	M. Fairbee	1090	56	65	sh	Ppss					5	D	L
808	Magnolia Petroleum Co.	1120	34	65	sh	Ppss						T	L
809	M. Mauer	1200	35	55	sh	Ppm	10	8- 5-52			6	D	L
810	Johnny Murray	1205	21	31	sh	Ppm	25				5	D	L
811	Harris Edwards	1185	40	64	sh	Ppm						D	L
812	Rudy Papiska	1180	28	59	sh	Ppm	13	8- 5-52	5		6	D	L
813	Julius Papp	1175	61+	61	gr	Q	16				6	D	L
814	Laurence Dean	1185	20	48	ss	Pph	Flows	8- 5-52	4		6	D	L
815	Roy Letterly	1190	48	78	sh	Ppm					5	D	L
816	O. L. Dean	1205	33+	33	gr	Q	12	8- 5-52	40		6	D	L
817	A. Sokolik	1210	81	91	ss	Ppc	22	8- 5-52	3	12	5	D	L
818	Magnolia Petroleum Co.	1210	50	75	ss	Ppc						T	L
819	John H. Richards	1220	26	65	sh	Ppm	8		10	5		D	L
820	J H. Leet	1220	26	57	ss	Ppc			3	6	6	D	L
821	Albert Mihalko	1170	47+	47	gr	Q					6	D	L
822	Fred Berg	1160	39	63	ss	Ppc	5		3		6	D	L
823	V. Conrad	1140	48+	48	gr	Q	13	8- 6-48			5	D	L
824	Erie Railroad	1140	20	161	ss	Ppc	15		60	45	12	I	L
825	Magnolia Petroleum Co.	1160	19	65	ss	Ppc						T	L
826	Podogil	1190	20	48	sh	Ppm	30	10- 6-50	7		3	D	L
827	Magn lia Petroleum Co.	1150	42	75	ss	Ppc						T	L
828	John Krupansky	1190	58	66	ss	Ppc	26	10- 9-50	25	8	6	D	L
829	Julius Treichel	1180	25	73	sh	Ppm					6	D	L
830	J. W. McCoy	1140	11	133	ss	Ppsc					5	D	L
831	C. R. Colton	1200	6	145	ss	Ppc					5	D	L
832	Stewart	1180	6	61	ss	Ppc	20	8- 6-52	5		4	D	L
833	Ohio Turnpike Comm.	1200	23	113	ss	Ppc-sc	9	4-28-54	60	80	8	PS	L
834	N. A. West	1180	20	90	ss	Ppc	11	10-27-51	2		6	D	L
835	Jack D. Willis	1150	40	83	sh	Ppm	19	6- 4-48	5		4	D	L
836	Ed. Ziska	1175	32	73	ss	Ppc					5	D	L
837	Magnolia Petroleum Co.	1260	6	65	ss	Pph-c						T	L
838	Bob Knipper	1220	27	50	ss	Ppc	30	9- 6-51	8	40	6	D	L
839	John Kubicek	1200	12	49	ss	Ppm			15	5	5	D	L
840	R. J. Plute	1240	31	48	sh	Ppm	33	11-24-52	20	5	4	D	L
841	Turner	1110	20	90	ss	Ppsc	50	6- -52	10		5	D	L
842	Harold Taylor	1170	38	66	sh	Ppm	2	3-25-53	10	32	4	D	L
843	J. T. Miner	1290	25	60	ss	Ppc	38	6-12-52	10		4	D	L
844	Magnolia Petroleum Co.	1180	33	65	sh	Ppm						T	L
845	do	1170	37	65	sh	Ppm						T	L
846	do	1180	18	65	ss	Ppc						T	L
847	do	1270	16	65	ss	Ppc						T	L
848	do	1160	33	65	sh	Ppm						T	L
849	do	1195	17	65	ss	Ppc						T	L
850	Edward Lake	1200	18	54	ss	Pph	29	4-11-53	10		6	D	L
851	James Cain	1170	35	110	ss	Ppsc					5	D	L
852	Bernard Paul	1110	17	48	ss	Ppc					6	D	L
853	James Belnap	1080	40	81	ss	Ppsc					6	D	L
854	Elmer Dezort	1200	13	60	ss	Pph					6	D	L
855	F. Shaykowski	1120	36	63	ss	Ppsc					6	D	L
856	Herman Pittsinger	1170	56	72	ss	Ppc	3	6- -54				D	
857	H. McClintock	1110	53	62	ss	Ppsc					6	D	L
858	E. Goddard	1260	15	55	ss	Ppc	25	11-15-54	15		6	D, S	L
859	H. Lucas	1120	30	64	ss	Ppc-sc	20	4-13-55	50	12	6	D	L
860	L. L. McGregor	1080	30	61	ss	Ppsc	15	1-19-56	15	5	4	D	L
861	Freedom Cong. Church	1175	51	105	ss	Ppc	20	4- 4-55	6		4	PS	L
862	H. W. Witherup	1225	46	96	ss	Ppc	45	3-24-55	5		4	D	L
863	A. Mihalko	1165	122	155	ss	Ppsc	26	5-12-56	8	80	6	D	L
864	J. E. Minski	1220	30	91	ss	Ppc			2	20	4	D	L
865	Ravenna Arsenal	1155	102	225	ss	Ppsc	60		35	5	6	T	L
866	do	1125	87+	87	gr	Q	15		15	75	6	T	L
867	do	1120	36	250	ss	Ppc-sc	37		82	131	8	T	L

TABLE 11.—*Records of water and test wells in Portage County*—Continued

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic unit	Water level: Feet below land surface	Water level: Date	Yield: Rate (gpm)	Yield: Draw-down (feet)	Diam-eter of well (inches)	Use	Remarks
	Hiram Township												
901	Mike Szabo	1120	41	74	ss	Ppsc						D	L
902	Norman Wizner	1100	37	56	ss	Ppsc						D	L
903	Robert Green	1080	51	64	ss	Ppsc						D	L
904	Ben Taylor	1140	13	84	ss	Ppc			18	3	5	D	L
905	Frank Mazveskas	1110	30	40	ss	Ppsc	2	2-18-49	24		5	D	L
906	Mike Demchak	1250	13	62	ss	Ppc					6	D	L
907	John Urban	1245	16	61	ss	Ppc					5	D	L
908	Mrs. E. Warner	1110	37	46	ss	Ppsc					5	D	L
909	Fred Green	1110	19	33	ss	Ppsc					6	D	L
910	Harry Rodgers	1110	15	53	ss	Ppsc					5	D	L
911	C. R. Carnes	1110	37	39	ss	Ppsc					5	D	L
912	James Casteel	1110	13	42	ss	Ppsc					6	D	L
913	Charles D. Saborn	1225	18	108	ss	Ppc	60	11-12-48	4	80	5	D	L
914	Robert C. Macaluso	1215	34	66	ss	Ppc					6	D	L
915	William Bunnison	1040	25	44	ss	Ppsc			10		6	D	L
916	J. T. Schneider	1080	20	80	ss	Ppsc	50	8-11-50	20		5	D	L
917	W. H. Martin	1270	13	56	ss	Pph	30	4- 7-50	5		6	D	L, A
918	R. J. Grabel	1030	15	61	ss	Ppsc						D	L
919	Ralph Notman	1120	131	155	ss	Ppsc	37	2-12-49	10	50	4	D	L
920	Dan Knippenberg	1315	20	53	sh	Ppm					6	D	L
921	Harry Lynn	1110	67+	67	gr	Q	13	3-31-48	12	20	5	D	L
922	G. E. Dreger	1190	3	98	ss	Ppc-sc	53	1-17-49	12		6	D	L
923	Jokkel	1110	18	50	ss	Ppsc	50	4-10-52			5	D	L
924	King	1020	8	85	ss	Ppsc					6	D	L
925	Sterling Trefroy	1030	38	80	ss	Ppsc	37	7- -50	20		6	D	L
926	B. Thrasher	1040	4	80	ss	Ppsc					6	D	L
927	Jack Stonkus	1140	91+	91	gr	Q	35	9-22-50	3	60	6	D	L
928	Nylon Products Co	1030	14	87	ss	Ppsc	30	2- 4-53	30	50	10	I	L
929	A. Aros	1140	15	150	ss	Ppsc	135	10- 3-52			6	D	L
930	T. Carlisle	1090	8	125	ss	Ppsc	40	9-28-52			6	D	L
931	Robert Tafel	1110	17	57	ss	Ppsc					6	D	L
932	Joe Kletecka	1040	24	77	ss	Ppsc	35	10- 7-53	20	30	6	D	L
933	Village of Hiram	1265	30	255	ss	Ppsc	49	1- -44	50		8	PS	L, T, One of 2 wells.
934	C. Molnar	1100	25	54	ss	Ppsc					5	D	L
935	R. Geiger	1140	6	34	ss	Ppsc					6	D	L
936	L. C. Sweet	1180	30	126	ss	Ppsc					6	D	L
937	D. Mitchel	1220	40	60	ss	Ppc	25	5-31-54	30	3	6	D	L
938	R. Smith	1100	11	72	ss	Ppsc					6	D	L
	Mantua Township												
1001	Joe Soddil	1230	100	120	ss	Ppsc						D	L
1002	Henry Ladd	1260	40	140	ss	Ppsc						D	L
1003	Carl Salzano	1190	15	102	ss	Ppc-sc	60	12-28-48	10	82	6	D	L
1004	Round-up Lake	1150	91+	91	gr	Q	17	5-17-51	150	38	6	PS	L, T
1005	John Merk	1160	24	57	ss	Ppsc			50	8	6	D	L
1006	Ralph Shaw	1160	20	68	ss	Ppsc			10		6	D	L
1007	Kenneth Monroe	1190	28	69	sh	Ppss					6	D	L
1008	A. L. Darling	1210	20	23	ss	Ppc	13	8-20-49	20		6	D	L
1009	E. W. Densmone	1190	28	34	sh	Ppss					6	D	L
1010	Wm. Hondashelt	1230	104+	104	gr	Q	48	10-16-51			6	D	L
1011	David Baranyai	1250	48	83	ss	Ppc	40	4-24-51	25	6	6	D	L
1012	P. S. Clemens	1265	65	95	ss	Ppc			6		6	D	L
1013	E. J. Kline	1250	80	89	ss	Ppc	59	3- 4-52	6	6	6	D	L
1014	E. C. Hammel	1200	18	35	ss	Ppc			35	5	6	D	L
1015	C. E. Hurst	1260	54	100	ss	Ppc			40	12	6	D	L
1016	F. W. Stebbins	1175	50	61	ss	Ppsc					6	D	L
1017	Bert Almy	1170	33	40	ss	Ppc	17	4-24-52	10	22	6	D	L
1018	George Yocum	1110	37+	37	gr	Q					4	D	L
1019	H. Tomada	1150	39+	39	gr	Q	9	5-20-50	16	10		D	L
1020	Frank Kun	1150	32	41	ss	Ppsc	4	3-18-48	5	10	4	D	L
1021	Andrew Molmar	1150	28+	28	gr	Q	10	7- 7-51	30		6	D	L
1022	Louis Vechery	1150	28+	28	gr	Q	1	8-29-50	70	6	6	D	L
1023	Michael Nyiri	1150	40+	40	gr	Q	1	8-29-50	70	6	6	D	L
1024	H. L. Chadwick	1150	46	142	ss	Ppc–sc	9	6-16-48	850	23	12	Ir	L, T
1025	A. W. Nowak	1150	41	45	ss	Ppsc	11	3-23-48	10	8	5	D	L
1026	Joe Macak	1150	27	49	ss	Ppsc	1	10- 7-48	10	20	6	D	L
1027	Andrew Rossl	1160	29	52	ss	Ppsc	22	3-26-48	15		5	D	L
1028	Lewry Mishel	1200	30+	30	gr	Q					6	D	L
1029		1230	73	75	ss	Ppc					6	D	L
1030	Mrs. George Brehm	1230	59+	59	gr	Q	32	5-18-49	15	32	6	D	L
1031	T. & A. Koptis	1220	75	112	ss	Ppc					6	D	L
1032	Joseph Battenbach	1180	39	82	ss	Ppc					5	D	L
1033	R. G. Mayhew	1150	60	61	ss	Ppsc			40	10	6	D	L
1034	Leon Cooper	1120	74+	74	gr	Q					6	D	L
1035	Ed Rodhe	1120	99+	99	gr	Q					6	D	L
1036	Roy Stamm	1110	76+	76	gr	Q	12	5-23-50	20		5	D	L
1037	F. G. Hubbard	1100	92+	92	gr	Q	20	3-29-51	10	30	6	D	L
1038	H. C. Holliday	1140	31	61	ss	Ppsc					6	D	L
1039	Glen S. Carlton	1250	41	70	ss	Ppc					6	D	L
1040	Laura Sherry	1180	66	87	ss	Ppsc	50	12-24-51	10	2	4	D	L
1041	John Vild	1160	36+	36	gr	Q				4	6	D	L
1042	M. C. Fetkovich	1120	64+	64	gr	Q	18	10-20-49	15		6	D	L
1043	Frank Hammel	1260	31	46	ss	Ppc	27	6-26-52	6	7	6	D	L, A
1044	L. Converse	1250	42	83	ss	Ppc	55	4- 2-52	9		5	D	L
1045	A. W. Novak, Jr	1165	34	40	sh	Ppss			18	15		D	L
1046	J. Kundrath	1120	134+	134	gr	Q	60	8-12-53	12	20	6	D	L
1047	Joe Piscola	1230	25	38	ss	Ppc	16	5- 9-53	25	4	6	D	L

