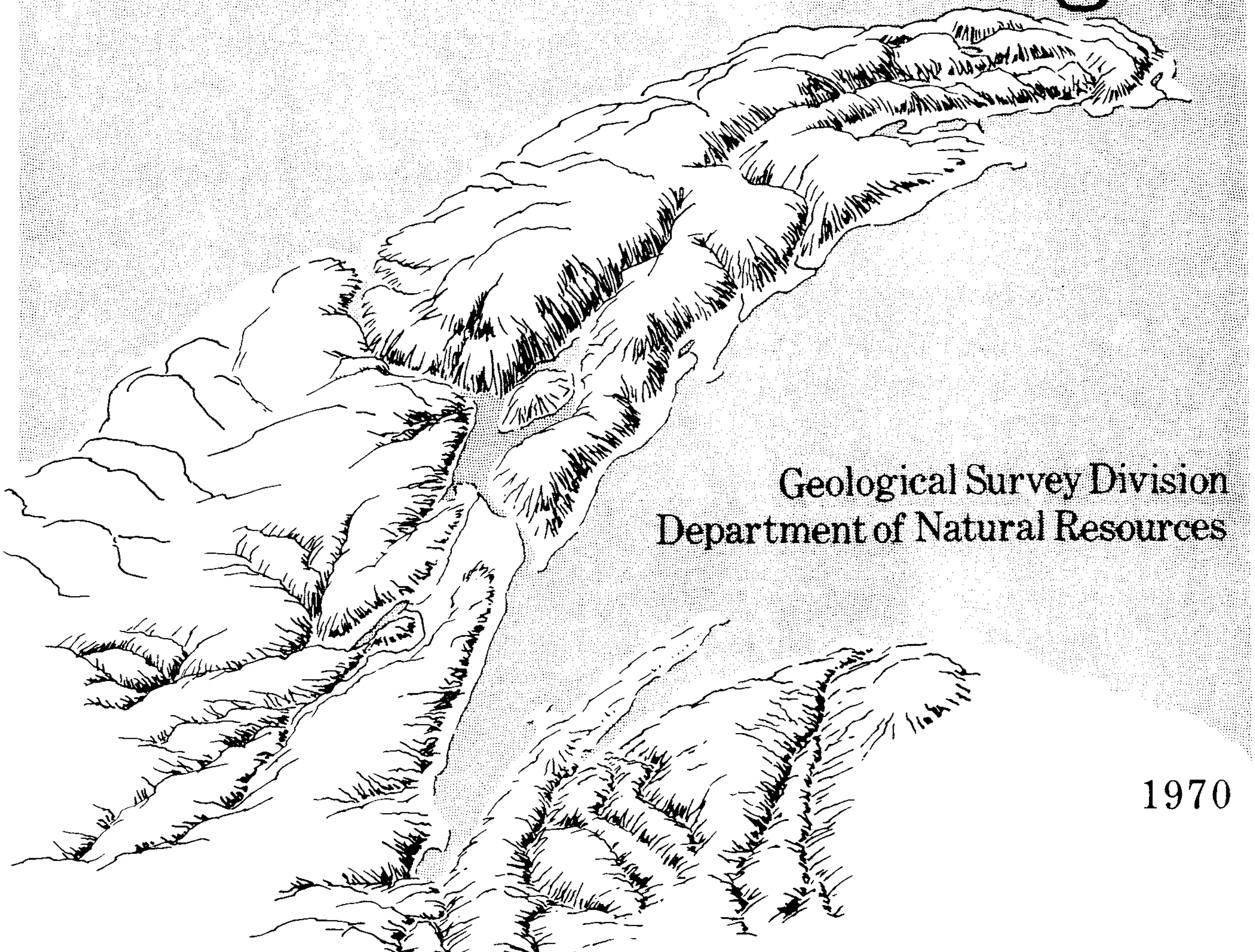
Water Investigation 10

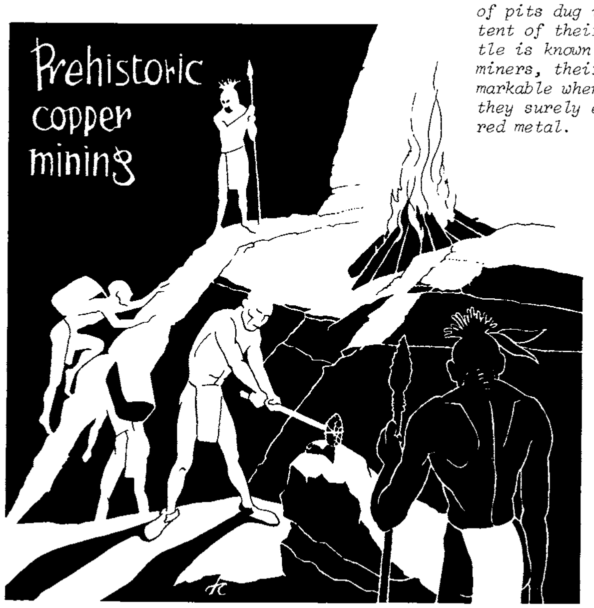
Ground Water and Geology of Keweenaw Peninsula, Michigan



Geological Survey Division
Department of Natural Resources

1970

From about 3000 BC to perhaps 1500 AD peoples of undetermined affinities mined much native copper on Isle Royale and in the Keweenaw Peninsula. The thousands of pits dug is some indication of the extent of their activity. Even though little is known about these early primitive miners, their feats are all the more remarkable when considering the hardships they surely endured in winning the prized red metal.



State of Michigan
Department of Natural Resources

Geological Survey Division

Water Investigation 10

GROUND WATER AND GEOLOGY OF KEWEENAW PENINSULA, MICHIGAN

by
C. J. Doonan, G. E. Hendrickson, and J. R. Byerlay

Prepared in cooperation with the Water Resources Division of the Geological Survey, United States Department of the Interior

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PREFACE

The purpose of this report is to provide information needed in the search for water supplies from wells or springs in Houghton and Keweenaw counties.

For many years the state and federal geological surveys have cooperated in producing basic information on water resources in Michigan. This report is one product of that continuing program; and was made possible by the assistance of county agencies, municipalities, industrial concerns, well drillers, and many local residents.

Detailed records on wells and chemical analyses are included in the several tables in the Appendix at the rear of the report.

The report was reviewed by Arthur E. Slaughter of the Geological Survey Division, Department of Natural Resources, and Norman Billings of the Bureau of Water Management, Department of Natural Resources. Artwork is by Jim Campbell.

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ILLUSTRATIONS

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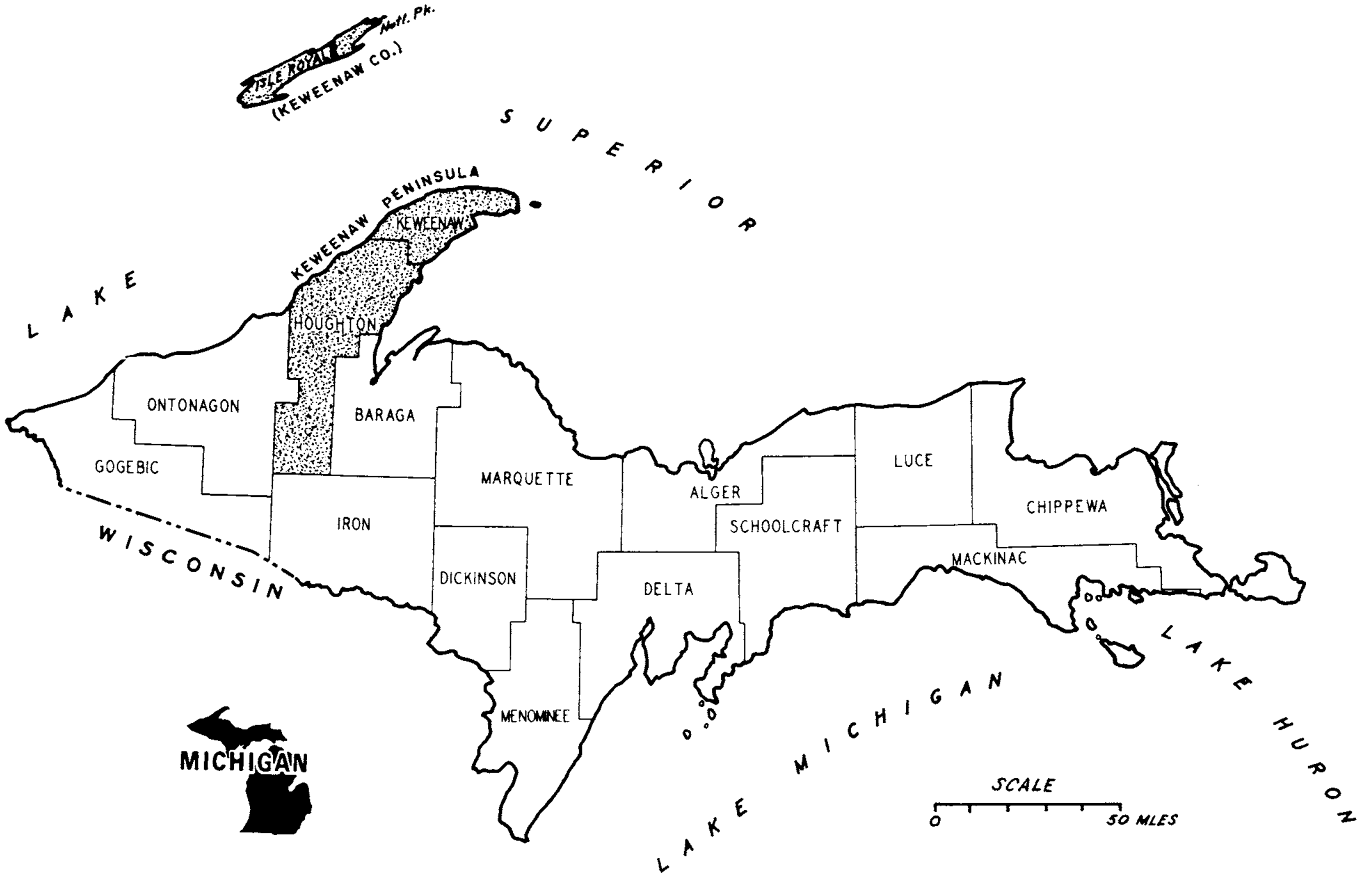

Figure 1 -- Keweenaw and Houghton counties in northwest part of Michigan's Upper Peninsula.

GROUND WATER AND GEOLOGY OF KEWEENAW PENINSULA, MICHIGAN

Abstract

Most wells in Houghton and Keweenaw Counties yield only enough water for a domestic supply, but a few yield several hundred gallons per minute. Bedrock aquifers supply most of the wells in Keweenaw County and about half the wells in Houghton County. Other wells are supplied by glacial aquifers--chiefly beds of sand and gravel in lakebeds and morainal deposits. All wells yielding more than 100 gallons per minute are in glacial deposits. The water from most wells is satisfactory for domestic use, but many wells produce water with troublesome amounts of iron. Water that is too salty for drinking is obtained from a few of the deeper bedrock wells. Most public supplies are obtained from wells and springs, but some are obtained from Lake Superior or from mine shafts.

INTRODUCTION

This report describes the geology of the Keweenaw and Houghton counties with particular attention to the glacial and bedrock aquifers that supply water to wells in the area. It also summarizes data on representative wells and springs. Supplementing the text and tables are maps showing bedrock and glacial geology, each with a key to the availability of ground water in the various aquifers. Also included is a map showing hydrologic data for selected wells.

Keweenaw and Houghton counties do not have abundant supplies of ground water, but most rural residents obtain enough water for domestic supplies from wells in bedrock or glacial drift. Several municipal supplies also are obtained, wholly or in part, from wells. The purpose of this report is to provide information needed in the search for ground-water supplies. The geologic information developed in this investigation should also be useful in managing other resources of the counties.

Descriptions of public water-supply systems, whether obtained from wells or surface-water sources, are included as permanent records needed to evaluate effects of future development. Data on other wells and springs are included in the Appendix.

Sources of Information

Information was obtained chiefly from: geologic data and records of water wells in the files of the Michigan Geological Survey Division and the U.S. Geological Survey, field inventory of selected wells, and reconnaissance mapping of surface formations. Well inventory data was related to the geologic information to determine the water-yielding character of the aquifers.

Well-Numbering System

The well-numbering system relates well location to the rectangular system of land subdivision referenced to the Michigan meridian and base line. The first and middle parts of a well number designate township and range; the last part designates both the section and well number within the section. Thus, "47N 35W 20-2" is well number two, in section 20, Township 47 North, Range 35 West.

Geography

Keweenaw and Houghton counties comprise the greater part of the Keweenaw Peninsula which juts into Lake Superior at the west end of Michigan's Upper Peninsula (fig. 1). The area is served by U.S. Highway 41 and State Highways 28, 35, 26, and 203. Common carrier service is provided by two railroads, one bus line and one airline.

The 1960 census showed that Houghton County had 24,181 people living in rural areas and an urban population of 11,473. All of Keweenaw County is classified as rural, with a 1960 population of 2,417.

Copper mining has been carried on in the area since 1843, but no mines have been in operation from August 1968 to the present (September 1969). Logging and lumber manufacturing are still active but not as extensive as at the turn of the century. The 1963 Census of Manufacturers lists 32 logging camps and contractors and 16 mills manufacturing lumber and flooring in the two counties.

Most of the farms are in the central part of the two-county area. Livestock and dairy products account for most of the farm income. Large quantities of potatoes and strawberries are grown.

In recent years, tourism and recreation have become important to the economy of the region. Each year more and more tourists visit the area to enjoy the rugged scenery, boating, fishing, and hunting. The low pollen count is an added attraction to hay fever sufferers.

Mining History

In the early 1840's, just a few years before the discovery of gold in California, the Keweenaw Peninsula was the site of America's first mining boom. Since then the Keweenaw has been one of the world's greatest copper mining districts. Nothing remotely resembling the native coppper deposits of the Keweenaw Peninsula is known anywhere else on this planet.

Development of copper mines in Michigan in the early 1900's paralleled the development of the American electrical industry. The two were interdependent.

Mining fortunes were made and lost in the Keweenaw. The Cliff Mine, near Eagle River, was one of the most successful of the early mines. During the period 1845 to 1880 the Cliff Mine produced 38 million pounds of copper, and returned to the investors about 2000 percent on paid-in capital. Most of the mining ventures in the Keweenaw, however, were not as successful as the Cliff Mine.

Increasing costs of mining, including the added costs of mining at ever-increasing depths, decreased profits to the point where mining became no longer profitable. Mining of native copper in the Keweenaw ceased in August 1968 with the closing of the Calumet and Hecla operation as the result of a labor dispute. The operation has not reopened at the time of publication of this report.

Topography and Drainage

The topography is dominated by the rugged hills of the "Copper Range" which trends northeast and east from the east-central part of Houghton County to the eastern tip of Keweenaw County. The highest peaks in this range are more than 1,500 feet above mean sea level, or about 900 feet above Lake Superior. Another highland area, at altitudes of 1,200 to 1,500 feet, is situated in the southern part of Houghton County. Here the topography is flat to gently rolling--in sharp contrast to the steep and rugged hills having numerous rock outcrops in the Copper Range. The remaining areas of the county are relatively flat to gently rolling at altitudes ranging from the level of Lake Superior (about 602 feet) to about 1,200 feet.

The Sturgeon River drainage system, the largest in the two counties, drains most of Houghton County lying south of Portage Lake and east of Highway M-26. The East Branch of the Ontonagon River drains the southern part of Houghton County. The remaining areas of the two counties are drained by small streams that flow from the highlands of the Copper Range to Lake Superior. These streams generally are short, having steep gradients. Rapids and waterfalls are common.

The rivers of Houghton and Keweenaw counties have not been extensively developed as a source of electric power. Upper Peninsula Power Company operates a generating plant at Prickett Dam on the main stream of the Sturgeon River. The dam and power plant are in Baraga County but most of the storage reservoir is in Houghton County.

GEOLOGY

The most conspicuous geologic features are the rugged hills comprised of exposures of bedrock. Over most of the area, however, glacial drift of Pleistocene age mantles the bedrock. The drift is thin or absent in much of the highlands area in the north and northeast, but is more than 150 feet thick in places in the central and southern parts of Houghton County. The geologic map, plate 1 (in pocket) shows the areal distribution of both bedrock and glacial deposits.

Bedrock Formations

The most prominent geologic feature of the Keweenaw Peninsula is the "Copper Range", a 4- to 12-mile wide central highland 700 feet above Lake Superior, extending southwestward more than 100 miles into Wisconsin. This highland is flanked on both sides by sandstone-floored lowlands gently sloping toward Lake Superior.

The Copper Range consists of Keweenawan lava flows and conglomerates dipping 35 to 60 degrees northwest and forming part of the southern limb of a great syncline beneath western Lake Superior. The northern limb emerges on Isle Royale and the north shore of Lake Superior. The western lowland is underlain by upper Keweenawan shales, sandstones, and siltstones derived largely from erosion of the lavas. The eastern lowland is separated from the highland by the Keweenaw fault, a major reverse fault which has formed a steep escarpment truncating the flat-lying Jacobsville Sandstone (inset on plate 1).

The age of the Jacobsville Sandstone is uncertain, being either Lower Cambrian or Upper Keweenawan. In the middle part of Houghton County occur two small areas of rocks not related to the Jacobsville Sandstone. One consists of Paleozoic carbonates, the other Lower Keweenawan lava flows. The southern part of the county is underlain by slate and graywacke of the Middle Precambrian Animikie Series.

The small area of Paleozoic limestone and dolomite at Limestone Mountain (Sec. 23, T51N, R35W) indicates Paleozoic seas were once present, but most of its sediments have been removed by erosion.

Animikie Series

The Michigamme Slate is the upper unit of the Animikie (or Huronian) Series of Middle Precambrian rocks which underlie the Keweenawan rock, forming the oldest bedrock in the Houghton-Keweenaw area. It consists of dark-colored slates and graywackes (a type of tough, clay-rich sandstone), and crops out or underlies variable amounts of drift in a three township area at the south end of Houghton County.

South Range Traps

Lower Keweenawan basaltic lava flows known as South Range Traps occur only in a 2- or 3-square mile area near the southwest corner of Houghton County. Northeast of this area the Jacobsville Sandstone lies unconformably on the Michigamme Slate.

Portage Lake Lava Series

The Portage Lake lavas consist of a series of several hundred basalt and andesite lava flows and interbedded conglomerates. The lavas reach their greatest known thickness (about 15,000 feet) in Keweenaw County. Farther south the Keweenaw fault cuts across the series leaving thickness of about 11,000 feet at Calumet and South Range, and only 8,000 feet at Victoria. The beds dip from 35 to 60 degrees northwest, somewhat less than the fault, which dips as much as 70 degrees northwest. Owing to thickening downdip, and flattening of the basin floor, the dip is gradually reduced away from the fault. Dips flatten somewhat in Keweenaw County; and on Isle Royale the series dips more gently, probably not more than 15 to 25 degrees southward.

