PROGRESS REPORT NUMBER 21

STATE OF MICHIGAN

DEPARTMENT OF CONSERVATION
GERALD E. EDDY, DIRECTOR

GEOLOGICAL SURVEY DIVISION
WILLIAM L. DAOUST, STATE GEOLOGIST

RECONNAISSANCE OF THE GROUND-WATER RESOURCES OF LUCE COUNTY, MICHIGAN

BY

KENNETH E. VANLIER
GEOLOGIST

PREPARED IN COOPERATION WITH THE
U. S. GEOLOGICAL SURVEY

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ABSTRACT

Luce County is in the eastern part of the Northern Peninsula of Michigan. The northern two-thirds of the county is covered by forests and forested swamps and is largely undeveloped and relatively inaccessible. Most of the inhabitants reside in the southern part of the county. Lumbering and the tourist industry are the backbone of the county's economy.

The entire county is underlain by bedrock formations of Paleozoic age. These formations, consisting of sandstone, shale, limestone, and dolomite, are mantled throughout most of the county by Pleistocene glacial deposits composed predominantly of sand.

Although tapped by only a few wells, the Jacobsville sandstone of Early and Middle Cambrian age, the Munising sandstone of Late Cambrian age, and the Hermansville formation of Middle Ordovician age are important potential sources of potable water throughout the county. The water is contained in openings along joints and bedding planes, where the rocks are fully cemented, and also in voids between sand grains where they are uncemented or only partially cemented. These formations are near the surface in the northern part of the county but dip southward to a depth of 1,000 feet, or a little more.

The Black River and Trenton formations of Middle Ordovician age, the Richmond group of Late Ordovician age, the Cataract formation of Early Silurian age, and the Burnt Bluff formation of Middle Silurian age are tapped by wells where they are near the surface. Water in these formations is contained mainly in solution openings along joints and bedding planes. Generally the water is hard and, where readily soluble minerals such as gypsum or halite are present in the rocks, is highly mineralized. Where

these rocks occur at depth or where solution openings have not been developed they are of low permeability, and the ground water contained in them generally is high in mineral content.

The glacial drift is the most important aquifer in Luce County, and also has the greatest potential for future development. Both the surficial and buried deposits of glacial outwash and sandy till in the drift are sources of large supplies of water. However, in some places in the county the drift consists wholly of clayey till, which yields only meager amounts of water to wells, and in a few places the drift is missing or is too thin to be a source of supply. All the large-capacity wells in the county tap glacial drift, and probably the drift would yield large supplies of water in the parts of the county not yet developed.

Ground water of good quality is present throughout nearly all of the county. The ground water is predominantly of the calcium magnesium bicarbonate and calcium sulfate types. The sandstone and glacial-drift aquifers generally yield soft or only moderately hard water of good chemical quality. These aquifers, however, may yield water of poorer quality where they are connected hydraulically to other aquifers containing very hard or saline water. Locally, gypsum-bearing strata of the Richmond group and of the Cataract formation yield water high in calcium and sulfate. Well 45N 10W 9-4, which tapped rocks of the Richmond group, yielded water containing appreciable quantities of sodium and chloride.

Although all the water used in the county is obtained from wells, the amount is only a small fraction of the available ground-water supply.

INTRODUCTION

Purpose and Scope of Study

A ground-water reconnaissance of the eastern part of the Northern Peninsula of Michigan on a county-unit basis was begun in 1955 as part of the continuing cooperative agreement between the Michigan Department of Conservation and the U. S. Geological Survey. The objective of the reconnaisasance was to determine the general occurrence, availability, quantity, and quality of ground water in the study area. To make the results available to the public with the least possible delay, progress reports are to be released upon completion of the reconnaissance in each county. This report is the third of the series of reconnaissance reports, and it summarizes the ground-water data obtained in Luce County. The first progress report of this series (Vanlier and Deutsch, 1958a) described the ground-water resources of Chippewa County and the second (Vanlier and Deutsch, 1958b) contained similar information for Mackinac County. Pertinent data from those reports are used freely herein.

The cooperative ground-water investigations in Michigan are directed jointly by A. N. Sayre, Chief, Ground Water Branch, U. S. Geological Survey, Washington, D. C., and W. L. Daoust, State Geologist, Michigan Department of Conservation, Lansing, Mich., and are under the direct supervision of Morris Deutsch, District Geologist, U. S. Geological Survey.

Previous Investigations

Many years prior to the investigation being discussed in this report--in fact, in the early part of the century--an investigation of flowing-well districts in the eastern end of the Northern Peninsula was made by Leverett (1906). Detailed investigations of the surface geology of Luce County were made several decades later, by Bergquist (1933, 1936). During the period 1934 through 1936, the Michigan Department of Conservation, in cooperation with the Civilian Conservation Corps, delineated areas of shallow ground-water supplies that might be tapped by fire-control wells. Some of the data gathered during that project have been included in this report. In 1949, J. G. Ferris, L. A. Wood, and E. A. Moulder of the U. S. Geological Survey made a reconnaissance to determine the probable effect that a canal at the level of Lake Superior and extending through the eastern part of the Peninsula would have on adjacent ground-water levels. Many of the data collected during that survey are contained in this report. A study of the Cambrian sandstones in the Northern Peninsula of Michigan by Hamblin (1958) revealed stratigraphic information pertinent to ground-water studies.

Various phases of the geology and hydrology of the Northern Peninsula are described in numerous other reports. A rather comprehensive bibliography of these works, which date back to 1821, is included in the report on Chippewa County by Vanlier and Deutsch (1958a). Further pertinent information on Luce County is contained in the publication entitled "An Index of Michigan Geology" by Martin and Straight (1956).

Acknowledgments

Special thanks are given to the well drillers and residents of Luce County and to the State, county, and municipal agencies whose cooperation made this report possible. Appreciation is expressed also to personnel of the Michigan Geological Survey and to members of the

Michigan Basin Geological Society, who furnished much valuable advice and assistance.

Well-Numbering System

The well-numbering system used in the report indicates the location of wells within the rectangular subdivisions of the public lands, with reference to the Michigan meridian and base line. The first two segments designate the township and range; the third segment designates both the section and the number assigned to the well within the section. Thus, well 50N 9W 25-1 is well number 1 in section 25, Township 50 North, Range 9 West. The 40-acre tract in which the well is located is shown for each well listed in the well records (table 3).

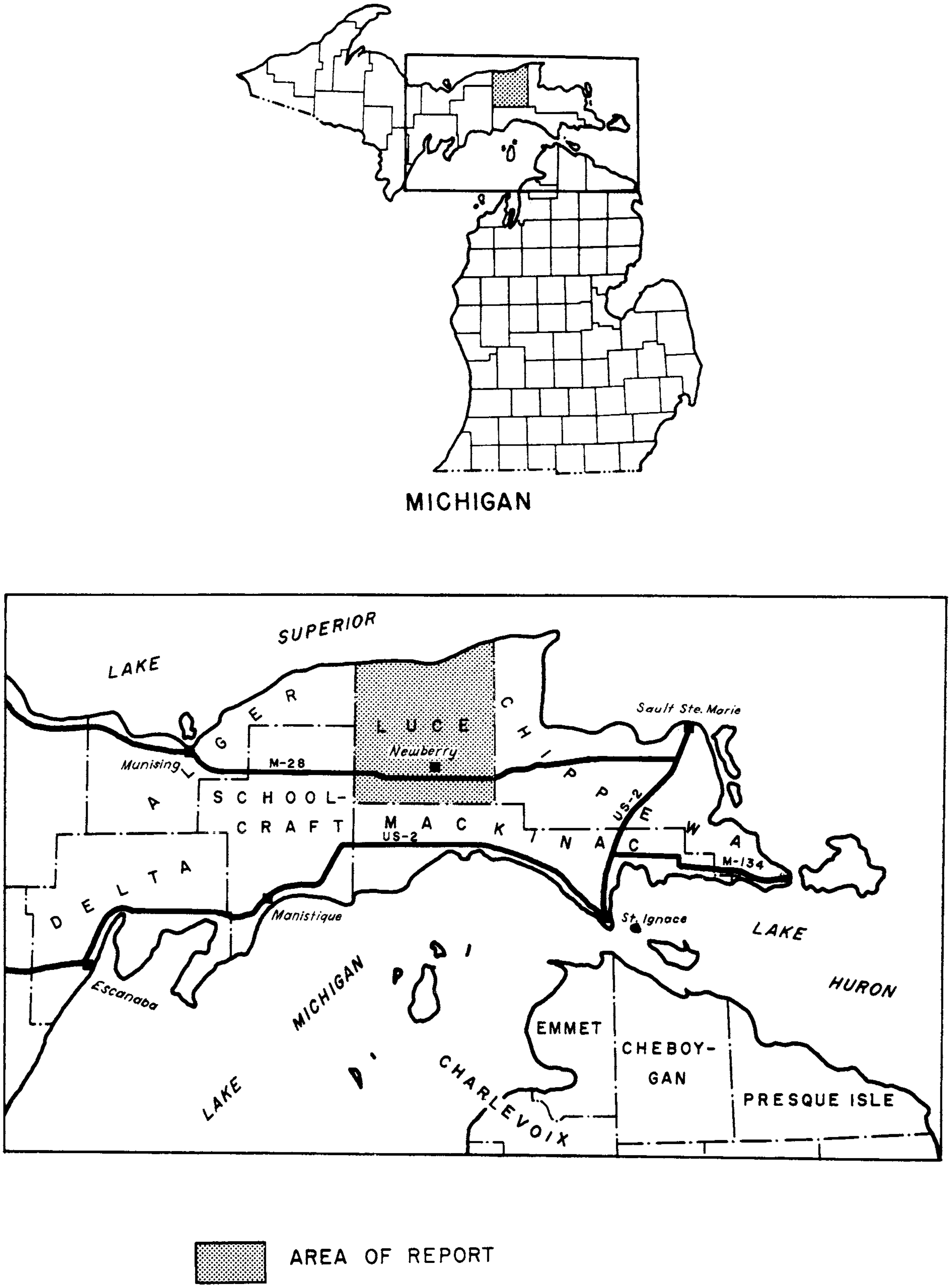


Figure I. Index map showing location of Luce County.

GEOGRAPHY

Location and Extent of Luce County

Luce County is in the eastern part of the Northern Peninsula of Michigan (fig. 1). The county is roughly square and is bounded on the north by Lake Superior, on the east by Chippewa County, on the south by Mackinac County, and on the west by Schoolcraft and Alger Counties. It has an area of about 900 square miles. The shoreline along Lake Superior has a length of about 31 miles.

Population and Economic Development

The population of the county in 1955 was estimated by the Michigan State Health Department to be 7,420; in 1950 it was 8,147 and in 1940 it was 7,423 according to the Bureau of the Census. The population for the City of Newberry for the same years was 2,610, 2,802, and 2,732, respectively.

The edonomy of Luce County is related primarily to its natural resources. The production of timber and timber products is the main industry. Two small dolomite quarries have been operated intermittently, and a number of sand and gravel pits are also worked as a source of aggregate or road metal. The natural scenic beauty, the inland lakes, and the wildlife of the county provide for a thriving tourist industry. The Newberry State Hospital provides employment for a number of people in the area.

The county is served by State Highways 28, 98, 117, and 135, and by the Duluth, South Shore and Atlantic Railroad (fig. 2).

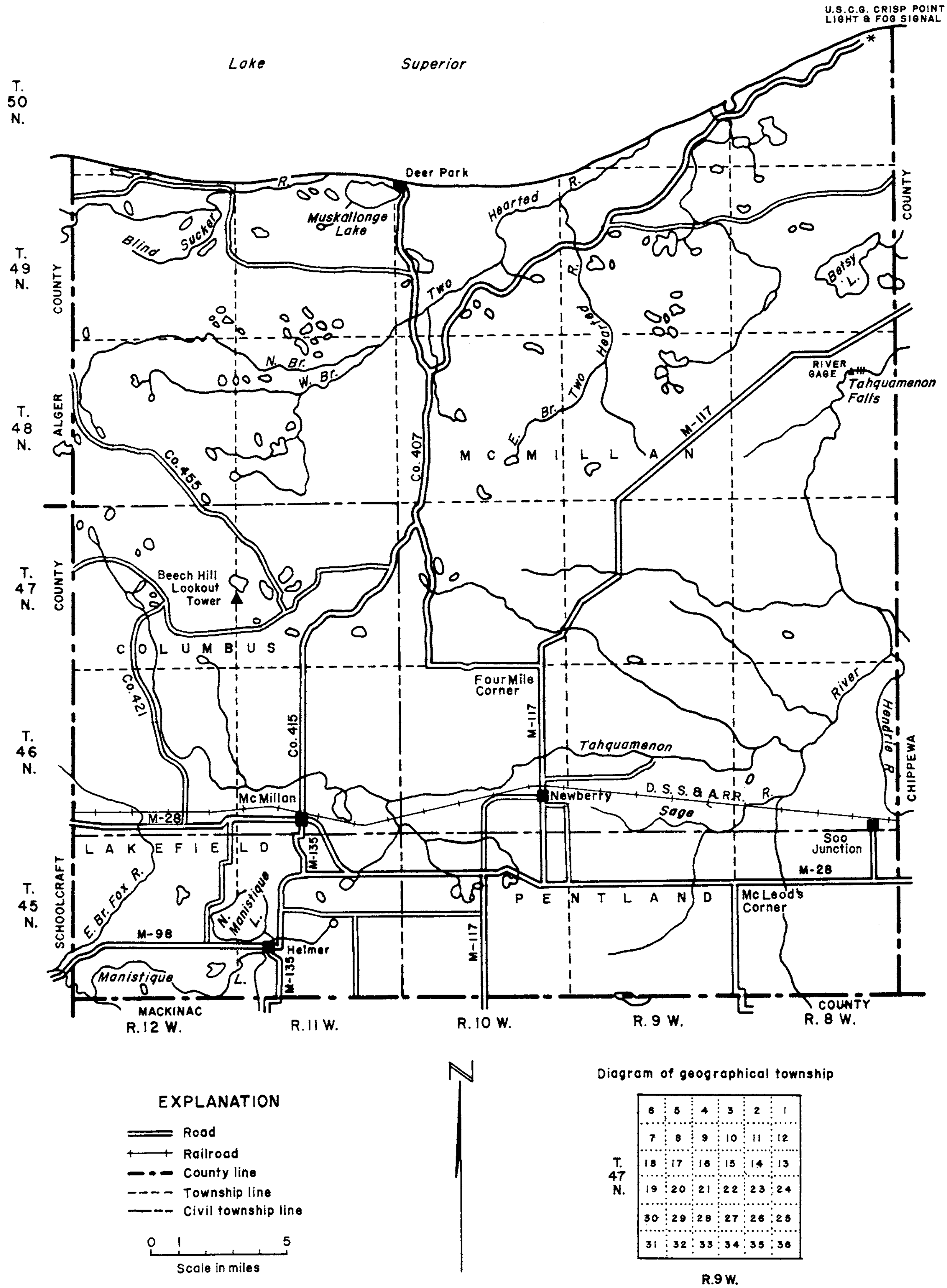


Figure 2. Map of Luce County.

Physiography

Luce County lies in the area that was once covered by the waters of glacial Lake Algonquin and other extinct glacial lakes (fig. 3). Its main physiographic features are the rather level lake plains formed by deposits of glacial-lake sediments and the extensive ridges or hills of the Newberry, Munising, and Crisp Point morainic systems (Bergquist, 1936). The moraines were deposited in glacial Lake Algonquin and other extinct glacial lakes and were modified somewhat by the wave action of the lakes.

Within Luce County, the Newberry moraine consists of a series of rough and irregular hills which extends from Manistique Lake to a point about 6 miles southeast of Newberry. The Munising morainic system is an undulating highland belt which crosses the central part of the county in a rough east-west arc (pl. 2). This belt of highlands is broken into a larger western segment and a smaller eastern segment. The western segment extends from the southern part of the boundary common to Alger and Luce Counties to a point a few miles north of Newberry, and the eastern segment is in T. 48N., Rs. 8 and 9 W. The Munising morainic system lies north of the Tahquamenon River except in the eastern part of the county, where it is breached by the river. The Crisp Point morainic system forms a broken belt of hills across the northern part of the county. This belt of hills is not as rough and distinct as the highlands of the other morainic systems.

Other highlands are formed by drift covered cuestas, or bedrock ridges in the southern part of the county. Rocks of the Burnt Bluff

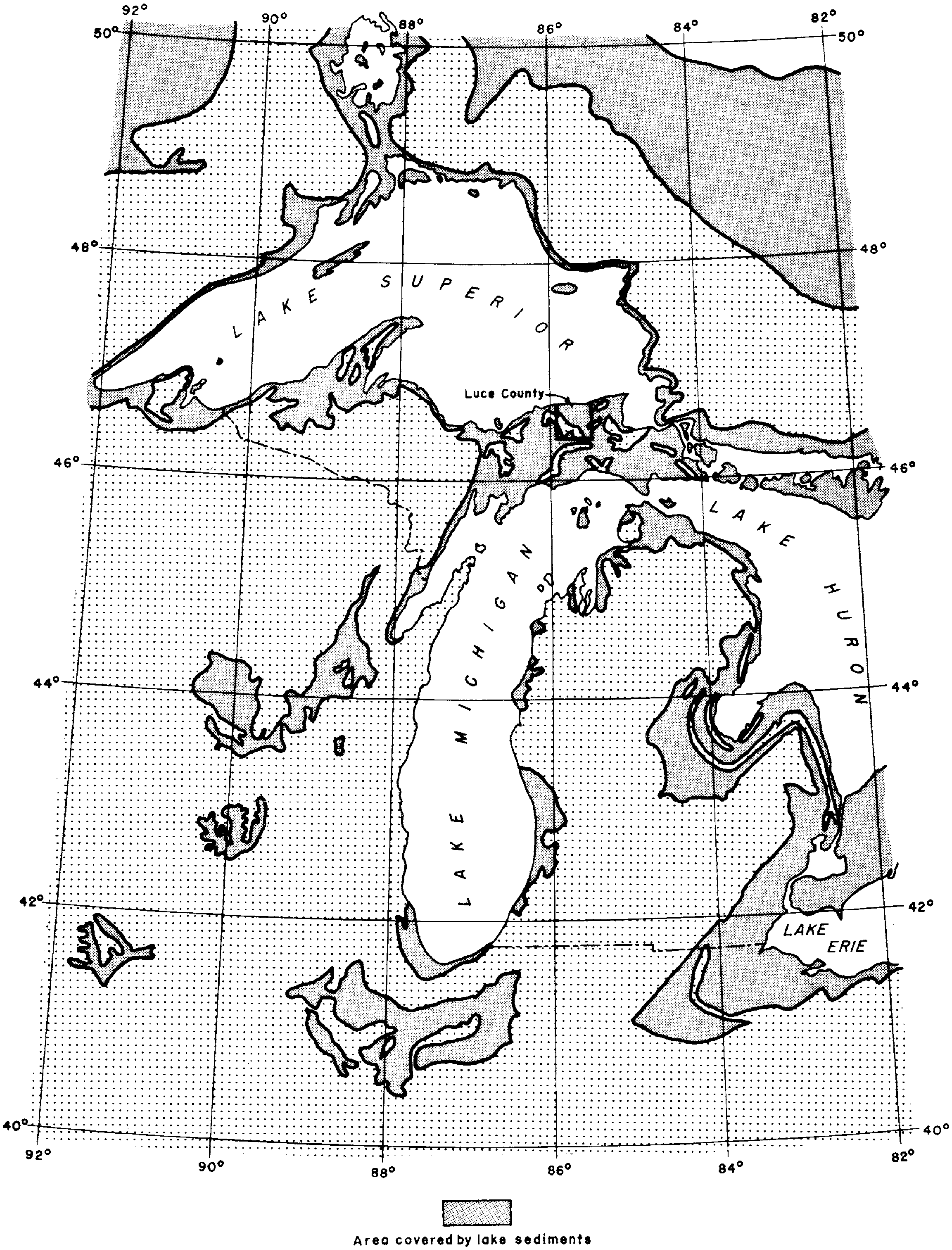


Figure 3. Map of the upper Great Lakes region showing areas of deposition in extinct glacial lakes.

formation form a prominent cuesta in adjacent areas of Mackinac County. The escarpment of this cuesta extends into Luce County and forms a prominent topographic feature along the southern boundary of the county in T. 45N., Rs 8 and 9 W. A smaller cuesta is formed by resistant dolomite in the lower part of the Cataract formation. This cuesta forms a highland of low relief in T. 45 N., R. 8 W. Elsewhere the cuesta is buried by morainal and associated glacial deposits.

Rather level lake plains and other minor features associated with glacial Lake Algonquin and post-Algonquin lakes characterize most of the remainder of the county. Extensive swamps and marshes occupy poorly drained segments of the lake plains.

Large areas of sand dunes lie along the Lake Superior shoreline. Locally, wave action has cut bluffs in the dunes.

Relief

The highest points in Luce County are two knobs on the Munising Moraine in the western part of the county. One of the knobs is in the southwestern part of T. 48 N., R. 12 W., the other is at Beech Hill Lookout Tower (fig. 2). The maximum altitudes of these knobs is slightly less than 1,200 feet. The highest points on the Newberry Moraine are south of McMillan, and reach altitudes slightly greater than 1,050 feet. The lowest areas in the county are along the shore of Lake Superior at an altitude of about 600 feet.

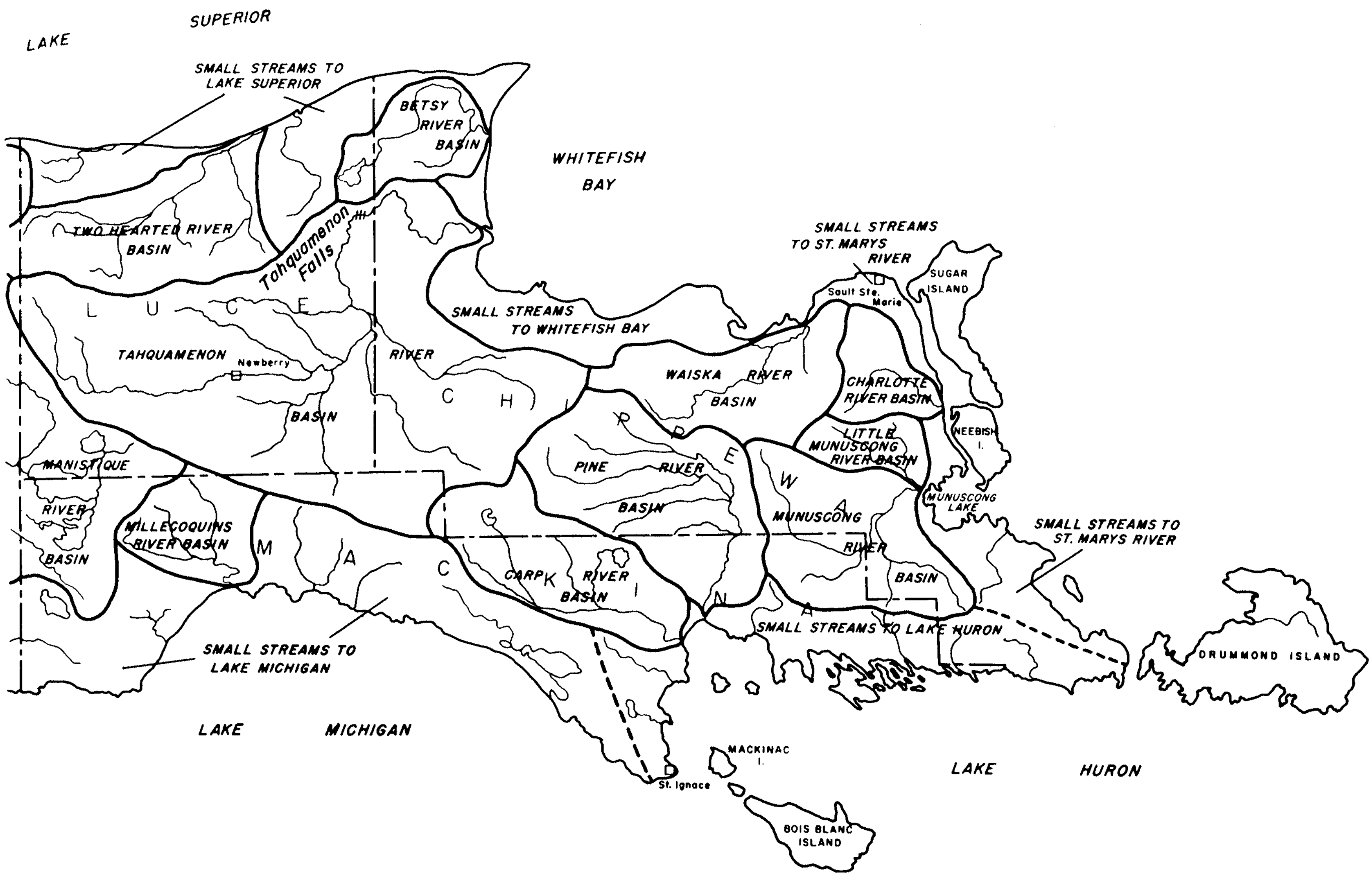


Figure 4. Map of Luce, Chippewa, and Mackinac Counties showing major drainage basins and drainage areas tributary to the Great Lakes.

