CANADA

DEPARTMENT OF MINES

AND

TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 308

GROUND-WATER RESOURCES OF EMILY TOWNSHIP, VICTORIA COUNTY ONTARIO

By

W. T. Hatfield

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INTRODUCTION

This report deals with the ground-water conditions of a township in the province of Ontario investigated by the Geological Survey of Canada. It is one of a series of ground-water reports on individual townships of Ontario.

All available information pertaining to the water wells in the area was recorded and water samples were taken for analysis. The elevation of the surface of the water in most of the wells was measured. As the ground-water conditions are directly related to the geology, the surface deposits were also studied and mapped.

Thanks are here extended to the farmers and to the residents of communities throughout the area for their co-operation and willingness to supply information regarding their wells. Valuable assistance was also given by well drillers and municipal waterworks authorities in the area.

Publication of Results

The essential information pertaining to ground-water conditions is being issued in reports covering each township investigated in the province of Ontario. These reports, as published, will be supplied directly to the proper municipal and township authorities. In addition, pertinent data on wells investigated in each township will be kept on file at Ottawa. The well record compilation sheets will not ordinarily accompany the reports, as, for most areas, they are too numerous. However, persons interested in individual wells may receive the information upon application to the Chief Geologist, Geological Survey of Canada, Ottawa. For this information the request should specify lot, concession, owner's name, and approximate location of the well -- at house, at barn, in pasture, etc.

With each report is a map consisting of two figures. Figure 1 shows the surface deposits that will be encountered in the area, and Figure 2 shows the positions of all wells for which records are available, together with the class of the well at each location.

GLOSSARY OF TERMS USED

Alluvium. Recent deposits of clay, silt, sand, gravel, and other material deposited in lake beds and in flood-plains of modern streams.

Aquifer. A porous bed, lens, pocket, or deposit of material that transmits water in sufficient quantity to satisfy pumping wells, flowing artesian wells, and springs.

Bedrock. Bedrock, as here used, refers to the consolidated deposits underlying the glacial drift. South of a line drawn between Midland, on Georgian Bay, and Kingston, the bedrock consists mainly of sedimentary rocks such as limestone, shale, slate, and sandstone; north of that line the bedrock consists chiefly of hard, crystalline, granitic rocks.

Contour. A line drawn on a map that passes through points that have the same elevation above mean sea-level.

Continental Ice-sheet. The great, broad ice-sheet that covered most of the surface of Canada many thousands of years ago.

Escarpment. A cliff or relatively steep slope separating two level or gently sloping areas.

Effluent Stream. A stream that receives water from a zone of saturation.

Flood-plain. A flat part in a river valley ordinarily above water, but covered with water when the river is in flood.

Glacial Drift. A general term that includes all the loose, unconsolidated materials that were deposited by the continental ice-sheet, or by waters associated with it. It includes till, deposits of stratified drift, and scattered boulders and rock fragments.

Several forms in which glacial drift occurs are as follows:

(1) End Moraine (Terminal Moraine). A more or less discontinuous ridge or series of ridges consisting of glacial drift that was laid down by the ice at the margin of a moving ice-sheet. The surface is characterized by irregular hills and undrained basins.

(2) Ground Moraine. A widely distributed moraine consisting of glacial drift deposited beneath an ice-sheet. The predominant material is till, which is clay containing stones. The topography may vary from flat to gently rolling.

(3) Kame Moraine. Assorted deposits of sandy and gravelly stratified drift laid down at or close to the ice margin. The topography is similar to that of an end moraine. Kame terraces are elongated deposits of this type laid down on the slopes of broad, flat-bottomed valleys.

(4) Drumlin. A smooth oval hill that has its long axis parallel with the direction of ice movement at that place. It is composed mainly of till.

(5) Esker. An irregular-crested ridge or series of discontinuous ridges of stratified drift deposited by a glacial stream that flowed beneath the continental ice-sheet or in deep crevasses within it. It is composed mainly of sand and gravel.

(6) Glacio-fluvial Deposits. Silt, sand, and gravel outwash deposited by streams resulting from the melting of the ice-sheet.

(7) Glacio-lacustrine Deposits. Clay, silt, and sand deposited in glacial lakes during the retreat of the ice-sheet. The clay deposits are commonly very distinctly stratified in layers a fraction of an inch to one or more feet in thickness; each layer is believed to represent deposition during one summer season and one winter season.

(8) Kame. An isolated mound or conical hill composed of stratified sand and gravel deposited in a crack or crevasse within the ice or in a depression along the ice front.

(9) Marine Deposits. Deposits laid down in the sea during the submergence that followed the withdrawal of the last ice-sheet. They consist chiefly of clay, silt, and sand, and have emerged beaches of sand and gravel associated with them.

(10) Shoreline. A discontinuous escarpment that indicates the former margin of a glacial lake or sea. It is accompanied by scattered deposits of sand and gravel located on former beaches and bars.

Ground Water. Sub-surface water in the zone of saturation below the water-table.