TABLE 11.—*Records of water and test wells in Portage County*—Continued

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic unit	Water level: Feet below land surface	Water level: Date	Yield: Rate (gpm)	Yield: Draw-down (feet)	Diam-eter of well (inches)	Use	Remarks
	Mantua Township—Continued												
1048	W. H. Bell	1145	24	38	ss	Ppsc	15	10- 1-52	20	----------	6	D	L
1049	Frank D. Toth	1195	29	35	ss	Ppss	12	12- 8-52	18	8	6	D	L
1050	David Baranyai	1190	39	52	ss	Ppsc	24	3- 4-53	10	----------	4	D	L
1051	E. R. Armour	1200	35	68	ss	Ppsc	33	9-12-54	5	----------	6	D	L
1052	Akron Products Co	1140	114+	114	gr	Q	12	12-11-53	19	20	6	I	L
1053	C. M. Stefaneck	1170	16	45	ss	Ppsc	16	3-26-56	10	6	6	D, S	L
1054	B. O. Patterson	1165	40	108	ss	Ppc-sc	40	10-22-55	10	----------	6	D	L
1055	J. Toth	1230	24	37	ss	Ppc	----------	----------	----------	----------	5	D	L
1056	Brunswick Development Co	1190	82+	82	gr	Q	----------	----------	----------	----------	6	D	L
1057	J. Zsoldos	1160	45	71	ss	Ppsc	18	3-15-55	18	8	6	D, S	L
1058	A. Sheery	1150	45	72	ss	Ppsc	Flows	5-19-56	20	35	6	D	L
1059	E. S. Thomas, Jr	1090	41	44	----------	----------	Flows	6-20-56	10	Flows	6	D	L
1060	H. A. Schippling	1090	85+	85	gr	Q	2	9-10-54	6	80	6	D	L
1061	G. Potter	1170	20	65	ss	Ppc	----------	----------	----------	----------	----------	D	L
1062	M. Kondik	1260	15	107	ss	Ppc	----------	----------	----------	----------	6	D	L
1063	E. J. Petras	1160	60+	60	gr	Q	38	5- 4-56	25	----------	6	D	L
1064	J. Hanning	1170	77	84	ss	Ppsc	38	9-30-54	12	16	6	D	L
1065	W. Barling	1190	70	114	ss	Ppsc	55	8-12-54	----------	----------	6	D	L
1066	G. Shay	1120	96+	96	sd	Q	41	5-21-54	30	8	6	D	L
1067	W. R. Pierce	1200	123+	123	gr	Q	93	11- 8-54	10	7	6	D	L
1068	J. Toth	1200	126	145	ss	Ppsc	105	2-18-56	8	26	6	D	L
1069	Stanton Builders	1180	122	145	ss	Ppsc	92	2- 2-56	10	18	6	D	L
1070	F. Clemens	1120	107	112	ss	Ppsc	40	11- 8-55	15	5	4	D	L
1071	R. Kenney	1140	81+	81	gr	Q	3	4-19-55	20	15	6	D	L
1072	J. Vargo	1150	61+	61	gr	Q	45	8-23-54	20	----------	6	D	L
	Nelson Township												
1101	Amstutz Hatchery	1090	6	100	ss	Ppsc	----------	----------	----------	----------	6	D	L
1102	Brumbaugh	1100	10	70	ss	Ppsc	----------	----------	----------	----------	----------	D	L
1103	A. W. Randall	1100	8	102	ss	Ppsc	21	7-31-52	----------	----------	6	D	L, Not used.
1104	Potter	1060	15	40	ss	Ppsc	28	7-31-52	----------	----------	----------	D	L
1105	John Soltis	1040	41	53	ss	Ppsc	----------	----------	----------	----------	----------	D	L
1106	B. Raskov	1140	16	73	ss	Ppc	41	7-30-52	----------	----------	5	D	L, Not used.
1107	Ed. Necuda	965	168	220	sh	D–M	40	7-30-52	3	----------	5	D	L
1108	J. Sebastian	970	130	150	sh	D–M	50	1- -48	----------	----------	5	D	L
1109	State of Ohio	940	8	154	ss	Mb	45	8- 1-52	----------	----------	5	PS	L
1110	Matt Smith	955	45	128	ss	Mb	49	2-27-48	----------	----------	6	D	L
1111	Joe Klouzal	990	36	134	ss	Mb	70	11-30-47	8	74	6	D	L
1112	Harbison-Walker Co	990	6	42	ss	Ppsc	12	5- 6-48	10	----------	6	I	L
1113	V. E. and R. L. Stroup	1125	9	70	ss	Ppc	----------	----------	----------	----------	6	D	L
1114	Joe Grabowski	1080	18	101	ss	Ppsc	30	7-31-52	30	10	6	D	L
1115	Magnolia Petroleum Co	1010	5	65	ss	Ppsc	----------	----------	----------	----------	----------	T	L
1116	William E. Asplin	950	128+	128	gr	Q	17	2-18-49	----------	35	6	D	L
1117	Charles Eckert	1040	6	46	ss	Ppsc	14	4-19-48	20	26	----------	D	L
1118	Jethro Patters	1060	13	85	ss	Ppsc	23	5- 4-48	5	----------	----------	D	L
1119	Frank O. McCoy	1080	5	75	ss	Ppsc	21	3-26-48	3	----------	6	D	L
1120	Louis Hrach	1130	16	36	----------	----------	8	1905	----------	----------	60	D	DU
1121	Taylor Hall	925	189+	189	gr	Q	20	7-29-52	----------	----------	----------	D	
1122	Pete Duch	1170	10	90	ss	Ppc	----------	----------	3	66	6	D	L
1123	A. A. Clapp	1140	20	77	ss	Ppc	13	7-30-52	5	----------	6	D	
1124	Emery Szabo	1150	7	147	ss	Ppc-sc	50	11-25-50	10	10	6	D	L
1125	B. Seehan	1165	8	139	ss	Ppc–sc	----------	----------	----------	----------	6	D	L
1126	Harry A. Clapp	1140	8	75	ss	Ppc	40	7-30-52	12	----------	6	D	L
1127	Garrettsville Board of Public Affairs.	1020	65	245	ss	Mb	37	12-20-52	60	----------	10	PS	L, T, One of 12 wells.
1128	Kubik	1020	4	33	ss	Ppsc	----------	----------	----------		36	D	L, Du
1129	R. E. Burns	940	112	146	ss	Mb	----------	----------	5	----------	6	D	L, A
1130	Crest Winterstein	920	77+	77	sd	Q	10	7-30-52	30	12	4	D	L
1131	Ralph Vandraski	1140	14	38	ss	Ppc	----------	----------	----------	----------	6	D	L
1132	Al Orban	1120	12	60	ss	Ppc	60	7- 2-51	----------	----------	6	D	L
1133	A. F. Barry	935	149	190	sh	D–M	20	8-20-52	1	80	6	D	L
1134	Anna Fanslaw	980	0	50	ss	Ppsc	20	6- 1-52	----------	----------	6	D	L
1135	Magnolia Petroleum Co	950	40	65	ss	Ppsc	20	----------	----------	----------	----------	T	L
1136	R. B. Burney	970	55	80	ss	Mb	28	5- 8-52	20	10	6	D	L
1137	Shillingburg	1040	6	62	ss	Ppsc	----------	----------	3	----------	6	D	L
1138	C. Masika	960	216+	216	gr	Q	----------	----------	----------	----------	6	D	L, Dry hole.
1139	D. Jagers	960	65+	65	gr	Q	25	10- 2-53	25	8	6	D	L
1141	Thomas Ellison	930	40	68	sh	Mc	55	4-27-54	10	----------	6	D	L
1142	George Barrier	950	24+	24	gr	Q	3	6-17-54	----------	----------	36	D	Du
1143	J. P. Bloom	985	8	85	ss	Ppsc	20	6-17-54	5	----------	----------	D	
1144	J. E. Dahl	960	155+	155	gr	Q	----------	----------	4	----------	----------	D	
1145	R. Majercak	955	60	135	ss	Mb	50	6-18-54	30	10	6	D	L
1146	J. Visocan	995	58	137	ss	Mb	60	5-28-55	20	20	5	D	L
1147	C. F. Lattimore	970	52	68	ss	Ppsc	12	2- 1-56	----------	----------	6	D	L
1148	General Refractories Co	985	9	57	ss	Ppsc	8	8-12-55	85	32	8	D	L, T
1149	M. Hrobak	1010	42	63	ss	Ppsc	----------	----------	17	----------	6	D	L
1150	Garrettsville Board of Public Affairs.	1040	125	250	ss	Mb	----------	----------	100	----------	10	PS	L, T, One of 12 wells.
1151	K. R. Mills	945	8	48	ss	Ppsc	----------	----------	----------	----------	5	D	L