Drainage

Nearly all of the county is drained by streams tributary to Lake Superior (fig. 4). A small area in the southwest corner of the county, including North Manistique Lake (fig. 2), is tributary to the Manistique drainage system, which empties into Lake Michigan, and a small part of T. 45 N., R. 10 W. drains to Lake Michigan through the Millecoquins River. The Tahquamenon River, which empties into Whitefish Bay of Lake Superior, is the largest stream in the county. At the Tahquamenon River Falls (fig. 2) near the Chippewa County line the river plunges over a 40-foot ledge of Cambrian sandstone. The Two Hearted River and several smaller streams flow directly into Lake Superior. The discharge of the Tahquamenon River for the period 1954 and 1955 is shown by a graph in figure 10.

Natural drainage is in an early stage of development as shown by the presence of extensive swamps and a great many (571) inland lakes. Drainage features are poorly developed in areas underlain by sandy soils because little surface runoff occurs. Drainage features are best developed in the topographically high areas underlain by clayey soils of low permeability.

Climate

Compared with that of other interior continental areas in the same latitude, the climate of Luce County is less rigorous because of the tempering effect of the Great Lakes. Average annual precipitation at Newberry State Hospital is about 28 inches and average annual temperature is 40.1° F. The average growing season is about 110 days, extending from the average date of the last killing frost, June 2, to that of the first killing frost, September 20.

GEOLOGY

Luce County is underlain by sedimentary rocks of Paleozoic age which, except for outcrops which are too small to be shown on plate 2, are mantled everywhere by glacial deposits of Pleistocene age. The areal distribution of the Paleozoic rocks is shown on plate 1. The lithologic and hydrologic properties of the various rock units underlying the county are described briefly in table 1, and more fully in the section on Ground Water. Plate 3 is an index to the location of the hydrologic, geologic and quality of water data.

Summary of Geologic History

Sandstone, shale, limestone, and dolomite, which were deposited in shallow seas that covered the Michigan basin during the Paleozoic era, underlie all of Luce County. During the Mesozoic and most of the Cenozoic eras the Paleozoic rocks were above sea level and were eroded by wind and running water. The erosion resulted in the basic topographic configuration of the present bedrock surface.

During the Pleistocene (glacial) epoch, which followed the long interval of erosion, the Michigan basin was buried at least four times under glacial ice that flowed southward from accumulation centers in Canada. The physiographic features formed during Mesozoic and early

Table 1.--Lithology and hydrology of rocks underlying Luce County

AGE			NAMES AND SYMBOLS USED IN THIS REPORT LITHOLOGY	THICK-NESS (feet)	HYDROLOGY	NAMES USED BY THE MICHIGAN GEOLOGICAL SURVEY: SERIES	GROUP	FORMATION
CENEZOIC	QUATERNARY	PLEISTOCENE	GLACIAL DRIFT, UNDIFFERENTIATED (Qgd) SAND (Qs); GRAVEL (Qg) SAND AND GRAVEL (Qsg) Heterogeneous assemblage of unsorted to slightly stratified clayey, sandy, and gravelly till, principally water-laid; stratified sand and gravel outwash; stratified clayey, silty, and sandy lake deposits; and wind-deposited sand.	0 to 320+	Principal aquifer in Luce County. Best yields from sand and gravel outwash deposits, many of which are incorporated within the morainic deposits. Small to moderate supplies from sandy and gravelly morainal till. Poor yields from clayey till. Small yields from lake-deposited sand. Moderate to large supplies from sand and gravel deposits overlain by lake-deposited silt, sand, and clay. Layers of lake-deposited clay and clay till are confining beds in some artesian systems.	GLACIAL DRIFT		
PALEOZOIC	SILURIAN	MIDDLE	BURNT BLUFF FORMATION (Sbb) Hard, resistant light-gray to gray thinly bedded to massive limestone and dolomitic limestone; contains beds of high-calcium limestone.	200±	Not tapped by wells in Luce County but would yield water to wells in the small area in T. 45 N., Rs. 8 and 9 W.	NIAGARAN	CLINTON	BURNT BLUFF
		EARLY	CATARACT FORMATION (Sc) Hard, resistant gray dolomite interbedded with gray and greenish-gray shale and gypsum.	200±	A source of water to a number of wells in the southern part of the county. Permeable as a result of solution along joints, or other fractures, and bedding planes. Generally yields water too hard for most uses. Locally contains highly mineralized water.	ALBION	CATARACT	MAYVILLE CABOT HEAD MANITOULON
	ORDOVICIAN	LATE	LIMESTONE AND DOLOMITE OF RICHMOND GROUP (Or) Gray to dark-brown dolomite and limestone interbedded with dark-colored shale.	200±	Yields water to several wells in the Newberry area and to one well south of McMillan. Generally yields hard water. Locally contains saline water.	CINCIN-NATIAN	RICHMOND	QUEENSTOWN? BIG HILL STONINGTON BILLS CREEK
			SHALE OF RICHMOND GROUP AND COLLINGWOOD FORMATION (Orc) Gray dolomite and black bituminous shale.	200±	Permeability low. Not a source of water to wells in Luce County.			COLLINGWOOD
		MIDDLE	TRENTON AND BLACK RIVER FORMATIONS (Otb) Hard gray and brown limestone and dolomite interbedded with shale and shaly limestone and dolomite.	200±	Not a source of water to wells at present. May yield fresh water from openings enlarged by solution where these strata form the bedrock surface. Probably contain saline water where overlain by younger consolidated rocks.	MOHAWK-IAN	TRENTON AND BLACK RIVER	TRENTON AND BLACK RIVER
			HERMANSVILLE FORMATION (Oh) White to gray fine- to medium-grained sandstone, and sandy dolomite.	50	These two sandstone formations constitute a single aquifer which is presumed to be a source of fresh water wherever present in the county. Water contained in openings along joints and bedding planes in cemented parts of aquifer and in interstices between individual grains in non-cemented parts.			HERMANSVILLE
	CAMBRIAN	LATE	MUNISING SANDSTONE (Єm) White to gray fine- to medium-grained sandstone.	200±		LAKE SUPE-RIOR		MUNISING
		EARLY AND MIDDLE	JACOBSVILLE SANDSTONE (Єj) Well-cemented quartzitic sandstone, red and pink with patches of white.	1,000+	Source of water to wells in Chippewa and Alger Counties and a potential source of water is here present in Luce County. Water contained in openings along joints and bedding planes; permeability decreases with depth.			JACOBSVILLE
PRECAMBRIAN			METAMORPHIC AND IGNEOUS ROCKS	?	Too deep to be an economical source of water supply. Permeability (probably) low.	PRECAMBRIAN, UNDIFFERENTIATED		

Cenozoic time were greatly modified by the advancing glaciers. The ice sheets transported vast amounts of a wide variety of rock material torn from the surface over which they moved, and when they melted, this material was deposited on the eroded Paleozoic rock surface.

At the close of the Pleistocene epoch, glacial Lake Algonquin covered nearly all of Luce County (fig. 3). Postglacial uplift of the land mass, which had been depressed by the ice, resulted in changes in drainage patterns, lake elevations, and shoreline positions. The result of these changes was a succession of postglacial upper Great Lakes, of which Lakes Superior, Michigan, and Huron represent the modern stage (Leverett and Taylor, 1915, chaps. 21-25). Inland bars, beaches, wave-cut benches, and dunes mark the shorelines of these successive lakes.

Bedrock Structure

Little is known of the configuration of the Precambrian rock surface upon which the Paleozoic sediments of Luce County were deposited. Although the Paleozoic sediments of the Michigan basin were deposited in nearly horizontal layers, gradual subsidence and compaction of the beds, which were contemporaneous with deposition and were greatest in the center of the basin, produced a bowl-shaped structure. The youngest beds are exposed at the surface in the central part of this structure in central Michigan and the rock units crop out in roughly concentric bands. Luce County is at the north edge of the structure where the oldest sedimentary rock units are exposed (fig. 5). The regional dip of these units here is southward at about 40 to 60 feet per mile. The units thicken toward the center of the basin.

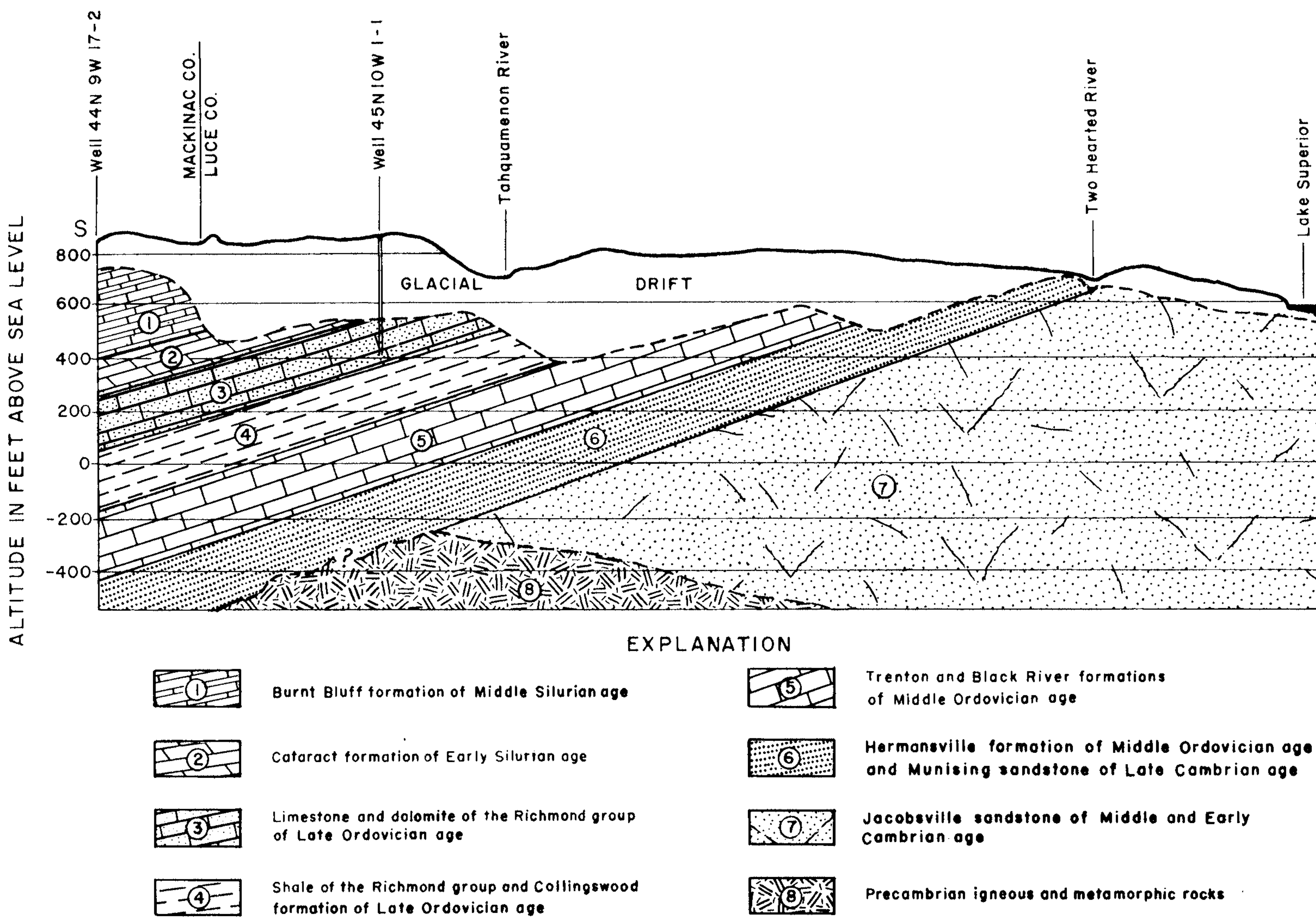


Figure 5. Generalized north-south geologic section through Luce County along line N-S shown on plate I.

GROUND WATER

Principles of Occurrence and Availability

A water-bearing formation that yields water in usable quantities is termed an "aquifer". In areas where ground water is difficult to obtain, a formation yielding less than a gallon per minute (gpm) to wells may be classified as an aquifer. In other areas, where wells may yield many gallons per minute, a rock from which wells obtain only a few gallons per minute might not be classified as an aquifer.

The capacity of a water-bearing material to transmit water under pressure is termed "permeability." The coefficient of permeability as used herein is reported in meinzers (Meinzer's units). The meinzer is defined as the rate of flow of water, in gallons per day, through a cross-sectional area of 1 square foot under a hydraulic gradient of 100 percent at a temperature of 60°F. The coefficient of permeability varies greatly, the variance depending in general upon the degree of assortment and the arrangement and size of the particles. Coefficients of permeability of most important water-bearing materials are greater than 10 meinzers. The permeability of the deposits of sand and gravel tapped by the large capacity wells in Luce County probably range from 200 to 1500 meinzers.

The specific capacity of a well is defined as the yield of water in gallons per minute for each foot of drawdown in water level caused by pumping of the well. It is a function of the permeability and thickness of the aquifer and of the efficiency of the well. The specific capacities of 20 wells tapping various aquifers in Luce County are listed in table 2.

Table 2.--Reported specific capacities of 20 wells in Luce County

Well number	Aquifer		Length of screen (feet)	Duration of test (hours)	Rate of discharge (gpm)	Drawdown (feet)	Specific capacity (gpm/per ft)
	Symbol	Lithology					
46N 11W 33-2	Qg	Gravel	-	-	350	20	17.5
46N 10W 24-4	Qsg	Sand and gravel	-	-	.25	4.5	.06
25-7	Qs	Sand, coarse	75	-	1,280	30	42
25-9	Qsg	Sand and gravel	20	23	715	29.5	24
36-4	Qs	Sand	6	-	100	6	17
36-5	Qsg	Sand and gravel	6	24	10	70	.14
45N 12W 22-1	Qs	Sand, coarse	5	-	15	18	.8
26-2	Qsg	Sand and gravel	3	-	14	10	1.4
45N 11W 4-3	Qs	Sand	5	6	5	8	.6
45N 10W 1-3	Or	Dolomite	-	-	170	42	4
1-7	Qg	Gravel	-	6	27.5	80	.35
1-8	Qsg	Sand and gravel	-	.5	300	84	3.6
1-9	Qsg	Do.	-	3	412	4.5	92
1-10	Qsg	Do.	10	-	540	68	8
1-12	Qsg	Do.	16	-	510	40	13
9-6	Or	Dolomite	-	2	10	21	.5
11-1	Qs	Sand, fine	-	-	1	5	.2
13-4	Qs	Sand, coarse	40	6	1,000	28	36
20-1	Qs	Sand, medium	6	5	10	15	.7
45N 8W 14-1	Sc	Dolomite	-	1	17	15	1.1

Ground water is the water in the zone of saturation, the zone in which all voids are filled with water under atmospheric or greater pressure. On the basis of water occurrence, aquifers may be classified as water-table or artesian. In a water-table aquifer, ground water is unconfined and its surface within the aquifer is termed the "water table". In an artesian aquifer, ground water is confined under pressure between relatively impermeable strata (strata through which water does not move readily). Under natural conditions, the water in a well finished in an artesian aquifer and tightly cased through the overlying confining bed (aquiclude) will rise above the bottom of that bed. An artesian aquifer is full of water at all times, even while water is being removed from it. In time, however, enough water may be pumped to draw the water level below the bottom of the overlying confining bed, thus creating water-table conditions locally. The imaginary surface connecting all points to which water would rise in wells tapping an artesian aquifer is called the "piezometric surface". In topographically low areas the piezometric surface may be higher than the land surface, and wells tapping artesian aquifers in these areas will flow.

Meinzer (1923) showed that the hydrologic properties (permeability and porosity) of aquifers are determined basically by the character of the interstices between grains, or open spaces within the rocks, that form the aquifers (fig. 6). Interstices in rocks can be grouped into two main classes--the original interstices which were formed when the rocks came into existence and the secondary interstices (joints, fissures,

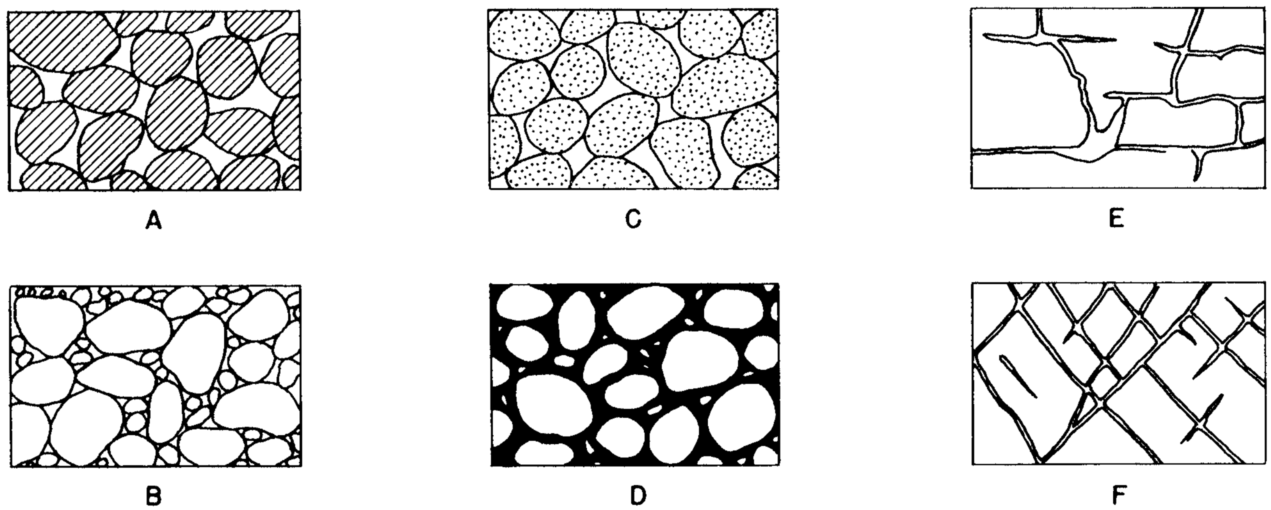


Figure 6. Diagram showing several types of rock interstices and the relation of rock texture to porosity. A, Well-sorted sedimentary deposit having high porosity; B, poorly sorted sedimentary deposit having low porosity; C, well-sorted sedimentary deposit consisting of pebbles that are themselves porous, so that the deposit as a whole has a very high porosity; D, well-sorted sedimentary deposit whose porosity has been diminished by the deposition of mineral matter in the interstices; E, rock rendered porous by solution; F, rock rendered porous by fracturing. (From Meinzer, 1923, p.3)

solution passages) which were developed later. The amount of water available to a well is governed by regional and local hydrologic and lithologic characteristics of the aquifer and by the climatic conditions and the hydraulic properties of the soils and subsurface rocks in the recharge areas.

The aquifers underlying Luce County consist of a variety of consolidated and unconsolidated rocks. The consolidated-rock aquifers are composed primarily of sandstone, limestone, or dolomite. In a sandstone aquifer water moves through interstices between individual sand grains and along joints, other fractures, and bedding planes. Movement of water in limestone and dolomite aquifers is predominantly through permeable zones which were developed by weathering and solution in areas where these rocks were exposed at the surface during preglacial time. Layers of shale interbedded with layers of limestone and dolomite are of low permeability and yield little water to wells. They are significant in the hydrologic system, however, because they impede vertical movement of ground water, and hence retard solution in underlying soluble rocks, and also act as confining beds in artesian systems. The unconsolidated aquifers are composed of glacial drift and in general are the most accessible source of water to wells in the county. The water in these aquifers is contained in the interstices between rock particles. The drift aquifers have the greatest potential for future development, but in those places in Luce County where the mantle of unconsolidated sediments is thin or lacks permeable zones, the consolidated-rock aquifers are the only source of ground water.

Ground Water in Consolidated Rocks

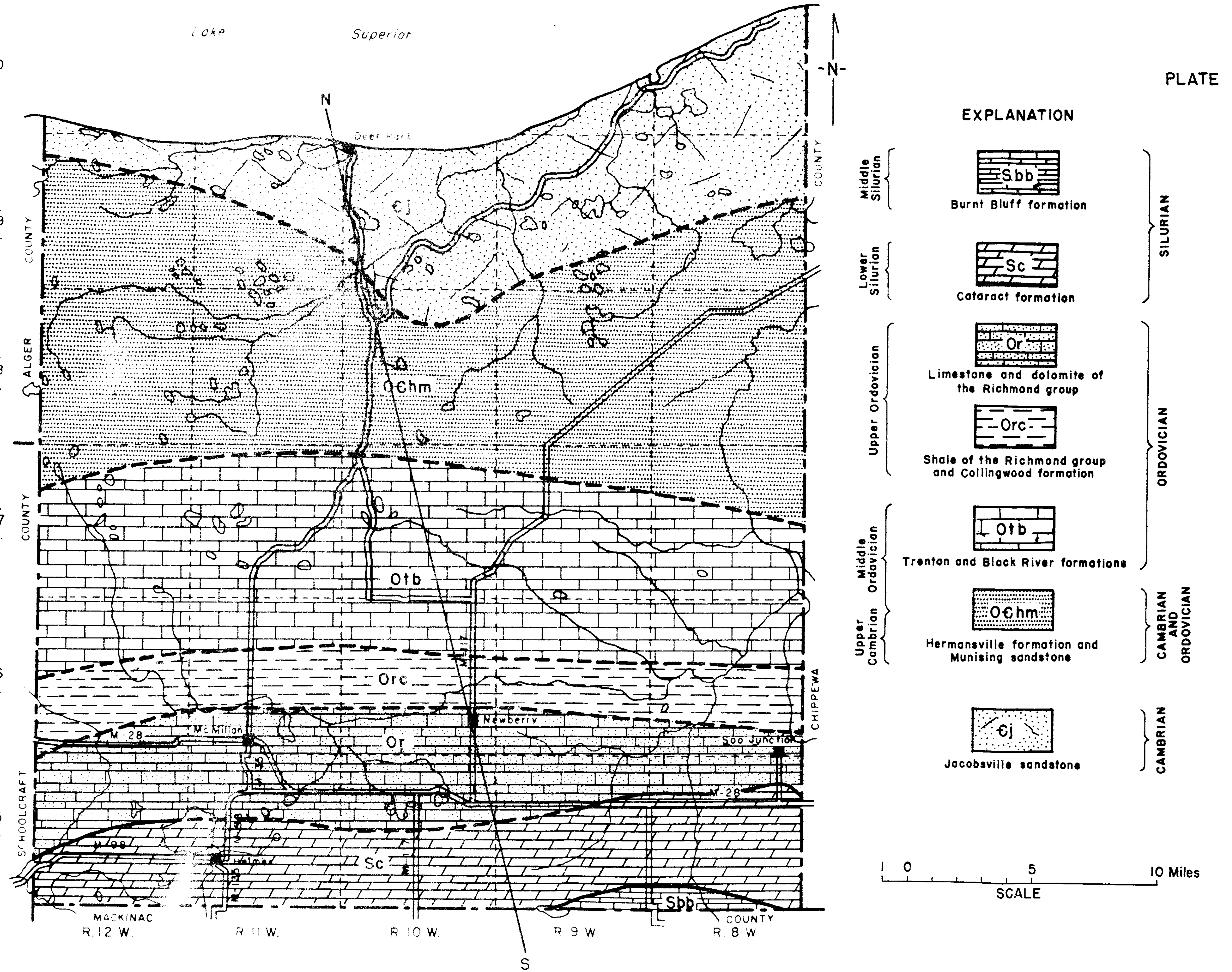
Precambrian Rocks

Precambrian rocks underlie all of Luce County. However, neither the depth to the surface of these rocks nor their composition or physical characteristics have been determined at any location in the county. Future development of Precambrian rocks as a source of water supply is very unlikely because of their depth and probable low permeability, and because in most of the county the Precambrian rocks are overlain by three formations which constitute an aquifer of moderate permeability.