Copper Harbor Conglomerate

The Copper Harbor Conglomerate overlies the Portage Lake lavas, and is composed of light-red to brown cemented, nonporous, boulder conglomerates and minor amounts of pebble conglomerate and arkosic (feldspar-rich) sandstone. Total thickness varies from 2300 to 5500 feet. The conglomerate dips 25 to 30 degrees northwest. In Keweenaw County and the northern end of Houghton County, the conglomerate includes two groups of lava flows called the Lakeshore traps--consisting of the upper trap, middle conglomerate, and lower trap. The part of the Copper Harbor conglomerate which lies below the traps is called the "Inner, or Great Conglomerate"; the part above, the "Outer Conglomerate". The Lakeshore traps thin or pinch out south of Township 55 North.

Nonesuch and Freda Units

The Nonesuch Shale and Freda Sandstone conformably overlie the Copper Harbor Conglomerate. They dip 19 or 20 degrees northwest. The Nonesuch averages 600 feet in thickness. The Freda lies conformably on the Nonesuch Shale and consists of alternating 3- or 4-foot layers of fine, arkosic sandstone and red micaceous silty shale. The Freda is exposed along the northwestern coast of the Keweenaw Peninsula and extends westward across Ontonagon County. According to Hamblin (1961) the Freda could exceed 14,000 feet in thickness, but only about 900 feet is found in Houghton County. Hamblin also indicates that the lower 1,500 feet is generally coarser than the upper part.

Jacobsville Sandstone

The Jacobsville is a light-red to brown, medium-grained quartz sandstone containing bleached spots or layers. It includes beds of fine-grained sandstone, shale, and conglomerate. The Jacobsville subcrops the entire Keweenaw lowland area covering the eastern half of the Peninsula.

The sandstone dips gently, 1 to 5 degrees, to the north and ranges in thickness from more than 1,000 feet to as much as 2,000 feet. Thinning to the south, it pinches out completely on the borders of the Precambrian highland in southeastern Houghton County--probably its source area.

Massive and crossbedded Jacobsville Sandstone is exposed in cliffs or underlies a thin veneer of beach sand along the Keweenaw Bay shoreline in Houghton and Keweenaw counties. It is covered by thin drift in large areas of the Keweenaw lowland on the east side of the Keweenaw Peninsula. Drift-filled preglacial valleys, however, may be as deep as 200 to 300 feet.

Glacial Formations

The Keweenaw Peninsula, like other parts of Michigan, has an uneven blanket of unconsolidated material covering the bedrock surface. This material consists of a mixture of sand, gravel, clay, and boulders, and is called glacial drift. A sequence of glaciers transported this material south during the Pleistocene Epoch. The two principal kinds of drift are stratified and unstratified.

Unstratified Deposits

Unstratified glacial drift, deposited directly from the ice with little water-sorting is called till--a heterogeneous mixture of clay, sand, gravel, and boulders. Till was dumped in conveyor-belt fashion along glacier margins to build moraines during intervals when the rate of melting at the front nearly equaled the rate of ice advance. Ground moraines, or till plains, were formed in two ways--by lodgment, plastering down, of till at the bottom of the moving ice sheet, or, by ablation, dropping in place, of till contained in melting and evaporating stagnant ice.

Most of the Keweenaw Peninsula is covered with salmon-colored till, varying from a few inches to more than 300 feet in thickness. It was deposited as ground moraine by the retreating Keweenaw Bay lobe. The blanket of till is very thin or completely absent on bedrock ridges of the Copper Range in Keweenaw County and on the highlands at the northern end of Houghton County. In these areas the thickest deposits occur in the valleys between ridges. Thinly covered bedrock ridges frequently resemble moraines.

Ground moraine is best developed topographically on the sandstone-floored lowlands which slope toward Lake Superior. The ground moraine extends to about 600 feet above the lake, on both sides of the Copper Range. This till surface was washed by lake waters ancestral to Lake Superior, as evidenced by patches of lake clays and sands on top of the till. Locally the till underlies outwash or kame complexes. In places, melt water streams have cut through the till and deposited stream sediments directly on bedrock.

The ground moraine on the Keweenaw lowland east of the Copper Range has a pink color and sandy texture derived from the underlying Jacobsville Sandstone. The till is generally less than 50 feet thick, thinning gradually eastward to a thin veneer on sandstone cliffs along Keweenaw Bay. A thin till layer covers the preglacial bedrock valley slopes of the Sturgeon River, Traprock River, and Torch Lake valleys. The preglacial Sturgeon River was a major trunk stream draining into Portage Lake and through Portage Gap. The Torch Lake and Traprock River valleys, however, were developed along the Keweenaw fault valley.

West and northwest of the Copper Range the ground moraine is less extensive. Local areas of thin till mixed with conglomerate eroded from the underlying bedrock resemble very gravelly outwash.

Moraines: The Keweenaw Moraine was deposited along the terminal margin of the Keweenaw Bay lobe. The moraine covers the Copper Range highland in central Houghton County, then curves eastward in southern Houghton County, conforming approximately to the outline of the bay. The Keweenaw Moraine is best developed on the Copper Range in central Houghton County between South Range and Winona. This area lies above the highest of the old glacial lakes, Lake Duluth. The salmon-colored clay till forms typical morainic topography over much of the area, although quite variable in thickness. Bedrock is at or near the surface in places, but in the moraine south of Painesdale, exploratory borings indicate drift thicknesses varying from 100 to 360 feet, leaving little doubt of its true morainic character.

A water-laid segment of the Keweenaw Moraine continues in a northwestward direction from the vicinity of South Range, down the west slope of the Copper Range for a distance of 5 or 6 miles north of the Portage Channel. This segment was laid down under the ice margin while the waters of Lake Duluth were ponded against the ice. The till is looser in texture than the clay till in the higher moraine and contains beds of lacustrine sand and poorly sorted gravel.

A few small moraines occur on the till-covered slopes north of Portage Lake. Also, several small kamic moraines with considerable relief occur above the flat till near Gay in the eastern lowland.

In southern Houghton County the Keweenaw Moraine curves eastward. A part of this moraine remains above glacial lake levels. Its texture is sandy. Topography is hilly or kamic with kettle basins, or lakes caused by melting of ice blocks formerly imbedded in the drift.

A section of the Marenisco Morainic Ridge crosses the southern end of Houghton County. This moraine stands higher than the Keweenaw Moraine and its texture and topography are sandy and kamic.

Stratified Deposits

Stratified drift originates from glacial melt water in two different ways--either in direct contact of melt waters with glacial ice, or by deposition away from the glacier margin. These occurrences are described next.

Ice-contact stratified drift includes eskers, kame terraces, kames, and kettles formed from sediment-laden melt waters in direct contact with thin stagnant ice. These stratified deposits, closely associated with till, show extreme range in grain size, and generally show deformation in bedding due to rapidly changing depositional conditions. Eskers are deposited in crevasses, or tunnels, at or near the base of the ice. When the materials collect in moulins (wells in the ice) or in small notches along the ice margin, they form low, steep sided ridgelike or flat-topped hills known as kames. Kettles, pits formed by delayed melting of sediment blanketed detached ice blocks, are associated with kames. Kame terraces are formed in glaciated valleys from sediment-laden melt waters confined between the ice and the valley wall. Ice-contact deposits grade directly into proglacial deposits.

Proglacial stratified drift includes outwash, stream, lake, and marine sediments carried and deposited by melt waters beyond the margin of the glacier. Outwash plains are deposited from broad sheet-like runoff at the ice margin, forming broad plains generally extending from a moraine and covering much of an earlier deposited ground moraine. Outwash is also deposited in valleys in front of the ice, grading upstream into ice-contact kame terraces on the ice margins. This type of proglacial deposit is called valley train outwash.

The clay and silt-sized particles washed out and carried along by melt water are deposited in lakes or ponded water occurring in front of the ice margin. Stratified proglacial deposits of this type consist of varying layers of sand, clay and silt deposited in the form of lakebeds, beaches, bars, and deltas.

The best developed *outwash* occurs in southern Houghton County in a broad, high delta plain between Frost and Sidnaw. The lower level is overlain by lake clays deposited below the waters of glacial Lake Ontonagon. The areas of outwash in central Houghton County are merely a veneer covering till on the upper slopes along the outer margin of the Keweenaw Moraine. Much of the outwash bordering the outer slope of the Keweenaw Moraine in central Houghton County was deposited below the waters of Lake Duluth and washed over or reworked by succeeding Lake Duluth.

As the ice melted back across the Peninsula, the deposition of stratified drift from the Keweenaw Lobe was controlled largely by existing topographic features such as gaps in the Copper Range, or where melt water streams formed kame terraces between the ice and steep ridge slopes. Outwash-filled gaps occur near Allouez, Mandan, and Eagle River. The gap near Mandan is a wind gap--now dry, but occupied by melt water streams during glacial times. Kame terraces flank both sides of Portage Gap east and west of Houghton and north toward Torch Lake, between Dollar Bay and Hubbell. Clusters of kames occur near Gay. Several eskers occur near the gaps at Allouez and Mandan.

Glacial lakebeds: Clay lakebeds cover two rather extensive areas--the plain bordering the inner slope of the Keweenaw Moraine at the south end of Keweenaw Bay, and the higher glacial Lake Ontonagon plain in the Kenton area in southwestern Houghton County. The Ontonagon plain is believed to overlie permeable till or outwash near its margins against higher moraine on the south and deltaic outwash on the north and east.

Most remaining areas of lakebeds and stream benches contain varying proportions of sand and clay, with sand predominating. Extensive areas of sandy glacial lakebed, benches and plains, generally highly dissected, occur in the lowlands on both sides of the Copper Range.

Beach deposits are largely low-lying sandy strand lines and dune areas formed during the slightly higher levels of glacial Lake Nipissing. Most of the dune area along the northwest shore of the Keweenaw Peninsula was formed during Nipissing time. Also, many of the small bordering lakes in Keweenaw County, such as Lac LaBelle, Gratiot Lake, and Schlatter Lake were formerly embayments which became isolated when waters of the Nipissing Great Lakes lowered to the present level.

Summary of Glacial History

The glacial drift in Houghton and Keweenaw counties was deposited by the Keweenaw sublobe of the Superior lobe. This sublobe moved westward across the Keweenaw Peninsula from Keweenaw Bay during the Valders advance of Wisconsin Glaciation, the last glacial ice in the Superior Basin. Till deposited by the Valders ice is generally pink in color due to mixing of hematite-rich clays from glacial Lake Keweenaw which occupied the Superior basin prior to the Valders advance. Although the area was glaciated many times during the Pleistocene Epoch, almost all traces of earlier glaciation have been obliterated.

The Keweenaw lobe spread westward across the Keweenaw Peninsula, southwestward for 25 to 30 miles beyond the south end of Keweenaw Bay, and southeastward onto the highlands in Baraga County, reaching its farthest advance about 11,000 years ago. As the glacier melted back, a series of proglacial lakes formed from ponded melt waters. One of them, glacial Lake Ontonagon, inundated a part of southern Houghton County, depositing lake sand and clay over materials deposited earlier by the retreating ice. Most of the deltaic outwash between Pori and Sidnaw was deposited in the border of Lake

Ontonagon. Lake Ontonagon shore lines are the highest in the Houghton-Keweenaw area, standing at 1320 to 1340 feet. Lake Ontonagon drained westward into other ice margin lakes which, in turn, were drained southward by the St. Croix River.

As the ice retreated to the position of the Keweenaw Moraine, the marginal lakes merged into one big lake, Lake Duluth. In Houghton County, much of the Keweenaw Moraine was deposited on the high Copper Range above the waters of Lake Duluth. A northern, water-laid segment of the moraine, however, was deposited at a lower elevation on the western slope of the Copper Range. A narrow belt of outwash was deposited on the lake border along the outer edge of the moraine, as the ice withdrew into the Keweenaw lowland. Due to downcutting of the outlet, Lake Duluth was gradually lowered, producing remnants of at least four beaches on the western slopes of the Copper Range. In Houghton County these beaches have been traced at elevations varying from 1,152 to 1,275 feet.

The exact position of the ice front with respect to Lake Duluth and its successors has not been clearly defined. Leverett (1929, p. 62) placed it tentatively in Keweenaw Bay during Duluth time. More recent studies by Farrand (1960) indicate Lake Duluth was confined to the area of the Superior Basin west of the Keweenaw Peninsula. Hughes (1963, p. 195) has further concluded from field observations that shore lines above the level of glacial Lake Nipissing, the immediate predecessor to the modern Lake Superior, are absent on the eastern slope of the Keweenaw Peninsula, except for an area south of Portage Lake. Ice-contact deposits were found--not shore lines, as Leverett had assumed. This evidence supports the theory that glacial Lake Algonquin, a major pre-Nipissing lake stage once believed to occupy the Michigan-Huron and Superior basins, was limited to the Michigan-Huron basin because glacial ice still occupied the eastern half of Lake Superior. Hughes, therefore, agrees with Hough Farrand and Black on the delineation of Lake Algonquin.

Retreat of the Keweenaw lobe over the remaining Keweenaw lowland prior to Nipissing times was fairly rapid. Evidence of rapid ice wastage in the form of ice contact features--eskers, kames, kame terraces, kame complexes--are more prevalent, however, in Keweenaw County and the northern end of Houghton County which was ice covered during the high glacial lake stages. Keweenaw County, therefore, was uncovered after the pre-Nipissing glacial lakes had subsided.

During the time the Keweenaw lobe occupied the Keweenaw lowland, melt waters were ponded in the lowland southwest of Baraga, in front of the ice. Hughes (p. 209) refers to this area as Lake Baraga, implying that it may have existed as a small, but separate, glacial lake at least during the earlier stages of Lake Duluth when the ice stood on the Keweenaw Moraine. Lake Baraga may have been connected with Duluth during its later stages for a short time prior to the uncovering of the Portage Channel. If so, the Lake Baraga spillways (Hughes, p. 209) located near Pori and Sidnaw could have served as a temporary outlet for Lake Duluth as well.

Melt waters from the southeastern border of the Keweenaw lobe drained to the southeast through a series of drainageways in Baraga and Marquette counties during the time when Lake Duluth was confined to the western Superior basin. Eventually, as the ice border receded far enough to uncover the Portage Channel, a drainageway for the waters of Lake Duluth was opened to the east as far as the Au Train-Whitefish River spillway and south to the Lake Michigan basin.

Because of continued retreat of the ice, the Au Train-Whitefish spillway was abandoned in favor of a lower outlet through the St. Mary's River channel. Eventually the entire Superior basin was uncovered and the resulting lake, glacial Lake Minong, was the first to occupy most of the Superior Basin. Further retreat opened a still lower series of outlets in the vicinity of North Bay, Ontario, which drained the water in the Superior basin to its lowest level, the Lake Houghton low stage, about 230 feet below the present Superior level (Farrand). The Portage Channel was probably high and dry at this time. Glacial rebound--a widespread gradual uplift of the earth's crust due to unloading of the glacial ice--eventually brought about abandonment of the North Bay outlet with subsequent rise in water level to the Nipissing Great Lakes stage. Drainage was southward at Port Huron, thence eastward through the Niagara River to the St. Lawrence River. Lake Nipissing occupied the entire northern Great Lakes--Michigan, Huron, and Superior. Since about 5000 to 4000 years ago, erosion of the Port Huron outlet has lowered these lakes to their present level.

Other Surface Deposits

Swamp

In this report, areas having more than 4- or 5-foot thicknesses of muck or peat are arbitrarily mapped as swamp. Generally they are associated with, and grade into recent stream deposits of sands and gravels. Most of the swamp areas occur in the Keweenaw lowland southeast of the Copper Range. Some occupy basins of extinct lakes filled with vegetation. In south-central Houghton County, a swamp overlies a large abandoned channelway, formerly a glacial lake outlet. Hence, beneath the swamp, stream sands and gravels may occur.

Recent Stream Deposits

In Keweenaw County, stream deposits are developed in valleys between ridges. These deposits generally overlie till, but locally may lie directly on bedrock. A broad glacial stream channel about two miles wide occupies the Traprock River valley from Lake Linden northeastward along the Keweenaw fault into Keweenaw County. The Sturgeon River occupies a very broad, well-developed preglacial bedrock valley extending south from the main body of Portage Lake and Otter Lake. Broad areas of muck and peat in this valley probably overlie stream deposits.

Made Land

Made land consists of stamp sand (mill tailings) and mine waste rock. Large areas of stamp sand border the west side of Torch Lake. Numerous narrow filled-in areas line both sides of the Portage Channel. Mine tailings and "poor-rock" piles are numerous in the Copper Range, many, too small to indicate on the map, are found on the central highland north of Houghton, near abandoned mine shafts.

GROUND-WATER RESOURCES

Availability

The quantity of water that can be obtained from wells in Houghton and Keweenaw counties varies widely from place to place. A few wells near Lake Superior, northwest of Calumet, yield several hundred gpm (gallons per minute) per well, but most wells in the two counties probably yield less than 10 gpm. Some wells fail to yield enough water for a domestic supply. In places alternate sources are lake and sand points buried just offshore in the Lake Superior sands. The quality of the water from most wells is satisfactory for domestic use, but many wells yield water containing enough iron to be troublesome. Water too salty for drinking is obtained from a few of the bedrock wells, but salty water is not a problem in most areas unless the wells are drilled more than 300 feet deep.

The location, depth, water-bearing formation, yield, and water quality of most wells are shown on plate 2 (in pocket). Yield is indicated in gpm where this information is available. Wells that satisfactorily supply a power pump generally yield at least 3 gpm, and many yield more than 10 gpm. Wells that supply a hand pump may yield less than 1 gpm, but many of these also may have the capability to yield 10 gpm or more.

The water-bearing character of bedrock and glacial drift is indicated on plate 1 (in pocket). Tables 1 and 2 summarize information on representative wells and springs; table 3 list drillers' logs of wells; table 4 provides data on well yields; and table 5 lists field analyses of water from wells. Analyses of water from springs are included in table 2.

Wells

Most ground-water supplies in Houghton and Keweenaw counties are obtained from drilled wells 4 to 6 inches in diameter and between 100 and 200 feet deep (table 1). About half of the wells inventoried were completed in bedrock.

Wells drilled into bedrock are generally cased through the overlying drift and a few feet into the rock, with the remainder of the hole left open. Wells completed in the glacial drift are cased down to the water-bearing zone where a screen is installed. Where glacial drift consists mostly of clay and silt, large diameter dug wells will generally yield more water than drilled or driven wells. Most dug wells visited were 3 to 4 feet in diameter and less than 20 feet deep. One household obtains its water from a well 8 feet in diameter blasted 25 feet into the Jacobsville Sandstone. In a few areas where the soil is mostly sand and gravel driven wells will yield enough water for a domestic supply. Along the Lake Superior shore, many cottage owners lay sand points horizontally on the lake bottom and pump water directly from the lake. Some systems include facilities for chlorine treatment whereas others use untreated water.

Springs

All of the springs visited had been developed by enlarging and deepening the discharge area and installing some sort of cribbing or structure to confine the water. Yields were generally less than 3 gpm (table 2) but in most cases the storage capacity of the confining structure permitted use of electric pumps. On one dairy farm, water flowing by gravity from a large spring could adequately supply a modern water system in all buildings. Two municipalities and one industry obtain their water from springs. The value of springs as a potential water supply is limited because they may be located too far from the point of intended use.

