WATER INVESTIGATION 5

GROUND-WATER RESOURCES OF DICKINSON COUNTY, MICHIGAN

GEOLOGICAL SURVEY DIVISION, MICHIGAN DEPARTMENT OF CONSERVATION

1966

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GEOLOGICAL SURVEY DIVISION

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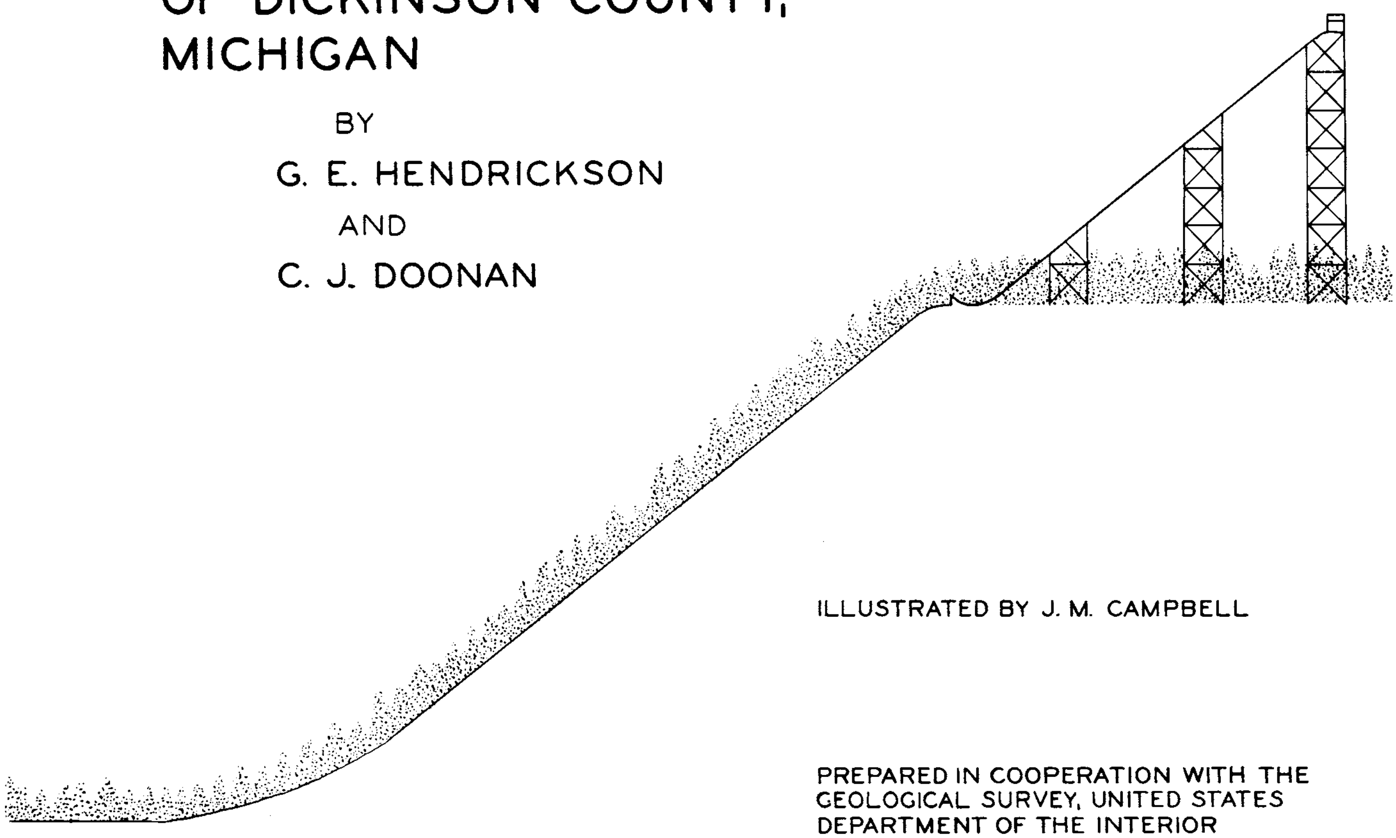
BY

G. E. HENDRICKSON

AND

C. J. DOONAN



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GEOLOGICAL SURVEY, UNITED STATES
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1966

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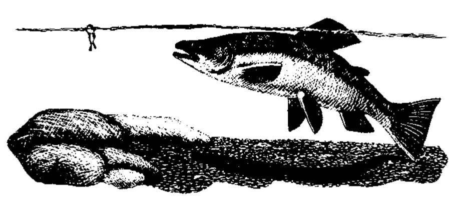

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PREFACE

Everyone that uses water has his own particular wants or needs concerning this resource. The rural resident may need to know where he can obtain a new water supply on his farm. The well driller would like to know the kinds of materials that will be encountered if he drills a well at a given locality. The irrigator wants to know if he can obtain water for irrigation, and if so, where? The city water manager may need to plan new well fields to supply large quantities of water for future demands. The industrial engineer would like to find the most favorable areas in Dickinson County for large production wells. And the urban resident may like to know where his water comes from and what its quality is.

It is hoped that this report will enable everyone to better understand the source, the availability, and the quality of the ground-water resource within the county.

The cooperation and assistance of personnel of federal, state and county agencies, municipalities, industrial concerns, well drillers, as well as many other individuals made this report possible. Special credits are due Mr. A. E. Slaughter, geologist with the State Geological Survey, for assistance in defining the geology of the county. Mr. Harry Kleiman furnished data on many wells in the county and reviewed the water-availability maps. Mr. Paul Trione, Norway City Manager, and Messrs. Louis Tomasini, Wm. Peterson and L. J. Alexander, of the Norway Department of Public Works, furnished information on water supply and mine flooding problems. Mr. Anton Kovochich and his staff at the Iron Mountain Water Department contributed public water supply data.

Lansing, Michigan
December, 1965

G. E. Hendrickson
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Water Resources Division
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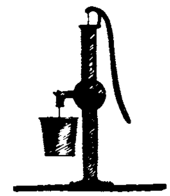


INTRODUCTION

Dickinson County has abundant, though unevenly distributed, ground-water resources that are little used at present. In some places enough water for industry or irrigation can be obtained from wells; in others, obtaining the small amount of water needed for a single household, or for a hunting or fishing camp is difficult, if not impossible. The purpose of this report is to provide public officials, industrial developers, farmers, rural residents, well drillers, consultants, and anyone else with basic information on obtaining water from wells and springs.

This report summarizes data on representative wells within the county and describes the geologic and hydrologic relationships. Well data are relatively abundant in the towns and along the major roads of the county, but sparse elsewhere. The description of the occurrence of ground water and the maps showing availability of ground water, therefore, are based largely on geologic information.

Analyses

The scarcity of well data also limits the information on quality of water. Laboratory analyses were made of samples from a few representative wells and one spring. Field analyses were made of samples from most wells visited. Because the low flow of streams is chiefly ground-water discharge, field analyses were also made of samples obtained from the major streams of the county during rainless periods. A few analyses of samples from lakes are included in the report to indicate the general range in the quality of water obtainable in the county.

Well Numbers and Sampling Sites

The well-numbering system used in this report corresponds to the rectangular system of land subdivisions with reference to the Michigan meridian and base line. The first two parts of a well number designate township and range; the last part designates both the section and the well within the section. Thus, 44N 27W 17-1 is well number one in section 17, Township 44 North, Range 27 West.

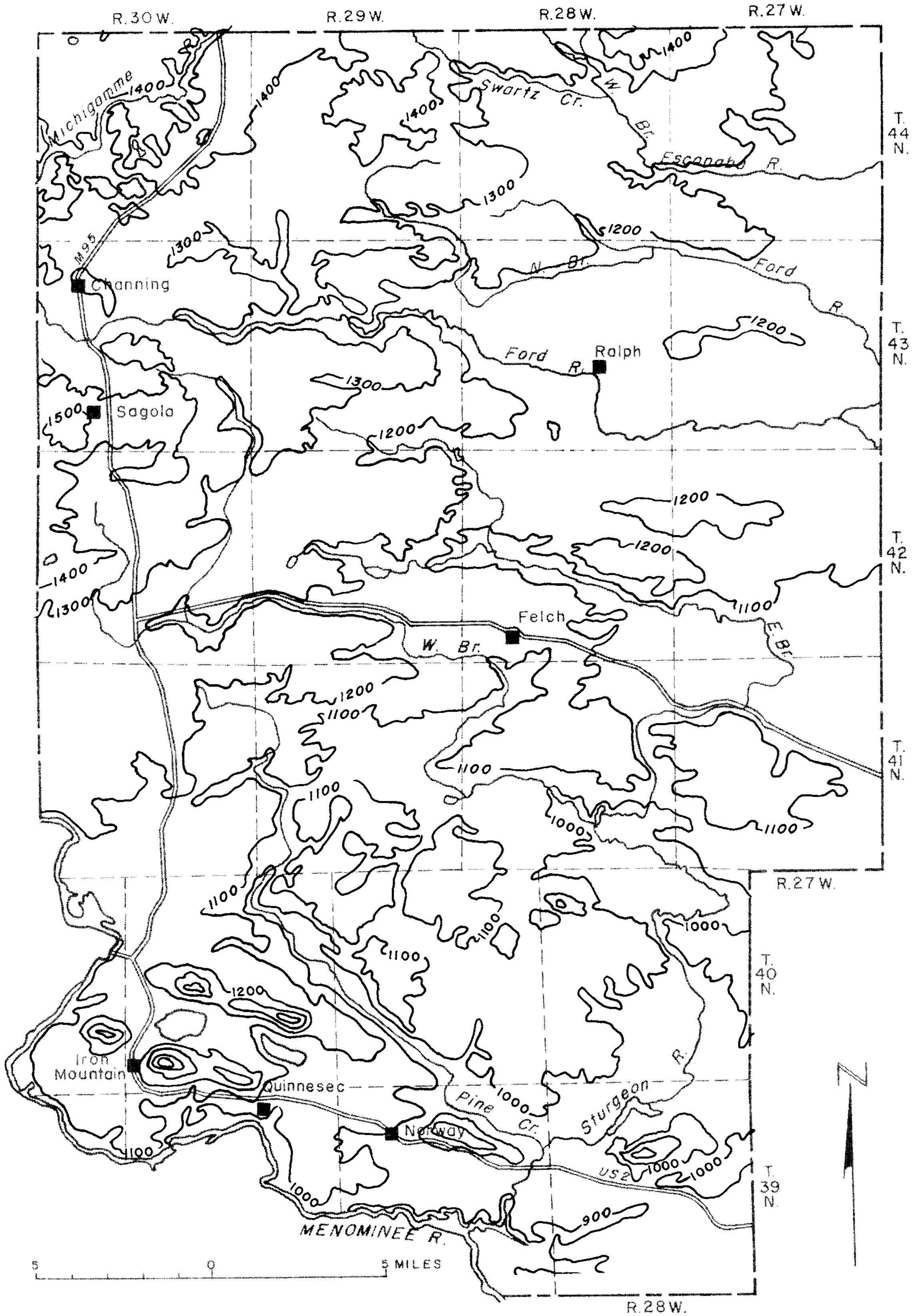
Surface water chemical data sites are identified by a serial number within the township. For example, site number 44N 30W-3 indicates the third sample collected in Township 44 North, Range 30 West.

Surface Geology and Topography

Although glacial drift covers most of the surface of Dickinson County, bedrock is exposed in the central and south-central areas (maps 1 and 2 in pocket). Small outcrops are also exposed at Randville and Felch and in many small patches elsewhere.

The glacial drift is composed of mixtures of sand and gravel, silt, clay, cobbles, and boulders. Bedrock includes dense igneous, sedimentary, and metamorphic rocks of Precambrian age and sandstones and dolomites of Cambrian and Ordovician age.

The relief of the glacial drift generally is characterized by rolling hills and swampy lowlands; the bedrock surface commonly is more



MAP 3. TOPOGRAPHY OF DICKINSON COUNTY, MICHIGAN.

rugged, but smoothed by the polishing action of the glacial ice. Many of the hills in both glacial and bedrock areas are more than 1,400 feet above sea level, and a few rise above 1,500 feet. The lowest elevation in the county is about 900 feet along the Menominee River in the southeast.

The Menominee River borders the county on the south, with the tributary Sturgeon and Pine rivers draining most of the central and southern areas. The northern part of the county is drained chiefly by the Ford River and the West Branch of the Escanaba. The Michigamme River drains a small area in the northwest corner.

Ground-Water Recharge

Rain and snow are the source of all water. Annual rainfall averages about 28 inches. Part of this rain and melting snow runs off over the surface of the ground and is carried off by streams or is stored in lakes. Another part is returned to the air by evaporation and transpiration of plants while the remainder, percolating down to ground-water reservoirs, is called ground-water recharge. Ground water moves slowly through the reservoirs to discharge into streams, lakes or swamps keeping them flowing during rainless periods.

The more rain and snowmelt entering the underground reservoirs, the greater the amount of ground water available for wells, and the greater the flow of streams during rainless periods. Sand and gravel occurring at the surface in places along the major streams of the county (map 1) are so permeable that as much as 10 inches of the rainfall and snowmelt is estimated to percolate down to the ground-water reservoir. By way of contrast, the steeply-sloping areas of Precambrian bedrock in the south-central part of the county are relatively impermeable. Probably not more than 1 inch of the rainfall and snowmelt recharges the ground-water reservoir in those areas. In addition, the openings between particles of sand and gravel can store and transmit much more water than the thin fracture-openings in the Precambrian rocks. Thus, wells drilled in the sand and gravel deposits generally yield much more water than wells in the Precambrian bedrock. In addition, streams flowing in the sand and gravel areas have higher flows during rainless periods than streams of comparable drainage area in Precambrian bedrock.

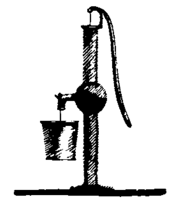
Not only the quantity but also the quality of water available is influenced by the character of earth materials. Rain or snow falling on the earth in inland areas is nearly pure, normally containing less than 10 ppm (parts per million) of dissolved solids. However, as soon as the water comes in contact with soils and rock, it begins to pick up soluble materials. Water passing quickly over the surface to lakes and streams has little time to dissolve mineral matter. On the other hand water percolating into the ground is able to pick up a greater amount of dissolved solids.

Economy and Water Development

Dickinson County, situated in the west central part of the Northern Peninsula of Michigan, has an area of 757 square miles and a population of 23,917 (1960). The county is served by five trunkline highways, three railroads and one airport. Most of the industry and 65 percent of the people are located in the cities of Iron Mountain, Kingsford, and Norway. Most of the land in the northern half of the county is taken up with state-owned acreage within the Sturgeon River State Forest and private hunting camps. Farms totalled 15 percent of the land area in 1954; by 1959 farmlands had declined to 10 percent. Of the 77 manufacturing establishments operating in 1962, 40 were making lumber or other wood products. A wide range of outdoor recreational activities attract tourists from a large area in the midwest. Furnishing services and accommodations during all seasons plays a major part in the economy.

