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CANADA
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GEOLOGICAL SURVEY OF CANADA
WATER SUPPLY PAPER No. 320

GROUND-WATER RESOURCES
OF
WHITCHURCH TOWNSHIP
YORK COUNTY
ONTARIO

By

H. N. Hainstock, E. B. Owen, and J. F. Caley



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NOTE:

Because of difficulties involved in reproduction, the tables of well records referred to are not included with this report. Information regarding individual wells may be obtained by writing to the Director, Geological Survey of Canada, Ottawa.

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Map - Whitchurch township, York county, Ontario:

- Figure 1. Map showing bedrock formations and surface deposits;
- Figure 2. Map showing the topography, and location and types of wells.

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 an 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 rise 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 ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$) 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 salt

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 (SO₄). Deposits of gypsum (CaSO₄·2H₂O) 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 (NO₃) 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 compounds 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 table¹ may be used to indicate the degree of hardness of a water:

<u>Total Hardness</u>	
<u>Parts per million</u>	<u>Character</u>
0-50	Very soft
50-100	Moderately soft
100-150	Slightly hard
150-200	Moderately hard
200-300	Hard
300 and over	Very hard

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

PART II

WHITCHURCH TOWNSHIP, YORK COUNTY, ONTARIO

Physical Features

Whitchurch township, an area of approximately 103 square miles, is in the east-central part of York county, southwestern Ontario. Its eastern boundary is the county line between Ontario and York counties, and its western boundary is Yonge Street. It is bounded on the north by East Gwillimbury township and on the south by Markham township.

The greater, northern, part of the area has rolling topography characterized by abrupt hills and deep, basin-like hollows. The southern part of the area is flat or gently undulating; smaller flat areas occur in the north-central part of the township and to the north of Musselman Lake, the latter being a sandy plain. A well-marked divide extends across the township 2 to 4 miles north of, and parallel with, the southern boundary of the township. It forms a part of the height of land between Lake Simcoe and Lake Ontario.

A number of small lakes occur throughout the southern part of the area. The largest of these are Wilcocks, Bond, St. George, and Ressor Lakes in the southwestern part of the township, and Musselman Lake in the east-central part of the area. Wilcocks Lake is the headwaters of East Branch Humber River. The township is drained by Humber, Holland, and Black Rivers, and by the headwaters of Rouge and Little Rouge Rivers. Holland River heads to the west of Musselman Lake and flows in a westerly direction to near Aurora where it bends sharply to the north, continuing in that direction until it leaves the township at Newmarket. It occupies a narrow, shallow valley from its head to Aurora, but from Aurora to Newmarket its valley is wide and fairly shallow. Two large tributaries of the Holland River flow in a northwesterly direction across the northwest corner of the township. Black River and Vivian Creek head in the northeastern part of the area and drain northward into Lake Simcoe. Several small streams that form the headwaters of Rouge and Little Rouge Rivers flow in a southerly direction from the height of land and drain the southern part of the area.

The township as a whole has a relief of more than 450 feet. The highest elevation is in the eastern part of the height of land, con. IX, lots 13 to 14, where an elevation of 1,225 feet above sea-level is attained. In its western part the height of land has an elevation of more than 1,075 feet. The elevation of land decreases gradually to the north and south of the height of land, being approximately 900 feet above sea-level along the eastern part of the northern boundary, 772 feet at the town of Newmarket, and 800 feet along the central part of the southern boundary of the township.

The mean annual temperature of the area is 44.2 degrees Fahrenheit. Normal annual precipitation is 28.4 inches with the greatest amount of precipitation during the months of June, July, September, and November. These figures were reported for Aurora, in the western part of the township.

Geology

Bedrock Formations. Bedrock does not outcrop in Whitchurch township and the type of bedrock that immediately underlies the drift is not definitely known. A general discussion of bedrock geology of the area is included in Part I of this report.

Unconsolidated Deposits. In the Toronto region, some 20 miles south of Whitchurch township, there is evidence of at least three successive advances and retreats of the continental ice-sheet. There, three distinct deposits of glacial till, separated by interglacial deposits of stratified sand and clay, are exposed in the lake-shore bluffs. In Whitchurch township, however, only those deposits laid down during the last movement of the ice-sheet are exposed at the surface. Older deposits of glacial drift and interglacial deposits doubtless compose some of the great thickness of glacial drift that is known to exist in this area.

In lot 4, con. I, a deep well drilled on the farm of J. H. C. Durham, Bond Lake, penetrated 570 feet of glacial drift before bedrock was encountered. This is the only locality in the township where the thickness of the drift is definitely known, but some conception of the thickness of drift at different places in the area can be ascertained from the following table:

Thickness of the Glacial Drift

Well No.	Concession	Lot	Depth to bedrock(feet)
6	I	2	166 +
	I	4	570
58	I	5	200 +
3	I	11	185 +
11	I	19	260 +
46	I	35	336 +
19	II	5	160 +
8	II	19	170 +
48	II	34	265 +
3	III	7	120 +
15	III	24	200 +
29	III	35	127 +
10	IV	2	107 +
1	IV	11	190 +
10	IV	19	201 +
8	IV	28	200 +
3	V	1	115 +
19	V	10	195 +
11	V	32	150 +
11	VI	5	87 +
9	VI	14	114 +
8	VI	24	110 +
20	VII	4	90 +
6	VII	12	160 +
7	VII	35	115 +
1	VIII	5	100 +
15	VIII	14	150 +
7	VIII	22	160 +

Well No.	Concession	Lot	Depth to bedrock(feet)
9	VIII	35	175 +
18	IX	14	159 +
7	IX	24	180 +

NOTE: The depths marked with a + sign indicate that the total thickness of glacial drift was not penetrated.

