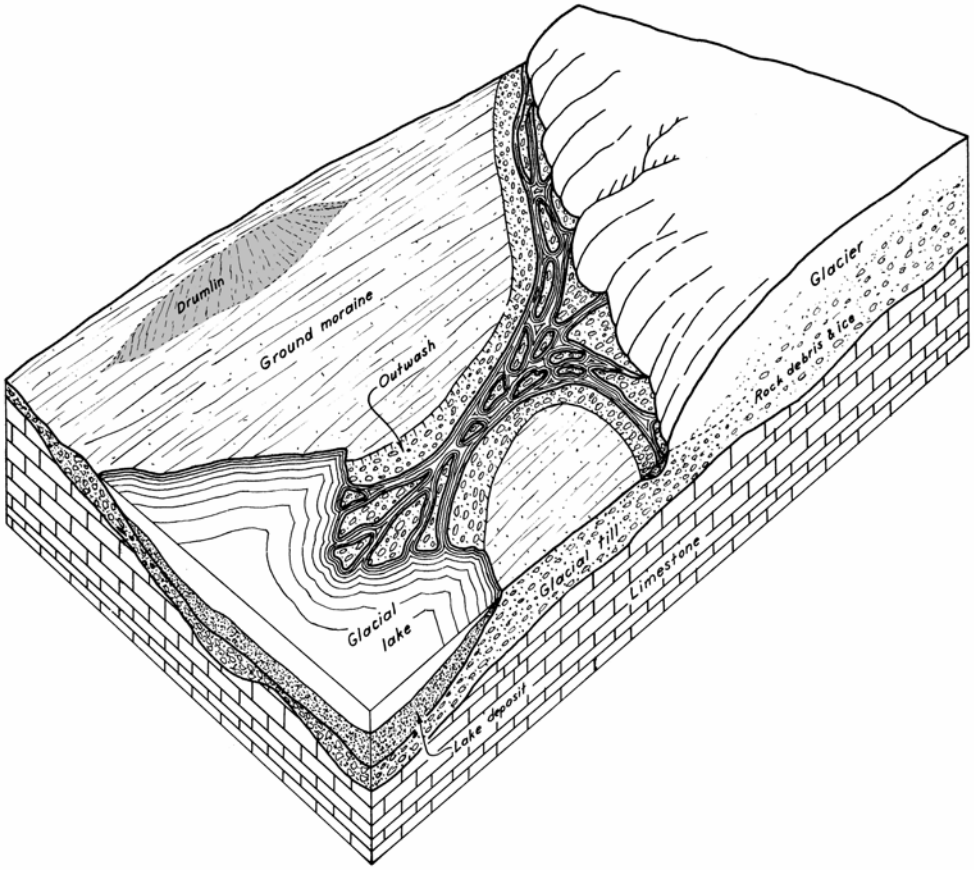
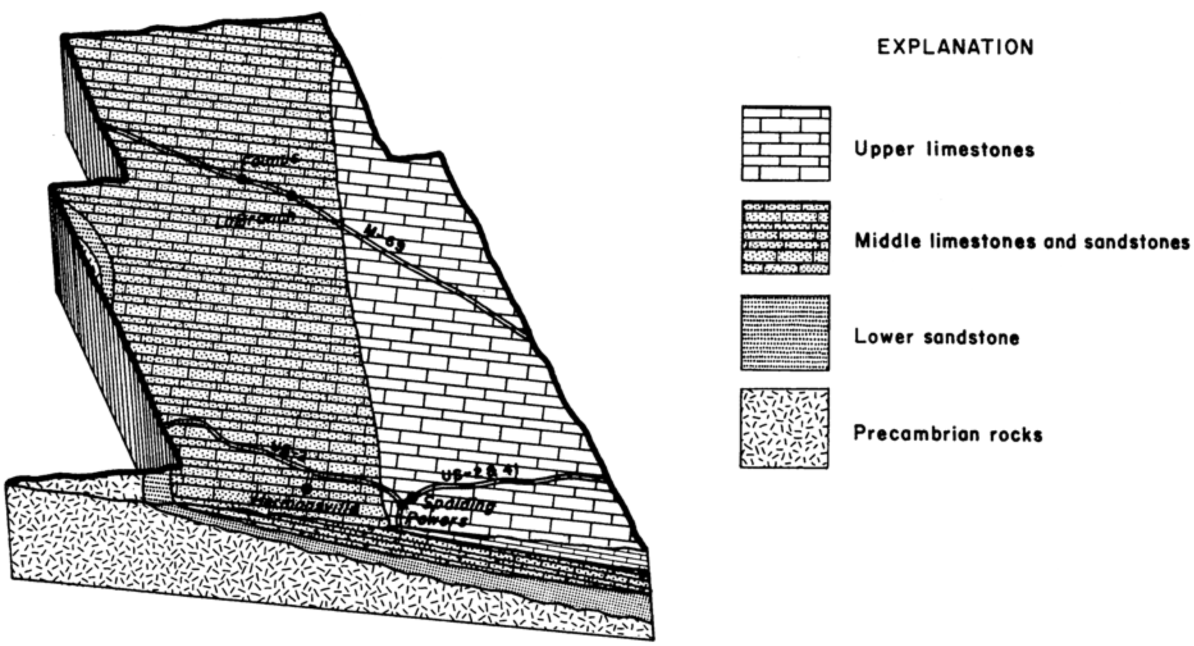


Water Investigation 2

Ground - Water in Menominee County

BY Kenneth E. Vanlier



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Water Investigation 2

Ground - Water in Menominee County

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FIGURES

Tables

State of Michigan - Department of Conservation
Geological Survey Section

Water Investigation 2

Ground - Water in Menominee County

BY Kenneth E. Vanlier

Prepared cooperatively by the Geological Survey, u. S. Department of the Interior, Lansing 1963

ACKNOWLEDGMENTS

This report would not have been possible without the cooperation of the well drillers working in Menominee County. They provided well records, well logs, water level data, quality of water information, data on well yields, and information on the depth to bedrock in various parts of the county. Special thanks are given to the Thomas Drilling Company of Peshtego, Wisconsin; Frank Kozikowski of Menominee, Michigan; C. 0. Rice of Escanaba, Michigan; Loren Anderson of Wallace, Michigan; Henry Le Beau of Nadeau, Michigan; and Dick Rice of Corney, Michigan, The interest and cooperation of the many well owners in the county is also gratefully acknowledged. Thanks are also due the personnel of the various state, county, and local agencies who provided much information and valuable help.

The Michigan Geological Survey and the U. S. Geological Survey cooperate in a continuing study of the state's water resources. This report is a part of the continuing program.

Figure 1. - Index map showing location of Menominee County, Michigan.

Ground Water in Menominee County

By
Kenneth E. Vanlier

Introduction

Most of us have read about impending water shortages, water pollution, and other water problems. Although it is true that some areas of the nation - face water shortages, it is also true that many areas have ample, unused water resources. It is just as useful to provide information on the "water rich" areas of the country as it is to show that some are fast becoming "water poor".

Although Menominee County has some water problems (such as the "sulfur" odor of water from some wells), it has large undeveloped water supplies which could support a much larger economic and industrial base. The need for increased economic growth and development is demonstrated by the fact that the county has decreased slightly in population since 1940. Many people born and raised in the county have had to move to other areas to find employment.

Purpose

The purpose of this report is to provide information on the ground - water resources for those people developing water supplies for homes, farms, cottages and industries in the county. At the present time all the water users outside the City of Menominee obtain their water supplies from wells. Use of ground water in the rural areas of the county probably will continue, because adequate water supplies can be obtained from wells at reasonable cost. Increased use of water for modern home appliances, farm uses, and the increasing use of areas along lakes and rivers for cottages and resorts will result in expanded development of the ground - water resources, New industries in the county will also require additional ground - water development.