In most areas private wells supply water for commercial and household uses. Industrial development is concentrated within the areas served by municipal water systems. Very few private wells provide ground water for industrial or commercial cooling processes. A private industrial well in Iron Mountain, however, pumps almost continuously from glacial drift at a rate of 20 to 25 gpm (gallons per minute) with no apparent effect on the reservoir.

At the present time, ground water is not being used to process iron ore, but is used for domestic purposes at the mines. As open pit mines deepen, dewatering may become necessary, possibly lowering ground-water levels in the area to some extent.



GROUND-WATER RESOURCES

The aquifers (water-bearing formations) of Dickinson County are in both glacial and bedrock deposits. Most of the ground-water is obtained from wells.

Wells range in diameter from 1¼ inches to 60 inches and in depth from 12 feet to more than 350 feet (table 1 in Appendix). Most of the wells are 5 to 6 inches in diameter and 25 to 100 feet deep. Some are driven and a few are dug, but most of the wells are constructed by drilling. Drilled and driven wells in glacial drift generally are equipped with steel casing and a screen or sand point, although a few drilled wells are not screened but left with the open end of the casing in the sand and gravel. Wells drilled into rock are cased through the glacial drift and a few feet into the underlying rock, with the remainder left open. Dug wells usually are cribbed with precase concrete or tile. For driller's logs of wells, see table 2 in Appendix.

Prospects of developing a successful well at any given location depend mostly on the earth materials underlying and surrounding the site, and the local topography.

Maps 1 and 2, (in pocket) showing availability of ground water, were prepared from records of existing wells, from information on the soils and the surface and bedrock geology, and from topographic information. Because of the scarcity of wells in many areas, they were prepared largely

TABLE 3.--PUMP TEST RESULTS

Well Number	Aquifer Pc = Precambrian Pa = Paleozoic Gd = Glacial drift	Yield (gal/min)	Drawdown (feet)	Duration of test (Hours)	Specific Capacity (gal/min/ft/ drawdown)
39N 28W 7-1	Pc	5	--	--	--
14-1	Gd	5	--	--	--
14-2	?	8	60	1	0.1
19-1	Pc	17	4	2	4.3
19-2	Pc	9	40	1½	0.2
19-3	Pc	12	--	--	--
20-1	Gd	30	--	--	--
20-2	Gd	20	15	2	1.3
24-1	Pa	240	--	--	--
30-1	Gd	5	6	½	0.8
30-2	Gd	40	10	2	4.0
30-3	Gd	5	--	--	2.5
30-4	Gd	10	4	¼	--
39N 29W 8-1	Gd	20	1½	2	13.3
22-1	Gd	15	4	8	3.8
25-1	Gd	30	10	2	3.0
36-1	Pc	20	10	2	2.0
39N 30W 3-2	Gd	125	12	8	10.4
4-1	Pc	20	10	--	2.0
40N 28W 12-1	Gd	4	90	½	0.04
26-1	Gd	3	40	1	0.8
35-1	Gd	3	5	2	0.6
40N 29W 28-1	Gd	3	8	1	0.4
40N 30W 8-1	Gd	15	4	4	3.8
17-1	Gd	3	8	1	0.4
18-2	Gd	30	5	8	6.0
18-4	Gd	12½	10	1	1.3
18-5	Gd	25	12	2	2.0
18-7	Gd	5	18	--	0.3
19-3	Gd	350?	--	6	--
21-1	Gd	15	4	3	3.8
23-1	Pc	6	56	2	0.1
28-1	Gd	30	20	6	1.5
40N 31W 24-1	Pa	15	3	1	5.0

Table 3.--Pump Test Results.--(Continued)

Well Number	Aquifer Pc = Precambrian Pa = Paleozoic Gd = Glacial drift	Yield (gal/min)	Drawdown (feet)	Duration of test (Hours)	Specific Capacity (gal/min/ft/ drawdown)
41N 30W 4-1	Pc	15	20	2	0.8
32-1	Pc	10	100	2	0.1
42N 29W 22-3	Gd (sand)	15	4	2	3.8
26-1	Pc	3	35	1	0.08
31-1	Pa	300	26	96	11.5
34-1	Pc	12	10	2	1.2
42N 30W 4-1	Pc	5	0	3	5.0
7-1	Pc	10	4	2	2.5
18-1	Gd	3	6	1	0.5
32-1	Gd	15	0	2	15.0
43N 27W 28-1	Pa	4	18	2	0.2
43N 28W 23-2	Pa	20	5	2	4.0
23-4	Pa	9	6	1	1.5
43N 30W 29-2	Pc	14	15	5	0.9
34-1	Gd	12	10	4	1.2
44N 28W 10-1	Gd	25	3	2	8.3
44N 30W 23-3	Pc	15	20	2	0.8
33-1	Gd	30	6	1	5.0

on geologic information. These maps show only areas generally favorable or unfavorable for obtaining a given amount of water. For example, an indication that an area will yield enough water for a domestic supply means the probability of a successful well is better than a fifty-fifty chance. It does not mean every well drilled will be successful. Conversely, an indication that an area will not yield enough water for domestic supplies does not mean every well drilled in the area will be a failure. Map 4 (in pocket) shows the locations of wells mentioned.

In this report water supplies are classified as follows:

	gal/min
Domestic	at least 1
Small	1 to 9
Moderate	10 to 100
Large	over 100

Glacial Aquifers

Glacial aquifers are the major source of ground water in the county (map 1). Most wells obtain water from sand and gravel, although some obtain small amounts of water from till. Capacities of drift wells range from less than 1 to more than 300 gpm per foot of drawdown (table 3). Thickness of glacial materials varies from a few inches to more than 150 feet. The surface of the bedrock beneath the drift is irregular, especially where the bedrock is of Precambrian age. In some instances a well may penetrate more than 100 feet of glacial materials, while nearby, another well may encounter bedrock at a depth of only a few feet.

Sand and Gravel

Sand and Gravel includes outwash and kames associated with end moraines.

Outwash consists of sediments deposited by braided streams and sheet runoff of meltwater issuing from the glacier front and is composed chiefly of stratified sand and gravel with some silt and clay. They are generally extensive, flat or gently sloping areas, referred to as "outwash plains". They may be pitted and irregular, however, where isolated blocks of ice were buried by outwash. Subsequent melting caused depressions which form many of today's "pit lakes".

Kames were laid down by meltwaters in contact with the glacier front, therefore, are closely associated with moraines. Like outwash, they are composed chiefly of stratified sand, gravel, silt, and clay, but they may also contain large pockets of unsorted till and boulders. Unlike outwash, beds of sand and gravel pinch out in short distances. Kame deposits are characterized by rounded or conical hills which merge with the rolling hills underlain by till.

Large-diameter wells (more than 12 inches) along major streams may yield more than 100 gpm. Most small-diameter wells will yield enough water for a modern domestic supply (at least 1 gpm). Some wells will fail to yield even 1 gpm because of relatively impermeable or thin drift. Most favorable sites are on low terraces, in valleys and along streams as far removed as possible from exposures of bedrock.

Till

Till includes both end moraines and till-plain deposits. End moraines are ridgelike accumulations of drift built up along the margin of the ice sheet. Till plains are flat or gently rolling deposits formed under the ice or where it did not form well-defined end moraines. Till is composed chiefly of unsorted, unstratified mixtures of sand, silt, clay, and stones. Small pockets of stratified sand and gravel are often present, but are minor in extent. Till was dumped directly from the melting ice with little or no transpiration by meltwater.

Only a few wells will yield more than 10 gpm. About half of the small-diameter wells will yield enough water for a modern domestic supply. Because of larger infiltration area and storage capacity, dug wells may be more successful in these deposits than drilled or driven wells. Many wells will fail to yield enough for a domestic supply because of relatively impermeable or thin drift.

Sandy Till (with pockets of sand and gravel)

Sandy Till (with pockets of sand and gravel) includes sand and gravel deposits associated with end moraines. Till consisting of a high content of sand is the predominant material in these areas, but pockets of sand and gravel are important locally. The topography is characterized by rolling hills.

Large-diameter wells located in valleys along streams or near lakes may yield as much as 100 gpm. Because the beds of sand and gravel generally are of small areal extent, water levels may decline more rapidly than would be expected in the more extensive outwash aquifers. Most small-diameter drilled and driven wells will yield enough water for a modern domestic supply. Some wells will fail to yield enough for a domestic supply because of relatively impermeable drift or bedrock at shallow depth.

Swamp Deposits

Swamp Deposits include peat and muck generally confined to flat lowland areas bordering streams and lakes and former lakes, originating subsequent to glaciation.

Large-diameter wells penetrating thick deposits of sand and gravel beneath the swamp deposits may yield more than 100 gpm. Most small-diameter wells will yield enough water for a modern domestic supply. Some wells may fail to yield enough for a domestic supply because of relatively impermeable or thin drift.

Bedrock Areas

Bedrock is either at the surface or encountered within a few feet of the surface. Some wells located in valleys along streams may obtain enough water from the drift for domestic purposes, but most will fail to obtain enough for even a hunting camp. If a well in the drift fails to yield water, possibly a small supply may be obtained by deepening the well a few feet into the underlying bedrock.

Bedrock Aquifers

The bedrock aquifers of Dickinson County include igneous, metamorphic, and sedimentary rocks (map 2). Bedrock is an important source of water in the eastern part and in isolated areas in the central part, but generally yields only small amounts elsewhere.

Precambrian rock formations occur, either at the surface or beneath the drift, throughout most of the county west of the eastern tier of townships (Range 27 West). Granite, schist, and gneiss predominate from the north-central to south-central parts. The remainder of the Precambrian area consists mostly of slates, quartzites, and volcanics.

Paleozoic sandstones and dolomites underlie the glacial drift in almost all of the eastern tier of townships (Range 27 West), parts of Range 28 West, and crop out or underlie the drift in small isolated patches in the central part.

Precambrian Aquifers

In many areas small quantities of water for domestic supplies are obtained at shallow depth from fractured and weathered Precambrian rocks. Capacities as high as 5 gpm per foot of drawdown have been reported, but most are less than 1 gpm per foot (table 3). Chances of obtaining water decrease with depth, and it is usually considered hopeless to drill more than 100 feet into these rocks. In faulted areas sandstone, apparently filling cracks and fissures at depths of several hundred feet (James and others, 1961), may produce enough water for a domestic supply, but the chances of encountering them are extremely small. Furthermore, any water obtained might be highly mineralized.

Other things being equal, there is a better chance of obtaining ground water from Precambrian rocks in valleys than on the highlands because weathered and fractured rock is more likely to occur below the water table in the valleys. Highland areas where Precambrian rocks crop out or are covered by a few feet of soil are the least favorable for obtaining ground water.

In upland areas where Precambrian bedrock is at or near the surface most wells in bedrock will fail to obtain enough water for a modern domestic supply. In valleys or along streams where bedrock is covered by more than 20 feet of permeable drift, wells drilled a few feet into the bedrock may yield enough water for a modern domestic supply, and a few may yield more than 10 gpm. Drilling over 100 feet into Precambrian formations is usually futile.

Paleozoic Aquifers

Small to moderate supplies of water are obtained from wells in sandstones and dolomites of Cambrian and Ordovician age in the eastern part of the county and in isolated areas in the central part. The reported yields of most wells in the Paleozoic aquifers are 20 gpm or less, but these yields generally represent the capacities of the pumps, not the potential of the wells. Probably most large-diameter wells drilled more than 50 feet into the Paleozoic bedrock would be capable of yielding as much as 50 gpm. A twelve-inch diameter well in section 31, T. 42N., R. 29W. yielded 320 gpm from sandstone. This well was pumped at a rate of 300 gpm for four days with a drawdown of about 26 feet (table 3). Reported capacities of other wells ranged from 0.2 to 5 gpm per foot of drawdown.

The base of the Paleozoic is in contact with the top of the Precambrian. The Paleozoic formations range in thickness from a feather-edge along their western margin to perhaps 100 feet or more in places along the eastern county line. Isolated outliers, as near Randville and Felch, have the same range of thickness.

Most wells drilled into the dolomitic formations will yield enough water for a modern domestic supply. Large-diameter wells drilled more than 50 feet into the dolomite rocks may yield as much as 50 gpm. Wells penetrating the underlying sandstones may yield over 100 gpm.

Most wells drilled into the sandstone will yield enough water for a modern domestic supply. Large-diameter wells drilled more than 50 feet into sandstone beds may yield more than 100 gpm. Some wells in bedrock will fail because impermeable shale or Precambrian rocks are encountered at shallow depth.

Ground-Water Storage

Ground water is stored in intergranular openings in glacial aquifers and in fracture openings in Precambrian formations. In sandstones water may be stored in both intergranular and fracture openings. The amount of water in storage in an aquifer varies. Fluctuations in storage are reflected in fluctuations in water levels in wells -- the water levels being high when storage is high and low when storage is low. Figure 1 shows fluctuations in water levels in a well in glacial drift.

Water levels rise in early spring with snowmelt. Later, growing vegetation uses much water that would otherwise pass down to the water table, and water levels decline. A secondary rise may occur in the fall after the vegetation dies, but before the ground is frozen. As winter advances most of the precipitation accumulates on the ground as snow, and water levels again decline until the spring thaws.

Unusually heavy rains may cause a rise in water table at any time -- especially where the water table is at shallow depth. In areas where the water table is more than 50 feet below land surface the effect of heavy rains are noticeably delayed. High water levels generally are associated with wet years and low water levels with dry years. However, the intensity of rainfall and the seasonal distribution and rate of snowmelt also affect the rate of recharge and, consequently, the elevation of the water table. There is no evidence of a long-term rise or fall in ground-water levels in unpumped areas of Dickinson County.