Two large lobes originating in a single ice-sheet laid down the uppermost deposits of glacial drift in Whitchurch township. The northern ice-lobe moved southward from the Georgian Bay district and the southern lobe moved northward from Lake Ontario. Glacial drift deposited by the southern lobe of ice appears to overlap the deposits of the northern lobe and to differ from them in composition.

All the glacial drift deposited by the advancing ice-sheet and from the base of the ice during its melting constitutes the ground moraine. All of lots 1 to 5, cons. III to X, and most of lots 6 to 8 of the same concessions are mantled by ground moraine deposited by the southern ice-lobe. It is composed mainly of boulder clay, or till, but pockets, lenses, and extensive layers of water-lain sand and gravel are fairly numerous within the material, especially in the vicinity of Stouffville. The boulder clay consists of buff to blue clay with embedded pebbles and boulders of Trenton limestone, Gloucester shale, and some Precambrian rocks. Most of the material appears to have been derived locally.

A small area in the northeast corner and another fairly large area in the north-central part of the township are mantled by ground moraine deposited by the northern ice-lobe. It is quite probable that some of the deposits between Aurora and Newmarket, which have been shown on the map as terminal moraine, may be ground moraine, but the rugged topography in this area suggests that the former interpretation is the more probable. The ground moraine in the northern part of the township is of much the same composition as that in the southern part, except that it is generally more sandy or silty and much of it is well stratified. It contains more Precambrian pebbles than that in the southern part and little or no Gloucester shale. Pockets of water-laid sand and gravel are common within the till, but appear to be less numerous than in the ground moraine of the southern part of the township. Terminal moraines formed by both the northern and southern ice-lobes, and which are more or less intermingled in an interlobate area, cover the greater part of the township. These moraines have been described by F. B. Taylor.^{1, 2}

¹The Moraine Systems of Southwestern Ontario; Trans., Canadian Institute, Toronto, 1913.

²Moraines north of Toronto; Ont. Dept of Mines, vol. XLI, pt. VII, 1932, pp. 56-60.

The terminal moraine deposited by the southern ice-lobe is approximately 2½ miles in width and extends from the southeast

corner of the area easterly across the township. The limits of its rough terrain are fairly well defined. Small lakes, among them Haynes Lake and Ressor Lake, are contained in some of the deep depressions that characterize the moraine topography. The material of the moraine is mainly boulder clay, but sand and gravel are not uncommon. A large area that is covered by stratified sand and gravel occurs in the southwest corner of the township, and several large deposits of gravel and sand occur immediately south and east of Musselman Lake. Pockets and lenses of sand and gravel appear to be fairly common, and in the eastern half of the area more or less continuous layers or tongues extend from the terminal moraine out under the ground moraine. A considerable amount of sand and gravel is encountered in deep drilled wells in most of the area covered by the terminal moraine.

The limits of the terminal moraine deposited by the northern ice-lobe are not so well defined. The front of this moraine is easily recognized north of Wilcocks Lake, but it is less distinct farther east. In the area to the north of Wilcocks Lake and that mapped as terminal moraine between Aurora and Newmarket, the material consists mainly of boulder clay, but elsewhere, except for some knolls of boulder clay, the predominant materials of this moraine are stratified silt, sand, and gravel. Sand and gravel also occurs as pockets, lenses, or fairly extensive layers in the boulder clay.

Streams that issues from the fronts of the ice-lobes during their melting transported large quantities of silt, sand, and gravel, and part of this material was deposited as outwash fans or plains in front of the moraines. In some areas the outwash materials are partly covered by glacial till due to a minor readvance of the ice-sheet. Where the streams issued from ice tunnels or ice channels, especially in areas of terminal moraine, the silt, sand, and gravel was locally bunched in hills or knolls known as kames. The outwash materials are mostly in the form of kames, but in a large flat area to the north of Musselman lake they constitute a sand plain. Kames also occur in a small area to the south of Wilcocks Lake and in an area of considerable width that extends from south of Aurora easterly to Vandorf and then northeasterly through Vivian. An old drainage channel that is occupied in part by Holland River can be traced from Musselman lake westward passing south of Aurora. It marks the course of a large river that flowed between the fronts of the ice-lobes and probably was instrumental in depositing much of the sand and gravel there. In some places the sand deposits are at least 135 feet thick. Some of the outwash material is undoubtedly from the southern terminal moraine, but the greater part of it appears to have come from the north and northeast.

Some alluvium occurs along Rouge River and its large tributary in lots 1 to 3, cons. IV and V, and alluvium may occur in parts of the Holland River Valley, although none has been shown there on the map. The flat valley that contains Wilcocks and St. George Lakes and the headwaters of Humber River is covered by thin deposits of sand mapped as alluvium.