Economy and Water Development

Menominee County is in the south - central part of the Upper Peninsula (fig, l), Menominee, (fig.

2), the largest city and the county seat, has a municipal water system supplied from Green Bay, Although the City of Menominee has some metal - fabricating industries, the economy of the county is related principally to the development and utilization of local natural resources including farming. The principal type of farming is dairy farming; however, some beef cattle are raised, and many different types of agricultural products are grown. Other industries utilizing natural resources include: production and processing of lumber and other forest products, mink ranching, commercial fishing, serving the tourist trade, and providing recreational facilities. These industries, especially farming, are dependent upon wells for water supplies. It appears that economic growth in the rural areas will depend to a large extent upon continued development of local natural resources, including the water resources.

The Ground - Water Environment

Throughout history a certain amount - of mysticism has been associated with underground water. This is quite natural as it cannot be seen, and we learn about it through observation of wells and springs. The occurrence and movement of underground water is controlled by natural physical laws, such as the law of gravity, and the more we learn the less mysterious it becomes.

Some materials in the earth's crust are like sponges in that they are full of small holes and channels through which ground water can move. If we can determine the depth, thickness and areal extent of these waterbearing materials, we can determine how much ground water is available. In many areas we can determine the main localities where precipitation enters the ground, and the rate at which water moves through the ground.

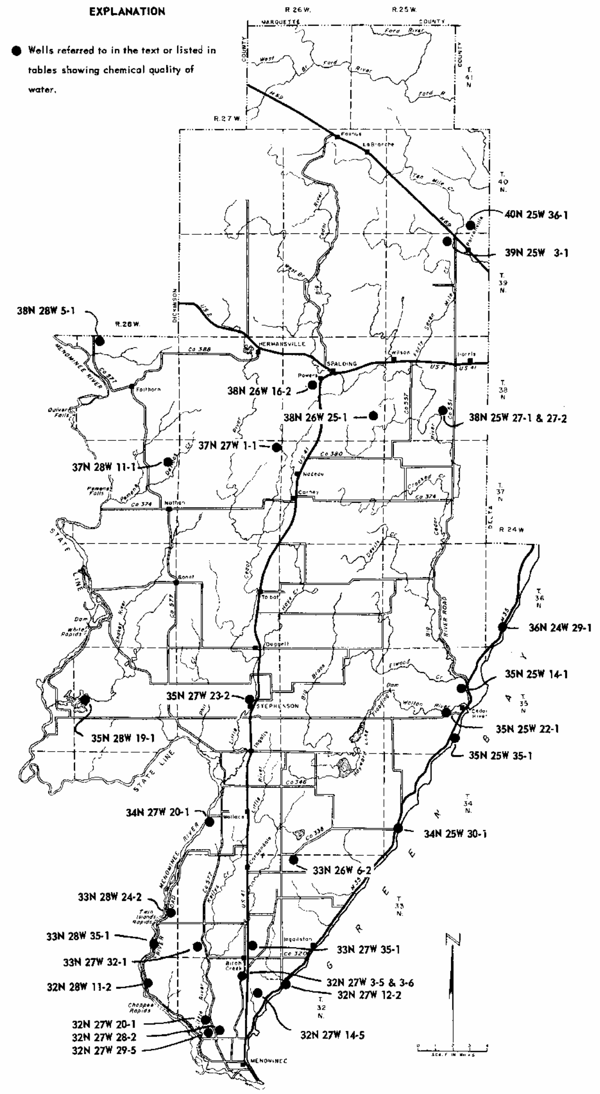


Figure 2. - Map of Menominee County showing well locations.

Earth materials that yield water to wells or springs are called aquifers. Although aquifers include many types of rock, they all contain openings through which water can move to wells or springs. There are five major aquifers or water - bearing rock units in the county (table 1). At least one of these units is present in all parts of the county. In many areas all five may be present. These water - bearing units are sources of water for domestic and farm needs and locally could yield as much as 300 gallons per minute (gpm) to large - capacity wells. The large - capacity wells generally are deep and often tap more than one water - bearing unit,

Water Quality

All natural waters, including rain and snow, contain a small amount of dissolved mineral matter. When rain or melting snow run over the ground or seep into the earth, they come into contact with and dissolve other minerals. Thus, all ground water and water in streams and lakes contain mineral matter dissolved from the surrounding soils and rock. The types and amount of mineral matter in the water depends on the types of rock and soil in the locality. The chief constituents in most of the waters of Menominee County are salts of calcium and magnesium dissolved from limestone and dolomite the principal rock types in the areas. The waters also contain iron, manganese, and sodium, and some waters contain hydrogen sulfide.

Calcium and magnesium cause water to be hard. Iron and manganese in excess of 0.3 ppm cause staining of plumbing fixtures and laundry. Chlorides in excess of 250 ppm give water a salty taste and corrode plumbing systems, and sulfates in excess of 250 ppm may produce a laxative effect. Hydrogen sulfide gives water a "sulfur" or rotten egg odor.

Nearly all of the wells that produce water containing excessive amounts of chloride, sulfate, or hydrogen sulfide are in the southern part of the county. The area of high chloride and sulfate water extends southward into Wisconsin.

Some of the ground waters in Menominee County contain objectionable concentrations of nitrate. The presence of excessive nitrates in water commonly indicates pollution from agricultural and human wastes. For instance, wells in barnyards may yield water containing nitrates.

Ground Water Reservoirs

Glacial Aquifers

The uppermost earth materials over nearly all the county were deposited by glaciers which pushed across the county many thousands of years ago. Most of the surface features - - the hills, valleys, lakes, and streams

- - were formed as a result of glacial activity. The most spectacular of the glacial features are the long northeast - southwest trending ridge - like hills called "drumlins". Most of the county is a large drumlin "field". The long axis or direction of the drumlins is parallel to the direction that the glacier moved as it pushed across the county.

Glacial materials can be separated into three broad groups: till, outwash, and lake - deposited sediments. Till is a mixture of clay, silt, and sand and gravel, including boulders, which was deposited directly by the glacier. Outwash.is material that was washed out of the glacier by streams flowing from the melting ice and snow. Figure 3 illustrates the way these types of glacial material were deposited.

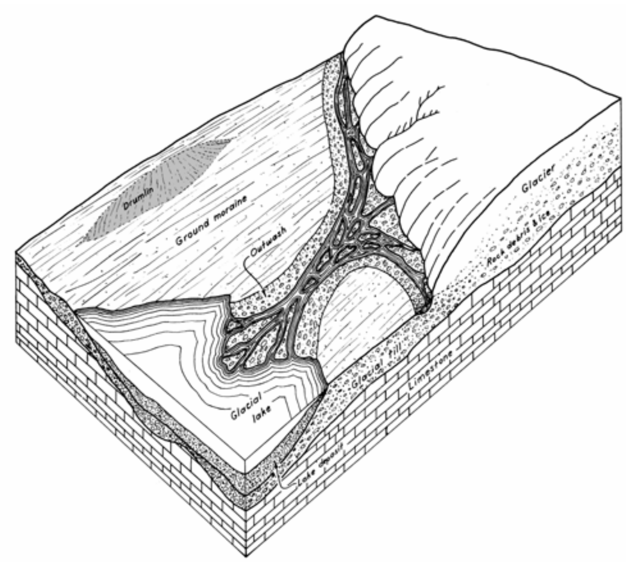
Many wells in the county obtain water from glacial aquifers. These wells are for the most part either drilled, cased, open - end wells which obtain water from beds of coarse gravel, or shallow - driven wells equipped with screened sandpoints. Very few of the drilled wells are equipped with well screens. Most of the water from the glacial drift ranges from hard to very hard and some contains objectionable amounts of iron.

