CANADA

DEPARTMENT OF MINES AND RESOURCES

MINES, FORESTS AND SCIENTIFIC SERVICES BRANCH

GEOLOGICAL SURVEY

WATER SUPPLY PAPER NO. 289

GROUND-WATER RESOURCES OF TORONTO GORE TOWNSHIP, PEEL COUNTY, ONTARIO

By

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

OTTAWA

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PART I

INTRODUCTION

This report deals with the ground-water conditions of part of an area in southern Ontario investigated by the Geological Survey in 1936 and 1937. The entire area covers approximately 800 square miles. It consists of King, Markham, Scarborough, Vaughan, and Whitchurch townships, York county; Albion and Toronto Gore townships, Peel county; and Pickering township, Ontario county.[1]

A gradually diminishing annual rainfall over the 5-year period 1931 to 1936, culminating in the extremely dry season of 1936, brought about a lowering of the ground-water level that resulted in serious water shortages in many localities. Many farmers found themselves virtually without water, and the supplies of some villages dwindled to quite insufficient amounts. The water supplies throughout the entire area are derived for the most part from ground water. The principal object of this report is, consequently, to aid those who are in need of new or further supplies.

As the ground water is directly related to the geology, both bedrock and superficial deposits were studied and mapped. All available information pertaining to some 8,700 wells was recorded and 280 water samples were collected for analysis. T. H. Clark (1936) and H. N. Hainstock (1937) mapped the superficial geology, and also directed the collection of water data. Dr. Clark was ably assisted in the field by J. H. Douglas, J. W. Britton, D. K. Stadleman, G. W. Matheson, M. E. Woods, and E. C. S. Gould, and Mr. Hainstock by J. H. Douglas, P. D. Bugg, M. E. Woods, W. B. Gray, E. A. Gray, W. E. Tweed, and J. P. Clancy. J. F. Caley, assisted by M. C. Gardiner, studied the bedrock formations.

Thanks are here extended to the farmers throughout the area for their co-operation and willingness to supply information regarding their wells. Valuable assistance was given by the well drillers and by several municipal authorities who willingly supplied all available data.

To H. C. Rickaby, Deputy Minister of Mines for Ontario, and R. B. Harkness, Ontario Natural Gas Commissioner, thanks are here expressed for their hearty co-operation in the work.

Publication of Results

The essential information pertaining to ground-water conditions is being issued in reports covering each township in the area. Township authorities will be supplied with the information covering their respective townships. In addition, pertinent data on each well have been compiled, and may be obtained from either the Chief Geologist, Geological Survey, Ottawa, or the Provincial Geologist, Ontario Department of Mines, Toronto. When requesting such additional information, the applicant should clearly state the exact location giving the lot and concession of the district about which data are required.

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

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1. The material contained in Part I of this report refers to the entire area comprising all the townships mentioned. The general discussion of ground water is universally applicable. Part II deals specifically with the ground-water conditions of one township.

GLOSSARY OF TERMS USED

Alluvium. Deposits of earth, clay, silt, sand, gravel, and other material in lake beds and in the flood plains of modern streams.

Aquifer. A geologic formation or structure that transmits water in sufficient quantity to satisfy pumping wells and springs.

Bedrock. Bedrock, as here used, refers to partly or wholly consolidated deposits of gravel, sand, silt, clay, and marl that are older than the glacial drift.

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

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

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

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. It includes all the loose unconsolidated materials that were deposited by the continental ice-sheet, or by waters associated with it. Clay containing boulders forms part of the drift and is referred to as glacial till or boulder clay. Glacial drift occurs in several forms:

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

(2) Kame Moraine. Assorted deposits of sand and gravel laid down at or close to the ice margin. The topography is similar to that of a terminal moraine.

(3) Drumlin. A smooth, oval hill composed mainly of glacial till, which has its long axis parallel to the direction of ice movement at that place.

(4) Ground Moraine. A boulder clay or till plain deposited at the base of the ice-sheet. The topography may vary from flat to gently rolling.

(5) Glacial Outwash. Sand and gravel plains or deltas formed by streams that issued from the continental ice-sheet.

(6) Shore Line. A discontinuous escarpment, which indicates the former margin of a glacial lake.

(7) Bay-mouth Bar. A ridge of interbedded sands and gravels formed across the mouth of a glacial-lake bay.

(8) Glacial-lake Deposits. Sand, silt, and clay plains formed in glacial lakes during the retreat of the ice-sheet.

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

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

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

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

Pre-glacial Land Surface. The surface of the land before it was covered by the continental ice-sheet.

Recent Deposits. Deposits that have been laid down by the agencies of water and wind since the disappearance of the continental ice-sheet.

Unconsolidated Deposits. The mantle or covering of alluvium or glacial drift consisting of loose sand, gravel, clay, silt, and boulders that overlie the bedrock.