Jacobsville Sandstone of Early and Middle Cambrian Age

The Jacobsville sandstone is the oldest Paleozoic sedimentary-rock unit in the county. Its maximum thickness is more than 1,000 feet. It is a hard, resistant quartzitic sandstone, the interstices between the sand grains being largely filled with silica cement and with a secondary growth of the fragment of crystalline quartz which form the individual sand grains. The formation is jointed. The sandstone is predominantly red but is mottled and streaked with white. This rather unique coloration is characteristic of the formation. The Jacobsville sandstone underlies nearly all of the county but is nearest the surface in the northern part, where it is mantled only by glacial drift. (See pl. 1). In this part of the county the sandstone and drift, where saturated, constitute essentially a single aquifer. However, the area is largely

. 1).



GEOLOGIC MAP OF LUCE COUNTY SHOWING BEDROCK FORMATIONS BENEATH SURFICIAL DEPOSITS undeveloped and none of the few wells present is known to have been drilled into the Jacobsville sandstone. Data from wells in adjacent Chippewa and Alger Counties indicate that the permeability of the Jacobsville sandstone is the result of jointing and weathering and decreases with depth.

Munising Sandstone of Late Cambrian Age

The Munising sandstone is a white to gray fine- to medium-grained sandstone. Parts of the formation are pink but can be readily distinguished from the red Jacobsville sandstone (Cohee, 1945). The formation is not as well cemented and therefore is less competent than either the underlying Jacobsville sandstone or the sandstone members of the overlying Hermansville limestone. In Alger County, a thin bed of conglomerate forms the basal member of the Munising (Hamblin, 1958), but it is not known whether the conglomerate extends into Luce County.

The Munising sandstone crops out at several places in the eastern part of the Northern Peninsula and in adjacent areas in Canada. The sandstone forms the famed pictured rocks and many of the waterfalls in Alger County. The only extensive exposures of the Munising in Luce County are at the falls of the Tahquamenon River and along the Two Hearted River for a distance of more than a mile upstream from the bridge across county road 407 (fig. 2). The Munising has not been completely penetrated in the drilling of any well in Luce County, and therefore the thickness of the formation is not known. Data from wells in other counties in the eastern part of the Northern Peninsula indicate that the sandstone is about 200 feet thick in Luce

County where it is overlain by younger consolidated rocks. Where it forms the bedrock surface, it ranges in thickness from about 200 feet along its boundary with the Hermansville formation to a featheredge along its boundary with the Jacobsville sandstone (pl. 1). It is not possible, however, to delineate the boundary between the Munising and Hermansville on plate 1 because of the lack of subsurface data, and because these formations crop out in so few places in the county. The only well in Luce County known to tap the Munising sandstone where it is mantled by younger consolidated rocks is well 45N 12W 21-2. In the area where the Munising forms the bedrock surface, it is tapped by a few wells ranging in depth from 11 to 86 feet (table 3).

Hermansville Formation of Middle Ordovician Age [1]

In the eastern part of the Northern Peninsula the Hermansville formation consists of beds of white and gray fine- to medium-grained sandstone, dolomitic sandstone, and sandy dolomite. Apparently, the amount of dolomite in the formation decreases from west to east, dolomitic strata being common in Alger County but not in Chippewa County. Within Luce County, the formation is believed to contain appreciable quantities of dolomitic cement. This is indicated in the vicinity of the Tahquamenon Falls, where the caprock at the falls is the competent, well-cemented basal layer of the Hermansville and the underlying, loosely cemented Munising sandstone has been cut away. Some of the sandstone layers in the Hermansville are lithologically similar to the Munising sandstone but can be distinguished from them because they differ in fossil content (Hamblin, 1958).

(1) The use of the term "Hermansville formation" in this report does not imply that the Michigan Geological Survey discredits the work done by Wm. Kenneth Hamblin resulting in Publication 51 "Cambrian Sandstones of Northern Michigan." The present work was too near completion to be revised when the above paper was published. (Editor's note)

Well 45N 12W 21-2 is the only well in Luce County known to tap the Hermansville formation. Although a log of this well is not available, the depth of 850 feet indicates that it taps both the Munising sandstone and beds of sandstone in the Hermansville formation, which form a single aquifer. The artesian pressure in this well and also in several wells in adjacent areas in Mackinac and Schoolcraft Counties that tap the same aquifer is great enough to cause water to flow at the land surface. In all of southern Luce County, where the aquifer is overlain by younger consolidated rocks, the water in this aquifer is confined under considerable artesian pressure and in much of this part of the county the piezometric surface is near or above the land surface.

The Munising sandstone and Hermansville formation in Luce County are believed to have considerable potential for future development. Wherever present within the county these formations probably are capable of yielding moderate supplies of potable water.

Trenton and Black River Formations of Middle Ordovician Age

The Trenton and Black River formations overlie the Hermansville formation in the southern part of Luce County. Where they form the bedrock surface (pl. 1) they are everywhere mantled by deposits of glacial drift. Outcrops of the formations in several places in Chippewa, Alger, and Delta Counties consist of a series of limestones, dolomites, and dolomitic shales (Hussey, 1936). Because they are similar in lithologic and hydrologic characteristics, the Trenton and Black River formations are treated as a single unit in this report.

In preglacial time these formations are believed to have been eroded to form a cuesta (Black River cuesta, Thwaites, 1946, p. 20), having a northward-facing escarpment and a gentle southward dip slope. This cuesta which is buried under glacial drift in Luce County, trends in a general east-west direction.

No wells in Luce County are known to tap the Trenton and Black River formations, but because these formations yield fresh water to several wells in Chippewa County, they probably would be a source of fresh water in Luce County also. In Chippewa County the water is contained in solution openings along fractures and bedding planes where these formations form the bedrock surface. As solution must have been greatest in the upper limestone and dolomite strata, the permeability of the rocks probably decreases with depth. The basal layers of the Black River formation form the aquiclude capping the Munising and Hermansville formations.

Well 44N 9W 17-2 in Mackinac County, about 10 miles south of Newberry, produced saline water from the Trenton and Black River formations (Vanlier and Deutsch, 1958b). It is believed that wells tapping these rocks in the southern part of Luce County where the formations are overlain by younger consolidated rocks would also produce saline water. These formations are not important as potential sources of water in the county because in the areas where they might produce fresh water, they are overlain generally by shallower and more prolific glacial-drift aquifers.

Collingwood Formation and Richmond Group of Late Ordovician Age

Shales of the Collingwood formation and Richmond group.--A sequence of black bituminous shale, the Collingwood formation and gray dolomitic shale of the basal unit of the Richmond group, overlies the rocks of Middle Ordovician age. This shale is nearly impermeable and therefore is not a source of water to wells in Luce County. The thickness of the sequence along the southern boundary of the county is believed to be about 200 feet.

Limestone and dolomite of the Richmond group.--The upper units of the Richmond group consist of limestone, dolomite and of shaly or sandy dolomite interbedded with layers of shale. The log of well 43N 13W 16-5 in Schoolcraft County indicates the presence of streaks of gypsum in these strata. The color of the dolomite ranges from gray to dark brown, whereas the shale is bluish-gray or black (see logs 45N 10W 1-1 and 9-4 in table 4). Where overlain by the Cataract formation in Luce County, these rocks are about 200 feet thick. Rocks of the Richmond group are not believed to crop out in Luce County.

The Richmond group is a source of water to a number of wells in the part of the county where these rocks form the bedrock surface (pl. 1). In places, water-bearing, permeable glacial drift overlies and is hydraulically connected with the Richmond and a well completed in one of the aquifers, may produce water from both aquifers. Several wells in the Newberry area and one well (45N 11W 8-2) near McMillan obtain fresh water from these rocks although well 45N 10W 9-4, which tapped the same aquifer, produced saline water.

Cataract Formation of Early Silurian Age

The Cataract formation is composed chiefly of dolomite and shale interbedded with thin layers of gypsum. The dolomite generally is gray to dark gray, but cuttings brought to the surface when wells are drilled into it often are somewhat blue when wet, and for this reason the formation is sometimes referred to as the "blue rock" by water-well drillers. The shale generally is dark gray, but green shale has been reported (Ehlers and Kesling, 1957, p. 5-7). The maximum thickness of the Cataract formation in Luce County is about 200 feet. The formation crops out in T. 45 N., R. 12 W., on the shore of Manistique Lake, and also in T. 45 N., R. 8 W.

The Cataract formation is a source of water to several wells in the southern part of the county where it forms the bedrock surface. Apparently, the water moves principally through solution openings along joints and bedding planes. It is believed that the Cataract formation will yield water to wells throughout the area where it forms the bedrock surface. Generally, however, water from the formation is very hard, and locally it is too highly mineralized for most uses.

Burnt Bluff Formation of Middle Silurian Age

A small, undeveloped area in southeastern Luce County is underlain by light gray to gray thinly bedded to massive limestones of the Burnt Bluff formation (pl. 1). The strata of the formation are hard and resistant. Some beds are dolomitic, but others are high in calcium content. Although no wells in Luce County are known to tap these rocks, the formation is a source of water to many wells in Mackinac County and where present in Luce County probably would yield water to wells.

Ground Water in Unconsolidated Rocks

Nearly all of Luce County is mantled by unconsolidated rocks of various types deposited during the Pleistocene epoch. These deposits are referred to collectively as "glacial drift". The types of drift (till, outwash, glacial-lake sediments, and dunes) are differentiated on the basis of their mode of deposition. Till is generally unstratified drift that was deposited directly by the ice, water playing a minimum part in the process of deposition. Outwash is stratified drift that was deposited by melt water flowing from the glacier. Glacial-lake sediments are stratified fine-grained rock materials that were deposited in glacial lakes. Dunes are composed of well-sorted sand deposited by wind action, principally during the glacial epoch.

The drift deposits differ not only in their mode of deposition but also in the source of the material. Although some of the material that makes up the drift was transported a great distance, most of the material was derived from nearby sources. Flint (1947, p. 114) states that "the average distance traveled by a rock fragment from the time it is picked up by the glacier until it is deposited is only a few miles". The glaciers moved in a southerly direction across Luce County, and much of the material plucked and scoured from the bedrock surface was deposited a few miles to the south when the glacier melted. Thus, the drift of Luce County is closely related to the bedrock formations of the county.

The drift in and immediately south of the area where the Jacobsville, Munising, and Hermansville formations compose the bedrock surface is made up predominantly of sand derived from these formations. Locally, in the southern part of the county, limestone fragments and clay derived from limestones and shales of Ordovician and Silurian age make up a large part of the drift mantle. However, most of the drift in Luce County is composed principally of quartz sand.

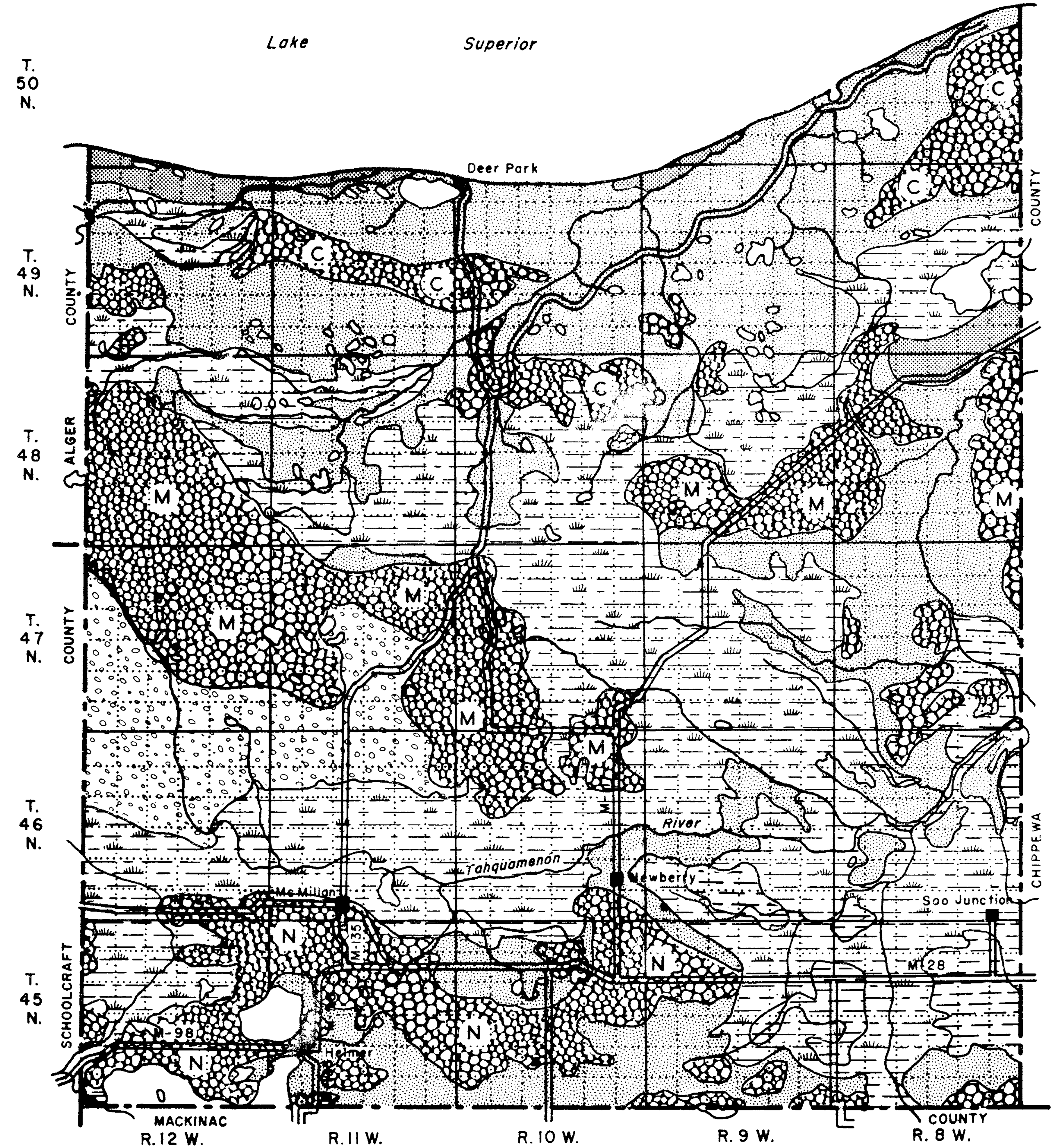
The permeability of the drift is governed by the size of the individual grains and by the degree of sorting. The most permeable drift sediments are the outwash deposits, which are composed of larger particles of rock debris and are relatively well sorted. Sandy and gravelly till containing only minor amounts of clay and silt is moderately permeable. Clayey till, however, is relatively impermeable. Dune sands and lake-deposited sands that are well sorted, even if relatively fine, also are moderately permeable, but lake-deposited silt, clay, and silty, clayey sand are generally of low permeability.

Plate 2 shows the areal distribution of the surficial glacial deposits. Because the surficial deposits may be underlain by glacial deposits of other types, the map should not be considered to indicate the presence of the same type of material throughout the drift section. Thus, the map can be used only as a general aid in locating ground-water supplies.

Morainic Deposits

Moraines are ridges composed predominantly of glacial till deposited along the relatively static front of a glacier. Three extensive morainic systems in Luce County have been described (Bergquist,

PLATE 2



EXPLANATION

MORAINIC DEPOSITS

Deposits of the Crisp Point morainic system
Composed predominantly of sand derived from the Munising and Jacobsville formations. May include some stratified sand and gravel outwash.

Deposits of the Munising morainic system.
Composed of deposits similar to the Crisp Point morainic system

Deposits of the Newberry morainic system
Composed of sand, gravel, and clayey till. Include several extensive deposits of stratified sand and gravel outwash.

LAKE-PLAIN DEPOSITS

Underlain by lake-deposited sand and silt.

Underlain by lake-deposited clay and silt.

Wetlands (swamps, marshes) underlain by lake-deposited sand, silt, or clay.

OUTWASH-PLAIN DEPOSITS

Underlain by stratified sand and gravel deposited by melt-water streams.

Well sorted windblown sand.

1 0 5 10 Miles

MAP OF THE SURFICIAL DEPOSITS IN LUCE COUNTY.

1933, 1936). The composition of the till in the three moraines is related to the bedrock sources from which the morainal deposits were derived. All the moraines, however, are composed largely of sandy till, most of which was deposited in and beneath the waters of Lake Algonquin. Three small areas of land-laid moraine were mapped by Bergquist (1936, fig. 12). The till deposited in water tends to be somewhat better sorted and stratified than till deposited on land.

Deposits of the Newberry morainic system.--The Newberry moraine is the southernmost and the oldest of the morainic systems in Luce County. This ridge of glacial till can be traced from a point southeast of Newberry to the southwest corner of Luce County (pl. 2). The topography of the moraine is generally rough and is characterized by knobs and basins. The lower part of the moraine was modified by the wave action of Lake Algonquin and by sediment deposition in the lake.

Bergquist (1936, p. 74) described the drift of the Newberry moraine in Luce County as follows:

> The glacial drift which constitutes the moraine is largely sandy, with local admixtures of clayey material. The soil of the sandy areas is loose textured, porous and open, and allows good drainage. The heavier phases are more compact and firm and tend to retain a greater amount of water. The more important areas of clayey drift are found in the vicinity of the Manistique lakes and south of McMillan. Foreign boulders and limestone slabs of local origin are abundantly scattered through the glacial

drift, especially in the more strongly developed inner portions of the moraine. In the weaker outer borders, the drift is sandy to gravelly in texture and erratics are generally quite scarce.

The thickness of the drift in this moraine differs considerably from place to place. The greatest known thickness is at well 45N 10W 1-1, which penetrates 320 feet of unconsolidated rock. The drift of the Newberry moraine is thinnest in those areas in which the Cataract formation crops out, in T. 45 N., R. 12 W.

The sandy till of the moraine is permeable and is a source of water to many wells throughout the area mapped as Newberry moraine (pl. 2). Most wells tapping this sandy till produce small to moderate supplies of water. However, wells tapping stratified sand and gravel outwash incorporated within the till of the Newberry moraine produce large supplies of water. All the large-capacity wells in the county (table 2), except well 47N 8W 24-1, produce water from sand and gravel deposits within or adjacent to the Newberry moraine. Logs of wells (table 4), and also the large quantities of gravel removed from pits throughout the moraine, indicate that a considerable amount of sand and gravel outwash is incorporated within the morainal material.

<u>Deposits of the Munising morainic system</u>.--The Munising morainic system crosses the central part of Luce County and is broken into two major segments (pl. 2). The moraine was described by Bergquist (1936, p. 79-80) as follows:

> Upon entering Luce County, the Munising morainic system takes a definite swing to the southeast and breaks off into the Tahquamenon swamp a few miles north of Dollarville. Like its counterpart south of the swamp (Newberry moraine), this moraine is not separable into distinct ridges but stands as a mass of undulating drift.
>
> On its inner border, the moraine here stands at an altitude of 750 to 800 feet and presents a strongly developed relief. The topography is generally quite undulating and in places broken by numerous basins which are hemmed in by knobs of varying heights. The drift is predominantly sandy and is locally interspersed with admixtures of gravel and clay. Erratics and occasional slabs of limestone are scattered through the section but not in such large quantity as in the moraine to the south. The limestone makes up a relatively small proportion of the drift but is conspicuous in the shore bluff which marks the northern margin of the moraine, south of Cold Spring in sec. 6, T. 47 N., R. 10 W. This shore feature marks the northern limit of limestone drift in Luce County....

The area occupied by the Munising moraine in Luce County is largely undeveloped, and only a few small-capacity wells have been drilled into the morainic deposits. These wells tap lenses of coarse sand or fine gravel. Most of the wells are completed at depths less than 100 feet.

Deposits of the Crisp Point morainic system.--The Crisp Point moraine is a rather poorly defined ridge of glacial drift which crosses the northern part of Luce County. The moraine is formed predominantly by sand derived from the underlying bedrock, but contains scattered patches of gravel and a few lenses of clay.

Few data other than records of the shallow fire-control test holes (table 3), are available concerning the water-bearing characteristics of ground-water potential of the drift in the area mapped as the Crisp Point moraine. Because the moraines and associated materials in this are are composed largely of sand, it is believed that they would yield moderate supplies of water to properly constructed wells.

Outwash Deposits

Outwash plains are underlain by stratified sand and gravel deposited by glacial melt-water streams. In Luce County the deposits are closely related to and in places are incorporated within the moraines. Only one major outwash plain was mapped in the county (pl. 2). The outwash was deposited in glacial lakes and tends to be deltaic. This outwash plain extends into the western part of Luce County from Schoolcraft and Alger Counties and was described by Bergquist (1936, p. 87) as follows:

> The eastern extension of the plain, continuing into Luce County, and especially that portion situated directly across the swamp from the village of McMillan,

seems to have formed in the wake of a rapidly retreating ice-border. Near its inner edge, the plain is generally smooth and unbroken. It contains coarse cobbly and gravelly material interspersed with occasional boulders which protude through from the underlying till. To the south, however, the surface of the apron is deeply trenched and pitted and presents a relief sufficiently rugged to be easily mistaken for a morainic feature. Superficial boulders are relatively rare in this area but may be encountered within a few feet of the surface as evidenced in the deeper skidding trails and along the floors of streams which have trenched their channels through the overwash.

Only a few shallow fire-control test holes have been drilled into this deposit of outwash, and little is known of the thickness of the deposit or of its water-yielding capacity. Outwash deposits, however, are the most permeable sediments within the glacial drift, and hence it is probable that moderate to large water supplies could be obtained from this deposit.

Glacial-Lake Deposits

Glacial lake plains, underlain by sand, silt, and clay deposited in the waters of Lake Algonquin, cover much of Luce County (fig. 3). In the northern tier of townships the lake sediments are composed predominantly of sand. Elsewhere, the lake deposits may be sandy or clayey, but in the large areas covered by swamps, the surficial lake sediments have not been differentiated (pl. 2). Well logs, however, indicate that extensive areas of the county may be underlain by clayey lake deposits.

Although the lake clays are not a source of water to wells and the lake-deposited sands generally will yield only small supplies of water, these lake deposits commonly mantle drift that is highly permeable. Locally, large supplies of water can be obtained from aquifers covered by lake deposits. Well 47N 8W 24-1 is reported by the owner to have flowed about 400 gpm from coarse gravel mantled by about 55 feet of lake-deposited clay, silt, and sand. The city of Newberry obtains large supplies of water from wells tapping sand and gravel in an area mantled by lake-deposited sand. Flowing wells in some of the swamp areas indicate that these swamps must be underlain by a relatively impermeable layer of silt and clay that is the upper confining layer in an artesian system.

Dune Sand

Extensive sand dunes are prominent features along the Lake Superior shore and in a large area north of the Tahquamenon Falls in Luce County. Numerous smaller dunes, which are not delineated on plate 2, are scattered over the lake plains throughout the county. A few of the dunes are being moved inland by winds blowing from Lake Superior. The dunes are composed of very well sorted windblown sand. Locally, saturated zones in these deposits may yield small supplies of water to properly constructed shallow wells, but in general the dunes are a poor potential source of water because they are above the water table. They have a high infiltration capacity, however, and provide an important avenue of recharge to underlying aquifers.

Permeability and Particle-Size Distribution of Selected Samples of Consolidated and Unconsolidated Sediments

Three samples of sandstone and ten of glacial drift were collected in and near Luce County for particle-size analysis and permeability determination in the Hydrologic Laboratory of the U. S. Geological Survey at Denver, Colo. The results of the tests were used as an aid in determining the origin of various glacial-drift deposits, the relative permeability of sandstone and drift deposits, and the relation of particle-size distribution to permeability.