Sources and Potential

Glacial Aquifers

Glacial aquifers supply about half of the wells in Houghton County and a few wells in Keweenaw County. Where present, the thickness of glacial drift ranges from a few feet to at least 312 feet. Yields of wells in the glacial aquifers range from the few gpm required to supply a hand pump to 760 gpm. None of the wells in the glacial drift yielded salty water, but many yielded water with troublesome amounts of iron.

Lakebeds: The most productive wells in the county are in areas where lakebeds are the surface formation. These are exposed in many areas along the shore line of the Keweenaw Peninsula and in lowland areas inland. In addition, thin deposits of lakebeds overlie morainal deposits in parts of areas mapped as moraine or ground moraine. The lake beds consist of alternating layers of clay, sand, silt and some gravel. Occasional boulders may also occur where these deposits are bordered by morainal or bedrock highlands. The lakebeds on the map are separated into clay lakebeds and sand lakebeds. Most of the lakebed area in the two counties is mapped as sand. All of the large-producing wells inventoried are in the sand lakebed areas. Some of the most productive wells may penetrate sand and gravel outwash below the lakebed deposits.

Three wells 78 to 100 feet deep near the mouth of Gardners Creek northwest of Calumet, yield 300 to 760 gpm from beds of sand 38 to 65 feet thick. Specific capacities of these wells range from 7.3 to 14.6 gpm per foot of drawdown. To the southwest, at McLain State Park, a well 55 feet deep yields 60 gpm from beds of sand with some gravel. Specific capacity of this well was only 2 gpm per foot. Other wells in lakebed areas generally yield smaller supplies of water, but most are adequate to supply a power pump.

Water from most wells in lakebeds is generally of satisfactory quality, only moderately hard. A few wells yield water with troublesome amounts of iron.

Moraines and ground moraines: Most of the wells in glacial drift obtain water from morainal deposits, probably because moraines and ground moraines are the predoninant glacial features in the two counties. The surficial map (plate 1) delineates high level (above glacial lakes) and low level (below glacial lakes) moraines and ground moraine. The high level moraines are further subdivided into clay till and sandy till mixed with sand and gravel. Well data are not sufficient to distinguish between the water-bearing properties of the three types of moraine and ground moraine shown on the map. However, the clay till of the high-level moraine would be expected to yield less water to wells than would the other two mapped units.

Yields of wells in morainal areas generally are great enough to supply a power pump; a few yield more than 20 gpm. Most wells penetrate beds of clay or sandy clay before they reach water-bearing beds of sand and gravel. Quality of water from wells in morainal deposits generally is satisfactory for domestic use, although many yield water containing objectionable amounts of iron.

Outwash deposits cover part of southern Houghton County and are scattered elsewhere. Because few well records were obtained in the outwash areas, the water-bearing properties must be inferred from the generally permeable character of the water-laid beds of sand and gravel predominant in outwash deposits. Probably most wells drilled into the thicker outwash deposits in southern Houghton County will yield more than 10 gpm, and possibly some wells may yield several hundred gpm. The outwash areas in central Houghton County probably are not favorable for obtaining large supplies of ground water because they are generally a thin veneer over till. Water quality from most wells in outwash should be satisfactory for domestic use.

Potential areas: Large areas in Houghton and Keweenaw counties are undeveloped or only sparsely developed. Existing wells, therefore, do not give a complete picture of the potential supply of ground water. If large supplies are needed in the future for municipal or industrial use, or for irrigation, test wells should be drilled in the more favorable areas of the two counties.

Outwash deposits have potential for large-capacity wells, especially where outwash borders the flood plains of perennial streams. The 40 sq. mi. of outwash deposits in southern Houghton County should be explored for productive aquifers. Another outwash area which may have potential for large-capacity wells is a buried channel extending northwest from Ahmeek between Hill Creek and Gratiot Creek (Hughes, 1963, p. 19). Although no wells were inventoried in this area, test borings indicate sand and gravel deposits as thick as 200 feet in places.

The large supplies obtained from a few wells in sand lakebeds along the Lake Superior shore line northwest of Calumet suggest that further exploration in the sand lakebed sediments may be justified. Induced infiltration from lakes or streams may add to the supplies in some areas.

Although morainal deposits generally are less favorable water-bearing materials than outwash or sandy lakebeds, a few wells in morainal deposits yield 20 gpm or more. Logs of wells in morainal deposits indicate that beds of water-bearing sand and gravel may be encounted at various depths. Test drilling may show many areas in the county where morainal deposits will yield moderate supplies.

Swamp and Stream Deposits

Areas mapped as swamp and recent stream deposits occur in the flood plains of the major streams and in broad lowland areas. The recent deposits of muck, peat, sand, and gravel generally are shallow, and in most places overlie sand and clay lakebeds and lowland morainal deposits. In a few places they overlie sand and gravel outwash deposits. Several wells in recent stream deposits yield moderate supplies of water, but probably some of them obtain water from underlying beds of sand and gravel. Wells located near streams generally have the advantage of shallow depth to water. In addition, aquifers supplying such wells may be recharged from the stream when the pumping level is drawn down below the level of the stream. Quality of water from wells in stream deposits generally is satisfactory for domestic use.

Bedrock Aquifers

About half of the wells in Houghton County and most wells in Keweenaw County obtain water from bedrock. Most of these are drilled wells more than 100 feet deep. Some (of the homes) are (supplied by) dug wells 10 to 15 feet deep. Bedrock crops out or is covered by thin drift in large areas in Keweenaw and northern Houghton counties. In these areas the drift generally is too thin to supply water to drilled wells, although a few dug wells may obtain water from the drift. Bedrock also supplies water to many wells outside those areas mapped as bedrock or thin drift, suggesting that the glacial drift is not permeable enough in many places to provide an adequate supply. Probably most wells in bedrock yield less than 10 gpm, but several yield more than 20 gpm. Water from most bedrock wells is soft to moderately hard; many yield water with objectionable amounts of iron and a few yield salty water.

Jacobsville Sandstone underlies the glacial drift in most of the southern and southeastern parts of the two counties. The Jacobsville yields small to moderate supplies of fresh water to most wells drilled into it. Almost all bedrock wells in the two counties yielding more than 20 gpm are in the Jacobsville Sandstone. Water is generally of satisfactory quality, although a few of the deeper wells may yield water too salty for domestic use. Most of the wells in the Jacobsville are in the range of 100 to 250 feet deep, but a few are shallower than 50 feet, and at least one is more than 400 feet deep.

Nonesuch Shale and Freda Sandstone underlie the glacial drift in northwestern Houghton County and in a narrow band along northern and northwestern Keweenaw County. Although these rock units underlie about 180 square miles, only a few wells obtain water from them. Yields generally are small, and some wells yield water too salty for domestic use.

Portage Lake lava series is exposed or underlies the glacial drift in a band 4 to 12 miles wide north and northwest of the area of Jacobsville Sandstone. A few wells yield small supplies of water from these rocks. Samples of water collected from a mine at different depths indicate that water increases in salinity with depth. Wells more than 300 feet deep may yield water too salty for domestic use.

Copper Harbor Conglomerate is exposed or underlies the glacial drift in a narrow band 1 to 3 miles wide north and northwest of the band of the Portage Lake Lava Series. Several wells near the north edge of Keweenaw County obtain small to moderate supplies of water from the Copper Harbor Conglomerate. In Houghton County northwest of Atlantic, yields up to 12 gpm have been reported. Water from some wells may be salty.

Animikie Series: Three wells in southeastern Houghton County obtain small amounts of water from the rocks of this series. Water is of satisfactory quality for domestic use.

South Range Traps underlie a very small area in southwestern Houghton County. No records were obtained from wells in these rocks.

Potential areas: The large area underlain by the Jacobsville Sandstone is generally the most favorable area in the county for developing moderate supplies of fresh water from wells in bedrock. Possibly large-diameter wells (more than 8 inches in diameter) may yield as much as 100 gpm in places. Water from most wells in the Jacobsville is fresh, but wells more than 300 feet deep may yield salty water in places. Wells in bedrock in other parts of the county generally will yield only small supplies, although moderate supplies may be obtained locally. Fractures yielding water diminish in size with increasing depth. Also deep wells are more likely to yield salty water than shallow wells. Least favorable areas for obtaining water from bedrock are the outcrop areas on or near hilltops.

Quality

Chemical analyses of water samples from 98 wells are listed in table 5. Analyses of water from 13 springs are included in table 2. The significance of chemical properties commonly associated with water are tabulated on the following page.

Water from most wells and springs in Houghton and Keweenaw counties is satisfactory for domestic and most other uses. The most common water-quality problem is staining of laundry, cooking utensils, and bathroom fixtures because of high iron content. About one third of the 98 wells and one of the 13 springs sampled yielded water containing more than 0.3 mg/l (milligrams per liter) of iron. High iron

Significance of chemical properties commonly associated with water

Constituent or physical property	Sources of cause	Significance
Silica (SiO_2).	Dissolved from practically all rocks and soils, usually in small amounts--1-30 mg/l. High concentrations, as much as 100 mg/l, generally occur in highly alkaline waters.	Forms hard scale in pipes and boilers. Carried over in steam of high pressure boilers to form deposits on blades of steam turbines. Inhibits deterioration of zeolite-type water softeners.
Iron (Fe).	Dissolved from practically all rocks and soils. May also be derived from iron pipes, pumps, and other equipment.	On exposure to air, iron in ground water oxidizes to reddish-brown sediment. More than about 0.3 mg/l stains laundry and utensils reddish-brown. Objectionable for food processing, beverages, dyeing, bleaching, ice manufacture, brewing and other processes. Federal drinking water standards suggest that iron should not exceed 0.3 mg/l. Larger quantities cause unpleasant taste and favor growth of iron bacteria.
Calcium (Ca) and Magnesium (Mg). .	Dissolved from practically all soils and rocks but especially from limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Magnesium is present in large quantities in sea water.	Cause most of the hardness and scale-forming properties of water; soap consuming. (See hardness.) Waters low in calcium and magnesium desired in eletroplating, tanning, dyeing, and textile manufacturing.
Sodium (Na) and Potassium (K). . .	Dissolved from practically all rocks and soils. Found also in ancient brines, sea water, some industrial brines, and sewage.	Large amounts as chlorides give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers and a high sodium ratio may limit the use of water for irrigation.
Bicarbonate (HCO_3) and Carbonate (CO_3).	Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite.	Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot-water facilities to form scale and release corrosive carbon dioxide gas.
Sulfate (SO_4).	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Usually present in mine waters and in some industrial wastes.	Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts sulfate in combination with other ions gives bitter taste to water. Some calcium sulfate is considered beneficial in the brewing process. Federal drinking water standards recommend that the sulfate content should not exceed 250 mg/l.
Chloride (Cl).	Dissolved from rocks and soils. Present in sewage and found in large amounts in ancient brines, sea water, and industrial brines.	In large amounts chloride salts give salty taste to water. In large quantities increases the corrosiveness of water. Federal drinking water standards recommend that the chloride content should not exceed 250 mg/l.
Nitrate (NO_3).	Decaying organic matter, sewage, and nitrates in soil.	Concentrations much greater than the local average may suggest pollution. There is evidence that more than about 45 mg/l of nitrate (NO_3) may cause a type of methemoglobinemia in infants, sometimes fatal. Water of high nitrate content should not be used in baby feeding (Maxcy, 1950, p. 265, App. D). Nitrate has shown to be helpful in reducing intercrystalline cracking of boiler steel. It encourages growth of algae and other organisms which produce undesirable tastes and odors.
Dissolved solids	Chiefly mineral constituents dissolved from rocks and soils. Includes any organic matter and some water of crystallization.	Federal drinking water standards recommend that the dissolved solids should not exceed 500 mg/l. Waters containing more than 1,000 mg/l of dissolved solids are unsuitable for many purposes.
Hardness as $CaCO_3$.	In most waters nearly all the hardness is due to calcium and magnesium.	Hard water consumes soap before a lather will form; deposits soap curd on bathtubs; forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called non-carbonate hardness. Waters of hardness as much as 60 mg/l are considered soft; 61 to 120 mg/l, moderately hard; 121 to 200, hard; more than 200, very hard.
Specific conductance (micromhos per centimeter at 25° C)	Mineral content of the water.	Specific conductance is a measure of the capacity of the water to conduct an electric current. Varies with concentration and degree of ionization of the constituents. Varies with temperature; reported at 25° C.
Hydrogen-ion concentration (pH). .	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxides and phosphates, silicates, and borates raise the pH.	A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. pH is a measure of the activity of the hydrogen ions. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals.

content was slightly more prevalent in drift wells than in rock wells. Most wells and springs yielded water that is soft to moderately hard. About one fourth of the wells and springs sampled yielded water that would be described as hard, containing more than 120 mg/l of hardness as $CaCO_3$ (calcium carbonate). Five of the 46 wells obtaining water from bedrock yielded water greater in salinity than is recommended for domestic use (chloride content more than 250 mg/l). None of the wells in drift yielded salty water.

The hardness and bicarbonate content of the samples indicate that the water is generally of the calcium magnesium bicarbonate type as are most fresh ground water supplies in Michigan. With few exceptions the water is moderately alkaline, with pH ranging from 7.1 to 8.5. A few samples are neutral or slightly acidic, with pH ranging from 5.0 to 7.0. Most samples with pH lower than 7.0 are soft and have a low specific conductance.

Chemical analysis of public supplies obtained from Lake Superior

	Eagle Harbor	Copper Harbor	Eagle River	Gay
Dissolved solids in mg/l:				
Total solids	60	88	352	76
Silica SiO_2	3	2	15	4
Iron Fe	0.5	0	0	0.3
Manganese Mn	0	0	0.1	0
Sodium Na	1.4	12	39	36
Potassium K	0.3	0.5	1.7	0.7
Nitrate NO_3	1.1	0	0	1.2
Chloride Cl	0	16	132	3
Sulfate SO_4	4	3	2	5
Bicarbonate HCO_3	59	59	135	68
Carbonate CO_3	0	0	0	0
Hardness $CaCO_3$	50	50	205	52
Fluoride F	0.1	0.15	0.45	0.15
pH	7.3	7.6	7.7	6.8
Specific conductance (micromhos at 25° C.)	100	160	540	125

Sample taken July 8, 1968
Analysis by Mich. Dept. Pub. Health

WATER SUPPLIES

Water from wells and springs supplies most of the demand in the two counties, but water from Lake Superior is used in areas where wells will not provide the needed amount. The largest use of ground water is for municipal and industrial supplies. Individual household systems and parks and recreational areas use only moderate supplies.

Municipalities

Most of the municipal water systems use ground water. Several townships maintain well fields and furnish water to unincorporated towns within the township. One city buys water from a privately-owned spring. A water authority pumps water from an abandoned mine and sells it to several other municipal systems. A privately-owned water company supplies ground water to users in several towns.

The municipalities located on the shore of Lake Superior in Keweenaw County use lake water, because large supplies of potable ground water are not generally available. Most of the intakes are offshore in 15 to 40 feet of water. At Eagle River a vertical shaft was sunk well below the level of the bottom of Lake Superior. A tunnel, was then constructed to a point under the lake where holes were driven upward to allow water to migrate downward into the tunnel. Chemical analyses of water samples from four systems using Lake Superior water indicate possible leakage of highly mineralized ground water into the tunnel. Chlorine is added in all the systems using Lake Superior water.

Following are brief descriptions of those municipal systems using ground water.

Adams Township and South Range

The Adams Township and South Range Village Water and Sewage Authority operates a large water system supplying several towns with water pumped from the abandoned Champion copper mine at Painesdale.

When the mine was operating, water migrating downward from the glacial drift hampered mining operations. A 6' x 7' tunnel about 3,000 feet long was constructed 112 feet below the surface to intercept the water before it reached the working level. When South Range Copper Company discontinued operations at the Champion mine the present owners took over the water system.

Water is transmitted through two separate systems. Houghton, Hancock, and Portage Township are served by a low pressure line with a 100,000-gallon overhead storage tank at Painesdale. Portage Township supplies the towns of Dodgeville and Hurontown. The second system is a high pressure line which serves Painesdale, Trimountain, Baltic and South Range. It includes overhead storage tanks of 200,000 and 100,000 gallons at Painesdale and Baltic, respectively. Chlorine is added to both systems. Peak demand is about 55 million gallons per month on the low pressure line and 12 million gallons per month on the high pressure line.

Chemical analysis of public supply obtained from abandoned Champion mine

Dissolved solids in mg/l:	
Total Solids	106
Silica SiO_2	12
Iron Fe	0
Manganese Mn	0
Calcium Ca	26
Magnesium Mg	5
Sodium Na	1.6
Potassium K	0.3
Nitrate NO_3	1.8
Chloride Cl	4
Sulfate SO_4	5
Bicarbonate HCO_3	100
Carbonate CO_3	0
Hardness $CaCO_3$	86
Fluoride F	0
pH	8.2
Specific conductance (micromhos at 25° C.)	170

Sample taken Jan. 12, 1968 at pumping station.
Analysis by Mich. Dept. Pub. Health

Franklin Township

Franklin Township supplies water to about 300 people at Ripley and Pewabic location, through two distribuiton systems. The Ripley system obtains water from two wells, 55N 34W 25-1 and 25-2, both finished in glacial drift.

At Pewabic location a spring, 55N 34W 25-3, has been developed by sinking a cast iron caisson 8 ft. in diameter, 6 feet into the discharge area.

Chemical analysis of public supply obtained from well 55N 34W 25-1

Dissolved solids in mg/l:	
Total solids	130
Silica SiO_2	15
Iron Fe	0.5
Manganese Mn	0.0
Calcium Ca	29
Magnesium Mg	6
Sodium Na	2.5
Potassium K	0.3
Nitrate NO_3	1.6
Chloride Cl	1
Sulfate SO_4	9
Bicarbonate HCO_3	115
Carbonate CO_3	0
Hardness $CaCO_3$	98
Fluoride F	0.1
pH	7.8
Specific conductance (micromhos at 25° C.)	220

Sample taken July 10, 1968
Analysis by Mich. Dept. Pub. Health

Lake Linden

Water for the municipal supply at Lake Linden comes from a field of six springs, known as Gregory Springs, located on a hillside east of town. Water from the five smaller springs is piped to a collector at the largest spring. It then flows into an underground reservoir and then pumped to a 50,000-gallon overhead tank. Pumpage averages 115,000 gallong per day.

The springs and reservoir are privately owned. The city buys raw water and adds chlorine. Each spring is protected by a concrete shelter. If this source of water should be accidently lost, the city has an agreement to purchase emergency supplies from Northern Michigan Water Company. About 575 customers are served by this system.

For the purpose of this report all six springs have been numbered 55N 32 W 5-1.

