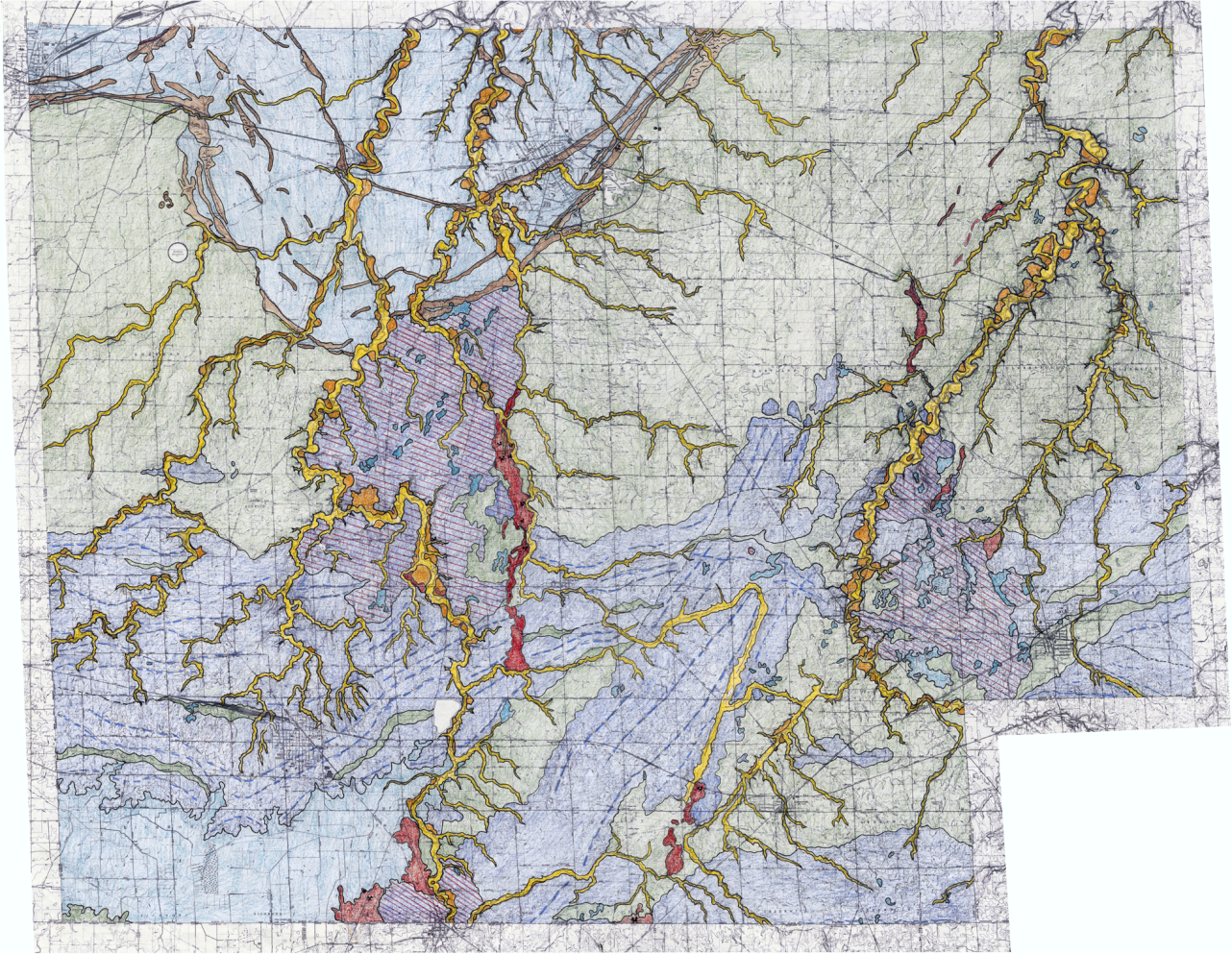


Glacial Geology of Huron County, Ohio

by
Stanley M. Totten



Open-File Report 85-2
Columbus 2017



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FOREWORD

Stan Totten worked on both his M.S. and Ph.D. with Dr. George White who was at the University of Illinois in Champaign-Urbana. Together, they spent every summer in the 1960s and early- to mid-1970s field mapping glacial geology in Ohio, one county at a time. As White's health declined during the late 1970s, Totten's role increased.

After graduation from the University of Illinois, Totten taught at Hanover College in southern Indiana. While teaching at Hanover College, he continued working summers for the Ohio Geological Survey mapping about one county each year. He conducted fieldwork each summer and then wrote the report and manuscript during the school year. Totten was dedicated, often working 12-hour days all summer to complete the fieldwork.

Lab analysis on samples collected in the field were conducted by either the Survey's sedimentology lab in Columbus, by John Szabo at the University of Akron, or by Totten's students at Hanover College.

Four mapping staff members joined the Survey during 1983–1984, along with a lab technician for the sedimentology lab, to form a Quaternary mapping subsection within the Regional Geology Section. Three of the new staff members, Rene Fernandez, Rick Pavey, and I, were assigned Seneca, Erie, and Sandusky Counties, respectively, in western north-central Ohio.

During the early 1980s, Totten was assigned to map several counties in eastern north-central Ohio, essentially an area between that previously mapped by White and Totten in northeastern Ohio and that being mapped by the newer staff members. Totten was tasked with extending westward the stratigraphic nomenclature used for the eastern Killbuck Lobe in Ashland, Medina, and Richland Counties, linking with mapping being done by the Quaternary mapping subsection. He mapped Crawford, Hardin, Huron, Lorain, Marion, and Morrow Counties during this period. Additional impetus for mapping in Morrow County was the result of research done for the field trip guidebook for the 1987 Midwest Friends of the Pleistocene Field Conference, which centered on Knox, Morrow, and Richland Counties.

Totten produced manuscript reports and draft maps (at a scale of 1:62,500) for each of these counties. The original goal was to publish a report of investigations for each county map and report that Totten produced, as well as the county maps and reports being produced by the Quaternary mapping subsection.

The maps and manuscripts were left unpublished for a number of reasons:

- The Survey encountered funding problems during the late 1980s, and the printing process was very expensive for both the maps and bound reports.
- The cartographic work for producing the maps was totally manual and involved an elaborate process of creating photographic negatives for base maps, peel-coats, scribing, type-setting and other steps that took a team almost a year to produce one map. And since there was inadequate cartographic staff to produce the maps and reports, this level of detail and completion was not provided for all the counties.
- Totten's ability to create tables, captions, and figures was very limited by the technology of that time, thus all this work fell on the editorial and graphics section.
- USGS funding supported reconnaissance-level mapping at a regional scale, and the concept of county-based maps and reports was abandoned by the Survey in favor of 30 x 60-minute quadrangle-based mapping initiatives. This was done to meet USGS standards being introduced nationally at that time.

It should be noted that these maps and reports are scanned as-is and may include typos, errors, editorial notes, and other marks. Maps are largely hand-colored and may represent the "final" of several versions. Legends accompanying the maps also may be hand-colored.

The Survey feels that these manuscripts may be of value to the public, academia, and perhaps consulting/geotechnical geologists. The reports contain a tremendous amount of particle size and mineralogical data and in-depth discussions of the materials and stratigraphy. The maps depict only the uppermost surficial materials and geomorphology, and they are very detailed. The maps and reports are of value to those who might need info on the background geology of a specific county, are doing detailed work in the county, or have a keen interest in the glacial geology of north-central Ohio.

Mike Angle
May 24, 2017

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PLATE

1. Glacial deposits of Huron County, Ohio

INTRODUCTION

Huron County is located in northern Ohio as close as 7 miles south of Lake Erie, 40 miles southwest of Cleveland, and 40 miles southeast of Toledo. It is bounded on the north by Erie County, on the east by Lorain and Ashland counties, on the south by Crawford, Richland, and Ashland counties, and on the west by Seneca County (fig. 1). The county lies between 82 20' and 82 50' west longitude, and between 40 59' and 41 17' north latitude. Huron County, which also originally included Erie County, was authorized in 1809 and was organized in 1815. Huron County was contained in the southwestern corner of the Connecticut Western Reserve land grant, and the Connecticut origin of the settlements is commemorated in many of the township and village names. The county was surveyed on a plan of five mile square townships, and townships were each divided into four sections. Many roads in the county follow the township and section lines. The county is moderately sized with an area of 497 square miles, and its population according to the 1980 Census was 54,490, of which 31,580 reside in incorporated cities and villages. The county seat and largest city is Norwalk (pop. 14,348) located near the northern edge of the county. Other cities are Willard (pop. 5,666) and Bellevue (pop. 3,949). The larger villages are New London (pop. 2,439), Greenwich (pop. 1,446), and Monroeville (pop. 1,336). Historically,

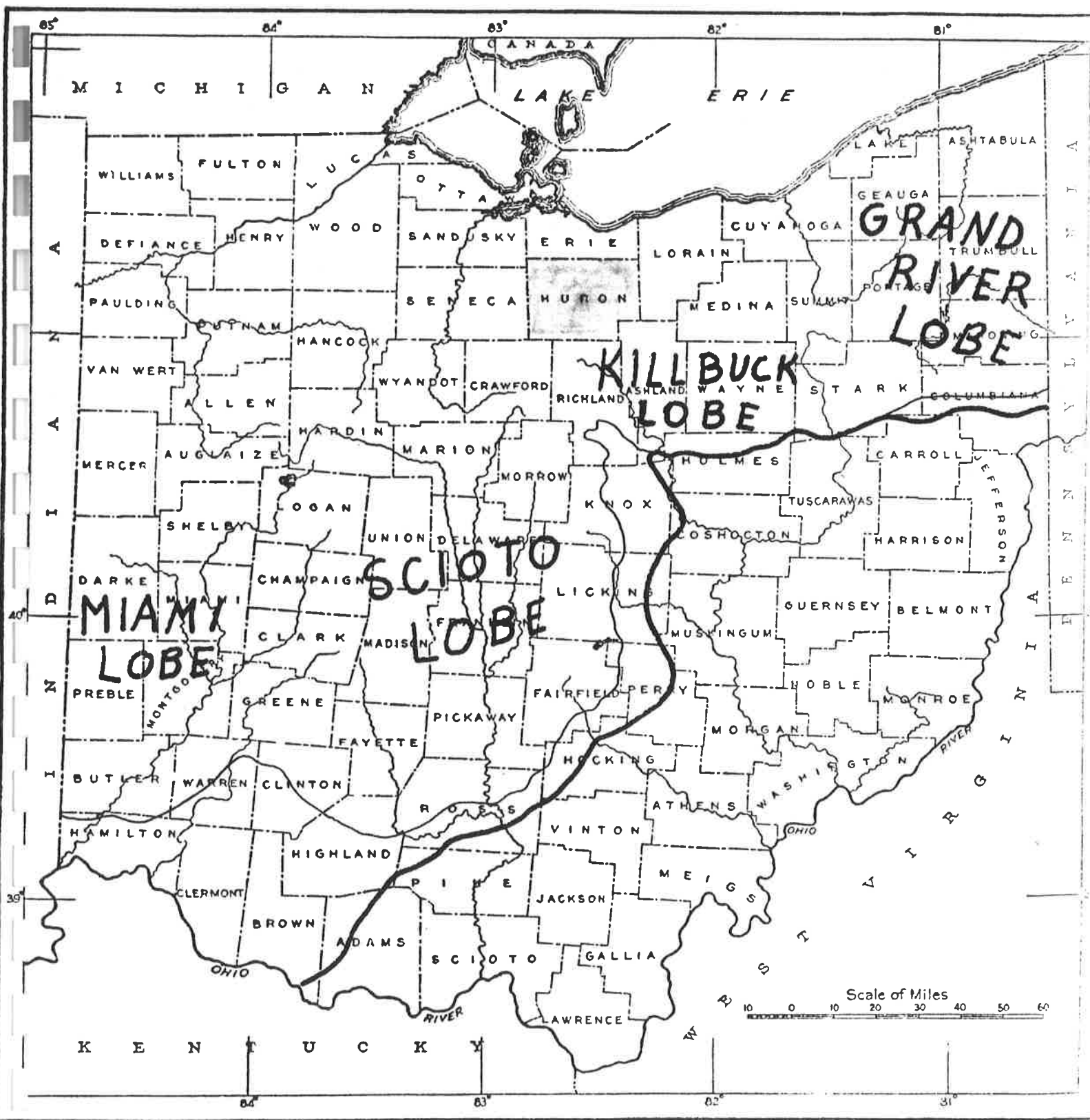


Figure 1. Map showing location of Huron County, glacial boundary (heavy line), Woodfordian drift boundary (light line), and glacial lobes.

the county has been a rural, agricultural area serviced by small villages and traversed by relatively few major highways. Drainage improvements and crop fertilization have transformed the county into one of the best agricultural areas of the state. The peat and muck soils of ancient Lake Willard, devoted largely to growing vegetables, rank among the most productive soils in North America.

The advent of the railroad led to important industrial development in Norwalk, Willard, Bellevue, Monroeville, and New London. Willard also contains important railroad terminals and shop facilities.

Topographic map coverage for Huron County is included on the following 7½ minute maps: Bellevue, Berlin Heights, Brighton, Centerton, Clarksfield, Flat Rock, Greenwich, ^{Kimball} Kipton, Milan, Monroeville, New London, New Washington, Norwalk, Nova, Olivesburg, Shelby, Shiloh, and Willard.

ACKNOWLEDGMENTS

This report is based primarily on field study by the author in the summer of 1983, aided by the study of aerial photographs, soil maps, and well records. Dennis Hull and Jim Ernst offered valuable comments and helpful suggestions in the field. John Szabo of the University of Akron analyzed till samples for grain size distribution and carbonate content. Mr. Horace Collins, State Geologist, provided support and encouragement in the development of this report.

PURPOSE AND SCOPE

This report describes the glacial drift, the surface material overlying the bedrock. Related to the glacial drift is an area of lake deposits about 7 miles wide in the northwestern part of the county. Stratigraphy of the deposits and the morphology of the land forms are described and correlated with deposits and surface features in adjacent counties in Ohio. Economic resources of the deposits are considered and suggestions made for their utilization and conservation.

This report will be of interest to various groups and individuals: highway engineers, construction firms, sand and gravel operators, architects and city planners, and soil scientists. Citizens who are or who will be responsible for planning and shaping the future of Lorain County for agriculture, urbanization, recreation, and industrialization will find this report useful for making their decisions.

PREVIOUS INVESTIGATIONS

One of the earliest investigations of the geology of northern Ohio including Huron County was made by Colonel Charles Whittlesey (1838, 1848, 1850, 1866, 1869). His observations focused on the lake ridges bordering Lake Erie and he was of the opinion (Whittlesey, 1850, p.32) that the ridges were not ancient beaches of the lake but were submarine deposits (sand bars). Newberry (1874) in an analysis of the surface features of Ohio gave an enlightened account of the beach ridges of Huron County, and the map following page 58 (map prepared by A.A. Wright) is the earliest detailed map showing the lake ridges of the county. Newberry's analysis (1874, pp. 63-65) of the origin of the beach ridges is an excellent example of the use of modern beach processes to explain ancient geologic features.

The earliest report specifically on the geology of Huron County was that of Read (1878, pp.290-309), who described the surface features, drift, bedrock, and economic deposits. Read recognized five terrace levels which he believed were "old water planes" or former levels of Lake Erie. He recognized the ancient sand dunes associated with the beach ridges in Lyme Township, and he mentioned that swamp soil (peat) which contained the remains of conifer trees extended beneath the dunes and sand ridges.

Leverett, in his monograph on the Erie Glacial Lobe (1902) described the topographic features and the materials of Huron County. His report contains the earliest delineation of the Defiance moraine in the county, and he described the eskers and raised beaches in considerable detail. Carney (1911) mapped the abandoned shorelines in Huron County in great detail, and his descriptions of these features have been useful in the present study. Forsyth (1959) has published interesting and useful maps of the beach ridges based primarily on Carney's mapping. Lake beds including the bed of Lake Willard were studied by Hubbard and Rockwood (1942). A recent study of glacial Lake Willard was made by Hodges (1979). A comprehensive report on the glacial and lacustrine deposits of Huron County was made by Campbell (1955).

The principal source of information regarding water supply is the report by Stout, VerSteeg, and Lamb (1943, pp.371-378). Preliminary maps of generalized ground water conditions of the Huron, Sandusky, and Vermilion river basins have been prepared by Stein (1962a, 1962b, 1962c), and Pree (1962) has prepared the ground water report for the Black River basin.

The detailed soil report and map of Huron County by Wildermuth, Mickelson, and Mozier (1955) is a useful but somewhat outdated reference in the study of the surficial materials. A new report is being prepared by Ernst.

Reports on adjacent counties provide information on glacial deposits along the margin of Huron County. County reports include Erie County (Campbell, 1955, Pavy^e, in preparation) to the north, Lorain County (Totten, in manuscript) to the east, Ashland County (White, 1977) to the southeast, Richland County (Totten, 1973) to the south, Crawford County (Totten, in preparation) to the southwest, Seneca County (Echelbarger, 1978, Fernandez, in preparation) to the west, and Sandusky County (Angle, in preparation) to the northwest.

PHYSIOGRAPHY

Topography

Huron County has a varied topography that ranges from flat to gently rolling to steeply sloping in places. The flat surfaces are the former lake bottoms of Lake Erie in the northwestern part of the county and Lake Willard in the southwestern part of the county. The central and southern parts of the county are gently rolling and are characterized by numerous swampy areas. The steepest topography is along valley walls where steep cliffs nearly 100 feet high may occur.

The topography of Huron County is controlled mainly by the nature of the glacial deposits. Dominating the topography are hummocky end moraines, irregular knobs, and swampy kettles. Several broad sandstone knobs occur in Townsend and Wakeman townships in the northeastern corner of the county, and several valleys have been deeply entrenched into both drift and bedrock. These valleys were cut as much as 200 feet below the uplands in several places during preglacial and interglacial times and then were partially filled with drift during and following glaciation. The modern valleys have been entrenched into these earlier deposits to depths of 70 feet or more.

The highest elevation in Huron County, approximately 1205 feet, is located in the Wabash moraine in southern Greenwich Township near the Huron—Richland county line. The lowest

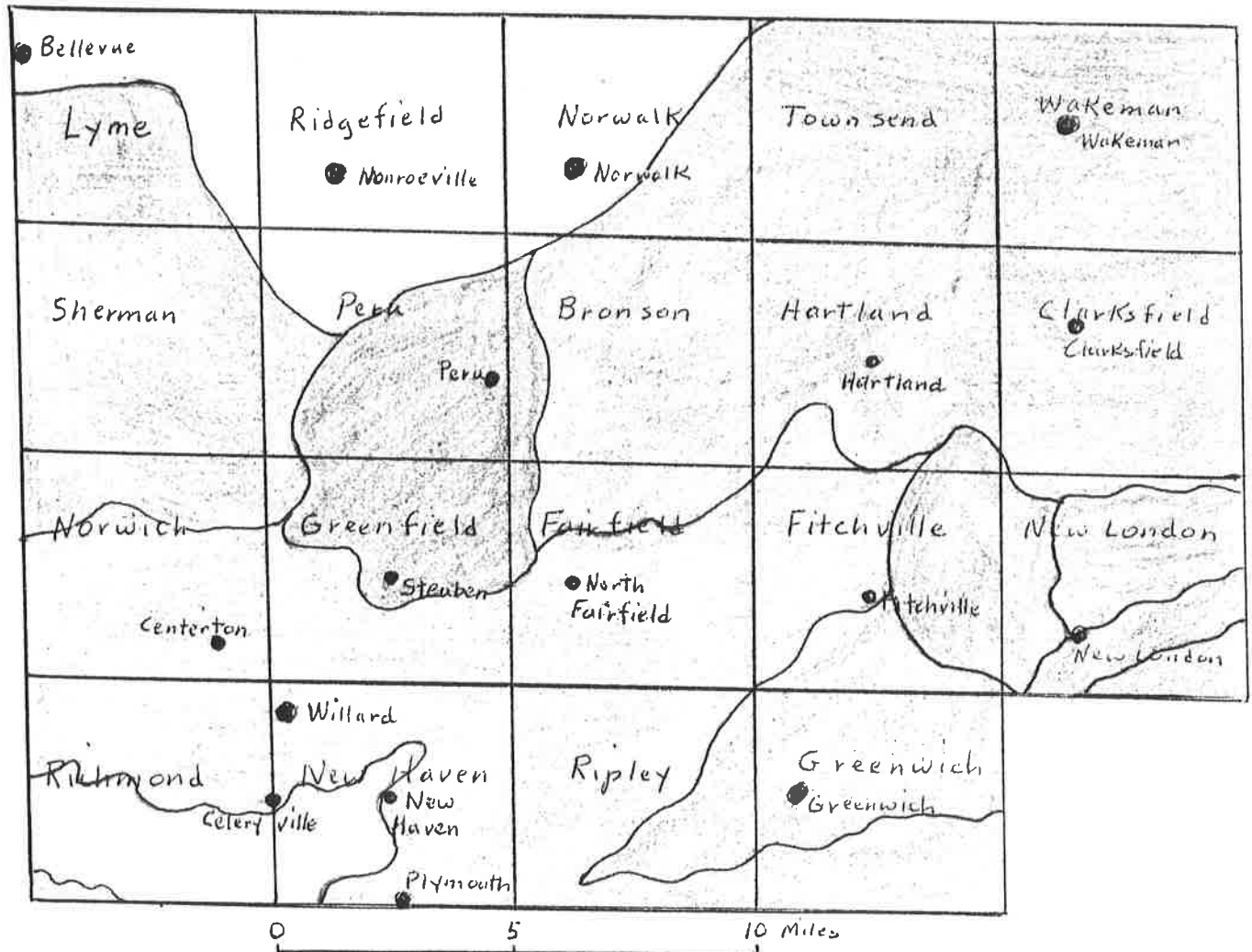
elevation in the county is about 600 feet in the valley of Huron River along the Huron—Erie county line in northern Norwalk Township.