TABLE 11.—*Records of water and test wells in Portage County*—Continued

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							Palmyra Township						
1201	D. C. Smith	1125	31+	31	gr	Q	12	8-30-51	25	2	5	D	L
1202	Frank Cambell	995	72	135	ss	Ppss	15	9- 3-51	5		6	D	L
1203	W. B. McKenzie	1010	105	189	sh	Ppss	45	1-17-48	5		5	D	L
1204	M. R. Johns	1025	53	109	ss	Ppc	30	7- 1-48	7	54	6	D	L
1205	Universal Sewer Pipe Co	1000	31	147	sh	Ppss					8	I	L
1206	Ohio Oil Co	1025	26	46	ss	Ppc						T	L
1207	do	1020	14	60	sh	Ppc						T	L
1208	do	1035	15	50	sh	Ppm						T	L
1209	Magnolia Petroleum Co	1005	95+	95	gr	Q						T	L
1210	do	1000	52	70	sh	Ppc						T	L
1211	do	1040	30	55	sh	Ppc						T	L
1212	Ohio Oil Co	1050	22	70	ss	Ppc						T	L
1214	Magnolia Petroleum Co	1120	4	46	ss	Pph						T	L
1215	do	1030	31	55	sh	Ppss						T	L
1216	do	1110	3	65	ss	Pph						T	L
1217	A. O. Hall	990	34	63	sh	Ppss	30	11-30-54	4	20	4	D	L
1218	Magnolia Petroleum Co	1060	2	55	ss	Ppc						T	L
1219	R. L. Fitzsimmons	1000	20	60	ss	Ppc	10	9-23-53	30	35	7	D	L
1220	Derby Louis	995	45	210	ss	Ppsc	40	9-15-53	1	170	7	D	L
1221	H. C. Ensinger	1030	20	66	ss	Ppc	30	4- 7-54	10	45	4	D	L
1222	Roy Hill	1045	8	75	ss	Ppc	12	10-18-53	10	60	6	D	L
1223	W. H. Williams	1030		111	ss	Ppc	38	10-20-53	10	42	6	D	L, Well originally 68 feet deep.
1224	Dale Miger	1045	66	90	ss	Ppc	90	2-28-53	9		6	D	L
1225	Frank Royer	1040	40	48	sh	Ppc	28	9-20-52	10	16	4	D	L
1226	R. W. Bigelow	1020	4	52	ss	Ppc	12	12-11-53	5	40	4	D	L
1227	J. A. Hill	1100	35	45	ss	Ppc	12	7-20-54	10	30	7	D	L
1228	R. D. Vaughn	1100	20	31	ss	Pph	10	7-28-54	10	5	4	D	L
1229	A. N. Nessenthaler	1090	18	119	sh	Ppc	15	10- 4-54	5	70	4	D	L
1230	O. E. Short	1005	50	68	sh	Ppss	20	8- 4-54	6	30	4	D	L
1231	C. H. Ocheltree	965	78	210	ss	Mb					5	D	L
1232	N. Simpson	1000	40	76	ss	Ppsc	23	9-23-54	3	76	7	D	L
1233	Ohio Central Telephone Co	1040	25	68	ss	Ppc	15	12- 8-55	4	53	4	I	L
1234	B. W. Ingram	1040	39	48	ss	Ppc	30	8- 6-54	8	18	6	D	L
1235	Southeast High School	1110	43	92	ss	Ppc	10	4-21-54	20	40	8	PS	L
1236	R. I. Shambach	1080	54	111	ss	Ppc	24	6-24-55	10	56	6	D	L
1237	L. Krose	1070	45	51	ss	Ppc	10	5- 9-55	10	10	6	D	L
1238	S.E. Ulrich	1110	16	36	ss	Pph	12	5-24-54	5	36	4	D	L
1239	K. K. Graham	1020	115	160	ss	Ppsc	25	11-26-54	5	75	4	D	L
1240	G. B. Shaw	1020	74	140	ss	Ppc	30	6-25-54	1	110	4	D	L
							Paris Township						
1301	Cook	960	220+	220	gr	Q	Flows	5-26-53	5	20	4	D	L
1302	George Makey	1005	94	101	ss	Ppsc	45	1- 7-48	6	5	4	D	L
1303	J. D. Wilhelm	980	124	137	ss	Ppsc	45	12-31-47	15	5	4	D	L
1304	Paris School	980	183	238	ss	Mb	41	12-15-48	25	15	7	D	L
1305	C. W. Headley	945	82	100	ss	Ppsc	23	1-23-48			6	D	L
1306	Magnolia Petroleum Co	950	95+	95	cl	Q						T	L
1307	do	960	105+	105	sd	Q						T	L
1308	do	960	0	65	ss	Ppsc						T	L
1309	do	990	21	55	sh	Ppss						T	L
1310	do	960	51	57	ss	Ppsc						T	L
1311	do	980	95+	95	sd	Q						T	L
1312	do	980	15	43	sh	Ppsc						T	L
1313	do	930	125+	125	gr	Q						T	L
1314	do	945	147	165	ss	Mb						T	L
1315	do	960	17	50	ss	Ppsc						T	L
1316	do	955	65	85	ss	Ppsc						T	L
1317	do	1050	10	45	ss	Ppsc						T	L
1318	do	960	50	70	ss	Ppsc						T	L
1319	W. F. Gebhart	1005	52	60	ss	Ppsc	12	8-24-53	20	10	4	D	L
1320	C. Roberts	960	108	115	ss	Ppsc	14	10-15-53	20	40	7	D	L
1321	C. E. Lutz	940	112	116	ss	Ppsc	1	4- 5-54	15	30	4	D	L
1322	R. O. Lee	985	30	65	ss	Ppsc						D	
1323	Howard Thomas	950	16	16	ss	Ppsc	2	6-22-54			36	D	Du
1324	G. L. Hoffman	970	25	72	ss	Ppsc			5		4	D	
1325	C. R. St. Clair	940	90	98	ss	Ppsc	Flows	10- 7-54	20	40	4	D	L
1326	Ravenna Arsenal	950	14	120	ss	Ppsc	4		80	96	6	T	L
1327	do	965	22	118	ss	Ppsc	Flows		75	75	12	T	L
1328	do	990	6	101	ss	Ppsc	34		25		6	T	L
1329	do	980	9	137	ss	Ppsc	34		25	12	6	T	L
1330	do	975	3	178	ss	Ppsc	57	10- 2-42	60	98	12	T	L
1331	do	945	36	125	ss	Ppsc	Flows	11-25-42	90	110	12	I	L
1332	do	1020	5	118	ss	Ppsc	25		40		6	T	L
1333	do	1010	10	155	ss	Ppsc	38		30	12	6	T	L
1334	do	1005	3	142	ss	Ppsc	55		16		6	T	L
1335	do	995	16	136	ss	Ppsc	29		25	35	6	T	L
1336	do	980	50	155	ss	Ppsc	17		260	99	12	I	L
1337	do	975	52	149	ss	Ppsc	12		40	100	8	T	L
1338	do	965	39	106	ss	Ppsc	21		50		8	T	L
1339	do	980	32	125	ss	Ppsc	13		55		8	T	L
1340	do	985	39	153	ss	Ppsc			83	80	8	T	L
1341	do	985	51	158	ss	Ppsc	27		57	95	8	T	L
1342	do	1060	12	215	ss	Ppsc			25	40	6	T	L
1343	do	1025	35	106	ss	Ppsc	4		40	35	6	T	L
1344	do	1035	34	130	ss	Ppsc	35		40	14	6	T	L
1345	do	1015	22	132	ss	Ppsc	3		30	6	6	T	L

TABLE 11.—*Records of water and test wells in Portage County*—Continued

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic unit	Water level: Feet below land surface	Water level: Date	Yield: Rate (gpm)	Yield: Draw-down (feet)	Diameter of well (inches)	Use	Remarks
	Paris Township—Continued												
1346	Ravenna Arsenal	1100	18	175	ss	Ppsc	16	--------	7	63	12	T	L
1347	----do	1040	12	173	ss	Ppsc	37	--------	40	60	12	T	L
1348	----do	985	32	158	ss	Ppsc	20	--------	135	90	12	I	L
1349	----do	990	131	172	ss	Ppsc	25	--------	128	85	12	I	L
1350	J. R. Martin	985	10	75	ss	Ppsc	22	9-11-54	10	18	4	D	L
1351	F. W. Harris	985	20	84	ss	Ppsc	--------	--------	--------	--------	6	D, S	L
1352	B. Chipukaizer	950	70	74	ss	Ppsc	13	6-22-54	10	10	7	D	L
1353	W. Luketic	935	140+	140	gr	Q	3	7- 5-55	18	9	5	D, S	L
1354	R. L. Turner	940	192+	192	gr	Q	10	9- 2-54	10	30	4	D	L
1355	F. Imoff	950	142+	142	gr	Q	6	3-14-55	12	50	5	D, S	L
1356	J. Harris	950	200+	200	gr	Q	Flows	8- 9-56	15	Flow	4	D	
1357	J. C. Gomer	1000	54	60	ss	Ppsc	12	7- 8-54	10	5	4	D	L
1358	F. W. Harris	965	165+	165	gr	Q	5	7- 5-55	15	1	4	D, S	L
1359	J. D. Drierbough	980	150+	150	gr	Q	12	7-20-55	5	60	4	D, S	L
1360	Ravenna Arsenal	985	42	175	ss	Ppsc	20	--------	40	80	6	T	L
1361	----do	980	8	130	ss	Ppsc	8	--------	180	78	12	I	
	Randolph Township												
1401	Carl Bauer	1190	78+	78	gr	Q	55	6- 2-51	8	12	4	D	L
1402	R. L. Carlson	1150	120+	120	gr	Q	42	7-28-50	5	--------	4	D	L
1403	Dale Neal	1200	41	70	ss	Pph	40	7-24-50	10	--------	4	D	L
1404	Earnest Bowman	1220	49	78	ss	Pph	50	8-22-50	11	10	4	D	L
1405	Earl Knisely	1150	26+	26	cl	Q	Flows	10- 2-51	1	26	4	D	L
1406	Grier Rainey	1210	35	108	ss	Pph	55	5-25-50	8	--------	4	D	L
1407	G. Amos	1190	24	57	ss	Ppm	25	11-10-51	6	--------	4	D	L
1408	F. G. Elders	1170	34	75	ss	Ppm	35	11- 8-49	5	--------	4	D	L
1409	E. G. Warner	1180	18	46	ss	Ppc	9	7-29-50	12	13	4	D	L
1410	E. Wilhite	1160	44+	44	gr	Q	27	12-27-49	8	--------	4	D	L
1411	Steve Nuspil	1205	30	135	ss	Pph–c	31	7-14-52	35	104	6	Ir	L, T
1412	----do	1200	67	325	ss	Ppc	40	1940	100	50	8	Ir	L, T
1413	H. C. Belding	1170	64+	64	gr	Q	40	11-11-50	12	4	4	D	L
1414	J. M. Moss	1110	53+	53	gr	Q	15	11-13-50	12	7	4	D	L
1415	Earl Caplinger	1125	202	232	ss	Ppsc	42	3-18-48	6	28	4	D	L
1416	E. W. Debolt	1130	87+	87	gr	Q	26	1-16-48	7	41	4	D	L
1417	Herman Miller	1120	130+	130	gr	Q	18	1-13-49	6	25	4	D	L
1418	John Larko	1220	137+	172	sh	Ppm	80	9-30-46	7	--------	4	D	L
1419	Anna Rhodes	1180	141+	141	gr	Q	40	9- 6-49	10	--------	4	D	L
1420	James Brumbaugh	1155	90	127	ss	Ppc	55	10- 8-49	20	--------	6	D	L
1421	Robert Hambrick	1140	95+	95	sd	Q	53	3-16-50	12	4	4	D	L
1422	Michell C. Warcher	1130	48+	48	gr	Q	15	1946	--------	--------	4	D	L
1423	C. J. Smith	1130	51	65	ss	Ppc	13	9- 9-48	7	4	4	D	L
1424	Ignatius Kiss	1155	39	54	sh	Ppc	16	10-30-50	10	--------	5	D	L
1425	Ralph Kline	1185	64	68	ls	Ppc	28	7- 4-53	--------	--------	4	D	L
1426	Lawrence Memmer	1140	24	69	ss	Ppc	30	3-16-54	15	15	4	D	L
1427	Hillfack	1165	112+	112	gr	Q	49	8- -54	--------	--------	4	D	L
1428	Gary Fox	1185	22	76	ss	Pph	2	5-22-53	60	18	6	Ir	L, C
1429	Brewer	1170	32	75	ss	Ppc	23	11- 2-53	--------	--------	4	D	L
1430	S. Unger	1165	69	80	ss	Ppc	30	10- 9-53	--------	--------	4	D	L
1431	Harry Lingel	1140	124+	124	gr	Q	40	10- 2-52	7	--------	4	D	L
1432	H. Kissel	1135	90+	90	gr	Q	33	8- 3-54	--------	--------	4	D	L
1433	Ada Weaver	1130	70+	70	gr	Q	35	3- 7-53	8	--------	4	D	L
1434	William Wise	1135	96	114	sh	Ppss	90	7- 9-53	--------	--------	4	D	L
1435	Meilander	1200	21	72	ss	Ppc	40	8-17-53	--------	--------	4	D	L
1436	H. Neidert	1170	30	72	ss	Ppc	25	12- 4-53	--------	--------	4	D	L
1437	Ted Alvis	1215	94	115	sh	Ppc	55	2- 3-54	10	10	4	D	L
1438	E. E. Kinkel	1180	45	64	ss	Ppc	18	1- -54	--------	--------	4	D	
1439	L. A. Eichler	1140	132+	132	gr	Q	13	1921	--------	--------	4	D	C
1440	C. Keen	1100	128+	128	sd	Q	--------	--------	--------	--------	4	D	
1441	S. Botz	1160	115+	115	sd	Q	--------	--------	--------	--------	4	D	
1442	C. Hostler	1100	57	57	sd	Q	10	6-27-50	10	10	4	D	L
1443	E. Miller	1165	98+	98	gr	Q	17	7-24-54	30	10	4	D	L
1444	Ralph Full	1165	43	75	sh	Ppc	17	7- 7-54	5	45	4	D	L
1446	M. Plant	1120	180+	180	gr	Q	17	3-15-54	15	12	4	D	L
1447	E. Faylor	1170	112+	112	gr	Q	30	7-28-54	10	60	4	D	L
1448	C. H. Laylanch	1130	185+	185	sd	Q	--------	--------	6	--------	--------	D	L
1449	R. A. Schultz	1170	22	35	ss	Q	4	8-29-55	25	14	4	D	L
1450	C. McMillen	1150	72	78	sh	Ppc	Flows	1-26-56	20	10	4	D	L
1452	B. McCormack	1155	58	85	ss	Ppc	24	6-15-54	--------	--------	4	D	L
1453	J. Jones	1150	96	105	sh	Ppss	21	6-12-54	--------	--------	4	D	L
1454	D. Agima	1135	207+	207	gr	Q	25	10-25-55	15	15	4	D	L
1455	A. Rothmell	1170	200+	200	gr	Q	70	6- 6-53	5	--------	4	D	L
1456	T. Thompson	1155	26	54	ss	Ppc	19	8-26-55	14	16	4	D	L
1457	J. King	1175	44	86	ss	Ppc	17	9-22-54	--------	--------	4	D	L
1458	J. Miller	1180	50	110	ss	Ppc	55	12-30-54	10	--------	4	D	
	Ravenna Township												
1501	--------	1100	80+	80	gr	Q	--------	--------	--------	--------	--------	D	
1502	--------	1135	35	135	ss	Ppsc	--------	--------	--------	--------	--------	D	L
1503	--------	1140	180+	180	gr	Q	--------	--------	--------	--------	--------	D	
1504	--------	1090	15	85	ss	Q	--------	--------	--------	--------	--------	D	
1505	Lina Walker	1080	109+	109	gr	Q	42	10- 1-47	6	38	4	D	L
1507	William Bousom	1095	87+	87	gr	Q	47	5- 6-50	12	3	4	D	L
1508	Cleveland Worsted Mills	1105	103+	103	sd	Q	51	6-19-51	7	--------	4	I	L
1509	Lucien Ernes	1120	111+	111	sd	Q	50	7-11-50	--------	--------	4	D	L
1510	Earl W. Armstrong	1080	58+	58	gr	Q	40	12- 1-51	7	--------	4	D	L