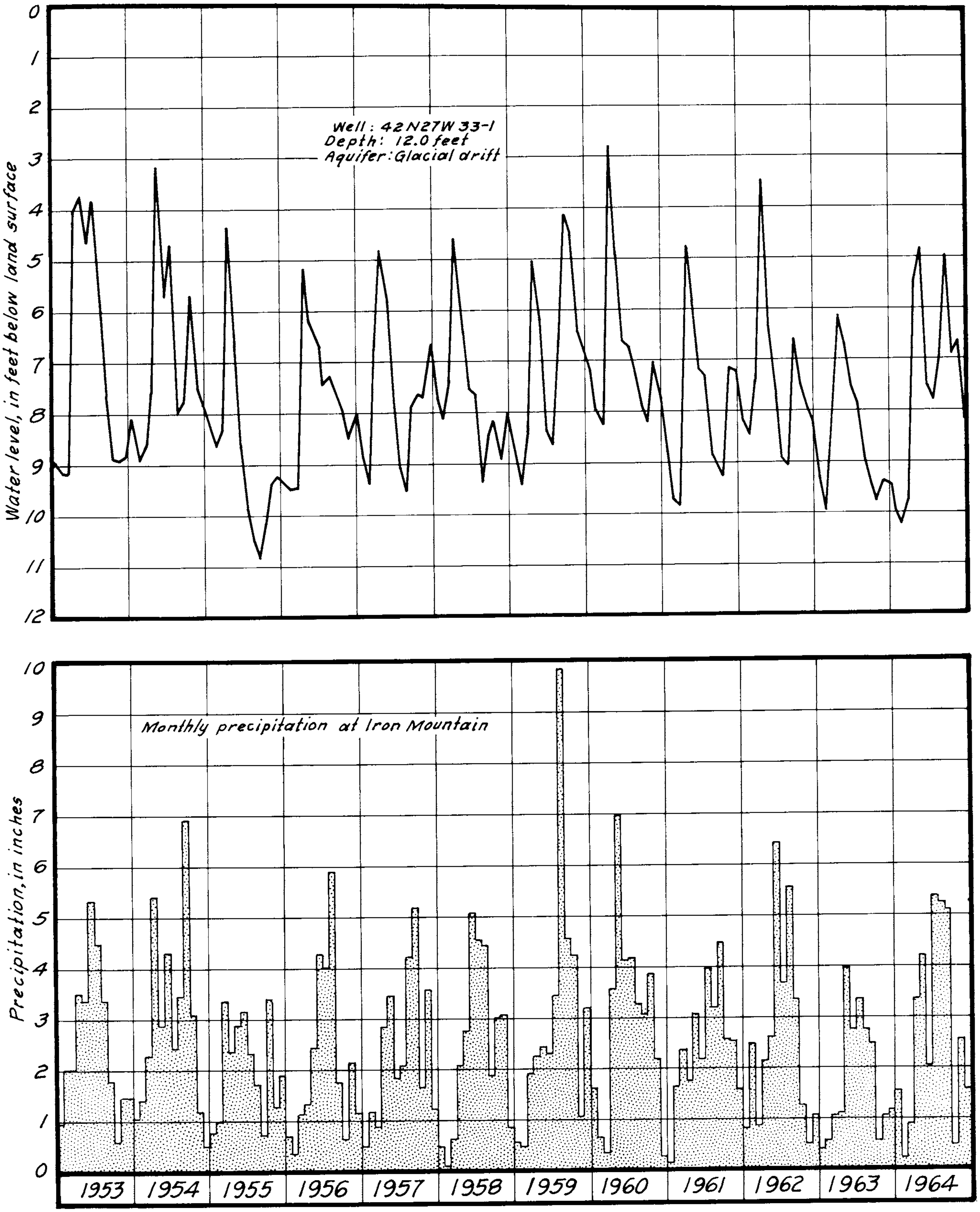
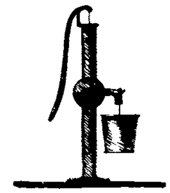


FIGURE 1. RELATIONSHIP OF PRECIPITATION TO WATER LEVELS IN A WELL DRILLED IN GLACIAL DRIFT.



QUALITY OF WATER

Water obtained from most wells in Dickinson County is suitable for household use and for most other uses (tables 4 and 5). Although the water is generally hard to very hard and, in some places, contains undesirable amounts of iron, household water-treatment systems can usually improve the quality to satisfactory standards. Water from most wells ranges in hardness from 150 to 250 ppm. A few wells and springs yield water with a hardness greater than 300 ppm. The iron content of water from wells in both drift and bedrock is quite variable, ranging from less than 0.1 to more than 4.0 ppm.

During periods of low flow, stream water is similar to water obtained from shallow drift wells except stream water generally is somewhat softer and has less iron content (table 6). The quality of water in lakes ranges widely. In most lakes having surface outlets, the quality is similar to stream water. Lakes without outlets generally have very soft water with hardness less than 20 ppm. Also the pH of such lakes usually is less than 7.0, indicating that the water is slightly acid.

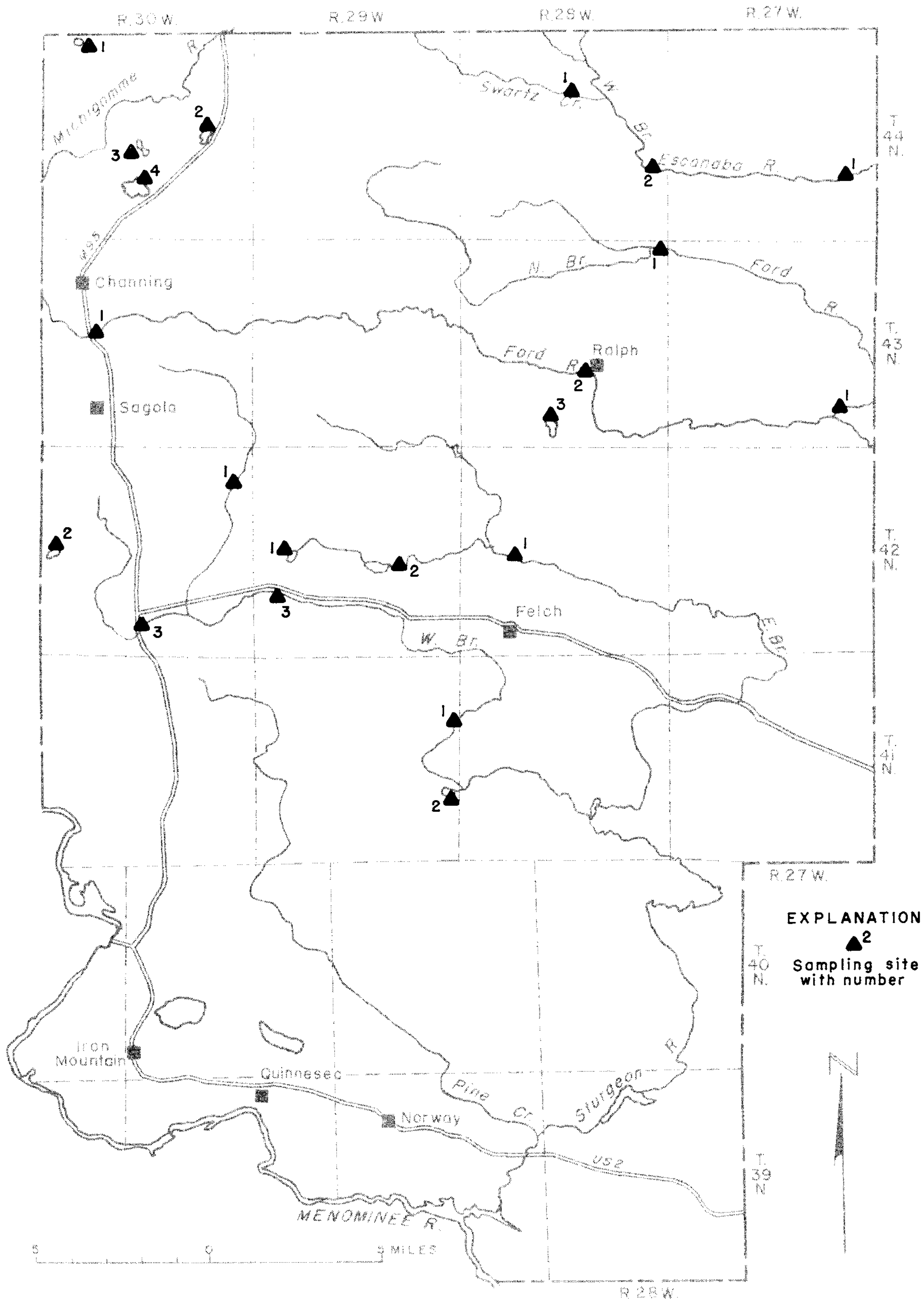


FIGURE 2. SAMPLING POINTS FROM STREAMS AND LAKES USED FOR CHEMICAL ANALYSES OF WATER.

TABLE 4.--LABORATORY ANALYSES OF WELL WATER

(By U. S. Geological Survey and Michigan Dept. of Health)

Well Number	Aquifer	Date Collected	Analyst	Chemical constituents in parts per million: Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness ($CaCO_3$)	Specific Conductance (Micromhos @ 25°C)	pH
44N 28W 10-1	Gd	7/31/64	USGS	----	--	--	----	184	19	1.5	0.1	---	189	314	8.1
43N 30W 29-3	Gd	1959	MDH	0.75	66	33	7.2	322	30	13	----	335	300	---	---
43N 30W 9-2	Pc	8/ 5/64	USGS	----	--	--	----	261	14	2.5	0.1	---	222	414	7.8
42N 28W 35-2 (Spring)	Gd	9/15/64	USGS	----	--	--	----	292	19	4.5	4.6	---	303	501	8.4
42N 28W 29-1	Pc	9/11/64	USGS	----	--	--	----	252	13	5.0	0.2	---	202	413	7.8
42N 27W 20-1	Pa	9/14/64	USGS	----	--	--	2.1	262	29	1.5	0.1	---	275	447	7.4
40N 30W 31-1	Gd	10/6/64	USGS	----	--	--	----	404	65	15	3.8	---	468	746	7.6
39N 30W 3-1	Gd	8/14/58	MDH	0.00	72	00	14.1	282	37	23	31	400	320	640	7.4
39N 28W 14-1	Gd	5/14/64	USGS	----	13	36	14.2	159	45	6	----	231	223	391	8.5
39N 28W 19-3	Pc	5/14/64	USGS	----	34	31	20.3	250	25	13	----	257	221	469	7.9

Pc = Precambrian
Pa = Paleozoic
Gd = Glacial drift

TABLE 5.--FIELD ANALYSES OF WELL WATER

Well Number	Aquifer Pc=Precambrian Pa=Paleozoic Gd=Glacial drift	Date	Hardness ($CaCO_3$)	Iron (Fe)	Specific Conductance (Micromohs at 25°C)	pH	Temperature (°F)
44N 30W 23-1	Pc	10/21/64	140	0.7	260	8.0	--
33-1	Gd	10/19/64	240	0.2	375	7.5	--
44N 28W 27-1	Gd	9/9/64	190	---	240	---	--
43N 30W 11-1	Pc	8/5/64	170	< 0.1	290	7.5	--
43N 29W 11-1 (Spring)	Gd	8/10/64	190	---	320	6.9	--
43N 28W 23-3	Gd	8/5/64	240	0.5	380	7.5	--
43N 27W 28-1	Pc	10/23/64	270	0.2	440	7.5	48
42N 30W 2-1	Pc	10/18/64	150	0.3	260	7.0	49
4-1	Pc	10/16/64	340	< 0.1	590	7.0	48
18-2	Pc	10/15/64	210	0.2	325	8.0	--
24-1	Pc	10/16/64	130	4.0	215	7.5	46
33-1	Pc	10/15/64	320	< 0.1	700	7.0	51
33-2	Pc	10/15/64	230	< 0.1	410	7.5	47
42N 29W 19-1 (Spring)	Gd	10/21/64	270	< 0.1	450	8.0	--
22-1	Gd	10/14/64	380	< 0.1	700	6.5	54
22-2 (Flows)	Gd(?)	10/14/64	260	< 0.1	510	7.5	42
31-1	Pa	11/18/64	220	< 0.1	420	7.0	--
33-1	--	10/7/64	290	< 0.1	410	7.0	53
42N 28W 5-5	Pa	10/23/64	220	0.7	320	7.5	45
32-1 (Spring)	Gd	9/17/64	640	---	1580	6.8	47
42N 27W 20-1	Pa	9/14/64	290	1.5	395	7.0	45
32-2	Pc	9/14/64	140	< 0.1	300	7.5	--
41N 30W 16-1	Gd	11/18/64	150	0.2	300	8.0	--
25-3	--	11/19/64	240	< 0.1	400	7.5	--
32-1	Pc	11/19/64	270	0.1	500	7.5	--

Table 5.--Field Analyses of Well Water.--Continued

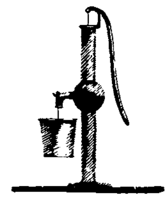
Well Number		Aquifer Pc=Precambrian Pa=Paleozoic Gd=Glacial drift	Date	Hardness ($CaCO_3$)	Iron (Fe)	Specific Conductance (Micromohs at 25°C)	pH	Temperature (°F)
41N 28W	8-1	Pa	11/6/64	220	< 0.1	360	7.5	48
	8-2	Gd	11/6/64	260	< 0.1	400	7.5	47
	28-1 (Spring)	Gd	11/13/64	220	0.3	325	7.5	47
	34-1	Gd	11/13/64	140	0.5	230	7.5	47
41N 27W	9-1	Pa	10/5/64	260	2.0	675	7.5	--
40N 30W	5-1	Gd(?)	12/10/64	150	---	275	8.0	51
	6-1	Gd	1964	260	< 0.1	---	7.5	56
	14-1	Pc(?)	1964	290	0.1	580	7.5	49
	14-2	--	12/14/64	240	1.5	420	7.5	48
	20-1 (Flows)	--	1964	220	0.1	385	7.0	49
	23-1	Pc	1964	300	0.2	500	7.5	--
40N 29W	6-2	Gd	9/11/64	240	0.2	---	8.0	--
40N 28W	10-1	Pc	12/9/64	270	< 0.1	640	8.0	47
39N 29W	2-1	Gd	1964	---	---	480	---	50
	14-2	Gd	12/15/64	170	0.1	340	7.5	--
	15-1	Gd	12/15/64	260	1.5	420	7.5	--
	20-1	Gd	1964	---	---	335	---	49
	22-1	Gd	1964	250	0.2	460	---	53
	26-1	Pc	1964	---	---	435	---	51
	36-1	Pc	1964	---	---	525	---	53
	36-2	--	1964	---	---	425	---	51
39N 28W	16-1	Pc	1964	---	---	380	---	50
	24-1	Pa	9/16/64	---	---	540	---	51
	30-8	Pc	12/15/64	310	< 0.1	480	7.5	--
	35-1	Pa	1964	---	---	660	---	53

(< = Less than)

TABLE 6.--ANALYSES OF SURFACE WATER

Source	Date	Field number	Specific Conductance (Micromhos at 25°C)	Hardness ($CaCO_3$)	Dissolved Oxygen	pH	Temperature (°F)
Streams:							
Swartz Creek below dam	9/18/64	44N 28W-1	230	140	8.4	7.3	53
West Br. Escanaba River	9/17/64	44N 28W-2	---	150	10.0	8.0	46
West Br. Escanaba River	9/17/64	44N 27W-1	---	150	10.0	7.5	--
Ford River at M95 bridge	9/17/64	43N 30W-1	300	190	10.0	7.3	52
North Br. Ford River	9/17/64	43N 28W-1	---	190	9.5	8.0	46
Ford River at Ralph	9/17/64	43N 28W-2	287	190	9.6	7.5	47
Ford River at Alfred	9/16/64	43N 27W-1	---	200	10.8	8.0	49
N. Br. of W. Br. Sturgeon River	10/8/64	42N 30W-1	300	200	----	7.5	45
West Br. Sturgeon River	10/16/64	42N 30W-3	285	200	----	7.5	47
Six Mile Creek	10/7/64	42N 29W-2	275	150	----	7.5	46
West Br. Sturgeon River	10/16/64	42N 29W-3	300	210	----	7.5	48
West Br. Sturgeon River	10/14/64	42N 28W-1	285	170	----	8.0	54
West Br. Sturgeon River	11/6/64	41N 29W-2	250	150	----	7.5	--
Lakes with outlets:							
Pickerel Lake	10/23/64	43N 28W-3	320	190	----	8.0	--
Solberg Lake	10/16/64	42N 29W-1	320	220	----	8.0	--
Lyons Lake	11/6/64	41N 29W-2	250	150	----	7.5	--
Lakes with no outlets:							
Coy Lake	10/21/64	44N 30W-1	70	50	----	7.0	--
Silver Lake	10/19/64	44N 30W-2	$\lessdot$ 50	20	----	6.5	--
Edey Lake	10/19/64	44N 30W-3	$\lessdot$ 50	20	----	6.0	--
Sawyer Lake	10/19/64	44N 30W-4	$\lessdot$ 50	20	----	6.5	--
Brush Lake	10/15/64	42N 30W-2	$\lessdot$ 50	20	----	6.0	54

($\lessdot$ = Less than)



WATER MANAGEMENT

Maintaining and improving public water supplies and providing adequate streamflow to dilute sewage and other wastes are the chief activities relating to management of water in Dickinson County at present. Another problem is flooding of iron mines in the southern part. Expected growth and development will add other water management problems.