Physiographic Provinces

General Statement

Huron County is located at the junction of three major physiographic sections as defined by Fenneman (1928, 1938) and modified by White (1934) and Campbell (1955). The three are the Eastern Lake Section of the Central Lowland Province in the northern part of the county, the Low Plateau Section of the Allegheny Plateau Section in the eastern half of the county, and the Till Plains Section of the Central Lowland Province in the western half of the county. The Low Plateau, first recognized by White (1934), is a transitional zone between the Till Plains and the Allegheny Plateau which occurs at the southeast corner of the county. The boundary between the Low Plateau and the Till Plains follows the contact between the Berea Sandstone to the east and the Bedford Shale to the west (fig. 3).

For this report, local physiographic divisions have been recognized (fig. 2) based on the prominent glacial features in Huron County. Only the Lake Plain in the northwestern part of the county is retained from the earlier classification. The main distinction in the classification used in this report is between the hummocky end moraine and gently rolling till plain. In addition the unique glacial features which include the bed of Lake Willard and the two areas of knob and kettle topography are given special recognition.







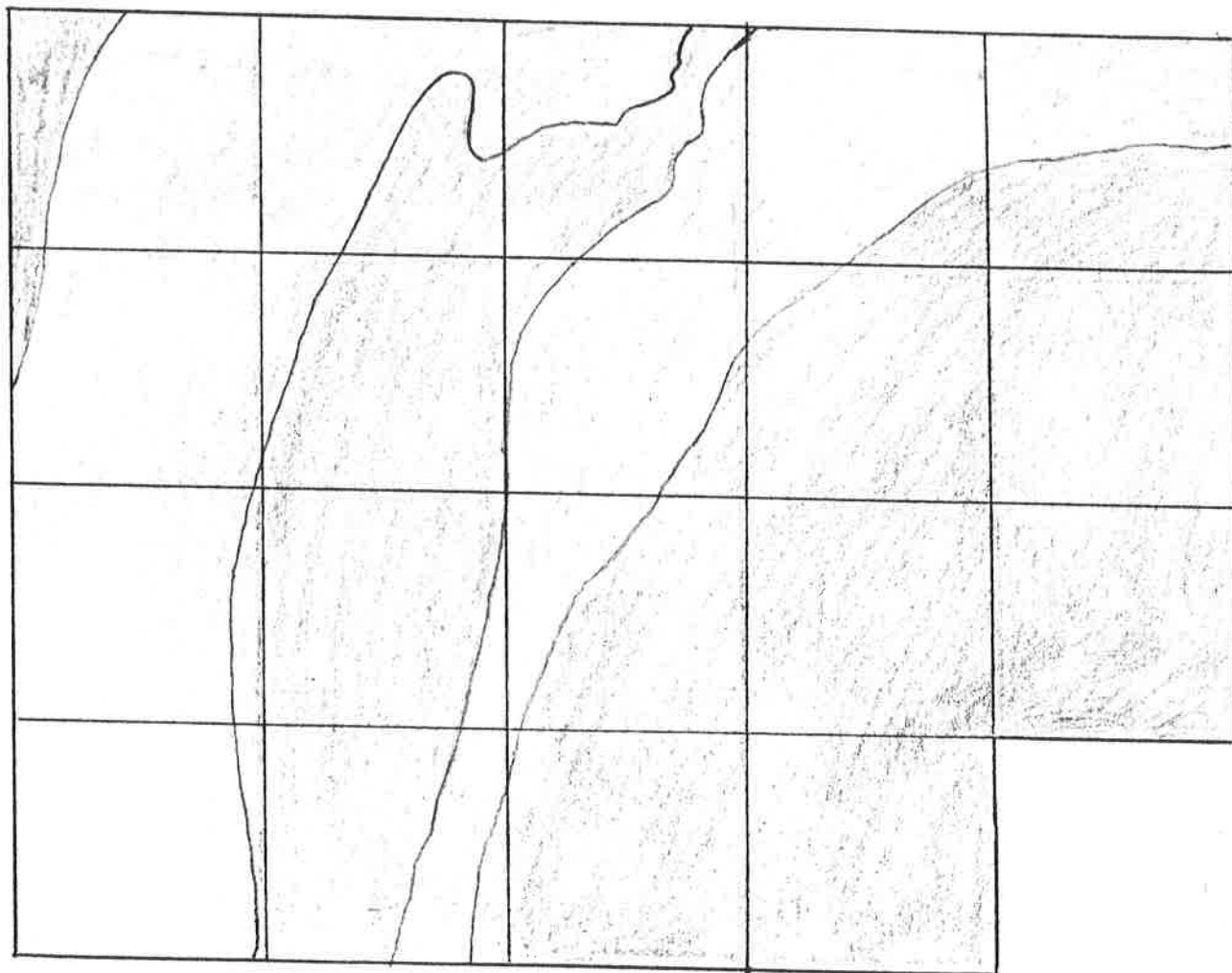


-  Lake Plain
-  Till Plain
-  Morainic Upland
-  Knob and Kettle Topography

Figure 2. Physiographic divisions of Huron County



Dev.-Miss. 

Devonian 

Mississippian



Cuyahoga Formation



Berea Sandstone



Bedford Shale

Figure 3. Generalized bedrock map of Huron County (after Campbell, 1955)

Till Plain

The Till Plain is a smooth, slightly undulating surface that comprises most of northern Huron County (fig. 2). A secondary area of Till Plain occurs in the southeastern corner of the county. Every township except Ridgefield, Richmond, and New Haven contains a portion of Till Plain, and six townships, Wakeman, Townsend, Clarksfield, Hartland, Bronson, and Sherman, are almost entirely covered by Till Plain. The smooth Till Plain surface resulted from several glacial advances during which the bedrock surface was scoured and most stream valleys were filled with drift. The major features on the Till Plain are the rounded Berea Sandstone knobs in Townsend and Wakeman townships, and numerous entrenched valleys which occur in many areas. The Till Plain surface is underlain by till of variable thickness, from a few inches to several tens of feet where buried valleys occur beneath its surface. The drift covering is particularly thin over the sandstone knobs, and generally is thin in a belt bordering the southern margin of the Lake Plain.

Morainic Upland

The morainic upland is a belt of smooth, rounded hummocks and broad ridges which trends east—west across the southern part of Huron County (fig. 2). The continuity of this belt is interrupted by a small area of knobs and kettles in Fitchville and New London townships, by an area of till plain centered in northern Greenwich Township, and by Lake Plain in New Haven and Richmond Townships. The Morainic Upland is formed by a composite of several end moraines, the Defiance, Delphi, New Washington, Ft. Wayne, and Wabash, which are closely bunched. Topographically, the moraines exhibit great diversity, ranging from broad smooth ridges to sharp knolls and hummocks. In most places, the Morainic Upland surface is moderately rolling, with hummocks 10 to 20 feet high arranged in a linear or ridge—like manner.

Knob and Kettle Topography

Two large somewhat oval areas of knob and kettle topography occur in Huron County (fig. 2). The larger area includes most of Peru Township, the northern half of Greenfield Township, the western fringe of Bronson Township, and the northwestern corner of Fairfield Township. The smaller knob and kettle area is located 8 miles east of the larger area, and includes eastern Fitchville Township, the western part of New London Township, and the southeastern corner of Hartland Township. These unusual areas are characterized by irregular masses of prominent knobs or knolls 20 to 40 feet high that resemble kames. The knolls contrast sharply with the smoother topography of the morainic ridges that border the knolls to the south. Irregularly shaped kettles of widely ranging sizes up to 0.4 mile long (Plate 1) are interspersed among the knolls. The eastern boundary of the larger knob and kettle area is marked by an esker which trends north-south in Bronson and Fairfield townships. East Branch Huron River also follows the eastern margin of this area. West Branch Huron River likewise marks the western boundary of knob and kettle topography in Peru Township; however in Greenfield Township, West Branch meanders through the heart of the knobs.

The smaller knob and kettle area is similar in appearance to the larger, and is characterized by several knobs that project nearly 40 feet above their surroundings. The prominent knolls along State Highway 162 between New London and Fitchville appear

to be situated on an earlier morainic ridge, which adds to the prominence of the knolls. The kettles in the smaller knob and kettle area are extensive, and in places attain a width of about 1 mile. The western margin of this area is marked by the valley of Vermilion River. Two small southward trending eskers, one in Hartland Township, the other in Clarksfield Township, terminate against or near to the northern margin of this area.

The knobs in both knob and kettle areas resemble kames. Some knobs may be typical kames composed of sand and gravel and which later were covered with till of variable thickness. Other knobs may be composed mostly or entirely of till. Till occurs at the surface in nearly every exposure in this area; masses of sand and gravel often are encountered in deep cuts.

Lake Plain

The Lake Plain in northwestern Huron County (fig. 2) is a nearly featureless northward sloping surface that was briefly covered by early stages of Lake Erie immediately following deglaciation of the county (Totten, 1985). During its highest level of 780 feet, about 14,500 YBP, (Totten, 1985), Lake Erie extended about 7 miles into Huron County, reaching its southernmost point in the Huron River embayment south of Monroeville. The area of lake plain includes all of Ridgefield Township, all but the southeastern corner of Norwalk Township, the northern part of Peru Township, and much of Lyme Township. The gradual northward slope of 10 to 20 feet per mile is broken by numerous beach ridge segments 3 to 6 feet high and by patches of dunes 5 to 20 feet high. The Lake Plain is dissected by East Branch and West Branch Huron River and their tributaries which are entrenched as much as 60 feet below the surface of the plain. The buried Norwalk Valley (fig. 5) trends north—northeastward across the plain. Elsewhere the plain is developed mainly in the bedrock which is thinly veneered with drift. In the Bellevue area where the bedrock consists of soluble carbonates, the lake plain surface is characterized by shallow sink holes, sinking streams, and underground drainage.

Lake Willard Plain

Ancient Lake Willard occupied an area of about 16 square miles in Richmond and New Haven townships. The lake spilled over a short distance into Richland and Seneca counties, and it is drained both by Honey Creek to the west and by West Branch Huron River to the northeast. The center of the lake basin is an almost featureless plain at an elevation of 925 to 930 feet. The margins and western part of the lake plain exhibit slight relief where the lacustrine sediment is draped over the gently rolling pre-lake topography. The lake shoreline at its maximum extent stood at about 940 feet to the north bounded by the Defiance moraine, and it stood at slightly higher elevations of 945 feet to 948 feet at the south. The higher shoreline levels were occupied only briefly, and lake levels fell to about 930 feet following deglaciation of northern Ohio. The Lake Willard Plain has poor natural drainage; ditching and tiling has turned the former swamp of pioneer days into some of the most fertile soil in the state of Ohio.

DRAINAGE

Modern Drainage

The major divide separating Ohio River drainage from Lake Erie drainage follows the belt of end moraines a short distance south of Huron County. Consequently, all of Huron County drains northward to Lake Erie. Nearly all of Huron County is drained by two major river systems, the Huron and Vermilion rivers, which have their headwaters in the prominent system of end moraines along the Huron-Richland county line. A small area of southwestern Huron County is drained by Honey Creek, and a small part of eastern Huron County is drained by Black River. In the northwestern corner of the county in the Bellevue area the surface waters have been diverted by sinkholes underground to create an area of internal drainage.

The drainage changes markedly from south to north in the county in response to changes in topography. In the southern half of the county where moraines are the dominant landform, the streams tend to be small, closely spaced, and have highly irregular courses as they flow between morainic elements and around groups of knolls. In the northern half of the county there are fewer but larger streams whose valleys are entrenched into the till plain and lake plain surfaces.

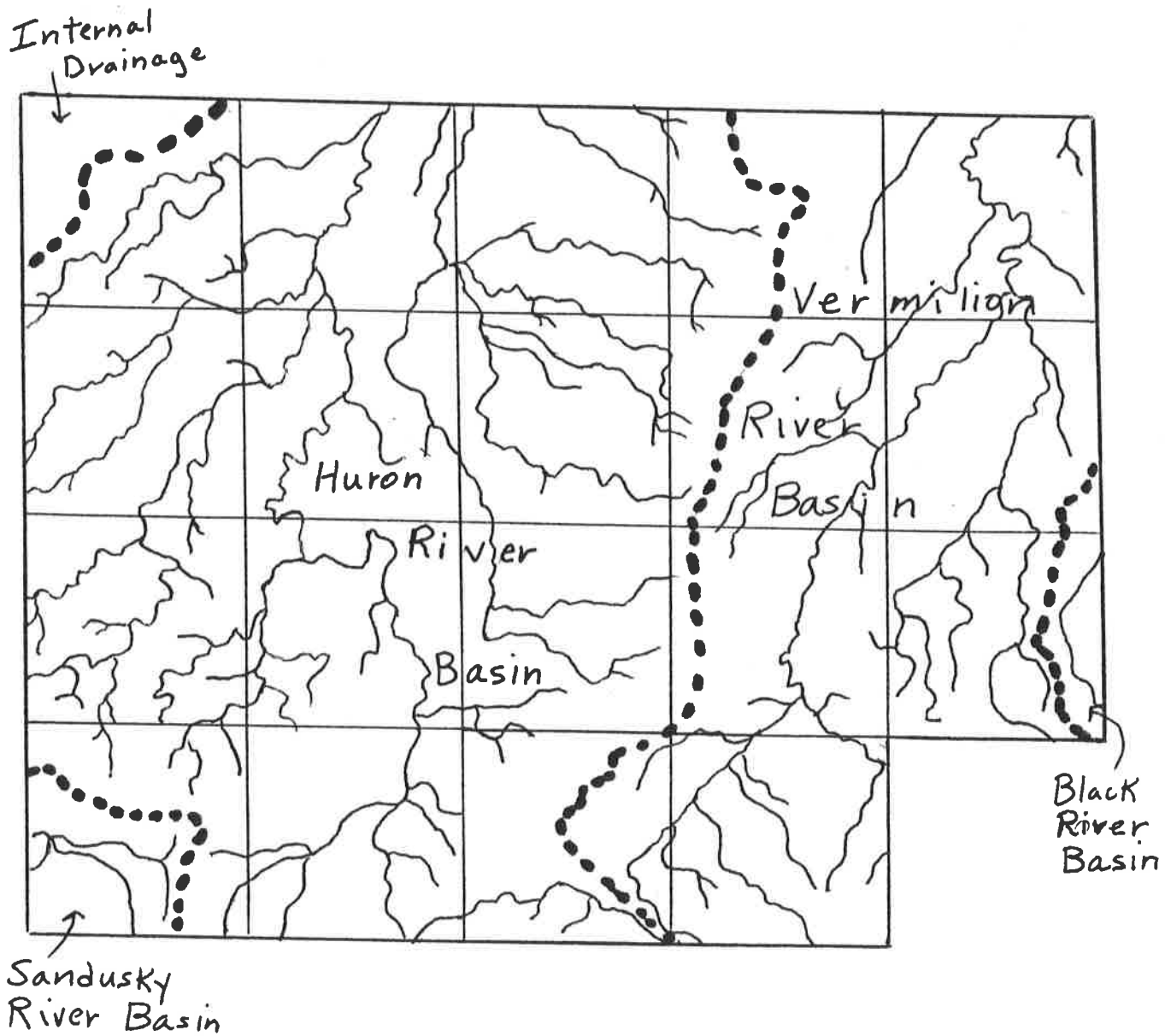


Figure 4. Modern drainage of Huron County
 Drainage divides shown by dashed lines.

Vermilion River Drainage Basin

The Vermilion River and its major tributaries including Southwest Branch, Indian Creek, and East Branch, drain nearly all of the eastern third of Huron County (fig. 4). The Vermilion River originates in Savannah Lakes in northern Ashland County and flows north-northwestward into Huron County at the northeastern corner of Greenwich Township. It continues its northwestward course to Fitchville, from which it follows a north-northeastward course to Clarksfield and Wakeman, and thence into Erie County. From Fitchville to Wakeman the valley of the Vermilion River is entrenched about 30 feet below the upland, and north of Wakeman the entrenchment is 60 feet or more. The flat bottom valley floor is 1500 to 2500 feet wide including the terrace remnants. Although the Vermilion River makes numerous sharp meanders, the valley follows a straight northeastward course, possibly joint controlled, from Fitchville to Wakeman. Several tributaries also have similar straight courses trending northeastward.

The drainage in New London and Fitchville townships is mostly poor or sluggish; many undrained depressions remain untouched by the modern drainage system. Southwest Branch Vermilion River, which originates in the Wabash moraine along the Huron-Richland county line, drains parts of Ripley and Greenwich townships and enters the Vermilion River a short distance south of Fitchville. Southwest Branch and its tributaries display prominent linear northeast and northwest trends which

appear to be joint controlled. East Branch Vermilion River originates in the Defiance moraine near New London, and it also has a northeastward trend in New London and Clarksfield townships. It enters the Vermilion River near the Wakeman-Clarksfield township line a short distance south of the village of Wakeman.

Black River Drainage Basin

The northeastern corner of New London Township is drained by East Creek, a tributary to West Branch Black River located primarily in Lorain County. East Creek flows northeastward for a distance of only about 2.5 miles in Huron County.

Huron River Drainage Basin

Nearly all of the western two-thirds of Huron County is drained by East Branch and West Branch Huron River and their many tributaries. Both East Branch and West Branch head near Greenwich and flow in a generally northward direction, their valleys coming as close as 0.5 mile in northern Peru Township. The two valleys join to form the Huron River in Erie County north of Norwalk only 0.2 mile north of the Huron-Erie county line.

East Branch originates in the large linear depression between two elements of the Delphi moraine in the southwestern corner of Fitchville Township. East Branch follows a highly irregular course north-northwestward as it cuts across elements of the Delphi and Defiance moraines. In Peru Township, the

valley of East Branch widens and becomes entrenched about 20 feet below the upland. Terraces are present in the valley bottom, and the stream assumes a meandering course within the wide valley. At the west edge of Norwalk the valley is entrenched 50 to 60 feet below the lake plain, and shale is exposed along the very steep valley walls near the Huron-Erie county line. Nearly all of the tributaries of East Branch enter from the east. Two of the largest tributaries are Cole Creek which drains much of Bronson Township, and Norwalk Creek which drains much of Norwalk Township.

West Branch Huron River heads in the Wabash moraine a short distance south of the Huron-Richland county line south of Greenwich. West Branch flows mainly westward across elements of the Wabash FT. Wayne and Delphi moraines in southern Ripley Township. Near Plymouth in southern New Haven, West Branch bends sharply northward and follows a northward course the entire length of the county. In New Haven and southern Greenfield Townships, West Branch flows across the northeast corner of the bed of ancient Lake Willard and across several elements of the Defiance moraine. In northern Greenfield Township, West Branch makes an abrupt turn westward around the knob and kettle topography of southern Peru Township. In northern Peru Township, West Branch resumes its northerly course across Peru and Ridgefield townships to the Huron-Erie county line where it makes an abrupt bend eastward to join with East Branch to form the Huron River. The valley of West Branch ranges in

width from about 0.2 mile wide near Plymouth to nearly 0.4 mile wide near Monroeville. The valley is entrenched 20 to 40 feet through the moraines of southern Huron County, and is entrenched 40 to 60 feet, mostly in shale, from Monroeville northward to the Huron-Erie county line. West Branch meanders within its wide valley, and terraces are well-preserved in the valley in many places.

Nearly all of the tributary drainage of West Branch enters from the west. These tributaries include Seymour Creek, Megginson Creek, Frink Run, Slate Run, Mud Run, Marsh Run, and Walnut Creek, and they collectively drain eastern Seneca County and western Huron County. Mud Run, Slate Run, and Frink Run have valleys sufficiently wide to have small terrace segments preserved in them.

Sandusky River Drainage Basin

Southwestern Richmond Township in the southwestern corner of Huron County is drained by Honey Creek which is a tributary of the Sandusky River. Honey Creek originates near Tiro in northeastern Crawford County and flows northward into Huron County to the ancient bed of Lake Willard where it makes a westward bend. Honey Creek flows west-northwestward along the southern border of the Defiance moraine from Richmond Township into Seneca County. Honey Creek drains about two-thirds of the Lake Willard plain including the central marsh area which is a wildlife refuge.

Pleistocene Drainage Systems

The Pleistocene and pre-Pleistocene drainage history of northern Ohio including Huron County is complicated and many details are imperfectly understood. Most reconstructions of pre-glacial drainage (Coffey, 1958; Stout and other, 1943) suggest that the drainage in Huron County was northward to a major river which flowed northeastward in what is now the Erie Basin occupied by Lake Erie. Glaciers scoured the weak sedimentary rock in the Erie Basin and in western Ohio south of Lake Erie, thereby removing much of the evidence for these ancient river valleys. A reconstruction of the buried valleys preserved in Huron County (fig. 5), based on the bedrock contour map (Plate 1), indicates the existence of two major northward trending buried valley systems. These systems are the Wakeman River system which formerly drained eastern Huron County, and the Norwalk River system which formerly drained western Huron County. This reconstruction is similar to that proposed by Stout and others (1943) and designated as Teays (preglacial). It is not known whether these buried valleys actually are preglacial or whether they have an interglacial origin. A cross-section (fig. 13) across the buried Norwalk River valley reveals the valley is shallow with gently sloping sides. Compared with modern valleys, the cross-section indicates the ancient Norwalk Valley probably was modified by glacial erosion, and perhaps only the lower part of the valley is preserved.



Figure 5. Buried valley systems of Huron County
(Based on bedrock contour map)

The course of the ancient Wakeman River is followed in some places by the modern Vermilion River and one or two of its tributaries. The course of the ancient Norwalk River is followed in a few places by tributaries of Huron River though the major Norwalk River channel is almost completely drift filled.