A well topping glacial drift near Faithorn (38N 28W 5 - 1), see table below, produced water containing an excessive amount of nitrate in the spring of 1963 - Nitrate commonly indicates pollution or contamination. The sample of water taken from the same well in August, 1963 had a much lower nitrate content, indicating that the contamination problem was temporary or seasonal. Additional data is needed to determine the actual source of pollution.

Chemical analysis of water samples from the Glacial Drift - see page 16

Geologic Age	Geologic Names	Water - Bearing rock units	Thickness (feet)	Lithology	Water - bearing characteristics
Pleistocene	Glacial drift:	Glacial Drift	0 to 200+	Most of the glacial deposits of the county are a mixture of clay, silt, sand and gravel. Locally, beds of water - bearing sand and gravel are included in the glacial deposits of sand and gravel are along the Menominee River in the west - central part of the county	The glacial drift deposits are a source of water to wells throughout the county. Most wells obtaining water from glacial deposits tap beds of coarse gravel. Some homes along Green Bay have shallow - driven wells which tap beds of lake - deposited sand. The glacial drift is an important source of water in the areas where the bedrocks yield "sulfur" water. Many of the wells obtaining water from the glacial drift in the "sulfur - water areas" are dug wells.
Middle Ordovician	Trenton Limestone Black River Limestone	Upper Limestones	0 to 300	Consists principally of beds of limestone and dolomite. Includes some beds of shale and shaley limestone and dolomite . In the southern part of the county the beds of shale and shaley limestone are thick and extensive.	These rocks are the source of water to most of the wells in the county. In the southern part of the county where the rocks are mantled by only a few feet of glacial drift, wells tapping the upper limestones generally are less than 40 feet deep. In the northern and central parts of the county wells tapping the upper limestones range from about 30 to about 300 feet in depth. In the southern part of the county these rocks yield water with a "sulfur" odor, especially at depths greater than 40 to 50 feet. Thus, wells in the southern part of the county generally are completed at as shallow a depth as is possible.
Early Ordovician Late Cambrian	St. Peter Sandstone Prarie du Chien Group Trempeleau Formation	Middle Limestones and Sandstones	0 to 300	Consists of beds of limestone and dolomite, sandstone, sandy and shaley dolomite, and dolomitic sandstone. The beds of sandstone are thicker and more extensive in the northern part of the county.	Both beds of limestone and sandstone are sources of water to wells. Wells tapping these rocks range from about 30 to about 200 feet in depth. Most wells, however, are less than 100 feet deep. Yields water of good quality in parts of the area where upper limestones yield "sulfur" water. Locally, these sandstones and limestones may yield sulfur water.
Cambrian	Franconia Sandstone Dresback Sandstone	Lower Sandstones	50 to 200	Consists of beds of pink, gray, and white sandstone. Some of the beds of sandstones contain large quantities of glauconite, a green mineral.	A source of water for domestic and farm needs in the areas where they are mantled directly by glacial drift. Where these rocks are covered by the middle limestones and sandstones and upper limestones they will yield 200 to 300 gpm to properly constructed deep wells.
Middle Precambrian Early Precambrian *Stratigraphic terms not reviewed for accuracy*	Michigamme Slate Vulcan Iron Formation Randville Dolomite Quinnesec Formation	Precambrian Rocks	Extends to great depth	Where the Precambrian rocks crop out in the western part of the county, they consist principally of dark gray - green schist, commonly called "green" stone. Wells at Powers penetrated several hundred feet of Randville Dolomite. Wells that were drilled to the Precambrian at Shakey Lakes Park and Stephenson penetrated pink granite.	These rocks are the source of water to a few wells in the west central part of the county where they crop out at the surface or are mantled directly by deposits of glacial drift. The permeability of these rocks results principally from jointing (fractures).

Table 1. - - Water - Bearing Rocks in Menominee County



EXPLANATION

Glacial till is a mixture of rock debris, clay, silt, sand, gravel, and boulders that is deposited when the ice melts. The ground moraines are underlain by till as are the long ridge - like drumlins. The rock debris carried by the glacier is torn and plucked from the bedrock surface (limestone in this sketch). The till therefore includes a high percentage of fragments from the underlying bedrock. In a limestone area, the till is composed largely of limestone blocks and fragments. In a sandstone area the till would include blocks of sandstone and would be sandy.

Outwash is composed largely of permeable sand and gravel deposited by the glacial meltwater stream. The finer sands, silts and clays are carried into the glacial lake by the glacial meltwaters. The sands, silts, and clay sink to the bottom of the glacial lake to form the lake deposit. When the lake recedes the take deposits remain as level lake plains. Dunes and beaches sometimes form at the edge of the glacial lake.

Figure 3. - Diagrammatic sketch showing mode of deposition of glacial sediments.

The county has four distinct types of glacial deposits which occur principally in four main areas (fig. 4). The availability of water from the glacial deposits varies considerably in these areas. Area of Drumlins and Ground Moraine

The area of drumlins and ground moraine includes (fig. 4) more than three - fourths of the county. The glacial deposits in this area are composed principally of a mixture of clay, silt, sand, and gravel. These deposits generally are less than 4 - 0 feet thick, although they are more than 100 feet thick under some of the larger drumlins. This area also includes several dozen places of bedrock outcrop where the glacial deposits are absent. The glacial deposits are only a few feet thick in the vicinity of the areas of bedrock outcrop.

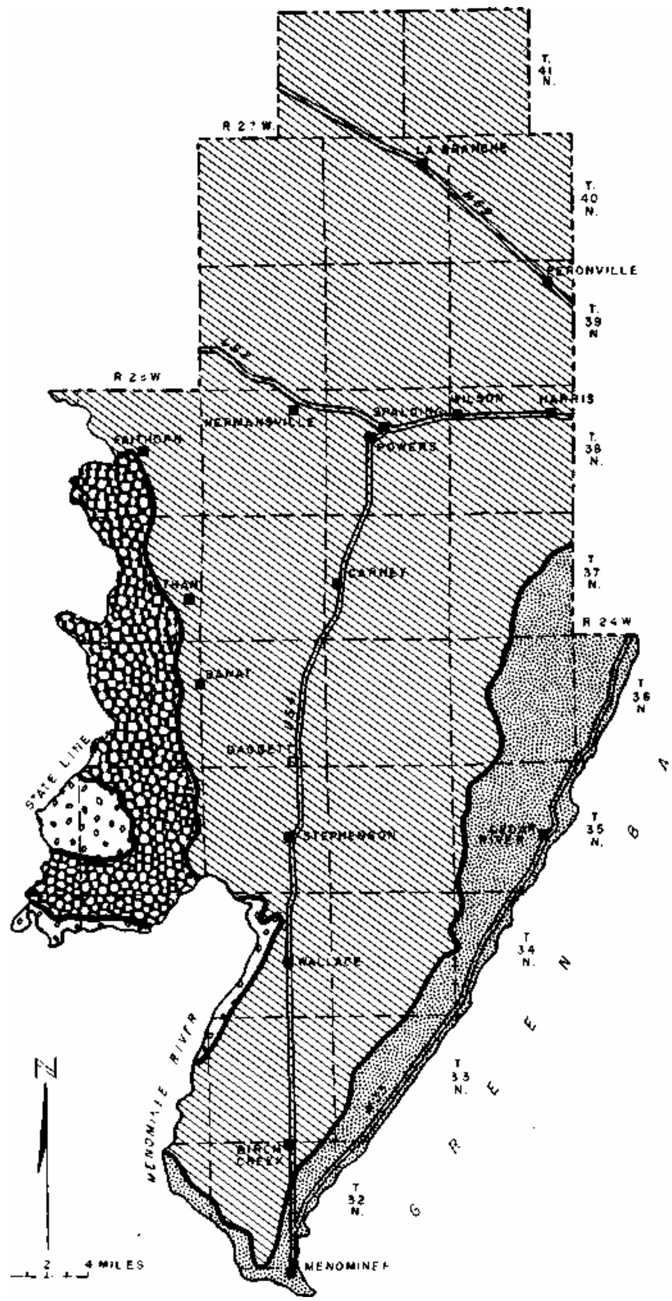


Figure 4. - Map showing general types of surficial glacial deposits and general availability of water from glacial aquifers.