Water-table. The upper limit of the part of the ground saturated with water. This may be very near the surface or many feet below it.

Perched Water. Water separated from an underlying body of ground water by unsaturated rock.

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

(1) Flowing Artesian Wells. Wells in which 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 intermittently dry.

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 as run-off; part evaporates either directly from the surface and from the upper mantle of soil, or indirectly through transpiration of plants; and the remainder sinks into the ground to be added to the ground-water supplies.

The proportion of the total precipitation that sinks below the ground will depend largely upon the type of soil or surface rock, and on the topography; more water will sink into sand and gravel for example, than into clay; if, on the other hand, the region is hilly and dissected by numerous streams, more water will be immediately drained from the surface than in a relatively flat area. Light, continued precipitation will furnish more water to the underground supply than brief torrential floods, during which the run-off may be nearly equal to the precipitation. Moisture falling on frozen ground will not usually find its way below the surface, and, therefore, will not materially replenish the ground-water supplies. Light rains falling during the growing season may be wholly absorbed by plants. The quantity of moisture lost through direct evaporation depends largely upon temperature, wind, and humidity.

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 area, for example, is about 30 inches, it will be seen that each year some 435,600,000 gallons fall on each square mile. If we estimate that only 10 per cent of this, namely 43,560,000 gallons, is contributed to the underground supplies, it will be seen that the annual recharge for the entire area of 800 square miles is 34,848,000,000 gallons. The annual consumption of water in this area is not known, but an estimate based upon per capita consumption shows it to be only about one-tenth of the annual recharge as estimated above. It seems reasonable then, to conclude that precipitation is adequate to furnish supplies of ground water for the area.

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 water-saturation. Water that sinks into the ground finds its way downward to where it either reaches this water-table or comes in contact with an impervious layer of rock. Such a layer may stop further downward percolation, resulting in perched water. If the 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.

All rocks are to some degree porous, that is, the individual grains or particles of which they are composed are partly surrounded by minute open spaces or pores. Water stored within the rocks fills these spaces. A fine-grained rock such as shale, limestone, or clay may have such small pores that the contained water will not flow readily, and wells sunk in such rocks may obtain little or no supply of water. Such rocks are considered impervious. Those rocks on the other hand that readily yield their water to wells are called water-bearing beds or aquifers. Sand and gravel, porous sandstone, and sand form good aquifers. A clean gravel constitutes one of the best types of aquifer, as it is sufficiently porous to yield its water freely.

Many shallow wells that derive their water from below the water-table have become dry. In many cases this is due to the lowering of the water-table below the bottom of the well. So long as the annual recharge is equal to or greater than the loss through consumption and underground drainage, there will be no lowering of the water-table, and hence wells sunk below this level will have a permanent supply. If, however, the annual precipitation were to decline over a period of years, the quantity of water available for recharging the underground supply would necessarily decrease, and if it were to decrease to a point where loss through consumption and underground drainage was greater than the annual recharge, the level of the water-table would be lowered and some wells would go dry. Such a decline in precipitation occurred in the general area under consideration during the 5-year period 1929 to 1935.

Although springs are utilized in some parts of this area, the chief method of recovering ground water is by means of wells. The quantity of water obtained from springs is usually small, but the town of Markham, with a population of about 1,[illegible]00, obtains its public water supply from such a source. Two types of wells are in common use, namely dug wells and drilled wells, the former outnumbering the latter by about ten to one. In places where the aquifer yields its water slowly, dug wells, because of their greater storage capacity, are more satisfactory than drilled wells. However, if proper precautions are not taken, dug wells are more likely to become contaminated by polluted surface waters, especially in barnyards. Ground water for industrial and commercial uses, where large quantities are required, is commonly obtained from the deeper drilled wells. When drilling such wells, the more shallow and perhaps smaller supplies can be cased off and drilling continued to where adequate supplies are encountered.

The wells have been classified as artesian and non-artesian, and artesian wells are subdivided into flowing artesian and non-flowing artesian. A fourth class, called intermittent non-artesian, comprises those wells that dry up periodically.

DESCRIPTIONS OF FORMATIONS AND THEIR WATER-BEARING PROPERTIES

Bedrock Formations

The bedrock formations that underlie the area are listed in the following table:[1]

[1]Caley, J. F.: Palaeozoic Geology of the Toronto-Hamilton area, Ontario, Geol. Surv., Canada, Mem. 244, p. 12 (1940).

Table of Formations

System	Formation	Thickness (Feet)	Lithology
Silurian	Lockport	151 ±	Light grey dolomite; some brownish, bituminous, dolomite at top.
	Medina	74 ±	Red, green, and grey shale; grey, sandy, and shaly dolomite (Cabot Head); grey, magnesian and argillaceous limestone (Manitoulin); grey sandstone (Whirlpool).
Ordovician	Queenston	340 - 400	Red, in part sandy, shale.
	Meaford	120 ±	Grey, bluish, and brownish shale, with thin layers of limestone; calcareous sandstone and arenaceous shale.
	Dundas	550 ±	Grey and blue shale; thin, sandy beds; thin, lenticular, limestone beds.