Drift Thickness

The thickness of glacial deposits overlying the bedrock in Huron County (fig. 6) ranges from near zero in portions of the till plain and lake plain in the northern part of the county to 200 feet or more in one or two buried valleys. Areas of thin drift may be determined from field observations in stream beds and along valley walls. Where the drift thickness is greater than a few feet, water well records (logs) represent the major source of subsurface information.

In general, the thinnest drift in the county, drift less than 20 feet thick, occurs in northwestern and north-central Huron County (fig. 6) in the till plain and the lake plain. Drift of moderate thickness, 50 to 100 feet, occurs in the area of end moraine in the southern part of the county. Drift in excess of 100 feet is found mainly in the Norwalk and Wakeman buried valleys (fig. 6). The average drift thickness in the county is 55 feet.

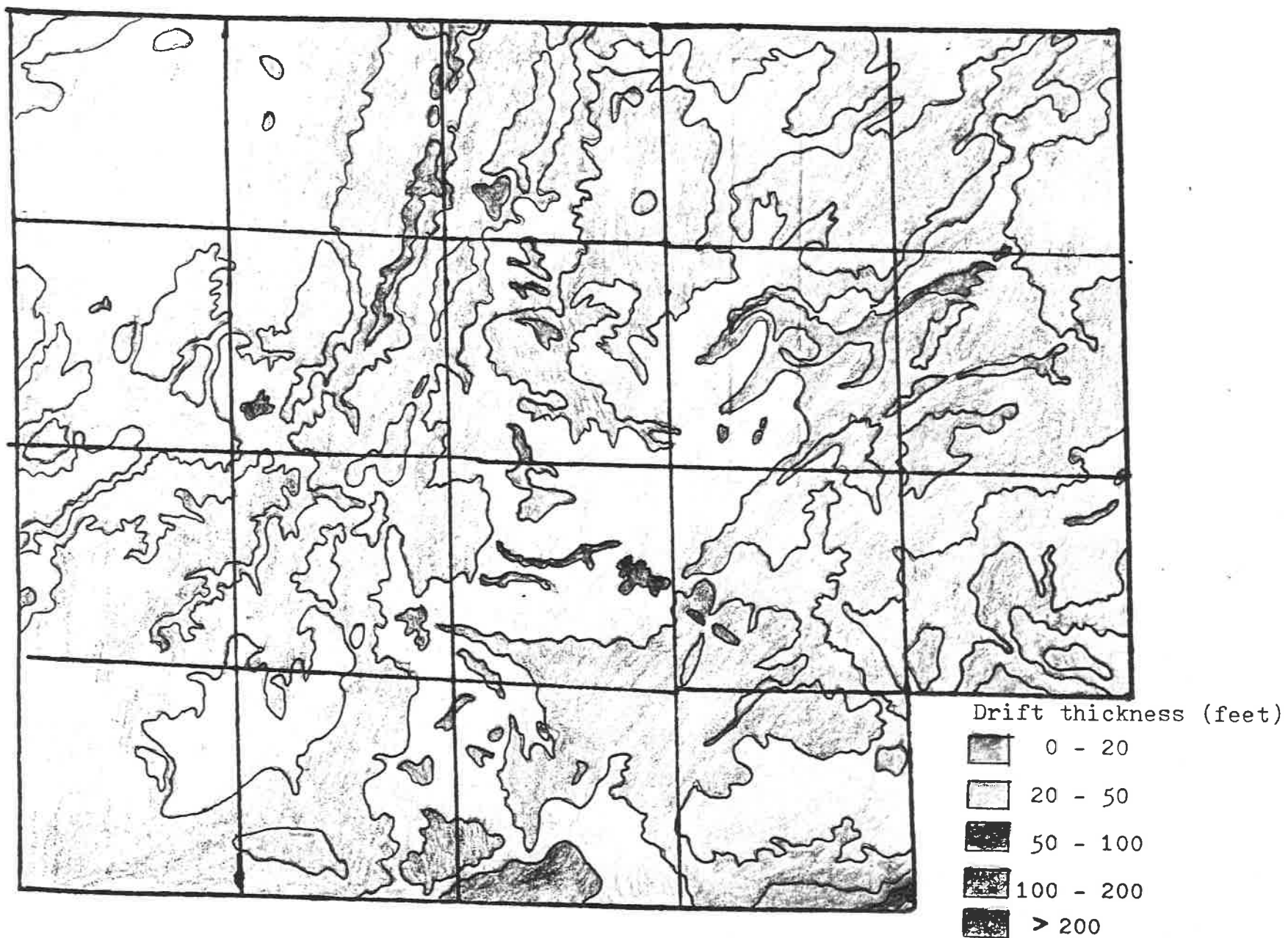


Figure 6. Drift-thickness map of Huron County
(Modified from open-file map prepared by

Glacial Erosion

Glaciers moving mainly southward in Huron County scoured the bedrock surface and removed all traces of preglacial soil developed on the bedrock. It is not possible to determine the amount of glacial erosion but some general postulations are possible. It is probable that glacial erosion was more effective in the shale of western Huron County than it was in the Berea and Cuyohoga sandstones and siltstones of eastern Huron County (fig. 3). As mentioned previously in this report, the buried Norwalk River valley, developed in shale, shows evidence of considerable glacial erosion.

Unknown amounts of older till may have been eroded during later ice advances, principally the Millbrook, as pre-Millbrook Till is scarce in Huron County. The only feature in Huron County of probable pre-Millbrook age, the Delphi moraine, apparently has been removed by glacial erosion over most of the county. Erosion of the underlying Millbrook Till by thinner ice associated with the Woodfordian glaciation apparently was negligible.

TILL DEPOSITS

Nearly all of the glacial deposits at the surface and in shallow to deep cuts in Huron County are of the Wisconsinan Stage, the latest stage in glacial history (table 1). It is probable that pre-Wisconsinan deposits occur deeply buried beneath Wisconsinan deposits, primarily in buried valleys and in the Delphi moraine.

Deposits of several advances of Wisconsinan ice are sufficiently distinctive to be separated in the exposures where they may be seen. It is to be expected that, in any large exposure showing considerable thickness of glacial material, the glacial material will have been deposited by more than one ice advance and will differ more or less in character. The till deposited by each ice advance often is very thin. The last ice advance into Huron County, ice that deposited the Hiram Till, covered all of the county. Yet the Hiram Till is thin or nonexistent at many places so that the uppermost recognizable till is not Hiram, but the earlier Hayesville Till. At places where the Hayesville Till is very thin, even earlier till may be evident close to the surface.

Table 1. Classification of glacial deposits in Huron County

Epoch	Stage	Substage	Unit or interval	Material	Approximate Dates (Years BP)	
Pleistocene	Wisconsinan	Woodfordian	Postglacial Late glacial	Alluvium, loess, peat, lacustrine, gravel, sand, silt and clay	15,000	
			Hiram Till	Dark brown clayey silty till	17,000	
			Hayesville Till	Dark brown silty till	19,500	
			Navarre Till	Yellow brown silty sandy till	23,000	
		Farm-dalian	Ice retreat (Plum Point Interstade)	Stones, silt, sand, and gravel	33,000(?)	
		Altonian	Millbrook Till (several units)	U	Olive brown, dark gray, and dark gray brown hard stony till; sand and gravel lenses	40,000 (75,000?)
				A		
				BI		
				BII		
	L					
Pre-Wisconsinan		"Old"	Dark gray brown silty, stony, pebbly till			

Character and Composition of the Till

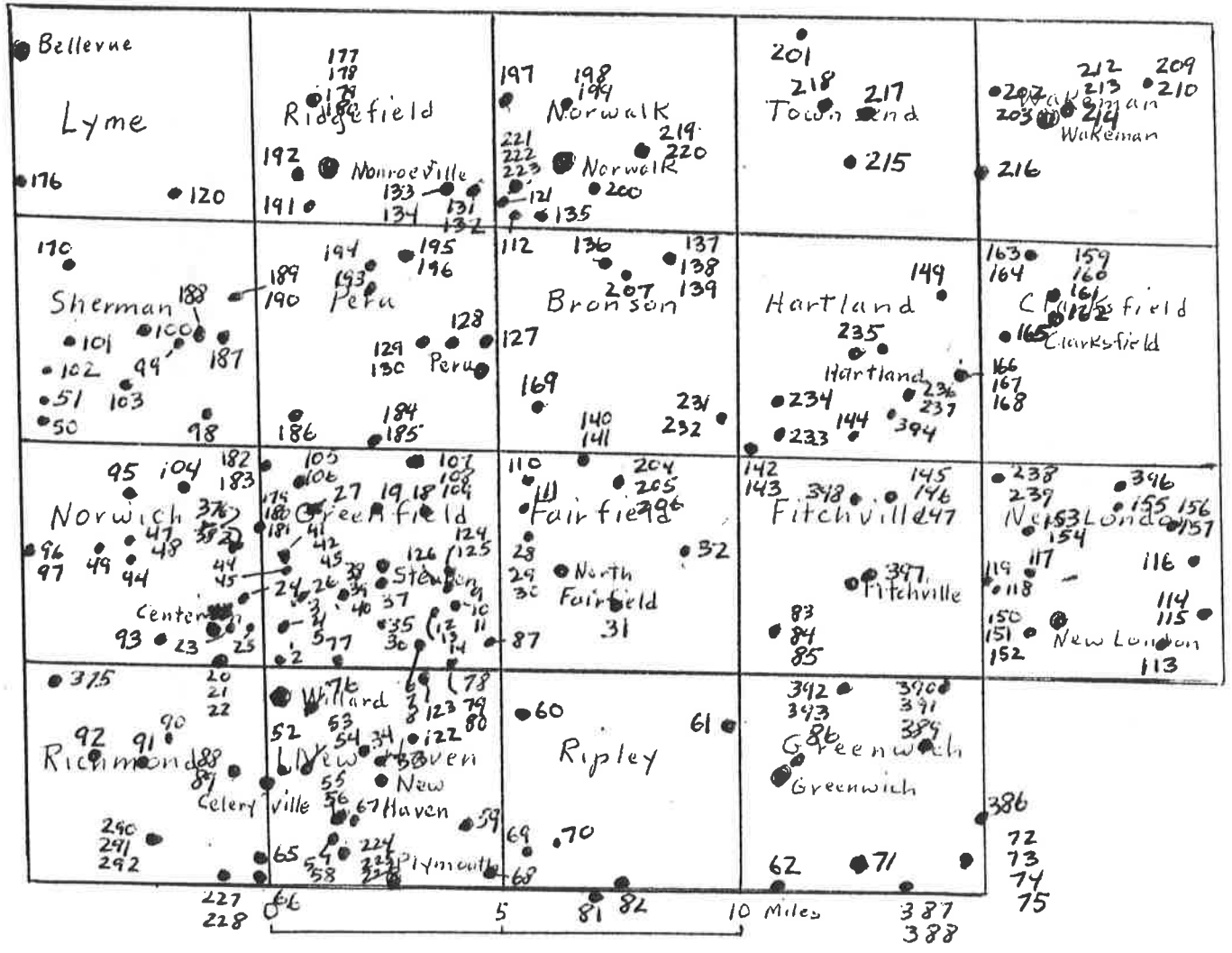
General Statement

The various tills in northern Ohio may be distinguished from one another by using several criteria including texture, composition, color, and weathering horizons. These characters are dealt with in more or less detail in several publications describing the glacial geology of Richland County (Totten, 1973), Wayne County (White, 1967), and Ashland County (White, 1977) to name just a few. In Huron County till of the latest (Hiram) ice advance forms the surface drift, but at some places where the latest till is thin or missing, an earlier till may be exposed at the surface. Earlier tills may be exposed in a few ravines and river valleys where postglacial erosion has cut away the younger tills.

Samples of unleached till were collected in all parts of the county for laboratory analysis (Fig. 7). Detailed laboratory analysis are given in Appendix 4.

Texture

Tills in northern Ohio range from quite sandy tills with a relatively low clay content to clayey tills with a low sand content. The texture (grain size) of each till is reasonably constant over a large area. The till at the surface in Huron County is clayey, but relatively silty and sandy tills are



171
172
173
174
175

Figure 7. Huron County sample localities

found a few feet below the clayey till. Textural data for Huron County tills are shown in Table 2.

Mineral Composition

Tills differ in content of quartz, feldspar, and carbonate minerals. The mineral composition of tills in northeastern Ohio to the east and south of Huron County has been the subject of studies by Totten (1960) and Heath (1963). These studies indicate that the quartz content of tills ranges from 65 to 89% being highest in the oldest tills. The feldspar content ranges from 11 to 35%, being highest in the youngest tills, and the carbonate content, composed of both calcite and dolomite, ranges from 5 to 21%. The carbonate content, including the calcite/dolomite ratios, has proven useful in identifying the units of Millbrook Till. Mineral content of tills is included in Appendix B.

Color

The color of till is a subtle but very useful physical characteristic in till identification. At almost every thick till section, two dominant colors may be seen: brown where oxidized at the surface and gray where unaltered at depth, the boundary between the colors commonly being 8 to 12 feet below the surface. The original gray color is due primarily to ferrous iron; oxidation to ferric iron gives the till a brown color, the shade of which is characteristic and consistent for each till. The oxidized tills at and near the surface of Huron County

Table 2. Statistical data of till sample analyses for Huron County

Till Unit	No. of Sam- ples	Sand		Silt		Clay		Calcite		Dolomite		Total Carbonate		<u>Calcite</u> <u>Dolomite</u>
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Hiram	38	18	6	42	6	40	7	5.4	2.9	5.9	1.8	11.3	3.8	0.92
Hayesville	75	21	4	44	6	35	6	6.4	3.8	5.6	1.9	12.1	4.9	1.14
Navarre	70	25	6	45	9	30	8	5.0	2.9	5.0	1.9	10.0	3.8	1.00
U	5	27	5	43	8	30	9	7.2	1.2	5.1	0.5	12.4	1.5	1.41
Millbrook	A	16	6	47	8	25	8	3.9	1.6	6.6	2.5	10.5	3.9	0.59
	BI	15	6	47	10	26	9	0.3	0.7	5.2	1.9	5.5	2.4	0.06
	BII	3	4	45	4	37	1	1.6	1.5	6.0	1.7	7.6	3.0	0.27
	BL	4	11	48	13	23	15	5.1	2.7	5.2	4.2	10.4	6.2	0.98
"Old"	2	20	5	56	4	24	1	5.6	7.9	7.4	1.3	13.0	9.2	0.76

are generally dark brown, tending toward chocolate brown, whereas the older subsurface tills are yellow brown to olive brown.

Weathering Horizons

Where the upper part of a till has not been removed by erosion or the work of man, tills can be divided vertically into five distinct horizons, based on degree of weathering, as shown in figure 8. In the weathering of till the first minerals to be attacked are the iron-bearing minerals, especially pyrite. These are oxidized, furnishing the brown color to the weathered till. Carbonates are leached, and the most resistant minerals, the silicates, are degraded.

Horizon 5 is the unaltered till; the iron bearing minerals have not been oxidized, and the carbonates have not been leached. On drillers' and engineers' records, this horizon is sometimes called "blue clay with stones", but the color is some shade of gray, rather than blue. Its top is 8 to 12 feet below the surface. In Huron County gray till may be seen in the deeper highway cuts, in gravel pit excavations, and in the cliff sections along major streams.

Horizon 4 is calcareous till similar to that of horizon 5, except oxidized to a brown color. The top of horizon 4 is also the depth of leaching, which ranges from about 2 feet below the surface in the Hiram Till to as much as 6 feet in Navarre Till.

Horizon 3 is similar to horizon 4, except that in horizon 3 the carbonates have been leached. Iron oxide and manganese

stains may be present along joints.

Horizon 2 (essentially the B₃ horizon of soil scientists) is the zone of decomposed till underlying the main part of the true soil. The horizon is not only oxidized and leached, but is also considerably weathered, and some of the pebbles and cobbles may have been decomposed. Some clay material has accumulated in the joints, and soil-forming processes are advanced. The material is not so completely weathered, however, that it cannot be identified as once having been till. The color of the upper part generally is a mixture of buff, gray, and brown. The lower part may have dark stains along the joints.

Horizon 1 is the soil, divided into the A and upper B soil horizons of pedologists. The characteristics of the soil differ with drainage and slope, as well as with parent material. The soils of Huron County are described in detail in a report with detailed maps (Wildermuth and others, 1955).

Millbrook Till

The Millbrook Till was named for a village in Wayne County by White (1961) who traced the deposit across Wayne and Ashland counties (White, 1967, 1977) mainly as a subsurface unit. Totten (1973) traced the Millbrook Till across Richland County into Huron County where the till occurs in the subsurface beneath Hiram, Hayesville, and Navarre Till. Because of its stratigraphic position beneath the younger tills, the Millbrook Till is exposed only in deep excavations and in stream cuts; still rarer are the places where a complete Millbrook section can be seen. Deep excavations and stream cuts have exposed Millbrook Till as much as 16 feet thick, and it is probable that Millbrook Till extends down to bedrock in many places. Millbrook Till is thought to average about 10 feet in thickness north of the Defiance moraine in the northern part of the county, and to average about 30 to 40 feet in thickness in the morainic areas in the southern and central parts of the county.

Millbrook Till may be recognized by its dense, hard (firm) nature and its silty, pebbly, stony texture. Typical Millbrook Till is much harder and compact than the overlying Woodfordian tills. Millbrook Till often exhibits reddish brown to black stains along prominent joints and in pebble molds. These rusty joints commonly extend downward one or two feet below the oxidized zone. The hard, compact till may be broken with difficulty, and the till breaks around pebbles and stones in such a way to

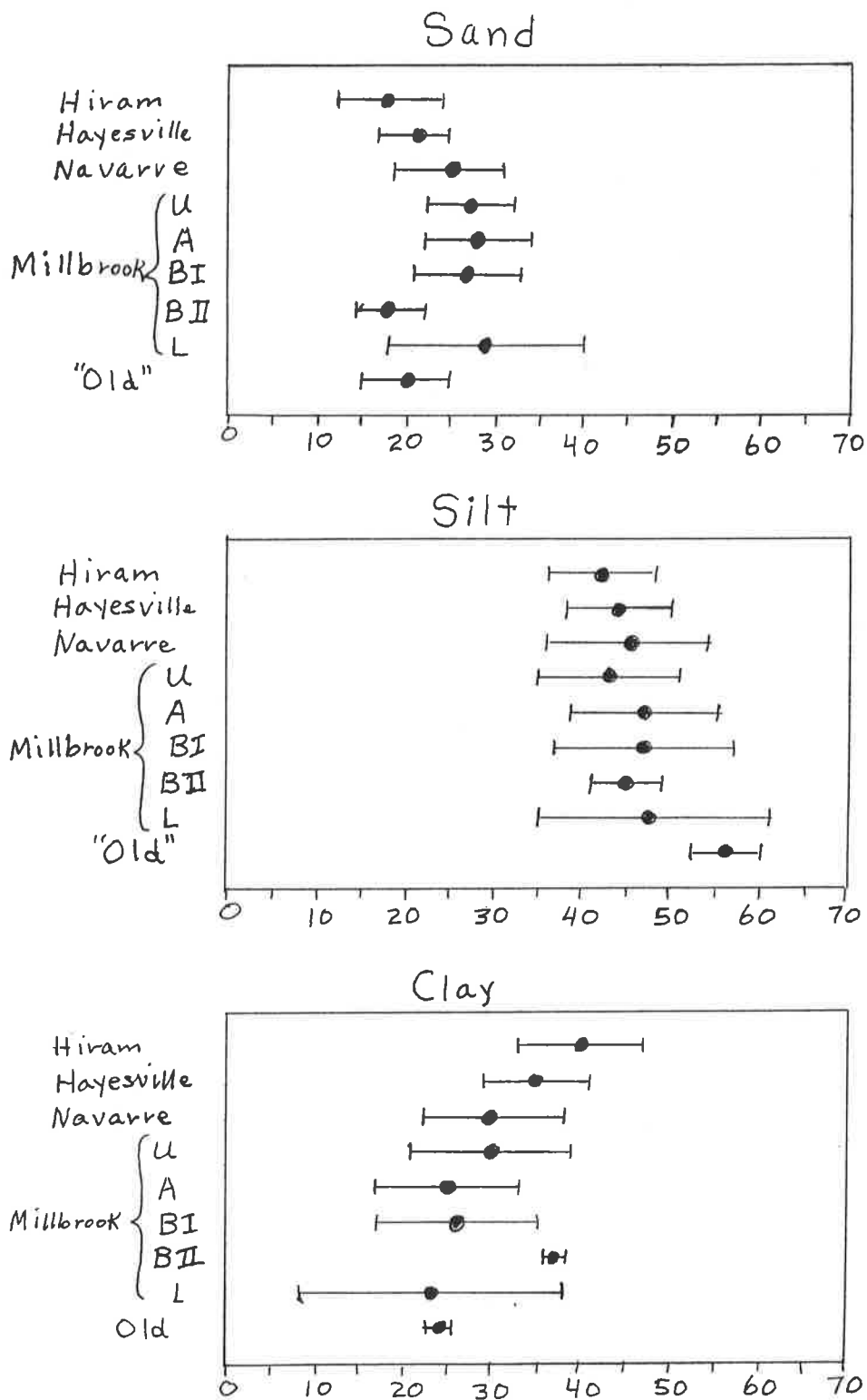


Figure 8. Plot of means (solid circles) and standard deviations (solid lines) of sand, silt, and clay percentages of Huron County till units.