Shallow Lake deposited sand and clay *stippled area*

Most of the surficial deposits in this area are of sand. Locally, however, they are of clay and in many places clay underlies the lake sand at shallow depth. Generally, the water table is at or near the surface throughout this area. Locally, especially along the shore of Green Bay, beds of sand provide adequate water for household needs to shallow - driven wells. In some places, beds of gravel are present at the base of the lake - deposited sand and clay. These gravel beds are tapped by a few drilled wells. Most wells in this area, however, tap the bedrock aquifers.

Till Plains, Drumlins and Shallow Outwash
diagonal lines

The glacial deposits in this area are composed principally of clay till. This till generally is not a source of water to drilled wells, although it will provide supplies adequate for farm or household needs to dug wells. Locally, within this area some drilled wells obtain water from beds of gravel which occur just above bedrock. This area includes some thin beds of surficial sand and gravel outwash which would yield water to wells. Most of this shallow out - wash, however, occurs in swamp and marshland areas. Most wells in this area tap the bedrock aquifers.

Marenisco Moraine
coarse gravel

The till of this area is very sandy. It includes beds of sand and gravel that are sources of water to wells supplying household and farm needs. Locally, the till may include beds of sand and gravel that would yield 100 to 200 gpm to properly constructed large diameter wells.

Glacial outwash
open small dots

Outwash is composed of permeable sand and gravel. These deposits are sources of water to some wells supplying household and other needs demanding a few gpm. Locally, these deposits may yield several hundred gpm to properly constructed, large diameter screened wells. Wells completed in these deposits at the present time, 1962, are either driven wells equipped with sand points or are drilled wells with natural gravel screens.

Most of the wells in the area of drumlins and ground moraine obtain water from the bedrock aquifers. The glacial drift deposits, however, are tapped by some wells, especially in the southern part of the county where the bedrock aquifers yield "sulfur" water. Wells tapping the drift in this area are of two types: large - diameter, shallow - dug wells; and drilled, cased wells completed in coarse gravel.

The glacial deposits in the northern part of the drumlin and ground moraine area tend to be more sandy than the deposits in the southern and central parts of the area. In some places in the northern part of the drumlin area the drift deposits may yield as much as 50 gpm to properly - constructed screened wells.

Areas of Glacial Lake Deposits

The flat, low - lying swampy area along Green Bay is underlain by lake - deposited clay, silt, and sand (fig. 4), These sediments were deposited in the ancient glacial lake that was a larger ancestor to the present Lake Michigan and Green Bay. The lake deposits generally form only a thin layer over deposits of glacial till, and hence in most places they are not an important source of water. Locally, along the shore of Green Bay, however, beds of lake - deposited sand are sources of water to shallow, small diameter, driven wells, and some drilled wells obtain water from beds of gravel underlying the lake deposits. Most wells in the area of lake deposits, however, obtain water from the bedrock aquifers.

Area of the Marenisco Moraine

The glacial deposits in the area of the Marenisco moraine in the western part of the county (fig. 4) are much thicker and more sandy than the glacial deposits in the central and southern parts of the county. As the soils in this area are not the best for agricultural purposes, the area has not been extensively developed into farmland and relatively few wells have been drilled.

The glacial deposits are potentially an important source of water and would yield adequate water for household needs throughout most of the area. Locally, thick and extensive beds of water - bearing sand and gravel may be included in the glacial drift in this area. Properly - constructed wells tapping such beds of sand and gravel would yield 100 to 200 gpm.

Areas of Outwash

Several areas along the Menominee River are underlain by deposits of sand and gravel outwash (fig. 4). A few wells obtain water from the out - wash deposits in these areas to supply household and other needs demanding only a few gpm. Most of the wells tapping these deposits are shallow - driven wells or drilled - cased wells completed with the open end of the casing in coarse gravel to form a natural gravel screen. Locally, the deposits are thick enough to supply several hundred gallons per minute to properly - constructed wells equipped with well screens.

Bedrock Aquifers

If you have a well in Menominee County, the chances are about 10 to 1 that it is completed in one of the bedrock aquifers of the county. This is not that the bedrock aquifers yield a better quality of water, or

that drillers prefer to complete wells in the bedrock, but simply that in most areas the bedrock aquifers are the only dependable sources of water to wells.

The bedrock aquifers consist of several rock types, of which the most predominant are limestone and sandstone. The term limestone as used here includes dolomite because most water well drillers do not distinguish between the two rock types. Beds of limestone and sandstone are present over all the county except for an area in the western part where Precambrian granites, schist and other types of crystalline rocks predominate.

The beds of limestone and sandstone dip gently towards Green Bay (fig. 5) - They rest upon a variety of Precambrian rocks. The surface of the Precambrian rocks is more than 900 feet above sea level where the Precambrian crops out in the area along the Menominee River and is more than 100 feet below sea level along Green Bay (fig. 10).

Water is contained principally in openings along fractures in the bedrock aquifers, but also moves between the grains of sand in beds of sand - stone. A permeable zone in a bedrock aquifer may be quite extensive so that nearly all the wells in an area are completed at about the same depth. Locally, however, it is necessary to drill some wells much deeper than other nearby wells.

The bedrocks of the county can be separated into four distinct water - bearing units (fig. 6, table 1). Some wells obtain water from more than one of these water - bearing units.

Upper Limestones

The uppermost bedrock aquifer in the eastern part of the county is composed principally of limestone. As these limestones overlie the other bedrock aquifers they are herein referred to as the upper limestones.

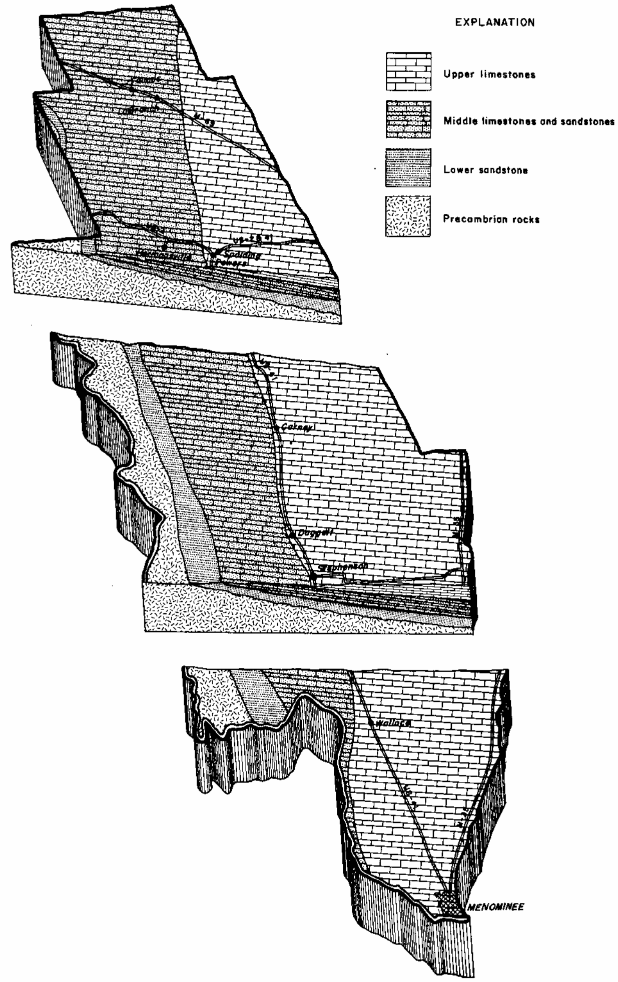


Figure 5. - Schematic split block diagram showing bedrock geology andstructure of Menominee County.