Water Supply

The boulder clay constituting the ground moraine is not a good source of water as most of it is so compact that water soaks into or out of it very slowly, being held there by molecular attraction. Little water is, consequently, recoverable by wells. Where the boulder clay or till is sandy it may, however, prove to be a fair source of water. In some places water may follow small more or less tubular openings in the clay, and most wells that encounter these openings yield a fairly large supply of water. These openings in the clay probably connect with lenses or pockets of porous, water-bearing sand or gravel within the till that are themselves good sources of water. They are very porous, and collect and store large quantities of water that is readily yielded to wells.

The boulder clay constituting the terminal moraines has the same water-bearing properties as that of the ground moraine, and similarly the lenses of sand and gravel located therein absorb and store large quantities of water, much of which is readily recoverable by wells. In some areas, however, the sand may be so fine that wells become plugged and are rendered useless.

The outwash materials consisting chiefly of silt, sand, and gravel are very porous and absorb most of the precipitation that falls on them. Much of this water is readily recoverable by wells, especially if the deposits consist of coarse sand or gravel. If, however, the materials are composed of silt or fine sand the wells tend to plug, and are rendered useless.

Alluvium in Whitchurch township is not an important source of water as the deposits are shallow and not extensive.

The position of the water-table does not remain constant but fluctuates during the year and from year to year. The decline in precipitation during the period 1930-36 resulted in the lowering of the water-table, and a considerable number of shallow wells became dry. The water levels in a number of wells, in Whitchurch and adjoining townships, were measured periodically from June to September of 1937 and for some wells also in August 1936. The results are given in the following table. These wells were not in use so that the fluctuations in water levels is believed to be the direct result of precipitation, evapo-transpiration, and other natural causes. A considerable amount of precipitation occurred during the months that the wells were measured.

Fluctuations of the Water Level in Selected Wells

Location of well		Township	Depth of well (feet)	Date of measurement	Depth of water (feet)
Con.	Lot				
R.I	9	Pickering	55	Aug. 12, 1936	35.0
				June 5, 1937	4.5
				July 19, 1937	6.4
				Aug. 27, 1937	7.7
				Sept. 24, 1937	9.3
R.I	9	Pickering	30	Aug. 21, 1936	20.0
				June 5, 1937	5.1
				July 19, 1937	7.6
				Aug. 27, 1937	10.3
				Sept. 24, 1937	11.3

Location of well		Township	Depth of well (feet)	Date of measurement	Depth of water (feet)
Con.	Lot				
VIII	18	Pickering		July 24, 1936	4.0
				June 5, 1937	3.5
				June 21, 1937	3.1
				July 19, 1937	5.4
				Aug. 27, 1937	7.2
I	1	Scarborough	16.8	Aug. 3, 1936	11.0
				June 7, 1937	5.7
				June 21, 1937	6.3
				July 19, 1937	7.7
				Aug. 27, 1937	9.7
Sept. 24, 1937	10.9				
II	25	Scarborough	44.7	Aug. 29, 1936	41.0
				June 7, 1937	37.2
				July 19, 1937	37.3
				Aug. 27, 1937	36.6
				Sept. 24, 1937	37.4
IV	28	Scarborough	41.3	Sept. 7, 1936	18.0
				June 7, 1937	7.9
				July 19, 1937	8.1
				Aug. 27, 1937	9.6
				Sept. 24, 1937	12.4
IV	14	Scarborough	17.6	July 29, 1936	15.0
				June 7, 1937	5.0
				July 19, 1937	5.5
				Aug. 27, 1937	5.6
				Sept. 24, 1937	6.2
VIII	10	Markham	33.4	June 8, 1937	18.0
				July 19, 1937	18.9
				Aug. 27, 1937	18.4
				Sept. 24, 1937	20.0
V	11	Markham	17.3	June 8, 1937	2.6
				July 19, 1937	3.0
				Aug. 27, 1937	3.7
				Sept. 24, 1937	4.7
I	4	Whitchurch	16.3	Aug. 31, 1936	6.0
				June 8, 1937	4.9
				July 19, 1937	4.1
				Aug. 27, 1937	6.2
				Sept. 24, 1937	7.2
IV	14	Whitchurch	32.5	Aug. 25, 1936	20.0
				June 8, 1937	6.5
				July 19, 1937	13.5
				Aug. 27, 1937	19.1
Sept. 24, 1937	20.8				
I	22	Vaughan	19.2	Sept. 5, 1936	16.0
				June 8, 1937	10.3
				July 19, 1937	13.3
				Aug. 27, 1937	14.4
				Sept. 24, 1937	16.2
IX	15	Vaughan	16.1	Sept. 21, 1936	5.0
				June 9, 1937	5.7
				July 12, 1937	6.9
				Aug. 27, 1937	9.4

The conditions that produce flowing-artesian wells, both in bedrock and glacial drift, are many. They have been fully described by T. C. Chamberlain¹, M. L. Fuller², Howard E. Simpson³,

¹The Requisite and Qualifying Conditions of Artesian wells; U. S. Geol. Surv., 5th Ann. Rept., 1884, pp. 125-173.

²Summary of the Controlling Factors of Artesian Flows; U. S. Geol. Surv., Bull. 319.