	Billings	100 - 250	Dark grey to nearly black, slightly bituminous shale.
	Trenton and Black River	550	Chiefly grey limestone, in places dolomitic and shaly; sandstone and arkose at the base.
Precambrian			Granitic and altered volcanic and sedimentary rocks.

Precambrian

These rocks consist of granitic and altered volcanic and sedimentary formations that underlie the Palaeozoic sediments unconformably. They are not an important source of water in the area. Water contained in these rocks probably occurs in joints and fissures. From the few wells that have reached the Precambrian, the water is reported to be highly mineralized.

Trenton and Black River Formations

The Trenton and Black River formations consist predominantly of grey and blue-grey limestone, and are at least 550 feet thick. Thin layers of shale occur in some parts of the succession, and dolomitic limestone may be present in the lower part of the Black River beds. Coarse sandstone or arkose, resting unconformably on the Precambrian, is known to occur in some localities.

Water found in these rocks occurs in cracks, fissures, or solution channels, and along bedding planes. The limestone itself is too fine grained and compact to be water yielding, but the coarse sandstone or arkose may contain a considerable quantity of water. Water derived from these formations is commonly highly mineralized and unfit for domestic use.

Collingwood Formation

The Collingwood formation consists of dark grey to black, fine-grained, thin-bedded, bituminous shale. It is about 30 feet thick. Water recoverable from these rocks occurs largely in fractures and along bedding planes; the shale itself is too fine grained to yield its water freely. The water obtained is usually too saline for either domestic or stock purposes.

Billings Formation

The Billings formation is a thin, and evenly bedded, soft, bituminous shale that weathers dark grey, bluish, or even yellowish. On fresh surfaces it is dark grey to nearly black, with distinct brown and green shades in many places. Much pyrite occurs in the darker parts.

The shales are exposed on both Rouge and Little Rouge Rivers a short distance above highway No. 2. They also outcrop on Duffin Creek, where they may be seen on lot 15, cons. II and III, and on lot 13, con. IV, Pickering tp. No other exposures of this formation occur in the area, but the shales underlie all that part east of a line joining the mouth of Rouge River and Lemonville.

Some water occurs along the bedding planes of this formation, but the quantity recoverable is small and the water saline.

Dundas Formation

The Dundas formation is prevailingly a bluish grey, thin-bedded shale that weathers somewhat lighter. There is, however, some variation from compact, blue, argillaceous shale to buff or yellowish, silty, and frequently arenaceous rock. Hard bands, both calcareous and arenaceous, occur interbedded with the shale; they rarely exceed a foot in thickness, the average being only a few inches. The formation is about 550 feet thick. It outcrops on Humber and West Humber Rivers in Vaughan and Toronto Gore townships respectively, and underlies the drift throughout most of Vaughan and King townships together with the western part of Whitchurch, Markham, and Scarborough townships and a small part of each of Albion and Toronto Gore townships.

Water occurs along the bedding and joint planes of the shales, but the rock itself is too dense to yield its water readily to wells. Where the formation occurs at or near the surface, small quantities of water suitable for domestic needs may be obtained from the upper 50 feet. Water obtained deeper in the formation is commonly too saline for either domestic or stock uses.

Meaford Formation

The Meaford formation as a whole consists of grey to bluish and even brownish, fissile shale with interstratified hard layers that vary in composition from impure calcareous sandstone to rather pure crystalline limestone. It is exposed on a small tributary of West Humber River in Toronto Gore and underlies the glacial drift near the extreme western part of the area. It is known to be about 115 feet thick on Credit River a short distance southwest of the area.

The shale of this formation is too compact to be a good source of water. Wells penetrating the formation have yielded moderate quantities of water presumably from bedding planes and joint cracks, but in most instances the water is saline and not suitable for domestic needs.

Queenston Formation

The Queenston formation consists of brick-red, thin-bedded, compact shale. It does not outcrop in the present area, but underlies the glacial drift in the northwest part of Albion and Toronto Gore townships. The rock is a very poor source of water. It has been penetrated by a few wells, but the quantity of water obtained is small and commonly too saline for domestic use.

Medina Formation

The Medina formation overlies the Queenston, and forms the basal part of the Silurian system in Ontario. It has been divided into three members, which, in ascending order, are: Whirlpool sandstone, Manitoulin dolomite, and Cabot Head shale.

Whirlpool Member. This member is typically a resistant, light grey, fine to medium-grained sandstone. It usually occurs in beds of considerable thickness, but, where seen in its entirety, the upper few feet are commonly more thinly bedded than the lower part. Wave marks are common, but are best developed in the upper, thinner beds. The sandstone outcrops in the northwestern corner of Albion township, where it lies at the base of the Niagara escarpment. Its thickness within the area is not known, but wells drilled for natural gas a few miles to the west of the area show 20 feet of sandstone present. No wells have penetrated this rock, so that its water-bearing properties are not definitely known. However, where it lies below the water-table this type of rock should form a good aquifer, due to its relatively high porosity.