The upper limestones are the principal source of water for.household use and other needs demanding a few gpm in more than half the county (fig. 6). These rocks are thickest along Green Bay, become thinner, and pinch out to the west. They include spme beds of shale and shaly limestone. Apparently the beds of shale are thicker and more extensive in the southern part of the county than in the northern part,

In several dozen places in the county, the upper limestones are at the surface or buried by only a few feet of glacial material. Generally, however, they are covered by 20 feet or more of glacial debris. Under some of the larger hills the limestones are covered by more than 100 feet of glacial material (see "glacial aquifers" above).

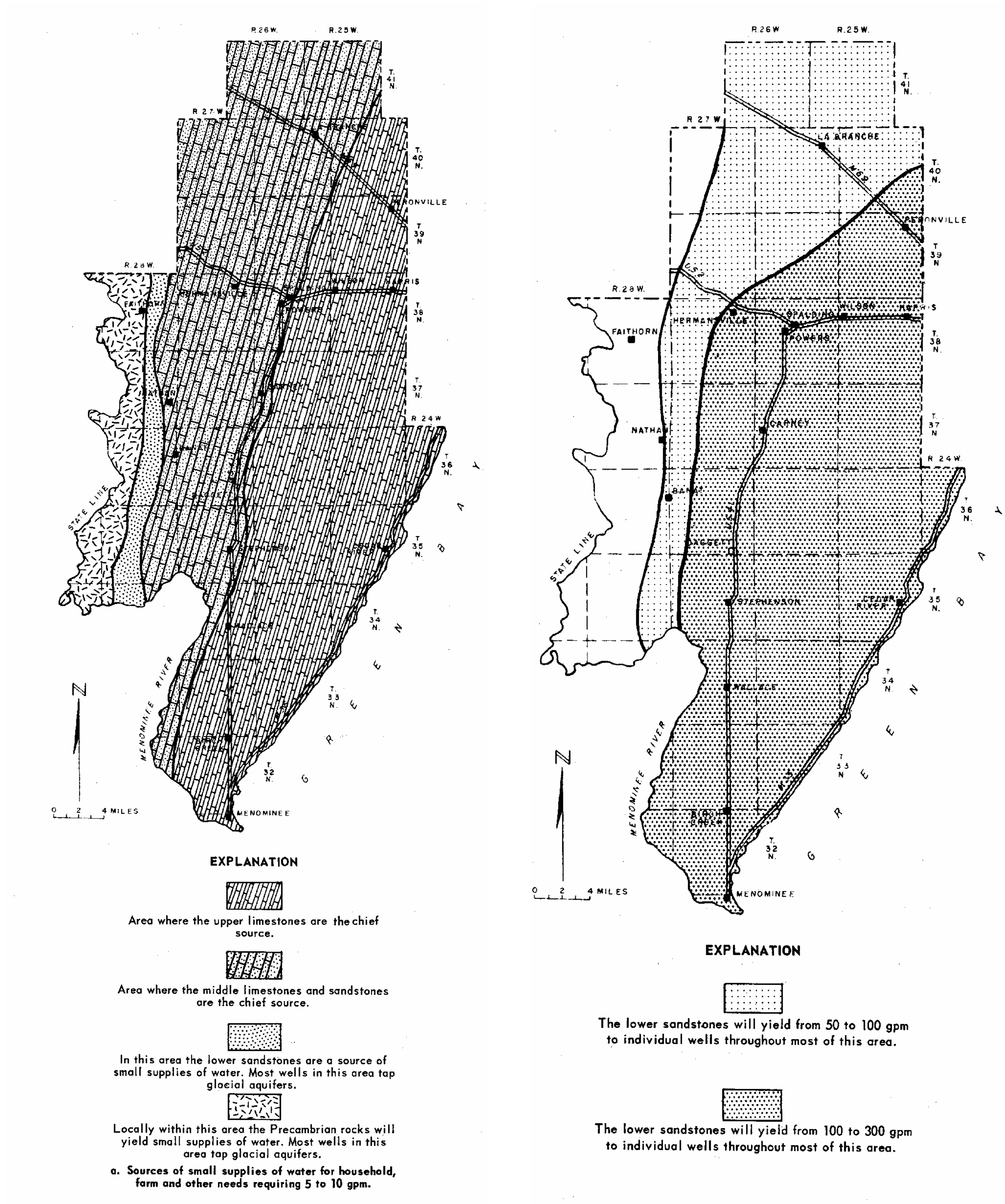


Figure 6 - Maps showing the availability of water from bedrock aquifers.

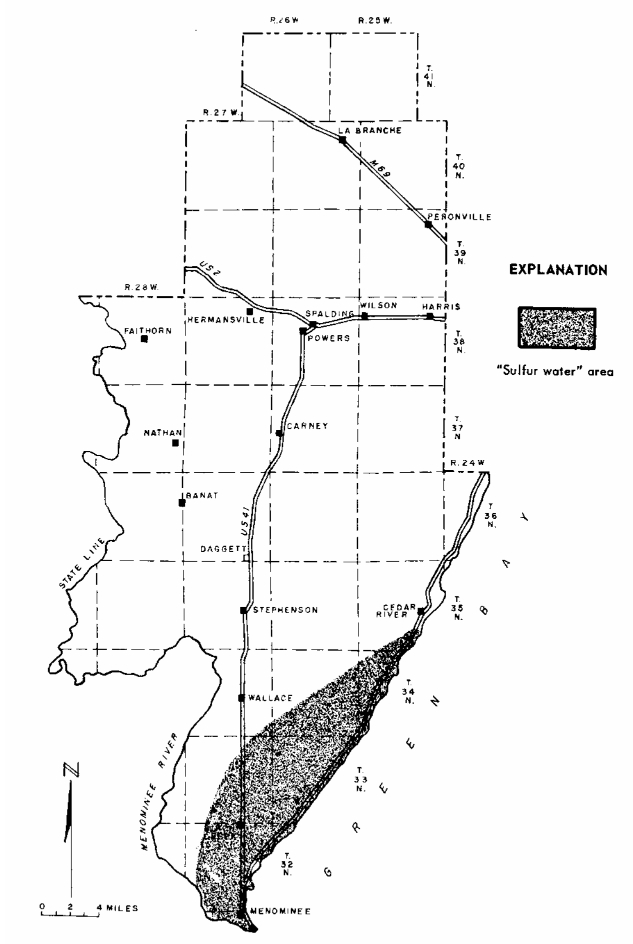


Figure 7. - Area where some wells yield sulfur water.

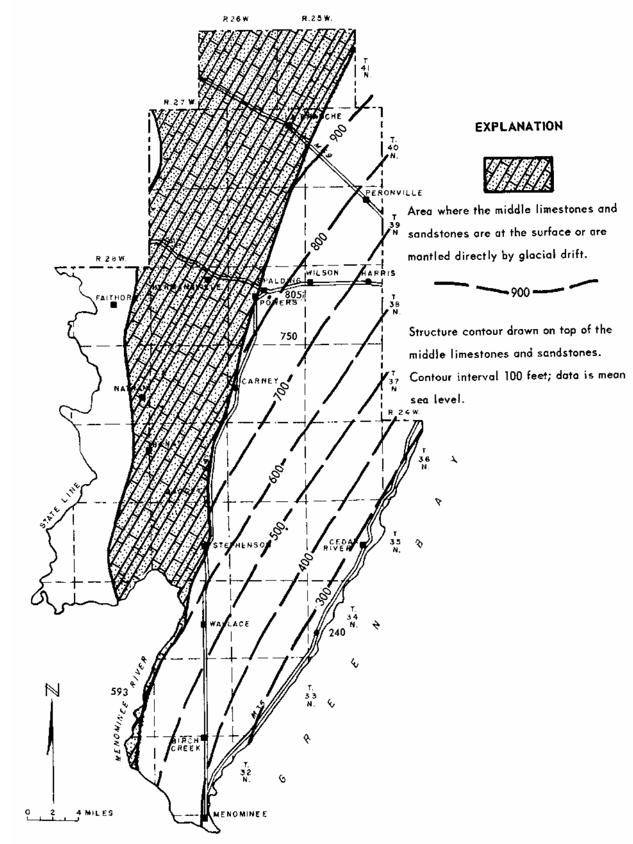


Figure 8. - Structure - contour map showing extent of the middle limestones and sandstones.