TABLE 11.—*Records of water and test wells in Portage County*—Continued

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic unit	Water level: Feet below land surface	Water level: Date	Yield: Rate (gpm)	Yield: Draw-down (feet)	Diam-eter of well (inches)	Use	Remarks
	Ravenna Township—Continued												
1511	George L. Bednom	1110	63	66	ss	Ppsc	30	5-23-51	10	5	4	D	L
1512	O. L. McGeotheim	1120	112	119	ss	Ppsc	69	10-22-49	7	----	4	D	L
1513	E. M. Henderson	1140	118	121	ss	Ppsc	86	1-18-48	6	6	4	D	L
1514	Woodrow Jones	1080	94	107	ss	Ppsc	56	10- 8-47	6	17	4	D	L
1515	L. E. Butcher	1120	64	86	ss	Ppsc	51	9-29-49	7	----	4	D	L
1516	W. E. Gouding	1100	91	98	ss	Ppsc	45	6- 8-49	7	5	4	D	L
1517	Michael Guilitto	1080	110+	110	gr	Q	15	3- 2-53	10	10	4	D	L
1518	John Volgyi	1080	114+	114	sd	Q	33	7-26-50	5	14	4	D	L
1519	A. J. Kunze	1130	80	91	ss	Ppsc	64	3- 4-50	7	----	4	D	L
1520	R. O'Neil	1120	68	103	sh	Ppss	74	9-24-51	8	----	4	D	L
1521	Robert Wright	1080	47	62	ss	Ppsc	15	7-10-50	10	5	4	D	L
1522	D. Sprott	1080	50+	50	gr	Q	20	10-28-49	5	----	4	D	L
1523	M. R. Taylor	1085	64+	64	gr	Q	21	11-11-49	5	----	4	D	L
1524	Edward Crock	1080	126+	126	sd	Q	29	10-29-49	3	40	4	D	L
1525	Joe Fitzgerald	1080	130	137	ss	Ppsc	70	5- 5-49	6	20	4	D	L
1526	H. J. Schaffer	1150	36	81	sh	Ppm	30	12-23-48	8	20	4	D	L
1527	A. Tellory	1130	40	68	ss	Ppsc	40	4-17-51	5	----	4	D	L
1528	State of Ohio	1110	23	72	ss	Ppsc	20	----	30	----	6	PS	L
1529	Clay Reseling	1055	57+	57	sd	Q	12	9-28-50	15	15	4	D	L
1530	O. B. Moore	1090	69+	69	gr	Q	10	4-21-49	5	10	4	D	L
1531	Lena Fambro	1105	58+	58	gr	Q	14	1-27-49	6	3	4	D	L
1532	M. L. Stewart	1110	50+	50	gr	Q	30	3- 6-52	7	----	4	D	L
1533	Fred Cooper	1110	49+	49	sd	Q	30	5- 3-52	10	10	4	D	L
1534	H. Drake	1095	51+	51	sd	Q	27	4-29-52	10	15	4	D	L
1535	W. L. Cooper	1100	66+	66	gr	Q	21	7-24-49	7	16	4	D	L
1536	James Hicks	1115	31	48	ss	Ppsc	20	3-22-50	7	----	4	D	L
1537	Cora Eatmon	1120	39	59	ss	Ppsc	29	7-16-49	5	7	4	D	L
1538	Albert Morris	1180	37	44	sh	Ppss	12	5- 1-52	10	----	4	D	L
1539	D. Rogero	1170	36	95	ss	Ppsc	25	5- 6-52	5	----	4	D	L
1540	J. H. Newhouse	1140	43	53	ss	Ppsc	16	1-20-50	10	----	4	D	L
1541	Charles Harper	1140	75	75+	sd	Q	34	4- 6-51	7	----	4	D	L
1542	Magnolia Petroleum Co.	1130	19	65	ss	Ppc-sc	----	----	----	----	----	T	L
1543	Glenn Peebles	1100	95	114	ss	Ppsc	28	10-26-51	20	12	4	D	L
1544	Henry Juvan	1120	14	54	ss	Ppsc	12	9- 8-48	6	7	4	D	L
1545	Pat Ruggles	1100	86+	86	gr	Q	47	4-16-52	8	----	4	D	L
1546	R. E. Sabin	1075	71+	71	gr	Q	17	7-26-51	5	8	4	D	L
1547	H. Moulds	1085	49+	49	gr	Q	11	9-10-51	11	9	6	D	L
1548	Joe Bednar	1110	49	86	ss	Ppsc	66	8-20-51	5	----	4	D	L
1549	C. P. Reithman	1090	30	74	ss	Ppsc	20	7- 6-50	10	----	4	D	L
1550	Magnolia Petroleum Co.	1110	30	65	sh	Ppss	----	----	----	----	----	T	L
1551	Pete Chlysta	1140	60	74	sh	Ppss	32	8- 3-51	10	----	4	D	L
1552	H. E. Retherford	1130	73+	73	sd	Q	----	----	30	3	6	D	L
1553	Charles E. Moore	1115	51+	51	gr	Q	32	4-21-51	6	----	4	D	L
1554	C. A. Wheaton	1120	50	70	sh	Ppss	20	10-15-47	2	----	4	D	L
1555	Magnolia Petroleum Co.	1080	93+	93	gr	Q	----	----	----	----	----	T	L
1556	----do.	1110	35	65	sh	Ppss	----	----	----	----	----	T	L
1557	Roy Bombarger	1120	50	82	ss	Ppsc	25	5- 3-52	25	4	6	D	L
1558	Charles Linton	1110	36	85	ss	Ppsc	40	7- 3-50	6	20	4	D	L
1559	L. H. Morgan	1125	40	87	ss	Ppsc	15	7-21-48	8	----	4	D	L
1560	Magnolia Petroleum Co.	1080	75+	75	gr	Q	----	----	----	----	----	T	L
1561	E. E. Ensinger	1160	19	84	ss	Ppc-sc	45	1-29-49	8	8	4	D	L
1562	Mike Ploeskunak	1125	70	101	ss	Ppsc	65	8-12-48	5	----	4	D	L
1563	W. A. Dunham	1120	41	53	sh	Ppss	83	7-26-48	5	6	4	D	L
1564	Scott Smith	1080	91+	91	sd	Q	40	10- 8-48	3	----	4	D	L
1565	Jolly Time Tavern	1030	157+	157	sd	Q	15	8- 5-49	5	35	4	D	L
1566	Magnolia Petroleum Co.	1030	135+	135	gr	Q	----	----	----	----	----	T	L
1567	----do.	1095	90+	90	gr	Q	----	----	----	----	----	T	L
1568	Herman Cummins	1090	68+	68	sd	Q	50	10- 1-48	3	----	4	D	L
1569	Magnolia Petroleum Co.	1110	95+	95	gr	Q	----	----	----	----	----	T	L
1570	----do.	1076	125+	125	cl	Q	----	----	----	----	----	T	L
1572	V. J. Knitze	1020	172	178	sh	Mc	20	6-26-53	15	15	4	D	L
1573	D. Phettuplace	995	29	60	ss	Ppsc	33	9- 8-52	6	----	4	D	L
1574	W. E. Waters	1150	40	86	ss	Ppsc	45	7-11-53	8	10	4	D	L
1575	Tillery	1100	26	46	ss	Ppsc	18	2- 3-53	8	----	4	D	L
1576	William Ferguson	1110	60	80	ss	Ppsc	45	3-18-53	6	----	4	D	L
1577	Jack Guilitto	1065	40	72	sh	Ppsc	40	1-30-53	6	----	4	D	L
1578	Robert Allman	1060	70+	70	sd	Q	21	5-26-53	10	5	4	D	L
1579	Ward Davis	980	78	86	ss	Ppsc	Flows	7-16-53	3	----	4	D	L
1580	D. Wendt	1120	85+	85	gr	Q	70	6-30-55	6	----	4	D	L
1581	J. Ferguson	1100	100+	100	sd	Q	55	5-24-54	6	----	4	D	L
1582	J. Guillitto	1080	64	80	sh	Ppsc	45	2-11-55	7	----	4	D	L
1583	Cottage Hill Farms	1035	126+	126	gr	Q	Flows	12-30-54	20	----	6	D, S	L
1584	J. Volgyi	1100	35	52	sh	Ppss	22	11-18-54	10	12	4	D	L
1585	P. L. Frank Construction Co.	1120	81	100	sh	Ppss	20	11-11-54	8	20	4	D	L
1586	R. Wilson	1140	22	52	sh	Ppss	12	5-26-56	4	14	4	D	L
1587	Happy Day School	1080	227+	227	sd	Q	28	4-30-54	15	67	----	PS	L
1588	E. W. Barry	1095	130+	130	gr	Q	58	1-11-54	20	26	6	D	L
1589	G. H. Harper	1085	81	107	ss	Ppsc	55	1-20-55	7	----	4	D	L
1590	B. R. Dean	1080	223+	223	gr	Q	32	4- 6-54	10	18	4	D	L
1591	J. L. Schoning	1080	110+	110	gr	Q	25	9- 2-55	5	70	----	D	L
1592	P. Tennant	1120	175+	175	gr	Q	42	5-29-56	10	5	4	D	L
1593	Troxell	1085	102+	102	sd	Q	10	8-15-54	15	20	4	D	L
1594	Romito Donnelly Corp.	1095	75	170	ss	Ppsc	24	7- 2-55	25	8	6	I	L
1595	Enduro Rubber Co.	1090	108+	108	gr	Q	22	3-10-55	40	5	6	I	L
1596	R. F. Morton	1090	125+	125	gr	Q	80	11- 6-53	5	----	4	D	L
1597	H. Myers	1090	84+	84	gr	Q	40	4-13-55	7	15	4	D	L
1598	J. Fitzgerald	1105	176+	176	sd	Q	50	1-13-55	7	35	4	D	L
1599	----do.	1080	143	151	ss	Ppsc	47	8-10-55	7	3	4	D	L