Manitoulin Member. This member does not outcrop within the area, but, as seen a few miles to the west, it consists essentially of buff weathering, grey, magnesian limestone, in part argillaceous, and disposed in even beds from 2 to 8 inches thick. The lower few feet show thin interbeds of soft grey or bluish grey shale from 2 to 4 inches thick. This rock underlies the glacial drift in the northwestern part of Albion township, and is about 25 feet thick.

Small quantities of water can be expected to occur along bedding planes and in solution cavities in this rock, but, as none of the wells examined penetrates this member, little definite information is available regarding its water-bearing properties.

Cabot Head Member. This member consists typically of red, green, and grey shales, sandy dolomite, shaly dolomite and ferruginous limy beds. It does not outcrop within the area, but can be seen in the railway cut at Limehouse a few miles to the west. It underlies the glacial drift only in the extreme northwest part of Albion township and is at least 40 feet thick. The shales do not form good aquifers due to their fine-grained texture, and the calcareous beds are few and too thin to hold much water. None of the wells examined penetrates the Cabot Head beds, but they are not thought to be an important source of water in the area.

Lockport Formation

The Lockport formation consists of magnesian limestone and dolomite, commonly light grey to bluish, fine to coarsely crystalline, in places quite porous, and disposed in beds from 2 to 4 feet thick, with both thicker and thinner beds locally developed. Jointing is general throughout the formation; it is commonly vertical but very irregular. Weathered surfaces may show joint cracks as much as a foot wide. These rocks may be seen in the extreme northwest part of Albion township, where they constitute the upper, cliff-forming member of the Niagara escarpment. The formation is perhaps 150 feet thick, with only the lower 50 feet occurring in the area of this report.

Appreciable quantities of water may occur in joint cracks, in solution cavities, and along bedding planes in this formation. Wells encountering these openings yield sufficient water for farm requirements. Numerous springs issue at the base of the Lockport formation where the contact with the underlying impervious Cabot Head is exposed by the topography. Some of these springs are reported to flow as much as 3,000 gallons an hour.

Unconsolidated Deposits

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 great quantities of loose rock debris, which was deposited when the ice finally melted. This material is unconsolidated, and is commonly called glacial drift. The ice-sheet advanced and retreated several times and on each retreat left an accumulation of drift on the surface over which it passed.

The area was entirely covered by one or more continental ice-sheets during Pleistocene time, and the final retreat of the ice left the bedrock surface covered to a variable depth with a mantle of glacial drift. This drift, together with flood plain deposits of alluvium, constitutes the unconsolidated deposits in the area. Most of the glacial drift consists of boulders and pebbles of various compositions and sizes embedded in a matrix of clay to form a more or less impervious mass known as boulder clay. Irregularly intermingled with this impervious mass, and also lying above, below, and between successive boulder-clay sheets, are beds, pockets, and lenses of sands and gravels that form the water-bearing members or aquifers of the drift. The following types of unconsolidated deposits occur in the area: (1) ground moraine; (2) terminal moraine; (3) kame moraine; (4) outwash sand and gravel; (5) glacial-lake deposits; (6) interglacial deposits; and (7) alluvium.

Ground Moraine. This type of glacial drift is chiefly boulder clay laid down at the base of the ice-sheet, and consists of a heterogeneous mixture of clay, boulders, and pebbles enclosing irregularly distributed lenses and pockets of water-laid sand and gravel.

Pore spaces in the boulder clay are very small, and much of the contained water is not recoverable through wells. However, where the clay is sandy, small domestic supplies may be obtained from it, and larger supplies, for industrial or municipal purposes, can be expected from the included lenses and pockets of sand and gravel.

At most places in the ground-moraine areas, water is obtained at depths of about 40 feet or less, but owing to the heterogeneous character of the deposits, it is not possible to predict the depth at which water may be encountered in any particular locality.

Terminal Moraine. Part of the load carried by the continental ice-sheet was dropped at its front or margin during pauses in the general retreat of the melting glacier. This load consisted of material gathered during the advance of the ice-sheet, and was deposited as a mixture of boulder clay, silt, sand, and gravel. Streams flowing from the melting ice carried away a large part of the silt, sand, and finer gravel, leaving chiefly compacted boulder clay and heaps of loose boulders as terminal moraine. In general, such material carries very little recoverable water, except where small lenses of sand or gravel are present.