³Geology and Ground-water Resources of North Dakota; U. S. Geol. Surv., Water-supply Paper 598, pp. 46-48.

and others. The essential conditions necessary for the existence of flowing-artesian wells are as follows: (1) An adequate supply of water in the intake area, i.e., the locality where the water enters the ground; (2) confining beds of some relatively impervious material that overlie the water-bearing beds and prevent the upward passage of the ground water; (3) the elevation of the intake area should be greater than that of the ground surface in the locality where the well penetrates the aquifer containing the water under pressure.

The areas in which the flowing-artesian wells occur are chiefly in the south part of the township. The aquifers producing the flow-artesian wells are believed to be directly connected with the terminal moraines. These water-bearing beds consist chiefly of sand and gravel and extend from the higher ground in the terminal moraine areas to points below the till of the ground moraine. Precipitation falling on the terminal moraines enters the ground and follows down its hydraulic gradient along the more permeable beds to points where it is confined below the till of the ground moraine. The pressure of the confined water is sufficiently great to cause it to rise into any well that may penetrate the beds in which it exists.

Thirty holes in the township failed to encounter water, and of these only six were sunk to depths greater than 100 feet. In the northwestern part of the township some difficulty is experienced in obtaining adequate supplies of water at shallow depths, but elsewhere little difficulty should be experienced in obtaining sufficient water for all farm and municipal needs at depth. All the wells and springs derive their water supply from the drift, mainly from pockets, lenses, and layers of sand and gravel within the till. Only one well is known to have been drilled into bedrock.

Drilling into the bedrock formations that underlie Whitchurch township in search for water is not advised as they lie at great depth and most of the water they yield is too saline to be used for farm or municipal use. A 1,292-foot well drilled in lot 4, con. I, on the farm of J. H. C. Durham, in search of gas and oil, encountered bedrock at a depth of 570 feet. Water was obtained from the Trenton limestone at a depth of 1,145 feet, but no information was secured as to the quantity.

Data on this well are not listed in the well compilation sheets, but it has been described by R. B. Harkness.

40th Annual Report of the Ontario Department of Mines, 1931, Pts. IV and V, p. 51.

With the exception of the area in the northwest corner of the township mentioned earlier, where deposits of sand and gravel in the upper part of the drift are scarce, little difficulty is experienced in obtaining water at depths down to 80 feet. Where sand and gravel deposits occur at the surface or are overlain by a thin covering of boulder clay, few shallow wells fail to encounter water in sufficient quantity for most farm needs. This is typical of the southeastern part of the area where the supply is particularly abundant. In those areas where the deposits of sand and gravel do not appear at the surface, there is no way of determining their location and extent except by sinking wells or test holes.

In some parts of the township, particularly in the northeast corner, difficulty may be experienced during drilling in controlling the fine sand that forms the water-bearing beds and in all probability screens will have to be utilized in wells penetrating these beds to ensure a sufficient supply of ground water.

At least 80 flowing-artesian wells exist in the area covered by lots 6 to 8, cons. IV and V, lots 1 to 8, cons. VI, VII, VIII, and the western part of con. IX. The wells vary in depth from 20 to approximately 100 feet, most being between 50 and 90 feet, and tap water-bearing beds of sand and gravel. In at least two places in this area two water-bearing horizons are known to exist. In lot 7, con. VI, on the farm of A. Neighorn, water under sufficient pressure to overflow the surface was encountered in sandy material overlying clay or "hardpan" at a depth of approximately 30 feet. A much stronger flow of water was obtained by drilling through the "hardpan" into fairly coarse gravel that occurs at a depth of 70 to 80 feet. It is reported that similar conditions exist in lot 4, con. VIII, on the property used by a goldfish supply company. During the summer of 1937, a well drilled by Rofrey Bros. for the Stouffville water works in lot 8, con. VIII, encountered water in fine sand at a depth of approximately 20 feet with sufficient pressure to flow at the surface. At a depth of approximately 90 feet, however, a medium coarse gravel was encountered that did not contain water. It is thought that this is similar to the deposit of gravel which is the source of the ground water for the flowing artesian wells to the south and southeast. It is not definitely known if the deposits of sand and gravel that form the water-bearing beds of the flowing wells in this area occur as continuous layers or as separate tongues extending southward from the terminal moraine. The former is probably true as most wells drilled in this district encounter water under sufficient pressure to overflow the surface. The water-bearing beds slope up northward into the terminal moraine and the difference in elevation between it and the well sites is the cause of the pressure. The water barely overflows the surface in many wells, but in others the piezometric surface is from 1 to 15 feet above the ground surface, and the

volume of ground water produced is reported to be from 10 to not less than 40 gallons an hour. Very little difficulty should be experienced in locating an abundant supply of usable water in the southeastern part of the township. Not all wells will flow, but the water should rise a considerable distance in the wells. Water from deeper wells may contain a considerable amount of iron.

At least 31 flowing-artesian wells are known to occur in the northwest corner of the township, in lots 26 to 35, con. I, lots 28 to 35, con. II, and lots 31 to 35, in the western part of con. III. Most of these wells are from 120 to 160 feet deep, but a few are less than 75 feet deep and some are over 200 feet deep. At least two water-bearing horizons occur in this area.

Seven wells derive water from sand that underlie blue clay at depths of 24 to 72 feet. The water is under sufficient pressure to overflow the surface, rising 3 feet above it in some places. This bed does not, however, appear to be continuous throughout the locality, as many wells passed through these horizons without encountering water. Other water-bearing deposits occur in narrow bands filling old drainage channels buried by drift that slope upward into the terminal moraine to the south. The water in these is of good quality and fairly abundant in quantity, being ample for all local requirements.