Public Water Supplies

Iron Mountain

The city of Iron Mountain maintains the largest public water supply system in the county, furnishing water to some 3,000 customers in Iron Mountain, Kingsford, East Kingsford and part of Breitung Township. During 1964, daily pumpage averaged nearly 1.5 million gallons (fig. 3) of both ground water and surface water. In summer, cooler water is obtained from an abandoned mine shaft, but during winter Lake Antoine supplies softer water. The mine shaft is 2,300 feet deep, with the pump set 90 feet below the surface. During August, 1964, temperature of the water from the shaft averaged 48°F., with a hardness of 310 ppm softened to about 85 ppm.

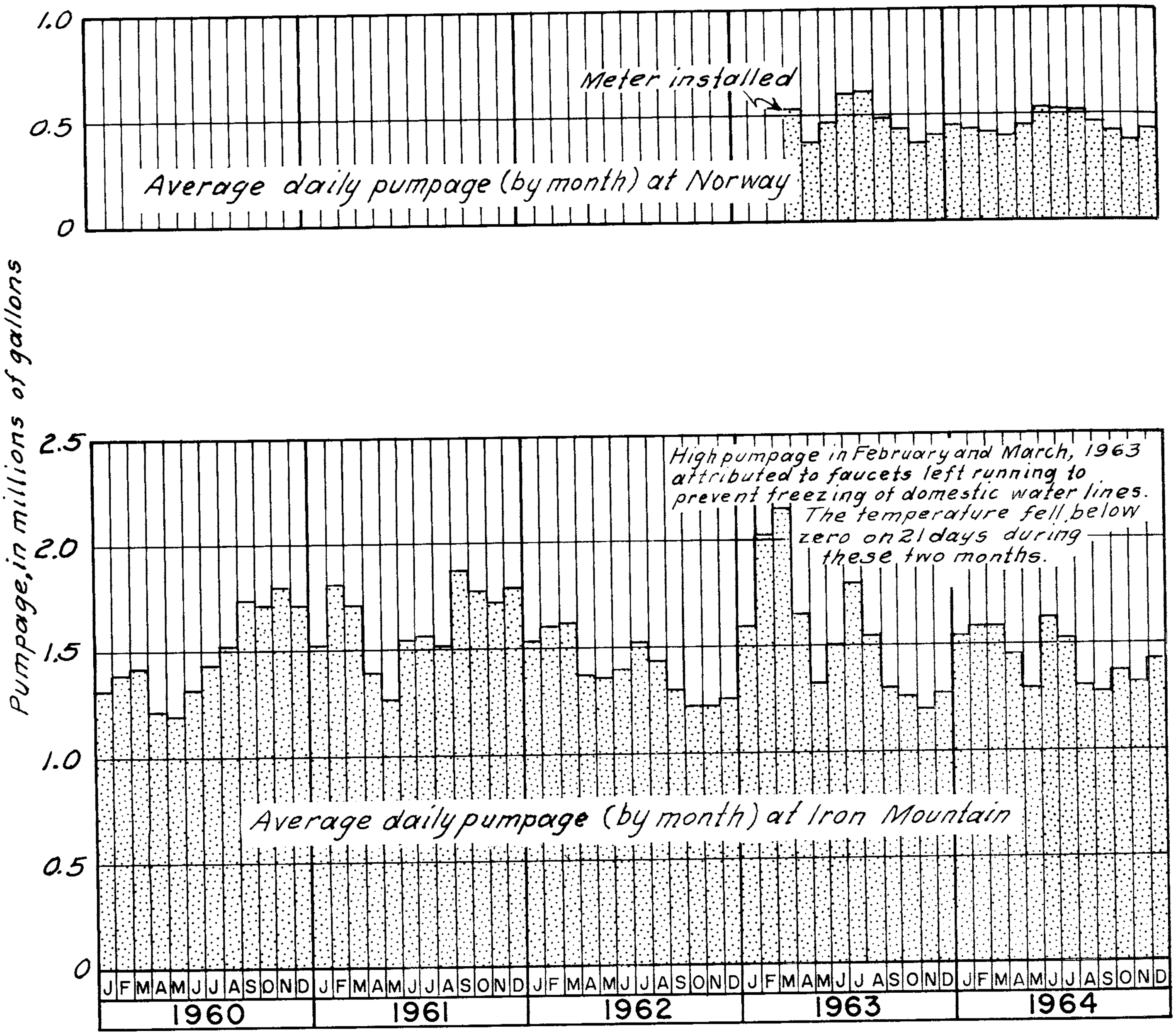


FIGURE 3. AVERAGE DAILY PUMPAGE (BY MONTH) AT IRON MOUNTAIN AND NORWAY.

Analysis of Water at Iron Mountain
(by City of Iron Mountain)

	Hamilton Shaft August, 1964	Lake Antoine April, 1964
Temperature, °F	48.05	39
pH	7.4	7.3
Free CO_2, ppm	229	----
Calcium (Ca), ppm	52.8	36.8
Magnesium (Mg), ppm	43.4	27.2
Noncarbonate hardness, ppm	23.8	9
Total hardness, ppm	310.3	206
Iron (Fe), ppm	0.0	0
Color	----	3
Turbidity	----	1
Odor	----	Musty smell @ 60°C
Alkalinity	----	197

Norway

The city of Norway furnished water to about 1,380 customers within the city and adjoining areas. Prior to 1959, water was obtained from both Lake Fumee and two wells near the lake. Water from the wells was harder than the lake water. The wells were abandoned in 1959.

Analysis of Municipal Water at Norway, July, 1952
(by Michigan Department of Health)

	parts per million	
	Wells	Lake
Total solids	240	196
Silica (SiO_2)	7.2	4
Iron (Fe)	.18	0
Sodium & potassium (Na + K)	2.3	3.8
Chloride (Cl)	Trace	Trace
Sulphate (SO_4)	19.2	15.1
Fluoride (F)	.15	.15
Hardness ($CaCO_3$)	228	178
Bicarbonate (HCO_3)	260	211
Calcium (Ca)	50	36.5
Magnesium (Mg)	25.2	21.6

During 1964, a little over 169 million gallons of water was metered at the municipal pumping station (fig. 3).

Breitung Township

Two 125- to 160-foot wells located in Quinnesec supply water for about 160 families in Breitung Township. The wells obtain water from the glacial drift.

Field Analysis of Water in Breitung Township, February 8, 1965

Specific conductance, micromhos @ 25°C	590
Chloride (Cl), ppm	30
Hardness ($CaCO_3$), ppm	500
Iron (Fe), ppm	<0.1
pH	7.5

Sagola Township

Sagola Township supplies water to approximately 50 customers in the town of Sagola. Water is from a 6-inch well 115 feet deep, probably tapping glacial gravels.

Analysis of Water in Sagola Township, August, 1959

	parts per million
Total solids	335
Silica (SiO_2)	13
Iron (Fe)	0.75
Calcium (Ca)	66
Magnesium (Mg)	33
Sodium & Potassium (Na + K)	7.2
Chloride (Cl)	13
Sulphate (SO_4)	30
Bicarbonate (HCO_3)	322
Total hardness ($CaCO_3$)	300
Fluoride (F)	0

Channing 4-H Club

In 1951 the Channing 4-H Club tried to develop a ground-water supply at their camp on Sawyer Lake. A 6-inch well encountered some water in the drift at a depth of about 65 feet. The quantity was insufficient so drilling continued until bedrock was reached at about 185 feet. The zone of fine sand, just above the rock, appeared capable of supplying an adequate amount of water; however, the sand was mixed with fine silt, and the water would not clear up. Even after extensive pumping, silt continued to cause malfunctioning of the system. Therefore, the well was abandoned and a chlorinator installed to make use of Sawyer Lake.

Industrial Water Supplies

In 1951 the Hanna Mining Company drilled a well at their Groveland Mine to test whether sufficient water was available to supply part of the needs of an iron ore beneficiation plant. Several more wells were drilled during 1957 and 1958, none of which indicated quantities sufficient to meet their needs. One of these wells was test pumped at slightly more than 300 gpm and is now used as the domestic supply in the mine buildings. On September 28, 1960, the Michigan Water Resources Commission issued a permit to divert not more than 4,500 gpm from the West Branch of the Sturgeon River. After the water is used in the mill, it passes into two large settling ponds; part is returned to the mill for re-use, while part flows into Pine Creek which joins the Sturgeon River several miles downstream from the point of the original diversion.

Mine Flooding

The southern part of Dickinson County contains many abandoned iron mine shafts and pits. When the mines were operating, a system of sumps and pumps was maintained to remove water seeping into working areas. After the mines were abandoned, water began to rise in the shafts to the extent that it now poses problems in some areas.

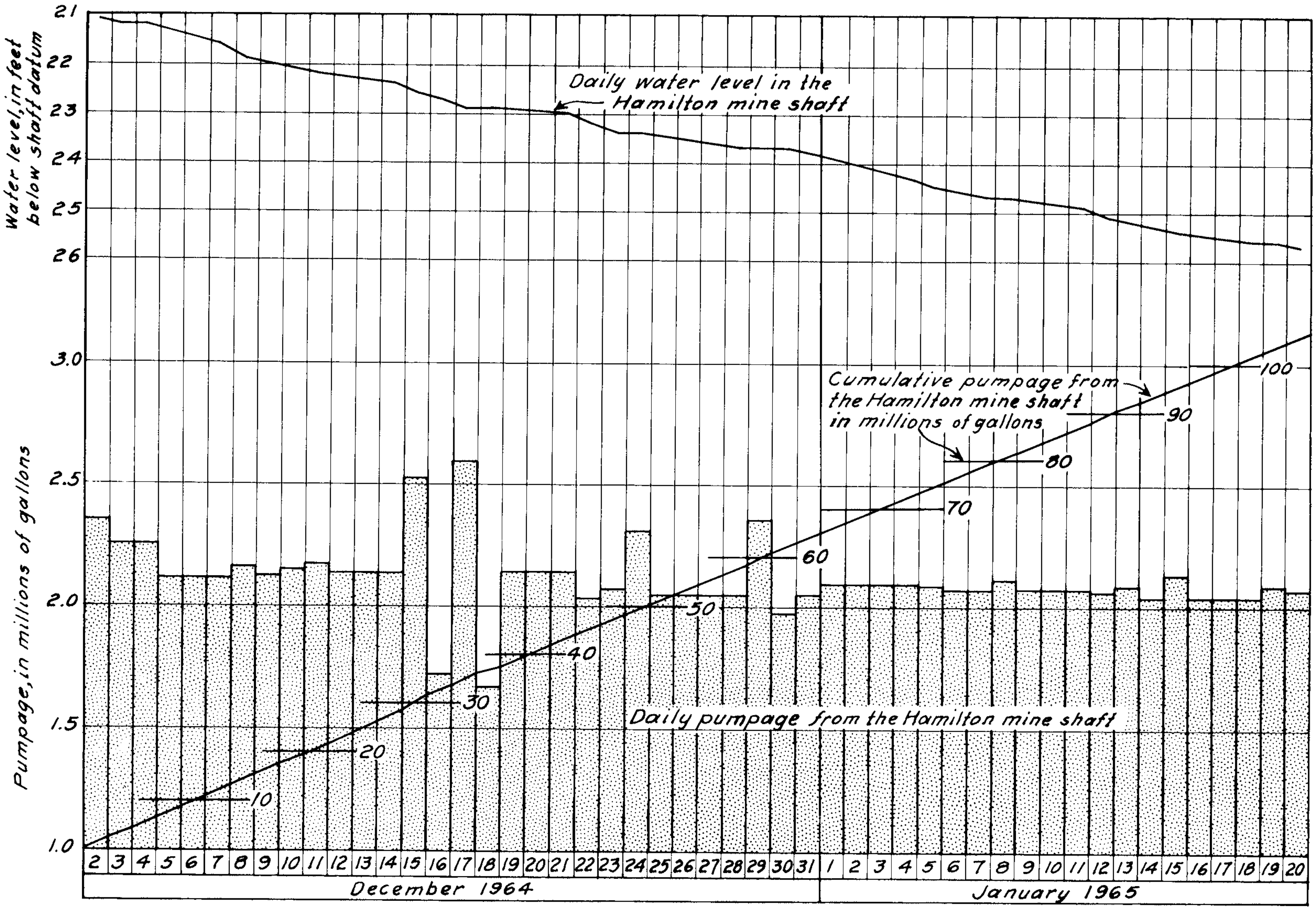


FIGURE 4. DAILY PUMPAGE AND WATER LEVELS IN THE HAMILTON SHAFT.

Iron Mountain

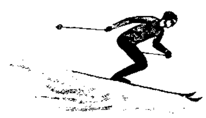
Water in the 2,300-foot deep Hamilton Shaft of the Chapin Mine has risen high enough to raise the water table and cause flooding of basements and storm drains in the northeast part of town. To relieve this situation and improve the water supply, the city pumps over a million gallons a day from the shaft into its water plant during the summer. In the winter, about two million gallons a day are pumped from the shaft into Lake Antoine. This procedure maintains the water at a safe level in the shaft and replaces water drawn from Lake Antoine into the city system (fig. 4).