Kame Moraine. The hilly region in the extreme north part of Markham and Vaughan townships is composed of boulder clay, sand, and gravel. Exposures show in road cuts at or near the tops of the hills; some of these are of sand, others of boulder clay. At one place a 6-foot layer of boulder clay overlies well-bedded sand, and wedges out southward; it is overlain by still more sand. This hilly area probably represents a terminal moraine, the sand and gravel being a mixture of outwash and kame deposits resulting from local readvances of the ice-front during its general retreat.

The typical terminal moraine part of the hilly region contains favourable aquifers at depth, but shallow wells do not, in general, yield adequate supplies. Water is obtained at depths of from 38 to 150 feet, with the deeper wells producing the more permanent and larger supplies. In the sand and gravel areas, however, where the deposits represent outwash and kame conditions, domestic supplies are obtained within about 17 feet of the surface.

Outwash Sand and Gravel. Sand and gravel carried out from the front of the melting ice-sheet and deposited on plains at or near such a front may form important aquifers. These deposits are porous, and readily absorb rain falling upon them. If they rest on impervious clay, which would prevent downward percolation of the water, they may become saturated to within a few feet of the surface. Shallow wells in such deposits can be expected to yield adequate domestic supplies. If the deposits are thick and contain extensive gravel lenses, they may yield supplies sufficient for industrial or municipal uses.

Glacial-lake Deposits. These deposits include the silt, sand, and gravel deposited in glacial Lake Iroquois. Most of the deposits consist of fine sand and silt, with the gravel occurring in the form of bay-mouth bars. The sandy deposits vary from a thin veneer to at least 10 feet in thickness; the gravel deposits reach a thickness of 40 feet. Such deposits are very porous, and will yield their water freely to shallow dug wells.

Interglacial Deposits. These deposits are exposed in Scarborough and Pickering townships, along the shore of Lake Ontario, where they consist typically of stratified sand overlying a grey, peaty clay. The clay is almost impervious and very little water can be expected from it. The stratified sand, however, does contain water, and springs issue from the contact of the sand and underlying clay in the cliffs along Lake Ontario. Unless the sand is so fine as to partly clog wells that are dug or drilled in it, a fair supply of water should be obtained.

Alluvium. Alluvial deposits consist of clay, silt, sand, and gravel laid down as flood-plain deposits along the valley bottoms of many streams. Locally these deposits may become very extensive. The water-bearing properties of alluvial deposits are variable, but, in general, such deposits form favourable aquifers. They are porous, and readily yield a part of their contained water, although, in places their porosity may be greatly reduced by the presence of fine silt and clay. This type of deposit may be expected to yield moderate domestic supplies through shallow wells, and larger supplies if the deposits are extensive.

WATER ANALYSES

Both the kind and quantity of mineral matter dissolved in a natural water depend largely upon the structure and chemical composition of the rocks with which the water has been in contact. Water may be polluted by organic matter or its decomposition products.

Two hundred and eighty samples of well water from the area were analysed for their mineral content in the laboratory of the Water Supply and Borings Section, Geological Survey, Department of Mines and Resources, Ottawa. The analyses are given in parts per million, that is, in parts by weight of the constituents in 1,000,000 parts by volume of water. No examination was made for bacteria, and hence a water that may be termed suitable for use on a basis of its mineral content might be condemned by reason of its bacterial content. Bacteriological analyses are made by the Provincial Department of Health, Toronto. As a rule, waters high in bacteria have been contaminated by polluted surface water.

The following mineral constituents include all that are normally found in natural waters in quantities sufficient to have any practical effect on the value of waters for ordinary uses.

Silica (SiO_2) is dissolved in small quantities from almost all rocks. It is not objectionable except in so far as it contributes to the formation of boiler scale.

Iron (Fe) in combination is dissolved from many rocks as well as from iron sulphide deposits with which the water comes in contact. It may also be dissolved from well casings, water pipes, and other fixtures in quantities large enough to be objectionable, but separates as the hydrated oxide upon exposure of the water to the atmosphere. Excessive iron in water causes staining on porcelain or enamelled ware, and renders the water unsuitable for laundry purposes. In the table of analyses accompanying this report, alumina is included with the iron and both are reported as the oxides.

Calcium (Ca) is dissolved from almost all rocks, though in greater quantities from limestone, dolomite, and gypsum. Magnesium (Mg) is similarly dissolved from many rocks, but particularly from dolomite. These constituents impart hardness to water and are active in contributing to the formation of boiler scale. The sulphate of magnesia ($MgSO_4$) combines with water to form "Epsom salts", and renders the water unwholesome if present in large amounts. Calcium salts in minor quantities have no injurious effects.

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 with that enclosed in marine sediments. No estimate of potassium (K) has been made, and any that may be present has been included as sodium. Moderate quantities of these constituents have little effect upon the suitability of a water for ordinary uses, but waters containing sodium in excess of about 100 parts a million may require careful operation of 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.