Hydrostatic Pressure. The pressure that causes water in a well to rise above the point at which it was first encountered.

Influent Stream. A stream that feeds water into a zone of saturation.

Impervious or Impermeable. Beds such as fine clays or shale are considered to be impervious or impermeable when they do not permit the perceptible passage or movement of ground water.

Pervious or Permeable. Beds are pervious or permeable when they permit the perceptible passage or movement of ground water, as, for example, porous sand, gravel, and sandstone.

Porosity. The porosity of a rock is its property of containing interstices or voids.

Pre-glacial Land Surface. The surface of the land as it existed before the ice-sheet covered it with drift.

Recent Deposits. Deposits that have been laid down by the agencies of water and wind since the disappearance of the continental ice-sheet; for example, alluvium in stream valleys.

Unconsolidated Deposits. The mantle or covering of loose, uncemented material overlying the bedrock. It consists of Glacial or Recent deposits of boulders, gravel, sand, silt, and clay.

Water-table. The upper limit of the part of the ground saturated with water. This may be near the surface or many feet below it. Water may be retained above the main water-table by a zone of impervious material; such water is said to be perched and its upper limit to be a perched water-table.

Wells. Holes sunk into the ground so as to obtain a supply of water. When no water is obtained they are referred to as dry holes. Wells yielding water are divided into four classes:

(1) Flowing Artesian Wells. Wells in which the water is under sufficient hydrostatic pressure to flow above the surface of the ground at the well.

(2) Non-flowing Artesian Wells. Wells in which the water is under hydrostatic pressure sufficient to raise it above the level of the aquifer, but not above the level of the ground at the well.

(3) Non-artesian Wells. Wells in which the water does not rise above the water-table or the aquifer.

(4) Intermittent Non-artesian Wells. Wells that are generally dry for a part of each year.

Zone of Saturation. The part of the ground, below a water-table that is saturated with water.

GENERAL DISCUSSION OF GROUND WATER

Almost all the water recovered from beneath the earth's surface for both domestic and industrial uses is meteoric water, that is, water derived from the atmosphere. Most of this water reaches the surface as rain or snow. Part of it is carried off by streams; part evaporates either directly from the surface and from the upper mantle of the soil or indirectly through transpiration of plants; the remainder infiltrates into the ground to be added to the ground-water supplies.

The proportion of the total precipitation that infiltrates from the surface into the zone of saturation will depend upon the surface topography and the type of soil or surface rock. More water will be absorbed in sandy or gravelly areas, for example, than in those covered with clay. Surface run-off will be greater in hilly areas than in those that are relatively flat. In sandy regions where relief is great, the first precipitation is absorbed and run-off only commences after continuous heavy rains. Light rains falling upon the surface of the earth during the growing season may be wholly absorbed by growing plants. The quantity of moisture lost through direct evaporation depends largely upon temperature, wind, and humidity. Ground water in areas overlain by pervious material may be recharged by influent streams carrying run-off from areas overlain by relatively impervious material.

Because of the large consumption of ground water in settled areas, it may seem surprising that precipitation can furnish and adequate supply. However, when it is borne in mind that a layer of water 1 inch deep over an area of 1 square mile amounts to approximately 14,520,000 imperial gallons, and that the annual precipitation in this region, for example, is about 30 inches, it will be seen that each year some 435,600,000 imperial gallons of water falls on each square mile. Although it would be impossible to determine the annual recharge of the ground-water supply of the area, if it were assumed that only 10 per cent of the total precipitation, namely 43,560,000 gallons, is contributed to the zone of saturation, it will be seen that the annual recharge for the entire area would be a very large volume. The annual consumption of water in all areas investigated is not known, but an estimate for some restricted areas, based on per capita consumption, shows it to be only about one-tenth of the annual recharge as estimated above.

In most regions of the world where precipitation is effective there is an underground horizon known as the ground-water level or water-table, which is the upper surface of the zone of saturation. The water-table commonly is a subdued replica of the surface topography. The water that enters from the surface into the unconsolidated deposits and rocks of the earth is drawn down by gravity to where it reaches the zone of saturation or comes in contact with a relatively impervious layer. Such a layer may stop further downward percolation, resulting in perched water and creating a perched water-table. If a water-table is at or near the surface, there will be a lake or swamp; if it is cut by a valley, there will be a stream in the valley. The terms influent and effluent are used with reference to streams and their relation to the water-table. An influent stream flows above the water-table and feeds water into the zone of saturation; an effluent stream flows at or below the water-table and receives water from the zone of saturation. An effluent stream may become influent and eventually dry up if the water-table is lowered sufficiently. The ground water in the zone of saturation is almost constantly on the move percolating towards some point of discharge, which may be a spring or a pumping well.