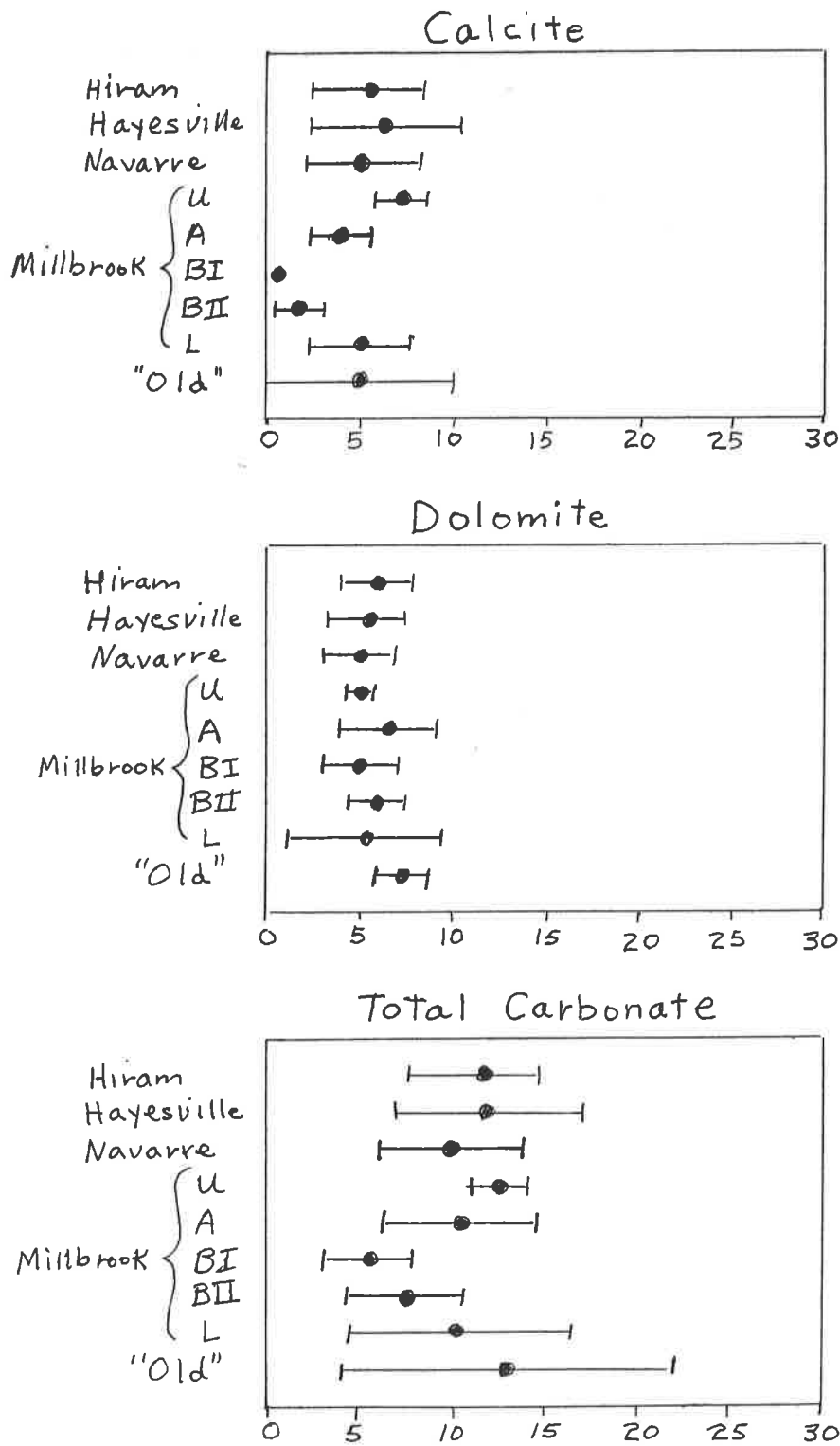
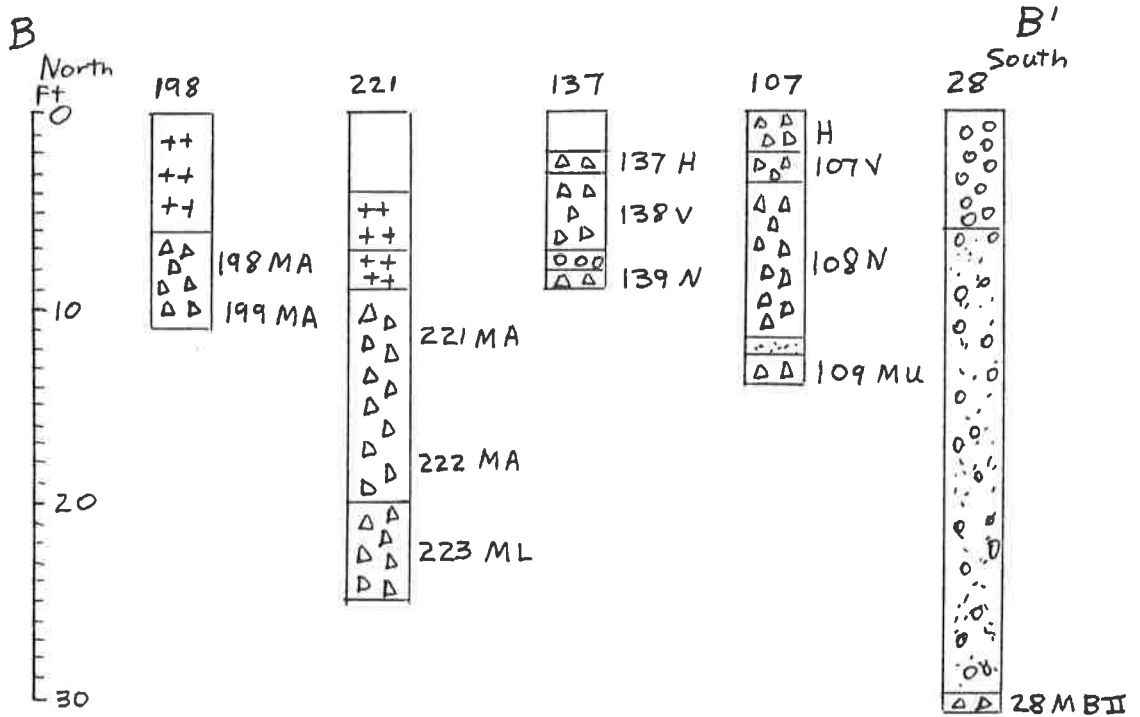
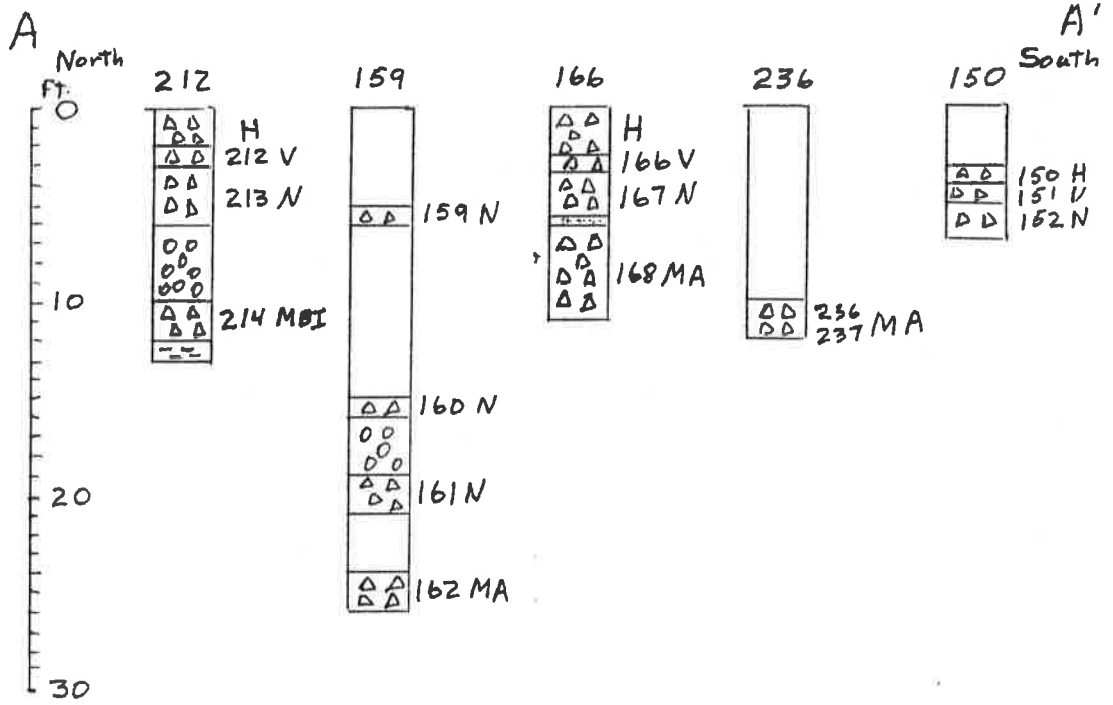


Figure 9. Plot of means (solid circles) and standard deviations (solid lines) of carbonate percentages of Huron County till units.



preserve perfectly the pebble shapes as molds.

Millbrook Till oxidizes to various shades of brown, most typically olive brown (2.5Y 4/4). Unoxidized Millbrook Till exhibits several shades of gray, most typically very dark gray (5Y 3/1).

In Huron County, Millbrook Till is divided into five units based on stratigraphic position, sand and gravel layers, and carbonate composition. These five units, designated from top to bottom U, A, BI, BII, and L have similar physical appearances and are best subdivided by carbonate composition.

The lowermost Millbrook unit, Unit L, occurs deeply buried beneath younger Millbrook till and gravel in the western part of the county, and this unit probably is (or was) present over the entire county, though it is rarely exposed. Its occurrence beneath 35 feet of gravel in New Haven Township and its occurrence near bedrock in Norwich Township are good indications that Unit L predates both the major kame and moraine building episodes of the Millbrook glaciation in Huron County. Unit L is silty, sandy, contains equal amounts of calcite and dolomite, and has a moderate carbonate content of 10.4 percent.

Unit BII is characterized by a high clay content and by relatively low calcite and total carbonate percentages. This unit also occurs deeply buried beneath younger Millbrook till and gravel. At the Price Sand and Gravel Company pit along Ridge Road in Fairfield Township, Unit BII occurs beneath 30 feet of gravel (the Norwalk esker). Unit BII also occurs at the base of the concrete spillway of Holiday Lakes north of Willard.

The distribution and thickness of this unit are unknown.

Unit BI is characterized by an extremely low calcite content (near zero) and a low 5.5 percent total carbonate content. Both the calcite and total carbonate values are significantly lower than the values for Unit BII, and these values are very much lower than the other tills in Huron County. Unit BI is widespread as a subsurface unit in Huron County where it often occurs near bedrock. The thickest exposure of Unit BI, 15 feet, occurs in the buried Norwalk River valley in southeastern Ridgefield Township. Near the northeast corner of Willard Reservoir, Unit BI is in two layers separated by very dark gray sand and gravel 4 feet thick.

Unit A is characterized by relatively low calcite content, relatively high dolomite content, and a relatively high sand content. It is the most widespread Millbrook unit in Huron County, and it apparently makes up the bulk of the Defiance moraine in the county, though exposures deep enough to prove this are lacking. The thickest exposure of Unit A is in the deep cuts along U.S. Route 20 Bypass southwest of Norwalk where the till is 11 feet thick. Unit A occurs in most deep exposures and it is well-exposed near Monroeville, Norwalk, and Clarksfield. It also occurs in the Defiance moraine north of Willard, but exposures are not adequate to determine its distribution in the moraine.

Unit U, the uppermost Millbrook unit, is characterized by a relatively high calcite content which averages 7.2 percent, and a high total carbonate percentage which averages 12.4 percent.

Unit U probably is widely distributed in Huron County though it is thin and discontinuous which makes tracing difficult. Its color is intermediate between the yellow brown Navarre and the olive brown of the Millbrook A and B units; however, Unit U is much harder and is more stony than Navarre Till.

The top of the Millbrook Till is characterized by a concentration of stones, silt, sand, and gravel, though the stone line is not as well-developed in Huron County as it is in Lorain County (Totten, in manuscript). This zone on top of the Millbrook is as much as 7 feet thick, though the normal thickness is 4 to 6 inches. A similar concentration of stones, sand, and gravel occurs between Millbrook units in many places.

The Millbrook Till and its correlatives form the bulk of the till in the moraines of north-central Ohio (Totten, 1969; White, 1982). The multiple units of Millbrook Till indicate a complex depositional history which probably includes both minor readvances during ice retreat, and thrusting of the ice near its outer margin.

The Millbrook Till and its correlatives are closely associated with thick, high quality gravel deposits in many places in north-central and northeastern Ohio (White, 1982; Totten, 1973). Much of the gravel in Huron County apparently was deposited by meltwaters from melting Millbrook ice.

The Millbrook Till is correlative with the Jelloway Till of the Scioto Lobe (Totten, 1973), the Mogodore Till of the Cuyahoga Lobe, and the Titusville Till of the Grand River Lobe

(White, 1982). White and others (1969) have assigned an Altonian (Early and/or Middle Wisconsinan) age for Titusville Till based on several radiocarbon dates of about 40,000 YBP.

Navarre Till

The Navarre Till, the oldest of three Wisconsinan (Woodfordian) tills deposited in Huron County, was named by White (1961) for the village of Navarre in southwestern Stark County. This till has been traced by White (1967; 1977) at the surface and in the subsurface across Wayne and Ashland Counties, and by Totten (1973) who traced the till across Richland County into Huron County. The Navarre Till in Huron County occurs as a subsurface unit covered by Hayesville and Hiram Till.

Navarre Till ranges in thickness from 0 to 16 feet and has an average thickness, where it could be measured, of 44 inches. The base of the Navarre is not seen in most roadcuts and thus the till thickness was measured in relatively few places.

Navarre Till is silty, relatively sandy and pebbly, and has a loose crumbly or friable structure. The oxidized color of the till typically is dark yellow brown (10YR 4/4). In a few places where the till is thick, unoxidized gray (10YR 4/1) Navarre Till occurs about 11 feet below the surface. Weathering of the till produces distinct horizontal partings and a platy appearance.

Analyses of Navarre Till samples (Table Z, Appendix A) average 25 percent sand, 45 percent silt, and 30 percent clay. The carbonate content of Navarre Till samples averages 5 percent calcite, 5 percent dolomite, and 10 percent total calcite, for

a calcite/dolomite ratio of 1. The Navarre Till is similar to the Millbrook Till (U unit) in composition and color. However, the Navarre Till is much softer than the compact, firm Millbrook Till.

Navarre Till contains abundant pebbles, and a freshly broken till surface often displays small orange "spots" which are the exposed cross-sections of broken iron-cemented sandstone pebbles. The interface between the Navarre and the overlying Hayesville Till often is marked by a variable zone 2 to 3 inches thick, consisting of silt, sand, gravel, and stones sufficiently numerous to be labelled a stone line. Silt and sand lenses occur at places along the interface and are common also in the till.

The Navarre Till is correlated with the Kent Till of the Grand River Lobe of northeastern Ohio which has a radiocarbon age of 23,000 YBP (White, 1968). Thus the Navarre Till is earliest Woodfordian in age.

Hayesville Till

The Hayesville Till was named for the village of Hayesville in southern Ashland County by White (1961) who traced the till into Lorain and Richland counties. Totten (1973) traced the till into Huron County, where it occurs widespread over the entire county beneath a thin covering of Hiram Till.

Hayesville Till ranges in thickness from 0 to at least 156 inches and has an average thickness of 27 inches. It is less than 2 feet thick over most of the county (fig. II), and in places is only a few inches thick. Except for a few local exceptions (fig. II), only in Greenfield Township and bordering areas does the thickness of Hayesville Till exceed 2 feet. North of Willard and in a few other places (fig. II), the Hayesville Till attains a thickness of 7 to 13 feet.

Hayesville Till is predominately silty to silty clayey in texture, and is intermediate in sand, silt, and clay percentages between the Hiram and Navarre tills. Hayesville Till samples (table 2, Appendix A) average 21 percent sand, 44 percent silt, and 35 percent clay. Till samples average 6.4 percent calcite, 5.6 percent dolomite, and 12.1 percent carbonate, for a calcite/dolomite ratio of 1.14. Its calcite and carbonate averages are higher than the other tills widespread in Huron County, but the difference in carbonate composition among the three Woodfordian tills is very slight.

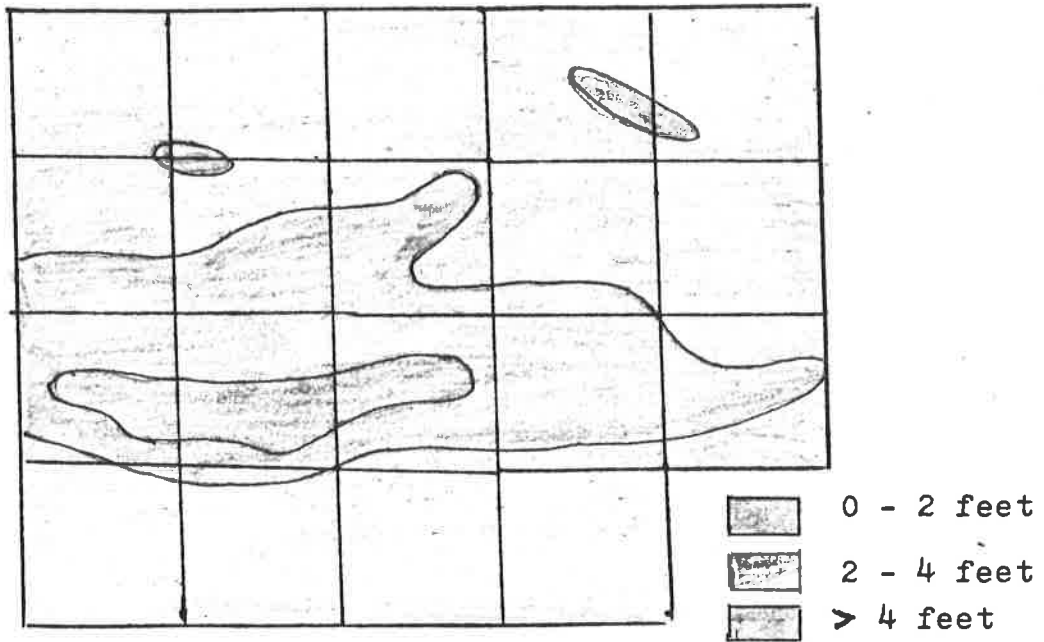


Figure 12 Generalized thickness of Hiram Till

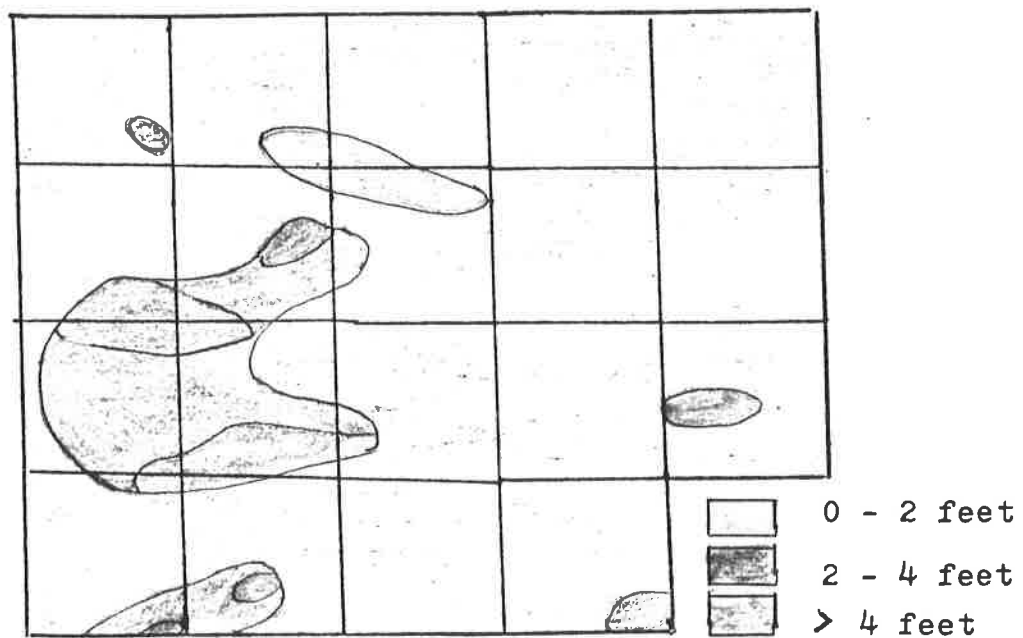


Figure 11 Generalized thickness of Hayesville Till

Hayesville Till is oxidized dark brown (10YR 4/3), a color very similar to the overlying Hiram Till. Some slight color variation has been noted in a few places where color notations 10YR 5/3, 10YR 4/4 (yellow brown), and "ginger" brown have been recorded. Unoxidized Hayesville Till at depths of 10 feet or more below the surface is dark gray to gray brown (10YR 4/1—10YR 3/2).

Hayesville Till breaks into large, roughly square blocks on a freshly exposed surface, and a short period of exposure causes horizontal partings to develop in the till, resulting in a platy structure. The till contains a moderate amount of pebbles and granules which are predominately sedimentary in origin—mostly shale. The presence of these granular particles is one of the best ways to distinguish between the Hayesville and Hiram tills.

The Hayesville Till is calcareous and secondary calcium carbonate may be concentrated in an area directly beneath the leached zone. Leaching of carbonates from the till is influenced by the thickness and composition of the overlying material. The depth of leaching may reach 42 inches if material overlying the Hayesville Till is thin or absent. In places where the thickness of the overlying material is less than two feet, the average depth of leaching is 34 inches.