TABLE 11.—*Records of water and test wells in Portage County*—Continued

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic unit	Water level: Feet below land surface	Water level: Date	Yield: Rate (gpm)	Yield: Draw-down (feet)	Diameter of well (inches)	Use	Remarks
	Rootstown Township												
1601	W. C. Speath	1050	90+	90	gr	Q	Flows	10-24-49	2	----	4	D	L
1602	Lloyd Latch	1100	54+	54	gr	Q	7	3- 3-51	15	14	4	D	L
1603	W. E. Blakely	1120	42	50	ss	Ppc	20	10-18-51	10	----	4	D	L
1604	R. Knapp	1120	32	63	ss	Ppc	25	4- 9-52	5	----	4	D	L
1605	Eugene Ringley	1115	30	104	sh	Ppm	17	8-12-50	2	100	4	D	L
1606	Pete Bobby	1100	145+	145	sd	Q	53	5-13-52	5	40	4	D	L
1607	A. L. Kovach	1100	64	88	sh	Ppss	23	8-17-51	8	49	4	D	L
1608	Arthur Harville	1180	69	85	sh	Ppm	26	4-11-51	10	----	4	D	L
1609	C. L. Wade	1120	82	84	ss	Ppsc	25	6- 6-50	15	10	4	D	L
1610	William Sands	1120	81	84	ss	Ppc	----	----	----	----	4	D	L
1611	Grant Beam	1100	107+	107	sd	Q	40	7-17-52	12	15	4	D	
1612	B. J. Duscek	1090	51+	51	gr	Q	35	6-21-51	8	5	4	D	L
1613	Lee J. Miller	1120	98+	98	gr	Q	71	7- 8-50	12	4	4	D	L
1614	George Hluck	1050	86	105	ss	Ppsc	50	10- 2-51	4	20	4	D	L
1615	Walter Ney, Jr.	1100	95+	95	gr	Q	60	9- 7-51	5	----	4	D	L
1616	T. G. Jenkins	1075	86+	86	gr	Q	35	2-23-48	10	5	4	D	L
1617	Joseph Bello	1140	4	50	ss	Pph	24	10-20-47	6	10	4	D	L
1618	Fred S. Geib	1165	4	43	ss	Pph	24	9- 6-49	----	----	4	D	L
1619	Cletus H. Kline	1120	106+	106	sd	Q	47	3-10-50	12	3	4	D	L
1620	E. O. Kelly	1150	41	52	ss	Pph	25	3-31-49	6	2	4	D	L
1621	Saben Sand & Gravel Co.	1075	145	213	ss	Ppsc	37	10-20-48	100	15	12	D	L
1622	Russ	1135	43	57	sh	Ppm	15	12-12-49	2	42	4	D	L
1623	J. L. Dreese	1080	94	95	ss	Ppsc	5	7-12-51	10	5	4	D	L
1624	O. Carr	1140	123+	123	gr	Q	----	----	----	----	4	D	L
1625	Ira Freeman	1110	65+	65	gr	Q	----	----	----	----	4	D	L
1626	Dora R. Guenther	1090	60+	60	sd	Q	15	7-27-53	15	25	4	D	L
1627	Robert E. Nelson	1100	134+	134	sd	Q	67	10-26-53	3	----	4	D	L
1628	W. B. Brown	1080	45+	45	gr	Q	15	7-13-53	15	10	4	D	L
1629	Walter Bogus	1160	101+	101	sd	Q	67	9-16-52	10	5	4	D	L
1630	Nick Sackraca	1090	110+	110	gr	Q	14	5-28-53	15	30	4	D	L
1631	Frank Lyons	1100	69	111	ss	Ppsc	30	6- 6-53	10	40	4	D	L
1632	Milton Tizer	1120	86	102	ss	Ppsc	50	10- 8-53	10	20	4	D	L
1633	Lotty Bettinger	1140	85	119	ss	Ppsc	60	7-17-53	20	15	4	D	L
1634	Dixie Douglas	1140	104	125	ss	Ppsc	50	8-10-53	5	50	4	D	L
1635	M. Bresky	1120	73	98	ss	Ppc	----	----	5	----	4	D	L
1636	Robert Blitz	1110	96	110	ss	Ppsc	25	8-17-53	5	----	4	D	L
1637	Peter Baber	1090	87+	87	gr	Q	20	1-16-53	----	----	4	D	L
1638	E. Jones	1090	101+	101	gr	Q	16	8-20-53	----	----	4	D	L
1639	Moore	1070	110+	110	sd	Q	----	----	8	10	4	D	
1640	K. E. Leinard	1160	45	48	ss	Pph	10	12-24-52	10	12	4	D	L
1641	Gutons Service Station	1145	70+	70	gr	Q	45	9-25-52	6	----	4	PS	L
1642	J. M. Hanker	1170	51	60	sh	Ppm	24	4-27-53	5	----	4	D	L
1643	R. L. Moore	1100	118+	118	sd	Q	65	6-11-53	10	15	4	D	L
1644	M. W. Wymer	1065	136+	136	gr	Q	8	3-26-54	10	25	4	D	L
1645	D. M. Buzek	1160	10	110	ss	Pph	7	6-10-52	175	13	12	Ir	L
1646	A. H. Rickenbacher	1065	100+	100	gr	Q	10	5-24-55	10	----	4	D	L
1647	F. Klinger	1105	125+	125	gr	Q	45	8-27-55	1	80	4	D	L
1648	P. Zahusky	1085	75	102	ss	Ppsc	15	8- 8-54	10	55	4	D	L
1649	J. C. Beat	1120	120	125	ss	Ppsc	10	5-19-56	60	40	4	D	L
1650	S. Laskas	1120	124+	124	gr	Q	30	8-18-53	10	35	4	D	L
1651	C. R. Saltsman	1085	121	141	ss	Ppsc	32	8-26-55	10	15	4	D	L
1652	S. A. Sims	1080	105	114	ss	Ppsc	----	----	----	----	4	D	L
1653	H. Hague	1160	15	72	ss	Pph	42	10-29-54	8	----	4	D	L
1654	M. R. Fausnaught	1150	190	207	sh	Ppss	85	8-15-55	5	60	4	D	L
1655	C. Wolohan	1160	6	69	ss	Pph	38	7-11-55	15	10	6	D	L
1656	Flint	1100	60	85	ss	Ppsc	17	8-23-55	10	25	4	D	L
1657	C. Guenther	1090	184+	184	gr	Q	----	----	----	----	4	D	L
1658	W. E. Eyre	1100	101+	101	gr	Q	46	9- 2-55	10	29	4	D	L
1659	A. Jones	1130	144	154	ss	Ppsc	50	4-29-55	10	15	4	D	L
	Shalersville Township												
1701	----	1180	20	52	sh	Ppss	----	----	----	----	----	D	L
1702	Peter Youngblood	1110	56+	56	gr	Q	2	5-15-47	42	3	8	Ir	L
1703	Harper	1180	32	63	ss	Ppc	----	----	----	----	----	D	L
1704	James Smith	1110	96	101	ss	Ppsc	12	6-30-50	15	15	4	D	L
1705	Shalersville School	1240	25	156	ss	Ppc	60	2-28-48	30	20	6	PS	L
1706	A. Stutz	1210	18	42	sh	Ppc	20	11- 1-51	6	----	4	D	L
1707	Carl Watson	1190	29+	29	gr	Q	16	8-15-51	8	----	4	D	L
1708	J. Chalker	1210	19	63	ss	Ppc	44	6-21-51	6	----	4	D	L
1709	Kenneth Snyder	1225	29	90	ss	Ppc	16	7-25-49	55	50	8	I	L, T
1710	State of Ohio	1200	31	53	ss	Ppc	33	7-24-52	7	----	5	PS	L
1711	Steve Stoller	1160	10	68	ss	Ppc	----	----	----	----	6	D	L
1712	A. K. Burroughs	1070	25	47	sh	Ppsc	Flows	7-24-52	1	----	4	D	L
1713	W. E. Shaffer	1080	27	73	ss	Ppsc	18	7-25-52	----	----	4	D	L
1714	P. Postletwaite	1185	56	93	ss	Ppc	10	5-13-50	12	80	4	D	L
1715	John Barnosky	1195	15	59	ss	Ppc	----	----	50	----	6	D	L
1716	Cusack	1190	10	88	ss	Ppsc	60	5-18-51	----	----	5	D	L
1717	Paul Hartman	1180	34+	34	gr	Q	19	10-18-51	10	----	6	D	L
1718	H. L. Correll	1080	74+	74	gr	Q	19	8- 7-52	5	5	4	D	L, A
1719	Simon Young	1100	53	63	ss	Ppsc	23	8- 7-52	10	2	4	D	L
1720	Egnatz Szalay	1185	30+	30	gr	Q	29	7-13-49	40	----	6	D	L
1721	John Pennell	1220	19	36	ss	Ppc	----	----	----	----	6	D	L
1722	Thomas Border	1240	16	69	ss	Ppc	27	6-21-51	5	----	4	D	L
1723	Leonard Popp	1200	50	54	ss	Ppc	----	----	15	----	6	D	L
1724	H. A. Hallstein	1140	69+	69	sd	Q	15	10-17-50	10	5	4	D	L
1725	do	1110	178	195	ss	Ppsc	20	12-14-50	5	40	4	D	L
1726	Magnolia Petroleum Co.	1120	30	65	sh	Ppss	----	----	----	----	----	T	L
1727	Merritt Powell	1220	37	130	ss	Ppc–sc	65	11-19-48	15	----	6	D	L