Chemical analysis of public supply obtained from spring 55N 32W 5-1

Dissolved solids in mg/l:	
Total solids	123
Iron Fe	0.1
Chloride Cl	8.4
Sulfate SO_4	18
Bicarbonate HCO_3	56
Carbonate CO_3	0
Hardness $CaCO_3$	81
Noncarbonate hardness	35
Alkalinity	46
pH	6.5
Specific conductance (micromhos at 25° C.)	190

Sample taken 1968
Analysis by U.S. Geological Survey

Torch Lake Township

Torch Lake Township supplies water to about 280 customers in the town of Hubble. The township operates three wells and also purchases 100,000 gallons of water per month from the Northern Michigan Water Company. Water consumption is metered; customers are billed quarterly.

The well field consists of five closely spaced bedrock wells, two of which have been abandoned because of low yield. Well 55N 33W 12-1 (Twp. well 1) drilled in 1960 and abandoned in 1962 is a 6-inch well 210 feet deep. Well 55N 33W 12-2 (Twp. well 2) also drilled in 1960 has a 5-inch casing and is 205 feet deep. Well 55N 33W 12-3 (Twp. well 3) was drilled to a depth of 210 feet in 1960, deepened to 275 feet in 1962, and then abandoned in 1963. Well 55N 33W 12-4 (Twp. well 4) is a 6-inch well 257 feet deep drilled in 1961; in 1962 the casing depth was increased from 18 to 41 feet. Well 55N 33W 12-5 (Twp. well 5) is a 6-inch well 400 feet deep drilled in 1962. All wells are completed in Jacobsville Sandstone. All except Twp. 1 have 30 feet of 19-inch casing driven outside the original casing, the annular space filled with concrete.

Driller's log 55N 33W 12-1 (Twp. well 1)
NW 1/4 SE 1/4 altitude 720',
drilled 1960, abandoned 1962

unit	thick. in ft.	bottom depth
Sandstone (Jacobsville)	40	40
Sandstone, reddish brown, vy fn to med grained, silty	10	50
Sandstone, reddish brown, vy fn to fn grained, silty	40	90
Sandstone, reddish brown, vy fn to med, with some cse grained, silty	5	95
Sandstone, reddish brown, vy fn to fn grained, silty	30	125
Sandstone, reddish brown, vy fn to cse grained, silty	5	130
Sandstone, reddish brown, vy fn to fn grained, silty	10	140
Sandstone, orange brown, vy fn to fn grained with some cse grains and silt	5	145
Sandstone, reddish brown, vy fn to fn grained with some cse grains and silt	35	180
Sandstone, light colored red-brown, vy fn to fn grained, silty	15	195
Sandstone, light red-brown, vy fn to fn grained, quartzose, little or no silt	5	200
Sandstone, light red-brown, vy fn to fn grained	5	205
Sandstone, light red-brown, vy fn to fn grained, silty	5	210

Driller's log 55N 33W 12-2 (Twp. well 2)
NW 1/4 SE 1/4 altitude 785'
drilled 1960

unit	thick. in ft.	bottom depth
Sandstone (Jacobsville), brownish red, vy fn to cse grained, silty	10	10
Sandstone, brownish red, vy fn to med grained with silt	75	85
Sandstone, brownish red, quartzitic, vy fn to med grained with vy little silt	15	100
Sandstone, brownish red, vy fn to med grained with silt	5	105
Sandstone, brownish red, vy fn to fn grained with silt	10	115
Sandstone, brownish red, vy fn to cse grained, with silt	5	120
Sandstone, brownish red, vy fn to fn grained with silt	5	125
Sandstone, brownish red, fn to med grained little or no silt	10	135
Sandstone, brownish red, vy fn to fn grained, silty	15	150
Sandstone, brownish red, fn to med grained, little silt	5	155
Sandstone, brownish red, vy fn to fn grained, silty	15	170
Sandstone, light brown, vy quartzose, vy fn to med grained, little to no silt	10	180
Sandstone, reddish brown, vy fn to fn grained, silty	5	185
Sandstone, light brown, vy quartzose, vy fn to med grained, little or no silt	5	190
Sandstone, brownish red, vy fn to fn grained, silty	5	195
Sandstone, brown to red, vy fn to med grained, quartzitic, some silt	10	205

Driller's log 55N 33W 12-3 (Twp. well 3)
NW 1/4 SE 1/4 altitude 800',
drilled 1960, abandoned 1963

unit	thick. in ft.	bottom depth
Sand, vy quartzose, light brown, fn to cse grained, some gravel fn to med grained	10	10
Sand, quartzose, light brown, fn to cse grained, with some gravel, fn to cse	10	20
Sand, quartzose, light brown, fn to med grained, gravel, fn to med grained	5	25
Sand, light brown, fn to cse, gravel fn to med, clean	5	30
Sand, light brown, fn to cse grained, small percent of gravel, fn to med grained	5	35
Sandstone (Jacobsville), reddish brown, quartzose, vy fn to med grained	15	50
Sandstone, reddish brown, quartzose, vy fn to cse grained, low percent of silt	25	75
Sandstone, reddish brown, quartzose, vy fn to med grained with small percent of cse grained	25	100
Sandstone, reddish brown, quartzose, vy fn to cse grained with silt	20	120
Sandstone, reddish brown, quartzose, vy fn to med grained with silt	60	180
No sample	10	190
Sandstone, reddish brown, quartzose, vy fn grained to fn grained and little silt	10	200
Sandstone, reddish brown, quartzose, vy fn grained to fn grained, clean	5	205

Driller's log 55N 33W 12-4 (Twp. well 4)
NW 1/4 SE 1/4 altitude 800',
drilled 1961

unit	thick. in ft.	bottom depth
Sand, red, med grained and sub-angular with clay	10	10
Sandstone (Jacobsville), red, fn to med grained	70	80
Sandstone, pink, med grained, some fines	10	90
Sandstone, red, fn grained with some med	10	100
Sandstone, red, fn to med grained	40	140
Sandstone, pink, fn to med grained	20	160
Sandstone, pink, fn grained with some med	20	180
Sandstone, red, fn to med grained	30	210
Sandstone, light red, med and fn grained	10	220
Sandstone, light red, med grained, some fn	20	240
Sandstone, red, fn to med grained	10	250
Sandstone, red, fn grained with med	10	260

Chemical analysis of public supply obtained from wells

	Twp. well 5	Twp. wells 2 and 4
Dissolved solids in mg/l:		
Silica SiO_2	8	---
Iron Fe	0	0.1
Manganese Mn	0	---
Calcium Ca	25	---
Magnesium Mg	7.7	---
Sodium Na	8.5	---
Potassium K	3.0	---
Nitrate NO_3	1.5	---
Chloride Cl	2	1
Sulfate SO_4	5	---
Bicarbonate HCO_3	135	---
Carbonate CO_3	0	---
Hardness $CaCO_3$	94	100
Fluoride F	0	0.1
pH	8.3	
Specific conductance (micromhos at 25° C.)	220	

Samples taken 1964 (No. 5) and 1961 (No. 2 & 4)
Analysis by Mich. Dept. Pub. Health

Osceola Township

Osceola Township supplies water to about 220 customers in the town of Dollar Bay. The water system includes a 12-inch well, 55N 33W 33-1, 44 feet deep and a 100,000-gallon elevated storage tank. The 25-hp. centrifugal pump has a capacity of 350 gpm. Most customers pay a flat monthly rate, but two large commercial users have their water consumption metered.

Driller's log 55N 33W 33-1
Gov't. lot 6, SE 1/4 SW 1/4
altitude 610', drilled 1958

unit	thick. in ft.	bottom depth
Existing well pit	8	8
Boulders and sand	5	13
Coarse sand and gravel	31	44

Chemical analysis of public supply obtained from well 55N 33W 33-1

Dissolved solids in mg/l:	
Total solids	170
Silica SiO_2	15
Iron Fe	0
Manganese Mn	0
Calcium Ca	38
Magnesium Mg	10
Sodium Na	4.6
Potassium K	0.9
Nitrate NO_3	7.1
Chloride Cl	5
Sulfate SO_4	16
Bicarbonate HCO_3	130
Carbonate CO_3	0
Hardness $CaCO_3$	125
Fluoride F	0.1
pH	8.4
Specific conductance (micromhos at 25° C.)	280

Sample taken 1960
Analysis by Mich. Dept. Pub. Health

Donken

About 1945 the Vulcan Corporation drilled two 6-inch wells at Donken to provide water for a mill and the local residents. Both wells are about 110 feet deep finished in bedrock. By September, 1968, the mill and most of the dwellings had been removed. Only well 53N 35W 31-1 was being used to supply water to the six remaining customers who pay a flat monthly rate.

Chemical analysis of well 53N 35W 31-1

Dissolved solids in mg/l:	
Hardness $CaCO_3$	100
Iron Fe	0.5
Chloride Cl	5
pH	7.5
Specific conductance (micromhos at 25° C.)	200

Sample taken Sept. 26, 1968
Field analysis by U.S.G.S.

Northern Michigan Water Company

Northern Michigan Water Company furnishes water to Calumet, Laurium, Copper City, Ahmeek, Mohawk, Fulton, part of Hubbell, rural areas near these towns, and Chassell (a separate system).

For many years the Company's water, except the Chassell supply, was taken from Lake Superior at the Calumet and Tamarack pumping stations. In 1968 three large-diameter, gravel-packed wells were constructed in the glacial drift near the Calumet pumping station, which was discontinued when the wells were put in use. The Tamarack Station is maintained on a standby basis. The 3500 customers use an average of 1.2 million gallons of water per day. Chlorine is added to both lake and well water.

At Chassell the company supplies water to about 250 customers from a spring, 54N 33W 31-2, located about a mile west of town. The spring consists of five openings in a hillside, all of which discharge into a storage reservoir. In 1962 a 10-inch, 400 foot deep test well, 53N 33W 5-2, was drilled south of town; yield was insufficient for municipal supply so the well was abandoned. A 5-inch well, 54N 33W 32-1, near the north edge of town was part of the system until 1965 when it was abandoned because of poor yield. For pump test results for well 56N 33W 5-1, 5-2 and 5-3 at the Calumet pumping station site, see table 4.

Driller's log Calumet 56N 33W 5-1 (Co. well 1) SE 1/4 NW 1/4 SW 1/4 altitude 610', drilled 1968

unit	thick. in ft.	bottom depth
White sand	2	2
Clay	3	5
Clay with large gravel	6	11
Coarse gravel and boulders	2	13
Hardpan with large rock	12	25
Medium dirty muddy sand	5	30
Sand with clay streaks	5	35
Medium sand	35	70
Fine sand	10	80
Tight fine sand	20	100

Driller's log Calumet 56N 33W 5-2 (Co. well 2) NW 1/4 NE 1/4 SW 1/4 altitude 610', drilled 1968

unit	thick. in ft.	bottom depth
Clay and boulders	5	5
Hardpan with large rocks	5	10
Sand with streaks of clay	5	15
Medium sand with streaks of clay	15	30
Coarse sand	5	35
Coarse sand	25	60
Medium to coarse sand	18	78

Driller's log Calumet 56N 33W 5-3 (Co. well 3) NW 1/4 SW 1/4 SW 1/4 altitude 610', drilled 1968

unit	thick. in ft.	bottom depth
Clay	3	3
Dirty, coarse sand and gravel with some large rock	13	16
Boulders and large rock	4	20
Large rock with hardpan	5	25
Hardpan with sand streaks and some large rock	32	57
Medium sand, with clay streaks between 57 and 60	5	62
Medium to coarse tan sand	33	95
Medium sand	3	98
Sand with clay streaks	2	100

Driller's log Chassell 53N 33W 5-2 60' E of center sec. 5 altitude 615', drilled 1962, abandoned

unit	thick. in ft.	bottom depth
Sand	6	6
Clay, red	17	23
"Eastern" sandstone	77	100
Jacobsville Sandstone: streaks of shale 5 to 8 ft. thick, red Conglomeratic occurring every 15 to 18 ft. non-water bearing	300	400

Chemical analysis of public supply obtained at Calumet Pump Station Field

	Co#1	Co#2	Co#3
Dissolved solids in mg/l:			
Total solids	150	160	166
Silica SiO_2	2	16	15
Iron Fe	0	0	0
Manganese Mn	0	0	0
Calcium Ca	36	38	34
Magnesium Mg	7	6	6
Sodium Na	4.8	4.1	9.4
Potassium	0.4	0.9	0.6
Nitrate NO_3	1.5	1.6	2.5
Chloride Cl	12	9	16
Sulfate SO_4	6	6	10
Bicarbonate HCO_3	125	130	125
Carbonate CO_3	0	0	0
Hardness $CaCO_3$	120	120	115
Fluoride F	0.1	0.2	0.1
pH	8.0	7.4	7.7
Specific conductance (micromhos at 25° C.)	260	250	290

Samples taken 1967 (#1) and 1968 (#2 and #3)
Analysis by Mich. Dept. Pub. Health

Chemical analysis of public supplies obtained at Chassell

	Spring 54N 33W 31-2	Abdn. Well 54N 33W 32-1
Dissolved solids in mg/l:		
Total solids	70	222
Silica SiO_2	14	12
Iron Fe	0.1	0.1
Manganese Mn	0	0
Calcium Ca	8	28
Magnesium Mg	2.2	11
Sodium Na	3.7	29.4
Potassium K	1	7.8
Nitrate NO_3	7	0
Chloride Cl	5	23
Sulfate SO_4	8	10
Bicarbonate HCO_3	22	183
Carbonate CO_3	0	0
Hardness $CaCO_3$	29	115
Fluoride F	0	0
pH	--	7.7
Specific conductance (micromhos at 25° C.)	--	370

Samples taken 1959
Analysis by Mich. Dept. Pub. Health

Industrial Supplies

Quincy Mining Company

The Quincy Mining Company operates three small water systems for its use and for nearby households.

At Ripley, wells 55N 34W 36-1 and 36-2 are pumped alternately to a reservoir above town. Daily use averages 20,000 gallons. Both are 6-inch wells 90 feet deep screened in sand and gravel. Both wells have been pumped at 50 gpm.

Two wells, 55N 33W 26-1 and 26-2, supply the reclamation plant and 22 houses at Mason. Well 26-1 is 4 inches in diameter and 90 feet deep finished in sandstone. Well 26-2 is a 5-inch well 100 feet deep also finished in sandstone. The wells are pumped on alternate months.

At Bunker Hill, well 55N 33W 23-1 furnishes water to three dwellings. This is a 4-inch well 131 feet deep completed in sandstone.

The following table shows the results of chemical analysis of a water sample from well 55N 34W 36-1 at Ripley and a composite sample from wells 55N 33W 26-1 and 26-2 at Mason.

Chemical analysis of public supplies operated by Quincy Mining Co.

	Ripley 55N 34W 36-1*	Mason 55N 33W 26-1 and 26-2**
Dissolved solids in mg/l:		
Total solids	130	185
Silica SiO_2	15	--
Iron	0.5	0.1
Manganese Mn	0	--
Calcium Ca	29	--
Magnesium Mg	6	--
Sodium Na	2.5	--
Potassium K	0.3	--
Nitrate NO_3	1.6	--
Chloride Cl	1	6.0
Sulfate SO_4	9	8.0
Bicarbonate HCO_3	115	158
Carbonate CO_3	0	0
Hardness $CaCO_3$	98	114
Fluoride F	0.1	--
Noncarbonate hardness	--	--
Alkalinity	--	130
pH	7.8	7.8
Specific conductance (micromhos at 25° C.)	220	285

Samples taken 1968
* Analysis by Mich. Dept. Pub. Health
** Analysis by U.S. Geological Survey

Bosch Brewing Company

Bosch Brewing Company has developed several springs to supply water to its Brewery northwest of Houghton. Four closely spaced springs have been developed and are all protected by one large shelter. Water from these four springs is piped to a central reservoir. Two smaller springs have individual shelters and also discharge water to the reservoir where it is stored and pumped to the plant as needed. Three small springs nearby have been developed but were not being used at the time of the inventory. For this report the six springs being used are considered as one source and assigned number 55N 35W 34-2. Total production of the six springs varies from 75 to 100 gpm.

Chemical analysis of public supplies operated by Bosch Brewing Co.

Dissolved solids in mg/l:	
Total solids	125
Nitrogen NH_3	0.02
" NO_2	0
" NO_3	1.34
Calcium Ca (ionic)	33
Magnesium Mg (ionic)	6.0
Iron Fe	0.04
Total Carbonate CO_2	37
Free CO_2	9
Sulfate SO_4	8
Chloride Cl	6

Silicate SiO_2	10
Phosphate P_2O_5	5
Bicarbonate HCO_3 (ionic)	102
Carbonate $CaCO_3$	0
Total hardness	104
Noncarbonate hardness	20
pH	7.7

Samples taken 1963
Analysis by J. E. Siebel & Sons Co. Inc., Chicago, Ill.

Other Supplies

Parks

Several parks and public fishing sites have water supplies, usually a well with a hand pump, but some have pressurized distribution systems.

The U.S. Forest Service operates three campgrounds in southern Houghton County all of which have wells equipped with hand pumps. Well 47N 36W 23-1 is in Lower Dam Campground. It is a 6-inch well 58 feet deep probably completed in bedrock. Water is of good quality and quite cold (7.5° C). Sparrow Rapids Campground is supplied by a 5-inch well 150 feet deep completed in sandstone (47N 37W 4-1). Water is of good quality except for high iron content. Well 49N 37W 10-1 at Bob Lake Campground is probably finished in glacial drift. Water is very soft, slightly acid, and iron content is very high.

The State public fishing site at Emily Lake has a hand pump on well 52N 36W 34-1. This is a 4-inch well 114 feet deep finished in glacial drift. Water is quite cold (7.5° C) and of good quality except for rather high iron content.

Stanton Township Park at Agate Beach is supplied by well 54N 36W 31-1 which has a hand pump. This well reportedly was drilled into bedrock, where salt water was encountered, then cemented and pulled back into glacial drift. The well now yields water containing only 15 mg/l of chloride, but iron content is high (1.3 mg/l). North Canal Park, also operated by Stanton Township, has a hand pump on well 56N 34W 28-3, a 5-inch well 80 feet deep completed in glacial drift. Water is moderately hard and contains less than 0.1 mg/l of iron. Water temperature is 7.5° C.

Michigan Department of Natural Resources operates three parks in the report area. Twin Lakes State Park in the west central part of Houghton County receives its water supply from well 52N 36W 22-3, a 5-inch well 180 feet deep finished in a 6-foot lense of sand and gravel. The distribution system includes a 500-gallon pressure tank. Chlorine is added to the water.

McLain State Park in Northwestern Houghton County has two wells and a 3,000-gallon storage and pressure tank. Well 56N 34W 22-1 is a 6-inch well drilled in 1946. This well is 200 feet deep completed in sandstone. Because of poor water quality this unit is maintained on a standby basis. Well 56N 34W 22-2 is a 6-inch well 55 feet deep completed in glacial drift. This well has been test pumped at 90 gpm.

Fort Wilkins State Park, at the tip of Keweenaw Peninsula, obtains its water supply from Lake Fanny Hooe and adds chlorine before the water enters the distribution system.

The water supply for Isle Royale National Park is obtained from Lake Superior. Eight intake pipes are installed in the lake each spring and removed in the fall. Eight separate water systems are used.