The contact or interface between the Hayesville Till and the overlying Hiram Till is the most difficult till contact to detect in northern Ohio because little if any foreign material occurs between the tills. At about half of the sections exposing the two tills in Huron County, the interface between them is marked by a thin 1 to 2 inch-thick zone consisting of silt, sand, and small pebbles. Typically, the contact is marked by thin silt "streaks" or "stringers." In places where the two tills are in direct contact with each other, the contact may be detected by a slight difference in texture and by the pebble-granule content.

Hayesville Till is sufficiently near the surface in many places to influence the development of the soil profile. In Richland County (Totten, 1973) to the south, the Bennington—Cardington soil has been mapped in areas covered by thin Hiram Till where the permeable Hayesville Till allows better drainage and deeper root penetration beneath thin Hiram Till. In Lorain County (Totten, in manuscript) to the east, the Mahoning-Tiro soil association has been mapped in places where thin Hiram Till overlies Hayesville Till. In Huron County, the Bennington-Cardington soil association, as well as the closely related Alexandria and Condit soils, have been mapped in areas where Hayesville Till is the dominant parent material (Wildermuth and others, 1955).

The Hayesville Till was deposited during the Woodfordian glacial stade, and is intermediate in age between the older Navarre Till and the younger Hiram Till. Its exact age in radiocarbon years has not been determined because of the lack of datable organic material associated with the till; its estimated age is about 18,500 YBP based on its relationship to deposits of known age.

Table 3 Major soil associations and parent materials of soils in Huron County (in part after Wildermuth, Mickelson, and Mozier, 1955)

<u>Soil Association</u>	<u>Parent material</u>
Ellsworth-Mahoning-Trumbull-Marengo	Hiram and Hayesville Tills
Alexandria-Cordington-Bennington-Condit	Thin Hiram and Hayesville Tills
Wooster-Canfield-Ravenna	Thin till over Berea Sandstone
Olena	Sand and gravel
Ottawa-Berrien	Loose sand (dunes)
Ruggles-Bogart-Wilmer-Olmstead	Sand, silt, clay, and gravel
Painesville-Caneadea-Canadice-Lorain-Monroeville	Lacustrine silt, sand and clay
Prout-Fries	Thin silt and clay over shale
Mentor-Glenford-Fitchville-Luray	Sand, silt and clay
Chili	Gravel and sand in beach ridges, kames and eskers
Chagrin-Lobdell-Wayland-Papakating	Alluvial sand, silt and clay
Rifle	Lacustrine peat and muck
Carlisle	Lacustrine muck and peat
Walkill	Silt over muck and peat

Hiram Till

The Hiram Till, the youngest till in Huron County, was named for the village of Hiram in northeastern Portage County by White (1960). A thin covering of Hiram Till extends over all of Huron County excepting along stream courses where it has been eroded away. Hiram Till may be considered to be the surface material over nearly all the county, the main exceptions being the lake plains in the northwest and southwest where lacustrine materials occur.

The thickness of Hiram Till ranges from 0 to 108 inches and averages 27 inches. The till thickness is quite consistent over much of the county as over half of the 60 recorded measurements are between 20 and 30 inches. Hiram Till more than 2 feet thick occurs in an east-west belt across the center of the county (fig. 12), parallel to and along the northern margin of the Defiance moraine. The thickest Hiram Till, more than 4 feet thick, occurs in a narrow belt across Fairfield, Greenfield, and Norwich townships. Apparently the Defiance moraine presented a physical barrier to ice which deposited the Hiram Till, creating a local zone in which an increased thickness of till was deposited.

The Hiram Till is oxidized to a dark brown (10 YR 4/3) often with a slightly different shade of dark brown from the underlying brown Hayesville Till. The difference in color between the Hiram and Hayesville tills is so slight as to not

be a reliable criterion for distinguishing between them. Hiram Till is rich in silt and clay, has a blocky or prismatic structure, and where calcareous has a moderate carbonate content. Where thick, the till may contain an accumulation of secondary calcium carbonate which forms light gray films or mottles. Hiram Till is very sparsely pebbly, contains almost no granules, and sometimes may be mistaken for lacustrine clay which it closely resembles.

The depth of leaching of carbonates is dependent primarily upon the thickness of Hiram Till. In places where leaching has not progressed through the entire thickness of Hiram Till, the leaching depth usually is between 20 and 28 inches, and averages 25 inches. In places where Hiram Till is thin or absent, the depth of leaching in the underlying Hayesville Till ranges from 30 to 42 inches and averages 34 inches. In places where both the Hiram and Hayesville tills are thin or absent, the depth of leaching in the underlying Navarre Till ranges from 35 to 48 inches and averages 40 inches. In the subsoil, weathering of Hiram Till develops horizontal partings and a fine prismatic structure.

Analyses of Hiram Till samples (table 2, Appendix A) indicate the till averages 18 percent sand, 42 percent silt, and 40 percent clay. Thus the Hiram has the lowest sand and silt percentages, and highest clay percentage, of any till in Huron County. The textural difference between the Hiram and Hayesville tills is not as marked in Huron County as it is in

Lorain County to the east (Totten, in manuscript). Hiram Till samples average 5.4 percent calcite and 5.9 percent dolomite for an average calcite/dolomite ratio of 0.92 and an average carbonate content of 11.3 percent.

The major soil association developed in Hiram Till is the Mahoning-Trumbull-Ellsworth-Marengo association (Wilderemuth and others, 1955). Ellsworth soils are moderately well drained and occur on gentle to steep slopes in both the till plain and the end moraines. Mahoning soils are somewhat poorly drained and occur on level to gently sloping areas. Trumbull soils are poorly drained and occur on nearly flat areas. The upper part of the Trumbull profile is mottled gray brown, characteristic of poor drainage.

Although the Hiram is the youngest till in the county, late glacial and post-glacial events were responsible for deposition of a wide variety of materials on top of the till in many places. Numerous undrained shallow depressions existed on the till surface, and these are wholly or partially filled with lacustrine sediments such as clay, silt, marl, and peat. The widespread glacial lake sediments in the northwestern and southwestern parts of the county are described in another section.

Wind blown silt called loess which forms a silt cap at the surface in counties to the south (Totten, 1973) is not widespread in Huron County. A silt cap of probable wind origin ranging in thickness from 10 to 22 inches and averaging 14

inches, was recorded at 9 localities located primarily in the southern half of the county. The two localities of apparent loess in the northern part of the county are from Lyme and Bronson townships. The loess is characterized by a loose, friable, nearly pure silt texture and an almost total lack of pebbles.

Lacustrine silts differ from loess in that the lake deposits usually show some stratification and contains some clay which causes the material to be more dense and compact. Loess may be widespread over the surface of Huron County, but if this is so, it is too thin to be recognized. Generally where loess is thinner than about 8 or 9 inches, it becomes mixed with the underlying till or other material by organic activity and agricultural practices, thus rendering the loess unidentifiable.

GEOMORPHOLOGY OF THE GLACIAL DRIFT

General Statement

The surface expression of the glacial drift in Huron County has been produced by several ice advances and, during some of the retreats, by outwash deposits laid down upon, within, or beyond the melting ice. In addition to ice-related deposits, numerous lakes existed for varying lengths of time during and after disappearance of the ice, and these lake beds and former shorelines form distinctive features.

End Moraines

General Statement

Four major end moraines can be traced from the west and southwest into Morrow County (Plate ^{fig. 13} 1). From south to north in the county, these moraines are the Wabash, FT. Wayne, New Washington, and Defiance moraines. In Huron County these moraines trend mainly east-west except in the southwestern part of the county where the moraines bend southwestward from the Killbuck lobe into the Scioto lobe. A fifth end moraine, the Delphi moraine, occurs only in Huron County, and it has a northeast-southwest trend different from the trend of the other moraines.

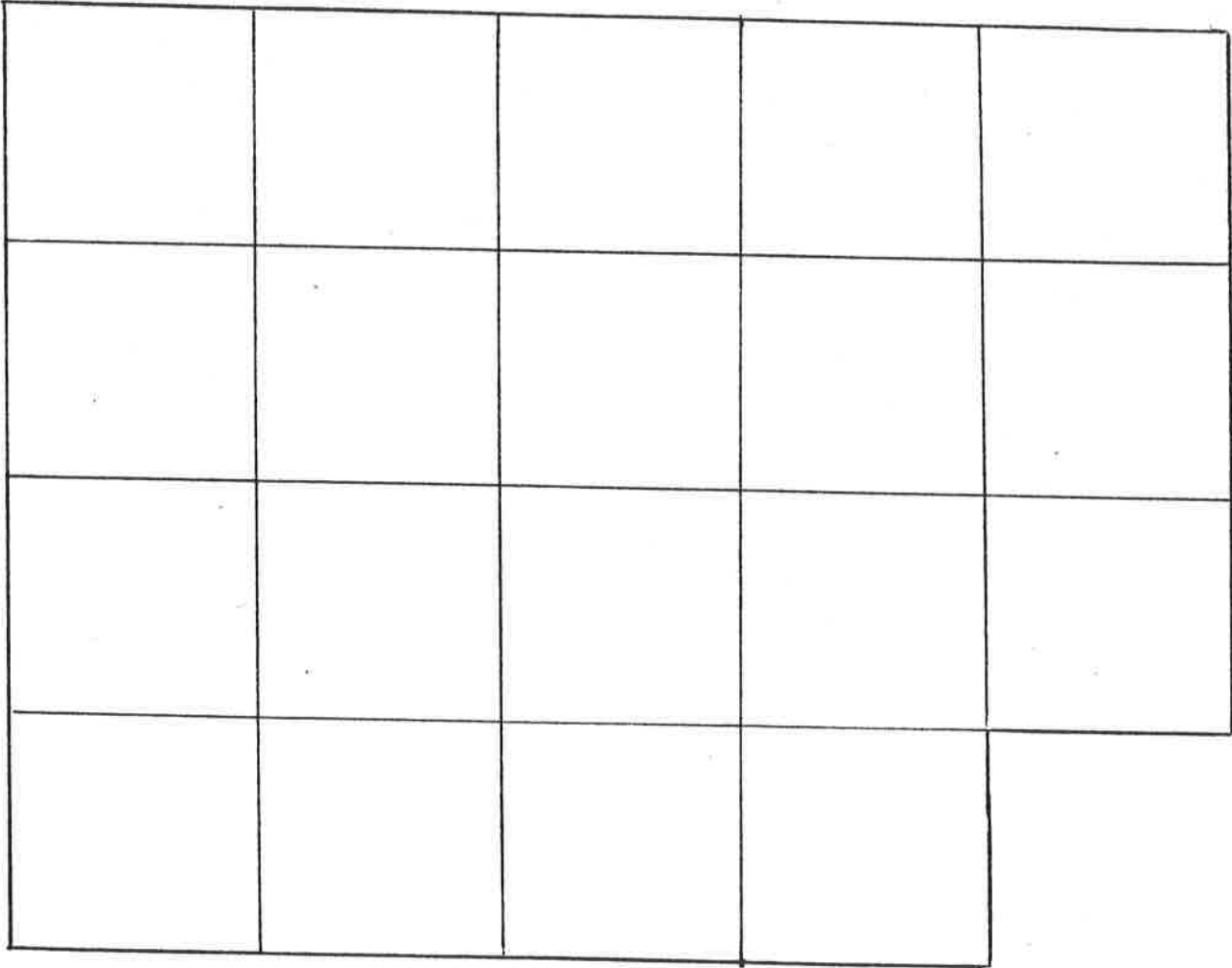


Figure 13. End moraines of Huron County
(to be completed later)

Moraines were distinguished primarily on field recognition of hummocky topography and on the construction of profiles from topographic maps to help identify ridges. Moraine mapping was complicated by the fact that the major moraines predate the last ice advances. These moraines have been overridden three times (or more in the case of the Delphi moraine) by ice which has smoothed the hummocky topography. In general, the northern, or proximal side of each morainic ridge is more smooth and presumably has been subjected to stronger ice scour than the southern or distal side of the ridge. The east-west trending end moraines were formed during the advance and retreat of one or more ice advances that deposited the Millbrook Till. White (1982) dated the Millbrook Till at about 40,000-35,000 RYBP. The Delphi moraine is older than the other moraines, and possibly may be as old as Illinoian.

Wabash Moraine

The Wabash moraine, the southern-most moraine in Huron County, consists of a single ridge about 0.7 mile high and 30 feet high that trends east-west along the Huron-Richland county line. Totten (1969, 1972) traced the Wabash moraine across the northwestern corner of Richland County into Huron County. The Wabash moraine enters Huron County about 2 miles east of Plymouth and extends eastward along the county line for a distance of about 10 miles into Ashland County. Elevations along the crest of the moraine exceed 1100 feet and two knolls in southern Greenwich Township exceed 1200 feet, the highest elevations in Huron County. Continuity of the ridge is interrupted by the valleys of West Branch Huron River and Southwest Branch Vermilion River.

FT. Wayne Moraine

The FT. Wayne moraine in Huron County is represented by an irregular belt of hummocky topography 0.8 to 1.8 miles wide which has an east-west trend across southern Ripley and Greenwich townships. The knolls of this complex morainic ridge rise 20 to 30 feet above the till plain. Totten (1969, 1972) traced the FT. Wayne moraine across the northwestern corner of Richland County into Huron County. In Huron County, the Ft. Wayne moraine can be traced from the east side of Plymouth eastward for a distance of 12 miles to the Huron-Ashland county line. The moraine becomes wider eastward and two separate crests can be distinguished in Greenwich Township. The FT. Wayne moraine is separated from the Wabash moraine on the south by a narrow band of till plain, whereas a belt of till plain as much as 2 miles wide occurs between the FT. Wayne moraine and the New Washington moraine to the north. The FT. Wayne moraine is dissected by several tributaries of Southwest Branch Vermilion River, and by West Branch Huron River.

New Washington Moraine

The New Washington moraine in Huron County is represented by 2 to 3 elements composed of irregular patches and ridges of hummocky topography north of the FT. Wayne moraine. Totten (1969, 1972) traced the New Washington ^{moraine} across the northwestern corner of Richland County into southwestern Huron County west of Plymouth. West and north of Plymouth the trend of the moraine is partially obscured by kames which are younger than the moraine. Northeast of Plymouth, the New Washington moraine trends northeastward to Delphi in central Ripley Township where it crosses diagonally the larger Delphi moraine. East of the Delphi moraine, the New Washington moraine is weakly developed. Only a single ridge and a few knolls mark the moraine north of Greenwich, Southwest of New London, knob and kettle topography obscures the trend of the moraine. However, southeast of New London in the southeastern corner of the county, the New Washington moraine is strongly developed, and three prominent crests can be traced eastward into Lorain and Ashland counties.

Defiance Moraine

The Defiance moraine is a wide belt of hummocky topography consisting of seven or more individual ridges or elements that have a general east-west trend in south-central Huron County (fig. 2, plate 1). In places the elements are separated from each other by narrow tracts of ground moraine; in other places the elements are closely bunched together to give the appearance of a single belt of jumbled knolls.

The Defiance moraine belt can be traced eastward from its type locality in western Ohio (Goldthwait and others, 1961) into Norwich and Richmond townships in western Huron County (Plate 1). At the Huron-Seneca county line, the Defiance moraine is 5.5 miles wide and consists of ten distinct ridges. A number of the Defiance moraine ridge crests converge and diverge several times as they are traced eastward across the county (Plate 1, fig. 13). Typically the number of distinct Defiance elements that can be recognized in Huron County ranges between six and seven. (fig 13).

The southern-most element of the Defiance moraine has a distinct southern border over most of Huron County. The valley of Honey Creek marks the moraine boundary at the Huron-Seneca county line. Farther east, the crest of the southern-most element rises about 25 feet above the flat plain of ancient Lake Willard. This element, about 0.7 mile wide, makes a southward loop into the Lake Willard lowland near Celeryville, from which it can be traced east-northeastward into Fairfield

Township where several elements are closely bunched. In eastern Fairfield Township, the southern margin of the Defiance moraine is bordered for a distance of three miles by the valley of East Branch Huron River. In western Fitchville Township a short distance west of Fitchville village, the southern margin of the Defiance moraine overlaps the northern end of the older Delphi moraine. East of Fitchville the southern Defiance margin is partially obscured by knob and kettle topography that originated from a later (post-Defiance) ice advance. The ridge traversed by State Highway 162 between Fitchville and New London is regarded as the southern-most Defiance element. East of New London the Defiance morainic elements have weak topographic expression and the southern margin is poorly defined. Near the Huron-Lorain County line, the Defiance and New Washington moraines nearly merge, and the narrow depression between the two moraines is located a short distance south of State Highway 162.

The highest and broadest element of the Defiance moraine in western Huron County is the second from the southern margin. This ridge is about 1.2 miles wide, about 30 feet high, and it serves as the drainage divide between Honey Creek and West Fork Black River. The major Defiance element exhibits a double crest in many places. It can be traced eastward across the southern part of the city of Willard to directly north of the Willard Reservoir and across southern Fairfield Township to Fitchville where its identity is confounded by superposed knob and kettle

topography. This element may constitute the major portion of the high ridge between Fitchville and New London. The other Defiance moraine elements situated north of the two elements previously described are grouped closely together, and the crests generally are less than 0.7 mile apart.

The northern boundary of the Defiance moraine is not as sharply defined as the southern boundary, yet it can be traced with some certainty across Huron County. In northern Norwich Township, the northern boundary of the moraine is followed for about two miles by State Highway 162. In northern Greenfield Township, the moraine boundary is obscured by the younger knob and kettle topography (fig. 2). East of the knob and kettle area the northern boundary of the moraine can be traced eastward from Hanville Corners to the northwestern corner of Fitchville Township where the Defiance moraine is superposed over the eroded remnants of the older Delphi moraine. The northern boundary extends eastward from the Fitchville-Hartland Township line to the Vermilion River valley where the boundary is obscured by knob and kettle topography. East of the Vermilion River, the Defiance moraine elements are weakly developed, and the northern boundary is indistinct. The boundary as mapped trends eastward across the northern boundary of New London Township to the Huron-Lorain county line.

Within the Defiance moraine complex, are narrow belts of till plain (Plate 1), a few of which are followed by small streams. The major streams in Huron County have cut valleys

across the elements of the Defiance moraine. These valleys are not deeply entrenched through the elements of the moraine, primarily because the elements are located near the headwaters of streams. Most small streams do not follow the depressions between moraine elements for any distance, but instead tend to flow around and between hummocks, and eventually reach the till plain to the north.

In the few deep exposures in the Defiance moraine, Millbrook Till makes up the core of the moraine. Hiram, Hayesville, and Navarre tills occur in the moraine, but only form a veneer or blanket over the Millbrook Till. Most likely the Defiance moraine was formed by an ice advance (or retreat) that deposited one of the younger (A) Millbrook till units. Ice advances that deposited the Navarre, Hayesville, and Hiram tills overrode the moraine, and in the process the morainic elements probably were slightly eroded and modified. The morainic elements are considerably smoother and less hummocky than unmodified moraines.