If the permeability of a sample is typical of that of the aquifer in the vicinity of the sampling point and if the thickness of the aquifer is known, then the coefficient of transmissibility can be computed. The coefficient of transmissibility is defined as the number of gallons of water per day, at the prevailing temperature, that will move through a vertical strip of the aquifer 1 foot wide and of a height equal to the full thickness of the aquifer, under a hydraulic gradient of 100 percent, or 1 foot per foot (gpd per foot); it is equal to the average field coefficient of permeability multiplied by the thickness of the aquifer, in feet. A rough approximation of the specific capacity of a 100-percent efficient 6-inch well penetrating the entire aquifer can then be made by dividing the transmissibility by 2,000. This calculation is based on an equation devised by Thiem (1906). For example, the laboratory determination of the coefficient of permeability of a sample of the Munising sandstone (Al 1) was 52 gpd per square foot, and the thickness of the formation is known to be about 200 feet. Hence,

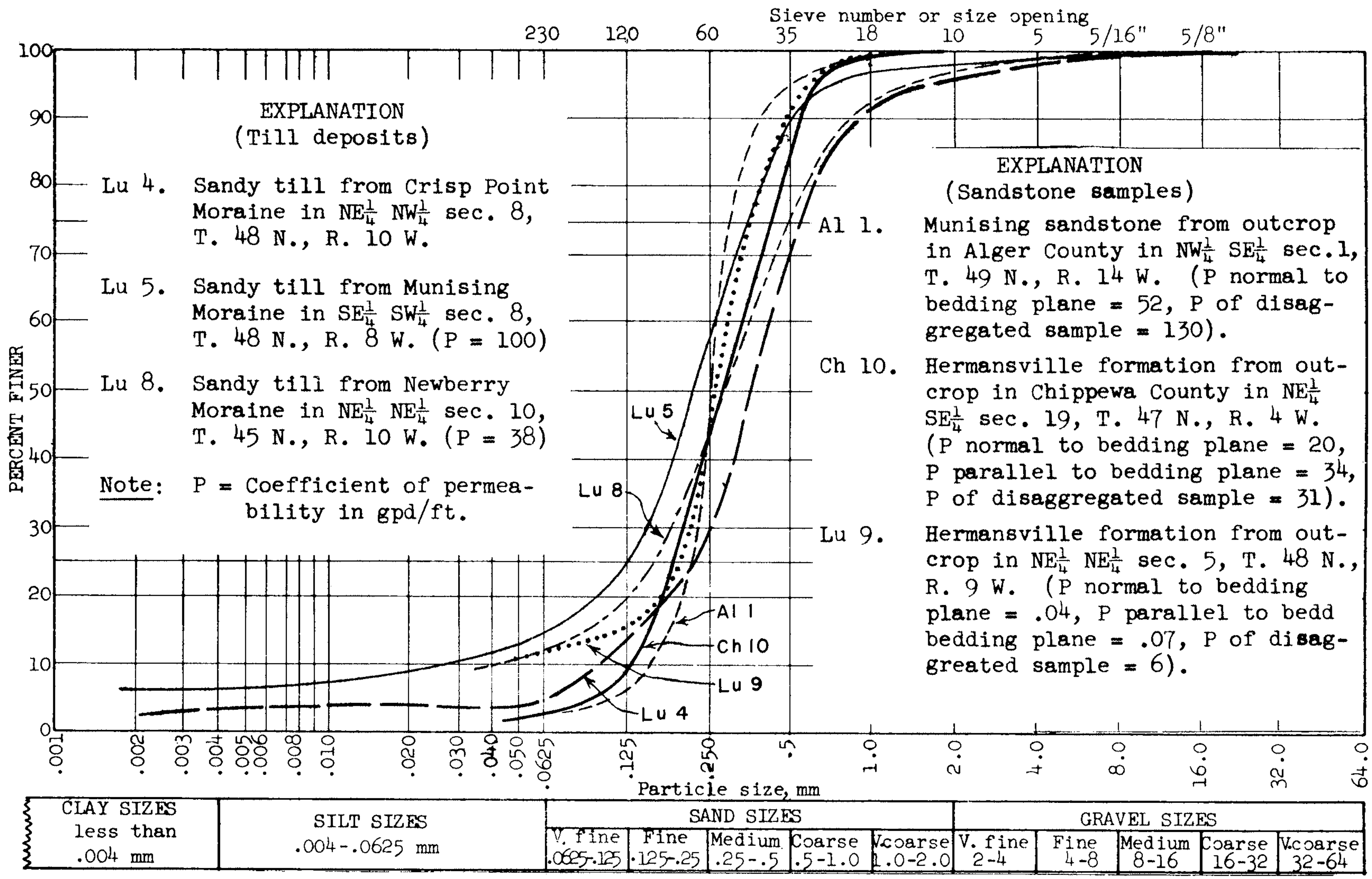


Figure 7. Particle-size distribution curves of samples of sandy till from Luce County and sandstone from Alger, Luce, and Chippewa Counties

the transmissibility is estimated to be 10,000 gpd per foot, and the specific capacity of an efficient well open to the full thickness of the aquifer would be about 5 gpm per foot of drawdown. The laboratory measurement of permeability was made at right angles to the bedding planes in the sandstone, and the permeability is probably a minimum value, as sedimentary rocks commonly are more permeable along than across the bedding.

The Munising sandstone is poorly cemented, and secondary openings along fractures and bedding planes are uncommon. Most of the water contained in the formation is believed to move through the primary interstices between individual sand grains. A particle-size analysis of a typical sample of sandstone from the Munising sandstone in Alger County (Al 1, fig. 7) shows that the sandstone consists predominantly (more than 90 percent) of fine- and medium-grained sand.

The Hermansville formation is similar lithologically to the Munising sandstone. Particle-size analysis of a sample of sandstone from the Hermansville in Luce County (Lu 9, fig. 7) shows that this sandstone also is fine to medium grained. However, the interstices between sand grains in some of the beds of the Hermansville are filled with dolomitic cement, which reduces the permeability of the formation considerably. The permeability normal to the bedding plane of sample Lu 9 was 0.04 gpd per square foot and parallel to the bedding plane was 0.07 gpd per square foot. The low permeability of sample Lu 9 is undoubtedly due to the presence of the dolomitic cement. This does not indicate, however, that the dolomitic beds will not yield appreciable quantities of water, inasmuch as most of the water in the well-cemented portions of the formation moves along fractures and bedding planes. Aquifer

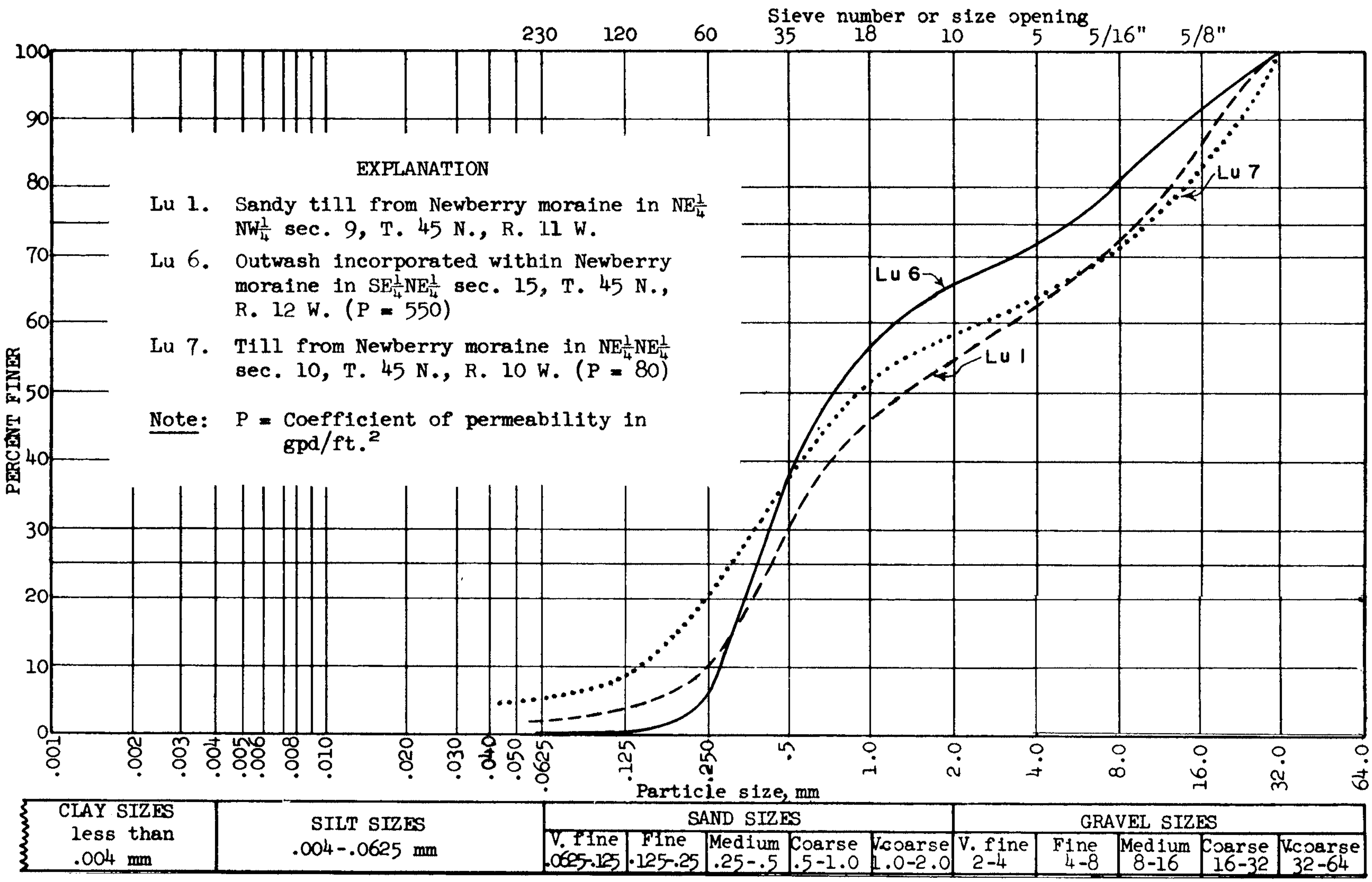


Figure 8. Particle-size distribution curves of samples of glacial sediments from Luce County

testing in the field would be required to determine the capacity of the dolomitic beds to yield water.

Another sandstone sample from the Hermansville formation collected in Chippewa County (Ch 10, fig. 7), also was very similar to the sample from the Munising sandstone. This sample, however, appeared to contain much less cementing material than sample Lu 9; its coefficient of permeability was 20 gpd per square foot normal to the bedding plane and 34 gpd per square foot parallel to the bedding plane.

Figure 7 also shows the particle-size distribution of three samples of sandy till. The similarity of these curves to those representing the Munising sandstone and Hermansville formation suggests strongly that the sandy till was derived primarily from those formations. The coefficients of permeability determined for samples Lu 5 and Lu 8 were 100 and 38 gpd per square foot, respectively. For purposes of comparison, the sandstone samples were disaggregated, and it was found that the coefficients of permeability of the two samples derived from the loosely cemented sandstones were nearly the same as those determined for the sandy till. Although disaggregation of the samples of loosely cemented sandstone did not increase their permeability appreciably, the disaggregation of the cemented sandstone sample (Lu 9) increased its permeability about 90 times.

The outwash sands and gravels are the most permeable deposits in the county, as shown by the results of tests on various wells to determine specific capacity (table 2). These sediments are the source of water to most of the large-capacity wells in the county. A particle-size analysis of a sample of outwash (Lu 6, fig. 8) shows that the

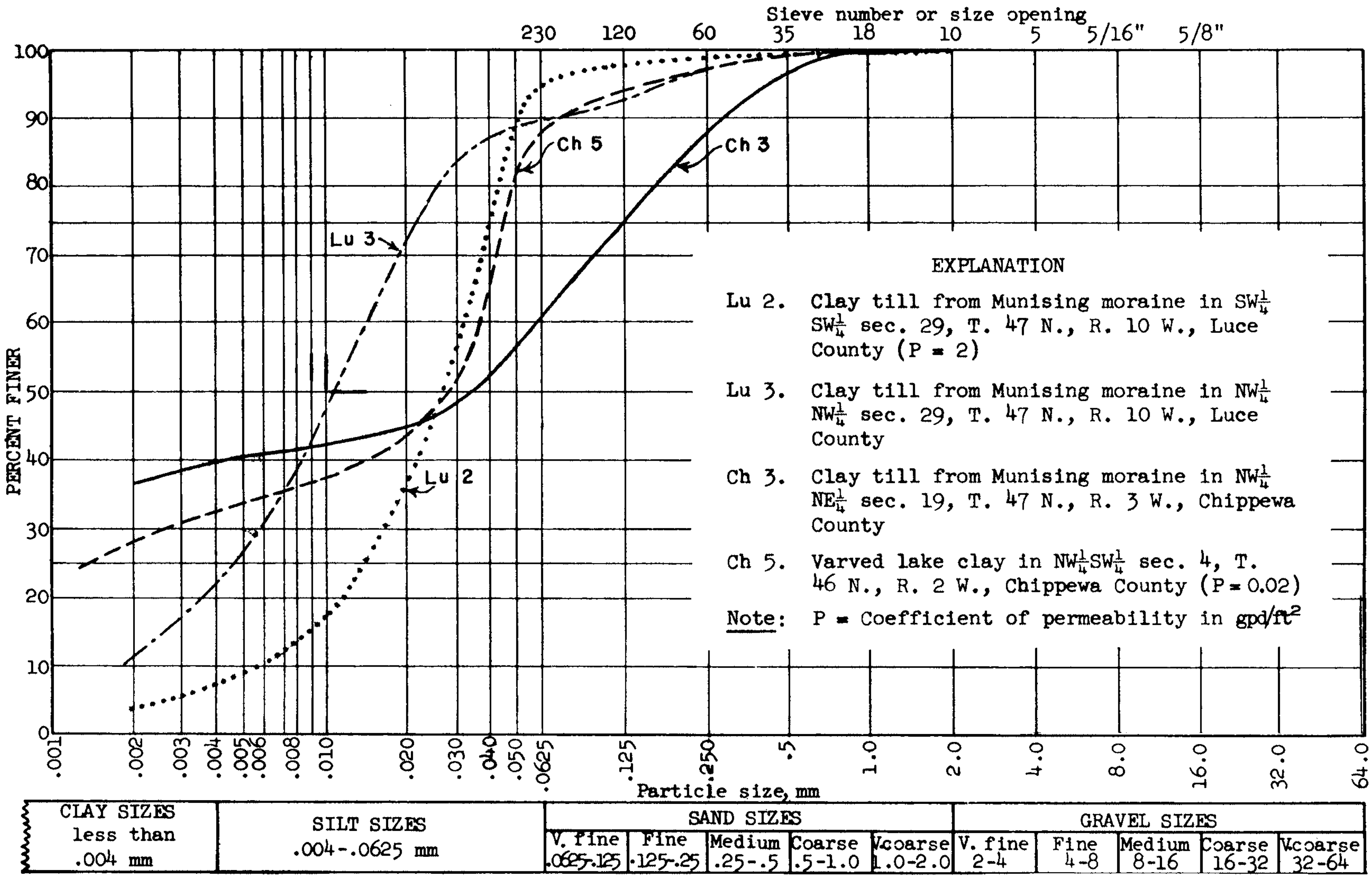


Figure 9. Particle-size distribution curves of samples of fine-grained glacial sediments from Luce and Chippewa Counties

outwash is very similar to till in nearby areas, except that it is somewhat better sorted. The coefficient of permeability of this sample, as determined in the laboratory, was 550 gpd per square foot, whereas that of a sample of till from the Newberry moraine (Lu 7, fig. 8) was 80 gpd per square foot. This difference in permeability may be attributed to the fact that the outwash contained less fine sand and practically no very fine sand, silt, or clay which would impede movement of water by clogging the interstices between the larger sand and gravel particles. A coefficient of permeability was not determined for sample Lu 1, but inspection of the particle-size-distribution curve (fig. 8) reveals that some till deposits may be very similar in composition to outwash deposits.

Particle-size analyses were made of two samples of fine-grained till from Luce County (Lu 2 and Lu 3, fig. 9). Although fine-grained till is commonly referred to as clay till, the analyses revealed that the material is composed largely of silt. The writer believes that the deposit from which the samples were taken was derived from glacial-lake sediments that were reworked and redeposited by later glacial action. Sample Lu 2 had a coefficient of permeability of 2 gpd per square foot, which is considerably greater than that of the sample of well-cemented sandstone from the Hermansville formation (Lu 9, fig. 7). However, fine-grained till sampled in Chippewa County (Ch 3, fig. 9) was poorly sorted and contained 40 percent clay; it is assumed to have been less permeable than samples Lu 2 and Lu 3.

Samples of glacial-lake deposits were not collected in Luce County, but a particle-size analysis of a sample of a varved lake deposit in Chippewa County (Ch 5, fig. 9) showed it to contain about 33 percent clay and 54 percent silt; the coefficient of permeability of the same sample was only 0.02 gpd per square foot. The permeability of clayey lake or till deposits in Luce County probably is similarly low.

Ground-Water Phase of the Hydrologic Cycle

Source and Recharge Areas

Precipitation is the initial source of all ground water in the aquifers of Luce County, with the possible but negligible exception of a very small amount of juvenile water from deep-seated sources. If all the moisture that fell upon the county (an average of 28 inches per year) were to infiltrate to the aquifers of the county, a supply of ground water greatly in excess of all foreseeable needs, would be assured. However, only a small part of the precipitation reaches the ground-water reservoirs; the much greater part of it evaporates, is consumed by plant life, or runs off into streams and lakes.

The amount of precipitation that does enter the ground-water reservoirs is governed by a number of factors. Among these are the duration, intensity, and type of precipitation; the density and type of vegetation; the topography; the porosity and permeability of the soil; the permeability, thickness, and structure of the subsoil and underlying rock formations; and the extent to which the aquifer is already saturated.

Much of Luce County is underlain by sandy permeable soils and subsoils, and where these are above the regional water table conditions are favorable for infiltration of precipitation. In the areas underlain by clay soils of low permeability, less water is able to infiltrate into the ground-water reservoirs.

Movement

The movement of water through the ground is similar to movement in surface streams in that the water moves by gravity from high to low levels. Ground water moves much more slowly than surface water, however, because of friction generated by the water as it percolates through the crevices and interstices in the earth's crust. Rates of ground-water movement range from a few feet per year to several feet or tens of feet per day. Water may travel great distances underground from recharge areas to areas downgradient, where it may once more reach the surface and join the flow of streams, appear as a seep or spring, enter a lake, escape directly to the atmosphere by evaporation or transpiration or be withdrawn from a well. Where undisturbed by manmade diversions, the water table of an unconfined aquifer conforms generally to the configuration of the overlying land surface. In the deeper artesian aquifers, however, the shape of the piezometric surface may differ considerably from that of the overlying land surface. Where more than one aquifer underlies the same area, water migrates or leaks from aquifers having a higher pressure head to those having lower head.

Discharge

Water is discharged from ground-water reservoirs by evaporation and transpiration, through wells, springs, and drains, and by flow into surface-water bodies. Because so much of the county is covered by dense forest and swamp vegetation, the amount of water discharged by transpiration represents a large percentage of the precipitation. Because the water table is shallow in much of the county, a substantial part of the water evaporated and transpired doubtless is ground water.

Considerable water is discharged from the shallow ground-water reservoirs through springs. Most of the springs in the county are along the edges of the moraines. Some of the ground water discharged in Luce County moves into the county from recharge areas in adjacent counties. Conversely, some of the precipitation which falls in Luce County becomes ground water and moves by underflow to be discharged outside of the county.

Discharge from wells is greatest in the vicinity of Newberry where several large-capacity wells are pumped and in the southern part of the county where most of the flowing wells are located. However, the total discharge of water from wells is small compared to total natural ground-water discharge.

Fluctuations of the Water Table

Climatic Influences

Although long-term water-level observations have not been made in Luce County, fluctuations of the water level in well 46N 4W 24-1 (fig. 10) in Chippewa County have been recorded for a number of years (Vanlier and Deutsch, 1958a). Because this well taps sand and gravel in an outwash deposit associated with the Munising morainic system, the water-level fluctuations in it are believed to be similar to those in wells tapping the glacial drift in Luce County.

Water levels fluctuate with changes in the rate of recharge to and discharge from the ground-water reservoirs. During the spring thaw, water levels in wells in Luce County rise in response to the infiltration of rain and melting snow, and during the summer they decline because ground-water discharge exceeds the recharge. The graphs in figure 10 show that precipitation during the summer growing months had little effect on either the water level in well 46N 4W 24-1 or on the discharge of the Tahquamenon River; nearly all the precipitation was consumed by vegetation or was evaporated. After the growing season, evapotranspiration losses were reduced and precipitation again caused rises in water levels. In the fall of 1954 infiltrating rain added considerably to both ground water in storage and discharge of the Tahquamenon River, but subsequent snowfall had little effect on ground water levels or the discharge of the river until the spring thaw. The considerable time lag between the peak in the discharge of the river and the highest ground-water levels shows that aquifers do not respond as quickly to precipitation as do surface streams.

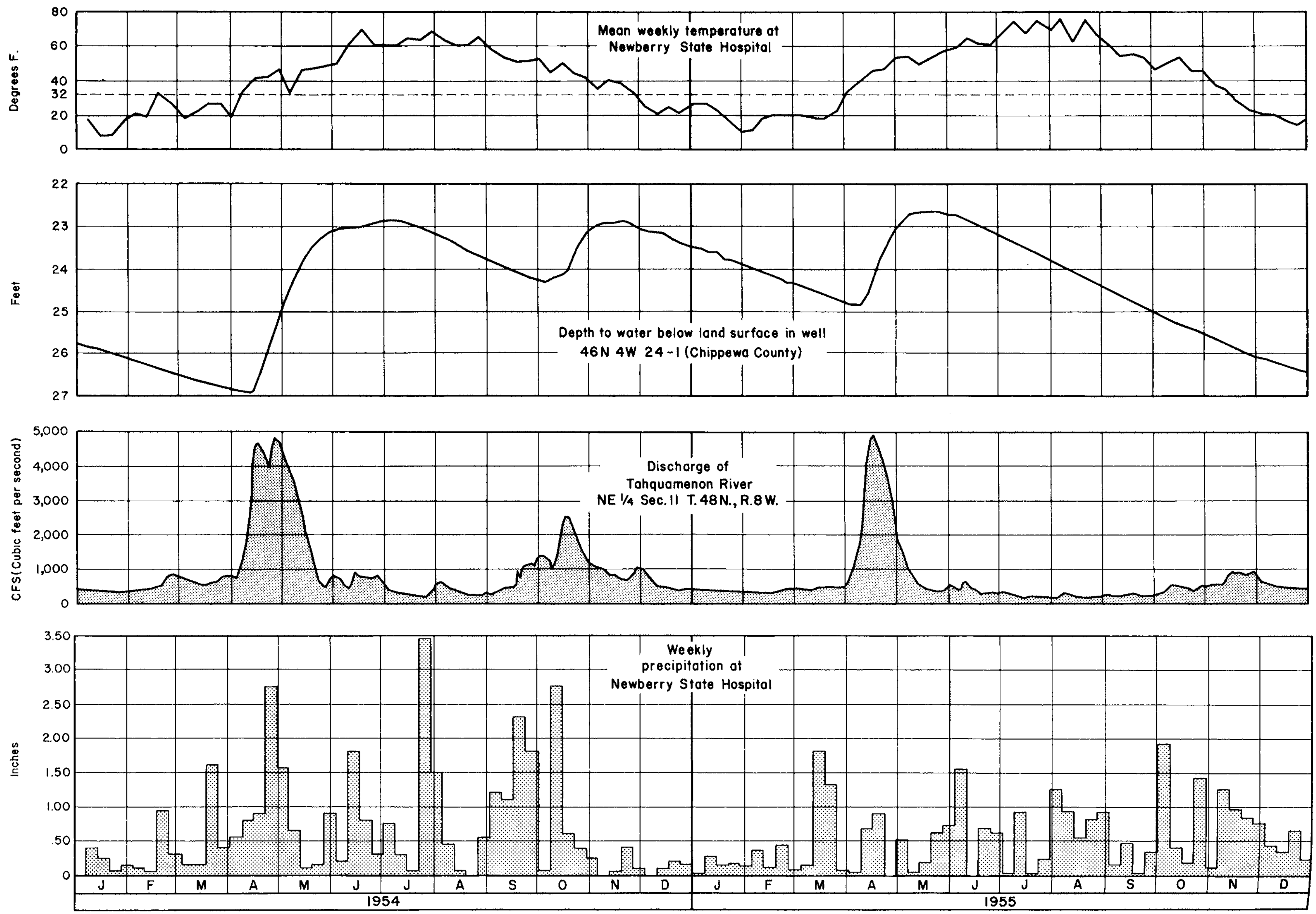


Figure 10. Graphs of air temperature, precipitation, ground-water levels, and discharge of the *Tahquamenon River.*

Fluctuations Due to Discharge from Wells

Generally, ground water is a renewable natural resource because it is replenished directly or indirectly by precipitation. If an aquifer is to be developed by means of wells so that a long-term yield can be obtained, the average rate of recharge to the aquifer must balance the average rate of discharge from the aquifer. In any aquifer in its natural state (before it is tapped by wells) an approximate dynamic equilibrium exists between recharge and discharge. When water is withdrawn from an aquifer by a well, a temporary change in the total discharge from the aquifer results. The discharge by the well causes a cone-shaped depression in the water table or piezometric surface around the discharging well. With continued discharge by the well, the cone expands until the resultant lowering of the water level causes a decrease in discharge from the aquifer or an increase in recharge to the aquifer, or a combination of the two, which again restores the aquifer to a state of equilibrium. If the discharge from a well or group of wells exceeds the total available recharge, the water level will continue to decline so long as the discharge continues.