All rocks and soils are to some degree porous, that is, the individual grains or particles of which they are composed are partly surrounded by minute interstices or open spaces that form the receptacles and conduits of ground water. In most rocks and soils the interstices are connected and large enough for the water to move from one opening to another. In some rocks or soils, however, they are largely isolated or too small to allow movement of water. The porosity of a material varies directly with the size and number of its interstices, which in turn depend chiefly upon the size, shape, arrangement, and degree of assortment of the constituent particles. Horizons within the earth's crust of fine-grained rock such as shale, limestone or dolomite, or unconsolidated clay or silt, may have such small interstices that the contained water will not flow readily and wells penetrating them may derive little or no water from them. Such horizons are considered impervious. Beds of more coarse-grained materials such as sand, gravel, or sandstone have greater porosity and readily yield their waters to wells. They are called water-bearing beds or aquifers. A clean water-bearing gravel is one of the best sources of water. This is true whether the water is derived from the zone of saturation or from a bed of gravel confined above, between, or below beds of less pervious material.

Consolidated rocks usually considered to be impervious may sometimes produce water in relatively good supply from openings within them of primary or secondary origin. Those of primary origin, original interstices, were created when the rocks came into existence as a result of the processes by which they were formed; e.g. bedding planes, and intergranular spaces. Secondary interstices comprise joints and other fracture openings, solution openings, and openings produced by several processes of minor importance, such as the work of plants and animals, mechanical erosion, and recrystallization; all of these involve movement of a type that acted after the consolidation of the rock. The most important interstices with respect to water supplies are the original interstices, next to them are the fracture and solution openings.

The most common wells and those that in drift-covered areas yield the largest aggregate supply of ground water are water-table wells. These are wells that derive their water from the zone of saturation. Many shallow wells become dry during the late summer and winter, or during periods of extreme drought. In most cases this is due to the lowering of the water-table below the bottom of the well. The grouping together of a number of water-table wells within a limited area will also lower the yield of any one of the wells. This is especially true of water-producing formations of low permeability. When a well penetrates an aquifer confined by impervious beds, water will be forced upward by hydrostatic pressure exerted at the point where the well enters the aquifer. If the hydrostatic pressure is great enough to force the water to or above the surface, a flowing well is formed.

Springs are formed where the water-table, or some water-bearing aquifer, outcrops at the surface of the ground. The water emerging from water-table springs is free-running water flowing down the gradient of the water-table. In many cases these springs occur as slow seeps along the steeper slopes of stream valleys. A large number in one area could maintain a swamp. A group of permanent springs occurring in one area could provide sufficient water to maintain a lake or form the source of a stream.

GENERAL DISCUSSION OF GROUND-WATER ANALYSIS

The mineral content of ground water is of interest to many besides those industries seeking water of specific quality. Both the kind and quantity of mineral matter dissolved in natural water depend upon the texture and chemical composition of the rocks with which the water has been in contact. Pollution is caused by contact with organic matter or its decomposition products. Analyses of well waters for mineral content are made by the Mines Branch, Department of Mines and Technical Surveys, Ottawa.

In any given area, an attempt is made to secure samples of water representative of all major aquifers. The quantities of the various constituents for which tests are made are given as "parts per million", which refers to the proportion by weight of each constituent in 1,000,000 parts of water.

The following mineral constituents are those commonly found in natural waters in quantities sufficient to have a practical effect on the value of the waters for ordinary uses:

Silica (SiO_2) may be derived from the solution of almost any rock-forming silicate, although its chief source is the feldspars. It is commonly determined in the analysis of water for use in steam boilers, as silica is classed as an objectionable encrustant.

Calcium (Ca). The chief source of calcium dissolved in ground water is the solution of limestone, gypsum, and dolomite. The common compounds of calcium are calcium carbonate ($CaCO_3$) and calcium sulphate ($CaSO_4$), neither of which has injurious effects upon the consumer, but both of which cause hardness and, the former, boiler scale.

Magnesium (Mg). The chief source of magnesium in ground water is dolomite, a carbonate of calcium and magnesium. The sulphate of magnesium ($MgSO_4$) combines with water to form Epsom-salts ($MgSO_4 \cdot 7H_2O$), and renders the water unwholesome if present in large amounts.

Sodium (Na) is found in all natural waters in various combinations, though its salts constitute only a small part of the total dissolved mineral matter in most waters in humid regions. Sodium salts may be present as a result of pollution by sewage, or of contamination by sea water either directly or by that enclosed in sediments of marine origin. Moderate quantities of these salts have little effect upon the suitability of a water for ordinary uses, but water containing sodium in excess of about 100 parts per million must be used with care in steam boilers to prevent foaming. Waters containing large quantities of sodium salts are injurious to crops and are, therefore, unfit for irrigation. The quantity of sodium salts may be so large as to render a water unfit for nearly all uses.

Potassium (K), like sodium, is derived originally from the alkaline feldspars and micas. It is of minor significance and is sometimes included with sodium in a chemical analysis.