TABLE 11.—*Records of water and test wells in Portage County*—Continued

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic unit	Water level: Feet below land surface	Water level: Date	Yield: Rate (gpm)	Yield: Draw-down (feet)	Diam-eter of well (inches)	Use	Remarks
	Shalersville Township—Continued												
1728	Henry Kotkowski	1220	57	70	ss	Ppc	35	4-28-52	40	5	6	D	L
1729	W. J. Hafemeister	1240	97	101	ss	Ppc	64	4-22-50	26	5	6	D	L
1730	William Jahn	1240	79	95	ss	Ppc	77	4-14-50	10	----	4	D	L
1731	Standard Slag Co.	1100	85+	85	gr	Q	18	7-20-51	1200	24	16	I	L, T
1732	Frank George	1110	62	69	ss	Ppsc	38	1- -48	20	23	5	D	L
1733	B. I. Grubb	1140	58	61	ss	Ppsc	30	8- 1-50	27	19	6	D	L
1734	D. A. Harlan	1200	62	116	ss	Ppsc	60	3- 6-52	6	----	4	D	L
1735	Harry Katkouski	1130	20	67	ss	Ppc–sc	37	5-28-53	25	8	6	D	L
1736	H. T. Stutz	1190	40	60	sh	Ppss	30	4-24-53	5	----	4	D	L
1737	C. J. Wieclaw	1100	75+	75	gr	Q	20	5-15-53	10	15	4	D	L
1738	P. L. Frank Construction Co.	1235	17	169	ss	Ppc–sc	65	9-18-53	6	21	5	D	L
1739	L. N. Rozehnal	1120	53+	53	gr	Q	5	10- 4-54	50	8	6	D	L
1740	C. E. Hertage	1190	32	53	sh	Ppc	15	8-17-53	10	12	4	D	L
1741	C. A. Pegg	1185	70	94	sh	Ppss	30	9-11-53	10	15	4	D	L
1742	Karl Brugmann	1140	20	180	ss	Ppc–sc	40	4- 4-53	90	----	5	I	L
1743	J. A. Rossa	1135	6	80	ss	Ppsc	55	12-20-52	5	----	4	D	L
1744	William Bonnath	1080	24	30	ss	Ppsc	12	10-20-53	10	6	4	D	L
1745	L. M. DeGarmo	1115	45	48	ss	Ppsc	14	----	6	----	4	D	L
1746	G. Koran	1130	140+	140	gr	Q	----	----	----	----	5	D	L
1747	C. A. DeZort	1170	85	181	ss	Ppsc	80	7-23-54	10	----	4	D	L
1748	C. Fear	1215	13	55	ss	Ppc	31	1- 5-55	15	12	6	D, S	L
1749	L. DeUnger	1195	70	117	ss	Ppc	65	12- 2-53	6	----	4	D	L
1750	R. W. Prohn	1200	43	57	sh	Ppss	35	12- 4-53	10	----	4	D	L
1751	L. B. Cooley	1150	79	82	ss	Ppsc	30	8-31-55	30	5	6	D, S	L
1752	M. Szenyes	1190	50	95	ss	Ppsc	38	6-30-55	7	----	4	D	L
1753	R. L. Garrett	1150	57	80	ss	Ppsc	35	7-30-55	20	----	4	S	L
1754	D. Chamberlain	1170	37	63	ss	Ppsc	23	4-19-55	20	----	4	PS	L
	Streetsboro Township												
1801	C. W. Wilcox	1035	135+	135	gr	Q	----	----	----	----	----	D	L
1802	L. J. Stutzman	1180	116+	116	gr	Q	56	1-21-50	25	25	6	D	L
1803	E. F. Svab	1030	115+	115	gr	Q	5	6-26-50	5	20	4	D	L
1804	H. A. Defer	1060	48+	48	gr	Q	40	3-23-51	4	2	6	D	L
1805	Mike Turk	1100	175+	175	gr	Q	38	6-14-48	9	52	5	PS	L
1806	D. L. Brewster	1120	54	90	ss	Ppsc	55	9-28-50	6	5	4	D	L
1807	Oscar Brugman	1120	105	108	ss	Ppsc	60	9-26-50	6	20	6	D	L
1808	C. F. Wojtkiewicz	1200	152	159	ss	Ppsc	95	10- 5-50	6	15	4	D	L
1809	Ross Wilcox	1140	127	141	ss	Ppsc	70	12- 7-48	6	8	4	D	L
1810	Leon Shafer	1100	96+	96	gr	Q	50	12-14-48	6	16	4	D	L
1811	Akins Construction Co.	1080	72	83	ss	Ppsc	Flows	10-27-50	10	0	4	D	L
1812	Richard Pennington	1080	39	82	ss	Ppsc	52	10-25-50	10	12	4	D	L
1813	Russell Hale	1130	81	110	ss	Ppsc	90	2-34-49	5	15	4	D	L
1814	G. V. Chiccola	1090	81	90	ss	Ppsc	54	8-24-48	5	30	6	D	L
1815	J. E. Nusbaum	1140	144+	144	gr	Q	76	1- 8-48	6	10	4	D	L
1816	R. T. Holland	1160	103+	103	gr	Q	89	10-23-50	5	1	4	D	L
1817	Albert Sheldon	1180	88	107	ss	Ppc	19	4- 2-49	18	----	5	D	L
1818	S. Shinke	1110	97	105	ss	Ppsc	56	8- 8-49	6	24	4	D	L
1819	Jack W. Lilly	1110	95+	95	gr	Q	48	8- 4-49	7	4	4	D	L
1820	Gilbert Crook	1120	118+	118	sd	Q	----	----	10	10	4	D	L
1821	James Robenstein	1140	136+	136	gr	Q	86	7- 6-50	5	34	4	D	L
1822	A. L. Ashton	1140	206+	206	sd	Q	103	7-28-49	5	50	4	D	L
1823	W. G. Hilston	1085	129	142	ss	Ppsc	60	10- 5-49	10	10	5	D	L
1824	Tony DeBaliso	1090	79+	79	gr	Q	67	9- 3-48	3	10	4	D	L
1825	Anna Wiencek	1130	66+	66	gr	Q	49	5-26-51	10	4	4	D	L
1826	E. H. Grocott	1080	31+	31	gr	Q	Flows	5-10-48	15	2	4	D	L
1827	J. L. Mann	1160	68+	68	gr	Q	29	5-29-48	7	16	4	D	L
1828	E. D. Evans	1110	82+	82	gr	Q	51	11-26-48	6	10	4	D	L
1829	H. Sidbert	1060	68+	68	sd	Q	40	7-28-50	5	10	4	D	L
1830	R. E. Weingart	1070	70+	70	gr	Q	8	8-14-53	800	10	12	Ir	L, T
1831	R. Gillis	1090	155+	155	gr	Q	----	----	5	20	6	D	L
1832	E. A. Defer	1100	71+	71	gr	Q	40	5-23-52	5	15	4	D	L
1833	A. L. Arnold	1140	73	97	ss	Ppsc	70	10-30-52	10	10	4	D	L, A
1834	G. D. Kutinsky	1050	67+	67	gr	Q	35	11-10-52	10	10	4	D	L
1835	F. L. Christner	1140	233+	233	sd	Q	85	8-29-53	5	----	4	D	L
1836	Joseph Norello	1005	100+	100	gr	Q	1	12-10-52	5	24	4	D	L
1837	E. R. Beck	1070	95	150	ss	Ppsc	6	5-23-53	150	16	6	I	L
1838	Cleat E. Corbett	1170	97	114	ss	Ppsc	74	6-30-53	10	12	4	D	L
1839	H. B. Olds	1150	125+	125	gr	Q	45	10-17-53	8	10	4	D	L
1840	M. D. Hart	1190	56	125	ss	Ppsc	95	6-23-52	7	----	5	D	L
1841	J. Tinka	1050	100	112	ss	Ppc	90	6-30-54	5	----	4	D	L
1842	F. Steuer	1020	137+	137	gr	----	Flows	4- 5-55	10	Flows	4	D	L
1843	Gulf Oil Co.	1040	279+	279	sd	----	14	6- 8-55	10	50	7	D	L
1844	Ohio Turnpike Comm.	1040	66+	66	gr	----	30	3-27-55	35	3	8	PS	L
1845	R. Shope	1135	85	92	ss	Ppsc	60	8-31-54	10	10	4	D	L
1846	W. Hawkins	1140	121	123	ss	Ppsc	70	8-20-55	20	4	4	D	L
1847	C. Heritage	1140	140+	140	gr	Q	75	6-10-54	8	15	4	D	L
1848	C. K. Cochran	1105	96+	96	gr	Q	30	8-31-55	12	15	4	D	L
1849	A. R. Mooney	1040	75+	75	gr	Q	8	7-26-55	10	10	4	D	L
1850	H. Turk	1100	113+	113	gr	Q	76	4- 9-55	10	4	4	D	L