Isle Royale National Park water supplies

	gallons per yr.	intake size inches
Rock Harbor	1,300,000	2
Mott Island	900,000	2½
Windigo	800,000	2
Davidson Island	50,000	1½
Amygdaloid Ranger Station	35,000	1
Daisy Farm Campground	20,000	1½
Ralph Cottage	20,000	1½
Malone Bay Ranger Station	15,000	1½

Households

In Keweenaw County household water supplies are obtained by several different methods. The most common sources of water are drilled wells 4 to 6 inches in diameter tapping the bedrock aquifer. Depths vary from 50 to 200 feet. Yield may be very low, and there is always a possibility that the water may contain large amounts of chloride. Only a few wells are finished in glacial drift. The drift wells are about equally divided between large diameter (24 to 48 inches) dug wells and 1¼ to 2 inch drive points. Many summer cottages along the shores of Lake Superior, and some of the large inland lakes, obtain water by laying small-diameter drive points on the lake bottom.

In Houghton County, household water supplies are obtained from both glacial drift and bedrock aquifers. Most wells are from 4 to 6 inches in diameter and may be as much as 300 feet deep. In areas of thin drift, or where the soil contains much silt or clay, many of the older homes have large-diameter dug wells. A few farms, especially in the southern part of the county, have developed springs to supply enough water for both household and stock use.

Camps and Cottages

Most hunting and fishing camps in the interior of these counties have drilled or dug wells; a few have small-diameter driven wells. Some camp owners have developed nearby springs; hand pumps are generally used, as most camps are in areas where elctricity is not available. Because of the cost of drilling and limited use, some hunting camps have no water supply.

Along the shores of Lake Superior and some inland lakes, colonies of summer cottages have developed. Much of Lake Superior's shore consists of rock outcrop or very thin glacial drift. Under these conditions many cottage owners obtain water from points placed on the lake bottom; some have drilled wells which produce small amounts of water from bedrock. Near inland lakes, drive points or dug wells will sometimes produce water from the glacial drift. Most cottages in these locations have electric pumps and pressurized water systems.

Motels and Resorts

Most motels are in areas served by municipal water systems, but a few obtain their water from drilled wells. Lake shore resorts with several housekeeping cottages may obtain water from drilled wells or from intakes in the lake. Lake water is chlorinated.

Farm Ponds

In 1968 the U.S. Soil Conservation Service reported about 400 farm ponds in use in Houghton and Keweenaw counties. Size varies from less than 1 acre to 80 acres, with most recently completed ponds averaging two to three acres.

Some ponds have springs in the bottom or sides, and nearly all have some ground-water seepage, but the principal source of water is surface runoff.

Farm ponds serve a variety of uses. Most supply irrigation water for strawberries or potatoes. Others provide water for livestock. Some are used to raise trout.

SUMMARY

Precambrian lava flows and conglomerates are prominently exposed in the "Copper Range", a highland area extending from the tip of the Keweenaw Peninsula southwestward through Keweenaw and Houghton counties. Most of the area is mantled by glacial drift, in places more than 150 feet thick.

The most productive water-bearing formations are beds of sand and gravel in the glacial drift and the Jacobsville Sandstone.

Beds of sand and gravel occur locally in all kinds of glacial deposits--moraines, outwash, and lakebeds. The probability of penetrating sand or gravel at any given site is difficult to predict. About half the wells in Houghton County and a few in Keweenaw County obtain water from sand and gravel.

The Jacobsville Sandstone underlies the glacial drift in most of the southern and southeastern parts of Keweenaw and Houghton counties. It yields small to moderate supplies of fresh water to most wells drilled into it.

Water from most wells in drift and bedrock is satisfactory for domestic use, but many yield water with objectional amounts of iron. A few of the deeper wells in bedrock yield water too salty for drinking.

Most public water supplies in the two counties are obtained from Lake Superior or from mine shafts, but a few are obtained from wells and springs.

# # #

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U.S. Geological Survey geologic quadrangle (GQ series) maps published during 1953-56 covering most of the Keweenaw Peninsula.

# # #

APPENDIX

Table 1.--Records of Wells

Explanation

Wells are identified according to their geographical township location, for example, "44N 38W 15-1 NE NW" refers to well no. 1 situated in the northeast quarter of the northwest quarter of section 15, of Township 44 North, Range 38 West. Altitudes are estimated from topographic maps. Water level in feet below land surface.

Gd	Glacial Drift	D	Domestic	O	Observation
Br	Bedrock	S	Stock	T	Test Hole
F	Flows above land surface	P	Public Supply	A	Abandoned
		I	Industrial		

Depth of well and water level in feet below land surface.
Altitudes are estimated from topographic maps.

Well Number	Location in section ¼ ¼	Owner	Driller	Date drilled	Diameter, in inches	Depth	Aquifer	Use	Water level	Date water level measured	Altitude	Depth to bedrock	Remarks
HOUGHTON COUNTY													
47N 35W 5-2	NW NE	H. P. Thompson	D. Johnson, Sr.	1940	5	130	Br	P	----	----	1380	--	Water is hard.
7-1	NE SE	M. Packer	D. Johnson, Sr.	1964	5	127	Br	D	92	1964	1520	20±	
47N 36W 23-1	SW SW	U.S.F.S.	--------	----	6	58	Br?	P	----	----	1380	--	Temp. 7.5°C. Lower Dam Campground.
47N 37W 4-1	NW NW	U.S.F.S.	--------	1966	5	150	Br	P	35	1966	1145	70	Temp. 8°C. Sparrow Rapids Campground.
7-1	SW SW	C. Loutinen	D. Johnson, Sr.	1952	5	196	Br	D	25	----	1200	175	
11-1	SE NE	U.S.F.S.	--------	----	6	94	Gd	P	21	----	1180	--	Kenton Ranger Station.
48N 35W 32-1	SW SE	H. P. Thompson	D. Johnson, Sr.	1958	5	131	Br	P	----	----	1380	--	
48N 37W 24-1	NE NW	U.S.F.S.	--------	----	-	---	Gd?	P	----	----	1405	--	Temp. 7.5°C; high iron; Connor Tower.
49N 37W 10-1	SE NE	U.S.F.S.	--------	1946	5	---	Gd?	P	----	----	1200	--	Temp. 8.5°C; Bob Lake Campground.
50N 36W 1-1	NE NW	Chas. Pietila	Johnson Bros.	1967	5	134	Gd	D	40	1967	840	--	
1-2	NE NE	Toivo Mutkala	Johnson Bros.	1966	5	134	Gd	D	30	1966	840	--	
3-1	SW SE	Holkonen Bros.	Owner	1925	-	16	Gd	D,S	----	----	1020	--	Dug well 6' by 6' concrete crib.
3-2	NE NW	L. Westenberg	Johnson Bros.	1967	5	207	Gd	D	155	1967	1050	--	
12-1	NW SW	H. Miller	Owner	1964	1¼	7	Gd	D	----	----	----	--	
12-2	SW SW	Wm. Clisch	Walitalo	1965	5	265	Br	D	F	1968	880	--	
51N 35W 24-1	NW NE	W. Juntunen	--------	----	5	425	Br	A	F	1968	740	--	High in chloride.
26-1	NW NE	R. Tuepeinen	Koykka	1968	5	135	Br	D	35	1968	780	45	High in iron.
32-1	SE SW	R. Juntunen	Koykka	1968	5	312	Gd	D	135	1968	990	--	
32-2	SE SE	L. Turunen	Johnson Bros.	1966	5	152	Gd	D	120	1966	980	--	
51N 36W 35-1	SW NW	W. Mattson	Johnson Bros.	1967	5	184	Gd	D	70	1967	1090	--	
52N 34W 8-1	NW NE	Wm. Hendrickson	Johnson Bros.	1949	6	127	Br	D	----	----	815	70±	Cased to 70 ft.
9-1	NE NW	P. Karvakko	Walitalo	1947	5	180	Br	D,P	----	----	836	--	Cased to 100 ft. Supplies a store and 2 homes.
11-2	NE NE	J. Savela	Walitalo	1963	5	53	Gd	D	30	1963	630	--	Hard water.
11-3	NE NE	R. Fitch	Koykka	1968	5	59	Gd	D	6	1968	620	--	
12-1	SW NE	W. Juntunen	Koykka	1968	5	46	Br	D	2	1968	615	25	
13-1	NW NE	J. Hakala	Koykka	1968	5	75	Br	D	30	1968	870	7	
16-1	SW SE	C. Koykka	Koykka	1965	5	142	Br	D	40	1965	800	--	Cased to 86 ft.
18-1	NE NW	A. Wayrynen	Walitalo	1950	6	150	Gd	D	----	----	740	--	High in iron.
33-1	NW NW	A. Johnson	--------	----	36	14	Gd	D	6	1968	840	14	High in iron.
52N 35W 25-1	SW NE	Mich. Tech. Forestry Club	Walitalo	----	5	168	Gd	P	F	1968	700	--	Est. flow 25 gpm.
52N 36W 21-1	SW NE	Wyandotte Hills Golf Club	Walitalo	1968	6	245	Br	P	----	----	1200	--	
22-1	NW NE	J. Peterson	Lingren	1947	5	162	Gd	P	80	1968	1200	--	Supplies residence, store, 5 cabins.
22-2	NW SE	State of Michigan	Siirtola	1968	6	182	Gd	P	83.50	10-14-68	1200	--	Twin Lakes administration building.
22-3	NE SW	State of Michigan	Walitalo	1956	5	180	Gd	P	93.17	5-21-64	1200	--	Twin Lakes State Park.
28-1	NW SW	Edw. Manninen	Johnson Bros.	1967	5	114	Gd	D	65	1967	1240	--	
30-1	NE SE	F. Cauthier	--------	----	48	20	Gd	D	12	1964	1300	25±	
34-1	NW SE	State of Michigan	Walitalo	1966	4	114	Gd	P	65	1966	1220	--	Emily Lake Campground.
53N 32W 4-1	SW SW	R. Karvakko	Owner's father	1918	30	12	Br	D	3	1968	665	6	
53N 33W 5-1	NW SW	D. Nivala	Siirtola	1967	6	222	Br	D,S	4	1967	620	192	
5-2	center	Village of Chassell	Layne-Northwest	1962	10	400	Br	T	----	----	615	23	Not enough water for municipal use.
6-1	NW SW	Carl Tuomi	Johnson Bros.	1958	5	168	Br	D,S	80	1958	820	--	Cased to 15 ft.
13-1	SE SE	P. Collins	Siirtola	1967	5	150	Br	D	15	1967	615	50	
13-2	SE NW	Wm. Lane	Siirtola	1968	5	160	Br	D	8	1968	610	139	High in iron.
13-3	NE SW	R. Bowden	Siirtola	1968	5	174	Br	D	5	1968	610	152	
22-1	SE NE	D. Kalliiainen	Siirtola	1967	5	107	Br	D	----	----	760	10	
24-1	NW NE	U. S. Coast Guard	--------	1938	4	89	Gd	P	----	----	610	--	Supplies 3 families and station; chlorinated.
35-1	SE NE	W. Montgomery	Johnson Bros.	1968	5	178	Br	D	65	1968	670	6	
53N 34W 4-1	NE NW	J. Mattila	Johnson Bros.	1948	6	143	Gd	D	----	----	940	--	Hard water.

Well Number	Location in section ¼ ¼	Owner	Driller	Date drilled	Diameter, in inches	Depth	Aquifer	Use	Water level	Date water level measured	Altitude	Depth to bedrock	Remarks
53N 34W 11-1	SW NW	S. Kauna	Walitalo	1948	5	112	Br	D	60	1948	980	8	Very soft water.
13-1	NE SE	Urho Metsa	Meyers	1921	5	120	Br	D,S	60	1968	810	8	
13-2	NE NW	Mrs. O. Walker	Koykka	1966	5	290	Br	D	50	1966	680	--	
16-2	NW SE	R. Golden	Johnson Bros.	1956	5	165	Br	D	----	----	900	--	
25-1	NE NW	J. Lindstrom	Walitala	1938	4	99	Br	D	----	----	920	15	
32-1	NE NE	D. Torro	Koykka	1968	5	68	Gd	D	12	1968	800	--	
53N 35W 8-1	SW SE	A. Niemi	--------	----	5	90	Br	P	----	----	1270	--	Well is very old, supplies home and store.
31-1	SE SW	Vulcan Corp.	Johnson Bros.	1945	6	110	Br	P	----	----	1300	--	Municipal supply for town of Donken.
31-2	SW NW	A. Dasse	Former owner	----	24	12	Gd	D	6	1968	1350	--	
53N 36W 3-1	NE SW	H. Autio	Koykka	1966	5	111	Br	D	40	1966	1000	43	
8-1	NE SW	Edw. Salmi	Siirtola	1967	6	74	Br	D	35	1967	920	57	
17-1	NW NE	Arvo Tuisku	Koykka	1966	5	84	Br	D	20	1966	940	70	650 mg/l chloride; very hard.
54N 32W 7-1	SE NW	A. Beaudoin	Siirtola	1968	5	124	Gd	D	6	1968	615	--	
22-1	SE SW	A. Lahti	Myers	1960	4	65	Br	D	6	1968	610	2	
54N 33W 1-1	NE NW	J. Neher	Siirtola	1968	5	170	Br	D	50	1968	718	45	
5-1	SE NW	Copper Motor Co.	Koykka	1967	7	116	Br	P	15	1967	640	10	
12-1	NW NW	V. J. Larivee	Siirtola	1968	6	185	Br	D	5	1968	615	120	
12-2	SE SE	B. Kallio	Koykka	1967	5	53	Gd	D	8	1967	610	--	
31-1	NW NW	R. Larson	Myers	1952	4	68	Br	D	----	----	940	--	Cased to 4 ft. Water corrodes metal pipes.
34-1	NW SE	W. Heikkila	Siirtola	1968	5	218	Gd	D	5	1968	610	--	
54N 34W 4-1	NW SW	J. Tolonen	Siirtola	1968	6	153	Br	D	20	1968	980	--	
4-2	NE SW	U. Tormala	Siirtola	1968	6	53	Br	D	2	1968	1000	28	
4-3	SE SW	R. Koskela	Siirtola	1966	5	33	Br	D	4	1966	1000	12	
13-1	SE SE	F. StAmour	Owner	----	36	8	Gd	D	1	1968	820	8	
27-2	SE SE	M. Kipina	Koykka	1967	5	130	Br	D	55	1967	960	56	
23-1	SW NW	E. Lund	Siirtola	1967	6	80	Br	D	27	1967	810	26	
27-1	NE NE	W. Seppanen	Owner	1928	48	27	Gd	D	----	----	860	--	Water has yellow color; iron 5.0 mg/l.
54N 35W 1-1	SE NW	Wm. Latila	--------	1945	--	80	Gd	D	----	----	1000	--	
54N 36W 31-1	NE NW	Stanton Twp.	Walitalo	----	5	--	Gd	P	----	----	620	--	Reported to have been drilled into bedrock but pulled back because of chloride.
35-1	NE SW	E. Wisti	Owner	----	48	14	Gd	D	----	----	980	--	Water slightly yellow.
55N 31W 3-1	NW NW	R. Sutinen	Siirtola	----	5	215	Br	D	2	1968	610	80	
4-1	NE SE	A. Lasanen	Owner	1935	1¼	8	Gd	D	----	----	610	--	
4-2	NE SE	J. Wiita	Siirtola	1967	5	48	Br	I	3	1967	612	16	
7-1	SW SE	A. Godin	Siirtola	1967	6	250	Br	D	0	1967	610	58	Water at land surface.
55N 32W 9-1	SW SE	J. Johnson	--------	----	48	10	Gd	D	4.0	5-22-68	780	--	Water slightly acid.
20-1	SW SE	Wm. Smith	Koykka	1967	5	53	Br	P	F	1967	640	32	Supplies drive-in root beer stand.
21-1	SW NW	F. King	Siirtola	1967	5	100	Br	D	6	1967	680	29	
25-1	SE NW	O. Koski	Siirtola	----	5	40	Br	D	2	1968	625	--	Cased to 20 ft.
25-2	NE SW	E. Koski	Siirtola	1968	6	85	Br	D	8	1968	625	22	
32-1	SW NW	R. Lervic	--------	1957	5	200±	Br	P	F	1968	610	--	Supplies store and residence.
32-2	SW NW	G. Beveridge, Sr.	Siirtola	1968	5	220	Br	D	5	1968	610	191	
55N 33W 8-1	NE SW	E. Holmbo	Siirtola	1968	6	107	Br	D	8	1968	1130	51	
8-2	SW NW	A. Latvila	Siirtola	1968	6	110	Br	D	20	1968	1090	29	
9-1	NE NW	C. Kopp	Siirtola	1968	6	82	Br	D	8	1968	1120	65	
12-1	NW SE	Torch Lake Twp.	Lentz & Son	1960	6	210	Br	A	93	1960	720	0	Abandoned 1962 Village of Hubbell prod. well No. 1.
12-2	NW SE	Torch Lake Twp.	Siirtola	1960	5	205	Br	P	106	1960	785	0	Village of Hubbell prod. well No. 2.
12-3	NW SE	Torch Lake Twp.	Siirtola	1960	5	275	Br	A	66	1960	800	35	Village of Hubbell prod. well No. 3 abandoned 1963.