Nearly all the wells tapping the upper limestones provide water for household or farm use or supply other needs where a maximum of 5 to 10 gpm (gallons per minute) is needed. In a few localities wells in the upper limestones might yield as much as 100 gpm.

Because so much of the county is underlain by the upper limestone aquifers, it would seem that in these areas there are no problems in obtaining adequate water for household or farm needs. The principal water problem in the area of upper limestones, however, is that locally the water has an obnoxious "sulfur" odor.

Many of the wells tapping the upper limestones in the southern part of the county produce "sulfur" water - water containing hydrogen sulfide gas (fig. 7). The "sulfur" water has an odor - somewhat similar to the odor of rotten eggs - and in general wells yielding "sulfur" water are not altogether satisfactory sources of water can be reduced by some types of home water - treatment equipment or by aeration (exposing to the air) prior to use. The shallower beds of limestone tend to be free from the "sulfur" gas. Thus, within the area where wells yield sulfur water, well drillers try to complete wells as shallow as possible. In some places, however, even the shallow limestone beds contain "sulfur" water.

Outside of the sulfur water areas water from the upper limestones is of fairly good chemical quality. It is hard and locally contains enough dissolved iron to cause staining, but otherwise is satisfactory for most uses (see table below). The objectionable concentrations of hardness and iron can be reduced by commonly - used home - treatment equipment.

Locally, where the beds of limestone are at the surface or at shallow depth, they are subject to contamination from barnyard wastes, septic tank effluents and other wastes disposed of on the surface.

Chemical analyses of water samples from the Upper Limestones - see page 16

Middle Limestones and Sandstones

Beds of limestone and sandstone that underlie the upper limestones are an important water - bearing unit in Menominee County. As these beds are overlain by the upper limestones and are underlain by a lower sandstone unit, they are referred to herein as the "middle limestones and sandstones" .

The middle limestones and sandstones include several geologic formations (table I). Locally the unit includes several beds of sandstone (see log of well 34N 25W 30 - 1. table 3); in other areas it is composed principally of limestone. Well drillers report that this middle bedrock unit includes some beds of shale or "soapstone". (Some well drillers use the term "soapstone" for shale or shaley limestone and dolomite.) The greatest thicknesses of shale have been reported in wells in the southern part of the county.

Both the limestone beds and the sandstone beds of this unit yield water to wells, as some wells reportedly produce water from a bed of sandstone and others from limestone. Undoubtedly, most wells obtain some water from both sandstone and limestone if both rock types are penetrated.

Most wells tapping the middle limestones and sandstones are in the west - central part of the county where these rocks crop out at the surface or are mantled directly by glacial drift (fig. 8). Wells in this area range from about 30 to 200 feet and average about 76 feet in depth. In general, wells obtaining water from this unit yield only 5 to 10 gpm. Some wells, however, probably would yield as much as 50 gpm if they were equipped with larger - capacity pumps.

The middle limestones and sandstones are also a source of water in the area where they are overlain by the upper limestones. In this area they are tapped by only a few wells. The wells drilled through the upper limestones into the middle limestones and sandstones are in the area where the upper limestones yield sulfur water (fig. 7). Well 34N 25W 30 - 1 (table 2 and 3) penetrates about 3°0 feet of upper limestone and 450 feet of the middle limestones and sandstones. The upper limestones yielded "salt and sulfur" water to this well; the middle limestones and sandstones, however, yield good water.

Most wells tapping this unit yield water of good quality although it is hard and locally contains objectionable amounts of iron. The hardness and the iron content can be reduced to satisfactory levels by commonly - used types of home water - treatment equipment. The following table lists analysis of water from wells tapping the middle limestones and sandstones.

Chemical analyses of water samples from Middle Limestones and Sandstones - see page 16

Wells 32 - N, 2?W 3 - 5, 20 - 1, 28 - 2, and 29 - 5 (tables 2 and 2) produced "sulfur" water from the middle limestones and sandstones in the area where the overlying upper limestones also yield sulfur water. The occurrence and areal distribution of sulfur water in the middle limestones and sandstones is not known. It probably is somewhat smaller than the area where the upper limestones yield sulfur water (fig. ?)•

The source of the "sulfur" (hydrogen sulfide gas) in the aquifers of the county also is not fully understood. Well 32N 27W 3 - 5 taps a bed of sandstone containing a large percentage of pyrite (fool's gold), a mineral composed of iron and sulfur. Chemical reduction of the pyrite could result in "sulfur" gas. The water from well 32N 27W3 - 5 also contains excessive amounts of sulfate and chloride (see table above). The origin and occurrence of high sulfate and chloride concentrations in ground water in the southern part of the county are discussed in the following section.

Lower Sandstones

A series of sandstone formations which lie below the middle limestones and sandstones is an important source of water to wells in Menominee County. The sandstones dip gently toward Green Bay below the middle limestones and sandstones (fig. 5). The "lower" sandstones are also an important aquifer in the eastern part of the Upper Peninsula and in the eastern part of

Wisconsin. The sandstones generally range from about 50 to 200 feet in thickness. However, they are more than 200 feet thick in the southern part of the county and less than 50 feet thick in some areas in the northern part of the county.

The lower sandstones are tapped by a few wells near the west boundary of the county, where they are mantled directly by glacial drift (fig. 9), and by several deep wells in the area where they are overlain by other bedrock aquifers. In general the sandstones are not an important source of water to wells supplying household needs, as in most areas they are overlain by shallower, more accessible aquifers. The aquifer is, however, an important source of water to wells supplying municipal and industrial needs. The village of Stephenson, the White House Milk Company at Stephenson, and the Pinecrest Sanatorium at Powers have deep wells that tap the lower sandstone. Each of these wells yields more than 200 gpm of water of good quality.

In the southern part of the county the lower sandstones may yield water of poor quality. Water sampled from well 32N 27W 3 - 6, which taps the lower sandstone, produced excessively hard water containing more than 1400 ppm of sulfate (see table below). This well is less than two miles from well 33N 2?W 32 - 1 which produces water containing only 38 ppm of sulfate. Wells tapping the lower sandstones in adjacent parts of Wisconsin, however, also produce water with excessive concentrations of sulfate. Other areas of high sulfate and chloride are present to the south in Wisconsin and to the north in Delta County, Michigan. Additional data are needed to accurately define areas in Menominee County where the lower sandstones contain water of poor quality.

The lower sandstone unit has considerable potential as a source of moderate to large supplies of water for municipal and industrial use over one - half of the county and, thus, is one of the most important aquifers in the county (fig. 6). Although an individual well tapping this aquifer may yield as much as 300 gpm, interference between wells would decrease individual well yields if several wells are drilled in the same locality. Interference between wells decreases with increasing distance between wells.