Iron (Fe) is almost invariably present in well waters, but rarely in large amounts. Salts, or compounds, of iron are dissolved from many rocks as well as from iron sulphide deposits with which the ground water comes in contact. It may also be dissolved from well casings, water pipes, and other fixtures in quantities large enough to be objectionable. Upon exposure of the water to the atmosphere, dissolved iron separates as the hydrated oxide that imparts a yellowish brown discoloration. Excessive iron in water causes staining on porcelain or enamelled ware and renders the water unsuitable for laundry purposes. Water is not considered drinkable if the iron content is more than 0.5 parts per million.

Sulphates (SO_4). Deposits of gypsum ($CaSO_4 \cdot 2H_2O$) are the principal source of sulphates dissolved in ground water; soluble sulphates, chiefly of magnesium and sodium, are other sources. Sulphates cause permanent hardness in water and form injurious boiler scale. Sodium and magnesium sulphates are laxative when present in quantities of more than 900 parts per million.

Chloride (Cl) is derived chiefly from organic materials or from marine rocks and sediments. It occurs usually as sodium chloride and less commonly as calcium chloride and magnesium chloride. Sodium chloride is a characteristic constituent of sewage and a locally abnormal amount suggests pollution. However, because chlorides may be derived from many sources, such abnormal quantities should not, in themselves, be taken as positive proof of pollution. Chlorides impart a salty taste to water if they are present in excess of 300 parts per million.

Nitrates (NO_3) are of minor importance in the study of ground water. Relatively large quantities in a water may represent pollution by sewage, or drainage from barnyards, or even from fertilized fields. It is recommended that a bacteriological test be made of water showing an appreciable nitrate content if it is to be used for domestic purposes.

Carbonate (CO_3) forms a large percentage of the solid compounds held in solution by the average ground water. The two chief sources are the decomposition of feldspars and the solution of limestone by water carrying carbonic acid in solution, which is the primary agent in rock decomposition. They are indicated in the table of analyses as alkalinity. Calcium and magnesium carbonates cause hardness in water, whereas sodium carbonate causes softness.

Bicarbonate (HCO_3). Carbon dioxide dissolved in water renders the insoluble calcium and magnesium carbonates soluble as bicarbonates. Boiling reverses the process by changing the bicarbonates into insoluble carbonates, which form a coating on the sides of cooking utensils.

Total Dissolved Solids (Residue on Evaporation). The term is applied to the residue obtained when a sample of water is evaporated to dryness. Waters are considered high in dissolved mineral solids when they contain more than 500 parts per million, but may be accepted for domestic use up to that point if no better supply is available. Residents, accustomed to the waters, may use waters that carry well over 1,000 parts per million of total dissolved solids without inconvenience, although persons not used to such highly mineralized waters would find them objectionable.

Hardness is a condition imparted to waters chiefly by dissolved calcium and magnesium compounds. It here refers to the soap-destroying power of water, that is, the power of the water first to use a certain amount of soap to precipitate the above compoun s before a lather is produced. The hardness of water in its original state is its total hardness. Permanent hardness remains after the water has been boiled, and is caused by mineral salts that cannot be removed from solution by boiling. It can be reduced by treating the water with natural softeners, such as ammonia or sodium carbonate, or with many manufactured softeners. Temporary hardness can be eliminated by boiling, and is due to the presence of bicarbonates of calcium and magnesium. Waters containing larger quantities of sodium carbonate than of calcium and magnesium compounds are soft, but if the latter compounds are more abundant the water is hard. The following table[1] may be used to indicate the degree of hardness of a water:

Total Hardness

Parts per million	Character
0-50	Very soft
50-100	Moderately soft
100-150	Slightly hard
150-200	Moderately hard
200-300	Hard
300 and over	Very hard

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[1] Thresh, J. C., and Beale, J. F.; The Examination of Waters and Water Supplies, p. 21, London, 1925.

EMILY TOWNSHIP, VICTORIA COUNTY, ONTARIO

Introduction

This report deals with the ground-water conditions of Emily township in south-central Ontario, based on investigations carried out during the summer of 1949. The writer expresses his appreciation to L. H. Green for his assistance in the field and to Dr. R. E. Dean, under whose supervision the program was carried out.

Emily township is situated in the southeast corner of Victoria county, Ontario, and comprises an area of about 100 square miles. Omemee, the only village in the township, has a population of about 660 and is situated 12 miles west of Peterborough on highway No. 7.

Physical Features

The topography of Emily township is roughly divided into two units by Pidgeon River, which flows northeasterly through the centre of the township.

Southeast of the river the topography is characterized by a large number of drumlins, and is very hilly with swampy areas occurring in places between the hills. Small streams originate in some of these swamps and, because of the high gradient of their valleys, have, in places, eroded deep gullies.

North of Pidgeon River the topography is much less rolling and in some places is almost level. There are several large swampy areas, the largest extending over an area of about 4 square miles in the central part of the four northern concessions. Limestone escarpments 10 to 25 feet high occur along the banks of Emily Creek. Although their present form is due to glaciation, they no doubt existed prior to the time of glaciation as a less prominent feature.