Well Number	Location in section ¼ ¼	Owner	Driller	Date drilled	Diameter, in inches	Depth	Aquifer	Use	Water level	Date water level measured	Altitude	Depth to bedrock	Remarks
55N 33W 12-4	NW SE	Torch Lake Twp.	Siirtola	1961	6	257	Br	P	126	1961	800	10	Village of Hubbell prod. well No. 4.
12-5	NW SE	Torch Lake Twp.	Siirtola	1962	6	400	Br	P	137	1963	----	--	Village of Hubbell prod. well No. 5.
17-1	SE SW	M. Kariala	Former owner	1920±	36	9	Gd	D	----	----	1115	--	Yield drops in dry years.
23-1	SW NW	Quincy Mining Co.	Myers	1938	4	131	Br	P	----	----	680	--	Supplies 3 houses at Bunker Hill.
26-1	NW NW	Quincy Mining Co.	Walitalo	1943	4	90	Br	P	11	1943	615	--	Prod. well No. 1 and
26-2	NW NW	Quincy Mining Co.	Siirtola	1965	5	100	Br	P	----	----	615	--	Prod. well No. 2 pumped alternately to supply mill and 22 houses at Mason.
33-1	SE SW	Oseola Twp.	Dunbar Drilling Co.	1958	12	44	Gd	P	10	1958	610	--	Municipal supply Village of Dollar Bay.
34-1	SE NE	Y. Hukkala	Siirtola	1968	5	108	Gd	D	24	1968	750	--	High in iron.
55N 34W 2-1	SW SE	J. Waara	Former owner	1953	36	30	Gd	D	----	----	960	--	
8-1	SW SE	P. Eilola	Siirtola	1967	5	146	Gd	P	F	9-19-68	615	--	Est. 10 gpm flow 1 ft. above land surface.
9-1	NE SW	J. Huru	Koykka	1966	5	164	Gd	D	F	1968	620	--	Est. 2 gpm flow. Supplies 2 houses.
10-1	SW NW	J. Christenson	Koykka	1967	5	226	Gd	D	120	1967	720	--	
17-1	NW NE	P. Lewis	Siirtola	1967	5	138	Gd	D	F	9-19 68	630	--	Est. 20-25 gpm flow.
20-1	SE NE	M. Erva	Koykka	1968	5	219	Br	D	35	1968	720	5	Poor yield, recovery rate 15 gph
23-1	NE NE	W. Maki	Owner	1918	36	20	Gd	D	----	----	1020	--	Yields yellow water.
25-1	SE SE	Franklin Twp.	Walitalo	1965	6	124	Gd	P	60	1965	660	--	Municipal supply at Ripley.
25-2	SE SE	Franklin Twp.	Walitalo	1968	6	125	Gd	P	67	1968	660	--	Municipal supply at Ripley.
34-1	SW SW	P. Kinnunen	Siirtola	1968	6	66	Br	D	20	1968	920	--	High in iron.
36-1	NW NE	Quincy Mining Co.	Siirtola	1963	6	91	Gd	P,I	----	----	615	--	
36-2	NW NE	Quincy Mining Co.	Siirtola	1963	6	90	Gd	P,I	----	----	615	--	
55N 35W 13-1	SE SE	J. Jones	Siirtola	1967	5	218	Gd	D	30	1967	720	--	
13-2	SW SE	Y. Frandy	Koykka	1968	5	116	Gd	D	----	----	730	--	
15-1	NE SE	R. Puuri	Siirtola	----	5	237	Br	D,S	----	----	820	--	Cased to 90 ft. High in chloride.
21-1	SW NW	H. Kalehmainen	Owner	----	1¼	12	Gd	D	----	----	680	--	Most nearby wells are shallow drive points.
24-1	NW NW	D. Juntunen	Siirtola	1967	5	110	Gd	P	30	1967	750	--	
55N 36W 25-1	SE NW	F. Brulle	Siirtola	1967	6	170	Br	D	60	1967	730	69	Poor yield.
25-2	SE NW	E. Faller	Siirtola	1967	6	240	Br	D	80	1967	740	73	Fair yield.
25-3	SE NW	M. Solminen	Siirtola	1967	6	194	Br	D	30	1967	730	76	Good yield reported.
56N 32W 16-1	NE SW	E. Lamppa	Owner	----	48	5	Gd	D	0	1968	680	--	Never goes dry.
21-1	NW SW	W. Kitti	Siirtola	1968	5	140	Gd	D	F	1968	655	--	Flows 1 gpm 1 foot above above land surface.
28-1	SW SW	Fiina Kuru	Siirtola	1968	6	198	Br	D	75	1968	630	77	
30-1	NW NE	N. Loven	Former owner	1928±	36	10	Gd	D	----	----	1090	10	
56N 33W 5-1	NW SW	Northern Mich. Water Co.	Layne-Northwest	1968	16	100	Gd	P	0	1968	610	--	
5-2	NE SW	Northern Mich. Water Co.	Layne-Northwest	1968	16	78	Gd	P	24	1968	610	--	
5-3	SW SW	Northern Mich. Water Co.	Layne-Northwest	1968	16	100	Gd	P	16	1968	610	--	
19-1	NE SW	Koskela Bros.	Kriese	1961	3	82	Gd	D	20	1961	920	--	Several springs in vicinity.
20-1	NE SE	J. Novak	Siirtola	1968	6	195	Br	D	12	1968	1150	50	
36-1	NW NE	L. Brouillette	Siirtola	1968	6	192	Br	D	20	1968	1070	12	
56N 34W 22-1	SW NW	State of Michigan	Johnson Bros.	1946	6	200	Br	P	12	1946	620	19	McLain State Park. Water high in chloride and iron.
22-2	NW NE	State of Michigan	C. Rice	1965	6	55	Gd	P	11	1965	620	--	
28-2	SE NW	G. Nelson	Walitalo	1952	5	75	Gd	D	----	----	660	--	
28-3	NW NW	Stanton Twp.	Johnson Bros.	1956	5	80	Gd	P	----	----	640	--	In Township Park.
28-4	SW SE	Wm. Juntunen	Johnson	1955	4	250	Gd	D	40	1955	----	--	Slight hydrogen sulfide odor after extensive pumping.
28-5	NE NW	National Park Service	Johnson Bros.	1967	5	124	Gd	P	22.3	6- 7-67	635	--	Main supply for station.
28-6	NW NE	U. S. Coast Guard	--------	1937	36	17	Gd	P	13	1963	625	--	Emergency supply for station.
28-1	NW NE	U. S. Coast Guard	--------	----	36	22	Gd	P	17.05	10-15-63	625	--	

Table 1.--Records of Wells.--Continued

Well Number	Location in section ¼ ¼	Owner	Driller	Date drilled	Diameter, in inches	Depth	Aquifer	Use	Water level	Date water level measured	Altitude	Depth to bedrock	Remarks
				KEWEENAW COUNTY									
56N 31W 6-1	NW NW	N. Oila	--------	1900±	96	25	Br	D	12	1968	810	2±	Well blasted out of rock.
57N 29W 11-1	NE SE	J. Helner	Siirtola	1962	---	106	Br	D	----	----	610	--	
11-2	NE SE	F. Cuch	Siirtola	1963	---	104	Br	D	----	----	610	--	Pump tested at 12 gpm.
57N 30W 8-1	NE NW	U. S. Government	Layne-Northwest	1950	8	500	Br	T	F	1950	750	59	Flowed 1 gpm. Test well for Calumet Air Force Base.
8-2	NE NW	U. S. Government	Layne-Northwest	1950	12	250	Br	P	F	1950	750	59	Calumet Air Force Base prod. well No. 1.
8-3	NE NW	U. S. Government	Dunbar Drilling	1958	12	342	Br	P	11	1958	750	--	Calumet Air Force Base prod. well No. 2.
35-1	NE SE	F. Pierce	--------	1966	4	240	Br?	D	----	----	620	--	
57N 32W 31-1	SE SW	E. Timonen	Owner	----	30	7	Gd	D	----	----	1150	--	Several springs nearby.
32-1	NE SW	Calumet & Heola	E. J. Longyear	1963	2½	211	Br	T	----	----	880	199	Copper ore exploration hole.
35-1	SE SE	Wm. Malila	Owner	----	24	6	Gd	D	----	----	775	--	
57N 33W 27-1	SW SE	J. Makela	Owner	----	48	12	Gd	D	----	----	685	--	
28-1	SE SE	R. Nelson	Siirtola	1967	5	55	Br	D	10	1967	610	23	
58N 28W 6-1	SW NE	Keweenaw Co.	Henry Lentz	----	---	450	Br	A	----	----	1130	0	Golf coarse well.
58N 29W 10-1	NW SE	A. Maki	Siirtola	1967	6	98	Br	D	4	1967	1025	6	
26-1	SE SW	F. Nordstrom	Siirtola	1968	6	140	Br	D	14	1968	620	12	
32-1	SE NW	Anderson's Cabins	--------	1941	3	30	Gd	P	28	1941	620	--	
32-2	SW NE	S. Warjakka	--------	1958	1¼	25	Gd	P,D	20	1958	630	--	Supplies bar and residence but not used for drinking.
33-1	SE NW	R. Ojala	Siirtola	1968	6	200	Br	D	8	1968	610	178	
33-2	SW SE	G. Jaaskelainen	Owner	1964	1¼	21	Gd	D	15	1964	605	--	
58N 30W 5-1	NW NW	R. Black	Walitalo	1958	6	108	Br	D	5	1958	610	2	High in chloride and hardness.
5-2	NW NW	State of Michigan	Siirtola	1967	6	120	Br	P	5	1967	605	40	Waterways Commission, Eagle Harbor Marina.
58N 31W 2-1	NW SW	C. Reynolds	Lentz	1958	6	100	Br	D	8	1958	610	--	Water has brown tint.
29-1	NW SW	R. McKinstry	Lentz	1965	7	110	Br	D	----	----	950	0	High in chloride.
31-1	SW NW	T. Stiglich	Pelligrenie	1943	5	86	Br	P	6	1943	955	12±	
36-1	SW SE	U. S. Corps of Engineers	Layne-Northwest	1950	8	66	Br	T	1	1950	1275	61	Might yield a small domestic supply.
36-2	SW SE	U. S. Corps of Engineers	LayneNorthwest	1950	8	51	Br	T	0	1950	1290	44	Might yield a small domestic supply from material above 13 ft.
59N 28W 32-1	SW NW	J. Markham	Lentz	1958	10	120	Br	D	35±	1958	630	0	Good production.
32-2	SE NW	D. Haskins	Lentz	1959	8	204	Br	A	23.38	8-18-59	620	--	Abandoned, poor production, high in chloride.
34-1	NE NW	W. Hassig	Siirtola	1967	6	135	Br	D	20	1967	610	26	
34-2	SE NW	E. Ruonavan	Siirtola	1967	6	120	Br	D	20	1967	620	0	
34-3	SE NW	W. Ruonavan	Siirtola	1967	6	70	Br	D	2	1967	620	6	
59N 29W 31-1	SW NE	O. Trethewey	Siirtola	1966	5	77	Br	D	----	----	620	10	
59N 30W 31-1	SW SE	U. S. Coast Guard	Siirtola	1968	6	130	Br	P	30	1968	610	10	Supplies light station & 3 families.
33-1	NE SE	R. Goodell	Walitalo	1965	7	100	Br	D	7	1965	610	0	
35-1	SE NE	H. Snure	Hakala	1958	---	113	Br	D	----	----	620	5	

Table 2.--Records of springs

Altitude in feet above mean sea level, estimated from U. S. G. S. topographic maps.
Chemical analysis made in field by U. S. G. S. personnel.

D - Domestic
P - Public supply
S - Stock
N - None
I - Industrial
< - Less than
U.S.F.S. - U. S. Forest Service

										Chemical constituents in milligrams per liter									
Spring Number	Location in section	Owner	Altitude	Use	Date sampled	Temperature (°C)	Estimated yield (gpm)	Specific conductance (Micromhos at 25°C)	pH	Alkalinity	Non carbonate hardness	Dissolved solids	Bicarbonate HCO_3	Carbonate CO_3	Sulfate SO_4	Chloride Cl	Hardness	Iron Fe	Remarks
47N 35W 5-1	SW SE	J. Bailey	--	D	9/10/68	7	2	220	7.0	--	--	--	--	--	--	--	150	0.2	24" dia. culvert buried 2 ft in ground. Public supply at roadside
29-1	SW SW	U. S. F. S.	1520	P	8/29/68	7	1	<50	7.3	15.6	0	10	19	0	7	1	13	--	30" conc. culvert 4 ft in ground electric pump to house.
47N 37W 17-1	SW SE	M.Pentti	1200	D	9/10/68	--	2	160	8.0	--	--	--	--	--	--	--	85	<0.1	Metal box 3'x4'x3' deep, water bubbles up through white sand. Electric pump pumps water to house.
21-1	NE NW	T. England	1200	D/S	9/10/68	--	--	150	8.2	--	--	--	--	--	--	--	70	<0.1	Concrete pit 5'x5'x3' deep. Electric pump supplies house, milk house and barn. Supplies 50-60 head of stock.
48N 37W 17-1	SE SE	G. Nordine	1120	D	8/28/68	7	3	85	6.9	34	3	55	42	0	12	2	37	--	24" concrete pipe buried 2 ft in ground water bubbles up through white sand.
50N 36W 5-1	SE SW	R. Seppanen	1120	P	9/11/68	--	--	320	6.0	--	--	--	--	--	--	10	190	0.4	Rock crib 4'x4'x16' deep, water bubbles up through sand. Supplies nursing home.
24-1	SW SW	W. Sullivan	1000	D	9/11/68	--	--	--	--	--	--	--	--	--	--	--	--	--	Wood crib water pumped to buildings. Rain caused water to be very cloudy, did not sample.
52N 34W 11-1	NE NE	J. Savela	615	N	9/19/68	10.5	<1	360	6.7	--	--	--	--	--	--	--	153	0.2	24" clay tile buried 4 ft with conc. cover. Former household supply, has flowed since 1898. Dissolved oxygen at overflow 7.2 mg/l.
53N 34W 16-1	NE NW	D. Tuohimaa	840	D	9/19/68	10.5	1	--	--	--	--	--	--	--	--	--	--	--	36" dia. concrete culvert buried 8 ft in ground. Electric pump to house.
54N 33W 31-2	NE SW	J. Hamar	840	P	1959	--	--	--	--	--	--	70	22	0	8	5	29	0.1	Public supply village of Chassell
55N 32W 5-1	SW NE	G. Gregory	650	P	12/10/68	--	80	190	7.1	46	35	123	56	0	18	8	81	0.15	See discussion of public supply for Lake Linden
55N 34W 5-1	NE NE	R. Lahti	680	D/S	9/24/68	--	10	220	8.0	84	18	146	102	0	18	40	102	0.2	Gravity flow to buildings. Concrete pit 4'x4'x10' deep meets state Grade A milk spec. Drilled well on same forty yields water containing 4750 mg/l of chloride from bedrock.
34-2	SE NW	Bosch Brewery	615	I	3/19/63	--	--	--	--	--	--	--	--	--	--	--	--	--	See discussion of Bosch Brewery

TABLE 3.--DRILLERS' WELL LOGS

Explanation

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

HOUGHTON COUNTY

	Thickness of unit	Bottom of unit
TOWNSHIP 47 NORTH: RANGE 37 WEST		
47N 37W 4-1 U. S. Forest Service (Sparrow Rapids Campground) NW¼ of NW¼ Section 4 Altitude: 1145		
Sand	10	10
Rocks and clay	40	50
Sand hardpan	30	80
Sandstone	70	150
47N 37W 11-1 U. S. Forest Service (Kenton Ranger Station) SE¼ of NE¼ Section 11 Altitude: 1180		
Sand and silt	40	40
Clean sand	8	48
Dense blue clay	30	78
Fine to coarse sand	16	94
Screen installed in excellent screening material		
TOWNSHIP 50 NORTH: RANGE 36 WEST		
50N 36W 1-1 Chas. Pietila NE¼ of NW¼ Section 1 Altitude: 840		
Sand	8	8
Sand, clayey	18	26
Clay, with gravel	20	46
Clay, sandy	30	76
Fine sand, clayey	20	96
Clay, with gravel	10	106
Sand, clayey	12	118
Sand, fine	6	124
Sand, coarse	10	134
50N 36W 1-2 Toivo Mutkala NE¼ of NE¼ Section 1 Altitude: 840		
Sand, fine	20	20
Clay, soft	30	50
Clay, with fine gravel	20	70
Gravel, some clay	30	100
Fine sand	10	110
Coarse sand, water bearing	31	141
50N 36W 3-2 Leonard Westenberg NE¼ of NW¼ Section 3 Altitude: 1050		
Sand, yellow, fine	30	30
Clay, soft	20	50
Clay, with fine gravel	60	110
Sand, clayey	40	150
Sand, white, fine	30	180
Sand, coarse, water bearing	27	207

	Thickness of unit	Bottom of unit
TOWNSHIP 51 NORTH: RANGE 35 WEST		
50N 35W 26-1 Rueben Tuepeinen NW¼ of NE¼ Section 26 Altitude: 780		
Clay	45	45
Sandstone	90	135
TOWNSHIP 51 NORTH: RANGE 36 WEST		
51N 36W 35-1 Wilbert Mattson SW¼ of NW¼ Section 35 Altitude: 1090		
Sand, clayey	30	30
Clay, soft	40	70
Clay, fine gravel	50	120
Sand, clayey	30	150
Sand, fine	20	170
Sand, coarse, water bearing	14	184
TOWNSHIP 52 NORTH: RANGE 34 WEST		
52N 34W 11-3 Robert Fitch NE¼ of NE¼ Section 11		
Sand, gravel	25	25
Sand, clayey	28	53
Sand	6	59
52N 34W 12-1 Waino Juntunen SW¼ of NE¼ Section 12 Altitude: 615		
Sand	25	25
Sandstone	21	46
52N 34W 13-1 John Hakala NW¼ of NE¼ Section 13 Altitude: 870		
Clay	7	7
Sandstone	68	75
TOWNSHIP 52 NORTH: RANGE 35 WEST		
52N 35W 25-1 Mich. Tech. Forestry Club SW¼ of NE¼ Section 25 Altitude: 700		
Clay	30	30
Sand	5	35
Clay	90	125
Sand	40	165
Gravel	3	168

TOWNSHIP 52 NORTH:
RANGE 36 WEST

52N 36W 22-2
State of Michigan
(Twin Lakes Administration Bldg.)
NW¼ of SE¼ Section 22
Altitude: 1200
(Log by Mich. Dept. of Natural Resources personnel from samples)

	Thickness of unit	Bottom of unit
Sand, tan, fine to coarse, some silt and fine gravel	5	5
Gravel, fine to medium, some coarse sand, trace of silt	5	10
Sand, tan, medium to coarse	5	15
Sand, tan, medium to coarse, some fine gravel, gravel red and black	10	25
Sand, tan, fine to coarse, some fine gravel	5	30
Clay, red	10	40
Sand, red, medium to coarse, very silty	5	45
Clay, red, high percentage of med. to coarse sand, some gravel and silt	35	80
Sand, red, fine to coarse, very, very silty	25	105
Sand, red, very fine to coarse, some fine gravel, trace of silt	5	110
Sand, tan, medium to coarse, some fine gravel	5	115
Sand, tan, coarse, some med. to fine, trace of silt	5	120
Silt, tan, some very, very fine sand	25	145
Sand, tan, medium, very silty	5	150
Sand, tan, med. some silt, trace med. gravel	15	165
Sand, tan to brown, coarse, some med. gravel	5	170
Sand, tan to brown, med. to coarse, 10% med. gravel	5	175
Sand, tan, red, brown; med. to coarse 25% fine to med. gravel	5	180
Sand, tan, red, brown; med. to coarse 40% fine to med. gravel	2	182
Sand, tan, red, brown, med. to coarse, 25% fine to med. gravel	2	184

52N 36W 28-1
Edw. Manninen
NW¼ of SW¼ Section 28
Altitude: 1240

	Thickness of unit	Bottom of unit
Sand, fine, yellow	10	10
Sand, clayey	12	22
Clay, with gravel	20	42
Coarse gravel with clay	30	72
Fine sand with clay	20	92
Fine gravel with clay	10	102
Sand, fine, clayey	6	108
Sand, coarse, water bearing	9	117

52N 36W 34-1
State of Michigan
(Emily Lake Campground)
NW¼ of SE¼ Section 34
Altitude: 1220

	Thickness of unit	Bottom of unit
Surface sand	10	10
Clay, sand	25	35
Fine dry sand	20	55
Silt, damp	25	80
Fine sand, with clay streaks	10	90
Sand, under .0010 inch	10	100
Water sand, poor	10	110
Good water sand	4	114