Sulphate (SO_4) is dissolved from deposits such as gypsum and sodium sulphate. It is also formed by oxidation of iron sulphides and is, therefore, found in mine waters. Sulphate, in combination with calcium and magnesium, causes formation of boiler scale; it also increases the cost of softening the water.

chloride is a characteristic constituent of sewage, and any locally abnormal quantity suggests pollution from this source. However, such abnormal quantities should not, in themselves, be taken as positive proof of pollution in view of the many sources from which chloride may be derived. Chlorides impart a salty taste to water, and if present much in excess of 300 parts a million, render it unfit for domestic use.

The term "total dissolved solids" 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 a million. Waters containing up to 500 parts a million may be accepted for domestic use provided they are otherwise satisfactory, but a content of 1,000 parts a million does not prohibit domestic use if no better supply is available. Residents accustomed to the waters may use those that carry much more than 1,000 parts a million of total dissolved solids without inconvenience, although persons not used to 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 amount of soap that must first be used to precipitate the above compounds before a lather is produced. The hardness of water in its original state is its total hardness, and is classified as "permanent hardness" and "temporary hardness". Permanent hardness remains after the water has been boiled. It is caused by mineral salts that cannot be removed from solution by boiling, but 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 large quantities of sodium carbonate and small amounts of calcium and magnesium compounds are soft, but if the latter compounds are present in large quantities the water is hard. The following table[1] t- l-

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

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 +	Very hard

The water samples analysed were taken from depths of from 7 to 462 feet, and with 51 exceptions all are from glacial drift. They show little variation in either the total dissolved solids or the quantities of the individual constituents. As far as mineral content is concerned, the waters are quite suitable for domestic and stock purposes as well as for most industrial uses. Softening would be desirable for laundry purposes. None of the drift waters analysed contains sufficient salts to render it injurious to crops and so unsuitable for irrigation.

PART II

TORONTO GORE TOWNSHIP, PEEL COUNTY, ONTARIO

Physical Features

Toronto Gore township is situated in the southeast corner of Peel county, and has an area of approximately 30 square miles. Its southernmost point lies 4 miles southwest of the town of Weston and 6 miles north of Lake Ontario.

The surface of Toronto Gore township is that of a relatively flat till plain, sloping gently toward the south. Surface elevations decrease from about 772 feet above sea-level in the northwest corner to about 531 feet in the southern part of the township. West Branch Humber River and Mimico Creek, together with their numerous small tributaries, cross the township in a general southeasterly direction. Many of the smaller creeks are dependent upon ground water for their flow and are dry or nearly so except at times of spring floods, or after heavy and prolonged rain. West Branch Humber River is the only permanent stream in the township. Most of the valleys have gently sloping sides with stream beds less than 25 feet below the general level of the surrounding country. In many places the smaller valleys lose their identity or become mere ditches in the surface.

Geology

Bedrock Formations. The greater part of Toronto Gore township is underlain by rocks of the Dundas formation of Ordovician age. These rocks consist of grey and blue shale, thin sandy beds, and thin, lenticular beds of limestone. Numerous outcrops of the Dundas occur along West Branch Humber River in lots 6 to 10, con. IX. The succeeding Meaford formation underlies the northwest corner of the township. It consists of grey, bluish, and brownish shale, with thin layers of limestone, calcareous sandstone, and arenaceous shale. Outcrops of the Meaford occur along several small creeks in lots 11 to 17, con. VII.

Unconsolidated Formations. The glacial drift covering Toronto Gore township consists entirely of ground moraine, which is chiefly a heterogenous mixture of clay, boulders, and pebbles, enclosing irregularly distributed lenses and pockets of water-laid sand and gravel. In that part of the township south of lot 1 (new division), an irregular deposit of fine sand is known to occur at the contact of the ground moraine and bedrock. This deposit varies from a few feet to at least 65 feet in thickness. It is an excellent source of ground water.

Alluvial deposits of clay, silt, sand, and gravel occur along the flood plain of West Branch Humber River. The deposits are thin, and are unimportant as sources of ground water. The material is derived mainly from the reworking of glacial drift.

The thickness of the unconsolidated deposits in Toronto Gore township varies from a few feet, in areas where bedrock outcrops, to at least 175 feet in lot 10, con. VIII. The glacial drift is thickest in what appears to be a buried stream channel in the bedrock. This buried channel crosses the township in a southeasterly direction, extending from lots 11 to 13 (new division), con. VII, to lots 12 to 15, con. IX. The thickness of the drift varies from 100 to 175 feet. Deep-drift wells in the remaining parts of the township are too scattered to provide evidence of further buried stream channels.