The average elevation in the township is slightly over 900 feet, Pidgeon Lake having an elevation of 807 feet above sea-level. The northern part of the township does not rise more than 125 feet above this, but the southern part is generally higher, and the highest elevation in the township, 1,150 feet, occurs in lot 5, con. II.

The mean annual temperature is 42 degrees Fahrenheit, the average daily temperature varying from 67 degrees in July to 16 degrees in February. There is no meteorological station in Emily township, but the normal annual precipitation in the town of Lindsay, about 5 miles west of Emily township, is 31.2 inches.

Geology and Ground-Water

Bedrock Formations and their Water-bearing Properties. Emily township is entirely underlaid by the Trenton and Black River formations of Ordovician age. These formations consist of grey to blue-grey limestone, with thin layers of gypsum, shale, and slate in some parts of the succession and dolomitic limestones in the lower part of the Black River. Coarse sandstone or arkose occurs in some localities resting unconformably on Precambrian granite and altered volcanic and sedimentary rocks. The thickness of the Palaeozoic beds varies, but in no place has it been found to exceed 550 feet. A well drilled for oil on the western boundary of concession XI cut limestone to a depth of 360 feet.

The limestone beds are proving to be a satisfactory source of water in Emily township, particularly from wells in the northern parts where the drift is too thin in many places to provide good aquifers.. The limestone is in general too fine grained to provide a large supply of water from the solid rock, but where there are fractures or cracks these act as reservoirs and passageways for the ground-water.

Twelve per cent of the wells in the townships were reported to obtain their water from this source, the greater number of these being in the northern eight concessions where bedrock is generally close to the surface.

Three wells draw water from the limestone, which is too saline for domestic or farm use. Data are insufficient to outline a definite area where this condition is likely to be encountered, but the depth of all three wells is 100 feet or more and it may be that the salt water occurs below this horizon in the limestone. It would probably be advisable, if a sufficient supply of good water is encountered above it, not to extend a well to this depth.

Gas was encountered in several wells in the limestone and is in places associated with the salt. Considerable exploration for both oil and gas has been carried out in and around Emily township since 1922, but as yet only traces of gas have been found.

A few wells produce water that has a decided odour of sulphur although otherwise relatively pure, free from excess salinity, and quite suitable for farm uses. This odour is believed to be due to the reduction of sulphates in the form of gypsum present in the limestone, and may be removed by aerating the water, which consists of bringing it into intimate contact with air. By this means oxygen is taken up by the water and carbon dioxide, sulphuretted hydrogen, and certain odour-producing substances of a volatile nature are expelled.

Unconsolidated Deposits and Their Water-bearing Properties. During the Pleistocene or Glacial epoch, great accumulations of ice formed at various centres in northern Canada. This ice moved out in all directions from these centres and covered large regions with what has been called the continental ice-sheet. As the ice advanced, it picked up loose rock debris that was transported and deposited elsewhere by the ice and by the waters released when the ice finally melted. This material is commonly called glacial drift. The ice-sheet advanced and retreated several times, and on each retreat left deposits of drift on the surface over which it passed. These deposits occur as ground moraine, glacio-fluvial deposits, and lacustrine deposits, and together with flood-plain deposits of alluvium constitute the unconsolidated deposits of the township.

Ground moraine occurs throughout Emily township, and is particularly common southeast of Pidgeon River. It consists of a heterogeneous mixture of clay, pebbles, and boulders, enclosing irregularly distributed lenses and pockets of water-laid sand and gravel. In the southern part of the area much of the ground moraine is in the form of drumlins: low, smooth, elliptical or dome-shaped hills as a rule elongated in the direction of the movement of the ice. The drumlins average half a mile in length and are roughly two to three times as long as they are wide. They vary greatly in height, some rising to over 100 feet above the surrounding country. A few drumlins are found in the northern part of the township, but are considerably smaller than those to the south.

Much of the ground moraine in the north is covered with a layer of fine sand, probably deposited by melt-waters from a stagnant or retreating ice-sheet, although bedding is faintly discernible in a few places only. The sand varies in thickness from a few inches to possibly 10 feet. The action of wind on it has resulted in the development of sand dunes or sand ridges across the area in a northwesterly direction. They are not in regular fields but are scattered unevenly across the area and range in height from 1 foot to 10 feet. Where protected by forest the dunes are covered with vegetation and fixed, but where the forest has been cleared the wind has renewed the movement of the dunes.

Kame deposits are common in Emily township, although most are small and comprise a relatively small part of the area mapped.

Kame moraines generally have an irregular surface with many knobs and kettles. They consist mainly of stratified sands and gravels overlying till and, in places where the material has been sorted by running water, the fine and coarse materials have been deposited in separated beds. These beds are very porous and the coarser beds are highly permeable. Kame moraines form the most elevated and hilly parts of the area and are of least value for agricultural purposes.[1]

[1] Putnam, D. F., and Chapman, L. J.: The Physiography of South-Central Ontario; Scientific Agriculture, 16; 9, May 1936.