Where a number of wells are pumped or allowed to flow, a composite cone of depression is formed and may extend over a large area. Water levels in wells within the cone of depression also are lowered even though the wells are not pumped. A lowering of the water table or piezometric surface, therefore, is a necessary result of the development of an aquifer. A good illustration of the above is provided by Leverett (1906, p. 41) who reported that flowing wells

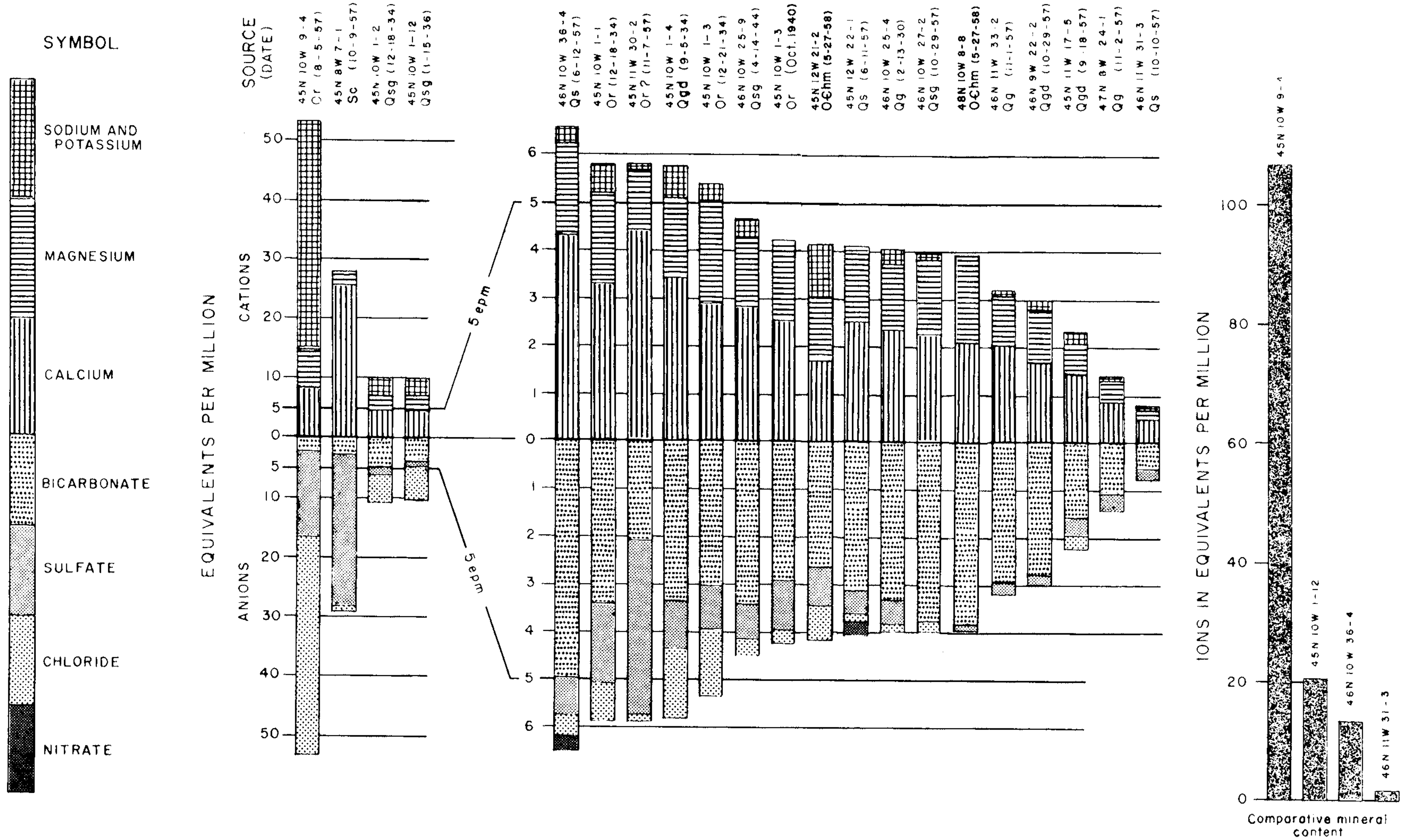


Figure 11 Chemical composition of ground water in Luce County

in the vicinity of the Newberry Lumber and Chemical Co. stopped flowing when the Company wells were pumped. Waste of water from unrestricted flowing wells or through underground leakage from poorly constructed wells or deteriorated well casings may result in sufficient lowering of the piezometric surface to cause some wells to stop flowing, decrease the discharge from others, and increase the cost of producing water.

Chemical Quality of the Water

Water percolating through soil and rocks dissolves some of the material with which it comes in contact. The amount and character of the dissolved mineral matter in ground water depend on the chemical and physical composition of the rocks through which the water moves, the duration of the contact, and other factors such as temperature, pressure, and amount of mixing, if any, with highly mineralized connate water (water entrapped at the time the sediment was deposited). Figure 11 illustrates graphically the chemical composition of 21 water samples from wells in Luce County, and table 5 lists analyses of 30 samples from wells tapping the glacial drift and 9 samples from wells tapping the bedrock. In figure 11 the analyses are expressed in equivalents per million--parts per million divided by the chemical equivalent weight of the constituent. The analyses in table 5 are given in parts per million.

The hardness of the water sampled in the county ranged from 24 to 1,750 parts per million (ppm). Hardness of water is due principally to salts of calcium and magnesium in solution. Limestone and dolomite strata and gypsum-bearing formations in the county are the major sources of calcium and magnesium ions in the ground water.

Water with respect to hardness is classified by the Michigan Department of Health (1948) as follows:

Class	Hardness (parts per million)
Very soft	less than 50
Soft	50-100
Moderately hard	100-200
Hard	200-300
Very hard	more than 300

Hardness is commonly computed also in grains per gallon. One grain per gallon equals 17.1 ppm.

Fresh Ground Water

The Jacobsville sandstone is not known to be the source of water to any of the wells in Luce County. Data from wells in Alger and Chippewa Counties indicate that this formation would yield moderately hard to hard water of the calcium bicarbonate type in Luce County.

Water in the Munising and Hermansville formations is also of the calcium magnesium bicarbonate type. The sample from well 48N 10W 8-8 which taps these formations in the northern part of the county where they form the bedrock surface had a hardness of 192 ppm and contained less than 1 ppm of chloride. The sample from well 45N 12W 21-2 which taps these formations where they are overlain by several hundred feet of younger consolidated rocks had a hardness of only 151 ppm, but contained 26 ppm of chloride. Data from Schoolcraft, Mackinac, and Chippewa Counties shows that the chloride content of water in these formations increases toward the center of the Michigan basin. However, the chloride content of the water in these rocks is relatively small throughout Luce County.

The limestone and dolomite of the Richmond group are a source of fresh water which also is predominantly of the calcium magnesium bicarbonate type. Locally, they contain significant amounts of chloride and sulfate. The chloride probably results from a mixing of fresh water with some of the saline water that also is present in these rocks. The sulfate probably results from the migration of the water through gypsum-bearing strata, either in rocks of the Richmond group or in the overlying Cataract formation. The sulfate content of samples of water from these rocks ranged from 45 to 680 ppm and the chloride content from 10 to 1,300 ppm. Sulfate or chloride content of drinking water should not exceed 250 ppm.

The Cataract formation is a source of fresh water to several wells in the county, but the water generally is hard to very hard and is very high in sulfate. Gypsum present in the formation which has been leached by percolating ground water is the source of calcium sulfate in the water.

The chemical quality of water in the glacial-drift aquifers differs considerably from place to place in the county. The differences in the quality of the water in the drift reflect in part the composition of the drift and in part the underlying bedrock formations. In the northern part of the county the drift is composed mainly of quartz sand; and only minor amounts of soluble minerals are present. Thus, water from the drift in the northern part of the county is soft and low in dissolved solids. On the other hand, the drift in the southern part of the county contains a larger proportion of soluble rock fragments--

limestone, dolomite, and gypsum--and thus most of the ground water is hard and contains higher concentrations of dissolved solids. Locally, however, shallow drift in the southern part of the county yields water low in dissolved solids, probably because the water passed through only a thin layer of material to reach the aquifer and has been in the aquifer only a relatively short time. The hardness of the water samples from the glacial drift ranged from 24 to 370 ppm. Half of the drift waters sampled were moderately hard. Six of the samples were in the soft or very soft class and nine were hard or very hard. The higher proportion of chloride present in the water from wells tapping the drift in the vicinity of the Newberry State Hospital probably reflects inflow of saline water from rocks of the Richmond group.

Saline Ground Water

Some of the aquifers in Luce County contain saline water. The term "saline water" is used in this report to mean water that contains more than 1,000 ppm of dissolved solids, regardless of the composition of the solids; saline water is not necessarily a sodium chloride water.

Although the Trenton and Black River formations are not known to yield water in Luce County, data from wells in other places in the eastern part of the Northern Peninsula indicate that these formations probably contain saline water in Luce County.

Well 45N 10W 9-4, which taps the Richmond group, was the only well sampled that yielded water containing appreciable concentrations of sodium and chloride. The chloride in water from the Richmond group is the result of the mixing of fresh water with connate water or was leached from halite contained in these rocks. The sample from 45N 10W 9-4 was high in calcium and sulfate also; the constituents probably were leached from gypsiferous strata.

Samples of water from well 45N 12W 34-1 and spring 45N 8W 7-1, both tapping the Cataract formation, had concentrations of 1,250 and 1,240 ppm of sulfate, respectively, and correspondingly high concentrations of calcium and hence are considered saline.

Utilization of Ground Water

Although Luce County is bounded on the north by the largest body of fresh water in the world, ground-water sources presently supply all the water for public, domestic, industrial, stock, and irrigation use. The city of Newberry has a municipal supply system, and the Newberry State Hospital has its own water-supply system. All other users obtain water from privately owned wells.

Most of the water used in Luce County is utilized for domestic purposes, but a small amount is used for stock watering and for industrial supply; one well (45N 10W 13-4) is used solely for irrigation. The total amount of ground water used in Luce County represents only a small fraction of the total resource available.

SUMMARY AND CONCLUSIONS

Throughout most of Luce County small to moderate supplies of potable water can be obtained from relatively shallow wells. In small local areas in the southern part of the county where the water in the shallow aquifers is of poor quality, wells can be drilled to the deep lying Munising and Hermansville formations which yield ground water of good quality.

The glacial-drift aquifers, which are the most accessible and are the source of water to most of the wells in the county, are believed to offer the greatest potential for future development. All the large capacity wells in the county tap drift aquifers, and test drilling would undoubtedly show many additional areas where large supplies could be obtained from drift aquifers. Supplies adequate for additional industrial, municipal, and irrigation use are believed to be available in the drift and bedrock aquifers in much of the county.

All the present water supplies in the county come from ground-water sources, but the amount used represents only a small fraction of the total resource available. A supply of ground water exceeding all foreseeable needs is assured by the average annual precipitation (about 28 inches) and the favorable conditions for recharge that exist throughout most of the county.

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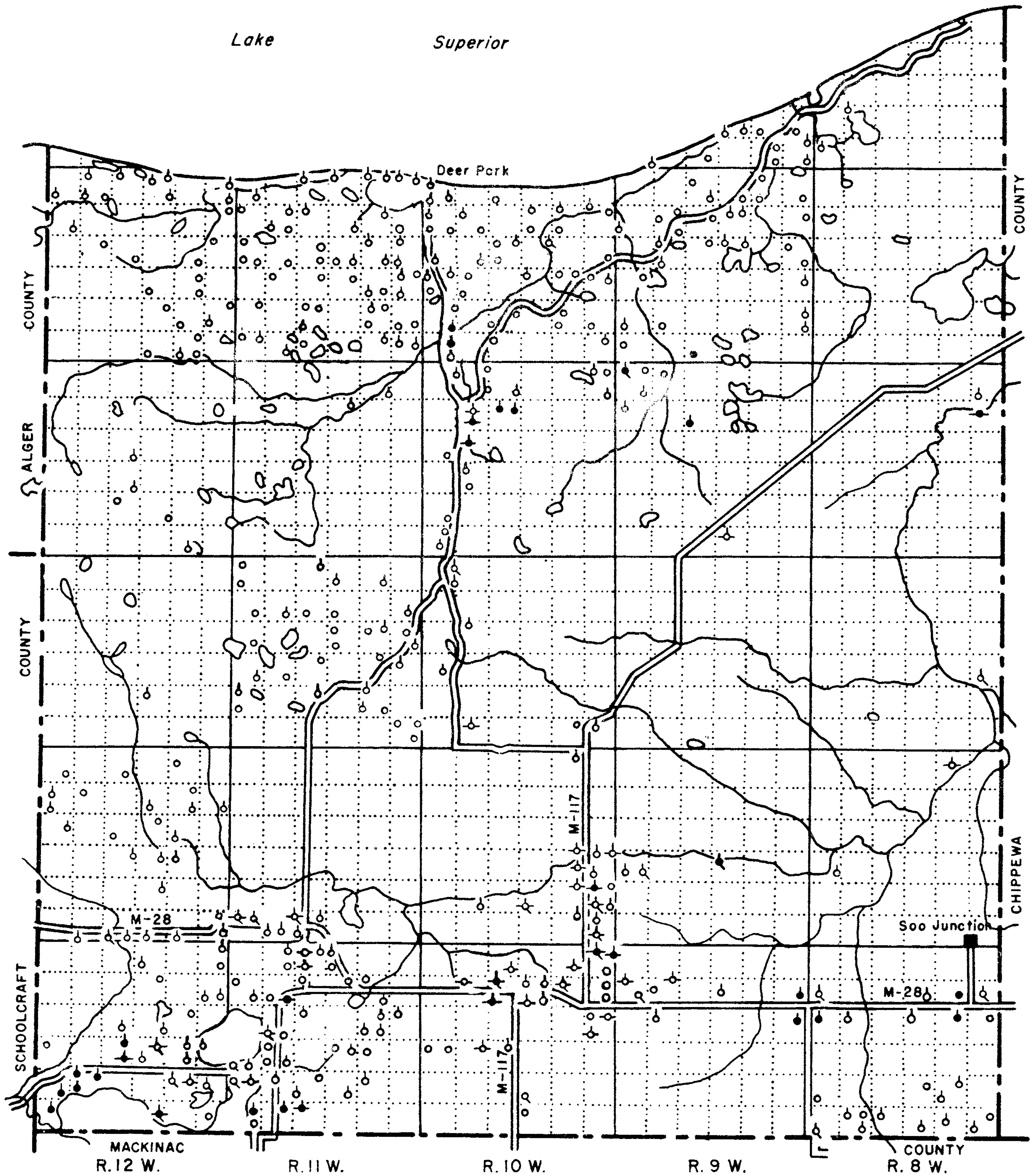
PLATE 3



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EXPLANATION

Well, test hole or spring

Record of water level or artesian pressure

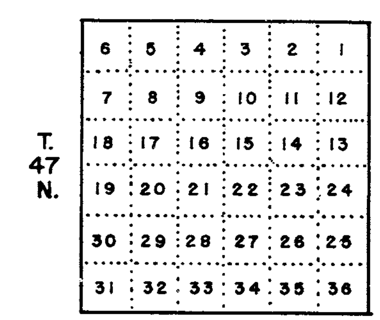
Log of well

Chemical analysis of water

Bedrock elevation report or indication

Note: Each symbol or symbol combination refers to information listed in Tables 3, 4, and 5 and represents one or more wells, testholes, and borings located in the quarter section in which plotted.

Diagram of geographical township



0 5 10 Miles
SCALE

MAP OF LUCE COUNTY SHOWING HYDROLOGIC, GEOLOGIC, AND QUALITY-OF-WATER DATA

Table 3.--Records of wells and test holes in Luce County

Owner: MDC, Michigan Department of Conservation. Where applicable, owner's designation also is listed.

Driller: CCC, Civilian Conservation Corps.

Year drilled: Data for most wells drilled in and before 1905 are taken from Leverett (1906) and from unpublished records of field investigations made by Frank Leverett of the U. S. Geological Survey.

Aquifer: Qgd, Quaternary glacial drift, undifferentiated; Qs, Quaternary sand; Qg, Quaternary gravel; Qsg, Quaternary sand and gravel; Sc, Cataract formation; Or, limestone and dolomite of the Richmond group; O€hm, Hermansville formation and Munising sandstone.

Use: D, domestic; In, industrial; P, public supply; S, stock; T, test; Tf, fire-control test well.

Water level: In feet below or above (+) land-surface datum. M, measured; R, reported.

Well number	Location in section ¼ of ¼	Owner	Driller	Year drilled	Depth (feet)	Diameter (inches)	Aquifer	Use	Water level	M or R	Date	Remarks
50N 9W												
25-1	NE SW	MDC	CCC	1935	19	2	Qs	Tf	-	-	-	
26-1	SW SW	MDC	CCC	1935	20	2	-	Tf	Dry	R	1935	Drilled in sand.
27-1	NE SW	Perue	George Pietscher	1954	30	2	Qgd	D	6	R	1954	Equipped with sandpoint.
27-2	NE SE	MDC	do.	-	30	3	Qgd	P	6	R	1957	Equipped with screen. Two Hearted Campground.
31-1	SW SE	George Pietscher	do.	-	32	2	Qs	D	15	R	1957	Equipped with screen.
33-1	NE SE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
35-1	SW SE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Do.
35-2	NW NE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in sand.
36-1	NE NE	MDC	CCC	1935	8	-	Qs	Tf	7.5	R	1935	Augered to water table.
36-2	SE SE	MDC	CCC	1935	9	-	Qs	Tf	8.2	R	1935	Do.
50N 8W												
11-1	NE NE	U. S. Coast Guard	-	1927	22	1½	Qs	P	-	-	-	Crisp Point Station. Abandoned.
29-1	- NW	MDC	-	-	32	1¼	Qgd	P	22	R	1957	Equipped with screen. Bodi Lake Campground.
31-1	NW NW	MDC	-	-	24	1¼	Qgd	P	16	R	1957	Culhane Lake Campground.
49N 12W												
1-1	NW NE	MDC	-	-	30	1¼	Qgd	P	18	R	1957	Equipped with screen. Lake Superior Campground.
1-2	NE SE	MDC	CCC	1935	15	-	Qs	Tf	14.5	R	1935	Augered to water table.
3-1	NW NE	MDC	CCC	1935	6	-	Qs	Tf	6	R	1935	Do.
3-2	SW NW	MDC	CCC	1935	9	-	Qsg	Tf	8.5	R	1935	Do.
3-3	SW SE	MDC	CCC	1935	3	-	Qs	Tf	2.5	R	1935	Do.
4-1	NE NW	MDC	CCC	1935	6	-	Qs	Tf	5.5	M	7-31-35	Do.
5-1	NE SE	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
5-2	NW SW	MDC	CCC	1935	4	-	Qs	Tf	3.8	M	7-31-35	Do.
5-3	SW NW	MDC	CCC	1935	16	-	Qs	Tf	16	M	9-24-35	Do.
6-1	NE SW	MDC	CCC	1935	5	-	Qs	Tf	4.2	M	7-31-35	Do.
7-1	SW SE	MDC	CCC	1935	13	-	Qs	Tf	13.0	M	7-31-35	Do.
12-1	NW NE	MDC	CCC	1935	15	2	Qs	Tf	-	-	-	
13-1	SE NW	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in sand.
14-1	SE SE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
16-1	SW SE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Do.
17-1	SW NE	MDC	CCC	1935	15	2	-	Tf	-	-	-	Drilled in sand.
22-1	SE SW	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
23-1	SE SE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Do.
23-2	NE NE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Do.
25-1	NW NE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Do.
25-2	NW SW	MDC	CCC	1935	2	-	Qs	Tf	1.2	M	8- 2-35	Augered to water level.
26-1	SE SW	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
27-1	NE NE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in sand and gravel
34-1	NE SW	MDC	CCC	1935	14	2	Qsg	Tf	-	-	1 -	
35-1	NE NE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
35-2	NE SE	MDC	CCC	1935	14	2	Qsg	Tf	-	-	-	
35-3	SE SW	MDC	CCC	1935	7	-	Qs	Tf	6.4	M	8- 6-35	Augered to water table.
49N 11W												
1-1	SE NW	MDC	-	-	40	1¼	Qs	P	22	R	1957	Equipped with screen. Muskallonge L. Campground.
1-2	SE NE	R. G. Freeborn	George Pietscher	-	23	2	Qs	P	19	R	1957	Equipped with sandpoint.
1-3	SE NW	O. Hart	do.	1954	32	2	Qs	D	12	R	1957	Do.
1-4	NW NE	M. Crawmer	do.	1954	32	2	Qs	P	12	R	1957	Equipped with screen.