The main supply in this northwest corner of the township occurs in sand or gravel at depths of 120 to 160 feet. These deposits are overlain by impervious blue clay and, in most but not all cases, the gravel underlies the sand. The aquifers for the deeper wells appear to be fairly continuous and probably underlie most, if not all, of the area in which flowing-artesian wells occur. Proof that several wells derive water from the same horizon is shown by the fact that the supply from some wells was appreciably decreased when the wells used by the town of Newmarket were drilled, especially the new well drilled in 1937. The water from this horizon is under considerable pressure and rises 1 foot to 5 feet above the surface. The water-bearing beds are thought to slope up into the terminal moraine to the south and the difference in elevation of the ground-water level in the water-bearing beds in the terminal moraine and at the various well sites accounts for the pressure. Most of the flowing-artesian wells occur in the wide valley of Holland River and its tributary. The possibilities of obtaining other flowing-artesian wells in this area appear to be very good. Wells drilled with the hope of encountering water under sufficient pressure to overflow the surface should be located at sites of low elevation, as it was noted that the water in a few wells in this area, situated at points of considerable elevation, did not flow although it did rise some distance in the wells.

Two flowing-artesian wells in lots 18 and 19, con. I, near Aurora, derive water from sand and gravel aquifers at 85, 100, and 160 feet. These aquifers are believed to be continuous with similar aquifers in King township to the west, but to be different from the aquifers yielding ground water to the flowing-artesian wells in the Newmarket area. Artesian pressures in these aquifers decreases towards higher ground to the south, and, in lot 15, water rises in non-flowing artesian wells only to within 6 feet of the surface.

Springs are fairly numerous throughout the township and at least 53 are being used for domestic or stock needs. They occur along drainage channels and at the bases of some hills. Water supplied by springs is abundant and of excellent quality. Numerous springs issue from the slope at the Stouffville water reservoir, and doubtless many not shown on the map occur in the township.

Community Supplies

Town of Aurora. The town of Aurora, population approximately 2,700, obtains its water supply from flowing-artesian wells. One flowing well is in Whitchurch township and the others, 7 in number, are in King township. The well in Whitchurch township, situated at the pumping station and standpipe, is 260 feet deep and derives water from sand and gravel at depths of 100 and 260 feet. The pressure is sufficient to raise the water 6 feet above the surface, and the water flows into a reservoir from where it is pumped into a standpipe. The flow from this well is approximately 50,000 gallons a day. Another reservoir of 35,000 gallons capacity on the west side of Yonge Street just south of the standpipe receives water from three flowing-artesian wells 91 to 98 feet deep. Water from four other flowing-artesian wells west of Yonge Street flows into a third reservoir of 11,000 gallons capacity. This water is obtained at depths of 119 to 140 feet and rises 6 to 8 feet above the surface. Water from all three reservoirs is pumped directly to the mains without processing. The daily consumption of water for Aurora is approximately 200,000 gallons. During 1936 some 77,000,000 gallons of water were obtained from the wells and there was a surplus of about 10,000,000 gallons.

Town of Newmarket. Newmarket, population 3,600, obtains its water supply from wells. Prior to 1937 the supply was derived from 3 flowing wells, 150, 200, and 300 feet deep. The water was pumped from a 100,000-gallon reservoir into a 175,000-gallon standpipe and thence to the mains. In 1937 a new well drilled by the International Water Supply Company came into use. Water was encountered in three horizons at depths of 90, 190, and 265 feet, but only that from the latter is being used. To remove impurities of sand, silt, iron, and natural gas, the water is first sprayed into a tank and then pumped through sand filters into the mains. Yield from this well is 140 gallons a minute.

Village of Stouffville. Stouffville, with a population of approximately 1,060, obtains its water supply from flowing-artesian wells and springs located in lot 9, con. VIII. Most of the water is derived from 8 flowing-artesian wells at depths of approximately 20 feet and is stored in two open cement and tile reservoirs of 250,000 and 300,000 gallons capacity. The water from a few springs is also diverted into the reservoirs. Water is piped by gravity to the town, which lies about 3 miles southeast of the reservoirs and 120 feet lower in elevation. It is used without purification. The average daily consumption is 75,000 gallons. The supply is sufficient for present needs.

During the summer of 1937 a test hole was drilled at the reservoirs in order to ascertain the possibilities of obtaining additional water below the level at which the present supply is derived. Water under artesian pressure was encountered in sand at about 20 feet. This was cased off and drilling continued to a total depth of 142 feet. At about 90 feet dry ground was encountered and at about 140 feet fine water-bearing sand. Water from this fine sand rose to within 40 or 50 feet of the surface, but in a period of 4 days sufficient sand had been drawn into the drill pipe to plug the lower 50 feet of the hole. The hole was then abandoned. Successful screening of the sand would be possible if it were necessary in the future to drill to this depth for water.

The water supplies of smaller communities throughout the township, such as Vandorf, Lemonville, Ringwood, Bethesda, Bloomington, Ballantrae, and Cedar Valley, are derived from privately owned wells. These wells are of various depths and obtain their water from the glacial drift. The supply is sufficient for local needs.