The largest kame deposit occurs in the middle of the southern four concessions. It comprises an area of about 5 square miles, and includes the highest part of the area. Another extensive kame deposit occurs on either side of Pidgeon River at Fee Landing. The topography northwest of the river is very rugged with large irregular humps of coarse gravel and boulders, but southeast of the river the material is mainly a well-sorted sand with only isolated humps of gravel.

A striking topographic feature of this township is a large esker that starts a mile northeast of the community of Downeyville and extends south in an arc to join a second esker running from Fee Landing to the southeast corner of the township. This esker consists of a ridge of coarse gravel or a series of ridges separated by deep gullies and troughs. It varies in height from 10 to 35 feet and its sides slope up to 60 degrees. Several smaller eskers occur in the area, two of which extend into Ennismore township to the northeast.

Water derived from the melting ice during the retreat of the last ice-sheet were dammed locally at a number of places and many small temporary lakes formed in the eastern parts of the township, particularly in the vicinity of the eskers. Thin deposits of lacustrine silts and sands were laid down in these lakes. It is probable that eskers acted as dams in many places and some of the gaps or breaks in the eskers may represent the drainage channels of these temporary lakes.

The thickness of the drift varies from over 200 feet along the south boundary to an average of 20 feet in the northern part of the area, where bedrock is exposed at many places.

The following table gives the thickness of drift in wells in various parts of the township.

Well No.	Concession	Lot	Depth to Bedrock
1	VI	2	148
1	VI	12	19
1	VI	14	45
1	VII	8	80
2	VII	18	8
3	VII	18	8
2	IX	9	12
3	IX	15	12
1	IX	16	10
1	IX	22	10
1	XI	20	30
3	XI	20	39
1	XII	2	13
2	XII	2	11
5	XII	14	18

Well No.	Concession	Lot	Depth to Bedrock
3	XIII	1	32
2	XIII	3	17
2	XIII	6	24
1	XIII	15	4
3	XIII	18	20
2	XIV	1	1
1	XIV	10	6
2	XIV	22	10

Eighty-eight per cent of the wells were reported to obtain their water from unconsolidated deposits and of these 16 per cent from glacial till. The interstices in till are commonly very small and, consequently, water moves very slowly through them. As a result wells in till go dry not so much because of fluctuations in the level of the ground-water table as because the rate of consumption is greater than the rate at which the aquifers can yield water to the wells. Such wells may be depleted if drawn upon heavily, but will regain their former water level if allowed to stand unused, or if the consumption is materially reduced. In Emily township lack of adequate supply in many of the wells reported as being intermittent or insufficient may be due largely to the poor water-yielding quality of the acquifers, and deepening of the wells is advised in the hope of penetrating more porous beds.

Because of the diversity of the material that forms the till it is difficult to predict the depth at which a permanent supply of water will be obtained. However, most wells should yield a good supply of water at depths not exceeding 40 feet in the hilly areas and 25 to 30 feet in the less rugged areas.

The kame deposits scattered throughout the township offers a much better source for ground-water than glacial till. Water cannot be expected at shallow depths in these deposits, but the supply will be greater because of the greater porosity of the sand and gravel of which they are composed.

Eighteen per cent of the wells were reported to obtain large quantities of water either from kame deposits or sand and gravel lenses in the till. Drilled wells employing well screens are best suited to exploit these deposits.

The lacustrine deposits in Emily township are not an important source of ground-water as they are generally too thin to provide suitable acquifers. Most wells in areas covered by these deposits derive their water from the underlying till or bedrock.

Over 75 per cent of the wells in the area, including most of the dug wells, were reported as being non-artesian, that is, wells in which the water does not rise above the level at which it was first encountered. Owing to the difficulty of digging a well much below the level of the water-table, drilling beyond the dug part has proved a satisfactory method of increasing the supply of water.

About 9 per cent of the wells were reported as being non-flowing artesian, that is, wells in which the water is under some hydrostatic pressure but not enough to cause the well to overflow. One well, however, in lot 6, con. VII, was reported to overflow after heavy rains and in the spring.

Springs are not an important source of water in the township as most of them are only small seepages that go dry in the summer; only eight are being utilized at present for farm and domestic uses. Some good springs occur along the sides of kames and eskers where porous, coarse material overlies relatively impervious fine material or glacial till.

Village Supplies

The village of Omemee obtains its water supply from privately owned wells, most of which are of the dug type. They range in depth from 14 to 26 feet and obtain water from till or lenses of sand and gravel in till. Ground-water conditions were found to be quite uniform throughout the town and it was necessary to investigate only about half the wells to locate the water-table and to obtain a good idea of the general ground-water conditions. Four of the wells investigated were reported to be intermittent, but these wells were found to have penetrated the water-table so short a distance that it sank below the bottom of the wells during periods of low precipitation. This condition could easily be remedied by deepening the wells only a few feet to allow for fluctuations in the level of the water-table.