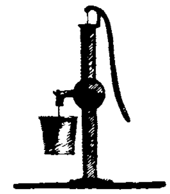
Norway

The mines at Norway were abandoned in 1945. Waters rose in the shafts and overflowed into the glacial drift, flooding low areas on the southwest side of the city. During December of 1949, as much as two feet of water entered basements not equipped with sump pumps. To relieve this flooding, the city installed a pump at 75 feet in the Aragon mine shaft. Present withdrawal is about 2,000 gpm. East of this shaft are other shafts and pits having water levels responding to pumping in the Aragon. One of these open-pit depressions, dry until 1948, had an estimated water depth of one hundred feet in 1951. However, pumping from the Aragon shaft has no visible effect on the water levels in shafts and pits farther east toward Vulcan, nor does it appear to affect the level of Hanbury Lake about a mile and a half southeast. By maintaining a 2,000 gpm rate of pumping, flooding can be held to a minimum. The water from the mine is extremely hard, but otherwise of fair quality. It is pumped into a small creek upstream from the city sewer outlet, thus diluting the sewage in the stream.

Field Analysis of Water from Norway Mine Shaft, February 8, 1965

Specific conductance, micromhos @ 25°C	725
Chloride (Cl), ppm	25
Hardness ($CaCO_3$), ppm	450
Iron (Fe), ppm	0.1
pH	7.0



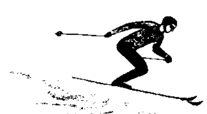


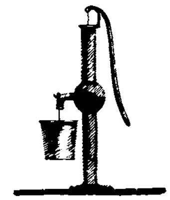
FUTURE NEEDS

Although the county has ample water for current needs, local problems may arise as a result of uneven distribution of supplies and possible conflicting demands. Additional development of water supplies will surely be needed to accommodate any large expansion of population and industrial development.

All sources of water in the county -- lakes, streams, and ground water -- are related to each other. Development of one source may influence the availability from another source. For example, development of new well fields along a stream may reduce the flow of the stream so that it is no longer adequate for waste disposal or for recreational use. Or, diversion of water from a lake may lower the water table so that the yield of nearby wells is decreased. Development of any source of water in the county should be guided by knowledge of the probable consequences of the development on that source as well as on all other sources.

Management decisions must be based on a thorough knowledge of streamflow, ground-water levels, lake levels, and quality of water obtained from reliable records. Also needed are data on water use, ground-water pumpage, surface-water diversions, and waste disposal. When collected over a sufficient period, these records provide more reliable information on the effects of future development than any intensive short-term study.





SUMMARY AND CONCLUSIONS

Dickinson County has abundant, though unevenly distributed, ground-water resources in glacial and bedrock aquifers. In some areas, wells in glacial drift or in sandstones of Cambrian or Ordovician age will yield several hundred gpm, while in other areas obtaining the few gpm needed for a domestic supply is difficult or impossible.

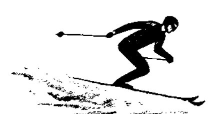
The most favorable areas for obtaining large supplies of water from wells are the sand and gravel deposits along major streams. The least favorable areas are where Precambrian crystalline rocks crop out or are covered by only a few feet of glacial drift.

Most wells are 5 to 6 inches in diameter, 25 to 100 feet deep, and constructed by drilling.

Well water is mostly hard to very hard, locally containing undesirable amounts of iron, but otherwise suitable for domestic and other uses. Household water treatment methods generally improve quality to satisfactory standards.

Public water supplies are obtained from lakes, wells, and an abandoned mine shaft.

Future expansion of population and industry in Dickinson County may bring water problems caused by uneven distribution of supplies and conflicting demands. Long-term records of streamflow, ground-water levels, lake levels, and quality of water from streams, lakes and wells will be needed to cope with future needs.



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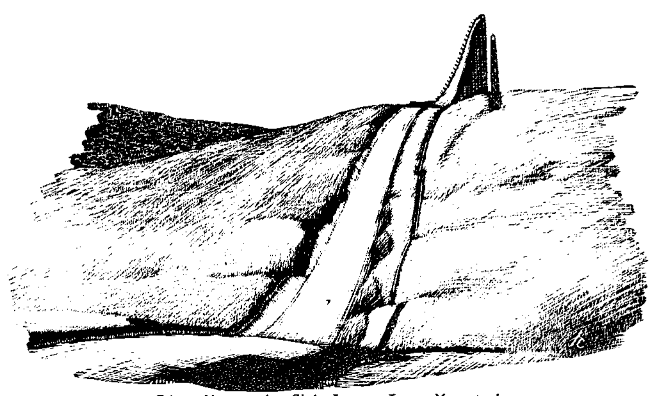

Pine Mountain Ski Jump, Iron Mountain

Table 1.--Well Records

Explanation

Wells are identified according to their geographical township location, for example, "44N 30W 23-1 SE NE" refers to well #1 situated in the southeast quarter of the northeast quarter of section 23, of Township 44 North, Range 30 West. Altitudes are estimated from topographic maps.

Pc .... Precambrian
Pa .... Paleozoic
Gd .... Glacial Drift

D .... Domestic
S .... Stock
P .... Public supply

I .... Industrial
O .... Observation

Well Number	Location in section ¼ ¼	Owner	Driller	Date drilled	Diameter	Depth	Aquifer	Use	Water level	Date	Altitude	Depth to bedrock	Remarks
44N 30W													
23-1	SE NE	Joe Dault	Anderson	1962	6	87	Pc	D	64	1962	1430	---	
23-2	SW NE	Joe Dault	Kleiman	1957	6	69	Pc	P	22	3-15-57	1420	60	
23-3	NE NE	E. J. DeGaynor	Kleiman	1958	6	79	Pc	D	13	6- 2-58	1420	68	
28-1	SE NE	Dick. Co. 4-H Club	Anderson	1951	6	185	Pc	P	110	8-13-51	1420	170	Well abandoned because of excessive silt. Cased to 170 feet.
33-1	NE NE	Bert Buckland	Kleiman	1962	3	71	Gd	D	32	7-16-62	1400	---	Cased to 68 feet.
44N 28W													
10-1	SE SW	Casper Uldriks	Kleiman	1962	3	59	Gd	D	36.27	7-30-64	1280	---	
27-1	SE SW	Ceasar Aimone	Owner	1934	60	13	Gd	D	11.16	9- 9-64	1260	---	
44N 27W													
17-1	NW SW	J. McGreger	Kleiman	1956	6	43	Gd	D	22	6- 9-56	1240	---	
43N 30W													
9-1	SW NW	O. Peterson	Anderson	----	5	28	Gd	D	18	----	1420	---	
9-2	NW SE	Lawrence Carey	Tuominen	1960	6	107	Pc	D	34	1960	1360	102	Cased to 102 feet.
11-1	NE SW	Fred Janus	Kleiman	1963	6	68	Pc	D	41	6-13-63	1360	18	Cased to 20 feet.
29-1	NE NE	F. Van Gilder	Anderson	1950	5	73	--	D	38	1950	1410	---	Cased to 66 feet.
29-2	SW SE	Amos Dishaw	Glass	1934	6	69	Pc	D	38	9-24-63	1480	40	
29-3	SE SE	Sagola Township	--------	1923	6	115	Gd	P	------	----	1440	---	Supplies 50 families.
30-1	SW SE	E. Johnson	Chiocchi	----	5	196	Pc	D	40	----	1530	40	Cased to 40 feet.
34-1	NW SW	Edgar Erickson	Kleiman	1960	5	93	Gd	D	20	7-27-60	1360	---	
43N 29W													
36-1	NE NW	--------	--------	1963 (?)	1¼	12	Gd	D	5.87	8-13-64	1180	---	
43N 28W													
23-1	NW SE	Paul Mariucci	Chiocchi	----	5	42	Pa	D	15	----	1190	22	Cased to 22 feet.
23-2	NE SW	John Cominsky	Kleiman	1959	5	60	Pa	D	31.19	3-18-64	1190	40	
23-3	NW SW	Gilbert J. Johnson	Owner	1963	1¼	28	Gd	D	4	11-11-63	1140	---	
23-4	SE SW	Norman Karstem	Kleiman	1961	3	49	Pa	D	44.47	8-24-64	1220	41	Cased to 45 feet.
23-5	SW SE	--------	--------	----	1¼	14	Gd	D	8.74	7-30-64	1200	---	Well abandoned.
27-1	SE NW	Sam Eutizzi	Chiocchi	----	5	62	Pa	D	30	----	1185	---	Cased to 22 feet.
43N 27W													
28-1	SE SE	Joseph Turini	Kleiman	1963	3	47	Pc	D	8	1963	1160	42	Cased to 42 feet.
42N 30W													
2-1	SE SE	Ron Koller	Kleiman	1964	4	30	Pc	D	18	2- 4-64	1320	13	Cased to 16 feet.
4-1	NE SW	Donald Johnson	Kleiman	1961	5	42	Pc	D	35	4-27-61	1420	20	Cased to 25 feet.
7-1	SE SW	Don Dario	Kleiman	----	4	59	Pc	D	49	1963	1410	45	
11-1	SW NW	Norman Mainville	Kleiman	1963	6	70	Gd	D	28	6-14-63	1340	---	
18-1	NW SW	John R. Williams	Kleiman	1961	6	32	Gd	D	------	----	1400	---	
18-2	SE NW	Frank Morrell	Chiocchi	----	5	159	Pc	D	------	----	1410	140	
18-3	NE NW	Leo Hart	Kleiman	1964	4	92	Gd	D	67	3-12-64	1390	---	
24-1	NW NE	Paul Richards	Kleiman	1959	5	39	Pc	D	9.31	10-16-64	1320	38	
26-1	SE NE	Herbert Locarelli	Kleiman	1958	6	36	Pc	D	23	9-24-58	1260	20	
28-1	SE SE	Elmer Schowalder	Chiocchi	----	5	203	Pa	D,S	40	----	1260	---	
32-1	NE SE	Clayton Rush	Kleiman	1957	6	133	Gd	D	70	7-25-57	1260	---	
33-1	NE SE	John Horwath	Chiocchi	----	5	105	Pc	P	------	----	1260	---	Cased to 40 feet.
33-2	NE SE	Harry Horwath	Chiocchi	----	5	72	Pc	D	20	10-15-64	1260	---	Cased to 30 feet.
42N 29W													
22-1	NE SE	August Zamboni	Owner	----	24	24	Gd	D	21	10-14-64	1120	---	Dug well.
22-2	NE SE	Watson	--------	----	4	39	--	D	flows	10-14-64	1130	---	
22-3	NE SE	Joe Lajennesse	Kleiman	----	4	28	Gd	D	5	10-15-63	1130	---	
26-1	SE SE	Carlton Cook	Kleiman	1961	6	57	Pc	D	6	5-29-61	1220	45	
30-1	NW SE	M. A. Hanna Co.	Layne NW	1957	12	85	Gd	O	20.05	11-18-64	1260	---	
31-1	NE SE	M. A. Hanna Co.	Layne NW	1951	12	128	Pa	D?	54	4- 2-51	1360	15	Used as domestic supply in iron ore plant.
32-1	SE NE	Roy Leonard	Kleiman	1958	6	38	Pa	D	23.67	3-19-64	1260	18	
32-2	NW SW	M. A. Hanna Co.	Layne NW	1958	10	161	Pc	O	16.01	11-18-64	1320	10	
33-1	NW SE	Einor Helander	T. Rice	1943	4	85	--	D	------	----	1240	---	Had unpleasant taste 1963.
34-1	SW NE	Fabian Steinbrecker	Kleiman	1958	6	82	Pc	D	39	8-12-58	1240	18	
34-2	SE SE	Ronald Bergstrom	Kleiman	1960	6	101	Pc	D	61	4-13-60	1160	52	
42N 28W													
5-1	SE NW	Kenneth Sheldon	Kleiman	1956	6	55	Pa	D	38	9-22-56	1160	15	
5-2	NE SE	Edward Lantz	Chiocchi	----	5	96	Pa	D	42	----	1200	---	Cased to 32 feet.
5-3	NE NW	Oliver Jedvick	Chiocchi	----	5	205	Pc	D	52	----	1160	---	Cased to 175 feet.
5-4	NW NE	--------	Owner	1964	1¼	22	Gd	D	7.06	9-11-64	1160	---	
5-5	NE SE	Roy Lantz	Chiocchi	1964	6	60	Pa	D	30	10-23-64	1180	---	
20-1	NE SW	Rudy Gustafson	Owner	1964	5	67	Gd	D	30	9-11-64	1140	---	Pumps fine silty sand.
29-1	NW NE	Clark Lucas	Chiocchi	1964	5	94	Pc	D	35	9-11-64	1180	---	
35-1	SE NE	Edwin Oman	Kleiman	1958	6	50	Gd	D	13	4-17-58	1120	---	