Delphi Moraine

The Delphi moraine is a broad, relatively short northeast-southwest trending ridge composed of five relatively distinct elements extending from central Hartland Township to southern Ripley Township, a distance of about 14 miles. This moraine was first mapped by Campbell (1955) who named it the Delphi Spur moraine for the small hamlet of Delphi in Ripley Township. Campbell (1955) described the Delphi moraine as consisting of two distinct parts separated by a prominent glacial outwash channel. The Delphi moraine is composed of five relatively distinct elements which have a total width of as much as 3.7 miles and which project 30 to 40 feet above their surroundings (fig. 14). The elements have broad, smooth crests, and relatively little hummocky topography is associated with the moraine, unlike the other moraines in the county. The outwash channel referred to by Campbell (1955) trends mainly north-south and cuts diagonally across all five Delphi elements. The moraine becomes smoother, lower, and less distinct toward the northeast, and it seems to "disappear" near the hamlet of Hartland in central Hartland Township. Adding to the confusion of topography is the Defiance moraine which crosses the Delphi moraine in northern Fitchville Township. Apparently the Delphi moraine is older than the other moraines including the Defiance in Huron County, even though the trends of the Delphi elements still can be recognized in a few places beneath the Defiance moraine. The Delphi elements have a smoother, less hummocky surface than the Defiance, and the Delphi moraine apparently

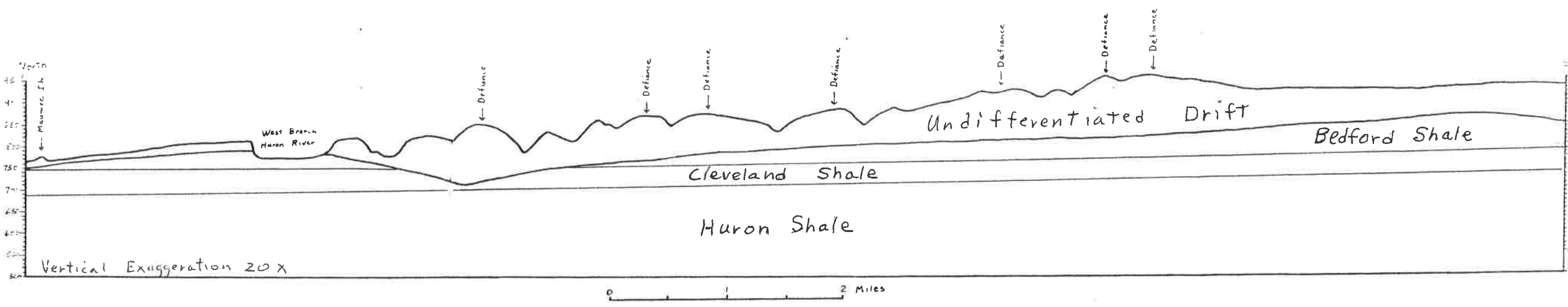


Figure 14. Cross-section of Huron County, from Maumee beach ridge to Huron-Richland County line at 82°43' West Longitude

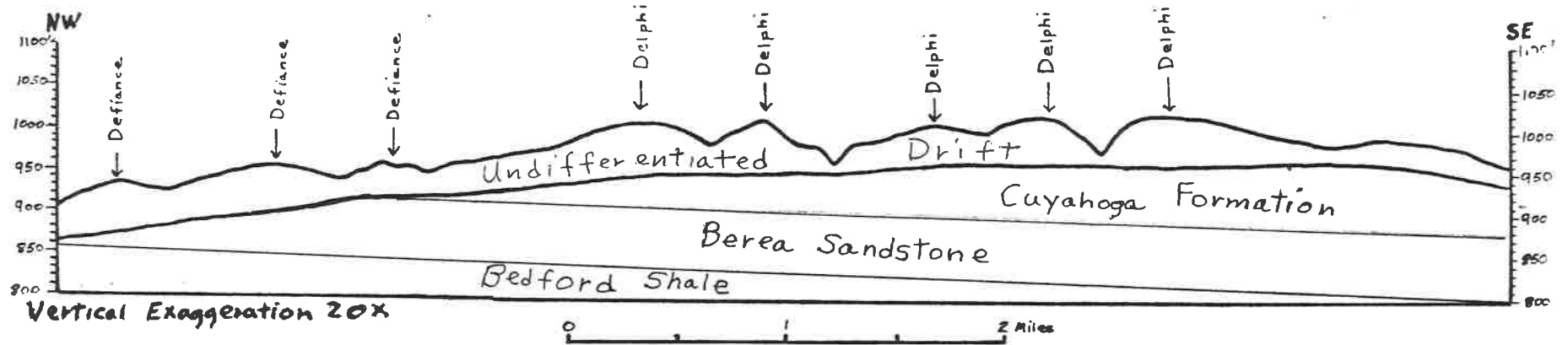


Figure 15. Cross-section of Huron County across the Delphi moraine and a portion of the Defiance moraine from Hanville Corners (northwest) to Fitchville-Greenwich Township line ((southeast)

was removed by glacial scouring northeast of Hartland, perhaps by the very ice that deposited the Defiance moraine. Likewise, the southwestern extent of the Delphi moraine is obscured by the New Washington and FT. Wayne moraines in Ripley Township. West Branch Huron River south of Delphi represents the southern limit to which the Delphi moraine can be traced. The Delphi moraine is unique among moraines in Huron County in that its northeast-southwest trend exhibits about 40° to 50° difference from the other moraines. Most likely the Delphi moraine was deposited by ice advancing southeastward into northern Ohio from a Huron Lobe source. Supporting this hypothesis are striations developed on limestone at the France Stone Company quarry near Flat Rock in Thompson Township, Seneca County. Four sets of striations are visible: S 40 W, South, S 50 E, and S 80 E. The most prominent and most recent striations likely were made by one or more Millbrook ice advances which deposited the Defiance, New Washington, FT. Wayne, and Wabash moraines. The S 80 E striations are the deepest and the oldest, and most probably were made by the ice advance that deposited the Delphi moraine. The S 50 E striations are faint and also were made by a pre-Millbrook ice advance, though not necessarily by the same advance that deposited the Delphi moraine. Crests of the Delphi moraine elements have trends that indicate the ice which deposited this moraine in Huron County advanced in a direction that varied from S 50 E to S 75 E. It is likely that the Delphi moraine predates the Millbrook ice advance,

and it is possible that the moraine predates the Wisconsin glacial stage. Till samples needed to help determine the age and source of the Delphi moraine are lacking.

BEACH RIDGES

General Statement

A series of beach ridges representing strandlines of earlier, higher stages of Lake Erie occur on the northward sloping lake plain in northwestern Huron County. These beach ridges which generally parallel the shoreline of Lake Erie now located about 7 miles north of Huron County, were mapped by Carney (1913) and by Totten (1982) who recognized as many as 20 separate ridges in northeastern Ohio. The beach ridges in northwestern Huron County belong to stages of lakes Maumee, Whittlesey, and Arkona which occur between the elevations of 780 and 695 feet (table 4). Although the beach ridges in northern Ohio typically are parallel to the east-northeast trending shoreline of Lake Erie, the ridges in Huron County exhibit a pronounced southerly trend into the broad Huron River embayment.

Maumee Beach Ridges

Four Maumee beach ridges, designated Maumee Ia (780 feet), Maumee Ib (774 feet), Maumee II (764 feet), and Maumee III (753 feet) occur in close proximity to each other in Huron County. The Maumee Ia ridge is discontinuous and can be recognized in very few places. A segment of this ridge about 500 feet wide and only a few feet high trends southwestward for about 4 miles

Table 4. Beach ridges of northern Ohio (after Totten, 1982)
 Elevations are of ridge crests, and ages are approximate.

<u>Beach ridge</u>	<u>Elevation (ft)</u>	<u>Age YBP</u>	<u>Outlet</u>
Maumee Ia	780	14,500	Wabash River, Indian
Maumee Ib	774	14,450	" " "
Maumee II	764	14,250	" " "
Maumee III	753	14,100	" " "
Whittlesey I	740	13,950	Grand River, Michigan
Whittlesey II	732	13,850	" " "
Arkona I	711	13,500	" " "
Arkona II	700	13,350	" " "
Arkona III	695	13,300	" " "
Warren I	686	13,050	" " "
Warren II	680	13,000	" " "
Warren III	670	12,900	" " "
Wayne	660	12,850	Mohawk River, New York
Grassmere	640	12,800	" " " "
Lundy	620	12,750	" " " "

in Norwalk Township southeast of Norwalk. Three short segments of Maumee Ia occur between West Branch Huron River and Slate Run in Peru Township at the southern most extent of Lake Maumee in Huron County. The Maumee Ia ridge is most continuous and extensive in Lyme Township where it can be traced for 8 miles along the west side of the Huron River embayment to Bellevue at the Huron-Sandusky county line. In southeastern Lyme Township, the ridge has a northward trend, is nearly 1000 feet wide in places, and is capped with dunes near Opperman Road. A few small dune patches occur on the till plain southwest of the ridge. The ridge makes a sharp bend westward in northern Lyme Township and is followed by U.S. Route 20 and Bauer Road to Bellevue. The Maumee Ib beach, elevation 774 feet, occurs as a narrow ridge, 300 to 400 feet wide and 5 to 8 feet high, which can be traced from the northeastern corner of Norwalk Township southwestward to Cole Creek. Between Cole Creek and West Branch Huron River the Maumee Ib ridge is absent. The ridge is well developed west of West Branch Huron River where it trends northwestward a distance of 8 miles to Strongs Ridge east of Bellevue. At Strongs Ridge, the Ib ridge bends sharply westward and can be traced to the south edge of Bellevue where it occurs 500 feet north of the Ia ridge. In the vicinity of Hunts Corners near the center of Lyme Township, the Ib ridge is a double ridge, the larger of which is traversed by Sandhill Road. A large dune field about 0.5 mile wide, with individual dunes as much as 25 feet high, is associated with the ridge

1 mile north of Hunts Corners. A smaller dune field occurs a short distance south of Hunts Corners.

The Maumee II beach ridge, with a crest elevation of 764 feet, is moderately well developed in Huron County. The ridge which is about 4 to 6 feet high and 300 to 500 feet wide, is situated about 500 feet northwest of the Maumee Ib ridge in Norwalk Township. In Peru Township between East Branch Huron River and Cole Creek the ridge is 500 to 1000 wide and is traversed by Settlement Road. West of West Branch Huron River the Maumee II ridge is represented by several short northwest trending ridge segments each of which is 0.5 to 1.0 mile long. In northwestern Lyme Township east of Bellevue, the Maumee II beach ridge is accentuated by dunes which occur on and adjacent to the ridge known as Strongs Ridge. A relatively steep slope occurs on the north side of Strongs Ridge for a distance of about 1 mile. This steep slope is a remnant of pre-Woodfordian cliff formed by wave action when the lake levels had stabilized at a high elevation for a considerable length of time. Similar cliffs are more extensive and much more prominent farther east in Lorain County (Totten, 1982). From Strongs Ridge, the Maumee II beach ridge can be traced westward to Bellevue, traversed by State Route 113.

Maumee beach gravels are poorly exposed in Huron County. The Maumee Ia beach ridge southeast of Norwalk is composed of 7 feet of poorly sorted gravel containing a silty clay matrix and cobbles up to 3 inches in diameter. The Maumee Ib ridge at the south edge of Norwalk is composed of 6 feet of fairly well sorted sand and gravel. The Maumee II ridge southeast of Norwalk is composed of 7 feet of sand and silt, and a few cobbles occur in the lower part. The Maumee III ridge southwest of Norwalk is composed of sandy gravel. Chili soil is developed in the gravelly Maumee ridges and Ottawa soil is developed in the dune sand associated with the ridges.

Whittlesey Beach Ridge

The Whittlesey lake stage in northern Ohio is represented by two beach ridges having crest elevations of 740 and 732 feet (Totten, 1982). In Huron County, only the Whittlesey II ridge with a crest elevation of 732 feet is represented. The Whittlesey II ridge is well-developed in Huron County, and it is nearly continuous across Norwalk and Ridgefield Townships, its continuity being broken only by the valleys of East Branch and West Branch Huron River—and several tributaries. The Whittlesey beach ridge is located near to the Maumee III ridge in Norwalk Township along the east side of the Huron embayment but the ridges diverge southwest of Norwalk where the Maumee and Whittlesey ridges are about 2 miles apart. The Whittlesey ridge is 5 to 8 feet high and 300 to 800 feet wide. Northeast of Norwalk near the Huron-Erie county line a dune field 0.2 mile wide and about 1 mile long occurs on the ridge and extends eastward a short distance to the Maumee ridges. The Whittlesey II ridge is followed by State Route 61 in Norwalk Township from the Huron-Erie county line through the center of Norwalk. Between Norwalk and Monroeville in Ridgeville Township, the Whittlesey ridge is followed by U.S. Route 20. At Monroeville, the ridge trends north-northwestward for 3.5 miles along the western margin of the embayment to the Huron-Erie county line. This portion of the ridge, which is 1,000 feet wide in places, is traversed by State Route 99. Whittlesey beach gravels are

very poorly exposed in Huron County, and no pits occur in the ridge. A few shallow cuts exposed medium fine sand and sandy gravel. Chili soil is developed in the gravelly Whittlesey ridge.

Arkona Beach Ridge

The Arkona lake stage in northern Ohio is represented by three beach ridges having crest elevations of 711,700 and 695 feet (Totten, 1982). The only Arkona stage represented in Huron County is Arkona III (elevation of 695 feet) which occurs north of Norwalk near the Huron-Erie county line. The Arkona III ridge is discontinuous, is about 0.2 miles wide and about 5 feet high, and only three short ridge segments, having a total length of three miles, are present in the county. A few small dunes occur on the ridge segment northeast of Norwalk at the Huron-Erie county line. The Arkona III ridge is composed of gravelly sand which has been excavated in two small borrow pits. A broad sheet of sand occurs on the lake plain between the elevations of 711 and 695 feet, the same elevations at which Arkona I and II ridges occur to the east. The well-drained Kibbie soil, highly regarded for vegetable crops, is developed in the sandy Arkona sediment.

Beach ridges having crest elevations below the Arkona 695 foot level do not occur in Huron county; these ridges occur in Erie County to the north.

Lake Willard

Lake Willard is the name applied to a large lake bed about 10 miles long and 5 miles wide located in the southwestern corner of Huron County. Small portions of the lake bed also occur in the northwestern corner of Richland County and in the northeastern corner of Crawford County. Lake Willard, which has previously been called Willard Lake, Willard Marsh, Huron Marsh, New Haven Marsh, Celeryville Muck Area, and The Muck, occupied the lowland between the Defiance moraine to the north and the New Washington moraine to the south. During its greatest extent, Lake Willard apparently reached a level of about 948 feet along its southern margin although a level of 940 feet appears to mark the upper limit of the lake along its northern margin. The maximum extent of the lake is based both on topography and the distribution of lacustrine sediment. No distinct shoreline or shore deposits such as beaches occur, and thus the lake margins (Plate 1) must be regarded as approximate. Outlets of Lake Willard include both Honey Creek to the west and West Branch Huron River to the northeast. As soon as ice had retreated northward into the Erie Basin, lake level dropped to about 930 feet for an appreciable period of time during which salt, clay, peat, and gyttja accumulated in the submerged part of the basin. *(algae jelly)*

One of the earliest studies of the lake bed was by Dachnowski (1912) who reported 17 feet of peat as occurring in the center of the marsh southwest of Celeryville. Hubbard and Rockwood (1942) mapped the lake bed on the basis of silt deposits which they recorded at elevations considerably higher than the levels recognized in this study. The lake levels postulated (Hubbard and Rockwood, 1942) of 980 to 985 feet on the south side of the lake and about 970 feet on the north side may have been based on a misidentification of Hiram Till as lacustrine sediment, a problem common to modern glacial studies in northern Ohio.

Drainage ditch exposures in the lake bed reveal a variety of deposits of both lacustrine and glacial origin. An exposure near the intersection of Coder and Line roads near the center of the lake bed revealed grayish black muck 1 foot thick overlying 1.75 feet of silty clay and 1.5 feet of bioturbated silty clay till (Hiram and/or Hayesville Till). A stone line occurred beneath the clayey till, and 4 feet of compact rusty Millbrook Till occurred beneath the stones. The basal unit exposed was a very dark gray gravel as much as 5 feet thick. Exposures in the eastern part of the lake bed west of State Highway 598 revealed 2 to 5 feet of peat overlying about 2 feet of gyttja and shell marl. Laminated clay and as much as 5 feet of Hayesville Till occurred beneath the gyttja, and 2 feet of water bearing sand was exposed in the bottom of the exposures. The sand has continuity with the nearby gravels of the Plymouth area kames, and the sand is under artesian pressure beneath the lake bed where the sand is

overlain by impermeable clay and till.

Hodges (1979) made a detailed study of the eastern end of the lake bed utilizing both cores and trenches. (fig. 16). The upper till in the core probably is Hayesville Till, and the lower till probably is Millbrook Till. About 19 feet of glaciofluvial sand and gravel occur between the two tills. Radiocarbon dates on two logs (fig. 16) indicate the lake may have temporarily drained or dried up as early as 12,500 R.C.Y.B.P., (Szabo and Hodges, 1980) and was "swampy" 9810 R.C.Y.B.P. The Rifle soil is developed in the peat that occurs at the surface over an area measuring approximately 2 miles wide and 4 miles long in the eastern part of the basin. Peat probably occurred at the surface of the lake bed in most places in pioneer days, but fire, wind erosion, and agricultural activity have reduced considerably the expanse and thickness of peat. Marengo and Bennington soils are developed in the silty and clayey lake bed sediments where peat is absent.

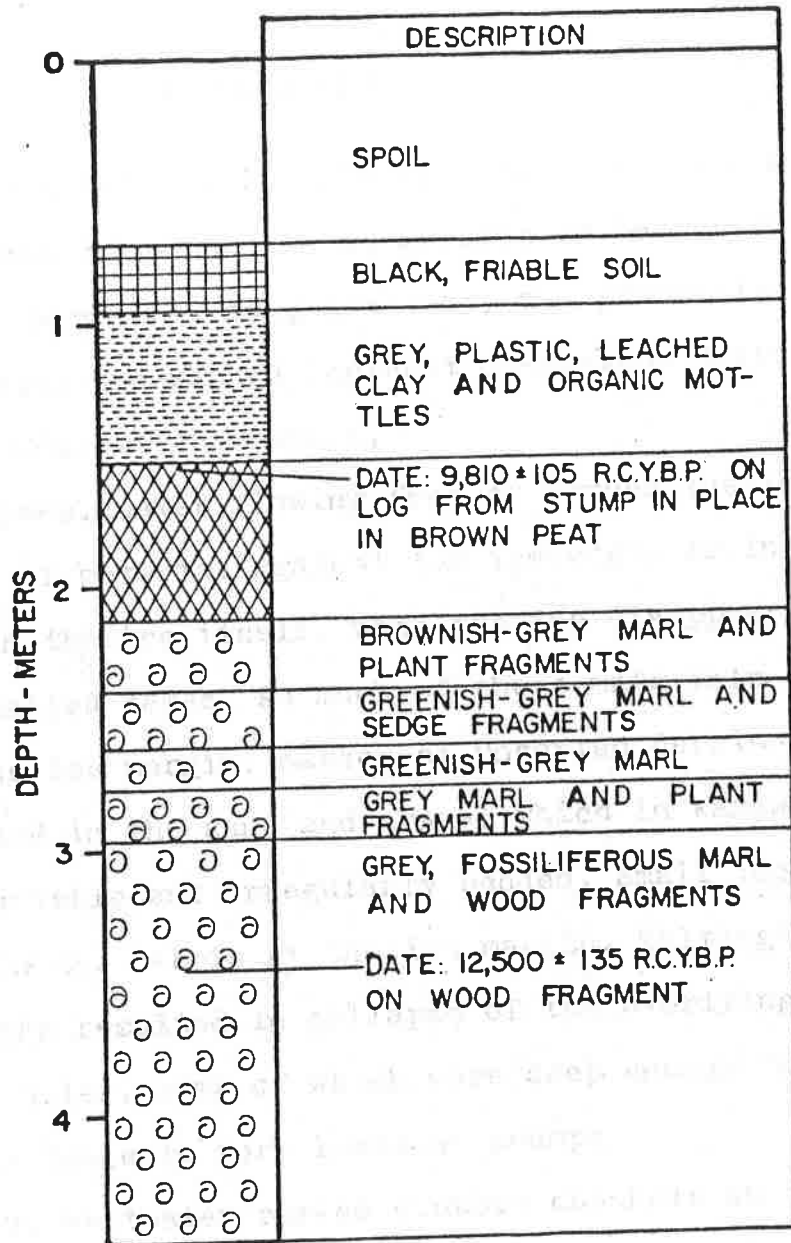


Figure 16. Section of sediments exposed in trench in Lake Willard (from Szabo and Hodges, 1980)

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ALLUVIAL (OUTWASH) DEPOSITS

Introduction

Water from the melting ice sheets carried gravel, sand, silt, and clay away from the ice to greater or lesser distances. The deposits are sorted as to grain size, and generally the finer silt and clay are washed farthest downstream leaving sand and gravel nearest the source.

In some places, water flowing from or across the ice deposited cones of material against the ice edge, or in holes or low places on the ice itself. When the ice disappeared, these became mounds called kames. As much of these materials were deposited at the ice margin, masses of unsorted debris (till) were incorporated in the sand and gravel which in kames tend to be highly variable and irregularly bedded. Small ice masses became buried in the debris at the ice margin. Melting of the buried ice blocks resulted in collapse of the overlying material to form kettle holes, some of which were deep enough to extend below the water table to form lakes or swamps.

Some of the meltwater carved sinuous channels on top of the ice sheet. Sand and gravel, representing the bedload of the stream, were deposited in the channel and also ~~were~~ deposited as kames at the front of the retreating glacier. When the ice finally melted, the sand and gravel formed a sinuous ridge known as an esker. In Huron County, the eskers trend north-south parallel to the direction of ice movement. Some meltwater also

flowed into large linear cracks in the ice known as crevasses, and the silt and sand deposited in the cracks are now preserved as low linear ridges known as crevasse fillings.

During deglaciation ice remained in some valleys and intermoraine lowlands after the uplands were free of ice, and meltwaters flowed on, around, or beneath the stagnant valley ice. Very little water could drain rapidly away from the glacier because the regional drainage in Huron County was northward toward the retreating ice sheet remaining to the north of the county was westward by way of Honey Creek. For a short time elongate lakes formed in the northward trending valleys until ice retreated into the Erie Basin.

Kames

Plymouth Kames

A large area of kames about 4 miles square is located in southern New Haven Township near the Huron-Richland county line. The kames, 15 to 25 feet high, are traversed by State Highway 61 between New Haven and Plymouth, and by State Highway 598 southwest of New Haven. At least 3 pits have been operated in these kames near State Highway 598, of which only the pit operated by the Abel Asphalt Company showed recent activity. In the Abel pit as much as 20 feet of sandy, well-sorted gravel is exposed, which is overlain in places by 0 to 8 feet of Hiram and Hayesville Till. Stony hard Millbrook Till occurs at the base of the gravel in the pit, and 14 feet of sandy gravel occurs beneath the till and below the water table. Gray Millbrook Till was dredged up with the lower gravel. At an abandoned pit Navarre Till also overlies the kame gravel. Thus much of the gravel is Millbrook in age, though the kame gravel near the surface could be of Navarre age. In places where the tills overlying the gravel are thin, Olena soil is developed in the gravel.

The Plymouth kame gravels are an important recharge area for groundwater. Water enters the gravel in the high kames and flows underground to areas beyond the kames. The water-bearing kame gravels occur beneath impermeable till and lacustrine clay

in the Willard bog area north and west of the kames. Occasionally, high pressures build up in the artesian system and cause ground water to break through the clay and to flow out at the surface of the bog as artesian springs.

Other Kames

An irregular grouping of kames resembling a discontinuous esker is located 2 miles west of Greenwich in eastern Ripley Township. The kames are strung over a distance of 2 miles in a north-south direction. The three largest kames each are about 0.3 mile wide and are about 20 feet high. Sand and sandy gravel similar to the Plymouth kame gravel is exposed in an old pit at the north end.

A group of small kames about 20 feet high occurs at the Huron-Richland county line in southern Ripley Township. All pits formerly operated in these kames which have been reclaimed.