TABLE 11.—*Records of water and test wells in Portage County*—Continued

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic unit	Water level: Feet below land surface	Water level: Date	Yield: Rate (gpm)	Yield: Draw-down (feet)	Diameter of well (inches)	Use	Remarks
	Suffield Township												
1901	Goodyear Aircraft Co	1140	43+	43	sd	Q	10	6-22-51	10	----	4	PS	L
1902	Norman Rausch	1160	27+	27	gr	Q	Flows	10-27-50	50	----	5	D	L
1903	John W. Hummell	1180	68+	68	sd	Q	24	7- 8-49	10	----	4	D	
1905	George Stout	1190	75+	75	gr	Q	35	5- 7-52	8	4	4	D	L
1906	A. A. Sheffler	1200	56+	56	gr	Q	40	5-27-50	10	----	4	D	L
1907	Willard C. Wallace	1160	57+	57	gr	Q	28	5-29-51	10	----	4	D	L
1908	O. N. Brown	1175	50	74	sh	Ppm	37	11-20-47	12	----	4	D	L
1909	T. W. Blue	1130	24	74	ss	Ppc	27	12-21-50	9	31	4	D	L
1910	Hubert Niner	1200	75	162	ss	Ppc	70	6-29-49	10	----	4	D	L
1911	Virgil Thomas	1150	51+	51	gr	Q	----	----	----	----	4	D	L
1912	Alfred Capps	1190	67	127	sh	Ppc	85	10-19-49	7	----	4	D	L
1913	J. R. Wilkins	1190	60+	60	gr	Q	43	12- 6-48	----	----	4	D	L
1914	W. R. Hunt	1190	95	122	sh	Ppm	31	8-10-49	9	50	4	D	L
1915	R. B. Cramer	1190	78	126	ss	Ppc	80	3-29-49	7	----	4	D	L
1916	C. E. Kefauver	1165	54+	54	gr	Q	22	4- 6-51	15	3	4	D	L
1917	H. A. Young	1150	68	85	sh	Ppss	20	5- 3-49	10	----	4	D	L
1918	C. L. Millinger	1130	49+	49	gr	Q	20	10- 2-48	----	----	4	D	L
1919	James D. Baxter	1185	49+	49	gr	Q	19	8-12-48	7	18	4	D	L
1920	Shurman Traugh	1180	66	70	ss	Ppc	----	----	----	----	4	D	L
1921	A. Miller	1190	69+	69	gr	Q	20	5-14-49	13	2	4	D	L
1922	O. F. Klodt	1120	23+	23	sd	Q	10	6-14-49	10	3	4	D	L
1923	A. R. Shackleton	1120	100+	100	gr	Q	15	6-16-49	10	----	4	D	L
1924	M. L. Fox	1160	38+	38	gr	Q	24	3- -49	10	----	4	D	L
1925	Dennis Swartz	1160	46+	46	gr	Q	34	5- 8-48	10	----	4	D	L
1926	A. F. Ritzman	1130	35+	35	gr	Q	15	1-12-49	----	----	4	D	L
1927	C. C. Akers	1150	50+	50	gr	Q	32	4-28-49	5	8	4	D	L
1928	D. V. Ulm	1170	46	73	sh	Ppm	25	8-20-48	15	20	4	D	L
1929	R. V. Yeich	1150	74	92	sh	Ppm	10	10- 4-47	7	55	4	D	L
1930	H. C. Strahler	1160	74+	74	gr	Q	26	5-10-52	8	27	4	D	L
1931	W. L. Rohrbaugh	1130	71+	71	gr	Q	29	1- 5-51	12	6	4	D	L
1932	Stanley Sycks	1140	100	105	ss	Ppsc	----	----	----	----	4	D	L
1933	W. E. Stroup	1130	99	101	ss	Ppsc	----	----	----	----	4	D	L
1935	George Moore	1185	51	59	ss	Ppc	38	6-11-52	15	----	4	D	L
1936	A. W. Jackson	1160	100	130	ss	Ppc	11	4-18-51	20	8	4	D	L, A
1937	William Horning	1195	111	144	sh	Ppc.	90	4-30-51	8	1	4	D	L
1938	W. H. Sadler	1200	95	117	ss	Ppc	60	9-28-49	15	----	4	D	L
1939	R. P. Michaell	1200	66+	66	gr	Q	50	10- -48	----	----	4	D	L
1940	John Miller	1160	29+	29	gr	Q	11	5-26-50	10	----	4	D	L
1941	I. A. Faylor	1205	76	100	ss	Ppc	50	10-29-48	20	----	6	D	L
1942	W. R. Cross, Jr	1185	60	90	ss	Ppc	65	6-29-49	10	----	4	D	L
1943	Goodyear Aircraft Co	1140	82	264	ss	Ppsc	13	3- 9-18	90	65	16	I	L
1944	do	1140	88+	88	gr	Q	18	6-25-52	250	10	10	I	L, A
1945	do	1140	156	167	ss	Ppsc	----	----	----	----	3	PS	L, A
1946	J. A. Simms	1140	80	86	ss	Ppsc	21	7-22-49	5	9	4	D	L
1947	Peter Steciow	1140	51	106	sh	Ppss	80	6-22-49	7	----	4	D	L
1948	H. L. Williams	1150	85	96	sh	Ppss	----	----	----	----	4	D	L
1950	Acme Products and Machinery Co.	1120	33	72	ss	Ppc	24	9- 8-51	12	26	4	I	L
1951	K. R. Davis, Jr	1210	82	145	ss	Ppc	----	----	----	----	4	D	L
1952	O. H. Karker	1150	46	56	ss	Ppc	30	10-19-53	12	4	4	D	L
1953	A. Baker	1190	103+	103	gr	Q	28	8- 5-53	----	----	4	D	L
1954	F. Edwards	1188	107	109	ss	Ppc	76	4- 6-53	9	----	4	D	L
1955	G. H. Huth	1230	140	147	sh	Ppss	36	12-22-52	5	12	4	D	L
1956	R. C. Bembeski	1200	101	122	sh	Ppc	87	7-16-53	6	18	4	D	L
1957	William Evans	1140	104	114	sh	Ppss	38	4- 7-54	5	----	4	D	L
1958	Donald Rader	1220	161+	161	sd	Q	80	11-20-53	10	10	4	D	L
1959	C. Wallace	1175	105+	105	gr	Q	44	3-27-54	----	----	4	D	L
1960	Henry Elmerick	1210	85	107	ss	Ppc	55	6-19-53	8	20	4	D	L
1961	Kenneth Hartong	1190	80+	80	gr	Q	48	5-29-53	16	----	4	D	L
1962	S. Horshak	1120	54	101	sh	Ppss	52	5-18-54	9	28	4	D	L
1963	D. Wise	1100	12	48	ss	Ppc	9	11-16-54	12	15	4	D	L
1964	V. J. Thomas	1170	110	119	ss	Ppc	----	----	----	----	4	D	L
1965	O. Cain	1200	106+	106	gr	Q	78	3-23-54	7	12	4	D	L
1966	J. Spires	1120	37	47	ss	Ppc	15	8- 4-54	12	5	4	D	L
1967	E. Higgins	1160	105+	105	gr	Q	18	4-21-55	10	24	4	D	L
1968	C. O. Fuller	1160	135+	135	gr	Q	17	7-27-55	20	----	4	D	L
1969	H. Horning	1125	115	125	ss	Ppsc	23	9-13-54	----	----	4	D	L
1970	T. R. Ellis	1190	90	96	ss	Ppc	39	7-24-54	20	----	4	D	L
1971	R. R. Huth	1205	132	145	ss	Ppc	70	11-17-55	5	----	4	D	L
1972	L. J. Johnson	1155	80	94	ss	Ppm	17	9-29-55	21	10	4	D	L
1973	D. Jarvis	1220	72	79	ss	Ppm	40	10-14-54	5	20	4	D	L
1974	W. Marshall	1180	60	100	ss	Ppc	32	9- -55	20	----	4	D	L
1975	J. Elmanes	1240	120	175	ss	Ppc	67	11-22-54	10	10	4	D	L
1976	J. Stanley	1160	80	145	ss	----	45	6- 6-55	10	5	4	D	L
1977	J. Stoddard	1170	120	124	ss	Ppc	39	11-12-55	15	11	4	D	L
1978	H. Lancester	1170	110+	110	gr	Q	30	10-12-55	12	----	4	D	L
1979	S. Sommers	1165	157	171	ss	Ppsc	27	12-21-55	14	----	4	D	L
1980	E. Young	1180	113+	113	gr	Q	30	7- 5-55	----	----	6	D	L
1981	W. Hughes	1160	180	238	ss	----	65	8- 6-55	10	----	4	D	L
1982	A. F. Rannegan	1170	163	190	ss	Ppsc	38	11-19-53	25	----	4	D	L
1983	Goodyear Co	1145	96	105	sh	Ppss	12	8-23-54	30	33	6	I	L
1984	G. Davis	1190	70	95	sh	Ppss	53	1954	15	5	4	D	L

TABLE 11.—*Records of water and test wells in Portage County*—Continued

Well	Owner or tenant	Altitude at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic unit	Water level: Feet below land surface	Water level: Date	Yield: Rate (gpm)	Yield: Draw-down (feet)	Diameter of well (inches)	Use	Remarks
	Windham Township												
2001	Magnolia Petroleum Co	950	90	115	ss	Ppsc						T	L
2002	Harley C. Rising	950	12	41	ss	Ppsc					6	D	L
2003	Magnolia Petroleum Co	940	10	65	ss	Ppsc						T	L
2004	Harbison-Walker Co	935	32	107	ss	Ppsc	14	8-27-51	50	73	10	I	L, Three similar wells.
2005	Magnolia Petroleum Co	960	3	45	ss	Ppsc						T	L
2006	do	980	27	55	ss	Ppsc						T	L
2007	do	1060	5	65	ss	Ppsc						T	L
2008	do	1105	12	65	ss	Ppsc						T	L
2009	R. Lemaster	915	15	130	sh	Mc					6	D	L, Dry, some gas.
2010	A. Breitenbach	1090	17	52	ss	Ppsc					6	D	L
2011	J. E. Sullinger	990	11	91	ss	Ppsc					6	D	L
2012	D. F. King	970	32	50	ss	Ppsc					6	D	L
2013	Don Belden	980	8	50	ss	Ppsc					6	D	L
2014	Magnolia Petroleum Co	980	105+	105	gr	Q						T	L
2015	do	1000	9	65	ss	Ppsc						T	L
2016	do	990	14	60	ss	Ppsc						T	L
2017	do	930	2	65	ss	Ppsc						T	L
2018	do	945	54	75	ss	Ppsc						T	L
2019	do	965	69	95	ss	Ppsc						T	L
2020	do	1040	15	65	sh	Ppss						T	L
2021	do	1095	25	65	sh	Ppss						T	L
2022	do	1005	12	47	ss	Ppsc						T	L
2023	do	1065	6	65	ss	Ppsc						T	L
2034	do	980	7	56	ss	Ppsc						T	L
2025	R. Stanley	975	60	81	ss	Ppsc	12	11-12-52	20	10	5	D	L
2026	M. J. Rothstein	1060	0	107	ss	Ppsc	62	6- -54	4			D	
2027	A. Jindra	940	140	233		O-M						D	Abandoned, salty.
2028	E. W. Goodaire	980	25	50	ss	Ppsc	Flows		5	40	7	D, S	L
2029	F. Mashuda Co	970	3	85	ss	Ppsc	30	11-23-54	8	10	7	I	L
2030	Ravenna Arsenal	970	110	156	ss	Ppsc	16		25		6	T	L
2031	do	980	4	91	ss	Ppsc	35		24		6	T	L
2032	do	960	20	60	ss	Ppsc	18		25	50	6	T	L
2033	do	985	9	145	ss	Ppsc	29		22	8	6	T	L
2034	do	1000	16	169	ss	Ppsc	40		30	15	6	T	L
2035	do	995	3	173	ss	Ppsc	32		30		6	T	L
2036	do	1005	3	167	ss	Ppsc	50		30		6	T	L
2037	E. Liddle	975		55	ss	Ppsc	20				6	O	

TABLE 12.—*Drillers' records of oil-and-gas wells in Portage County*

[Data shown only to the approximate base of potable-ground-water zone. Altitude of wellhead follows well number. The locations of the wells are shown on pl. 2]

	Thickness (feet)	Depth (feet)
Atwater Township:		
Well P-1; 1,140 ft		
Glacial drift	17	17
Sandstone	58	75
Shale	15	90
Sandstone	20	110
Shale	305	415
Shale and sandstone	28	443
Sandstone	29	472
Shale	6	478
Sandstone (some gas)	3	481
Sandstone (some heavy oil)	6	487
Sandstone (salt water)	75	562
Shale	1	563
Sandstone	60	623
Well P-2; 1,160 ft		
Glacial drift	58	58
Shale	157	215
Sandstone	85	300
Shale	153	453
Sandstone	24	477
Shale	8	485
Sandstone	95	580
Shale	233	813
Aurora Township:		
Well P-3; 1,160 ft		
Glacial drift	15	15
Sandstone	85	100
Shale	187	287
Sandstone	43	330
Shale and sandstone	670	1,000

TABLE 12.—*Drillers' records of oil-and-gas wells in Portage County*—Continued

	Thickness (feet)	Depth (feet)
Brimfield Township:		
Well P-4; 1,080 ft		
Glacial drift	85	85
Sandstone	100	185
Sandstone	55	380
Deerfield Township:		
Well P-5; 1,070 ft		
Glacial drift	40	40
Shale	10	50
Limestone	4	54
Shale	157	211
Sandstone	54	265
Shale	115	380
Sandstone	29	409
Shale	31	440
Sandstone	20	460
Shale	40	500
Edinburg Township:		
Well P-6; 1,125 ft		
Sandstone	130	270
Sandstone	125	500
Well P-7; 1,160 ft		
Glacial drift	188	188
Shale	287	475
Sandstone	25	500
Shale	10	510
Sandstone	22	532
Shale	505	1,037
Well P-8; 1,175 ft		
Glacial drift	40	40
Shale	45	85

TABLE 12.—*Drillers' records of oil-and-gas wells in Portage County*—Continued

	Thickness (feet)	Depth (feet)
Edinburg Township—Continued		
Well P-8; 1,175 ft—Continued		
Sandstone	105	190
Shale	24	214
(Coal streak at 210 feet)		
Shale	256	470
Sandstone	20	490
Shale	10	500
Well P-9; 1,150 ft		
Glacial drift	11	11
Shale	4	15
Sandstone	3	18
Shale	6	24
Sandstone	41	65
Shale	43	108
Sandstone	17	125
Shale	15	140
Sandstone	205	345
Shale and sandstone	5	350
Sandstone	79	429
Shale and sandstone	281	710
Franklin Township:		
Well P-10; 1,080 ft		
Glacial drift	345	345
Shale	1, 845	2, 190
Freedom Township:		
Well P-11; 1,100 ft		
Glacial drift	49	49
Shale	21	70
Sandstone	85	155
Shale	103	258
Sandstone	33	291
Sandstone	52	403
Nelson Township:		
Well P-12; 1,000 ft		
Sandstone	148	198
Well P-13; 1,020 ft		
Sandstone	42	168
Sandstone	9	240
Palmyra Township:		
Well P-14; 1,135 ft		
Glacial drift	10	10
Shale	540	550
Sandstone	7	557
Shale	50	670
Paris Township:		
Well P-15; 1,000 ft		
Glacial drift	22	22
Shale	98	120
Sandstone	50	170
Shale	1, 380	1, 550
Randolph Township:		
Well P-16; 1,200 ft		
Glacial drift	130	130
Shale	80	210
Sandstone	195	405
Shale	67	472
Sandstone	51	523
Shale and sandstone	97	620
Ravenna Township:		
Well P-17; 1,060 ft		
Glacial drift	229	229
Sandstone	26	255
Shale	3	258
Sandstone	20	278
Shale	12	290
Sandstone	2	292
Shale	864	1, 156