Table 1.--Well Records.--Continued

Well Number	Location in section ¼	¼	Owner	Driller	Date drilled	Diameter	Depth	Aquifer	Use	Water level	Date	Altitude	Depth to bedrock	Remarks
42N 27W														
20-1	NE	NW	Joe Trepanier	Chiocchi	----	5	60	Pa	D	21.92	9-14-64	1200	---	Cased to 25 feet.
26-1	SW	NW	J. B. Erickson	Kleiman	1956	6	68	Gd	D	4	10- 2-56	1100	---	
29-1	NW	SE	Sanford Olson	Chiocchi	----	5	72	Pa	D	44	----	1080	---	
32-1	SE	NW	Wm. Dawe	Chiocchi	----	5	76	Pa	D	50	----	1130	---	Cased to 32 feet.
32-2	SW	SW	S. J. Peterson	Chiocchi	----	5	138	Pc	D	40	----	1120	---	Cased to 40 feet.
33-1	NE	NW	E. W. LaFreniere	--------	----	36	12	Gd	O	11.19	3-17-64	1060	---	WMP obs. well #10.
41N 30W														
3-1	NE	SW	Duane Pollack	Kleiman	1960	6	78	Gd	D	13	8-24-60	1260	78	Gravel 70 to 77 feet.
4-1	NE	SW	E. J. Verrette	Kleiman	1958	6	80	Pc	D	39	3- 4-58	1300	75	Rock bluff 100' South.
16-1	NW	NE	Herman Bremer	Kleiman	1958	6	40	Gd	D	4	6-19-58	1200	---	Rock bluff 100' West.
17-1	NE	NE	Ellen Sjoquist	Kleiman	1958	6	30	Gd	D	24	7-31-58	1260	---	
25-1	NE	SW	Dick. Co. Rd. Comm.	WMP Co.	1948	1¼	20	Gd	O	dry	11-19-64	1220	---	Contains water in spring.
25-2	SE	NE	Oscar Martinson	Owner	----	48	12	Gd	O	11.42	12- 2-63	1200	---	WMP Co. obs. well.
25-3	SE	NE	Oscar Martinson	Anderson	1949	6	54	--	D	33	9-49	1200	---	
25-4	NW	SE	William Carollâ	--------	----	6	60	--	D	------	----	1240	---	
25-5	SE	NW	Mel Martin	Kleiman	1955	6	120	Pc	D	14	7- 7-55	1260	63	
27-1	NW	SE	John Colombo	Kleiman	1958	6	104	Gd	D	------	----	1200	---	Pulled casing back to 51 ft.
27-2	SE	SW	Darwin Wilson	Chiocchi	----	5	49	Gd	D	30	----	1190	---	
28-1	SE	SE	Merriman Comm. Bldg.	Anderson	1957	6	70	--	P	37	1957	1170	---	Screen finish.
30-1	NE	NW	Maitland Dow	Anderson	----	6	63	--	D	15	----	1180	---	
32-1	SE	NE	Norm LaFarve	Kleiman	1964	7	150	Pc	D	18	5-20-64	1240	50	Cased to 54 feet.
34-1	SE	SW	Elerde Faius	Anderson	----	6	128	--	D	85	----	1270	---	Screen finish.
41N 28W														
1-1	SE	SE	Carl Johnson	Chiocchi	----	6	240	Pc	D	72	----	1160	---	Cased to 72 feet.
8-1	SE	SW	John L. Peterson	Chiocchi	1953	4	42	Pa	D	16	1953	1150	8	
12-1	SE	NE	Harry Peterson	C. Rice	1930	4½	197	Pa?	D	50	3- 3-61	1040	---	
34-1	NW	SW	Marlin & Griffee	Owners	1961	1¼	13	Gd	D	8.72	11-13-64	990	5	Pipe in fracture in bedrock.
41N 27W														
2-1	NE	NW	A. Francke	Anderson	----	6	40	Gd?	D	34	----	1180	---	
6-1	SE	SE	Allen Johnson	Chiocchi	----	5	105	--	D	8	----	1170	---	Cased to 88 feet.
7-1	NE	NE	Pat Milligan, Jr.	Chiocchi	1959	5	109	Pc	D	67	1959	1180	---	Cased to 67 feet.
7-2	SW	NW	Pat Milligan	Chiocchi	1963	5	72	Pc	D	22	1963	1060	---	Cased to 22 feet. Open finish.
7-3	NW	SE	Foster City Cemetery	T. Rice	1948	6	55	--	P	------	----	1060	---	
7-4	SW	SW	Reuben Skogman	Chiocchi	----	5	96	Pa	D	64	----	1150	---	On top of bluff. Cased to 10 feet.
9-1	SE	NW	Dale Sigler	Chiocchi	----	6	90	Pa	D	10	----	1040	---	Water contains 2.0 ppm iron.
40N 31W														
23-1	SE	SE	Pine Mt. Corp.	Rometti	1961	6	116	Pa	I	50.72	9- 5-61	1165	32	
23-2	SE	SE	Pine Mt. Corp.	Rometti	1961	6	150	Pa	I	------	----	1165	32	
23-3	SE	SE	Pine Mt. Corp.	Rometti	1961	6	125	Pa	I	------	----	1170	32+	Cased to 34 feet.
40N 30W														
5-1	SW	NW	John DeGrave	Anderson	1957	5	88	Gd?	D	67	1957	1200	---	
6-1	SE	SW	Joseph Giachino	Rometti	1963	6	31	Gd	D	10	1963	1200	---	Screen finish.
6-2	SE	SE	Joseph Langford	Kleiman	1958	6	82	Gd	D	------	----	1180	---	
8-1	SW	NW	Wes Fontenhio	Kleiman	1963	4	36	Gd	D	16	7-63	1120	---	
14-1	SE	SW	Dave Heidke	Anderson	1962	6	110	Pc ?	D	78	9-62	1100	110	
14-2	SW	SE	Wm. Haigh	Anderson	1964	6	110	--	D	72	1964	1100	---	Cased to 90 feet.
17-1	SE	NE	Immanuel Baptist Church	Kleiman	1962	3	19	Gd	P	6	6-16-62	1180	---	
18-1	SE	SW	Jerry Miksa	Kleiman	1959	6	78	Gd	D	17	6-13-59	1140	---	
18-2	SE	SW	H. B. Miller	Kleiman	1959	6	79	Gd	D	39	10-21-59	1140	---	
18-3	SE	SW	M. Tousignant	Kleiman	1956	6	64	Gd	D	29	----	1140	---	
18-4	NE	SW	F. Hermance	Kleiman	1958	6	71	Gd	P	34	10- 3-58	1160	---	
18-5	NE	SW	Otto Kelberg	Kleiman	1960	6	83	Gd	P	27	5-19-60	1180	---	
18-6	NW	NW	Charles Lindberg	Kleiman	1955	6	20	Gd	D	4	8-21-55	1160	---	
18-7	NE	NW	Erwin Smolinski	Kleiman	1960	6	41	Gd	D	4	11-28-60	1180	---	
19-1	NE	NW	Reuben Hamari	Kleiman	1959	6	81	Gd	D	35	9-26-59	1140	---	
19-2	NW	NE	Bacco Const. Co.	Kleiman	1958	6	48	Gd	D	21	7- 1-58	1160	---	
19-3	SE	NE	Esau Cohodes	Kleiman	1958	6	52	Gd	D	12	9-24-58	1140	---	
20-1	SE	NE	City of Iron Mountain	--------	----	2	---	--	P	Flows	9-17-64	1160	---	Flows 20 ft. above lake
21-1	SE	SW	Dickinson County	Kleiman	1957	6	30	Gd	D	4	11-15-57	1160		
23-1	NE	NE	John Pengrazi	Kleiman	1963	4½	60	Pc	D	14	11-63	1100	---	Cased to 29 feet.
23-2	NE	SE	Eugene Bronz	Kleiman	1962	6	107	Pa	D	5	4-62	1180	100	Cased to 102 feet.
24-1	NE	SW	John Fontecchio	Kleiman	1963	6	46	Gd	D	26	10- 1-63	1140	---	
27-1	NE	SW	Allan Carlson	Kleiman	1959	6	75	Gd	D	26	4-20-59	1150	---	Occasionally shows slight red color.
27-2	SW	NW	F. Pesavento	Kleiman	1959	6	65	Gd	D	36	4-16-59	1180	---	
27-3	SW	SW	Richard Waldbilig	Kleiman	1955	6	64	Gd	D	28	10-20-55	1180	---	
28-1	SW	NW	Jane Thekan	Kleiman	1962	6	49	Gd	D	5	4-26-62	1160	---	Water silty if pumped at more than 30 gpm.
31-1	SW	NW	Zacks Fruit Co.	Kleiman	1958	6	70	Gd	I	14	----	1140	---	
40N 29W														
6-1	SW	NW	Mich. Dept. Cons.	Kleiman	1964	4	30	Gd	-	17.97	9- 8-64	1120	27	Insufficient water to develop well. Casing pulled.
6-2	NW	SW	Mich. Dept. Cons.	Kleiman	1964	4	37	Gd	-	12.22	9-11-64	1120	37	Screen plugged with silt. Casing pulled.
28-1	NE	NW	George Branback	Kleiman	1962	3	30	Gd	D	19	9-11-62	1160	---	
28-2	SW	NE	Howard Hammill	Kleiman	1961	3	21	Pc	-	dry	10-30-61	1140	21	
29-1	SW	SW	Stanish Bal	Anderson	1961	6	52	Pc ?	S	2	1961	1100	---	Cased to 18 feet.
31-1	SW	SE	Joe Baciak	Anderson	1963	6	200	Pa	D	40	1963	1100	68	Cased to 68 feet.
40N 28W														
4-1	NE	SE	C. M. Huck	Anderson	----	5	52	Gd?	D	36	----	1000	---	
4-2	NW	SW	Anton Stockovitz	Anderson	----	6	80	Pc ?	D	35	----	990	---	Cased to 38 feet.
10-1	NE	SW	Clyde Randall	Chiocchi	----	5	96	Pc	D	32	----	980	---	Cased to 35 feet.
12-1	NW	NW	Wm. Asselin	Kleiman	1960	5	157	Gd	D	19	10-21-60	980	60	Cased to 60 feet. Casing dynamited at 41 ft. to provide additional supply.

Table 1.--Well Records.--Continued

Well Number	Location in section ¼	¼	Owner	Driller	Date drilled	Diameter	Depth	Aquifer	Use	Water level	Date	Altitude	Depth to bedrock	Remarks
40N 28W (Cont'd)														
26-1	NE	SE	H. Cousineau	Kleiman	1963	3	70	Gd	D	19	5-10-63	980	---	
35-1	SW	NE	Bernard Rossato	Kleiman	1961	3	57	Gd	D	46	7- 3-61	1000	---	
39N 31W														
12-1	NE	SE	Wis. Mich. Power Co.	Anderson	----	6	345	--	-	8	----	1100	---	Open finish
12-2	NE	SE	Wis. Mich. Power Co.	Anderson	----	8	72	--	-	45	----	1100	---	Screen finish
39N 30W														
1-1	SW	NW	Glenn Anderson	Anderson	----	6	100	Pc	D	16	----	1060	30	
1-2	SW	SW	Alfred Oelke	Chiocchi	----	5	327	Pc	-	75	----	1060	---	Cased to 73 feet.
2-1	NW	SW	Louis Chiocchi	Chiocchi	1963	6	228	Pc	D	40	1963	1040	37	Cased to 37 feet.
3-1	SE	NE	Breitung Township	--------	1942	20	125	Gd	P	------	----	1040	---	Gravel pack finish.
3-2	SE	NE	Breitung Township	Layne NW	1953	8	160	Gd	P	60	4-53	1040	---	Screen finish.
4-1	NW	NE	Guy Gustaffson	Anderson	1960	6	35	Pc	P	28	4-61	1050	---	
8-1		NW	Wis. Mich. Power Co.	Anderson	1959	6	92	Pa	D	55	----	1000	---	Screen finish.
13-1	Center		Kimberly-Clark Corp.	Kleiman	1956	6	140	Gd	O	132.75	10-28-64	1051	---	
13-2	NW	SW	Kimberly-Clark Corp.	Kleiman	1957	6	118	Gd	O	111.52	10-28-64	1041	---	
13-3	SW	NW	Kimberly-Clark Corp.	Kleiman	1956	6	50	Gd	O	dry	3- 7-56	1052	50	
13-4	NE	NW	Wallace Jones	Chiocchi	----	5	114	Gd	D	92	----	1040	---	
14-1	Center		Kimberly-Clark Corp.	Kleiman	1956	6	95	Gd	O	78.41	10-28-64	1025	95	Gravel packed screen finish.
14-2	Center		Kimberly-Clark Corp.	Kleiman	1957	6	30	Gd	O	12.68	10-28-64	960	---	Water level fluctuates with river.
39N 29W														
2-1	SW	NE	Wm. LaVoie	Anderson	1946	5	72	Gd	D	36	9-64	980	---	
5-1		SE	Americo Tinti	Anderson	1949	6	174	--	D	75	1949	1040	---	Cased to 68 ft. Open finish.
8-1	NE	SE	James Stewart	Kleiman	1958	6	112	Gd	I	56	6- 5-58	940	---	Water contains excessive ferric iron.
12-1	SW	SW	Stan Baciak	Chiocchi	----	6	168	Pa	D	40	1963	1040	---	Open finish.
14-1	NW	SW	Frances Girardi	Chiocchi	----	5	47	Gd	D	20	9-15-64	860	---	
14-2	SW	SW	R. Haferkorn	Owner	----	36	21	Gd	S	12	1964	850	---	
15-1	SE	SE	Joseph Haferkorn	Chiocchi	----	5	158	Gd	D	45	9-64	840	---	Slight taste.
17-1	SE	NE	Lewis Rector	Kleiman	1958	6	140	Pc	D	------	----	940	50	
20-1	NW	NE	Joe Palluch	Chiocchi	1961	6	40	Gd	D	15	----	----	---	
22-1	SW	SE	Mike Mannicor	Kleiman	1963	4	88	Gd	D	28	10-30-63	860	---	
25-1	NE	NE	Francis Sweig	Kleiman	1962	3	70	Gd	D	3	6-16-62	860	---	
26-1	NE	SE	Adam Ball	Chiocchi	1959	5	349	Pc	D	60	----	----	80	
27-1	NE	SE	City of Norway	Kleiman	1958	6	40	Gd	D	10	11-26-58	----	---	Supplies 3 houses.
36-1	SE	NE	Henry Varda	Kleiman	1963	7	101	Pc	D	42	10-63	----	100	
39N 28W														
7-1	SW	SW	Murriel Girard	Chiocchi	----	5	268	Pc	D	60	----	880	62	Cased to 62 feet.
7-2	SW	SW	Joe Drie	Kleiman	----	5	69	Gd	D	15	----	880	---	
8-1	SE	NE	Wis. Mich. Power Co.	Anderson	1962	6	87	Pc	P	21.06	9-15-64	900	37	
14-1	NW	NW	Paul Hupp	Anderson	1959	6	39	Gd	D	25	1959	970	---	Screen finish.
14-2	SW	SE	Robert Bunt	Glass	1962	6	167	Pc ?	D	90	6- 3-61	1060	87	
16-1	NW	NW	Steve Bubloni	Anderson	1963	6	150	Pc	D	72.57	9-15-64	1040	72	Cased to 100 feet.
16-2	SW	SE	Frank Habamer	Anderson	----	6	42	Gd	D	18	----	1060	---	
18-1	NW	NW	Kaspinski Tavern	Anderson	1961	6	72	Gd?	P	51	9-61	900	---	Cased to bottom.
19-1	SW	SW	Leonard Losito	Kleiman	1962	3	27	Pc	D	3	6-16-62	850	16	
19-2	SW	SW	Sue McCormick	Kleiman	1961	3	45	Pc	D	------	----	850	42	
19-3	NW	NW	Walter Breclaw	Chiocchi	----	5	275	Pc	D	76.42	5-14-64	860	---	Cased to 74 feet.
20-1	SW	SE	George DeRidder	Kleiman	1962	3	40	Gd	D	24	6-20-62	860	---	
20-2	SE	SE	Ed. Bouchey	Kleiman	1963	3	120	Gd	D	6	4-30-63	860	---	
21-1	NW	SW	Clifford Frenn	Chiocchi	----	5	196	Pc	D	85	----	----	---	Cased to 96 feet.
24-1	SW	SE	C. Linder	Le Beau	1963	5	100	Pa	D	77.28	9-15-64	1020	---	Open finish.
25-1	NW	NE	Richard Skog	Anderson	1948	6	88	--	D	61	1948	1000	---	Cased to 73 feet.
30-1	NW	NE	Frank Bray	Kleiman	1962	3	18	Gd	D	7	6-10-62	860	---	
30-2	NW	NE	Ernest Cosanova	Kleiman	1961	3	18	Gd	D	flow	6- 9-61	860	---	Flowed 0.5 ft. above land surface 6-9-61
30-3	SW	NE	Mary Johnson	Kleiman	1962	3	34	Pc	D	17	6- 7-62	860	23	Cased to 24 feet.
30-4	SW	NE	Lee Johnson	Kleiman	1962	3	27	Gd	D	flow	6- 2-62	840	---	Flowed 5 gpm 3 ft. above land surface 6-2-62
30-5	SE	NW	Harry Teafoe	Chiocchi	----	5	368	Pc	D	28	----	----	---	Cased to 35 feet.
30-6	SW	NW	Dickinson Co. Park	Chiocchi	----	5	91	Gd	P	47	----	----	---	
30-7	SW	NE	Carroll Asp	Chiocchi	----	5	58	Pc	D	22	----	----	---	Cased to 38 feet.
30-8	SE	NW	Carl Danelison	Chiocchi	1953	5	57	Pc	D	14	----	----	---	Cased to 20 feet.
32-1	SW	SW	Julius Van Wiele	Owner	1950	6	132	Gd	S	20	1950	----	132	Pulled casing back 0.5 ft. into gravel
35-1	NW	NW	Ed Magnuson	Le Beau	1947	6	120	Pa	D	55	1947	----	96	Cased to 96 feet.