Analyses of Water Samples

One hundred and twenty-four samples of well waters from Whitchurch township were analysed for their mineral content in the laboratory of the Geological Survey of Canada. The samples were taken from depths of from 0 foot to 336 feet, and all are from glacial drift. Most of them were found to be suitable for domestic and farm use.

Amounts* of Dissolved Mineral Matter in Waters Collected in Whitchurch Township

Constituent	Water from glacial drift (124 analyses)		
	Maximum	Average	Minimum
Total dissolved solids	940	351	80
Silica (SiO ₂)	30	15	2
Iron (Fe ₂ O ₃) and alumina (Al ₂ O ₃)	64	7	2
Calcium (Ca)	217	74	11
Magnesium (Mg)	34	19	3
Sodium (Na)	102	23	nil
Sulphate (SO ₄)	149	41	8
Chloride (Cl)	156	22	3
Total hardness	800	296	45

*In parts per million.

Conclusions

This investigation warrants the following conclusions:

1. In most parts of Whitchurch township ground-water supplies are fairly abundant. Most wells, except those in the northwestern corner of the township, supply ground water from depths of 80 feet or less.

2. Precipitation appears to be sufficient to furnish adequate supplies of ground water, but in times of drought, or during extended periods of decreased rainfall, consumption may be greater than recharge, resulting in a lowering of the water-table. Some wells go dry at such times, and it may be necessary to deepen them to ensure a permanent supply of water.
3. The quantity of ground water available from a well depends upon the porosity, thickness, and extent of the aquifer penetrated.
4. Aquifers in ground and terminal moraine areas are irregular lenses, pockets, and sheets of sand and/or gravel confined upon, within, or beneath relatively impervious clay or clay till.
5. Ground water is abundant and readily recoverable in the interlobate, or kame moraine, area in the central part of the township. However, the depth at which water may be reached varies considerably over this area.
6. Fine sand of some aquifers may plug wells and make them useless as a source of water. Screens have been used effectively to stop the flow of sand and ensure permanent supplies of water.
7. Flowing wells are numerous in two large areas within the township. Sand and gravel aquifers in those areas lie directly upon or beneath confining layers of clay or clay till. The aquifers have a fairly steep gradient up onto the terminal moraines, and the difference in elevation between the point where water enters the aquifer on the moraines and the point where it is released in the well forms sufficient hydrostatic pressure to cause the water to flow above the ground level.
8. Drilling into bedrock underlying the glacial drift is not advised. Water derived from this source will in all probability be too salty for domestic use.

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Sample Number	Owner	Lot	Concession	Depth of well (Feet)	* Aquifer	Total Dissolved Solids (parts per million)	Constituents as Analysed (parts per million)										Hardness as CaCO ₃ (pts. per million)		
							Silica (SiO ₂)	Iron & Aluminum (Fe & Al)	Calcium (Ca)	Magnesium (Mg)	Alkalis (as Na)	Sulphate (SO ₄)	Chloride (Cl)	Nitrate (NO ₃)	Bicarbonate (HCO ₃)	Alkalinity (as CaCO ₃)	Ca hardness (as CaCO ₃)	Mg hardness (as CaCO ₃)	Total hardness (as CaCO ₃)
1	Webster	5	I	120	D.	300	22	8	79	26	5	65	7	220			260		
2	Jones	5	I	180	D.	280	16	10	71	26	3	53	5	230			320		
3	F.J. Berry	11	I	185	S.	320	4	4	86	26	3	41	6	285			360		
4	Monkman	11	I	156	S.	340	14	12	93	28	14	69	8	290			300		
5	E.M. Woods	14	I	50	D.	280	6	4	74	7	3	33	5	165			220		
6	Jarvis	15	I	75	G.	220	10	6	72	15	2	16	3	155			240		
7	Jarvis	15	I	75	D.	260	8	6	69	15	3	36	3	220			260		
8	W. Wood	17	I	85	S.	280	14	6	80	20	2	13	19	245			240		
9	Town of Aurora	19	I	260	S.G.	280	16	6	66	19	4	36	3	215			260		
10	D. Morgan	21	I	55	D.	580	22	4	106	32	42	149	70	235			480		
11	A. McElroy	23	I	40	D.	500	12	4	97	26	28	90	84	200			400		
12	A. Robinson	24	I	50	D.	940	12	4	152	38	40	134	156	265			500		
13	P. Smith	26	I	160	G.	180	10	4	40	16	30	36	7	185			240		
14	Town of Newmarket	33	I	200	S.	340	16	2	31	17	56	15	86	180			240		
15	"	33	I	300	G.	340	16	2	31	17	56	15	86	180			240		
16	E. Fogal	34	I	15	G.	620	16	4	157	24	25	143	60	315			400		
17	C.H. Lloyd	35	I	51	S.	740	10	4	129	33	28	110	52	260			520		
18	E. Norris	35	I	180	G.	220	16	6	40	22	44	39	23	180			280		
19	M. Cullen	35	I	336	G.	280	10	4	46	20	44	43	41	149			260		
20	R. Gould	35	I	250	D.	240	10	4	37	22	40	38	37	180			240		
21	W. Carlisle	2	II	115	G.	260	10	4	879	18	8	37	6	230			260		
22	Langley	5	III	160	S.	260	10	6	71	22	18	41	6	235			260		
23	Allen	9	III	100	S.G.	260	16	6	71	15	7	37	7	210			220		
24	F. Bell	11	II	165	S.	320	10	6	86	26	7	49	12	270			280		
25	Howard	15	II	90	S.	280	12	6	86	11	8	23	11	240			280		
26	E.G. Pindar	21	II	28	S.	340	14	4	106	16	56	56	16	210			200		
27	E.G. Pindar	21	II	125	G.	280	14	4	97	19	33	33	6	210			280		