The drilled wells are from 60 to 85 feet deep and obtain their water from the drift. One was reported to bottom on the limestone bedrock.

The community of Downeyville also obtains its water supply from privately owned wells. The depth of the dug wells varies from 30 to 50 feet and most of them derive their water from seepage through the till. One well derives its water from a lens of sand at a depth of 16 feet.

Analyses of Water Samples

Twelve samples of well water from Emily township were analysed for their mineral content in the laboratory of the Mines Branch, Department of Mines and Technical Surveys, Ottawa. An attempt was made to obtain samples from all major aquifers and from depths of 9 to 159 feet. Nine samples were taken of water from drift and three from bedrock.

The results show considerable variations in both the total dissolved solids and individual mineral constituents.

In all but No. 5 the water was found to be quite suitable for both domestic and stock uses. The total hardness varies from 270 to 508, showing that tho waters range from hard to excessively hard. Evidently large amounts of lime are dissolved by the water as it passes through the drift and bedrock.

Sample No. 5 deserves special mention. The amount of total dissolved solids is greatly in excess of that found in the other samples, the increase being mainly in sodium chloride. This imparts a strong salty taste to the water and renders it unfit for either domestic or stock use. Three wells of this type are known in the township, all obtaining their water from the bedrock. There is insufficient data at present to predict where this condition will be encountered, and the possibility of reaching salty water in any bedrock well, particularly the deeper ones, must be borne in mind.

The presence of sulphur or sulphur dioxide was found in a few wells in the township. This impurity imparts to the water a strong offensive odour that will generally disappear if the water is allowed to stand exposed to the air for a short time. It is probably caused by chemical action on sulphates present in the rock through which the water passes, in which case no harm can result, but may be due to the presence of sulphur-forming bacteria. It might be advisable to have such water tested by the proper authorities.

Amounts[1] of Dissolved Material in Water Samples Collected in Emily Township

Constituent	Water from glacial drift and bedrock (11 analyses)		
	Maximum	Average	Minimum
Total dissolved solids........	508	330	228
Silica........................	28.0	18.6	11.9
Calcium.......................	184.5	74.5	42.5
Magnesium.....................	39.6	22.8	7.6
Sodium........................	80.0	20.0	2.8
Potassium.....................	15.1	5.9	1.0
Sulphate......................	167.5	41.9	10.7
Chloride......................	152.3	35.9	0.7
Nitrate.......................	91.9	16.9	0.0
Carbonate.....................	14.4	5.7	0.0
Bicarbonate...................	452.6	250.9	175.7
Total hardness................	643.3	279.6	179.4

[1] In parts per million.

Conclusions

This investigation warrants the following conclusions.

1. Ground-water supplies in Emily township are not abundant, but are adequate for domestic, stock, and municipal purposes.
2. Precipitation is sufficient to maintain the level of the ground-water except in times of drought, or during extended periods of decreased rainfall, then consumption may be greater than the recharge. This would result in a lowering of the water-table and some wells would go dry. It would then be necessary to deepen wells so affected.

3. The water-table apparently occurs within 40 feet of the surface over most of the township and is possibly within 20 feet in the northern concessions.
4. Eighty-eight per cent of wells derive their water from glacial deposits, the remainder from bedrock.
5. The best sources of water in ground moraine are lenses and pockets of sand and gravel. These are irregular in size and distribution.
6. In areas of kame sand and gravel an abundant supply of water is obtainable at depths similar to those in ground moraine areas.
7. The source of ground-water in the bedrock is in fractures and cracks rather than in the rock itself, which is too fine grained and compact to hold an appreciable amount of water.
8. It is possible to obtain ground-water nearly everywhere in the township, but it is not always possible to predict the depth at which a favourable aquifer may be penetrated.
9. Even though the water-table may occur within a few feet of the surface, the type of material encountered at that depth may yield its water so slowly that wells in it are not satisfactory.
10. So far as mineral content is concerned, water derived from glacial deposits in Emily township, although generally hard, is of good quality and satisfactory for domestic and farm uses.
11. Water derived from bedrock is ordinarily of good quality and similar to that obtained from the glacial deposits. In wells drilled to depths of over 75 feet there is, however, a possibility of contamination by salt, gas, or sulphur gas and, if a suitable supply of water is obtainable at shallower depths, further drilling is not advised.