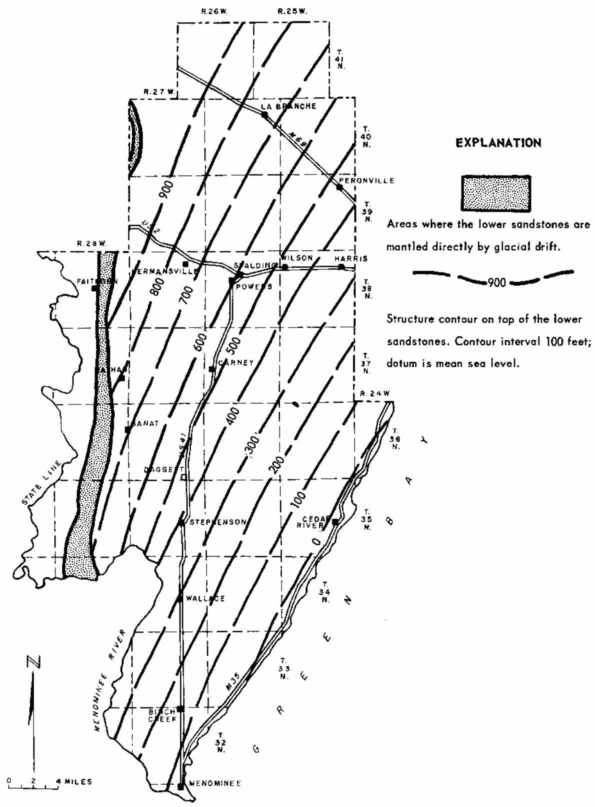


Figure 9. - Structure - contour map showing extent of the lower sandstones.

Chemical analyses of water samples from Lower Sandstones - see page 16

Analyses by the Michigan Department of Health

Precambrian Rocks

The lowest and deepest aquifer in the county is composed of very ancient crystalline, metamorphic and sedimentary rocks, such as granite, schist, marble and iron formation. These Precambrian rocks are sometimes referred to as the "basement" rocks as they are under all of the other rock formations in the county (fig. 6).

The Precambrian rocks are not an important source of water except in the western part of the county where they crop out at the surface or are mantled directly by glacial drift (fig. 10). In this area they are the only source of water if the glacial drift is not present or does not yield water.

Ground water is contained principally in the openings along the fractures (cracks) in the Precambrian rocks. These rocks are more

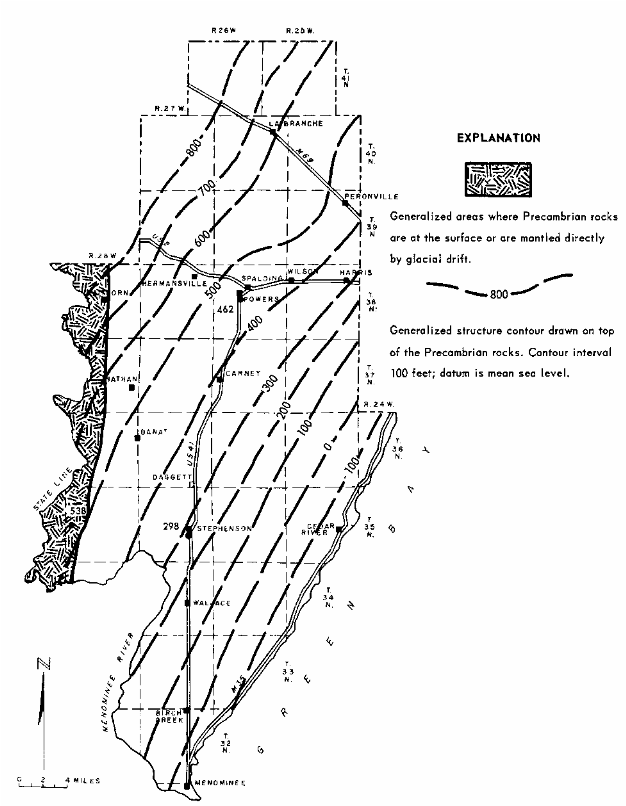


Figure 10. - Structure - contour map showing extent of Precambrian rocks.

fractured and broken near the surface than they are at depth. The weight of the overlying rocks tends to squeeze the openings together and in most areas these rocks probably do not yield water at depths of more than 200 to 300 feet.

Well 38N 26W 16 - 1 at Powers obtained some water from Precambrian dolomite (Randville Dolomite) at a depth greater than 500 feet. The openings in the dolomite, however, have been enlarged by solution and thus remain open at much greater depth.

As only a few wells in the county are completed in Precambrian rocks little is known of the chemical quality of the water from the Precambrian. Well 35N 28W 19 - 1 (as shown in table below) yielded good water with only 76 pprn of hardness.

Chemical analysis of water sample from Precambrian Rocks - see page 16

The Origin, Movement and Discharge of Ground Water

Ground - water is a renewable resource because it is continually replenished by precipitation, 4he process whereby precipitation falls on the ground, evaporates, is used by plants, or moves to the lakes and rivers and then to the ocean, eventually to evaporate and return to the atmosphere, is called the hydrologic cycle. The ground - water phase of the hydrologic cycle involves the recharge to, movement in, and discharge from the ground - water reservoirs. Under natural conditions water infiltrates into the ground - water reservoirs and under the force of gravity moves by underflow to the lakes, swamps and streams,, This recharge to the aquifers is balanced by natural discharge.

This balance is disturbed when water is pumped from a well. In time an aquifer will adjust to the withdrawal of water from the well and a new "balance" will be established. This new balance would be achieved by an increase in recharge to the aquifer and/or a decrease in natural discharge from the aquifer. The amount of water discharging naturally from the aquifers in Menominee County greatly exceeds the amount of water pumped from wells. Thus ,the potential for development of the ground - water resources of the county exceeds any forseeable development for many years to come.

The shape of the water table, the top of the ground - water reservoir, in Menominee County is somewhat similar to the shape of the land surface (fig,11) except that the "hills" on the water table are not so high, and the gradients are not so steep. In many low areas the water table surface and the land surface coincide. These areas are swampy or have a stream running through them. The piezometric (water pressure) surfaces in the deeper aquifers are somewhat similar in shape to the water table. The "hills" in the piezometric surface are not as high as the water - table hills, the slopes are not as steep, and the valleys, are not as low. The piezometric surfaces are above the land surface in some areas, and wells tapping the artesian aquifers in these areas flow. The largest areas of artesian flow occur along the shore of Green Bay.

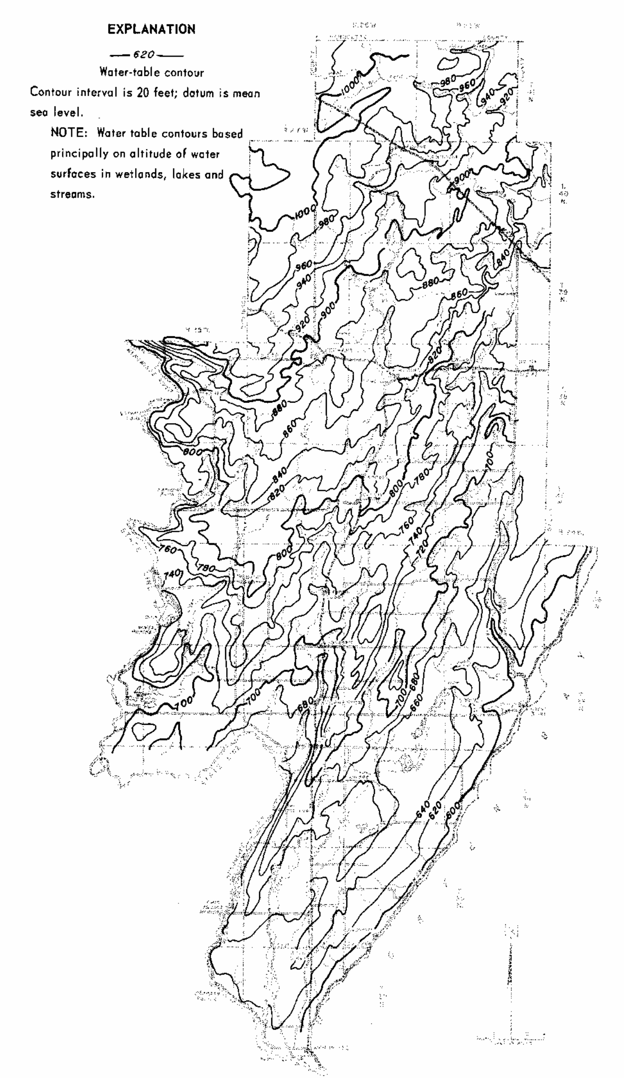


Figure 11. - Map showing generalized contours on the water table in Menominee County.