ANALYSES OF WELL WATERS FROM WHITCHURCH TOWNSHIP, YORK COUNTY, ONTARIO

Sample Number	Owner	Lot	Concession	Depth of well (Feet)	Aquifer	Total dissolved solids (parts per million)	Constituents as Analysed (parts per million)										Hardness as CaCO ₃ (pts. per million)					
							Silica (SiO ₂)	Iron & Aluminum (Fe) (Al)	Calcium (Ca)	Magnesium (Mg)	Alkalis (as Na)	Sulphate (SO ₄)	Chloride (Cl)	Nitrate (NO ₃)	Bicarbonate (HCO ₃)	Alkalinity (as CaCO ₃)	Ca hardness (as CaCO ₃)	Mg hardness (as CaCO ₃)	Total hardness (as CaCO ₃)			
28	F. Graham	23	II	85	S.G.	340	16	4	72	30	3	56	17						230			380
29	R. Playter	27	II	45	D.	560	12	6	103	31	42	115	51						245			500
30	A.P. Williamson	27	III	76	D.	180	12	2	17	10	3	15	10						145			115
31	A. Starr	32	III	150	D.	340	12	2	86	24	9	77	16						220			280
32	A. E. Starr	32	II	52	D.	260	20	4	60	23	31	15	3						245			250
33	F. Baillee	33	II	125	D.	240	18	4	51	23	31	34	10						240			300
34	Smith	7	III		D.	300	10	2	79	22	5	45	7						245			280
35	C. Billing	12	III		D.	280	12	6	86	24	1	49	13						250			240
36	Vandort	17	III	140	D.	180	10	16	23	20	13	20	4						140			150
37	A. McDonald	17	III	125	D.	380	12	2	66	25	18	31	7						265			300
38	J. Petch	21	III	63	D.	720	14	4	160	34	13	72	56						280			550
39	R. Willis	24	III	2	D.	80	4	6	11	3	13	13	3						50			45
40	N. Kay	25	III	110	D.	180	14	2	31	30	10	5	5						150			260
41	H. Osely	27	III	110	D.	320	8	2	77	24	24	54	5						180			300
42	C. J. Toole	30	III	Spr	D.	280	14	4	49	22	10	26	4						240			280
43	A.H. Flintoff	31	III	125	D.	260	12	2	54	25	8	13	5						215			250
44	School	31	III	116	D.	260	10	4	54	24	9	33	3						210			260
45	A. Starr	32	III	60	D.	260	12	2	66	21	14	52	5						220			260
46	W. Duffy	35	III	127	D.	380	10	10	72	26	24	66	20						220			400
47	C.C. Thompson	2	IV	107	D.	300	12	12	66	16	24	30	13						235			240
48	L. Brillinger	9	IV	43	D.	300	8	6	34	10	21	30	12						225			300
49	Preston	13	IV	100	D.	300	14	4	71	24	21	49	7						260			280
50	Radmore	13	IV	155	D.	400	6	8	60	6	15	15	7						370			320
51	Preston	13	IV	29	D.	420	12	8	33	33	25	49	41						260			300
52	Preston	13	IV		D.	340	10		37	6		8	9						315			320

ANALYSES OF WELL WATERS FROM WHITCHURCH TOWNSHIP, YORK COUNTY, ONTARIO

Sample Number	Owner	Lot	Concession	Depth of well (Feet)	Aquifer	Total dissolved solids (parts per million)	Constituents as Analysed (parts per million)										Hardness as CaCO ₃ (pts. per million)			
							Silica (SiO ₂)	Iron & Aluminum (Fe)	Calcium (Ca)	Magnesium (Mg)	Alkalies (as Na)	Sulphate (SO ₄)	Chloride (Cl)	Nitrate (NO ₃)	Bicarbonate (HCO ₃)	Alkalinity (as CaCO ₃)	Ca hardness (as CaCO ₃)	Mg hardness (as CaCO ₃)	Total hardness (as CaCO ₃)	
55	H. A. Switzer	21	IV	93	D.	340	8	2	74	23	1	36	8							280
56	C.W. Bostwick	24	IV	30	D.	320	8	2	77	24	10	54	5							300
57	C. Greenwood	26	IV	50	D.	600	16	4	129	32	3	100	30							425
58	B. Dike	28	IV	200	D.	180	12	2	120	9		23	3							150
59	F.S. Sheridan	33	IV	45	D.	500	16	2	114	26		100	25							400
60	E. Clubine	1	IV	17	D.	500	16	34	37	30		36	35							460
61	Bolender	7	V	110	D.	280	4	36	43	15		28	11							280
62	F. Allen	10	V	145	D.	260	4	48	29	11		25	10							240
63	W. Winterstein	10	V	195	D.	200	10	6	54	9	8	15	5							200
64	W. Winterstein	10	V	20	D.	620	6	6	31	17		25	38							440
65	W.R. Chapman	13	V	52	D.	400	8	54	114	15		26	20							320
66	W.R. Chapman	13	V	152	D.	320	6	6	34	18		25	6							300
67	W.R. Clarke	13	V	150	D.	340	6	64	29	11		64	8							320
68	Fines	17	V	31	D.	580	10	2	114	11	21	48	15							360
69	H. McClune	30	V	120	D.	220	18	4	57	14		26	3							300
70	Sinclair Estate	30	V	16	D.	520	18	2	129	18		107	15							400
71	S. Hope	32	V	44	D.	260	30	2	49	21		18	9							300
72	F. Stockley	5	V	87	D.	340	18	62	29	19		79	27							260
73	Wells	10	VI	90	D.	260	8	8	86	7		26	9							260
74	S. Castle	14	VI	114	D.	280	8	4	83	15		31	6							280
75	P. Wright	21	VI	21	D.	260	12	4	72	6		39	8							260
76	P. Kaufman	32	VI	32	D.	240	12	2	66	8	31	30	3							240
77	Timbers Hall	4	VIII	4	D.	200	20	4	57	19		20	10							200
78	Hall	10	VIII	92	D.	220	10	8	69	10		23	3							220
79	S. Sibley	12	VII	20	D.	220	10	2	77	13		36	5							220