The two large knob and kettle complexes previously described (fig. 2) resemble kame topography. The knobs are veneered with Hiram and Hayesville Till, and no pits or deep excavations occur to reveal the nature of the materials at depth. Most excavations reveal sand and silt beneath the tills, but gravel seems to be lacking. It is possible that many of the knobs are composed of till. Hayesville and Hiram till overlie the sandy kames which probably are of Navarre age. The kettles in these complexes are relatively shallow, and many are filled with peat, silt, and clay.

Eskers

Norwalk Esker

The Norwalk esker is a north-south trending ridge about 6.5 miles long which occurs along the western border of Bronson and Fairfield townships about 4 miles south of Norwalk. The esker ranges in width from 500 to 0.4 mile, and its crest rises 20 to 40 feet above its surroundings. The ridge, which resembles a chain of kames strung end to end, is traversed over its entire distance by Ridge Road. A gap occurs in the esker near its southern end, and it is breached by East Branch Huron River near its northern end. In places the esker is a double ridge, and small branch ridges extend a short distance away from the main ridge like branches on a tree.

At least 11 sand and gravel pits have been operated in the esker, the most recent of which was operated by Price Sand and Gravel Company. At the Price pit, 6 feet of coarse cobbly gravel 24 feet of gravelly sand. Gray Millbrook BII till occurs in the bottom of the pit beneath the gravel. At two other pits, 30 feet of sand and gravelly sand is exposed, and a till cover is lacking although till has been reported at the surface along the flanks of the esker. Most of the old pits were located in the northern and central parts where the esker was widest. Considerably more gravel remains in the esker although the position of Ridge Road astride some of the thickest gravel

currently precludes maximum development of the deposit.

The esker probably originated when a southward flowing stream, perhaps following a large crevasse in the ice surface, discharged at the steep frontal slope of the ice. A delta probably was formed at the point of discharge, and as the ice retreated, the point of discharge likewise retreated forming a chain of kames. In several places the stream was braided, and branches resulted in the esker.

Hartland Esker

The Hartland esker, two miles long and 500 to 1500 feet wide, trends north-south in the northeastern corner of Hartland Township. Its entire length is traversed by Cook Road. The Hartland esker, like the Norwalk esker, resembles a chain of kames, and the two eskers probably had a similar origin. An excavation in the esker revealed as much as 25 feet of poorly sorted gravel that varied from stony at the top to sandy at the base. Silty sand was exposed in a small cut along Cook Road. Olena soil is developed in the mainly sandy esker sediments. No till was visible in either exposure.

Clarksfield Esker

The third esker in Huron County ^{the Clarksfield esker,} occurs a short distance east of the Vermilion River valley in southwestern Clarksfield Township and in the northeastern corner of Fitchville Township. The esker, which has a south-southwestward trend, begins about 0.25 mile southwest of Clarksfield and trends southwestward near to and parallel to the east side of the Vermilion River valley. The esker consists of four segments about 700 feet wide and 10 to 15 feet high having a total length of 3.5 miles spread over a distance of 4.5 miles. Sand and gravel are exposed in one esker segment, and Olena and Chili soils are developed in the coarse sediment.

Wakeman Crevasse Fillings

Several short low linear ridges composed of silt and fine sand occur in Wakeman Township in the northeastern corner of the county. All of the ridges, the longest of which is 0.6 mile, trend southwestward from the longest segment. These ridges appear to represent the filling of crevasses on stagnant ice.

Alluvial Terraces

General Statement

The modern drainage of Huron County flows northward into Lake Erie. The present drainage was established primarily following the Millbrook glaciation as a direct result of two conditions: (1) prominent east-west trending end moraines at the southern margin of the county blocked southward drainage, and (2) Millbrook ice depressed the crust in the Erie Basin for a considerable period and created a slight northward tilt of Huron County thereby allowing streams a steeper northward gradient. Northward drainage became well established and were able to entrench their valleys to keep pace with glacio-isostatic rebound and the lowering of lake levels. One to three sets of northward sloping terrace levels are present along the major valleys and along several tributaries (Plate 1). These terraces are not outwash terraces typical of the southward flowing streams in Ohio which carried glacial meltwater. Instead, these terraces represent floodplains cut by streams that had baselevels, higher than present, determined by levels of Lake Erie during the Plum Point Interstadial. The streams responsible for the terraces had gradients of about 7 to 15 feet per mile and remained at stable baselevels for sufficiently long intervals for extensive lateral cutting to occur.

These terraces formerly were veneered with thin deposits of sand and gravel. However, the present terrace surface is the result of modification of the original by both ice and water. In places the terraces have a hummocky appearance, which is attributed to the deposition of thin till on the terraces during the Woodfordian glaciation. Post-glacial streams occupied the terraces for a few hundred years during the Maumee-Arkona-Whittlesey-Warren lake stages. Consequently the terraces contain in their upper part silty, sandy, gravelly alluvial materials from which Lobdell, Wayland, and Chili soils have been developed.

Vermilion River Terraces

Remnants of three surfaces of alluvial terraces occur in the valley of Vermilion River in eastern Huron County. The highest terrace in the valley is represented by many small segments, the largest of which is 0.5 mile long and 0.3 mile wide (Plate 1). The terrace has an elevation of 960 feet in southern Fitchville Township at the Huron-Ashland county line, an elevation of 940 feet at Fitchville, and an elevation of 890 feet near Clarksville. From Clarksville north to Wakeman and the Huron-Erie county line the highest terrace is represented by four segments having elevations ranging from 880 feet to 840 feet. The total length of the terrace in Huron County is about 17 miles, and the gradient of the terrace surface is about 7 feet wide per mile toward the north.

Remnants of a middle terrace surface are preserved in Vermilion Valley between Clarksville and the Huron-Erie county line. Segments of the middle terrace, the largest of which is about 0.6 mile long and 0.4 mile wide, range in elevation from 870 feet at Clarksville to 790 feet at the Huron-Erie county line. This terrace has a northward slope of about 12 feet per mile over a distance of 6.5 miles.

Remnants of a low terrace occur in Vermilion Valley near the Huron-Erie county line. This low elevation is near to, and appears to merge with the modern floodplain surface.

The alluvial sediments underlying the terrace surfaces are quite variable, and range in size from silt to coarse gravel.

East Branch Huron River Terrace

Numerous small terrace remnants are preserved in the valley of East Branch in northeastern Peru, eastern Ridgefield, and northwestern Norwalk townships. East Branch meanders from one side of the valley to the other and has succeeded in eroding much of its formerly extensive terrace. The largest preserved terrace remnant, about 1 mile long and nearly 1,000 feet wide, occurs on the west side of the valley in northern Peru Township. A small knoll, probably a kame, occurs on the terrace surface. The terrace elevations range from 780 feet south of Peru to 625 feet at the Huron-Erie county line, for a gradient of 15.5 feet per mile over a distance of 10 miles.

West Branch Huron River Terrace

Many remnants of an extensive terrace occur in the valley of West Branch extending from the south edge of Huron County northward 25 miles to the north edge of the county where West Branch and East Branch join to form the Huron River. In New Haven Township near Plymouth the terrace remnants mostly are narrow and discontinuous. In Greenfield Township the valley widens and the terrace reaches a width of 0.5 mile. In the northern part of Greenfield Township three large terrace remnants contain on their surfaces conspicuous knolls which have a hummocky surface similar to the knob and kettle topography of the surrounding upland. The terrace is poorly preserved in southern

Peru Township; however in northern Peru Township and in Ridgefield Township the terrace is more continuous. The broad meanders of West Branch have eroded the terrace primarily at the outside parts of the meander bends or loops. Thus the preserved parts of the terrace occur in alternating positions along both east and west sides of the valley. Terrace elevations range from 1,000 feet near Plymouth to 890 feet at Willard Reservoir, 685 feet at Monroeville, and 635 feet at the Huron-Erie county line, for a gradient of about 15 feet per mile.

The terrace sediments are highly variable, but appear to be mostly silt and fine sand. The Glenford soil is developed in the silty terrace sediments near Monroeville.

Slate Run Terrace

Slate Run is the largest of the several small tributary valleys in Huron County which contain remnants of alluvial terraces. Slate Run, which meanders across Norwich and Sherman Townships and across the northwestern corner of Peru Township to join West Branch south of Monroeville, has a well-preserved terrace on the northwestern side of the valley in Norwich Township. One terrace remnant is nearly four miles long and 400 feet wide. The terrace has an elevation of 865 feet near the Huron-Seneca county line and an elevation of 725 feet where it joins with West Branch for a gradient of 13 feet per mile over a distance of 11 miles. Mud Run, a tributary of Slate Run in Norwich Township, also contains several terrace remnants, the longest

of which is 0.8 mile long and 400 feet wide. Exposures in the Slate Run terrace along Jennifer Road revealed 4 feet of silt at the surface. In places the terrace surface is hummocky, suggesting the terrace surface has been modified, possibly by ice.

MINERAL RESOURCES

General Statement

The mineral resources of the glacial drift in Huron County consist of sand and gravel and groundwater. These are discussed in detail below.

The resources of the bedrock do not form a part of this report, and only a brief summary is possible. In earlier times the Berea Sandstone in Lorain County to the east provided significant amounts of stone for the construction industry, but the Berea Sandstone in Huron County was not quarried. The Berea quarry nearest to Huron County was located at Plymouth in Richland County just south of the Huron-Richland county line. A small quarry in the Berea Sandstone in northern Townsend Township produces decorative slabs of stone for the construction industry.

A short distance north and west of Huron County near Bellevue, the Columbus and Delaware limestones of Devonian age are extremely quarried for aggregate. These limestones occur in the subsurface in Huron County and at present are not considered to be of economic importance in the county.

Petroleum production in Huron County is relatively minor and as of 1974 (Delrosse and Vohwinkle), 9 small natural gas pools and 3 small oil pools had been identified. Natural gas has been encountered in wells drilled in Fitchville, Hartland, and Bronson townships. In two pools in Hartland Township, natural gas was discovered in 1936 at depths of 225—250 in the Ohio Shale. Oil has been encountered in wells drilled in Townsend Township. A well drilled in 1965 to a depth of 3740 feet discovered oil in the Knox Dolomite.

Sand and Gravel

General Statement

Sand and gravel have been excavated from numerous pits in Huron County since pioneer days. However, only one pit, located in the valley of Cole Creek southwest of Norwalk is currently producing large amounts of commercial gravel in the county. Three or four other pits in the county have produced significant amounts of commercial gravel in the past and have some potential for future production.

Price Sand and Gravel Pit

The major commercial sand and gravel pit in the county is operated by Price Sand and Gravel Company in the valley of Cole Creek about 1.5 mile southwest of Norwalk. The deposit consists mostly of gravelly sand 40 to 65 feet thick which occurs below the water table and must be dredged. Good quality mason sand is obtained in a washing operation and gravel is produced as a by-product. Yellow clay as much as 10 feet thick overlies the sand and gravel. This sand and gravel deposit may have formed as outwash transported southward from melting ice or it may be a nonglacial fluvial deposit of northward flowing Cole Creek.

Kame Gravel Deposits

The major kame gravel deposits occur in southern New Haven Township near Plymouth where two pits have been operated commercially in the past. The largest of the two pits is located on the east side of State Highway 598 about 0.5 mile north of the Richland-Huron county line. About 20 feet of gravel occurs above the water table in the pit and an additional 12 feet of gravel has been dredged below the water table. Till as much as 8 feet thick occurs above the gravel, a lens of till about 1 foot thick occurs above the gravel, a lens of till about 1 foot thick occurs near the water table, and till of unknown thickness occurs about 14 feet below the water table. Bank run gravel only is produced from these kames and the marginal quality of the gravel may limit future production. As with much gravel in northeastern Ohio (White, 1982) it is possible that higher quality gravel could be obtained below the water table.

The small tract of kames in southern Ripley Township along the Huron-Richland county line contains minor amounts of gravel that has not been quarried in recent times. This deposit most likely could be utilized as a source of bank run gravel for local use.

The knob and kettle area (fig. 2) in the north-central part of the county is unexplored and undeveloped with regards to sand and gravel. The knobs resemble kames and most exposures in the knobs reveal sand and silt beneath 5 to 10 feet of Hiram and Hayesville Till. As much as 15 feet of sand and silt has

been recorded in the knobs and greater thicknesses are possible. It is possible that the deposits contain too little gravel and too much fine material to have commercial potential. Also it is possible that many of the knobs are composed of till.

Esker Gravel Deposits

The major esker gravel deposit in Huron County is the Norwalk esker which begins about 4 miles south of Norwalk and extends southward a distance of about 6 miles. According to local accounts, at least 11 pits were operated in the esker, but only two of these have been recently active. At the Price Sand and Gravel Company pit, the major deposit consisted of 24 feet of fairly well-sorted cross-bedded sand and gravelly sand. The sand is underlain by Millbrook Till of undetermined thickness and is overlain by 6 feet of coarse cobbly gravel. At the other large pit in the esker 0.7 mile north of the Price pit 25 feet of well-sorted sandy gravel is exposed. Gravel reserves in the Norwalk esker are relatively abundant but the thickest deposits are beneath Ridge Road which would have to be relocated to obtain the gravel. The gravel consists mostly of sedimentary material which is not particularly durable. Another potential problem is a lack of coarse material in the deposit.

The small esker in northeastern Hartland Township is composed of poorly sorted sand and gravel as much as 25 feet thick. The gravel appears to be of rather poor quality, and the reserves

are limited by the small size of the esker. The Clarksville esker also is small and contains very limited reserves of sand and gravel. The esker-like feature composed largely of kames 2 miles west of Greenwich in Ripley Township contains small reserves of sand and gravel. One abandoned and overgrown pit in the deposit revealed about 20 feet of sand and gravel.

Beach Ridge Gravel Deposits

The sand and gravel reserves in the beach ridges and associated dunes of Huron County are not very extensive mainly because the beach ridge deposits are neither thick nor wide. Also, the beach ridges are composed primarily of poor quality gravel composed of soft siltstone and sandstone material. The thickest deposits are in the dune areas and are composed entirely of sand. Consequently the sand and gravel is not quarried extensively on a commercial basis, and the several pits in the ridge and dune deposits are very small and provide "borrow" or fill material. Generally, the beaches at higher elevations are composed of coarser material than the beaches at lower elevations. An exposure in a pit in the Maumee Ia ridge (elevation 780 feet) revealed 7 feet of poorly sorted cobbly gravel in a silty and clayey matrix. An exposure in the Maumee II ridge (elevation 760 feet) revealed 7 feet of sand and silt which contained a few pebbles and cobbles. An excavation in the Maumee III ridge (elevation 750 feet) revealed sandy gravel. The Whittlesey II

beach ridge is composed primarily of sand and medium to fine grained gravel. The Arkona III ridge is composed of sand and gravelly sand.

Alluvial Terrace Gravel Deposits

Minor amounts of sand and gravel occur beneath portions of the terrace surfaces of several streams and rivers in Huron County. Natural exposures of the alluvial deposits are rare, and the best indication of the nature of the materials is from the soils developed in them. Chili soils are developed mainly in gravelly materials and are the best indicator of gravel at or near the surface. Chili soils are mapped on the extensive remnants of the Vermilion River and these terraces provide the best prospects for obtaining terrace gravel. These terrace gravels most likely are thin, poorly sorted, and of rather poor quality.

WATER SUPPLY

This report does not deal with water supply in any detail but some suggestions can be made. An earlier report by Stout, VerSteeg, and Lamb (1943, pp.371—378) gives some information about water supplies of the villages in the county, and maps by Stein (1962 a,b,c) and Pree (1962) summarize more recent information. Historically, most of the water used in Huron County has come from wells completed both in bedrock and glacial drift, but in recent times large reservoirs have been constructed to store surface water for water systems serving Bellevue, Norwalk, Willard, Greenwich, and the Lake Willard—Celeryville truck farming area.

In general, ground water in Huron County is scarce in many places and it often contains undesirable substances. The most reliable source of ground water is the Berea Sandstone in the eastern part of the county (fig. 3). Wells in the Berea Sandstone generally yield 5 to 20 gallons per minute of good quality water (Stein, 1962a) which is sufficient for most farm or domestic uses. Yields from other bedrock units in the county generally are unreliable and may contain sulfur. Sand and gravel lenses in the glacial drift may yield 5 to 25 gallons per minute (Stein 1962a; 1962c). Water from the glacial drift is relatively hard and it contains varying amounts of iron.

The highest groundwater yields in the county, 25 to 100 gallons per minute, occur in the Norwalk and Wakeman buried valleys (fig. 5) which contain thick lenses of sand and gravel. The buried valley north of Wakeman is filled primarily with till which yields very little water, and the best yields in the buried valley are in New London Township where glacial meltwaters drained southward.

ENVIRONMENTAL AND ENGINEERING GEOLOGY

General Statement

The environment is influenced in general by the major physiographic divisions (fig.2) and in detail by the glacial and post--glacial forms and materials that comprise or mantle them. The glacial drift is an important factor in performance of engineering structures built upon or in the drift. The thickness, composition, and surface configuration of the drift must be considered. Of great importance for large structures or those involving deep excavation is the vertical variation in the drift, because at most places the till or tills below are of different composition, texture, and engineering properties. Gravel and sand may underlie the upper tills at depths ranging from a few feet to 50 feet or more, and be water bearing.

Engineering interpretations of the surface soils of Huron County will be treated in the soil report by Ernst (in preparation). That report should be consulted for specific engineering test data and classification both in the Unified and in the AASHTO systems. The test data recorded in the soil survey pertain primarily to the upper 60 inches of the soil. The present geological report deals not only with the surface material, but is also concerned with the whole column of glacial deposits. These reports therefore are complimentary to each other. This geological report cannot provide sufficient detail for planning at a specific site, but they can point out features of the glacial

stratigraphy that should be anticipated in detailed engineering investigations for a specific site.

The subsurface material becomes of increasingly greater importance as larger and larger structures and deeper and deeper excavations become more common. The parent material of soils over 80 percent Huron County is developed in the relatively clay-rich Hiram and Hayesville tills. The material beneath the Hayesville generally is less clayey and may have more desirable engineering properties. In some projects, it may be desirable to strip off and discard the clayey till to take advantage of the more permeable material below. Also, the "interfaces" between till units often are water-bearing and this must be taken into account in excavations because water seeping causes piping and slumping.

Till Plain

The Till Plain represents a very gently rolling to nearly featureless surface in the northern half of Huron County (fig. 2). This surface is dissected by numerous stream channels which provide fair to moderate drainage for the relatively clayey surface. The drainage of the area has been improved considerably since pioneer days by dredging and tiling so that the soil has relatively high productivity. Homesites and other construction projects should be carefully planned to provide adequate drainage. Potential problems are wet basements and inoperative septic systems,

particularly where homesites are closely spaced.

In areas of Till Plain dominated by the sandstone knobs, the drift is thin and the soil is more sandy. These sandy areas are better drained and have relatively few limitations for construction projects.

Lake Plain

The flat Lake Plain in northwestern Huron County with its sandy ridges and sheet sands is a distinctive section. Bedrock is close to the surface except for the buried Norwalk valley (fig. 5), and the beach-dune ridges. The beach-dune ridges and related sandy plains generally are well-drained and were the sites from earliest days of roads along which some of the earliest buildings were constructed. The beach ridges not only make ideal road beds and homesites, but their sandy soil also is prized for orchards, truck farming, and nurseries. Unfortunately the beach ridges are of limited extent and are already developed to the extent that relatively little beach ridge area is available for future development.

The nearly flat plain of former Lake Willard is underlain by peat and muck in many places. Most of the lacustrine materials deposited in this ancient lake have low bearing strength and have severe limitations for most construction projects. The areas underlain by peat are ideal for truck farming. Areas where the peat has burned are best suited for general agricultural use. Artificial drainage is required for the successful agricultural use of the Lake Willard plain.

Morainic Upland

The end moraines in the southern part of the county are areas of more or less rolling topography, scenically interesting, and are somewhat better drained than the surrounding areas. Numerous streams, several of which are entrenched through the moraines, offer opportunities for the construction of lakes. The Holiday Lakes development north of Willard is an example of one type of use of the natural resources of this area. Caution should be used in the installation of septic waste disposal systems as the relatively clayey till at the surface over most of this area is very slowly permeable and will accept effluent with difficulty.

Knob and Kettle Topography

The two knob and kettle areas (fig. 2) of Huron County are regions of topographic contrasts which present numerous potential environmental problems. The knobs are fairly well drained and are suited for a variety of uses if not too steep. The numerous depressions tend to be swampy and are unsuited for many uses unless artificially drained. The clay, muck, and peat that have collected in many of the depressions generally are unsuitable soil materials for construction purposes.

WASTE DISPOSAL

Solid Waste

The safe and prudent disposal of solid waste is becoming more important as the population increases, as the amount of waste multiplies, and as environmental regulations become more detailed. Open burning and dumping have been illegal in Ohio since 1969 and the sanitary landfill method has become the standard method of disposing of solid waste. Landfills should be located in areas of Huron County that have a thick till cover, have a low water table, have slight to gentle slope, and are not closely adjacent to urban centers. Areas where bedrock is closer than 25 feet of the surface should be avoided as should sand and gravel areas, valley bottoms, and steep hillsides. A comprehensive review of geologic considerations for selecting landfill sites is given by Groenewold (1974). The drift thickness map (fig. 6) is a most useful tool for preliminary selection of possible landfill sites in the county. Most of Huron County is underlain by drift at least 25 feet thick, and most of the drift is till, especially beyond the confines of the two buried valleys. The till, actually a stratigraphic sequence composed of several till sheets, is suitable for most types of landfill operation. Two problems that may be encountered are the possibility of a high water table and the presence of water-bearing gravel between

till sheets. Groenewald (1974) states that the minimum amount of till or similar material between the solid waste and the water table should be 5 to 30 feet depending on the circumstances, and he advises 25 feet for Ohio. If other conditions are suitable, the water table may be lowered and kept low by pumping ground water from wells or by constructing deep drainage ditches to a nearby valley. The drainage operation should be monitored carefully to ensure that effluent does not contaminate the water being drained from the area.