Table 3.--Records of wells and test holes in Luce County--Continued

Well Number	Location in section (¼ of ¼)	Owner	Driller	Year drilled	Depth (feet)	Diameter (inches)	Aquifer	Use	Water level	M or R	Date	Remarks
49N 11W Continued												
1-5	SE NW	MDC	CCC	1935	19	2	Qs	P	10	M	5-27-35	
1-6	NW NE	Henry St. Peters	-	1929	21	1¼	Qs	P	-	-	-	Former Coast Guard site.
1-7	NW NE	do.	-	-	200	-	-	-	-	-	-	
2-1	NW NW	Bernard McTiver	George Pietscher	-	22	2	Qs	D	9	R	1957	Equipped with screen.
2-2	NW NE	Schuster	do.	-	65	2	Qg	D	9	R	1957	Do.
2-3	NW NE	Betty Schuster	do.	1956	118	2	Qgd	D	12	R	1956	Equipped with 10-ft. screen.
2-4	NW NE	Schuster Store	do.	-	65	2	Qs	P	12	R	1957	Equipped with screen.
3-1	NW NW	MDC	CCC	1935	16	-	Qs	Tf	16	M	1935	Augered to water table.
4-1	SW NW	MDC	CCC	1935	12	-	Qs	Tf	11.3	M	6-18-35	Do.
6-2	SE SE	MDC	CCC	1935	20	-	Qs	Tf	19.8	M	7-26-35	Do.
7-1	NW NW	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
8-1	SE SE	MDC	CCC	1935	19	2	-	Tf	-	-	-	Drilled in sand and clay.
8-2	SW SE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	
8-3	NW SW	MDC	CCC	1935	13	-	Qsg	Tf	13	M	8-14-35	Augered to water table.
8-4	NE NE	MDC	CCC	1935	7	-	Qs	Tf	7	M	9-26-35	Do.
9-1	SW NW	MDC	CCC	1935	7	-	Qs	Tf	6.2	M	6-28-35	Do.
10-1	SE SE	MDC	CCC	1935	15	2	Qs	Tf	-	-	-	
10-2	SW SE	MDC	CCC	1935	12	-	Qsg	Tf	11.7	M	6-28-35	Do.
11-1	NW NE	W. Kane	George Pietscher	1954	89	2	Qg	D	8	R	1954	
11-2	NE NE	DeVire	do.	-	46	2	Qg	D	9	R	1957	
11-3	NE NE	"Doc" Carlson	do.	1955	50	2	Qs	D	4	R	1955	Equipped with screen.
11-4	SW NE	MDC	CCC	1935	9	-	Qsg	Tf	8	R	6-22-35	Augered to water table.
11-5	SE NE	MDC	CCC	1935	14	-	Qsg	Tf	13.5	M	9-24-35	Do.
12-1	SW SW	MDC	CCC	1935	14	2	Qsg	Tf	-	-	-	Drilled in sand and gravel.
13-1	SE NW	MDC	CCC	1935	19	2	Qs	Tf	-	-	-	Drilled in sand.
13-2	NE NW	MDC	CCC	1935	14	-	Qs	Tf	13.5	M	9-17-35	Augered to water table.
13-3	SE SW	MDC	CCC	1935	12	-	Qs	Tf	12	M	9-17-35	Do.
14-1	NE SE	MDC	CCC	1935	18	-	Qs	Tf	18	M	9-17-35	Do.
14-2	NE NW	MDC	CCC	1935	7	-	Qs	Tf	6.5	M	9-18-35	Do.
15-1	NW SW	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
15-2	NE SE	MDC	CCC	1935	12	-	Qs	Tf	11.5	M	8-14-35	Augered to water table.
16-1	NE NE	MDC	CCC	1935	19	2	Qg	Tf	-	-	-	
16-2	SW SE	MDC	CCC	1935	20	-	-	Tf	dry	R	6-22-35	Augered in coarse sand.
17-1	SE SE	MDC	CCC	1935	9	2	-	Tf	dry	R	1935	**Drilled in sand and gravel. Destroyed**
17-2	SW SE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
18-1	SE SE	MDC	CCC	1935	15	2	-	Tf	dry	R	1935	**Drilled in sand. Destroyed.**
18-2	SW NW	MDC	CCC	1935	15	2	Qs	Tf	-	-	-	
18-3	SE SW	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
20-1	NW NW	MDC	CCC	1935	19	2	-	Tf	dry	R	1935	**Drilled in coarse sand. Destroyed.**
20-2	NE NW	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
21-1	NE NE	MDC	CCC	1935	18	-	-	Tf	dry	R	1935	**Drilled in sand. Destroyed.**
22-1	SE NE	MDC	CCC	1935	19	2	-	Tf	dry	R	1935	**Drilled in sand and gravel. Destroyed.**
22-2	SW NE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
22-3	NE NE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in sand.
23-1	SE SE	MDC	CCC	1935	19	2	-	Tf	dry	R	1935	**Drilled in sand. Destroyed.**
23-2	SW SW	MDC	CCC	1935	9	-	Qs	Tf	8.6	M	5-16-35	Augered to water table.
24-2	NW NW	MDC	CCC	1935	11	-	Qs	Tf	10.3	M	6- 5-35	Do.
24-3	SW NE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in sand and fine gravel.
24-4	NW SW	MDC	CCC	1935	16	-	Qs	Tf	16	R	6-22-35	Augered to water table.
25-1	NE SE	MDC	CCC	1935	14	2	Qsg	Tf	-	-	-	
25-2	NW SW	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
26-1	SW NW	MDC	-	-	34	1¼	Qs	P	24	R	1957	**Holland Lake Campground.**
26-2	SW SW	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
26-3	SE NE	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
28-1	- SW	MDC	-	-	32	1¼	Qs	P	20	R	1957	Equipped with screen. **Pratt Lake Campground.**
28-2	NE NE	MDC	CCC	1935	17	2	Qsg	Tf	-	-	-	
28-3	NW NW	MDC	CCC	1935	19	2	Qs	Tf	-	-	-	

Table 3.--Records of wells and test holes in Luce County--Continued

Well number	Location in section ¼ of ¼	Owner	Driller	Year drilled	Depth (feet)	Diameter (inches)	Aquifer	Use	Water level	M or R	Date	Remarks
49N 11W	Continued											
30-1	SE NE	MDC	CCC	1935	18	2	Qs	Tf	-	-	-	
31-1	NE NE	MDC	CCC	1935	20	-	Qsg	Tf	19.4	M	6-14-35	Augered to water table.
31-2	NW NW	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
32-1	SW SE	MDC	CCC	1935	6	-	Qs	Tf	5.5	M	6-14-35	Augered to water table.
33-1	NW NW	MDC	CCC	1935	15	2	Qs	Tf	-	-	-	
35-1	SE NE	MDC	CCC	1935	4	-	Qs	Tf	3.5	M	6-13-35	Do.
36-1	SW NE	MDC	CCC	1935	12	-	Qs	Tf	11.5	M	6-24-35	Do.
36-2	NW NW	MDC	CCC	1935	5	-	Qs	Tf	4.5	M	1935	Do.
49N 10W												
4-1	NE SW	MDC	CCC	1935	19	2	Qsg	Tf	-	-	-	
6-1	SW SE	MDC	CCC	1935	8	-	Qs	Tf	1.5	M	6-28-35	Augered to water table.
6-2	SW SW	MDC	CCC	1935	7	-	Qs	Tf	7.0	M	9-20-35	Do.
6-3	SW NW	Harry Heidt	George Pietscher	1935	35	2	Qs	D	10	R	1955	Equipped with sandpoint.
6-4	SW NW	R. M. Robinson	do.	1954	32	2	Qs	D	10	R	1955	Do.
6-5	SW NW	Richard Beach	do.	1955	34	2	Qs	D	10	R	1955	Do.
7-1	SW SW	MDC	CCC	1935	17	2	Qs	Tf	-	-	-	
7-2	SE SE	MDC	CCC	1935	19	2	Qs	Tf	-	-	-	
7-3	SW NW	MDC	CCC	1935	19	-	Qsg	Tf	19.0	M	6-28-35	Augered to water table.
8-1	NE SE	MDC	CCC	1935	19	2	-	Tf	dry	R	1935	**Drilled in sand. Destroyed.**
8-2	NW NW	MDC	CCC	1935	12	-	Qs	Tf	11.5	M	6-28-35	Augered to water table.
10-1	SW SW	MDC	CCC	1935	17	2	Qs	Tf	-	-	-	
10-2	SW NW	MDC	CCC	1935	15	2	Qs	Tf	-	-	-	
11-1	SW SW	MDC	CCC	1935	19	2	Qs	Tf	-	-	-	
11-2	NW NW	MDC	CCC	1935	19	2	Qs	Tf	-	-	-	
11-3	SE NW	MDC	-	-	24	1¼	Qs	P	12	R	1957	Equipped with screen. Reed and Green Bridge Campground.
12-1	SW NE	MDC Do.	CCC	1935	18	2	Qs	Tf	-	-	-	
12-2	NE NW	Two Hearted Club	George Pietscher	-	110	2	Qs	D	30	R	1957	Equipped with screen.
13-1	NE SE	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Augered in sand.
15-1	SE NE	Joseph Bugai	George Pietscher	1956	107	2	Qs	D	45	R	1956	Equipped with screen.
16-1	SE SW	MDC	CCC	1935	19	2	Qs	Tf	-	-	-	
16-2	NW NW	MDC	CCC	1935	19	2	-	Tf	dry	R	1935	Destroyed.
16-3	SE NE	MDC	CCC	1935	18	-	Qs	Tf	18	M	8-12-35	Augered to water table.
17-1	NE SE	MDC	CCC	1935	19	2	Qs	Tf	13	R	6-21-35	
18-1	SW SW	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
18-2	NW SW	MDC	CCC	1935	16	-	Qs	Tf	15.5	R	8-14-35	
19-1	SW NE	MDC	George Pietscher	1955	31	3	Qs	P	21	R	1955	Equipped with screen. Perch Lake Campground.
19-2	SE SW	MDC	MDC	1929	22	1¼	Qs	P	-	-	-	Abandoned.
19-3	SW NW	MDC	CCC	1935	9	-	Qs	Tf	8.2	M	6- ?-35	Augered to water table.
20-1	SE NW	MDC	-	1936	35	4	Qgd	P	-	-	-	Lake Superior CCC camp well. Abandoned.
20-2	SW SW	MDC	CCC	1935	15	2	Qsg	Tf	-	-	-	
22-1	NW NW	MDC	CCC	1935	3	-	Qs	Tf	2.4	M	6- 7-35	Augered to water table.
23-1	SE NE	MDC	CCC	1935	19	2	Qsg	Tf	-	-	-	
23-2	SE NW	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in silt and clay.
24-1	NE NW	MDC	CCC	1935	19	2	Qs	Tf	-	-	-	
24-2	SW NE	MDC	CCC	1935	4	-	Qs	Tf	3.7	M	6- 6-35	Augered to water table.
25-1	SE SW	MDC	CCC	1935	19	-	Qsg	Tf	-	-	-	
26-1	NE NW	MDC	CCC	1935	19	-	Qs	Tf	-	-	-	
26-2	SW SW	MDC	CCC	1935	14	-	Qsg	Tf	-	-	-	
28-1	SE SW	MDC	CCC	1935	14	-	Qs	Tf	-	-	-	
28-2	NE NE	MDC	CCC	1935	15	-	Qs	Tf	-	-	-	
30-2	SW NE	MDC	CCC	1935	15	2	Qsg	Tf	-	-	-	
30-3	SE SE	MDC	George Pietscher	1957	50	3	OChm	P	30	R	1957	Cased to 49 feet. High Bridge Campground.
31-1	NW SE	MDC	CCC	1935	3	-	Qs	Tf	2.5	M	6-13-35	Augered to water table.
31-2	NW NE	B. Snooks	George Pietscher	1954	17	2	OChm	P	-	-	-	Flows. Bedrock at 2 ft.
33-1	SW NW	MDC	CCC	1935	2	-	Qs	Tf	2.0	M	6-13-35	Augered to water table.
36-1	SW NE	MDC	CCC	1935	11	-	Qs	Tf	10.5	M	6- 6-35	Do.
49N 9W												
1-1	NW SE	MDC	CCC	1935	19	2	Qs	Tf	-	-	-	
2-1	NW NW	MDC	CCC	1935	19	2	Qs	Tf	-	-	-	
2-2	NE SW	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Drilled in sand.
3-1	NW SE	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Do.

Table 3.--Records of wells and test holes in Luce County--Continued

Well number	Location in section ¼ of ¼	Owner	Driller	Year drilled	Depth (feet)	Diameter (inches)	Aquifer	Use	Water level	M or R	Date	Remarks
49N 9W Continued												
4-1	SW NW	MDC	CCC	1935	19	2	-	Tf	dry	R	1935	Drilled in sand and gravel.
4-2	SE SE	MDC	CCC	1935	10	-	Qs	Tf	9.5	M	7-23-35	
7-1	SE SW	MDC	CCC	1935	16	-	Qs	Tf	16	M	7-25-35	
8-1	NE SE	MDC	CCC	1935	19	-	-	Tf	dry	R	1935	Drilled in coarse sand.
8-2	NE NW	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Drilled in sand.
8-3	NW NE	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Do.
9-1	SW NE	MDC	CCC	1935	18	-	Qs	Tf	-	-	-	
10-1	SE NE	MDC	CCC	1935	14	-	Qs	Tf	8	R	1935	
10-2	NE NW	MDC	CCC	1935	11	-	Qs	Tf	10.4	M	6-12-35	
12-1	SW NE	MDC	CCC	1935	14	-	Qs	Tf	-	-	-	
13-1	NW SE	MDC	CCC	1935	14	-	Qs	Tf	-	-	-	
13-2	NE NW	MDC	CCC	1935	14	-	Qs	Tf	-	-	-	
15-1	NW NE	MDC	CCC	1935	9	-	Qs	Tf	8.5	M	6-21-35	
15-2	SE NW	MDC	-	1 -	30	1¼	Qs	Tf	20	R	1957	Equipped with screen. **Pike Lake Campground.**
16-1	NW NE	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
17-1	NW SW	MDC	CCC	1935	12	2	Qs	Tf	11.4	M	6-11-35	
17-2	NW NW	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Drilled in coarse sand.
17-3	SE NW	MDC	CCC	1935	15	-	-	Tf	15	M	8-12-35	
19-1	NE NE	MDC	CCC	1935	19	2	Qs	Tf	-	-	-	
24-1	NW NE	MDC	CCC	1935	4	-	Qs	Tf	3	M	6-21-35	
25-1	NW NE	MDC	CCC	1935	8	-	Qs	Tf	7.3	M	6-21-35	
25-2	SW SE	MDC	CCC	1935	15	-	Qs	Tf	3	M	6-21-35	
29-1	NE SW	MDC	CCC	1935	15	-	Qs	Tf	-	-	-	
30-1	NE SW	MDC	CCC	1935	17	-	Qs	Tf	17	M	7- 3-35	
31-1	NE NW	MDC	CCC	1935	14	2	Qgd	Tf	-	-	-	
33-1	SW SW	MDC	CCC	1935	14	-	O€hm	Tf	-	-	-	Bedrock at 7 ft.?
48N 12W												
16-1	SE SE	Camp Dillingham	George Pietscher	1956	58	2	Qg	D	30	R	1956	Equipped with screen.
21-1	SE SE	MDC	CCC	1935	4	2	Qs	Tf	3.5	R	8- 7-35	
27-1	NW SE	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Drilled in coarse sand.
28-1	NE NW	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Drilled in sand.
35-1	SW SE	MDC	CCC	1935	15	2	Qsg	Tf	15.0	M		
48N 11W												
2-1	NW SE	MDC	CCC	1935	6	2	Qs	Tf	5.3	M	7-24-35	
10-1	SW NE	MDC	CCC	1935	4	2	Qs	Tf	1.0	M	7-24-35	
48N 10W												
1-1	NE NE	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Drilled in coarse sand.
1-2	SE SE	MDC	CCC	1935	14	2	Qs	Tf	6.5	M	6-27-35	
1-3	SE NW	Arnold Allagars	George Pietscher	1956	106	2	Qg	P	85	R	1956	Equipped with sandpoint.
4-1	NE SE	MDC	CCC	1935	20	2	Qgd	Tf	2	R	1935	
5-1	NE NE	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
5-2	NE SE	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
6-1	NW NE	MDC	CCC	1935	3	2	Qs	Tf	2.4	M	6-13-35	
8-1	NW NW	MDC	CCC	1935	13	2	Qg	Tf	6.8	M	6-13-35	
8-2	SW NW	Sherman Hickman	George Pietscher	1936	37	1¼	Qgd	D	-	-	-	Destroyed.
8-3	SW NW	do.	do.	1954	76	2	Qg	P	10	R	1954	Equipped with sandpoint.
8-4	NW SW	do.	do.	1957	73	2	Qs	D	0.8	R	6- ?-57	Do.
8-5	NW SW	Robert Farnham	do.	1956	35	2	Qg	D	7	R	1956	Do.
8-6	NW SW	Charles Thatcher	do.	1956	36	2	Qsg	D	6	R	1957	Equipped with screen.
8-7	NW NW	Norman Somerville	do.	1956	35	2	Qg	P	26	R	1956	Do.
8-8	NW SW	Harold Hunter	do.	1955	84	2	O€hm	D	8	R	1957	Bedrock at 84 ft.
8-9	NW SW	Harold Miner	do.	1957	76	2	Qs	D	0.8	R	1957	Equipped with sandpoint.
9-1	NW NE	MDC	CCC	1935	20	2	Qgd	Tf	3	M	6-24-35	
9-2	NW NE	Fuller	George Pietscher	1954	11	2	O€hm	D	4	R	1954	Bedrock at 4 ft.
9-3	NW NW	G. S. McIntire	do.	-	23	2	O€hm	D	7	R	1957	Do.
17-1	NW NW	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
17-2	NW NW	John Slawick	George Pietscher	1957	86	2	O€hm	D	6	R	1957	Bedrock at 68 ft.
18-1	SE SE	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
20-1	SW SW	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
20-2	SW NW	Luce County	-	-	24	1¼	Qgd	P	5.12	M	8- 2-57	Abandoned Road Camp.
20-3	SE NW	do.	-	-	10	6	Qgd	P	3.18	M	8- 2-57	Do.
30-1	SE SE	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
31-1	SE NE	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
31-2	SW SE	G. S. Hart	George Pietscher	1954	26	2	Qg	D	12	R	1954	

Table 3.--Records of wells and test holes in Luce County--Continued

Well number	Location in section ¼ of ¼	Owner	Driller	Year drilled	Depth (feet)	Diameter (inches)	Aquifer	Use	Water level	M or R	Date	Remarks
48N 9W												
5-1	NW NW	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Drilled in sand and gravel.
6-1	SW SE	MDC	CCC	1935	9	2	Qs	Tf	8.5	R	1935	
6-2	NE NE	MDC	CCC	1935	19	2	Qs	Tf	-	-	-	
6-3	NW NW	East Branch Club	George Pietscher	1955	58	2	Qs	D	25	R	1955	Bedrock at 58 ft. Equipped with screen.
7-1	SW NW	MDC	CCC	1935	5	2	Qs	Tf	4.2	R	1935	
9-1	NE SW	Mellons	George Pietscher	-	40	2	OЄhm	D	10	R	1957	
34-1	NW NW	Russell Lehman	Warren Saunders	1956	32	2	Qs	P	17	R	1956	Equipped with 90 gauze sandpoint.
48N 8W												
1-1	SW SW	MDC	Ross Payton	1947	44	2	Qs	P	20	R	1947	Tahquamenon State Park. Equipped with 3 ft. - 80 gauze screen.
12-1	- NW	MDC	do.	1949	25	2	OЄhm	P	-	-	-	Bedrock at 10 ft.
47N 12W												
27-1	- NW	Weaver	George Pietscher	1954	147	2	Qgd	D	47	R	1954	Equipped with screen.
47N 11W												
2-1	NW SE	MDC	CCC	1935	6	-	Qsg	Tf	6	R	1934	Augered to water table.
3-1	NW SW	MDC	CCC	1935	4	-	Qs	Tf	4	R	1935	Do.
4-1	NW NE	MDC	CCC	1935	11	2	Qs	Tf	11	R	1935	
6-1	SW SW	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Drilled in sand.
6-2	NW NW	MDC	CCC	1936	20	2	-	Tf	dry	R	1936	Do.
7-1	NW SE	MDC	CCC	1935	18	2	Qg	Tf	-	-	-	
8-1	SW SE	MDC	CCC	1935	4	2	Qs	Tf	3.6	R	1935	Augered to water table.
9-1	SE SW	MDC	CCC	1935	17	2	Qs	Tf	-	-	-	
10-1	SW SW	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
12-1	NE SE	MDC	CCC	1935	14	2	Qs	Tf	5	R	1935	
13-1	SE NE	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Augered in sand.
13-2	SW NE	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Do.
13-3	NW SE	Otto Rinner	George Pietscher	1956	84	2	Qg	D	6	R	1956	Equipped with 4 ft.- screen.
14-1	SE NW	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Augered in sand.
14-2	SE NE	MDC	CCC	1935	4	-	Qsg	Tf	3.7	R	1935	Augered to water table.
15-1	SW NW	MDC	CCC	1935	18	2	Qs	Tf	-	-	-	
15-2	SW SW	MDC	CCC	1935	20	-	-	Tf	dry	R	1935	Augered in coarse sand.
18-1	NW SE	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Drilled in sand.
19-1	SW SE	MDC	CCC	1935	12	2	Qs	Tf	11.8	M	7-17-35	
20-1	SW SE	MDC	CCC	1935	19	2	Qgd	Tf	-	-	-	
21-1	SE NE	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
23-1	SE NE	MDC	CCC	1935	15	2	Qs	Tf	-	-	-	
24-1	NE NW	MDC	CCC	1935	7	2	Qs	Tf	7.0	M	1935	
26-1	NE NW	MDC	CCC	1935	18	-	Qs	Tf	17.2	M	1935	Augered to water table.
26-2	NW SW	MDC	CCC	1935	15	2	Qs	Tf	5.5	M	1935	
26-3	SE SE	MDC	CCC	1935	13	2	Qgd	Tf	-	-	-	
28-1	SE NE	MDC	CCC	1935	16	-	Qs	Tf	16	M	7- 2-35	Do.
30-1	NW SW	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Drilled in sand.
30-2	NE NE	-	-	-	23	$1\frac{1}{4}$	-	D	18.86	M	10-30-57	
36-1	NE NE	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Do.
36-2	SW SE	MDC	CCC	1935	14	2	Qs	Tf	-	-	-	
36-3	NE NW	MDC	CCC	1935	20	2	-	Tf	dry	R	1935	Do.
47N 10W												
6-1	SW NE	James Foster	George Pietscher	-	35	2	Qg	D	4	R	1957	Equipped with screen.
6-2	NW SE	Douglas Williams	do.	-	65	2	Qs	D	10	R	1957	Do.
6-3	SW SE	John Mathews	do.	-	65	2	Qsg	D	7	R	1957	Do.
6-4	NW SE	Alvin Holton	do.	-	80	2	Qs	D	1	R	1957	Do.
6-5	SW NE	George Pietscher	do.	1949	23	2	Qs	D	1.5	R	1957	Do.
6-6	SW SE	Robert Kenicott	do.	-	65	2	Qs	D	10	R	1957	Equipped with sandpoint.
6-7	SW NE	Dwight VanEpps	do.	-	35	2	Qs	P	4	R	1957	Do.
6-8	SW NE	Frank Wisevogel	do.	-	35	2	Qg	D	4	R	1957	Do.
17-1	NW NW	John McLeod	-	1905	27	-	Qs	-	15	R	1905	
19-1	NW SE	Basset	George Pietscher	1954	74	2	Qg	D	40	R	1954	Do.
32-1	NW NW	Wm. E. Fidora	do.	1956	160	2	Qg	D	40	R	1956	Do.
35-1	NE NE	W. Green	-	1905	41	-	-	-	-	-	-	
36-1	SW NW	Thomas Burns	George Pietscher	1954	89	2	Qgd	D	12	R	1954	Equipped with screen.
47N 8W												
24-1	SE SW	Kenneth Slater	Kenneth Slater	1949	55	5	Qg	P	+12	R	1949	Flowed 400 gpm. Open-end casing.