TABLE 12.—*Drillers' records of oil-and-gas wells in Portage County*—Continued

	Thickness (feet)	Depth (feet)
Ravenna Township—Continued		
Well P-18; 1,100 ft		
Glacial drift	225	225
Sandstone	25	250
Sandstone	5	410
Well P-19; 1,035 ft		
Sandstone	55	170
Well P-20; 1,030 ft		
Glacial drift	208	208
Sandstone	29	237
Shale	23	360
Sandstone	10	370
Shale	1, 105	1, 475
Rootstown Township:		
Well P-21; 1,010 ft		
Glacial drift	160	160
Sandstone	20	180
Shale and thin sandstone	1, 320	1, 500
Well P-22; 1,010 ft		
Glacial drift	70	70
Sandstone	94	164
Shale and thin sandstone	76	240
Sandstone	40	280
Well P-23; 1,050 ft		
Glacial drift	96	96
Sandstone	116	212
Shale	78	290
Sandstone	68	358
Shale	1, 182	1, 540
Well P-24; 1,010 ft		
Glacial drift	35	35
Sandstone	125	160
Shale	85	245
Sandstone	55	300
Shale	1, 225	1, 525
Shalersville Township:		
Well P-25; 1,100 ft		
Glacial drift	195	195
Shale and thin sandstone	125	320
Sandstone	6	326
Shale and thin sandstone	1, 174	1, 500
Well P-26; 1,150 ft		
Sandstone	50	156
Sandstone	109	319
Well P-27; 1,150 ft		
Glacial drift	60	60
Shale	105	165
Sandstone	120	285
Shale	80	365
Sandstone	100	375
Shale	1, 945	2, 320
Streetsboro Township:		
Well P-28; 1,150 ft		
Glacial drift	84	84
Sandstone	76	160
Shale	90	350
Sandstone	5	355
Shale	1, 270	1, 625
Suffield Township:		
Well P-29; 1,160 ft		
Glacial drift	113	113
Sandstone	226	383
Shale	185	568
Shale and thin sandstone	104	672

TABLE 13.—*Thickness of glacial drift in Portage County on the basis of seismic determinations*

Seismic site	Thickness (feet)
Aurora Township	
Sp-1	653
2	662
3	660
4	632
5	197
6	182
7	380
8	111
Brimfield Township	
Br-1	97
2	138
3	100
4	109
5	107
7	121
8	109
9	141
10	230
11	205
12	120
A	55
B	101
C	104
D	102
Franklin Township	
Fr-1	252
2	312
3	146
A	350
B	326
C	355
D	311
E	166
F	287
G	177
H	286
I	321
J	296
K	110
L	128
M	61
Hiram Township	
H-1	245
2	48
3	102
Nelson Township	
N-1	75
2	77
3	260
4	277
Paris Township	
Sp-9	96
10	151
11	171
12	266
13	173
Randolph Township	
Ra-2	133
3	223
4	128
5	149
6	147
7	94
8	134
9	85
10	140
11	160
12	175
Ravenna Township	
Rv-1	275
A	266
Ravenna Township—Con.	
Rv-B	75
C	71
D	99
E	90
F	77
G	155
Rootstown Township	
Ro-1	91
2	98
3	145
4	211
5	140
6	254
7	119
8	90
9	292
10	154
C	139
D	94
E	82
F	196
G	164
H	160
Streetsboro Township	
St-1	431
2	498
3	484
4	397
5	204
6	127
12	450
13	215
14	463
D	440
E	336
F	426
G	371
H	349
I	106
J	121

TABLE 14.—*Geologic sections of the consolidated rocks in Portage County*

ATWATER TOWNSHIP

[Section recorded in strip mine of Petersen Coal Co., about 1 mile south of U.S. Route 224 and 0.6 mile west of Atwater-Deerfield Township line]

	Ft	*in*
Pennsylvanian System, Pottsville Formation:		
Homewood Member:		
Sandstone, light-yellow-brown, fine-grained, micaceous, clayey	3+	0
Mercer Member:		
Shale, greenish-gray-brown, silty to sandy, fissile	3	4
Shale, light-gray, micaceous to sandy	4	0
Shale, black; streaks of bright coal (Tionesta)	0	6
Clay, sandy, hard; oolitic texture in places	8	6
Shale, dark-brownish-gray to black; carbonaceous in places	0	7
Shale, light-gray, sandy	6	0
Shale, black, hard, sandy, carbonacous	9	6
Coal, bony to dull, banded (Bedford)	3–6	0

TABLE 14.—*Geologic sections of the consolidated rocks in Portage County*—Continued

DEERFIELD-ATWATER TOWNSHIP

[Section recorded along Willow Creek, 100 yd east and west of Deerfield-Atwater Township line]

	Ft	*in*
Pennsylvanian System, Pottsville Formation:		
Mercer Member:		
Coal, bright, blocky, bituminous (Bedford)	3	7
Clay, plastic	3+	0
Covered. Shale and clay	28	7
Limestone, dark-blue; massive except for lower 6 in. that is platy and fine grained to granular (Lower Mercer)	2	11
Shale, black, fissile, carbonaceous (Middle Mercer coal horizon)	0	6
Shale, dark gray, clayey, partly carbonaceous	0	7
Clay, plastic, very shaley	0	2
Shale, gray, clayey; few carbonaceous streaks	1	6
Shale, black, hard, sandy to micaceous, fissile	0	8
Shale, gray, clayey	2	7
Shale, black, fissile, carbonaceous	0	8
Shale, gray, clayey	1	0
Shale, black, fissile, carbonaceous	0	4
Shale, dark-gray, silty	0	1
Coal, bright, banded (Lower Mercer)	0	2
Clay, gray, plastic; few plant impressions	2+	0

EDINBURG TOWNSHIP

[Section recorded along Silver Creek, for distance of 1 mile, above bridge on Charlestown-Edinburg Township line, 0.5 mile west of the common corner between Charlestown, Paris, Palmyra, and Edinburg Townships]

	Ft	*in*
Pennsylvanian System, Pottsville Formation:		
Homewood Member:		
Sandstone, light-tan-gray, coarse-grained	5+	0
Mercer Member:		
Covered	16	6
Shale, black, silty	0	6
Clay, sandy	3	0
Shale, black, sandy, blocky; in 1-ft ledges	6	0
Siderite ore, nodular	0	8
Shale, black, silty, partly covered	2	0
Coal, bright and dull (Bedford)	3	0
Clay, silty to sandy	4	0
Shale, gray, silty to sandy, fissile	5	0
Siderite ore, nodular, continuous	1	8
Shale, gray to gray-black, silty, fissile	25	0
Siderite ore, nodular, continuous	0	3
Shale, gray, sandy, fissile	5	0
Connoquenessing Member:		
Sandstone, light-gray; contains flagstone layers	15	0
Shale unit of Sharon Member:		
Shale, gray to gray-black, silty, fissile; contains a few ironstone concretions	17	0
Covered interval. Possibly same as unit below	10−	0
Shale, black	1+	0
Coal, blocky; in stream bottom (Sharon)	0	3
Covered interval	20+	0
Conglomerate unit of Sharon Member:		
Sandstone, massive, light-tan-gray	20+	0

TABLE 14.—*Geologic sections of the consolidated rocks in Portage County*—Continued

FREEDOM TOWNSHIP

[Section recorded along a tributary of Eagle Creek that rises south from bridge on the Hiram-Freedom Township line, 0.2 mile west of State Route 700]

	Ft	in
Pennsylvanian System, Pottsville Formation:		
Connoquenessing Member:		
Sandstone, massive, light-gray, medium- to coarse-grained	10	0
Sandstone, light-gray, fine-grained, micaceous; contains plant fossils	6	8
Sandstone, light-gray, silty, micaceous; contains many plant fossils and coal streaks	1	5
Shale unit of Sharon Member:		
Coal, bright, discontinuous	0	1
Sandstone, light-gray, coarse-grained	0	3
Coal, bright	0	1
Clay, light-gray, fat	0	1
Shale, light-gray-blue, silty; contains plant fossils; in places an angular conglomerate composed of chips of underclay, shale, sandstone, and bright coal	1	0
Coal, bright	0	2
Siltstone, blue-gray; contains coal and shale fragements	0	3
Shale, black, carbonaceous	1	0
Shale, light-blue-gray, sandy	0	2
Coal; bright in places; concretions at base	0	2
Clay, light-blue-gray; sandy at base and fatter upwards	2	6
Shale, light-blue-gray, silty, fissile	5	0
Shale, blue-gray, very sandy (flaggy); contains 1- to 3-in. concretions	5	5
Shale, blue-gray, silty, mostly covered; contains plant fossils	8	0
Conglomerate unit of Sharon Member:		
Sandstone, light-tan-gray, coarse-grained; crossbedded to the southwest	20	0

HIRAM TOWNSHIP

[Section recorded along a subtributary of Eagle Creek that rises to the west just north of the bridge on the Hiram-Freedom Township line, 0.2 mile west of State Route 700]

	Ft	in
Pennsylvanian System, Pottsville Formation:		
Connoquenessing Member:		
Sandstone, light-gray, fine- to medium-grained, micaceous; crossbedded to southwest	11	0
Shale unit of Sharon Member:		
Shale, gray, hard, silty	6	0
Shale, blue-gray, sandy, with flagstone layers	7	0
Siltstone, blue-gray; contains angular fragments of shale	0	2
Shale, dark-gray, silty	16	5
Sandstone, light-gray, micaceous	0	4

TABLE 14.—*Geologic sections of the consolidated rocks in Portage County*—Continued

HIRAM TOWNSHIP—Continued

	Ft	in
Pennsylvanian System, Pottsville Formation—Continued		
Shale unit of Sharon Member—Continued		
Shale, gray-black, silty; contains a few concretions	5	6
Conglomerate unit of Sharon Member:		
Sandstone, light-tan-gray, medium- to coarse-grained; crossbedded to southeast	20	0

[Section recorded along tributary of Eagle Creek that rises to the south from the Erie Railroad in Hiram Township, on the Freedom-Hiram Township line, 2.2 miles east of the common corner of Mantua, Hiram, Freedom, and Shalersville Townships]

	Ft	in
Pennsylvanian System, Pottsville Formation:		
Homewood Member:		
Sandstone, massive, clayey	20+	0
Mercer Member:		
Shale, gray, silty, even-bedded; contains plant fossils	2	0
Shale, light-gray, clayey to silty	2	0
Shale, black, carbonaceous	0	8
Shale, light-gray, clayey, even-bedded	2	0
Clay, fat, light-brown; contains plant fragments	3	0
Shale, dark-gray, sandy; contains plant fragments	2	6
Shale, light-gray, very sandy	2	6
Concretionary layer, light-gray, hard	0	8
Shale, light-gray	0	8
Shale, black, hard, fissile, carbonaceous	3	0
Shale, light-gray, clayey	1	6
Shale, black, hard, fissile, carbonaceous	0	2
Clay, lean, light-brown	7	6
Shale, light-blue-gray; contains silty beds	15	0
Connoquenessing Member:		
Sandstone, light-gray, clayey, micaceous; crossbedded to southwest; contains plant fossils	5	0
Shale, light-gray, clayey to silty; contains concretions	4	0
Shale, gray, very sandy; many plant fossils; coal streaks up to ¼ in. thick; in places a weak conglomerate with angular pebbles of silty clay	3	0
Sandstone, blue-gray, fine-grained	8	0
Sandstone, medium- to coarse-grained, clayey, micaceous; crossbedded to west, southwest, southeast, north, and northwest; numerous plant fossils; in places beds containing numerous rounded pebbles and granules of quartz	23	0
Shale unit of Sharon Member:		
Shale, medium-gray, silty to clayey; in places finely laminated gray and darker gray	25	0
Conglomerate unit of Sharon Member:		
Sandstone, light-gray, medium- to fine-grained; crossbedded to southwest	20+	0