The following table indicates the minimum thickness of drift at several localities:

Well No.[1]	Concession	Lot	Depth (feet)	Aquifer
3	VII	4	90	quicksand
6	VII	5	65[2]	shale
8	VII	5	80[2]	shale
8	VII	8	150[2]	shale
7	VII	2 N.D.[3]	17[2]	shale
12	VII	4 N.D.	5[2]	shale
6	VII	7 N.D.	23[2]	shale
14	VII	8 N.D.	75[2]	shale
15	VII	8 N.D.	96	gravel
2	VII	12 N.D.	90	gravel (?)
4	VII	13 N.D.	120	gravel (?)
3	VII	16 N.D.	15[2]	shale
5	VIII	10	60[2]	shale
7	VIII	10	175	clay (?)
4	VIII	11	69[2]	shale
8	VIII	14	120[2]	shale
12	VIII	15	95	gravel
5	VIII	2 N.D.	107	gravel
2	VIII	7 N.D.	106	gravel
7	VIII	8 N.D.	60[2]	gravel
2	VIII	11 N.D.	12[2]	shale
16	VIII	13 N.D.	19[2]	shale
2	VIII	16 N.D.	46[2]	shale
6	VIII	17 N.D.	14[2]	shale
2	IX	15	96	sand

Well No.[1]	Concession	Lot	Depth (feet)	Aquifer
1	IX	1 N.D.	118	gravel
13	IX	4 N.D.	40[2]	shale
3	IX	6 N.D.	35[2]	shale
4	IX	12 N.D.	27[2]	shale
2	IX	17 N.D.	40[2]	shale
3	X	3 N.D.	110[2]	shale
6	X	4 N.D.	78	sand
8	X	8 N.D.	36[2]	shale
13	X	13 N.D.	25[2]	shale
3	XI	11 N.D.	70[2]	shale
6	XI	12 N.D.	41[2]	shale
15	XI	15 N.D.	80[2]	shale
2	XI	16 N.D.	40[2]	shale
5	XI	17 N.D.	4[illegible][2]	shale
5	XII	15 N.D.	75[2]	shale
3	XII	16 N.D.	76[2]	shale
6	XII	17 N.D.	98[2]	shale

[1]Well numbers used refer to those wells on which data have been compiled, as indicated on page 2 of this report.

[2]To bedrock.

[3]New division.

Water Supply

The supply of ground water in Toronto Gore township is not abundant, and throughout the northern part of the township is insufficient for stock needs. About 59 per cent of the wells in the township are of the dug type, and about 59 per cent obtain their water supply from a depth of 40 feet or less. A survey of the well records shows that about [illegible]2 per cent of the wells have a permanent water supply; the remainder constitute dry holes, wells that go dry periodically, and wells that went dry apparently as a result of the last period of extremely dry weather (1931-1936).

Of the 343 wells and springs in Toronto Gore township, 218 obtain their water from glacial deposits, 120 from bedrock, and the remaining 5 from unknown sources. In most wells, the statements of owners and drillers as to the character of the aquifer were accepted. In describing the principal water-bearing beds in the glacial deposits, no account is taken of their age with respect to the successive advances and retreats of the ice-sheet, as the water-bearing properties of the aquifers seem to be independent of their position within the drift.

In many parts of the township, wells in the boulder clay, which covers almost the entire surface, have encountered sand and gravel beds that yield sufficient water for domestic needs, but only a limited supply for stock. The lack of water in the boulder clay is largely due to the fact that the irregularly distributed lenses and pockets of sand and gravel, which occur in the boulder clay and ordinarily supply most of the ground water from it, are not as numerous or extensive as normally would be expected. This is probably due to the thinness of the glacial drift overlying the bedrock in many parts of the township.

Wells in the boulder clay that do not encounter a sand or gravel deposit are usually unsatisfactory. These wells go dry, not as a result of any fluctuation in the general ground-water level, but because the rate of consumption is greater than the rate at which the aquifer will yield water to the wells. Such wells may easily be depleted if drawn upon heavily, but may gradually regain their former level if allowed to stand unused, or if consumption is materially reduced. There is no way of ascertaining where a deposit of water-bearing sand and gravel may occur in the boulder clay, unless it outcrops at the surface or has been located by test borings.

The intake area for the ground water includes almost the entire surface of Toronto Gore township, as well as areas to the north. Water-table contours, drawn through the water levels of non-artesian wells, show a gradual slope from north to south across the township. The movement of ground water through an aquifer takes place down the hydraulic gradient, and hence it is probable that areas to the north contribute to the ground-water supplies recovered in Toronto Gore township.

The bedrock formations that immediately underlie the glacial drift in Toronto Gore township are not a good source of ground water, although 120 wells are known to be deriving their water from them. The water from the shallow wells in the bedrock is usually satisfactory, but that from the deeper wells contains a large amount of sodium chloride (common salt), which renders it unfit for domestic use. Approximately 60 per cent of the wells that derive their water from bedrock yield water that contains an excessive amount of dissolved solids. A sufficient supply of water satisfactory for most domestic purposes may be obtained from the rock where it occurs near the surface, but the supply will be small and might readily be affected by drought.