Table 3.--Records of wells and test holes in Luce County--Continued

Well number	Location in section ¼ of ¼	Owner	Driller	Year drilled	Depth (feet)	Diameter (inches)	Aquifer	Use	Water level	M or R	Date	Remarks
46N 12W												
2-1	SE NW	MDC	CCC	1934	15	2	-	Tf	dry	R	1934	Drilled in sand.
4-1	NE SE	MDC	CCC	1934	19	2	-	Tf	dry	R	1934	Do.
6-1	NW SE	MDC	CCC	1934	18	2	Qs	Tf	-	-	-	
7-1	NE NW	MDC	CCC	1934	14	2	Qs	Tf	2.79	M	11- 5-34	
7-2	SE SW	MDC	CCC	1934	19	2	Qs	Tf	5.60	R	1934	
8-1	NE NW	MDC	CCC	1934	17	2	Qs	Tf	-	-	-	
10-1	SW SW	MDC	CCC	1934	18	2	Qs	Tf	13.62	M	11- 5-34	
11-1	NW NE	MDC	CCC	1934	18	2	Qs	Tf	-	-	-	
11-2	SE SE	MDC	CCC	1934	15	2	Qs	Tf	7.05	M	11- 5-34	
12-1	SE SE	MDC	CCC	1934	15	2	Qs	Tf	2.93	M	11- 5-34	
14-1	NW SW	MDC	CCC	1934	15	2	Qs	Tf	2.54	M	11- 5-34	
15-1	NE NE	MDC	CCC	1934	19	2	Qs	Tf	-	-	-	
16-1	NW SW	MDC	CCC	1934	19	2	Qs	Tf	-	-	-	
18-1	NE NE	MDC	CCC	1934	19	2	Qs	Tf	3.30	M	11- 5-34	
21-1	NE NE	MDC	CCC	1934	15	2	Qs	Tf	2.57	M	11- 5-34	
22-1	SW NE	MDC	CCC	1934	14	2	Qs	Tf	.44	M	11- 5-34	
23-1	NW NW	John Hanger	-	1919	20	1	Qs	D	-	-	-	
27-1	NE NE	MDC	CCC	1934	75	2	Qs	Tf	.47	M	11- 5-34	
32-1	SW SW	MDC	CCC	1934	15	2	Qs	Tf	.20	M	11- 5-34	
33-1	SE SW	MDC	CCC	1934	15	2	Qs	Tf	10.02	M	11- 5-34	
33-2	NE SE	L. C. Dyer	L. C. Dyer	1954	70	1½	Qs	D	70	R	1954	Equipped with sandpoint.
34-1	NW SW	MDC	CCC	1934	12	2	Qs	Tf	3.82	M	11- 5-34	
35-1	NE SW	M. J. Gochenour	Harry Roat	-	135	4	Qs	D	-	-	-	Not used.
35-2	NE SW	do.	M. J. Gochenour	1955	22	1¼	Qs	P	16	R	1957	Equipped with sandpoint.
36-1	NW SE	MDC	CCC	1934	15	2	Qs	Tf	3.01	M	11- 8-34	
36-2	SW NE	Charles Kubont	Harry Roat	-	140	2	Qgd	D,S	-	-	-	
46N 11W												
31-1	SE NE	O. R. Musgrave	Harry Roat	1914	96	3	Qs	D,S	66	R	1955	Equipped with sandpoint.
31-2	SE NW	Floyd McInnis	do.	-	130	2	Qgd	D	-	-	-	
31-3	SE NW	Robert Meister	Robert Meister	1950	15	2	Qs	P	1	R	1957	Do.
32-1	NW SE	Harley Gebhart	Gilbert Fyvie	1941	34	4	Qsg	P	11	R	1957	Do.
32-2	NW SE	F. F. Morrison	F. F. Morrison	1949	42	4	Qsg	D	7	R	1957	Do.
32-3	NE SW	Milton Brown	do.	-	30	3	Qsg	D	18	R	1957	Do.
33-1	SE NW	Columbus Twp. School	-	1905	80	1¼	Qs	P	-	-	-	Abandoned.
33-2	SE NW	do.	F. F. Morrison	1935	40	4	Qg	P	+21	R	1935	Flowed 350 gpm. Open-end casing.
33-3	SW NE	Cooperage Co.	-	1905	60	-	Qgd	I	16	R	1905	Destroyed.
33-4	SW NE	Perry Marks	Harry Roat	1907	72	2	Qs	P	39	R	1956	Equipped with screen.
33-5	SE NW	H. J. Skinner	do.	-	62	3	Qsg	P	-	-	-	Destroyed.
33-6	SE NW	do.	H. J. Skinner	-	105	3	Qs	T	-	-	-	Did not yield water.
33-7	SE NW	do.	do.	-	62	3	Qs	T	-	-	-	Do.
33-8	NE SW	do.	Harry Roat	-	92	3	Qsg	D	-	-	-	Destroyed.
33-9	NE SW	do.	Fred Roat	1953	131	4	Qsg	D	48	R	1953	Equipped with screen.
33-10	SW NW	Bell	F. F. Morrison	1940	48	3	Qsg	D	42	R	1940	Equipped with sandpoint. Not used
33-11	NE SW	Columbus Twp. Park	do.	1935	47	3	Qsg	P	40	R	1935	Equipped with sandpoint.
46N 10W												
2-1	SE NE	Carl Simi	George Pietscher	1955	86	2	Qg	D	9	R	1955	Equipped with 12 ft.-screen.
23-1	NE NE	Harvey Chamberlin	-	-	134	2	Qs	D	-	-	-	Flows.
23-2	NE NE	W. O. Blankenship	Jess Dyer	1949	155	3	Qsg	D	-	-	-	Flows.
23-3	SW SE	Bob Schjoth	George Pietscher	1956	160	2	Qgd	D	-	-	-	Flows. Equipped with screen.
24-1	SW NW	Robert Craig	do.	-	80	2	Qs	D	-	-	-	Flows. Drilled originally to 170 ft.
24-2	SW NW	Wesley Sutton	Ross Rayton	1957	135	2	Qs	P	-	-	-	Flows. Equipped with 12-ft. screen.
24-3	NW SW	Joseph Russell	George Pietscher	-	90	3	Qg	P	-	-	-	Flows. Open-end casing.
24-4	NW NE	Ryberg	J. Sommerville	1897	142	3	Qsg	D	+9	R	1905	Flowed.
25-1	NW SE	Harris	-	1905	60	1¼	Qgd	D	-	-	-	Flowed. Destroyed.
25-2	SW NE	D.S.S. and A.R.R. a/	-	1889	54	1¼	Qsg	D	-	-	-	Destroyed.
25-3	NW SW	City of Newberry	-	1900	110	6	Qg	P	10	R	1905	Five municipal supply wells. Destroyed.
25-4	NW SW	do.	-	1916	110	6	Qg	P	-	-	-	Former municipal supply. Destroyed.
25-5	NW SW	do.	-	1929	120	10	Qsg		14.38	M	6-21-57	
25-6	NW SW	do.	-	1929	120	10	Qsg	P	-	-	-	

a/ Duluth South Shore and Atlantic Railroad

Table 3.--Records of wells and test holes in Luce County--Continued

Well number	Location in section (¼ of ¼)	Owner	Driller	Year drilled	Depth (feet)	Diameter (inches)	Aquifer	Use	Water level	M or R	Date	Remarks
46N 10W Continued												
25-7	NW NW	City of Newberry	Layne Northwest Co.	1938	132	38	Qs	P	-	-	-	Flows. Formerly Newberry Lumber and Chemical Co. Equipped with 16-in. screen.
25-8	NW SW	do.	do.	1943	145	8	Qsg	T	-	-	-	Site of well 46N 10W 25-9.
25-9	NW SW	do.	do.	1943	130	26	Qsg	P	17	R	1943	Equipped with 20 ft. of 12-in. screen.
25-10	NW NW	Newberry Lumber and Chemical Co.	-	1902	80	-	Qgd	I	-	-	-	Flowed. Abandoned.
25-11	- NW	do.	F. F. Copeland	1904	100	-	Qs	I	-	-	-	Abandoned.
25-12	SW NW	do.	Layne Northwest Co.	1937	125	8	Qs	T	-	-	-	Flowed.
25-13	NW NW	do.	do.	1937	146	4	Qs	T	-	-	-	Bedrock at 141 ft.
25-14	SW NW	do.	do.	1937	145	4	Qs	T	-	-	-	Site of well 46N 10W 25-7.
25-15	SW NW	do.	do.	1937	141	4	Qs	T	-	-	-	
25-16	NW NW	do.	do.	1937	140	4	Qs	T	-	-	-	Bedrock at 138 ft.
25-17	NW NW	do.	do.	1937	134	4	Qs	T	-	-	-	
25-18	NW NW	do.	do.	1937	129	4	Qs	T	-	-	-	
25-19	SE NW	Jack Lehto	-	-	60	2	Qs	D	10	R	1957	
26-1	NE NE	Ben Alson	-	1905	30	-	Qs	D	-	-	-	Flowed.
27-1	SW SW	Bruce Stephens	-	-	25	1¼	Qgd	P	-	-	-	Not used.
27-2	NW SW	Fred Kimmel	-	1887	95	3	Qsg	D,S	+16	R	1957	Flows.
27-3	NW SW	Danaher Lumber Co.	-	1883	140	3	Qgd	I	-	-	-	Flowed. Destroyed.
27-4	NW SW	Fred Kimmel	-	1884	130	6	Qgd	D	-	-	-	Flows
29-1	SW SE	MDC	-	-	120	3	Qgd	P	+4	M	10-29-57	Flows.
35-1	NE NE	W. E. Lavender	Elwin Anderson	1948	69	6	Qgd	P	53	R	1948	Equipped with 4 ft. of 18-slot screen.
36-1	NW NW	Elsie Miller	-	-	100	3	Qgd	P	-	-	-	Abandoned.
36-2	NW NW	W. W. Wilkens	George Pietscher	1956	88	2	Qs	D	28	R	1957	Equipped with screen.
36-3	NW NW	do.	Hunter	1948	68	2	Qsg	P	28	R	1957	Equipped with sandpoint.
36-4	SW SW	Melvin Edwards	Dunbar Drilling Co.	1956	158	6	Qs	P	124	R	8- ?-56	Equipped with 6 ft.of 10-slot screen.
36-5	SW SW	Clare Hettrick	W. W. Stevenson	1957	214	4	Qsg	P	117.04	M	9-20-57	Equipped with 20-slot screen 208-214 ft.
36-6	SW NW	Nelson Bros.	George Pietscher	1955	147	2	Qg	D	60	R	8-13-57	Equipped with screen.
46N 9W												
19-1	SW SW	Elmer Mosio	Elmer Mosio	1932	38	1¼	Qs	D	+3	M	6-26-57	Flows. Equipped with sandpoint
19-2	SE SE	Henry Frazure	Ross Payton	1957	135	2	Qsg	D	-	-	-	Flows.
22-1	NW NW	Legg	George Pietscher	-	23	2	Or?	D	8	R	1957	Bedrock reported at 12 ft.
22-2	NW NW	do.	-	-	14	2	Qgd	D	-	-	-	Flows.
46N 8W												
2-1	- -	White and France	James Sommerville	1893	172	3	Qg	I	+8	R	1893	Flowed.
19-1	SE SE	Deadman's Farm	-	-	-	-	-	D	-	-	-	Flows. Abandoned.
45N 12W												
1-1	SW SE	MDC	CCC	1934	18	2	-	Tf	-	-	-	
1-2	NW NE	MDC	CCC	1934	15	2	Qs	Tf	0.71	M	11- 8-34	
3-1	SE SW	MDC	CCC	1934	14	2	Qs	Tf	6.48	M	11- 8-34	
10-1	NE NE	MDC	CCC	1934	18	2	-	Tf	dry	R	11- 8-34	Drilled in sand.
12-1	SE SE	George Roat	James Sommerville	-	76	3	Qsg	D,S	36	R	1957	
12-2	SW SW	MDC	CCC	1934	18	2	Qs	Tf	11.76	M	11- 8-34	Clay at 18 ft.
12-3	SE SE	MDC	CCC	1934	15	2	Qs	Tf	10.96	M	11- 8-34	
14-1	SE NE	MDC	CCC	1934	15	2	Qs	Tf	5.55	M	11- 8-34	
15-1	NE SE	MDC	CCC	1934	15	2	Qs	Tf	6.90	M	11- 8-34	
16-1	SE SE	MDC	CCC	1934	18	2	Qs	Tf	7.05	M	11- 8-34	
19-1	NW NW	MDC	CCC	1934	14	2	Qs	Tf	-	-	-	
21-1	SW SE	John Richards	-	1895	76	3	Qs	D	68	R	1905	Bedrock at 76 ft.
21-2	SE NE	G. and M. Liston	Elwin Anderson	1956	850	6	O€bm	D	+33	R	1956	Bedrock at 80 ft. Flows.
22-1	SE NE	Alex McCarron	Dunbar Drilling Co.	1952	79	6	Qs	D,S	55	R	1952	Equipped with 10-slot screen 74-79 ft.
22-2	SE SW	MDC	CCC	1934	14	2	Qgd	Tf	2.73	M	11- 8-34	
23-1	SW SE	Smathers School	Harry Roat	1923	70	4	Qs	P	50	R	1957	Equipped with 10-slot screen.
23-2	SE NE	Cecil Zellar	o.	-	60	6	Qs	D,S	10	R	1957	Equipped with screen.

Table 3.--Records of wells and test holes in Luce County--Continued

Well number	Location in section ¼ of ¼	Owner	Driller	Year drilled	Depth (feet)	Diameter (inches)	Aquifer	Use	Water level	M or R	Date	Remarks
45N 12W Continued												
24-1	SW NW	N. Welder	George Pietscher	1954	32	2	Qg	D	5	R	1954	Equipped with sandpoint.
25-1	NW SW	Vernon Cummings	-	-	-	-	Qgd	D	-	-	-	Improved spring.
26-1	NW NW	Fred Everling	Harry Roat	1908	70	3	Qgd	P	-	-	-	
26-2	NE NE	R. W. Byers	Dunbar Drilling Co.	1952	64	6	Qsg	D,S	50	R	8-27-52	Equipped with 20 slot screen 61-64 ft.
26-3	SW NW	Elton Greenfield	Gilbert Fyvie	1955	-	4	Qgd	D	+8.5	M	6-19-57	Flows.
26-4	NE NW	MDC	CCC	1934	15	2	Qs	Tf	4.49	M	11- 8-34	
29-1	NW NE	Charles Orr	-	1905	96	-	Sc	P	60	R	1905	Bedrock at 40 ft.
29-2	SW NW	A. C. McKinnon	-	1904	86	6	Sc	D,S	56	R	1905	Do.
29-3	SE SW	Allen Lander	-	1928	80	4	Sc	P	3	R	1957	Bedrock at 4 ft.
29-4	SE SW	do.	Elwin Anderson	1944	90	5	Sc	P	3	R	1957	Do.
29-5	SE NE	MDC	CCC	1934	14	2	Qs	Tf	1.60	M	11- 8-34	
30-1	NE SE	Harry Zellar	-	1887	85	5	Sc	D,S	20	R	1905	Bedrock at 18 ft.
31-1	SW NE	Byron Shields	Elwin Anderson	1949	25	6	Sc	D	9	R	1957	Bedrock at 60 ft. Flowed from original 140 ft. depth.
31-2	SW NE	Vernon Cummings	W. J. Rodgers	-	20	6	Qg	P	9	R	1957	
34-1	NE SE	Elton Greenfield	Harry Roat	1928	58	4½	Sc	P	+7.5	R	1957	Bedrock at 4 ft.
34-2	NE SE	do.	do.	1928	103	4	Sc	D,S	37	R	1957	Bedrock at 36 ft.
36-1	SE SW	Margaret Newbrough	-	-	85	4	-	P	-	-	-	
45N 11W												
3-1	NW NW	Ernest Staley	-	-	61	3	Qgd	I	+2.5	M	1957	Flows ½ gpm. Abandoned.
3-2	SE SW	Mrs. Elmer Fritz	Jess Dyer	1945	127	2	Qs	D	-	-	-	Equipped with sandpoint.
3-3	SE SW	Brown and Petend	do.	1945	137	2	Qsg	P	-	-	-	Do.
4-1	NE NE	MDC	CCC	1934	13	2	Qs	Tf	.62	M	11- 8-34	
4-2	SE NW	William Blankenship	-	1920	200	3	-	T	dry	R	1930	Drilled in sand.
4-3	NE SW	Ray Newhouse	W. and W. Stephenson	1957	268	4	Qs	D	178	R	1957	Equipped with 20-slot screen 263-268 ft.
5-1	NW NE	MDC	CCC	1934	15	2	Qs	Tf	2.27	M	11- 8-34	
5-2	SW SE	MDC	CCC	1934	17	2	Qs	Tf	-	-	-	
7-1	SE NW	Roy Simmons	Harry Roat	-	96	3	Qgd	D	-	-	-	
7-2	NW SE	MDC	CCC	1934	19	2	Qs	Tf	6.10	M	11- 8-34	
8-1	NE SW	MDC	CCC	1934	18	2	Qs	Tf	-	-	-	
8-2	- SE	Charles Simmons	W. and W. Stephenson	1957	115	4	Or	P	-	-	-	Bedrock at 90 ft.
9-2	SW NW	MDC	do.	1934	19	2	Qs	Tf	-	-	-	
10-1	SW NE	MDC	do.	1934	19	2	Qs	Tf	-	-	-	
11-1	SW NW	Stanley Miller	-	1921	81	3	Qgd	P	-	-	-	
11-2	NW SE	MDC	CCC	1934	19	2	Qs	Tf	7.72	M	11- 8-34	
13-1	SW NW	MDC	CCC	1934	19	2	Qs	Tf	9.72	M	11- 8-34	
14-1	NE SE	Roy Fyvie	Roy Fyvie	-	72	4	Qs	D,S	25	R	1957	Equipped with sandpoint.
14-2	SE SW	do.	do.	-	212	3	Qs	S	70	R	1957	Do. Abandoned.
14-3	SE NE	Gordon Aten	W. J. Rodgers	1951	300	6	Qs	D	25	R	1957	Equipped with screen. Used also for irrigation.
16-1	SE NW	Russell Clark	Russell Clark	1956	13	1¼	Qs	D	4	R	1957	Equipped with sandpoint.
16-2	SW NW	MDC	CCC	1934	19	2	Qs	Tf	12.68	M	11- 8-34	
17-1	NW SE	Mrs. E. Stone	-	-	45	1¼	Qs	P	-	-	-	
17-2	NW SE	do.	-	-	80	4	Qs	P	-	-	-	
17-3	SW SW	John Fyvie	-	1905	58	-	Qsg	D,S	7	R	1905	
17-4	NW SW	Florence Lyberg	-	-	29	1¼	Qgd	D	-	-	-	Spring not used.
17-5	NW SW	do.	-	-	-	-	Qgd	-	-	-	-	
19-1	SE SW	Luce Co. Park	-	-	160	4	-	P	-	-	-	
19-2	NE SE	Goldthorpe Enterprises	Gilbert Fyvie	-	40	4	Qs	D	5	R	1957	Equipped with screen.
19-3	SW SW	William Gabbard	-	-	87	3	Qgd	P	-	-	-	
20-1	SW SW	Goldthorpe Enterprises	Goldthorpe Enterprises	-	22	1¼	Qs	P	-	-	-	Equipped with sandpoint.
20-2	NW SE	Andrew Neiger	Gilbert Fyvie	-	42	2	Qs	D	+8	R	1957	Flows.
20-3	NE NW	MDC	CCC	1934	15	2	Qs	Tf	-	-	-	
22-1	NW NW	MDC	CCC	1934	19	2	Qs	Tf	-	-	-	
22-2	NE NE	MDC	CCC	1934	15	2	Qs	Tf	4.34	M	11- 8-34	
23-1	SW NW	MDC	CCC	1934	19	2	Qs	Tf	-	-	-	
26-1	SE NW	MDC	CCC	1934	19	2	Qs	Tf	14.8	M	11- 8-34	
27-1	SE SE	MDC	CCC	1934	15	2	Qs	Tf	.90	M	11- 8-34	

Table 3.--Records of wells and test holes in Luce County--Continued

Well number	Location in section ¼ of ¼	Owner	Driller	Year drilled	Depth (feet)	Diameter (inches)	Aquifer	Use	Water level	M or R	Date	Remarks
45N 11W Continued												
28-1	SE SW	Wilfred Thorley	-	-	50	3	Qs	P,S	39	R	1957	Equipped with sandpoint.
28-2	NW NE	MDC	CCC	1934	12	2	Qsg	Tf	-	-	-	
29-2	SE NW	MDC	CCC	1934	15	2	Qs	Tf	3.16	M	11- 8-34	
30-1	SE NE	Helmer Resort	James Sommerville	1901	70	3	Qg	P	+8	R	1905	Flows.
30-2	NE NW	John Dudley	-	1941	750	3	Or?	P	-	-	-	Reported depth not verified.
30-3	NE NE	MDC	CCC	1934	19	3	Qs	Tf	10.27	R	4-30-35	
31-1	SE SE	A. C. Anderson	-	1946	26	4	Qgd	P	-	-	-	
31-2	NE SE	William Ritterhoff	-	-	80	2	-	-	-	-	-	
31-3	NE SE	do.	-	-	140	6	Sc	P	-	-	-	Abandoned.
31-5	SE NE	Dr. Campbell	-	1957	70	4	Sc	D	+.5	R	1957	Flows. Cased to 30 ft.
31-6	SE NE	Clarence Bonifield	W. and W. Stephenson	1948	89	6	Sc	P	.0	R	1948	Cased to 59 ft.
32-1	SW NE	Gordon Kalnback	do.	1943	42	4	Sc	D,S	16	R	1957	Bedrock at 30 ft.
33-1	NW NW	Marks School	W. J. Rodgers	1945	185	6	Sc	P	45	R	1957	Bedrock at 70 ft.
33-3	NW NW	do.	-	-	50	3	Qs	P	-	-	-	Abandoned.
45N 10W												
1-1	NE NW	Newberry State Hospital East Well	Thomas Percy	1893	451	8	Or	P	106	R	1- ?-35	Bedrock at 320 ft. Destroyed.
1-2	SE NW	Newberry State Hospital South Well	-	1905	246	8	Qsg	P	104	R	1- ?-35	Destroyed.
1-3	NE NW	Newberry State Hospital 2	-	1914	337	8	Or	P	110	R	1- ?-35	Bedrock at 320 ft.
1-4	NW NW	do. 1	Harry Roat	1923	230	8	Qgd	P	110	R	1- ?-35	Screened 210-230 ft.
1-5	NW NW	do. TW 1	Dunbar Drilling Co.	1947	303	-	Qgd	T	117	R	4-15-47	Bedrock at 295 ft.
1-6	NW NE	do. TW 2	do.	1947	319	-	Qgd	T	101	R	1947	Bedrock at 317 ft.
1-7	SW NE	do. TW 3	do.	1947	255	-	Qg	T	88	R	1947	
1-8	SE NW	do. TW 4	do.	1947	255	-	Qsg	T	65	R	1947	Site of well 45N 10W 1-10.
1-9	SW NE	do. TW 5	do.	1947	155	-	Qsg	T	47	R	6- ?-47	Site of well 45N 10W 1-11.
1-10	SE NW	do. 4	do.	1949	274	12	Qsg	P	72	R	2-15-49	125-slot screen 263-273 ft.
1-11	SW NE	do. 5	do.	1948	145	12	Qsg	P	48.57	M	9-16-49	Screened 130-143 ft.
1-12	SE NW	do. 3	Edward Christman	1936	240	10	Qsg	P	114	R	1- ?-36	Equipped with 20-slot screen 210-218 ft. 30-slot screen 218-236 ft.
1-13	NW NW	Pratt School	James Sommerville	1905	138	-	Qgd	P	-	-	-	Abandoned.
1-16	NE SE	Leroy Davis	-	-	168	2½	Qgd	D,S	-	-	-	Equipped with 80-slot screen.
2-2	SW SE	Swanson Bros.	John Swanson	1899	84	1¼	Qs	D	+2	R	1905	Flows.
2-3	SW SE	do.	do.	1915	74	3	Qg	D,S	+12	R	1915	Do.
4-1	SE SE	Thomas Watson	-	1905	106	-	Qg	D,S	0	R	1957	
8-1	SE NW	Edward Felman	-	1929	139	4½	Qgd	D	-	-	-	Do.
9-1	SE NW	C. O. Grant	-	1905	192	3	Qg	S	135	R	1905	Formerly Templeton School well.
9-3	SW NW	James Plesscher	-	1905	103	-	Qg	D	+11	R	1905	Flows.
9-4	SW NW	do.	A. R. Trent	1957	283	4	Or	-	-	-	-	Flows. Bedrock at 148 ft. Produced saline water.
9-5	NE SW	Art. Keifert	George Pietscher	-	175	2	Qg	D	7	R	1957	Equipped with sandpoint.
9-6	NE SW	do.	W. and W. Stephenson	1957	215	4	Or	D	19	R	1957	Bedrock at 210 ft.
10-1	SW SW	Blaine Pentland	James Sommerville	1899	103	1½	Qg	D,S	+1.5	R	1905	Flows. Equipped with sandpoint.
10-2	SW SW	do.	John Swanson	1917	103	2	Qs	D,S	-	-	-	Flows.
10-3	SW NW	C. O. Grant	-	1905	196	3	Qgd	D,S	135	R	1905	Equipped with screen.
10-4	NE NW	Kenneth Watson	-	1900	150	3	Qgd	-	75	R	1905	
10-5	NE NW	do.	Kenneth Watson	1953	150	3	Qg	D	78	R	1953	Do.
10-6	NW SE	William Lambert	Ross Payton	1957	50	4	Qg	P	29.73	M	6-27-57	Equipped with 80-slot screen.
10-7	SW NE	Pentland Twp. Hall	do.	1957	121	4	Qg	P	40	R	6- ?-57	Do.
11-1	NW NW	Herman Peterson	do.	1901	60	2	Qs	D	+6	R	1957	Flows 1 gpm.
11-2	SE NW	Nels Selberg	W. and W. Stephenson	1957	156	4	Qg	D	+5	R	1957	Flows 10 gpm.