TOWNSHIP 53 NORTH:
RANGE 32 WEST

53N 32W 4-1
R. Karvakko
SW¼ of SW¼ Section 4
Altitude: 665

	Thickness of unit	Bottom of unit
Clay, sandy	6	6
Sandstone	6	12

TOWNSHIP 53 NORTH:
RANGE 33 WEST

53N 33W 5-1
David Nivala
NW¼ of SW¼ Section 5
Altitude: 620

	Thickness of unit	Bottom of unit
Red clay	192	192
Red sandstone	30	222

53N 33W 5-2
Village of Chassell
Center of Section 5
Altitude: 615
Abandoned test hole, inadequate yield

	Thickness of unit	Bottom of unit
Sand	6	6
Clay, red	17	23
"Eastern" sandstone	77	100
Jacobsville sandstone: streaks of shale 5'-8' thick, red conglomeratic, occurring every 15'-18' non-water bearing	300	400

53N 33W 13-1
Phillip Collins
SE¼ of SE¼ Section 13
Altitude: 615

	Thickness of unit	Bottom of unit
Sand, fine to coarse	50	50
Red sandstone	100	150

53N 33W 13-2
William Lane
SE¼ of NW¼ Section 13
Altitude: 610

	Thickness of unit	Bottom of unit
Sand, clayey	139	139
Red sandstone	21	160

53N 33W 13-3
Robert Bowden
NE¼ of SW¼ Section 13
Altitude: 610

	Thickness of unit	Bottom of unit
Sand, clayey	152	152
Red sandstone	22	174

53N 33W 22-1
David Kalliiainen
SW¼ of NE¼ Section 22
Altitude: 760

	Thickness of unit	Bottom of unit
Sand, clayey	10	10
Red, sandstone	97	107

	Thickness of unit	Bottom of unit
53N 33W 35-1		
W. Montgomery		
SE¼ of NE¼ Section 35		
Altitude: 670		
Clay, some gravel	2	2
Clay, some sandstone	4	6
Sandstone, firm	172	178
TOWNSHIP 53 NORTH: RANGE 34 WEST		
53N 34W 32-1		
Donald Torro		
NE¼ of NE¼ Section 32		
Altitude: 800		
Clay	15	15
Sand, gravel	45	60
Clay	6	66
Sand, gravel	2	68
TOWNSHIP 53 NORTH: RANGE 36 WEST		
53N 36W 3-1		
Henry Autio		
NE¼ of SW¼ Section 3		
Altitude: 1000		
Clay	43	43
Sandstone	68	111
53N 36W 8-1		
Ewald Salmi		
NE¼ of SW¼ Section 8		
Altitude: 920		
Sand, clayey	57	57
Red sandstone (slate)	17	74
53N 36W 17-1		
Arvo Tuisku		
NW¼ of NE¼ Section 17		
Altitude: 940		
Sand	30	30
Clay	40	70
Sandstone	14	84
TOWNSHIP 54 NORTH: RANGE 32 WEST		
54N 32W 7-1		
Alfred Beaudoin		
SE¼ of NW¼ Section 7		
Altitude: 615		
Sand, clayey	122	122
Gravel, water bearing	2	124

	Thickness of unit	Bottom of unit
TOWNSHIP 54 NORTH: RANGE 33 WEST		
54N 33W 1-1		
Joseph Neher		
NE¼ of NW¼ Section 1		
Altitude: 718		
Sand, clayey	45	45
Red sandstone	125	170
54N 33W 5-1		
Copper Motor Co.		
SE¼ of NW¼ Section 5		
Altitude: 640		
Sand	10	10
Sandstone	106	116
54N 33W 12-1		
V. J. Larivee		
NW¼ of NW¼ Section 12		
Altitude: 615		
Sand, clayey	120	120
Red sandstone	62	182
54N 33W 12-2		
B. Kallio		
SE¼ of SE¼ Section 12		
Altitude: 610		
Sand, gravel	20	20
Clay	18	38
Sand	11	49
Gravel	4	53
54N 33W 34-1		
Walter Heikkila		
NW¼ of SE¼ Section 34		
Altitude: 610		
Sand, clayey	29	29
Gravel, water bearing	2	31
Sand, clayey	167	198
Clay, with fine gravel	20	218
Drilled to 31 feet, not enough water, well deepened to present depth		
TOWNSHIP 54 NORTH: RANGE 34 WEST		
54N 34W 4-1		
John Tolonen		
NW¼ of SW¼ Section 4		
Altitude: 980		
Sand and hardpan	78	78
Red slate rock	47	125
Gray hardrock	28	153

	Thickness of unit	Bottom of unit
54N 34W 4-2 Urho Tormala NE¼ of SW¼ Section 4 Altitude: 1000		
Sand, hardpan	28	28
Hard ledge rock	25	53
54N 34W 4-3 Richard Koskela SE¼ of SW¼ Section 4 Altitude: 1000		
Hardpan	12	12
Ledge rock	21	33
54N 34W 23-1 Eero Lund SW¼ of NW¼ Section 23 Altitude: 810		
Sand, clayey	26	26
Red sandstone	54	80
54N 34W 27-2 Matt Kipina SE¼ of SE¼ Section 27 Altitude: 960		
Sand	56	56
Sandstone	74	130
TOWNSHIP 55 NORTH: RANGE 31 WEST		
55N 31W 3-1 Rudolph Sutinen NW¼ of NW¼ Section 3 Altitude: 610		
Sand, clayey	80	80
Red sandstone	135	215
55N 31W 4-2 James Wiita NE¼ of SE¼ Section 4 Altitude: 612		
Sand, clayey	16	16
Red sandstone	32	48
55N 31W 7-1 Mrs. Alvin Godin SW¼ of SE¼ Section 7 Altitude: 610		
Sand, clayey	58	58
Red sandstone	192	250
TOWNSHIP 55 NORTH: RANGE 32 WEST		
55N 32W 20-1 William Smith SW¼ of SW¼ Section 20 Altitude: 640		
Sand, gravel, silt	26	26
Clay	6	32
Sandstone	21	53
55N 32W 21-1 Francis King SW¼ of NW¼ Section 21 Altitude: 680		
Sand, clayey	29	29
Red sandstone	71	100
55N 32W 25-2 Edw. Koski NE¼ of SW¼ Section 25 Altitude: 625		
Sand, clayey	22	22
Red sandstone	63	85
55N 32W 32-2 George Beveridge, Jr. SW¼ of NW¼ Section 32 Altitude: 610		
Sand, clay	191	191
Red sandstone	29	220
TOWNSHIP 55 NORTH: RANGE 33 WEST		
55N 33W 8-1 Edwin Holmbo NE¼ of SW¼ Section 8 Altitude: 1130		
Hardpan, boulders	51	51
Hard ledge rock	56	107
55N 33W 8-2 Aileen Latvala SW¼ of NW¼ Section 8 Altitude: 1090		
Hardpan and boulders	29	29
Hard rock ledge	81	110
55N 33W 9-1 Charles Kopp NE¼ of NW¼ Section 9 Altitude: 1120		
Hardpan and boulders	65	65
Hard ledge rock	17	82
55N 33W 34-1 Yalmer Hukkala SE¼ of NE¼ Section 34 Altitude: 750		
Sand, clayey	104	104
Gravel, water bearing	4	108
TOWNSHIP 55 NORTH: RANGE 34 WEST		
55N 34W 8-1 Paul Eilola SW¼ of SE¼ Section 8 Altitude: 615		
Sand, clayey	36	36
Fine brown sand	50	86
Clay, soft	56	142
Gravel, water bearing	4	146

	Thickness of unit	Bottom of unit
55N 34W 9-1 John Huru, NE¼ of SW¼ Section 9, Altitude: 620		
Sand and rocks	6	6
Sand	117	123
Clay	37	160
Sand and gravel	3	163
Gravel	1	164
55N 34W 10-1 John Christenson, SW¼ of NW¼ Section 10, Altitude: 720		
Sand and gravel	13	13
Clay	97	110
Sand	5	115
Clay	85	200
Sand	20	220
Sandy gravel	6	226
55N 34W 17-1 Paul Lewis, NW¼ of NE¼ Section 17, Altitude: 630		
Sand, yellow, fine	85	85
Clay	50	135
Gravel, water bearing	3	138
55N 34W 20-1 Milton Erva, SE¼ of NE¼ Section 20, Altitude: 720		
Sand, gravel	5	5
Sandstone	214	219
55N 34W 34-1 Peter Kinnunen, SW¼ of SW¼ Section 34, Altitude: 920		
Sand, clayey	60	60
Gravel, some clay	3	63
Gravel, water bearing	3	66
TOWNSHIP 55 NORTH: RANGE 35 WEST		
55N 35W 13-1 John Jones, SE¼ of SE¼ Section 13, Altitude: 720		
Sand, fine	70	70
Clay, red	100	170
Sand, fine	28	198
Gravel, fine	20	218
55N 35W 13-2 Yalmer Frandy, SW¼ of SE¼ Section 13, Altitude: 730		
Clay	10	10
Sand	40	50
Clay	40	90
Sand	26	116
55N 35W 24-1 Donald Juntunen, NW¼ of NW¼ Section 24, Altitude: 750		
Sand, clayey	30	30
Clay, red	60	90
Sand, gravel	20	110
55N 36W 25-1 Francis Brulle, SE¼ of NW¼ Section 25, Altitude: 730		
Sand, clayey	69	69
Red sandstone	101	170
55N 36W 25-2 Edward Faller, SE¼ of NW¼ Section 25, Altitude: 740		
Sand, clayey	73	73
Red sandstone	167	240
55N 36W 25-3 Matt Salminen, SE¼ of NW¼ Section 25, Altitude: 730		
Sand, clayey	76	76
Red sandstone	118	194
TOWNSHIP 56 NORTH: RANGE 32 WEST		
56N 32W 21-1 Walter Kitti, NW¼ of SW¼ Section 21, Altitude: 655		
Sand, clayey	136	136
Gravel, water bearing	4	140
56N 32W 28-1 Fiina Kuru, SW¼ of SW¼ Section 28, Altitude: 630		
Sand, clayey	77	77
Red sandstone	121	198
TOWNSHIP 56 NORTH: RANGE 33 WEST		
56N 33W 20-1 J. J. Novak, NE¼ of SE¼ Section 20, Altitude: 1150		
Sand, clayey	50	50
Ledge rock	145	195
56N 33W 36-1 L. Brouillette, NW¼ of NE¼ Section 36, Altitude: 1070		
Sand, clayey	12	12
Hardrock	180	192

	Thickness of unit	Bottom of unit
TOWNSHIP 56 NORTH: RANGE 34 WEST		
56N 34W 22-1 State of Michigan (McLain State Park) SW¼ of NW¼ Section 22 Altitude: 620		
Glacial drift		
Sand, medium grained, clean	15	15
Sand, med. to coarse, some fine gravel, clean	2	17
Gravel, coarse, very few fines in sample	2	19
Freda Formation		
Sandstone, very fine grained, dark red	4	23
Sandstone, very fine grained, reddish gray	3	26
Sandstone, very fine grained, red, lighter red 30-40	14	40
Sandstone, fine to med. grained, dark red, with an apparent thin stringer of gray	5	45
Sandstone, very fine to silty, red, laminar structure apparent	10	55
Sandstone, very fine to coarse, red to reddish gray	10	65
Sandstone, medium grained, reddish gray, clean	5	70
Sandstone, fine to med. grained, reddish gray	15	85
Siltstone, shaley and sandy dark red	5	90
Sandstone, very fine to coarse, red, poorly sorted, silty at 115	50	140
Sandstone, medium grained, red	5	145
Sandstone, very fine to fine grained, red	35	180
Sandstone, fine to medium grained, red	10	190
Sandstone, very fine to medium grained, red	10	200
56N 34W 22-2 State of Michigan (McLain State Park) NW¼ of NE¼ Section 22 Altitude: 620 (Log by Mich. Dept. of Natural Resources personnel from samples)		
Sand, brown, med. with fine, subrounded, frosted grains, very slightly silty	5	5
Sand, brown, med. with fine to coarse, subrounded to rounded, frosted with transparent grains, silt negligible	5	10
Sand, pink to tan, med. to coarse, subrounded to rounded, frosted with transparent grains, and high silt content	10	20
Sand, tan, fine to medium, with very fine, subrounded to rounded, frosted with transparent grains, reduced silt content	5	25
Sand, tan, very fine to fine, with medium to trace of coarse, angular to rounded, frosted with transparent grains, silty	5	30
Sand, tan, very fine to fine with med. to coarse and very small show of gravel, fine, subrounded to rounded, frosted with transparent, silty	5	35

(continued in next column)

	Thickness of unit	Bottom of unit
Sand, tan, very fine to fine with med. to coarse and small show of gravel, fine to med., subrounded to rounded, frosted with transparent, silty	5	40
Sand, tan, very fine to fine with med. to coarse and gravel show, fine to pea sized, subrounded to rounded, frosted with transparent, silty	5	45
Gravel, fine to coarse (½") sand, tan, fine	5	50
Sand, very very fine to medium with coarse, grains as above, gravel, med. to pea size, silty	5	55
56N 34W 28-5 National Park Service NE¼ of NW¼ Section 28 Altitude: 635		
Previously constructed well pit	6	6
Gravel, to golf ball size and larger, some med. sand	24	30
Fine sand	13	43
Fine sand and clay	5	48
Black clay	1	49
Tan clay, a few fine gravel stones	6	55
Tan sandy clay	5	60
Tan clay a little sand	9	69
Clay, some sand and med. gravel	17	86
Clay, with fine sand, a few pebbles	4	90
Clay, fine sand, small gravel	2	92
Fine to med. sand, clayey	27	119
Fine to med. sand, some coarse sand, med. gravel, trace of clay	5	124
Fine to med. sand show of clay	1	125

KEWEENAW COUNTY

	Thickness of unit	Bottom of unit
TOWNSHIP 57 NORTH: RANGE 30 WEST		
57N 30W 8-1 Calumet Air Force Station NE¼ of NW¼ Section 8 Altitude: 750 Test hole at site of well 57N 30W 8-2		
Log from samples		
Glacial drift		
Muck and peat, black to dark brown	0.5	0.5
Sand, dark to medium brown, carbonaceous	1.0	1.5
Sand, tan to light brown, med. to coarse grained, slightly clayey to silty, with 2 to 5% of gravel up to 2 inches	3.5	5.0
Sand, uniform, tan to light brown, medium to fine grained, slightly clayey to silty with very little gravel	19.5	24.5
Alternate layers of clayey sand, sand and gravel, coarse grained gravel, cobbles, and reddish brown and green silty sandy stoney clay	7.5	32.0
Sand and gravel, clayey to sandy and stoney clay	3	35
Clay, reddish-tan to brown, sandy, stoney with some stoney layers: 46-48 very stoney	19	54
Clay, bright brownish red, to coarse, sandy to clayey sand (evidently oxidized sandstone and shale bedrocks)	5	59

(continued on next page)

	Thickness of unit	Bottom of unit
57N 30W 8-1 (continued)		
Sandstone-Jacobsville		
Mottled, red and white, fine grained, with shale layers from 73 to 77 feet	32.5	91.5
Uniform, reddish brown, fine, medium, and very fine grained, slightly clayey to silty, with 2 to 5 percent of coarse grains	98.5	190
Uniform, grayish brown, medium and fine grained, very slightly clayey to silty, with 2 to 5 percent of coarse grains	10	200
Uniform, tan, medium and fine grained	10	210
Uniform, creamy tan, fine, and medium grained, slightly clayey to silty, with some red shale	10	220
Uniform, reddish brown, fine, medium and very fine grained, slightly clayey to silty, with 2 to 5 percent of coarse grains	20	240
Similar to above unit but tan, and little silt to clay content	10	250
Uniform, red to reddish brown, fine, very fine, and some medium grained, slightly silty to clayey	10	260
Uniform, tannish brown, fine, very fine and some medium grained, slightly silty to clayey	15	275
Uniform, red to reddish brown, fine, very fine, and some medium grained, slightly silty to clayey	25	300
Conglomerate		
Sixty-five percent sand; coarse grained to fine grained gravel; thirty-five percent sand, medium and fine grained; some white mottling	5	305
Sixty percent sand, medium grained; twenty-five percent sand, coarse grained to fine gravel; fifteen percent sand, fine grained	5	310
Sixty-five percent sand, coarse grained to fine grained gravel; thirty-five percent sand, medium and fine grained	5	315
Sixty percent sand, coarse grained to fine grained gravel; thirty-five percent sand, medium and fine grained; five percent shale, red; some white mottling	5	320
Sand, medium grained	5	325
Similar to segment 300 to 305 feet	5	330
Shale		
Silt to clay, uniform, bright, reddish brown, gummy; some white mottling from 330 to 335 and from 345 to 350	35	365
Silt to clay, uniform, bright reddish brown slightly gummy	20	385
Shale and sandstone (transition unit)		
Sand, brisk red, clayey to sandy clay	5	390
Sandstone		
Sand, brick red, uniform, fine to medium grained, clayey	10	400
Shale		
Silt to clay, uniform, slightly gummy; bright reddish brown to 425 feet dark brown below 425 feet. Sandy 10% to 20% fine to coarse sand 400 to 420 feet. Very gummy 420 to 500 feet.	100	500

	Thickness of unit	Bottom of unit
57N 30W 8-3 Calumet Air Force Station NE¼ of NW¼ Section 8 Altitude: 750		
Sand, clay and gravel	25	25
Clay	19	44
Sand, rock	56	100
Shale	10	110
Shale and sandrock	60	170
Shale	82	252
Sandrock	6	258
Shale	70	328
Conglomerate	7	335
Shale	7	342
TOWNSHIP 57 NORTH: RANGE 32 WEST		
57N 32W 32-1 Calumet and Hecla NE¼ of SW¼ Section 32 Altitude: 880		
Diamond drill, copper exploration hole		
Sand and peat	12	12
Boulders and gravel	3	15
Medium gravel and sand	3	18
Sand	3	21
Boulders	2	23
Coarse gravel	7	30
Boulders, some gravel	20	50
Boulders	6	56
Coarse gravel	10	66
Boulders and some gravel	10	76
Gravel	12	88
Sand	107	195
Boulders	4	199
Bedrock	1	200
Trap	11	211
TOWNSHIP 57 NORTH: RANGE 33 WEST		
57N 33W 28-1 Russell Nelson SE¼ of SE¼ Section 28 Altitude: 610		
Sand, fine	23	23
Red rock	32	55
TOWNSHIP 58 NORTH: RANGE 29 WEST		
58N 29W 10-1 Alvin Maki NW¼ of SE¼ Section 10 Altitude: 1025		
Sand and boulders	6	6
Gray hardrock	92	98
58N 29W 26-1 F. Nordstrom SE¼ of SW¼ Section 26 Altitude: 620		
Gravel and sand	12	12
Ledge rock	128	140