Sample Number	Owner	Lot	Concession	Depth of well (Feet)	Aquifer	Total dissolved solids parts per million	Constituents as Analysed (parts per million) Silica (S_iO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Alkalis (as Na)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Bicarbonate (HCO_3)	Alkalinity (as $CaCO_3$)	Hardness as $CaCO_3$ (pts.per million) Ca hardness (as $CaCO_3$)	Mg hardness (as $CaCO_3$)	Total hardness (as $CaCO_3$)
1	R. McCausland	1	12	10	H	443	17.8	-	66.0	33.0	45.8	52.3	72.2	27	233.0	241.4	167.4	135.8	300.5
2	H. McGahey	2	13	66	Ls	822	12.4	-	184.5	39.6	31.3	167.5	152.3	11.5	452.6	371.0	480.3	16.0	64.33
3	L. Harrington	4	11	40	H	320	21.2	-	91.5	31.0	27.2	55.1	17.3	91.9	279.4	229.0	228.3	127.6	355.9
5	M. McBrien	9	7	90	Ls	3768	10.8	-	317.2	163.9	791.0	34.2	2031.8	12.0	163.5	134.0	791.4	674.4	1465.8
6	M. McBrien	8	7	100	Ls	270	26.0	-	43.8	21.9	12.8	31.3	2.2	5.5	207.4	170.0	109.3	90.1	199.4
8	W. Magee	11	1	5	G	228	180	-	50.0	13.5	3.8	20.2	1.4	8.0	175.7	144.0	124.8	55.6	180.4
9	R. Fitchett	23	2	144	S	268	192	-	49.6	13.5	7.0	10.7	1.4	trace	219.6	198.0	123.8	55.6	179.4
10	I. Fee	11	1	159	G	280	160	-	66.7	13.8	3.8	20.2	0.7	16.8	202.5	202.0	166.4	56.8	223.2
11	R. Skuce	4	1	38	H	316	158	-	75.0	13.8	6.8	18.9	4.3	21.3	229.4	218.0	187.1	56.8	243.9
12	P. Sears	18	13	11	H	508	119	-	59.8	28.8	86.7	32.9	122.4	3.5	222.8	218.6	149.2	118.5	267.7
VILLAGE OF DOWNEYVILLE																			
4	J. Gosselin			16	S	360	12.4	-	90.0	7.6	26.9	32.1	6.5	24.8	279.4	229.0	224.3	31.3	255.6
VILLAGE OF OMEMEE																			
7	Mrs. Wm. Fee			60	H	316	28.0	-	42.5	34.1	13.9	19.4	15.1	1.2	258.6	212.0	106.0	140.3	246.3

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Number and character of wells and springs	CONCESSIONS I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	OMEMEE	DOWNEYVILLE	Total No. in township	Percentage of total
Total number of wells	58	63	60	71	50	41	52	34	41	42	40	32	61	46	59	8	758	100.0
Dug	52	55	53	55	37	34	42	31	32	35	33	30	51	39	51	6	636	84.0
Drilled	6	8	7	16	13	7	10	3	9	7	7	2	10	7	8	2	122	16.0
Wells 0 - 20 feet deep	23	30	27	33	21	16	24	19	17	15	13	22	41	29	30	1	361	48.0
21 - 40	24	16	22	23	16	12	20	12	17	20	21	8	14	9	21	2	257	34.0
41 - 60	4	6	5	6	2	7	2	0	2	5	2	1	2	3	1	3	51	6.5
61 - 80	3	4	2	3	4	3	1	0	0	1	0	1	4	1	3	1	31	4.2
81 - 100	0	2	2	4	4	0	4	1	1	0	2	0	0	1	1	1	23	3.0
Over 100	4	4	2	2	2	2	1	2	4	0	1	0	0	2	0	0	26	3.4
Depth unknown	0	1	0	0	1	1	0	0	0	1	1	0	0	1	3	0	9	1.3
Wells that yield hard water	58	63	60	71	50	41	51	34	41	42	40	32	61	44	57	8	753	99.9
soft water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0.05
salty water	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	3	0.05
Wells with aquifer in sand	1	2	6	6	4	8	6	1	4	3	3	0	0	0	0	1	45	5.9
in gravel	5	12	6	11	13	11	6	0	3	1	4	5	2	1	8	0	88	11.9
in till	31	24	12	12	1	2	8	4	2	5	3	1	7	4	7	4	127	16.5
In bedrock (Limestone)	0	0	0	4	3	6	9	2	14	9	9	7	17	8	1	1	90	12.0
In glacial drift	20	20	36	37	23	11	18	24	11	5	13	13	11	10	37	0	289	38.0
Unknown	1	5	0	1	6	3	5	3	7	19	8	6	24	23	6	2	119	16.0

	CONCESSIONS														OMEMEE	DOWNEYVILLE	Total No. in township	Percentage of total
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV				
Flowing artesian wells	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0.01
Non-flowing artesian wells	3	5	2	9	10	4	1	4	6	3	4	2	6	2	4	2	67	8.85
Non-artesian wells	46	50	48	54	31	25	37	28	29	30	29	30	48	33	48	4	570	75.30
Springs	2	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	8	1.5
Wells with non-permanent supply	2	2	4	2	4	7	6	2	4	4	1	0	5	8	4	1	56	7.4
Insufficient supply	5	1	3	2	1	5	9	2	4	4	1	1	8	4	4	1	56	7.4
Dry Holes	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	4	0.04
Unknown	5	3	4	5	4	4	7	0	2	5	5	0	1	3	3	1	52	6.8
Wells not used	9	17	6	9	8	4	6	8	9	7	8	8	12	16	4	0	121	16.0