Sample Number	Owner	Lot	Concession	Depth of well (feet)	* Aquifer	Total dissolved solids (parts per million)	Constituents as Analysed (parts per million)										Hardness as CaCO ₃ (pts. per million)		
							Silica (SiO ₂)	Iron & Aluminum (Fe & Al)	Calcium (Ca)	Magnesium (Mg)	Alkalis (as Na)	Sulphate (SO ₄)	Chloride (Cl)	Nitrate (NO ₃)	Bicarbonate (HCO ₃)	Alkalinity (as CaCO ₃)	Ca hardness (as CaCO ₃)	Mg hardness (as CaCO ₃)	Total hardness (as CaCO ₃)
107	Forfar	21	IX	56	D.	220	10	4	92	11	6	33	17			210		220	
108	G. Walker	26	IX	46	D.	240	12	6	80	11	5	36	7			210		240	
109	T. Moorehead	35	IX	100	D.	240	22	4	69	18	3	34	5			210		240	
110	Aurora Tap Water					320	18	4	77	22		26	4			240		300	
111	Newmarket Tap Water					460	14	20	57	24	95	33	90			285		280	
112	Reesor Lake					120	2	6	26	4	20	18	7			95		80	

* C.- Clay
 G.- Gravel
 S.- Sand
 D.- Drift

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Number and character of wells and springs	Concessions										Total No. in township	Percentage of total
	I	II	III	IV	V	VI	VII	VIII	IX	X		
Total number	255	156	148	138	111	102	129	1173	112	19	1343	64.0
Dug wells	175	89	109	113	79	51	81	88	58	16	859	0.6
Bored wells	64	0	0	1	3	2	41	81	47	3	413	30.7
Drilled wells	8	0	35	20	0	0	0	1	1	0	10	0.9
Driven wells	8	8	4	4	4	11	6	3	5	0	53	3.9
Springs												
Wells 0-40 feet deep	170	80	87	103	83	56	79	90	59	11	818	60.9
Wells 41-80 feet deep	23	21	34	15	8	24	26	40	38	8	237	17.9
Wells 81-120 feet deep	20	22	13	7	8	11	13	19	9	0	122	9.0
Wells 121-160 feet deep	20	26	10	3	4	0	3	5	5	0	76	5.6
Wells 161-200 feet deep	8	2	2	2	1	0	0	1	1	0	17	1.2
Wells over 200 feet deep	4	1	0	1	0	0	0	0	0	0	6	0.5
Wells depth unknown	10	4	2	7	7	11	8	18	0	0	67	4.9
Wells that yield hard water	242	144	138	132	104	90	117	165	113	18	1253	93.3
Wells that yield soft water	1	0	0	2	1	0	2	0	1	0	7	0.5
Wells that yield salty water	0	0	0	0	0	0	0	0	0	0	0	
Wells with aquifer in sand	103	47	60	40	52	54	71	105	78	5	615	45.7
Wells with aquifer in gravel	54	37	21	18	4	22	16	17	10	5	204	15.2
Wells with aquifer in clay	22	27	26	32	24	10	10	17	9	1	178	13.2
Wells with aquifer in drift	68	41	32	47	29	14	27	29	12	7	306	22.9
Wells with aquifer in bedrock	0	0	0	0	0	0	0	0	0	0	0	
Wells with aquifer unknown	4	0	3	1	0	1	1	0	0	0	10	0.9
Flowing wells	11	21	4	2	10	23	21	14	5	1	112	8.4
Non-flowing wells	232	123	134	132	95	67	98	151	99	17	1148	85.4
Wells with permanent supply	204	114	112	110	85	83	109	153	96	16	1082	80.4
Wells with non-permanent supply	39	30	26	24	20	7	10	12	8	2	178	13.2
Dry holes	4	4	6	0	2	1	4	5	3	1	30	2.2
Wells not used	30	16	13	9	6	5	11	13	9	4	116	8.6