Table 3.--Records of wells and test holes in Luce County--Continued

Well number	Location in section	Owner	Driller	Year drilled	Depth (feet)	Diameter (inches)	Aquifer	Use	Water level	M or R	Date	Remarks
45N 10W Continued												
12-1	SE SE	Clarence Eddy	-	-	115	1½	Qgd	P	-	-	-	
12-2	SE SE	Cliff Roberts	Ross Payton	1927	120	3	Qgd	P	-	-	-	
12-3	NE NE	Emerson Luchow	-	1953	68	2	Qgd	D	-	-	-	Equipped with sandpoint.
13-1	NW NW	Fred Victorson	-	-	92	2	Qgd	P	-	-	-	Plugged and abandoned.
13-2	NW NE	John Burback	-	1907	113	1¼	Qsg	D	-	-	-	
13-3	NW SW	D. J. Wood	Dunbar Drilling Co.	1948	70	6	Qs	D,S	-	-	-	Equipped with screen.
13-4	NE SW	do.	do.	1948	270	12	Qs	-	65	R	1948	Screened 143-183 ft. Irrigation well.
13-5	NW NW	Fred Victorson	Elwin Anderson	1957	136	4	Qs	D	-	-	-	Screened 131-136 ft.
13-6	NE NE	Claude Atkins	do.	1954	125	4	Qs	P	-	-	-	Screened 121-125 ft.
19-1	NE NW	Harold Harter	-	1905	84	-	Qg	D	-	-	-	Abandoned.
19-2	- NE	Paul Dake	-	1893	53	-	Qs	D	-	-	-	
20-1	- NE	Clarence Grand	W. and W. Stephenson	1957	274	4	Qs	D	50	R	1957	Equipped with 20-slot screen 268-274 ft.
21-1	NE NE	Paul Dake	-	1890	85	-	Qgd	D,S	65	R	1905	Destroyed.
21-2	NE NE	do.	Ross Payton	1957	123	2	Qgd	D,S	-	-	-	Equipped with screen.
27-1	SW SW	Lawrence Dumas	A. L. Rupert	-	62	2	Qs	D	-	-	-	Equipped with sandpoint.
34-1	NW NW	Amos Whittenmeyer	do.	-	32	2	Qgd	D	-	-	-	Do.
45N 9W												
7-1	NE NW	Hanna Hedburg	George Pietscher	1957	165	2	Qs	-	-	-	-	Screened at 121 ft. Not used.
7-2	NE NW	do.	-	-	121	3	Qs	-	86.02	M	8-29-57	Not used.
7-3	SE SE	Wallace Bridges	Wallace Bridges	1957	140	1¼	Qs	D	-	-	-	Equipped with sandpoint.
8-1	SW NE	Newberry State Hospital	-	1905	180	3	Qs	P,S	-	-	-	Abandoned. Hospital farm.
8-2	SW NE	do.	Dunbar Drilling Co.	1949	178	6	Qs	P,S	63	R	10- ?-49	Screened 168-178 ft. Hosp. farm.
8-3	SW NE	do.	Hunter	1946	67	4	Qs	P,S	52	R	5- 9-49	Screened 63-67 ft.
8-4	SE SW	Nelson Neff	-	-	186	2	Qsg	P	-	-	-	Abandoned.
10-1	SE SW	Edward Schultz	Edward Schultz	-	22	1¼	Qs	D	6	R	1957	Equipped with sandpoint.
10-2	SE SW	do.	do.	-	28	1½	Qs	D	12	R	1957	Do.
12-1	SE SE	Emerson Luchow	Elwin Anderson	1943	100	6	Sc	D	16	R	1957	Bedrock at 25 ft.
13-1	NE NE	R. Launsbury	do.	1948	105	6	Sc	D	15	R	1948	Cased to 23 ft.
17-1	NE NW	Toivo Aho	-	-	67	-	Qs	D	-	-	-	Sand from surface to 67 ft.
17-2	NE NW	do.	Ross Payton	1957	88	4	Qs	P	62	R	1957	Screened 83-88 ft.
45N 8W												
7-1	NE SW	-	-	-	-	-	Sc	-	-	-	-	Spring.
10-1	SW SE	Ray VanZoren	-	-	10	24	Qgd	-	5.77	M	10- 7-57	Bedrock at 10 ft. Not used.
11-1	SE SE	White Cloud Motel	Elwin Anderson	1948	67	6	Sc	P	-	-	-	Bedrock at 12 ft.
12-1	NW SW	A. F. McLean	-	1928	53	1¼	Qs	P	-	-	-	Flows. Open-end casing. Red clay to 53 ft.
13-1	NE NE	MDC	CCC	1941	13	2	-	Tf	-	-	-	
14-1	NE NE	Henry Ehr	Elwin Anderson	1948	75	6	Sc	P	17	R	1957	Bedrock at 12 ft.
15-1	NW NW	-	-	-	5	24	Qgd	-	+.2	M	10- 7-57	Improved spring.
17-1	NE NW	MDC	CCC	1934	9	2	Qs	Tf	.7	M	1934	
18-1	NW NW	Mrs. Frank Clayton	-	-	37	6	Sc	P	16.34	M	8-28-57	Bedrock at 24 ft. Not used.
18-2	NW NW	do.	Elwin Anderson	1948	94	6	Sc	P	15	R	1948	Cased to 24 ft.
18-3	NE NW	Bernhard Titze	do.	1948	97	6	Sc	P	-	-	-	Cased to 26 ft.
26-1	NE NE	MDC	CCC	1934	12	2	Qg	Tf	0	R	1934	Drilled through clay to gravel.
26-2	NW SW	MDC	CCC	1934	11	2	Qgd	Tf	4.5	M	10- 6-34	
27-1	SE NE	MDC	CCC	1934	11	2	-	Tf	-	-	-	Drilled in red clay.
30-1	SW SW	MDC	CCC	1934	12	2	-	Tf	-	-	-	Do.
31-1	SE SW	MDC		-	-	-	Qs	P	-	-	-	Improved spring. Supplies fire tower.
32-1	NW NE	MDC	CCC	1934	10	2	-	Tf	-	-	-	Drilled in red clay.
32-2	NE NW	MDC	CCC	1934	14	2	Qs	Tf	2.2	M	10-18-34	
32-3	SE SE	MDC	CCC	1934	14	2	Qgd	Tf	8.8	M	9-11-34	
33-1	SE NW	MDC	CCC	1934	14	2	Qs	Tf	2.6	M	10- 6-34	
34-1	NW SE	MDC	CCC	1934	14	2	Qs	Tf	8.9	M	11- 6-34	
35-1	NE NW	MDC	CCC	1934	15	2	Qs	Tf	1.8	M	11- 6-34	
36-1	SW SW	MDC	CCC	1934	13	2	Qs	Tf	6.0	M	8- 1-34	
36-2	NW NE	MDC	CCC	1934	13	2	-	Tf	-	-	-	Drilled in sand and red clay.

Table 4.--Logs of wells and test holes in Luce County

Thickness in feet. Depth in feet below land surface.

	Thickness	Depth
48N 10W 8-3		
Glacial drift:		
Sand, clay, and gravel	37	37
Quicksand	2	39
Clay	20	59
Quicksand	2	61
Sand, fine, white	2	63
Sand, coarse	2	65
Gravel	11	76
48N 10W 8-4		
Glacial drift:		
Sand, clay, and gravel, layered	32	32
Gravel	10	42
Clay	22	64
Quicksand	1	65
Sand, fine, white	2	67
Sand, coarse, white	6	73
48N 10W 8-8		
Glacial drift:		
Sand, clay, and gravel, layered	32	32
Gravel, water-bearing	10	42
Clay	22	64
Quicksand	4	68
Sand, white	16	84
Munising sandstone:		
Sandstone	2	86
48N 10W 17-2		
Glacial drift:		
Sand, clay, and gravel, layered	32	32
Gravel	10	42
Clay	26	68
Munising sandstone:		
Sand, fine to coarse, white	15	83
Sandstone	3	86
48N 9W 34-1		
Glacial drift:		
Sand and hardpan	21	21
Gravel	2	23
Hardpan	2	25
Sand	7	32
48N 8W 12-1		
No record (glacial drift)	15	15
Munising sandstone:		
Sandstone	10	25
47N 10W 32-1		
Glacial drift:		
Clay and gravel	30	30
Quicksand	130	160
Gravel, water-bearing, at	-	160
46N 11W 31-3		
Glacial drift:		
Quicksand	0	11
Gravel	4	15
Hardpan at	-	15
46N 11W 33-2		
Glacial drift:		
Muck and sand	4	4
Clay, red	35	39
Gravel	1	40
46N 11W 33-10		
Glacial drift:		
Clay	44	44
Sand and gravel	6	50
Clay at	-	50
46N 10W 23-2		
Glacial drift:		
Sand	19	19
Clay	119	138
Quicksand	1	139
Clay	11	150
Sand and fine gravel	5	155
46N 10W 23-3		
Glacial drift:		
Clay	80	80
Quicksand	75	155
Sand	5	160
46N 10W 24-4		
Glacial drift:		
Muck	5	5
Clay	80	85
Quicksand and gravel	55	140
46N 10W 25-2		
Glacial drift:		
Clay, red, hard	40	40
Sand and gravel	14	54
46N 10W 25-3		
Glacial drift:		
Sand	90	90
Gravel	20	110
46N 10W 25-7		
Glacial drift:		
Sand, fine to coarse	132	132
46N 10W 25-8		
Glacial drift:		
Topsoil	1	1
Sand, fine	19	20
Sand, fine to coarse	10	30
Clay	4	34
Sand, medium to coarse	5	39
Sand, clean, coarse, and streak of gravel	7	46
Sand, fine to medium	13	59
Sand, fine	6	65
Sand, fine to coarse	4	69
Sand, very coarse	15	84
Gravel, fine	26	110
Sand, fine	26	136
Sand, coarse, and fine gravel	9	145
46N 10W 25-11		
Glacial drift:		
Fill and topsoil	5	5
Clay, red, plastic	20	25
Sand, fine	15	40
46N 10W 25-11--Continued		
Sand, medium	40	80
Sand, coarse	20	100
46N 10W 25-12		
Glacial drift:		
Fill and topsoil	9	9
Sand, muddy, gray	7	16
Clay, gray	10	26
Sand, muddy, fine	3	29
Sand	20	49
Sand, medium, clean	5	54
Sand, fine, clean	10	64
Sand, medium, clean	30	94
Sand, fine, clean	18	112
Sand, medium, clean	3	115
Sand, coarse, clean	10	125
46N 10W 25-13		
Glacial drift:		
Fill and topsoil	7	7
Clay, gravelly	13	20
Sand, fine, muddy	4	24
Sand, fine	16	40
Sand, fine, clean	11	51
Sand, medium, clean	3	54
Sand, coarse, clean	2	56
Sand, medium, clean	4	60
Sand, fine, clean	8	68
Sand, medium, clean	19	87
Sand, coarse, clean	5	92
Sand, medium, clean	41	133
Gravel, coarse, and clay	2	135
Gravel, fine, with streaks of clay	6	141
Richmond group:		
Limestone and shale	5	146
46N 10W 25-14		
Glacial drift:		
Fill and topsoil	5	5
Clay	8	13
Sand, fine	32	45
Sand, medium to coarse	80	125
Sand, muddy, and gravel	7	132
Clay, gray	11	143
Richmond group:	2	145
46N 10W 25-15		
Glacial drift:		
Fill and topsoil	4	4
Clay	14	18
Sand, fine	38	56
Sand, medium to coarse	62	118
Sand, fine, clean	16	134
Sand, muddy, and gravel	7	141
46N 10W 25-16		
Glacial drift:		
Muck	10	10
Sand, muddy, fine	4	14
Clay	6	20
Sand, muddy, fine	4	24
Sand, fine to medium	52	76
Sand, medium, coarse	33	109
Sand, fine	6	115
Sand, very coarse	1	116
Clay	22	138
Richmond group:	2	140

Table 4.--Logs of wells and test holes in Luce County.--Continued

	Thick-ness	Depth
46N 10W 25-17		
Glacial drift:		
Fill and muck	6	6
Clay	23	29
Sand, fine	89	118
Clay	6	124
Sand, fine, muddy	10	134
Clay at	-	134
46N 10W 25-18		
Glacial drift:		
Fill and muck	14	14
Clay and fine sand	15	29
Sand, fine	49	78
Sand, medium to coarse	7	85
Sand, fine	10	95
Sand, medium	3	98
Sand, very fine	14	112
Sand, fine	11	123
Clay	6	129
46N 10W 26-1		
Glacial drift:		
Sand	3	3
Clay	6	9
Sand	21	30
46N 10W 27-3		
Glacial drift:		
Sand	50	50
Clay	3	53
Sand	67	120
Gravel, hardpan	10	130
Richmond group at	-	130
46N 10W 36-4		
Glacial drift:		
Sand	158	158
46N 10W 36-5		
Glacial drift:		
Gravel, coarse	45	45
Gravel and clay	105	150
Sand, fine gravel, and clay	50	200
Sand, fine	8	208
Sand, water-bearing	6	214
46N 8W 2-1		
Glacial drift:		
Clay, soft	169	169
Gravel	3	172
Trenton and Black River formations at	-	172
45N 12W 21-1		
Glacial drift:		
Clay	12	12
Sand	64	76
Cataract formation at	-	76
45N 12W 22-1		
Glacial drift:		
No record	7	7
Clay, sandy	18	25
Sand	48	73
Sand, coarse	4	77
Sand	2	79
45N 12W 26-2		
Glacial drift:		
Topsoil	5	5
Sand, dirty	15	20
Sand	38	58
Gravel and sand	6	64

	Thick-ness	Depth
45N 12W 34-1		
Glacial drift:		
Sand	4	4
Cataract formation:		
Dolomite	54	58
45N 11W 4-2		
Glacial drift:		
Sand with a few boulders	200	200
45N 11W 4-3		
Glacial drift:		
Sand	60	60
Sand and light clay mixture	40	100
Sand and clay mixture	100	200
Clay	40	240
Sand, fine	23	263
Sand, water-bearing	5	268
45N 11W 8-2		
Glacial drift:		
Sand	30	30
Sand and clay	60	90
Richmond group:		
Limestone	25	115
45N 11W 17-3		
Glacial drift:		
Clay	40	40
Gravel, sandy	18	58
45N 11W 30-1		
Glacial drift:		
Clay	69	69
Gravel	1	70
45N 11W 33-1		
Glacial drift:		
Sand with some boulders	60	60
Quicksand, water-bearing	10	70
Cataract formation:		
Dolomite	44	114
Shale	10	124
Dolomite	3	127
Shale	33	160
Dolomite, water-bearing	25	185
45N 10W 1-1		
Glacial drift:		
No record	120	120
Quicksand	129	249
Gravel at	-	249
Gravel, sand, and clay	71	320
Richmond group:		
Limestone, sandy, dark	80	400
Shale, blue	51	451
45N 10W 1-5		
Glacial drift:		
Sand with gravel	117	117
Sand	33	150
Sand, fine	35	185
Sand	35	220
Sand and clay	5	225
Sand, fine	45	270
Hardpan	25	295
Richmond group:		
Limestone	8	303
45N 10W 1-6		
Glacial drift:		
Sand	80	80
Sand, coarse	20	100
Sand and clay	120	220

	Thick-ness	Depth
45N 10W 1-6--Continued		
Sand	25	245
Sand and clay	72	317
Richmond group:		
Limestone	2	319
45N 10W 1-7		
Glacial drift:		
Sand with gravel	88	88
Sand	40	128
Hardpan	22	150
Sand, coarse	15	165
Clay and sand	20	185
Clay and stones	10	195
Hardpan	25	220
Gravel	28	248
Clay and stones	7	255
45N 10W 1-8		
Glacial drift:		
Sand	10	10
Sand and stones	45	55
Sand	55	110
Clay, sandy	30	140
Sand	90	230
Gravel, coarse, and sand	15	245
Clay, sandy	10	255
45N 10W 1-9		
Glacial drift:		
Sand	95	95
Gravel, clean, coarse	53	148
Hardpan	7	155
45N 10W 1-12		
Glacial drift:		
Sand	15	15
Sand, fine	15	30
Sand, coarse	30	60
Sand, fine	110	170
Gravel, coarse, sand and clay	40	210
Gravel, coarse, and sand	19	229
Gravel, coarse, sand and clay	2	231
Sand and clay	9	240
45N 10W 2-2		
Glacial drift:		
Sand	84	84
45N 10W 4-1		
Glacial drift:		
Hardpan and clay	20	20
Quicksand	86	106
Gravel at	-	106
45N 10W 8-1		
Glacial drift:		
Clay, red	80	80
Sand, brown	50	130
Gravel, coarse	2	132
Richmond group:	7	139
45N 10W 9-3		
Glacial drift:		
Clay, red	40	40
Quicksand	60	100
Gravel	3	103
45N 10W 9-4		
Glacial drift:		
No record	126	126
Silt, sand, clay, and gravel, layered	22	148

Table 4.--Logs of wells and test holes in Luce County.--Continued

	Thickness	Depth
45N 10W 9-4--Continued		
Richmond group:		
Dolomite, hard, gray-brown	4	152
Shale, blue-black	10	162
Shale, soft, blue, and blue-black, layered	48	210
Limestone	13	223
Shale, blue	30	253
Limestone, dark	2	255
Shale, black	8	263
Limestone	9	272
Shale	11	283
45N 10W 9-6		
Glacial drift:		
Gravel, clay, and sand	25	25
Sand, fine, and clay	55	80
Clay	100	180
Sand, fine	30	210
Richmond group:		
Limestone	5	215
45N 10W 10-1		
Glacial drift:		
Clay, red	90	90
Sand	13	103
45N 10W 11-1		
Glacial drift:		
Clay, red	52	52
Quicksand	1	53
45N 10W 11-2		
Glacial drift:		
Topsoil and sand	15	15
Clay, solid	135	150
Sand, fine	2	152
Sand, coarse	3	155
Sand, coarse, and gravel	1	156
45N 10W 13-2		
Glacial drift:		
Sand, brown, gravelly	113	113
45N 10W 13-4		
Glacial drift:		
Sand, fine, with streaks of gravel	143	143
Sand, coarse	40	183
Sand, fine	87	270
45N 10W 20-1		
Glacial drift:		
Sand and boulders	15	15
Clay	253	268
Sand	6	274
45N 9W 7-1		
Glacial drift:		
Sand, fine	123	123
Clay	3	126
Sand, very fine	39	165
45N 9W 8-1		
Glacial drift:		
Sand, very fine	110	110
Sand, water-bearing at	-	110
Sand, very fine	50	160
Hardpan, blue	7	167
Sand	13	180
45N 9W 8-2		
Glacial drift:		
Sand, very fine, dry	58	58
Sand, fine, dry	100	158
Sand, fine, clean	7	165
Clay, stones, and sand	13	178

Table 5.--Chemical analyses of ground water in Luce County

Aquifer sampled: Qgd, Quaternary glacial drift undifferentiated; Qs, Quaternary sand; Qg, Quaternary gravel; Qsg, Quaternary sand and gravel; Sc, Cataract formation; Or, Dolomite of the Richmond group; OЄhm, Hermansville formation and Munising sandstone.

Analyst: M, Michigan Department of Health; U, U. S. Geological Survey.

Potassium: + indicates potassium (K) included in figure listed under sodium.

Well number	Aquifer	Analyst	Date collected	Chemical constituents (parts per million)													Hardness as $CaCO_3$ (parts per million)	Specific conductance (micromhos at 25°C)	pH	Temperature (°F)
				Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids				
49N 10W																				
15-1	Qs	M	10-31-57	-	-	-	-	-	-	-	-	-	-	-	-	-	98	-	-	-
48N 10W																				
8-8	OЄhm	U	5-27-58	10	0.53	0.02	42	21	0.7	1.1	232	8.0	0.5	0	0.1	192	192	349	7.8	44.8
48N 9W																				
6-3	Qs	M	10-31-57	-	-	-	7.2	1.4	-	-	34	-	-	-	-	-	24	80	-	44.5
47N 10W																				
6-7	Qs	M	10-28-57	-	-	-	22	7.3	-	-	97	-	-	-	-	-	86	200	-	-
47N 8W																				
24-1	Qg	U	11- 2-57	11	.01	.04	17	5.4	1.9	.8	67	12	1.0	0.1	.9	83	64	135	7.0	44.5
46N 12W																				
33-2	Qs	M	10-10-57	-	-	-	34	15	-	-	159	-	-	-	-	-	145	280	-	-
46N 11W																				
31-1	Qs	M	10-10-57	-	-	-	56	19	-	-	220	-	15	-	-	-	220	420	-	-
31-2	Qgd	M	10-10-57	-	-	-	40	17	-	-	181	-	-	-	-	-	170	310	-	-
31-3	Qs	U	10-10-57	5.7	.15	.02	9.7	2.8	.8	.9	33	11	.5	.1	1.6	51	36	82	5.9	-
33-2	Qg	U	11- 1-57	11	.18	.0	41	13	1.5	.8	180	9	1.0	.1	1.0	162	156	301	7.7	47
46N 10W																				
25-4	Qg	M	2-13-30	9.2	-	-	47	17	6.9	+	199	26	7	-	-	208	182	-	-	-
25-8	Qsg	M	6- ?-43	-	.3	-	-	-	-	-	-	-	10	-	-	-	155	-	-	-
25-9	Qsg	M	4-14-44	-	-	-	57	18	9	+	207	35	13	a/	-	278	210	-	-	-
27-2	Qsg	U	10-29-57	16	.38	.02	45	19	2.9	2.4	230	9.2	1.0	.3	.4	203	190	361	7.4	45.4
36-4	Qs	U	6-12-57	11	.07	.06	86	24	8	.9	304	36	17	.1	18	358	313	589	7.6	45
46N 9W																				
19-2	Qsg	M	6-26-57	-	-	-	32	19	-	-	193	-	-	-	-	-	160	350	-	-
22-2	Qgd	M	10-17-57	-	-	-	30	13	-	-	173	-	-	-	-	-	130	300	-	-
22-2	Qgd	U	10-29-57	13	.08	.02	34	13	4.1	2.1	171	9.2	.5	.4	.2	152	139	276	7.6	46.8
45N 12W																				
21-2	OЄhm	U	5-27-58	8.2	.62	.0	34	16	25	3.6	162	38	26	.8	.1	230	151	415	7.6	49.3
22-1	Qs	U	6-11-57	9.1	.25	.03	51	18	1.7	.7	190	22	6	.1	17	224	201	376	7.7	54
25-1	Qgd	M	10-11-57	-	-	-	82	-	-	-	274	55	-	-	-	-	315	600	-	47.3
26-1	Qgd	M	6-19-57	-	-	-	24	-	-	-	-	5.5	-	-	-	-	98	190	8.0	47
34-1	Sc	M	6-19-57	-	-	-	550	-	-	-	-	1250	-	-	-	-	1750	2250	7.3	46.5
45N 11W																				
17-5	Qgd	U	9-18-57	1.8	.22	.02	29	7.4	5.4	.7	96	16	12	1.1	.3	130	103	229	7.1	44.5
19-3	Qgd	M	11- 1-57	-	-	-	100	13	-	-	135	200	-	-	-	-	305	600	-	-
30-2	Or ?	U	11- 7-57	13	.49	0	90	15	2.8	1.2	128	174	4.5	.1	.2	384	286	552	7.4	-
45N 10W																				
1-1	Or	M	12-18-34	6.4	-	-	67	23	15	+	203	81	29	-	2	322	260	-	-	-
1-2	Qsg	M	12-18-34	4.8	-	-	100	28	78	+	282	74	150	-	17	-	362	-	-	-
1-3	Or	M	12-21-34	4.0	-	-	59	26	6.9	+	185	45	50	-	-	306	250	-	-	-
1-3	Or	M	10- ?-40	9.6	-	-	52	17	5.3	+	176	52	10	-	-	240	200	-	-	-
1-4	Qgd	M	9- 5-34	3.2	-	-	68	21	15	+	200	48	54	-	-	326	258	-	-	-
1-12	Qsg	M	1-15-36	8.8	-	-	97	32	66	+	214	43	208	-	1.8	616	370	-	-	-
9-4	Or	M	8- 5-57	-	-	-	164	83	874	-	131	680	1300	-	-	-	750	5800	-	45
11-1	Qs	M	9-19-57	-	-	-	32	-	-	-	176	6	-	-	-	-	-	300	-	-
27-1	Qs	M	10-10-57	-	-	-	50	17	-	-	210	-	-	-	-	-	195	360	-	47
45N 9W																				
7-3	Qs	M	10- 9-57	-	-	-	37	17	-	-	151	25	0	-	-	-	160	300	-	-
45N 8W																				
7-1	Sc	U	10- 9-57	12	.05	.03	521	28	13	1.9	145	1240	23	.4	.2	2070	1420	2110	7.4	-
12-1	Qs	M	10-10-57	-	-	-	44	22	5.5	.9	218	20	1	-	-	-	200	390	-	45
31-1	Qs	M	10- 9-57	-	-	-	58	13	-	-	216	-	-	-	-	-	200	360	-	-

a/ Trace