Huron County has several areas that appear suitable for landfill sites. The most suitable areas appear to be in the Till Plain and Morainic Upland in southwestern Hartland Township and northwestern Fitchville Township. Any future landfill in the county can be expected to have its lower part in Millbrook Till. The Millbrook Till is more compact than the overlying tills, and is excavated with difficulty.

Besides the compact nature of the till, other potential problems include gravel lenses and joints in the till. Both the gravel lenses and the joints could permit effluent to percolate toward aquifers if they are not properly sealed with an impermeable barrier. A careful engineering study should be made before a proposed landfill site is selected.

Septic Tanks And Tile Fields

The disposal of sewage effluent from septic tanks is a significant problem in many parts of the county that are not served by municipal sewers and sewage treatment plants. The geologic factors which affect the operation of septic tanks include permeability of the soil, depth to bedrock, depth to the water table, slope, and drainage. Limitations affecting proper disposal will be listed by Ernst (in preparation) for each of the soil series for the county. In general, the soils over most of the county have severe limitations for septic tanks, mostly due to the low permeability of the Hiram and Hayesville tills which form the surface materials. Many localities are characterized by a seasonably high water table, and tile fields may be flooded by rising water levels in wet seasons.

Possible areas acceptable for disposal of effluent are the sandy terraces, kames, and beach ridges (Plate 1). Other places appearing suitable are the Berea Sandstone knobs and a few other places where sandy till or sand is close to the surface. The sands and gravels have high percolation rates and thus effluent may travel some distance to wells and contaminate nearby ground water supplies.

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APPENDIX A

Huron County Till Analyses

Huron County Samples

Sample No.	Township	Age Assignment	Depth Collected Inches	Grain-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	Total
1	New Haven	H	40	20	43	37	9.5	5.0	14.5
2	New Haven	V	52	21	38	41	5.3	6.5	11.8
4	Greenfield	N	72	42	42	16	6.2	6.8	13.0
5	Greenfield	M-A	84	34	48	18	3.0	6.1	9.1
6	Greenfield	H	36	20	44	36	7.2	4.8	12.0
7	Greenfield	V	70	21	42	37	8.2	3.4	11.6
8	Greenfield	N	96	22	38	40	5.2	5.3	10.5
9	Greenfield	V	96	19	44	37	3.7	6.1	9.8
11	Greenfield	M B I	240	21	41	38	0	4.8	4.8
12	Greenfield	V	48	23	52	25	7.6	8.4	16.0
13	Greenfield	V	60	27	50	23	7.6	6.1	13.7
14	Greenfield	V	132	22	46	32	6.2	7.4	13.6
16	Greenfield	M-U	240	35	35	30	5.6	4.7	10.3
19	Greenfield	H	30	24	40	36	7.9	5.9	13.8
20	Richmond	H	36	3	31	66	7.7	4.3	12.0
21	Richmond	V	54	24	38	38	7.7	7.1	14.8
22	Richmond	V	66	19	41	40	7.4	5.3	12.7
23	Norwich	H	26	18	38	44	0	3.9	3.9
24	Norwich	H	72	20	27	53	7.3	4.8	12.1
25	Norwich	H	72	13	50	37	2.1	6.6	8.7
26	Greenfield	H	48	21	39	40	7.1	8.3	15.4
27	Greenfield	H	60	13	54	33	2.5	7.9	10.4
30	Fairfield	M. B II	360	19	44	38	1.9	5.4	7.3
31	Fairfield	M A	96	34	40	26	3.3	4.3	7.6
32	Fairfield	H	48	26	33	41	7.5	7.4	14.9
33	New Haven	H	34	15	43	42	5.7	7.9	13.6
34	New Haven	H	30	19	43	38	0.8	4.3	5.1
35	Greenfield	H	24	21	39	40	6.8	5.7	12.5
36	Greenfield	V	36	22	37	41	8.5	2.0	10.5
37	Greenfield	V	60	23	41	36	7.0	3.9	10.9
38	Greenfield	H	28	19	40	41	4.6	4.8	9.4
39	Greenfield	V	72	21	35	44	3.8	4.1	7.9
40	Greenfield	V	120	21	34	45	9.6	7.4	17.0
41	Greenfield	H	72	12	50	38	5.7	8.8	14.5

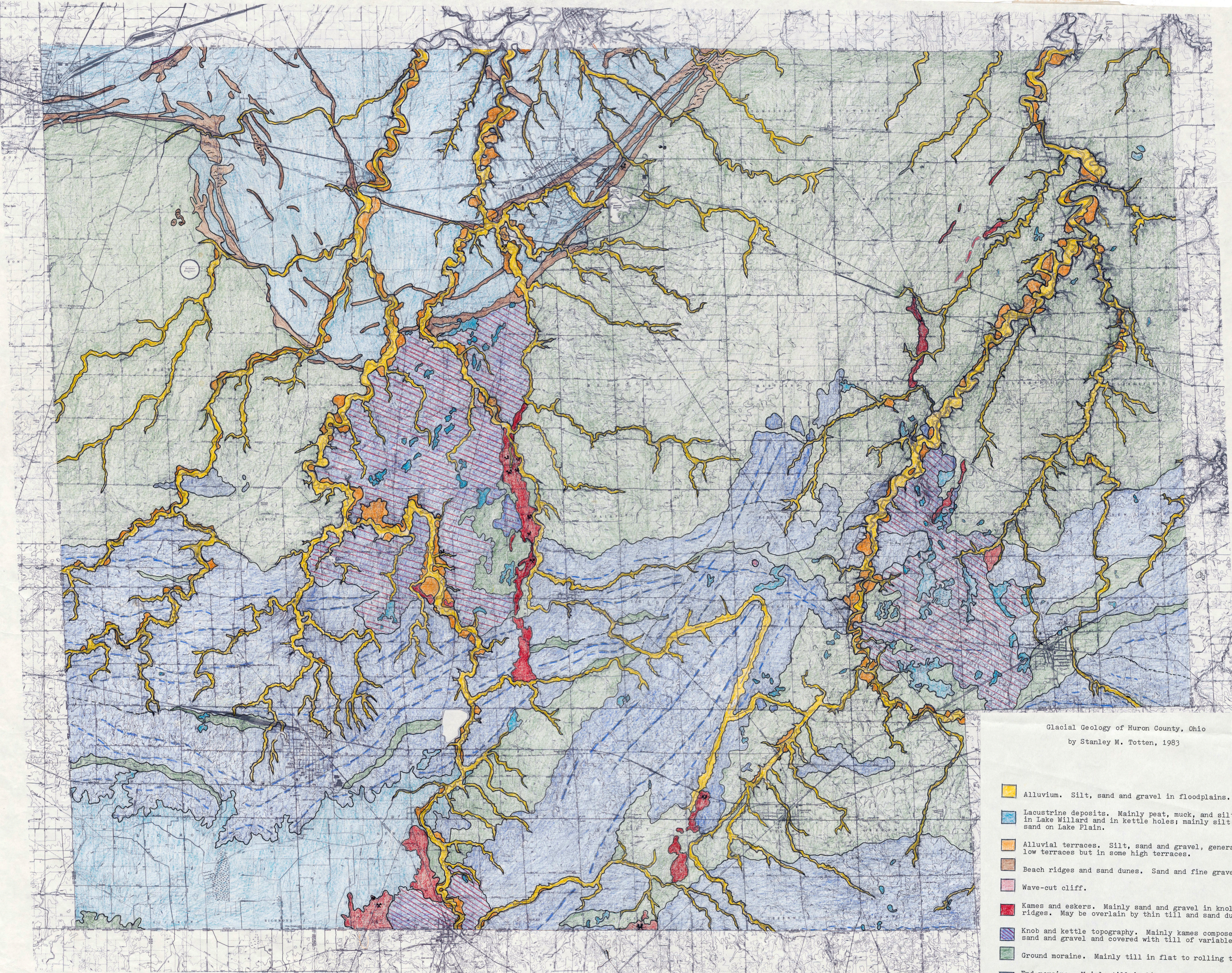
Sample No.	Township	Age Assignment	Depth Collected Inches	Grain-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	Total
42	Greenfield	N	108	40	40	20	7.3	3.9	11.2
44	Greenfield	M B#	-	14	49	37	2.9	7.9	10.8
46	Greenfield	Old	-	16	59	25	0	6.5	6.5
47	Norwich	H	36	20	42	38	6.2	6.3	12.5
48	Norwich	V	72	21	37	42	9.5	5.7	15.2
49	Norwich	H	36	15	34	51	1.9	11.0	12.9
50	Sherman	H	40	17	38	45	6.7	5.9	12.6
51	Sherman	Old	60	23	54	23	11.2	8.3	19.5
52	New Haven	V	30	17	47	36	5.9	4.5	10.4
53	New Haven	V	42	18	45	37	5.8	5.7	11.5
54	New Haven	N	57	16	49	35	7.0	4.3	11.3
57	New Haven	N	72	19	48	33	0.7	5.0	5.7
59	New Haven	N	60	25	45	30	2.0	3.2	5.2
60	Ripley	N	46	29	51	20	0	5.7	5.7
61	Ripley	N	56	24	51	25	0	3.9	3.9
62	Greenwich	V	44	17	40	43	1.3	2.8	4.1
63	Ripley	N	84	33	53	14	0	4.8	4.8
64	Ripley	V	38	18	51	31	0	5.3	5.3
65	Ripley	N	50	17	49	34	4.5	4.8	9.3
65-A	Richmond	V	72	29	49	22	0	4.4	4.4
66	Richmond	V	90	16	55	29	0	4.4	4.4
67	New Haven	V	84	19	50	31	0	7.8	7.8
68	New Haven	N	36	28	50	22	2.7	2.6	5.3
69	Ripley	N	48	30	29	41	3.4	7.8	11.2
70	Ripley	N	38	28	52	20	5.2	6.0	11.2
71	Greenwich	N	75	21	43	36	1.7	3.9	5.6
72	Greenwich	V	50	14	51	35	3.6	3.0	6.6
73	Greenwich	N	100	27	49	24	7.6	4.1	11.7
74	Greenwich	M U	160	31	43	26	4.2	8.0	12.2
75	Greenwich	M B I	200	22	51	27	0.8	3.9	4.7
76	New Haven	V	72	20	48	32	8.3	3.0	11.3
77	Greenfield	V	60	21	44	35	7.3	5.7	13.0
78	Greenfield	M A	72	35	47	18	8.9	13.2	22.1
79	Greenfield	M B I	96	43	27	30	2.4	9.6	12.0

Sample No.	Township	Age Assignment	Depth Collected Inches	Grain-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	Total
80	Greenfield	M BI	160	28	23	49	0	5.6	5.6
83	Fitchville	H	24	5	35	60	2.6	5.2	7.8
84	Fitchville	V	28	34	36	30	3.0	7.5	10.5
85	Fitchville	N	36	22	53	25	0	0	0
86	Greenwich	N	48	32	49	19	1.2	5.3	6.5
87	Greenwich	N	84	18	45	37	4.8	7.0	11.8
88	Richmond	H	60	21	41	38	10.9	4.3	15.2
89	Richmond	V	72	17	53	30	5.3	5.7	11.0
90	Richmond	H	21	17	41	42	3.9	7.2	11.1
91	Richmond	V	33	19	43	38	9.0	7.0	16.0
92	Richmond	H	30	14	37	49	4.0	5.6	9.6
93	Norwich	V	37	18	38	44	10.1	6.6	16.7
94	Norwich	V	60	21	55	24	12.4	6.0	18.4
95	Norwich	V	48	20	45	35	5.8	6.6	12.4
96	Norwich	M BI	84	23	46	31	0	5.0	5.0
97	Norwich	M L	98	44	38	18	7.7	7.5	15.2
98	Sherman	V	32	20	45	35	3.3	5.3	8.6
99	Sherman	N	60	30	57	13	7.6	5.2	12.8
100	Sherman	V	41	18	42	40	9.0	7.0	16.0
101	Sherman	V	30	14	49	37	22.6	13.6	36.2
102	Sherman	V	35	21	49	30	6.8	6.6	13.4
103	Sherman	V	30	18	47	35	13.6	7.9	21.5
104	Norwich	V	96	20	47	33	7.1	6.5	13.6
105	Greenfield	V	96	17	51	32	5.7	9.3	15.0
106	Greenfield	V	120	10	52	38	2.0	7.0	9.0
107	Greenfield	V	40	16	52	32	7.8	4.8	12.6
108	Greenfield	N	120	22	49	29	7.3	4.8	12.1
109	Greenfield	M U	156	27	49	24	7.3	5.3	12.6
114	New London	H	24	22	44	34	7.3	6.2	13.5
115	New London	V	28	22	44	34	7.3	5.3	12.6
116	New London	V	26	20	48	32	9.3	4.9	14.2
117	New London	V	50	21	47	31	8.2	5.7	13.9
119	New London	N	48	26	45	29	6.4	5.3	11.7
120	Lyme	V	45	16	47	37	0	0	0

Sample No.	Township	Age Assignment	Depth Collected Inches	Gmin-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	Total
123	New Haven	N	120	17	55	28	5.0	5.3	10.3
124	Greenfield	N	60	29	54	17	2.0	8.0	10.0
125	Greenfield	M A	150	24	46	30	3.1	4.8	7.9
126	Greenfield	M BI	150	22	45	33	0.9	6.1	7.0
127	Peru	V	50	24	42	34	4.9	6.1	11.0
128	Peru	V	84	24	43	33	5.0	4.4	9.4
129	Peru	H	72	10	48	42	0	1.2	1.2
130	Peru	V	108	23	42	35	6.4	4.3	10.7
131	Ridgefield	H	50	3	55	42	6.0	4.2	10.2
132	Ridgefield	V	74	22	45	33	5.5	4.8	10.3
133	Ridgefield	V	144	21	42	37	6.8	5.7	12.5
134	Ridgefield	M BI	312	20	41	35	0	7.9	7.9
135	Norwalk	N	60	28	50	22	5.7	11.1	16.8
136	Bronson	V	55	24	46	30	4.4	6.6	11.0
137	Bronson	H	36	21	38	41	3.6	4.1	7.7
138	Bronson	V	72	25	31	38	6.2	7.5	13.7
139	Bronson	N	85	22	49	29	3.6	5.3	8.9
140	Fairfield	H	25	21	45	34	5.4	5.7	11.1
141	Fairfield	V	42	21	41	38	9.1	7.1	16.2
142	Hartland	H	26	20	38	42	4.8	8.9	13.7
143	Hartland	V	36	24	33	43	10.1	6.2	16.3
144	Hartland	V	26	24	48	28	6.5	7.2	13.7
145	Fitchville	H	36	27	40	33	5.7	5.1	10.8
146	Fitchville	V	54	29	36	35	6.9	6.0	12.9
147	Fitchville	N	78	28	43	29	7.1	3.7	10.8
148	Hartland	N	50	29	49	22	5.0	6.2	11.2
150	New London	H	48	22	42	36	13.2	9.5	22.7
151	New London	V	54	23	37	40	12.6	5.9	18.5
152	New London	N	70	20	39	41	8.6	6.6	15.2
153	New London	V	50	28	37	35	3.6	6.3	9.9
154	New London	N	62	29	43	28	9.8	4.9	14.7
155	New London	N	50	23	41	36	7.5	4.2	11.7
156	New London	V	37	21	60	19	13.2	4.0	17.2
157	New London	N	45	24	41	36	8.8	5.3	14.1

Sample No.	Township	Age Assignment	Depth Collected Inches	Grain-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	Total
158	Clarksfield	N	48	23	38	39	6.9	2.6	10.5
159	Clarksfield	N	66	23	49	28	6.9	5.8	12.7
160	Clarksfield	N	180	22	50	28	6.8	3.9	10.7
161	Clarksfield	N	240	21	51	28	6.4	5.3	11.7
162	Clarksfield	M A	300	26	38	36	3.1	5.1	8.2
163	Clarksfield	V	26	21	44	35	11.5	8.0	19.5
164	Clarksfield	N	32	28	51	21	5.8	8.0	13.8
165	Clarksfield	N	28	24	47	29	7.9	4.0	11.9
166	Hartland	V	36	21	45	34	7.6	6.5	14.1
167	Hartland	N	72	36	37	27	4.3	7.4	12.2
168	Hartland	M A	106	17	67	16	4.4	9.4	13.8
169	Branson	N	50	30	19	51	4.8	8.9	13.7
170	Sherman	N	42	21	42	37	4.6	5.9	10.5
176	Lyme	N	35	23	48	29	5.6	5.4	11.0
177	Ridgefield	H	25	20	53	27	4.4	6.1	10.5
178	Ridgefield	V	30	21	54	25	6.7	6.1	12.8
179	Ridgefield	N	37	28	49	23	0	2.5	2.5
180	Ridgefield	M BI	48	28	52	20	0	1.6	1.6
178 A	Norwich	N	72	21	41	38	7.4	6.5	13.9
179 A	Norwich	H	22	18	46	36	3.9	5.9	9.8
180 A	Norwich	V	30	20	46	34	1.7	4.3	6.0
181	Norwich	N	36	20	43	36	7.7	8.4	16.1
182	Greenfield	V	30	20	40	40	4.7	6.0	10.7
183	Greenfield	N	42	19	49	31	7.4	3.7	11.1
184	Peru	H	23	20	39	41	2.6	4.8	7.4
185	Peru	V	47	21	45	34	4.9	5.0	9.9
187	Sherman	V	30	19	43	38	6.4	6.0	12.4
188	Sherman	H	26	19	49	35	4.8	4.5	14.3
189	Sherman	N	60	26	55	19	0	4.4	4.4
190	Sherman	M BI	100	27	54	19	0	4.8	4.8
191	Ridgefield	V	48	19	48	33	5.8	4.7	10.5
193	Peru	N	50	22	41	37	6.5	3.2	9.7
194	Peru	M A	170	42	38	20	4.8	9.1	13.9
195	Peru	N	96	16	48	36	7.7	5.7	13.4

Sample No.	Township	Age Assignment	Depth collected Inches	Grain-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	Total
196	Peru	M BI	108	30	53	17	0	4.8	4.8
197	Norwalk	M A	-	26	49	25	5.8	8.0	13.8
198	Norwalk	M A	120	25	45	30	3.4	7.9	11.3
199	Norwalk	M A	132	22	50	28	3.5	5.5	9.0
201	Townsend	N	36	26	42	32	2.7	2.1	4.8
202	Wakeman	V	25	31	43	26	6.8	5.5	12.3
203	Wakeman	N	37	31	44	25	9.1	4.8	13.9
204	Fairfield	H	30	21	42	37	4.8	5.9	10.7
205	Fairfield	V	35	20	45	35	9.1	4.3	13.4
206	Fairfield	N	40	21	42	37	7.6	5.7	13.3
207	Bronson	M U	84	24	38	38	7.2	5.6	12.8
208	Clarksfield	N	37	25	34	41	6.4	5.3	11.7
209	Wakeman	V	30	23	39	38	7.3	5.8	13.1
210	Wakeman	N	38	20	57	23	7.5	6.2	13.7
211	Wakeman	N	72	26	42	32	1.2	5.3	6.5
212	Wakeman	V	28	26	45	29	5.3	4.5	9.8
213	Wakeman	N	58	30	37	33	0	5.4	5.4
214	Wakeman	M BI	130	21	51	28	0	5.1	5.1
215	Townsend	V	26	20	46	34	7.1	6.2	13.3
216	Townsend	V	30	21	40	39	3.9	4.7	8.6
217	Townsend	N	43	23	40	37	12.1	3.5	15.6
218	Townsend	N	38	21	36	43	5.5	4.1	9.6
220	Norwalk	N	90	24	37	39	7.2	4.2	11.4
221	Norwalk	M. A.	120	23	34	43	3.7	5.8	9.5
222	Norwalk	M A	170	28	60	12	3.9	5.1	9.0
223	Norwalk	M L	230	25	40	35	5.8	2.0	7.8
224	New Haven	V	72	10	28	62	0	1.6	1.6
226	New Haven	M L	360	19	47	34	1.3	1.4	2.7
227	Richmond	V	80	16	50	34	1.7	4.3	6.0
228	Richmond	M A	106	22	55	23	2.1	4.9	7.0
231	Bronson	H	28	23	38	39	1.7	4.6	6.3
232	Bronson	V	34	22	55	23	0.7	5.3	6.0
233	Hartland	N	72	26	44	30	3.6	4.5	8.1
234	Hartland	N	39	26	40	34	7.7	3.2	10.9



Glacial Geology of Huron County, Ohio
 by Stanley M. Totten, 1983

- Alluvium. Silt, sand and gravel in floodplains.
- Lacustrine deposits. Mainly peat, muck, and silty clay in Lake Willard and in kettle holes; mainly silt and fine sand on Lake Plain.
- Alluvial terraces. Silt, sand and gravel, generally in low terraces but in some high terraces.
- Beach ridges and sand dunes. Sand and fine gravel.
- Wave-cut cliff.
- Kames and eskers. Mainly sand and gravel in knolls and ridges. May be overlain by thin till and sand dunes.
- Knob and kettle topography. Mainly kames composed of sand and gravel and covered with till of variable thickness.
- Ground moraine. Mainly till in flat to rolling topography.
- End moraine. Mainly till in linear belts of hummocky topography. Some ridges are broad and smooth. Includes irregular patches of hummocks along valley sides.
- Gravel Pit, active.
- Gravel Pit, small or abandoned.
- Boundary between moraines.
- Crest of end moraine.
- Dunes





Ohio Department of Natural Resources
Division of Geological Survey
2045 Morse Road, Bldg. C-1
Columbus, OH 43229-6693
Telephone: (614) 265-6576
Fax: (614) 447-1918