Summary and Conclusions

Menominee County is underlain by five major water - bearing units. Each - of these units includes a variety of rock types and include one or more geologic formations.

Water for household, farm, and other needs requiring from 5 to 10 gpm can be obtained from wells throughout the county. Wells supplying these needs range from less than 20 to 720 feet in depth. Most wells, however, are less than 100 feet deep, and most are drilled, cased wells, and obtain water from bedrock aquifers. Dug and driven wells are also used.

Moderate to large supplies of water (50 to 300 gpm per well) can be obtained from the lower sandstone unit throughout most of the county. Except for a small area in the southern part of the county, the water from this aquifer is of - good chemical quality, low in iron and of moderate hardness. Wells presently tapping this aquifer for municipal or industrial supply are about 400 or more feet deep.

In a few localities the other water - bearing units may yield moderate supplies of water (50 to 100 gpm) and it may be possible to develop several hundreds of gpm from wells tapping glacial outwash in the western part of the county.

The quality of water from the five water - bearing units varies considerably. Most of the water is hard and some of the water contains objectionable amounts of iron. The greatest quality problem, however, is in the southern part of the county where the bedrock aquifers yield "sulfur" water. The "sulfur" water problem generally is overcome by completing wells at as shallow a depth as is possible. In some of this area dug wells provide the most satisfactory source of water for household use.

Selected References

This list is provided for those who wish to obtain additional information on the general geology or water resources of Menominee County* The reports can be obtained from or examined at the offices of the Michigan Geological Survey in Escanaba and Lansing,

Hamblin, W, K., Cambrian Sandstones of Northern Michigan: Michigan Geological Survey (Publication 51), 1958,

Ryling, Roy W., A Preliminary Study of the Distribution of Saline Water in the Bedrock Aquifers of Eastern Wisconsin; Wisconsin Geological and Natural History Survey, University of Wisconsin (information Circular Number 5).

Verweibe, W, A., Geology of Menominee County: Michigan Land Economic Survey (geologic report with maps), 1925.

Verweibe, W, A., Surface Geology of Menominee County: Michigan Academy of Science Papers (Volume ?), 1926, pp. l67 - l69.

Reports on the ground - water resources of Delta, Alger, and other counties in the eastern part of the Upper Peninsula can be obtained from the Michigan Department of Conservation,

Well number	Date collected	Chemical constituents in parts per million											Specific conductance (micromhos at 25° C)	pH
		Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$		
Glacial Drift														
38N 28W 5 - 1	4 - 5 - 63	.48	94	39	36	1.2	408	41	17	97	533	395	846	7.9
38N 28W 5 - 1	8 - 15 - 63	.1	- - -	- - -	- - -	- - -	- - -	- - -	15	19	- - -	390	- - -	- - -
25N 25W 14 - 1	6 - 21 - 62	.27	35	26	52	4.5	160	89	64	- - -	372	195	640	8.1
33N 28W 35 - 1	5 - 8 - 62	.02	34	26	4.6	1.3	230	12	0	- - -	214	192	373	7.9
33N 26W 6 - 2	4 - 4 - 63	.04	64	23	2.4	1.4	262	16	8.0	- - -	266	254	459	8.4
Upper Limestones														
40N 25W 36 - 1	4 - 5 - 63	1.3	67	23	6.5	3.7	294	33	8.0	- - -	280	262	507	7.3
39N 25W 3 - 1	4 - 15 - 63	.85	82	21	3.4	1.7	330	24	5.0	- - -	303	291	535	7.2
38N 25W 27 - 1	4 - 15 - 63	.33	94	30	8.3	7.4	338	47	36	- - -	430	358	710	7.1
38N 25W 27 - 2	4 - 15 - 63	.07	119	22	3.8	1.3	412	30	14		441	388	723	7.0
36N 24W 29 - 1	4 - 5 - 63	- - -	26	14	31	2.9	174	24	10	- - -	209	123	568	8.0
35N 25W 22 - 1	8 - 16 - 63	- - -	39	22	45	10	226	62	30	2.9	337	188	566	7.3
35N 25W 22 - 1	6 - 9 - 62	.01	45	30	42	28	240	65	38	- - -	422	236	704	8.6
35 N 25W 35 - 1	4 - 4 - 63	.48	50	24	8.4	1.9	280	9.6	8.0	- - -	266	224	442	7.4
33N 27W 35 - 1	4 - 5 - 63	.10	67	31	7.8	3.4	254	69	31	- - -	350	295	582	7.6
32N 27W 12 - 2	5 - 5 - 62	.55	39	23	7.2	1.6	236	6.0	6.0	- - -	237	192	382	7.9
32N 27W 14 - 5	6 - 21 - 62	.39	48	34	4.4	1.0	248	29	6.0	- - -	284	260	480	8.6
Middle Limestones & Sandstones														
38N 26W 25 - 1	5 - 8 - 62	0.10	59	25	2.2	2.5	288	18	1.5	- - -	260	250	473	7.8
37N 27W 1 - 1	5 - 7 - 62	.93	57	33	3.8	2.2	288	42	7.0	- - -	309	278	524	8.1
34N 27W 20 - 1	4 - 4 - 63	.59	40	21	6.3	3.6	238	12	10	- - -	187	187	370	7.6
34N 25W 30 - 1	4 - 4 - 63	.18	41	19	43	4.4	152	80	56	- - -	230	180	561	7.5
33N 28W 24 - 2	4 - 4 - 63		47	25	6.4	2.0	250	24	4	- - -	231	220	425	7.6
32N 28W 11 - 2	4 - 5 - 63	.92	48	23	3.8	3.0	254	16	5.0	- - -	223	215	410	7.7
32N 27W 3 - 5	6 - 30 - 60	5.6	374	87	235	18	110	1390	172	- - -	2480	1290	2870	6.8
Lower Sandstones														
38N 26W 16 - 2	4 - 8 - 63	0.62	52	22	9.4	4.2	280	16	1.0	- - -	235	220	441	7.3
37N 28W 11 - 1	4 - 5 - 63	.33	88	37	3.4	1.4	306	97	27	- - -	460	372	681	7.7
35N 27W 23 - 2	12 - 9 - 52	- - -	64	22	6.3	9	288	14	9	- - -	272	250	530	7.6
33N 27W 32 - 1	4 - 5 - 63	18	55	16	21	3.8	242	38	18	- - -	277	203	468	8.0
32N 27W 3 - 6	1956	- - -	- - -	- - -	- - -	- - -	- - -	- - -	96	- - -	- - -	1675	- - -	- - -
32N 27W 3 - 6	3 - 3 - 60	- - -	260	73	299	- - -	290	1410	95	- - -	- - -	950	- - -	- - -
Precambrian Rocks														
35N 28W 19 - 1	4 - 5 - 63	- - -	21	5.8	95	3.4	80	4.8	- - -	154	315	76	630	7.6

Table 2 Chemical Analyses of Water Samples

Analyses done by U. S. Geological Survey // Well Numbers in gray done by Michigan Department of Health