TABLE 2.--DRILLERS' WELL LOGS

Explanation

Altitudes estimated from topographic maps.
Figures given are in feet.

	Thickness of unit	Bottom of unit
TOWNSHIP 44 NORTH; RANGE 30 WEST		
44N 30W 23-2 Joseph Dault SW¼ NE¼ Section 23 Altitude: 1420		
Sand	30	30
Hardpan	5	35
Some gravel mix	5	40
Lake sand	5	45
Clay	5	50
Hardpan	10	60
Slate	8	68
44N 30W 23-3 E. J. De Gaynor NE¼ NE¼ Section 23 Altitude: 1420		
Sand	10	10
Gravel, fine	10	20
Sand, rough	10	30
Sand, sharp	10	40
Hardpan	20	60
Gravel (water)	2	62
Hardpan	6	68
Slate (water)	11	79
44N 30W 28-1 Dickinson Co. 4-H Club SE¼ NE¼ Section 28 Altitude: 1420		
Pit	10	10
Sandy clay, fine (poor permeability)	60	70
Very fine quick sand	10	80
Clay, no sand	85	165
Fine sand, no water	1	166
Clay	4	170
Black quartzitic chips, some pyrite, not slate	15	185
44N 30W 33-1 Bert Buckland NE¼ NE¼ Section 33 Altitude: 1400		
Sandy clay	12	12
Clay	30	42
Clay and small rocks	12	54
Sandy loam (water)	1	55
Intermittent clay and sand	10	65
Watersand, coarse	6½	71½
TOWNSHIP 44 NORTH; RANGE 28 WEST		
44N 28W 10-1 Casper Uldriks SE¼ SW¼ Section 10 Altitude: 1280		
Sandy loam	5	5
Gravel and boulders	15	20
Sand	5	25
Pink clay	8	33
Clean fine sand	5	38
Dirty fine sand	17	55
Clean coarse watersand	4	59
TOWNSHIP 44 NORTH; RANGE 27 WEST		
44N 27W 17-1 James McGreger NW¼ SW¼ Section 17 Altitude: 1240		
Rough gravel	20	20
Hardpan	11	31
Clay and boulders	10	41
Hard cemented gravel	2	43

	Thickness of unit	Bottom of unit
TOWNSHIP 43 NORTH; RANGE 30 WEST		
43N 30W 11-1 Fred Janus NE¼ SW¼ Section 11 Altitude: 1360		
Sand	18	18
Red hematite	50	68
43N 30W 29-2 Amos Dishaw SW¼ SE¼ Section 29 Altitude: 1480		
Red clay	40	40
Hematite	29	69
43N 30W 34-1 Edgar Erickson NW¼ SW¼ Section 34 Altitude: 1360		
Sandy loam	15	15
Limestone rock	3	18
Hardpan	30	48
Pea gravel with water	2	50
Sandstone boulder	2	52
Hardpan with water	8	60
Sand with brown clay seams	10	70
Hardpan	10	80
Sand with brown clay	7	87
Pea gravel	6	93
TOWNSHIP 43 NORTH; RANGE 28 WEST		
43N 28W 23-2 John Cominsky NE¼ SW¼ Section 23 Altitude: 1190		
Topsoil and gravel	5	5
Gravel	10	15
Hardpan	10	25
Hardpan, some water	10	35
Hardpan	5	40
Sandstone	20	60
43N 28W 23-4 Norman Karsten SE¼ SW¼ Section 23 Altitude: 1220		
Sandy loam	5	5
Hardpan	5	10
Limestone boulder	12	22
Pink clay hardpan	19	41
Yellow sandstone	4	45
Blue sandstone	5	50
TOWNSHIP 43 NORTH; RANGE 27 WEST		
43N 27W 28-1 Joseph Turini SE¼ SE¼ Section 28 Altitude: 1160		
Sandy loam	2	2
Hardpan and boulders	38	40
Coarse sand, water	2	42
Ledge	5	47
TOWNSHIP 42 NORTH; RANGE 30 WEST		
42N 30W 2-1 G. R. Rumpf SE¼ SE¼ Section 2 Altitude: 1320		
Topsoil	2½	2½
Red clay, boulders	11	13½
Schist, mica, decomposed	4½	18
Schist, weathered	2½	20½
Blue hematite	10	30½

	Thickness of unit	Bottom of unit
42N 30W 4-1 Donald T. Johnson NE¼ SW¼ Section 4 Altitude: 1420		
Sandy loam	15	15
Hardpan and gravel	5	20
Sandstone	5	25
Green limestone and Randville dolomite	17	42
42N 30W 7-1 Don Dario SE¼ SW¼ Section 7 Altitude: 1410		
Topsoil	13	13
Gravel, hardpan	17	30
Limestone floater	5	35
Red clay	10	45
Slate hematite	14	59
42N 30W 11-1 Norm Mainville SW¼ NW¼ Section 11 Altitude: 1340		
Fine sand	5	5
Sharp sand	20	25
Clay and sand	15	40
Sand and water	10	50
Black silt	15	65
Red clay	5	70
42N 30W 18-1 John R. Williams NW¼ SW¼ Section 18 Altitude: 1400		
Hardpan and boulders	17	17
Clayey sand, a little water	8	25
Hardpan	4	29
Gravel, water	2' 9"	31' 9"
Ledge (?)		
42N 30W 18-3 Leo Hart NE¼ NW¼ Section 18 Altitude: 1400		
Red clay, boulders	20	20
Gravel and sand	4	24
Hardpan	6	30
Clayey sand	20	50
Clayey sand (redder)	12	62
Hardpan, some rock	10	72
Clayey sand	15	87
Clean, medium coarse sand	5	92
42N 30W 24-1 Paul Richards NW¼ NE¼ Section 24 Altitude: 1320		
Topsoil and boulders	5	5
Boulders, dynamited	3	8
Gravel	9	17
Hardpan	13	30
Large hard rock	3	33
Gravel and hardpan	5	38
Granite	1' 5"	39' 5"
42N 30W 26-1 Herbert Locarelli SE¼ NE¼ Section 26 Altitude: 1260		
Sandy loam	10	10
Hardpan	5	15
Blue clay	5	20
Inadequate water @ 20		
Sandstone and conglomerate	12	32
Slate	4	36

	Thickness of unit	Bottom of unit
42N 30W 32-1 Clayton Rush NE¼ SE¼ Section 32 Altitude: 1260		
Sand	25	25
Clay	5	30
Clay and sand	10	40
Clay and fine sand	40	80
Red sticky clay	6	86
Hardpan	38	124
Silt, very fine sand	2	126
Gravel and sand	2	128
Gravel	5	133
TOWNSHIP 42 NORTH; RANGE 29 WEST		
42N 29W 22-3 Joe Lajennesse NE¼ SE¼ Section 22 Altitude: 1130		
Black clay	23½	23½
Red clay	1	24½
Coarse sand	4	28½
42N 29W 26-1 Carlton Cook SE¼ SE¼ Section 26 Altitude: 1220		
Soapstone and clay	45	45
Some sandstone	5	50
Granite, some water	2	52
Granite and water	5	57
42N 29W 30-1 M. A. Hanna Co. NW¼ SE¼ Section 30 Altitude: 1260		
Dirt and gravel	5	5
Semi-hardpan	10	15
Sand and gravel	20	35
Fine sand and gravel	5	40
Sand and fine gravel	5	45
Coarse sand	5	50
Sand	5	55
Fine clayey sand	10	65
Fine sandy clay	10	75
Clay	10	85
42N 29W 31-1 M. A. Hanna Co. NE¼ SE¼ Section 31 Altitude: 1340		
Overburden	15	15
Sandstone	113	128
42N 29W 32-1 Roy Leonard SE¼ NE¼ Section 32 Altitude: 1260		
Surface clay	10	10
Hardpan	4	14
Big rock (dynamited)	1	15
Gravel	3	18
Red sandstone	20	38
42N 29W 32-2 M. A. Hanna Co. NW¼ SW¼ Section 32 Altitude: 1320		
Clayey sand	10	10
Sandstone, light brown to reddish brown or buff	149	159
Schist, oxidized and quartz	12	161
42N 29W 34-1 Fabian Steinbrecker SW¼ NE¼ Section 34 Altitude: 1240		
Clay loam	5	5
Clay loam, hardpan	10	15
Sand	3	18
White sandstone	7	25
White sandstone; red water	25	50
Iron ore, water	28	78
Brown ochre ore; water	4	82
42N 29W 34-2 Ronald Bergstrom SE¼ SE¼ Section 34 Altitude: 1160		
Clay soil	12	12
Gravel	8	20
Hardpan	20	40
Boulder	2	42
Hardpan	10	52
Iron ore	50	102
TOWNSHIP 42 NORTH; RANGE 28 WEST		
42N 28W 5-1 Kenneth Sheldon SE¼ NW¼ Section 5 Altitude: 1160		
Clay loam	5	5
Gravel	5	10
Hardpan	5	15
Sandstone	40	55
42N 28W 35-1 Edwin Oman SE¼ NE¼ Section 35 Altitude: 1120		
Topsoil	10	10
Hardpan	30	40
Hardpan, some water	5	45
Hardpan, water	5	50
TOWNSHIP 42 NORTH; RANGE 27 WEST		
42N 27W 26-1 Paul Rahm SW¼ NW¼ Section 26 Altitude: 1100		
Clay loam	5	5
Gravel	5	10
Hardpan	25	35
Clay	5	40
Hardpan	25	65
Gravel	2	67
TOWNSHIP 41 NORTH; RANGE 30 WEST		
41N 30W 3-1 Duane Pollock NE¼ SW¼ Section 3 Altitude: 1260		
Topsoil	5	5
Dry hardpan, large boulders	45	50
Wet hardpan	10	60
Hardpan and gravel	10	70
Gravel with water	7	77
Granite ledge	2	79
41N 30W 4-1 E. J. Verrette NE¼ SW¼ Section 4 Altitude: 1310		
Clay loam	5	5
Gravel	15	20
Clay	10	30
Clay, some water	10	40
Hardpan, gravel	10	50
Sand and clay	5	55
Gravel, clay mix	10	65
Gravel	5	70
Iron ore	2	72
Cemented gravel	3	75
Slate	5	80
41N 30W 16-1 Herman Bremer NW¼ NE¼ Section 16 Altitude: 1200		
Sand	20	20
Silt and sand	5	25
Sand	15	40
41N 30W 17-1 Ellen Sjoquist NE¼ NE¼ Section 17 Altitude: 1260		
Sand	5	5
Gravel	10	15
Hardpan	15	30
41N 30W 25-5 Mel Martin SE¼ NW¼ Section 25 Altitude: 1260		
Clay	27	27
Gravel	6	33
Hardpan	10	43
Blue clay and dyke	20	63
Iron ore	30	93
Quartz	1	94
Slate	9	103
Dyke	16	119
Granite	1	120
41N 30W 27-1 John Colombo NW¼ SE¼ Section 27 Altitude: 1200		
Gravel	0	30
Sand and clay	20	50
Gravel	3	53
Drilled to 104 ft., sand silt water mix. Pulled casing back to 51 ft.		
41N 30W 32-1 Norm La Farve SE¼ NE¼ Section 32 Altitude: 1240		
Hardpan and boulders	50	50
Water level at 16 ft.		
Badwater Greenstone	73	123
Quartzite (water on contact)	1	124
Water level at 13 ft.		
Greenstone and intermittant seams of quartz, white and pink	26	150
TOWNSHIP 40 NORTH; RANGE 31 WEST		
40N 31W 23-1 Pine Mountain Corp. SE¼ SE¼ Section 23 Altitude: 1165		
Glacial drift	32	32
Cambrian sandstone, tan, fine grained	28	60
Lens of sandstone, white crystalline encountered	10	70
Well finished in sandstone, tan, fine grained	46	116
40N 31W 23-2 Pine Mountain Corp. SE¼ SE¼ Section 23 Altitude: 1165		
Glacial drift	32	32
Cambrian sandstone, tan fine grained	28	60
Lens of sandstone, white crystalline encountered	10	70
Well finished in sandstone, tan, fine grained	80	150

TABLE 2.--DRILLERS' WELL LOGS.--Continued

40N 31W 23-3
Pine Mountain Corp.
SE¼ SE¼ Section 23
Altitude: 1170

	Thickness of unit	Bottom of unit
Glacial drift	32	32
Cambrian sandstone, tan fine grained	28	60
Lens of sandstone, white crystalline encountered	10	70
Well finished in sandstone, tan, fine grained	55	125

TOWNSHIP 40 NORTH;
RANGE 30 WEST

40N 30W 6-2
Joseph Langsford
SE¼ SE¼ Section 6
Altitude: 1180

	Thickness of unit	Bottom of unit
Rough gravel	15	15
Gravel	5	20
Sand	10	30
Sand, some water	15	45
Sand	10	55
Clay	10	65
Fine sand	5	70
Sand	8	78
Gravel, water	4	82

40N 30W 8-1
W. Fontenlio
SW¼ NW¼ Section 8
Altitude: 1120

	Thickness of unit	Bottom of unit
Clay and boulders	20	20
Gravel	6	26
Clay and sand	3	29
Fine sand	4	33
Mica sand	3	36

40N 30W 17-1
Immanuel Baptist Church
SE¼ NE¼ Section 17
Altitude: 1180

	Thickness of unit	Bottom of unit
Topsoil	2	2
Hardpan	16	18
Gravel	½	18½

40N 30W 18-1
Jerry Miksa
SE¼ SW¼ Section 18
Altitude: 1140

	Thickness of unit	Bottom of unit
Gravel	19	19
Boulder	1	20
Sand	5	25
Sand and clay	10	35
Hardpan and boulders slow water seepage	27	62
Gravel and clay	8	70
Gravel and clay mix some water	5	75
Hardpan	2	77
Gravel-water vein	1	78
Abundant water		

40N 30W 18-2
H. B. Miller
SE¼ SW¼ Section 18
Altitude: 1140

	Thickness of unit	Bottom of unit
Topsoil and gravel	10	10
Sharp sand	5	15
Clay, gravel mix	5	20
Hardpan	10	30
Red hardpan	5	35
Hardpan	15	50
Sand and water mix	5	55
Red hardpan	15	70
Sharp sand and water	8	78

40N 30W 18-3
Melvin Tousignant
SE¼ SW¼ Section 18
Altitude: 1140

	Thickness of unit	Bottom of unit
Clay and boulders	4	4
Gravel	42	46
Clay	8	54
Coarse sand	10	64