	Thickness of unit	Bottom of unit
58N 29W 33-1 Rudolph Ojala SE¼ of NW¼ Section 33 Altitude: 610		
Sand, clayey	178	178
Red sandstone	22	200
TOWNSHIP 58 NORTH: RANGE 30 WEST		
58N 30W 5-2 State of Michigan, Water Ways Commission NW¼ of NW¼ Section 5 Altitude: 605		
Sand and gravel	40	40
Conglomerate rock	80	120
TOWNSHIP 58 NORTH: RANGE 31 WEST		
58N 31W 36-1 Calumet Air Force Station SW¼ of SW¼ of SE¼ Section 36 Altitude: 1275 Test hole abandoned, not enough water		
Topsoil, weathered, hardpan, or till; clay, sandy, stoney, brown	2	2
Rocks and boulders	1	3
Hardpan or till, reddish brown, sandy	7	10
Hardpan or till, reddish brown, with pebbles and boulders	2	12
Hardpan or till, reddish brown, clayey	14	26
Hardpan or till, reddish brown, sandy	8	34
Hardpan or till, reddish brown, with pebbles	4	38
Hardpan or till, reddish brown, clayey	7	45
Hardpan or till, reddish brown, sandy	10	55
Hardpan or till, brown, clayey	2	57
Hardpan, brown and green, clayey and stoney with broken weathered green amygolaloidal basalt	4	61
Bedrock, basalt, green amygdaloidal	5.3	66.3
58N 31W 36-2 Calumet Air Force Station NW¼ of SW¼ of SE¼ Section 36 Altitude: 1290 Test hole, abandoned, not enough water		
Muck and sandy topsoil	0.5	0.5
Sand, coarse to fine grained, gravelly, very slightly clayey, light gray to yellow, some cobbles	1.5	2.0
Sand, medium to fine grained, gravelly, tan to grayish brown, some cobbles	11	13
Hardpan, reddish brown, clayey	2	15
Hardpan, reddish brown, sandy, with pebbles, cobbles	5	20
Hardpan, reddish brown, sandy	8	28
Hardpan, reddish brown, clayey, with pebbles	1	29

(continued in next column)

	Thickness of unit	Bottom of unit
Hardpan, reddish brown, sandy, with pebbles	2	31
Hardpan, reddish brown, clayey, with pebbles and cobbles	4	35
Hardpan, reddish brown, sandy, no pebbles	3	38
Hardpan, brown with green clay streaks, slightly sandy	3	41
Hardpan, brown, sandy, with pebbles and cobbles	2	43
Bedrock, traprock and dark green amygdoloidal basalt, indurated from 43.5 to 45.5 and from 51.0 to 51.4 feet	8.4	51.4
TOWNSHIP 59 NORTH: RANGE 38 WEST		
59N 28W 34-1 Walter Hassig M.D. NE¼ of NW¼ Section 34 Altitude: 610		
Sand and beach pebbles	26	26
Hardrock	109	135
59N 28W 34-2 Edwin Ruonavan SE¼ of NW¼ Section 34 Altitude: 620		
Hardrock	120	120
59N 28W 34-3 Walter Ruonavan SE¼ of NW¼ Section 34 Altitude: 620		
Sand hardpan	6	6
Hard gray rock	64	70
TOWNSHIP 59 NORTH: RANGE 29 WEST		
59N 29W 31-1 Orville Trethewey SW¼ of NE¼ Section 31 Altitude: 620		
Sand	10	10
Hardrock	67	77
TOWNSHIP 59 NORTH: RANGE 30 WEST		
59N 30W 31-1 U. S. Coast Guard (Eagle Harbor Light Station) SW¼ of SE¼ Section 31 Altitude: 610		
Sand and gravel	10	10
Conglomerate rock	120	130
59N 30W 35-1 Howard Snure SE¼ of NE¼ Section 35 Altitude: 620		
Overburden materials	5	5
Basalts	105	110
Conglomeratic	3	113

TABLE 4.--YIELD OF WELLS

Well Number	Aquifer Gd = Glacial drift Br = Bedrock	Yield (gpm)	Drawdown (feet)	Duration of test (hours)	Specific Capacity (gpm/ft drawdown)
		Houghton County			
47N37W 11-1	Gd	25	5	-	5.0
50N36W 1-1	Gd	10	10	2	1.0
1-2	Gd	10	10	3	1.0
3-2	Gd	15	5	4	3.0
51N35W 32-2	Gd	10	5	4	2.0
51N36W 35-1	Gd	15	1	4	15.0
52N34W 11-3	Gd	20	34	1	0.6
12-1	Br	12	13	1	0.9
13-1	Br	20	10	1	2.0
52N36W 22-2	Gd	40	6.33	5	6.3
22-3	Gd	5	26.74	7.5	0.2
28-1	Gd	15	15	2	1.0
34-1	Gd	20	20	4	1.0
53N33W 5-1	Br	14	35	-	0.4
13-1	Br	6	115	-	0.05
13-2	Br	16	32	1	0.5
13-3	Br	24	25	1	1.0
35-1	Br	10	35	2	0.3
53N34W 32-1	Gd	25	13	1	1.9
53N36W 3-1	Br	25	10	1	2.5
8-1	Br	10	13	-	0.8
17-1	Br	25	5	1	5.0
54N32W 7-1	Gd	24	35	1	0.7
54N33W 1-1	Br	4	70	-	0.06
5-1	Br	25	15	1	1.7
12-1	Br	16	55	1	0.3
12-2	Gd	20	22	1	0.9
34-1	Gd	6	135	1	0.04
54N34W 4-3	Br	15	6	1	2.5
23-1	Br	7	43	1	0.2
27-2	Br	15	45	1	0.3
55N31W 3-1	Br	6	148	1	0.04
7-1	Br	4	250	1	0.02
55N32W 20-1	Br	1.25	30	1	0.04
21-1	Br	8	74	1	0.1
25-2	Br	26	32	-	0.8
32-1	Br	5	55	1	0.09
55N33W 8-1	Br	2.5	99	1	0.03
8-2	Br	28	90	1	0.3
9-1	Br	10	32	1	0.3
12-1	Br	15	11	-	1.4
12-2	Br	46	55	-	0.8
12-3	Br	10	34	-	0.3
12-4	Br	20	67	19	0.3
12-5	Br	23	119	48	0.2
26-1	Br	27	4	-	6.7
34-1	Gd	16	36	1	0.4

TABLE 4.--YIELD OF WELLS--continued

Well Number	Aquifer Gd = Glacial drift Br = Bedrock	Yield (gpm)	Drawdown (feet)	Duration of test (hours)	Specific Capacity (gpm/ft drawdown)
55N34W 8-1	Gd	24	15	1	1.6
9-1	Gd	25	20	1	1.3
10-1	Gd	25	5	1	5.0
20-1	Br	0.3	184	-	0.002
34-1	Gd	18	20	1	0.9
55N35W 13-1	Gd	8	50	-	0.2
55N36W 25-1	Br	0.3	110	1	0.003
25-2	Br	1	160	1	0.006
25-3	Br	6	110	1	0.05
56N32W 21-1	Gd	12	100	1	0.1
28-1	Br	7	105	1	0.7
56N33W 5-1	Gd	760	52	4	15
5-2	Gd	300	27	5	11
5-3	Gd	300	41	5	7.3
20-1	Br	3.5	183	1	0.02
36-1	Br	1	162	1	0.006
56N34W 22-1	Br	13	88	8	0.1
22-2	Gd	60	33	8	1.8
28-5	Gd	30	8	4	3.8
		Keweenaw County			
57N30W 8-2	Br	45	25	23	1.8
at 250 ft 8-3	Br	30	191	19	0.16
at 342 ft "	Br	30	144	48	0.2
57N33W 28-1	Br	15	20	-	0.8
58N29W 10-1	Br	4	94	1	0.04
33-1	Br	0.5	17	1	0.03
58N30W 5-1	Br	10	13	48	0.2
5-2	Br	12	115	-	0.1
58N31W 2-1	Br	10	92	1	0.1
59N28W 34-2	Br	14	60	-	0.2
34-3	Br	10	68	-	0.1
59N29W 31-1	Br	6	60	1	0.1
59N30W 31-1	Br	7	100	-	0.07
33-1	Br	20	35	5	0.6

Table 5.--Chemical analysis of water from wells

Aquifer Gd - Glacial drift
Br - Bedrock
< - Less than
> - More than
* Analysis by M.D.H.

Dissolved constituents expressed in milligrams per liter

Well number	Aquifer	Date sampled	Iron (Fe)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Alkalinity	Hardness	Non carbonate hardness	Carbonate (CO_3)	Dissolved solids	Specific conductance (micromohs at 25°C)	pH	Temperature (°C)
Houghton County														
47N 35W 5-2	Gd	9-10-68	1.7	--	--	--	--	250	--	--	--	320	7.6	--
7-1	Br	9-10-68	0.4	--	--	--	--	200	--	--	--	95	7.0	9
47N 36W 23-1	Br?	9-13-68	--	51	9	1	41	39	0	0	52	80	7.8	7.5
47N 37W 4-1	Br	8-28-68	2.3	93	7.5	2	76	60	0	0	94	145	7.9	8
7-1	Br	9-10-68	<0.1	--	--	--	--	85	--	--	--	180	8.1	--
11-1	Gd	12-9-68	0.1	147	7.0	3	120	112	0	0	156	240	8.0	--
32-1	Br	9-10-68	<0.1	--	--	--	--	100	--	--	--	180	8.5	--
48N 37W 24-1	Gd	8-28-68	3.5	94	9	2	79	80	3	2	104	160	8.5	7.5
49N 37W 10-1	--	9-11-68	>5.0	--	--	5	--	17	--	--	--	70	6.0	8.5
50N 36W 3-1	Gd	9-11-68	0.4	--	--	40	--	120	--	--	--	340	6.0	--
3-2	Gd	9-11-68	<0.1	--	--	--	--	120	--	--	--	250	8.0	--
12-1	Gd	9-11-68	<0.1	--	--	--	--	120	--	--	--	240	7.8	--
12-2	Br	9-11-68	<0.1	144	8	<1.0	118	80	0	0	153	235	8.2	--
51N 35W 26-1	Br	9-18-68	>5.0	--	--	10	--	185	--	--	--	360	7.5	--
32-1	Gd	9-11-68	0.5	115	6	<1.0	95	70	0	0	126	190	8.1	--
32-2	Gd	9-11-68	0.1	--	--	--	--	135	--	--	--	300	7.7	--
51N 36W 35-1	Gd	9-11-68	0.4	--	--	<5	--	120	--	--	--	250	8.1	--
52N 34W 8-1	Br	10-8-68	<0.1	173	7	2	142	140	0	0	182	275	7.8	--
9-1	Br	10-8-68	<0.1	--	--	5	--	85	--	--	--	190	8.0	--
11-2	Gd	9-19-68	0.6	--	--	5	--	220	--	--	--	420	7.1	--
12-1	Br	9-19-68	<0.1	149	7	1	122	115	0	0	162	245	8.1	9.0
18-1	Gd	10-7-68	1.2	115	7	2	94	85	0	0	117	180	8.2	--
33-1	Gd	10-7-68	1.2	--	--	--	--	50	--	--	--	130	6.0	--
52N 35W 25-1	Gd	9-18-68	0.7	129	5	1	106	90	0	0	140	200	8.2	8.0
52N 36W 22-1	Gd	9-26-68	<0.1	89	5	<1	73	60	0	0	88	130	8.0	--
22-2	Gd	11---68	0.2	--	--	0	--	100	--	--	--	--	8.6	--
28-1	Gd	9-26-68	0.1	110	7	15	90	110	18	0	150	230	7.8	--
30-1	Gd	9-26-68	0.1	121	9	9	100	100	3	0	153	235	7.1	--
34-1	Gd	8-30-68	1.0	126	9	2	103	100	0	0	127	195	8.1	7.5
53N 32W 4-1	Br	11-26-68	0.2	--	--	--	--	35	--	--	--	90	5.8	7.0
53N 33W 5-1	Br	10-10-68	--	154	13	44	126	110	0	0	254	390	8.1	--
6-1	Br	10-8-68	0.2	37	8	5	30	50	--	0	65	100	6.5	--
13-2	Br	12-11-68	1.6	190	5	6	156	125	0	0	208	320	8.2	--
53N 34W 4-1	Gd	9-27-68	<0.1	--	--	75	--	200	--	--	--	410	7.5	--
11-1	Br	10-8-68	<0.1	10	9	3	8	15	6	0	<32	<50	5.8	--
13-1	Br	5-28-68	<0.1	--	--	--	--	35	--	--	--	65	5.0	--
13-2	Br	10-8-68	0.5	159	21	140	130	120	0	0	435	660	8.1	--
16-2	Br	10-8-68	<0.1	88	7	2	72	70	0	0	104	150	7.5	--
25-1	Br	10-8-68	<0.1	--	--	20	--	85	--	--	--	200	6.0	--
53N 35W 8-1	Br	9-26-68	<0.1	222	6	30	154	180	28	0	208	340	7.9	--
31-2	Gd	9-26-68	0.4	--	--	<5	--	50	--	--	--	120	6.0	--
53N 36W 17-1	Br	9-20-68	0.5	139	6	650	114	590	456	0	1365	2100	7.9	--
54N 32W 22-1	Br	11-26-68	0.3	184	8	<5	151	105	0	0	195	290	8.2	--
54N 33W 1-1	Br	11-12-68	0.4	63	9	1	52	50	0	0	--	115	7.5	--
31-1	Br	10-8-68	<0.1	--	--	--	--	50	--	--	--	125	5.7	--

Dissolved constituents expressed in milligrams per liter

Well number	Aquifer	Date sampled	Iron (Fe)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Alkalinity	Hardness	Non carbonate hardness	Carbonate (CO_3)	Dissolved solids	Specific conductance (micromohs at 25°C)	pH	Temperature (°C)
						Houghton County.--Continued								
54N 34W 4-1	Br	9-26-68	0.2	--	--	10	--	15	--	--	--	175	9.0	--
13-1	Gd	10-8-68	<0.1	27	14	1	22	30	2	0	55	80	6.5	--
23-1	Br	9-27-68	0.4	120	5	1	98	85	0	0	123	175	8.0	--
27-1	Gd	9-27-68	5.0	--	--	<5	--	30	--	--	--	190	6.6	--
54N 35W 1-1	Gd	9-26-68	0.2	--	--	<5	--	50	--	--	--	95	8.5	--
54N 36W 31-1	Gd	9-20-68	1.3	--	--	15	--	85	--	--	--	200	8.4	7.5
35-1	Gd	9-26-68	0.4	178	15	35	146	155	10	0	254	380	6.0	--
55N 31W 4-1	Gd	11-12-68	0.2	63	8	2	52	54	0	0	--	120	7.5	--
4-2	Br	11-23-68	<0.1	109	9	7	89	70	--	0	--	200	7.5	--
55N 32W 9-1	Gd	5-22-68	0.2	--	--	--	--	35	--	--	--	90	5.5	--
25-1	Br	11-13-68	2.2	55	10	5	45	50	3	0	--	100	6.5	--
32-1	Br	11-13-68	<0.1	129	--	--	106	100	0	--	--	220	8.0	--
55N 33W 17-1	Gd	10-9-68	0.2	24	8	1	20	23	3	0	34	52	6.5	--
34-1	Gd	11-12-68	1.4	143	8	1	117	100	0	0	--	220	7.9	--
55N 34W 2-1	Gd	10-10-68	<0.1	--	--	--	--	35	--	--	--	130	6.5	--
8-1	Gd	9-19-68	0.2	112	7	14	92	88	0	0	150	230	8.5	8
9-1	Gd	10-10-68	<0.1	105	7	25	86	88	2	0	162	250	8.0	--
17-1	Gd	9-19-68	0.2	--	--	10	--	120	--	--	--	250	8.0	8
20-1	Br	9-24-68	0.2	--	--	35	--	<15	--	--	--	330	8.5	--
23-1	Gd	10-10-68	<0.1	27	8	1	22	30	2	0	39	60	6.0	--
34-1	Gd	9-25-68	1.3	--	--	5	--	120	--	--	--	230	7.8	--
55N 35W 15-1	Br	9-24-68	<0.1	119	16	405	98	80	0	2	975	1500	8.5	--
21-1	Gd	9-26-68	0.2	159	32	15	130	165	33	0	237	360	7.5	--
24-1	Gd	9-19-68	0.2	112	9	1	92	100	0	0	136	210	8.0	--
55N 36W 25-1	Br	9-19-68	0.2	171	17	25	148	4	0	8	247	380	9.0	--
56N 32W 16-1	Gd	10-9-68	0.2	10	14	18	8	50	41	0	91	140	6.0	--
21-1	Gd	10-9-68	<0.1	107	8	3	88	82	0	0	127	195	7.9	8
30-1	Gd	10-9-68	0.7	100	25	26	82	90	8	0	208	320	7.0	--
56N 33W 19-1	Gd	10-10-68	0.2	107	12	3	88	100	10	0	133	205	7.8	--
20-1	Br	10-10-68	<0.1	127	8	2	104	10	0	22	137	210	9.6	--
36-1	Br	11-12-68	--	122	16	8	100	117	17	0	--	260	6.9	--
56N 34W 22-1	Br	8-19-52*	2.4	--	--	235	--	170	--	--	--	--	6.9	--
22-2	Gd	9-19-68*	0.8	--	0	0	--	110	--	--	--	--	7.9	--
28-2	Gd	4-26-67	<0.1	--	--	--	--	135	--	--	--	260	7.9	--
28-3	Gd	4-26-67	<0.1	--	--	--	--	85	--	--	--	150	8.0	7
28-4	Gd	4-26-67	<0.1	--	--	--	--	102	--	--	--	240	8.0	--
28-5	Gd	7-18-67	<0.1	140	11	4	--	129	14	0	150	230	8.0	7
28-6	Gd	12-11-68	--	58	11	7	48	60	12	0	91	140	7.0	--
							Keweenaw County							
56N 31W 6-1	Br	11-25-68	--	32	11	1	26	28	2	0	--	85	6.5	--
57N 30W 8-2	Br	11-20-68	<0.1	132	12	25	108	108	0	0	--	310	8.0	9
8-3	Br	11-20-68	0.1	142	11	8	116	113	0	0	--	260	7.9	9
5 N 32W 31-1	Gd	11-25-68	--	102	9	1	84	76	0	0	--	180	7.1	--
57N 33W 27-1	Gd	11-25-68	--	93	11	2	76	76	0	0	--	180	6.7	--
58N 29W 32-2	Gd	11-23-68	0.2	73	9	1	60	60	0	0	--	130	7.7	--
33-2	Gd	11-23-68	<0.1	73	10	1	6	9	3	0	--	<50	5.7	--
58N 30W 5-1	Br	11-19-68	<0.1	96	110	414	79	190	115	0	--	1600	7.4	--
58N 31W 2-1	Br	11-21-68	0.4	184	9	8	151	40	0	0	--	310	8.0	--
29-1	Br	1968*	0.7	--	--	500	--	170	--	--	--	--	--	--
31-1	Br	11-19-68	<0.1	117	9	209	96	190	97	0	--	890	8.0	--
59N 29W 32-1	Br	11-19-68	<0.1	215	12	4	176	80	0	0	--	350	7.9	--
32-2	Br	8-18-59	1.0	0	27	320	--	45	45	30	636	1210	10.1	8
59N 30W 31-1	Br	11-19-68	<0.1	85	10	112	104	10	0	33	--	600	8.0	--
33-1	Br	11-19-68	0.2	255	9	9	209	140	0	0	--	420	7.2	--

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