Extensive deposits of water-bearing sands and gravels occur in a buried stream channel that extends in a southeasterly direction across the central part of the township. Several wells derive an abundant supply of ground water from those deposits. This water is under sufficient hydrostatic pressure to rise within a few feet of the surface. Two flowing-artesian wells, in lots 11 and 12 (new division), con. VII, obtain their water from the thick gravel deposits of the buried stream channel to which reference has been made. These two wells were sunk where the buried channel is narrow, and probably more such wells could be obtained in that vicinity. Farther south, where the channel is considerably wider and deeper, there is less possibility of obtaining flowing-artesian wells. The main source of supply of the ground water contained in the buried stream channel is the area to the northwest of the township.

Relatively few springs occur in Toronto Gore township, and these are not considered an important source of ground water. Springs generally occur where porous sand and gravel beds or lenses resting upon boulder clay are exposed by natural slopes or stream valleys. However, in Toronto Gore township, the relief is so slight that there are only a few places where such conditions exist.

Village Supplies

All the small communities in Toronto Gore township obtain their water from privately owned wells, the supply coming from both the glacial drift and the underlying bedrock.

Conclusions

This investigation warrants the following conclusions:

1. Ground-water supplies in Toronto Gore township are adequate for domestic needs, but are not everywhere sufficient to meet the larger demands for stock or industrial purposes.

2. Precipitation appears sufficient to furnish adequate supplies of ground water. In times of drought, or during extended periods of decreased rainfall, annual consumption may be greater than the annual recharge, resulting in the lowering of the water-table. Some wells may go dry at times, and it may be necessary to deepen such wells.

3. The lack of wells in Toronto Gore township capable of producing water sufficient for all farm needs is due chiefly to the absence of extensive water-bearing sand and gravel lenses and pockets in the boulder clay.

4. In areas where the ground-water supply is insufficient, it is suggested that more than one well be sunk in an effort to locate different sand and gravel lenses, and thereby obtain a sufficient aggregate supply of water.

5. There is no way of ascertaining where a deposit of water-bearing sand and gravel may occur in the boulder clay, unless it outcrops at the surface or has been located by test borings.

6. It is possible to obtain ground water nearly everywhere in the township, but it is not always possible to predict the depth at which favourable aquifers will be penetrated.

7. Drilling into the bedrock underlying the glacial drift is not advised, as water recovered from the bedrock will, in all probability, be too salty for domestic use.

8. Relatively few springs occur in Toronto Gore township. They are not considered an important source of water.

9. It is thought that further flowing-artesian wells might be obtained in the area about lots 11 to 13 (new division), con. VII.

Summary of Wells and Springs

Number and Character of Wells and Springs	CONCESSIONS VII	VIII	IX	X	XI	XII	Total No. in Township	Percentage of Total
Total number of wells	108	78	67	52	26	12	343	
Dug ~~wells~~	59	37	46	37	16	7	202	58.8
Bored ~~wells~~	1	4	1	1	9	0	16	4.6
Drilled ~~wells~~	47	36	20	13	0	5	121	35.5
Springs	1	1	0	1	1	0	4	1.2
Wells 0-40 feet deep	60	36	48	38	15	5	202	58.8
~~Wells~~ 41-80 ~~feet deep~~	15	18	8	9	5	2	57	16.6
~~Wells~~ 81-120 ~~feet deep~~	22	16	6	5	4	3	56	16.3
~~Wells~~ 121-160 ~~feet deep~~	6	4	1	0	1	2	14	4.3
~~Wells~~ 160-200 feet ~~deep~~	2	1	0	0	0	0	3	0.8
~~Wells~~ over 200 ~~feet deep~~	1	0	0	0	0	0	1	0.3
~~Wells with~~ depths unknown	2	3	4	0	1	0	10	2.9
Wells that yield hard water	105	76	66	52	26	11	336	97.9
~~Wells that~~ yield soft water	0	0	0	0	0	0	0	
~~Wells that~~ yield salty water	27	22	8	8	4	1	70	20.4
Wells with aquifer in sand	10	9	14	10	3	2	48	14.0
~~Wells with aquifer~~ in gravel	11	11	10	4	5	1	42	12.2
~~Wells with aquifer~~ in clay	5	5	3	1	0	0	14	4.0
~~Wells with aquifer~~ in drift[1]	32	17	20	24	11	5	109	32.2
~~Wells with aquifer~~ in bedrock	48	32	17	13	7	3	120	34.9
~~Wells with aquifer~~ unknown	0	3	2	0	0	0	5	1.4
Flowing wells	2	0	0	0	0	0	2	0.6
Non-flowing wells	103	76	66	51	25	11	332	96.8
Wells with permanent supply	91	66	49	43	21	10	280	81.6
Wells with non-permanent supply	14	10	17	8	4	1	54	15.7
Dry holes	2	1	1	0	0	1	5	1.1
Wells not used	17	13	10	5	2	0	47	13.7

[1] Sand, silt, sandy clay or sand and gravel