40N 30W 18-5
Otto Kelberg
NE¼ SW¼ Section 18
Altitude: 1180

	Thickness of unit	Bottom of unit
Topsoil	5	5
Gravel and hardpan	9	14
Hardpan	41	55
Hardpan and gravel	10	65
Hardpan	5	70
Gravel	13	83

40N 30W 18-6
Charles Lindberg
NW¼ NW¼ Section 18
Altitude: 1160

	Thickness of unit	Bottom of unit
Gravel and hardpan	7	7
Rock	5	12
Gravel and clay	8	20

40N 30W 18-7
Erwin Smolinski
NE¼ NW¼ Section 18
Altitude: 1180

	Thickness of unit	Bottom of unit
Gravel and hardpan	15	15
Water-bearing gravel	5	20
Hardpan and gravel seams	21	41
Water-bearing gravel	½	41½

40N 30W 19-1
Reuben Hamari
NE¼ NW¼ Section 19
Altitude: 1140

	Thickness of unit	Bottom of unit
Topsoil, gravel	10	10
Gravel, clay	10	20
Red hardpan	10	30
Gray hardpan and sand	10	40
Fine sand, silt	10	50
Fine sand	5	55
Clay	5	60
Gray clay	10	70
Gravel, clay mix	8	78
Clean gravel, water	3	81

40N 30W 19-2
Sacco Construction Co.
NW¼ NE¼ Section 19
Altitude: 1160

	Thickness of unit	Bottom of unit
Gravel	10	10
Hardpan, some gravel	10	20
Gravel	5	25
Hardpan	5	30
Red hardpan	5	35
Gravel	5	40
Fine gravel	8	48

40N 30W 19-3
Esau Cohodes
SE¼ NE¼ Section 19
Altitude: 1140

	Thickness of unit	Bottom of unit
Gravel	15	15
Sand, some water	5	20
Fine sand	20	40
Hardpan	5	45
Gravel	3	48
Hardpan	1	49
Gravel, water	3	52

40N 30W 21-1
Dickinson County Park
SE¼ SW¼ Section 21
Altitude: 1160

	Thickness of unit	Bottom of unit
Clay loam	5	5
Sand	20	25
Hardpan	4	29
Gravel, water	1	30

40N 30W 23-2
Eugene Bronz
NE¼ SE¼ Section 23
Altitude: 1180

	Thickness of unit	Bottom of unit
Hardpan and boulders	100	100
Sandstone, white	7	107

40N 30W 24-1
John Fontecchio
NE¼ SW¼ Section 24
Altitude: 1140

	Thickness of unit	Bottom of unit
Topsoil	10	10
Gravel	20	30
Hardpan	7' 9"	37' 9"

40N 30W 27-1
Allan Carlson
NE¼ SW¼ Section 27
Altitude: 1150

	Thickness of unit	Bottom of unit
Gravel	42	42
Hardpan	18	60
Sand, gravel	5	65
Gravel, hardpan	10	75

40N 30W 27-2
Ferdinand Pesavento
SW¼ NW¼ Section 27
Altitude: 1180

	Thickness of unit	Bottom of unit
Topsoil	10	10
Sand and boulders	10	20
Hardpan	15	35
Hardpan and sand	5	40
Sand, some water	5	45
Hardpan, sand	5	50
Gravel, water	15	65

40N 30W 27-3
Richard Waldbilig
SW¼ SW¼ Section 27
Altitude: 1180

	Thickness of unit	Bottom of unit
Clay loam	24	24
Rock ledge	9	33
Gravel	6	39
Clay loam, rock	15	54
Hardpan	9	63
Gravel	1½	64½

40N 30W 28-1
Jane Thekan
SW¼ NW¼ Section 28
Altitude: 1160

	Thickness of unit	Bottom of unit
Topsoil	3	3
Red hardpan and boulders	43	46
Sand, gravel and water	2	48
Silt	2	50

40N 30W 31-1
Zachs Fruit Company
NW¼ Section 31
Altitude: 1140

	Thickness of unit	Bottom of unit
Fill, gravel	5	5
Gravel	15	20
Slate and gravel	5	25
Fine gravel	5	30
Red iron ore, clay, gravel	10	40
Hardpan and gravel	20	60
Hardpan, red iron ore, clay	5	65
Water-bearing gravel	5	70

TOWNSHIP 40 NORTH;
RANGE 29 WEST

40N 29W 6-1
Mich. Dept. of Conservation
NW¼ NW¼ Section 6
Altitude: 1120

	Thickness of unit	Bottom of unit
Topsoil	3	3
Gravel	7	10
Clay	10	20
Hardpan	5	25
Hardpan (ledge)	3	28
Insufficient water to develop well		

40N 29W 6-2
Mich. Dept. of Conservation
NW¼ SW¼ Section 6
Altitude: 1120

	Thickness of unit	Bottom of unit
Fill	5	5
Silt, clay, fine sand	5	10

	Thickness of unit	Bottom of unit
40N 29W 6-2 Continued		
Silt, clay with coarse gravel	5	15
Silt, clay, fine sand	5	20
Clay, buff, silty	5	25
Clay, buff, silty, trace of very fine sand	10	35
Sand, very fine, silty, trace of fine gravel	at	35
Gravel, pea sized	1	36
Sand very fine, silty and coarse gravel	½	36½
Clay, buff, silty	½	37
Gneiss	at	37
40N 29W 28-1 George Branback NE¼ NW¼ Section 28 Altitude: 1160		
Soil	12	12
Hardpan and boulders	17	29
Gravel	1	30
40N 29W 28-2 Howard Hammill SW¼ NE¼ Section 28 Altitude: 1140		
Clay and boulders	15	15
Hardpan, boulders, sand	6	21
Ledge at		21
Dry hole		
40N 29W 31-1 Joe Baciak SW¼ SE¼ Section 31 Altitude:		
Hardpan	68	68
Sandstone	50	118
Limestone	4	122
Sandstone	14	136
Sandstone, red	50	186
Red rock	12	198
TOWNSHIP 40 NORTH; RANGE 28 WEST		
40N 28W 12-1 William Asselin NW¼ NW¼ Section 12 Altitude: 980		
Humus, clay, boulders	5	5
Hardpan, red; boulders	15	20
Hardpan, red	20	40
Gravel	½	40½
Hardpan, dark	4½	45
Paint rock, gray (soft)	15	60
Paint rock, gray (hard)	5	65
Intermittant strata hard to soft	45	110
Paint rock, various colors		
Slate, soft	20	130
Slate, hard	15	145
Intermittant hard and soft slate strata	5	150
Granite ledge, very hard	7	157
40N 28W 26-1 Hector Cousineau NE¼ SE¼ Section 26 Altitude: 980		
Red clay	40	40
Pink clay and gravel	26	66
Fine clayey sand and water	4	70
40N 28W 35-1 Bernard Rossato SW¼ NE¼ Section 35 Altitude: 1000		
Old well pit	38	38
Pink clay and boulders	10	48
Sand and water	½	48½
Wet pink clay	8½	57
Sand and gravel, water	½	57½
TOWNSHIP 39 NORTH; RANGE 30 WEST		
39N 30W 3-2 Breitung Township SE¼ NE¼ Section 3 Altitude: 1040		
Gravel, sand	0	95
Fine tight sand with streaks of clay	25	120
Fine, tan, muddy sand	20	140
Medium tan sand	20	160
39N 30W 13-1 Kimberly-Clark Corp. Center of Section 13 Altitude: 1051		
Clay, brown, sandy	10	10
Gravel, medium, sandy clayey	10	20
Gravel, fine; loose sand	10	30
Sand, very fine to fine	20	50
Sand, medium to fine	10	60
Sand, very fine to coarse	10	70
Sand, very fine to medium	10	80
Sand, fine to coarse	10	90
Sand, very fine, silty	10	100
Clay, silty	10	110
No sample	10	120
Gravel, fine to medium with fine sand	20	140
39N 30W 13-2 Kimberly-Clark Corp. NW¼ SW¼ Section 13 Altitude: 1041		
Sandy loam	5	5
Gravel, clay mix	5	10
Gravel	5	15
Sand	10	25
Fine sand and clay	15	40
Clay	5	45
Clay and fine sand	5	50
Gravel and clay mix	5	55
Gravel	15	70
Sharp sand	20	90
Red packed sand	5	95
Sand	23	118
39N 30W 13-3 Kimberly-Clark Corp. SW¼ NW¼ Section 13 Altitude: 1052		
Sand, fine to coarse, very silty, some fine gravel	10	10
Sand, fine to coarse, fairly clean	10	20
Clay, gravelly, gray	10	30
Sand, fine to coarse	20	50
Ledge		
39N 30W 14-1 Kimberly-Clark Corp. Center East ½ Section 14 Altitude: 1025		
Sand, fine, silty	30	30
Clay, silty and sandy	20	50
Sand, very fine, silty	40	90
39N 30W 14-2 Kimberly-Clark Corp. Center Section 14 Altitude: 960		
Sand, fine, silty	20	20
Gravel, medium to coarse clean	10	30
TOWNSHIP 39 NORTH; RANGE 29 WEST		
39N 29W 8-1 James Stewart NE¼ SE¼ Section 8 Altitude: 940		
Sand	15	15
Sharp red sand	20	35
Beach sand	77	112
39N 29W 17-1 Lewis Rector SE¼ NE¼ Section 17 Altitude: 940		
Sand	30	30
Clay	5	35
Hardpan, water	15	50
Rock, ledge	8	58
Slate	12	70
Slate ore	10	80
Red slate ore	10	90
Black slate	10	100
Red slate	20	120
Black slate	5	125
Red slate	10	135
Slate	5	140
39N 29W 22-1 M. Mannicor SW¼ SE¼ Section 22 Altitude: 860		
Topsoil	5	5
Clay and sand	8	13
Clay	5	18
Sand	6	24
Red clay, and sand	3	27
Red clay	18	45
Clay and sand	10	55
Sand	2	57
Red clay and sand	15	72
Sand	16	88
39N 29W 25-1 Francis Sweig NE¼ NE¼ Section 25 Altitude: 860		
Sand and clay	15	15
Sand and clay and water	50	65
Medium coarse sand and water	5	70
39N 29W 26-1 Adam Ball NE¼ SE¼ Section 26 Altitude:		
Red clay	60	60
Gravel	20	80
Slate hematite	269	349
39N 29W 27-1 City of Norway NE¼ SE¼ Section 27 Altitude:		
Sandy loam	10	10
Sand	10	20
Hardpan	15	35
Gravel	5	40
39N 29W 36-1 Henry Varda SE¼ NE¼ Section 36 Altitude:		
Clayey sand	86	86
Hardpan	14	100
Pea gravel, broken hematite	1	101
TOWNSHIP 39 NORTH; RANGE 28 WEST		
39N 28W 7-1 Murriel Girard SW¼ SW¼ Section 7 Altitude: 900		
Glacial drift	62	62
Dolomite	206	268
39N 28W 7-2 Joe Drie SW¼ SW¼ Section 7 Altitude: 880		
Clay	30	30
Sand and gravel	39	69

TABLE 2.--DRILLERS' WELL LOGS.--Continued

39N 28W 14-2
Robert Bunt
SW¼ SE¼ Section 14
Altitude: 1080

	Thickness of unit	Bottom of unit
Clay and boulders	80	80
Ledge	87	167

39N 28W 19-1
Leonard Losito
SW¼ SW¼ Section 19
Altitude: 850

	Thickness of unit	Bottom of unit
Humus	5	5
Gravel hardpan	11	16
Slate hematite	11	27

39N 28W 19-2
Sue McCormick
SW¼ SW¼ Section 19
Altitude: 850

	Thickness of unit	Bottom of unit
Sandy loam	5	5
Hardpan, boulders	5	10
Pink hardpan	8	18
Clayey sand, water, could not be screened	4	22
Sand, hardpan	12	34
Gravel, hardpan, little water	8	42
Slate, iron ore, water	3	45

39N 28W 20-2
Ed Bouchey
SE¼ SE¼ Section 20
Altitude: 860

	Thickness of unit	Bottom of unit
Humus	2	2
Gravel	7	9
Pink clay	14	23
Clayey sand, water	3	26
White clay	90	116
Coarse sand, water	5	121

39N 28W 30-1
Frank Bray
NW¼ NE¼ Section 30
Altitude: 850

	Thickness of unit	Bottom of unit
Humus	5	5
Pink clay	12	17
Coarse gravel	1	18

39N 28W 30-2
Mrs. Ernest Casanova
NW¼ NE¼ Section 30
Altitude: 840

	Thickness of unit	Bottom of unit
Sandy loam	5	5
Pink clay	10	15
Coarse sand and water	5	20

39N 28W 30-3
Mary Johnson
SW¼ NE¼ Section 30
Altitude: 860

	Thickness of unit	Bottom of unit
Humus	5	5
Gravel	15	20
Hardpan	3	23
Schist ledge	11	34

39N 28W 30-4
Lee Johnson
SW¼ NE¼ Section 30
Altitude: 840

	Thickness of unit	Bottom of unit
Humus	3	3
Sand	7	10
Hardpan	13	23
Medium coarse sand	4	27

39N 28W 32-1
Julius Van Wiele
SW¼ SW¼ Section 32
Altitude: 985

	Thickness of unit	Bottom of unit
Clay	131	131
Gravel, clean	1	132
Hit granite at 132		

39N 28W 35-1
Ed Magnuson
NW¼ NW¼ Section 35
Altitude:

	Thickness of unit	Bottom of unit
Glacial drift	96	96
Sandstone	24	120

ABSTRACT

The abundant ground-water resources of Dickinson County are not evenly distributed. Wells yielding several hundred gallons per minute can be obtained in some parts of the county while in other parts obtaining the few gallons per minute needed for a single household is difficult or impossible. Water from wells generally is hard and locally contains objectionable amounts of iron, but is otherwise suitable in quality for most uses. Public water supplies in the county are obtained from wells, lakes, and an abandoned mine shaft. Maps showing the availability of ground water in drift and bedrock aquifers are included.

On the rear cover:

Cornish water pump at the site of the abandoned Chapin iron mine in Iron Mountain. This huge pump, installed in 1893, was the largest of its type ever built in the United States. It could lift about 4,000,000 gallons of water a day from a depth of 1,500 feet. The 40-foot flywheel weighs 160 tons.

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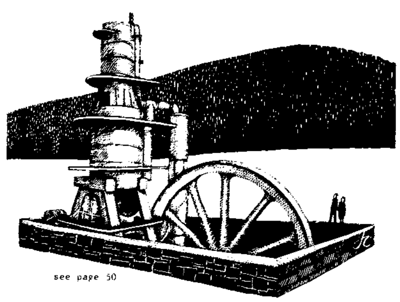

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Michigan Geological Survey, Water Investigation 5, GROUND-WATER RESOURCES OF DICKINSON COUNTY, MICHIGAN, 1966.