CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 306

GROUND-WATER RESOURCES OF O'LEARY MAP-AREA, PRINCE COUNTY, PRINCE EDWARD ISLAND

By

E. B. Owen and E. I. K. Pollitt

OTTAWA

1950

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INTRODUCTION

This report deals with ground-water conditions of a map-area in the province of Prince Edward Island investigated by the Geological Survey of Canada during the field season of 1949. It is one of a series of ground-water reports which it is hoped will eventually cover all of Prince Edward Island.

As ground-water conditions are directly related to the geology, the surface deposits were studied and mapped by E.B. Owen, assisted by W. T. Hatfield in 1948. E. I. K. Pollitt, assisted by R. K. Mudford, collected the water data in 1949. Thanks are here extended to these assistants for their hearty co-operation. All available information pertaining to the water wells in the area was recorded and water samples were taken for analyses. The elevation of the surface of the water in certain wells was measured. It is intended to repeat these measurements each year to determine any fluctuations in the water-table.

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 also given by well drillers in the area, particularly Mr. Vaughan H. Groom of the Trask Well Drilling Company. The writers also wish to express their appreciation to Mr. S. G. Ives, manager for the Commissioners of Sewers and Water Supply, Charlottetown, for his kind assistance.

PUBLICATION OF RESULTS

It is planned that the essential information pertaining to ground-water conditions will be issued in reports covering each of ten map-areas in the province of Prince Edward Island. The proper authorities will be supplied with the information pertaining to their respective areas. In addition, pertinent data on most of the wells in each map-area will be compiled. Owing to the great number of wells, the compilation sheets will not ordinarily accompany the reports. However, information regarding particular wells may be obtained from the Chief Geologist, Geological Survey of Canada, Ottawa.

With each report are two maps. Fig. 1 shows the distribution of different types of surface deposits, and Fig. 2 shows the position of all wells for which records are available, together with the class of well at each location.

In order to facilitate plotting and locating wells, each lot was subdivided in Fig. 2 into areas about 1 mile square. These subdivisions were numbered vertically from north to south and lettered horizontally from west to east. Wells were numbered consecutively for each subdivision.

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 consolidated deposits of gravel, sand, silt, clay, or 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, broad ice-sheet that covered most of the surface of Canada many thousands of years ago.

Escarpment. A cliff or relatively steep slope separating 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 occur are as follows:

(1) End Moraine (Recessional 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 at the base of 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.

(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 glacial 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. 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.

(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 by the sea during the submergence that followed the withdrawal of the last ice-sheet. The deposits 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. Subsurface 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 clay 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 sands, 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 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 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 the relief is great, the first precipitation is absorbed and run-off only commences after continuous heavy rains. Light, continued precipitation will normally furnish more water to the underground supply than brief torrential floods, during which the run-off will nearly equal the precipitation. Frozen soil is quite impermeable and moisture falling upon it will not usually find its way below the surface. Accordingly, during the winter, very little water reaches the zone of saturation. 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.

The average monthly and annual precipitation (in inches) at Charlottetown, Hamilton, and Summerside, observed over periods of 65, 16, and 18 years respectively is as follows:[1]

[1] Data from "Climatic Summaries for Selected Meteorological Stations in the Dominion of Canada", Vol. I, Meterorological Division, Department of Transport, Canada.

	Yrs. obs.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
C.	65	3.76	3.01	3.15	2.78	2.66	2.58	2.98	3.35	3.40	4.07	3.75	3.98	39.47
H.	16	3.03	2.60	3.75	3.27	2.52	2.60	2.94	3.45	3.12	3.12	3.75	2.97	37.12
S.	18	2.68	3.11	3.10	2.75	2.86	2.77	3.62	3.59	3.32	3.36	3.70	3.80	38.66

C.-- Charlottetown; H.-- Hamilton; S.-- Summerside

If Summerside is used as an example and 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, it will be seen that an average of 561,343,200 imperial gallons of water fall on each square mile in the Summerside area in 1 year. Although it would not be possible 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 reached the zone of saturation, it will be seen that the annual recharge for 1 square mile would be 5,613,432 gallons. If there is a daily consumption of 200 gallons per farm and 35 gallons per person in the communities, an estimate of the total consumption for O'Leary map-area (200 square miles) shows it to be only 7.2 per cent of the estimated annual recharge. If, on the other hand, 360 gallons per farm are consumed as well as 60 gallons per person in the communities, then 12.8 per cent of the recharge is used annually. It seems reasonable to conclude that precipitation is adequate to furnish supplies of ground water for O'Leary map-area and possibly the entire province.

The monthly and annual precipitation from 1947 to 1949 at meteorological stations within the area is given on page 6.

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. The water that enters from the surface into the rocks of the earth is drawn down by gravity to where it either reaches the zone of saturation or comes in contact with a relatively impervious layer of rock. 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 feeds water into a zone of saturation and an effluent stream receives water from a zone of saturation. The ground water in the zone of saturation is almost constantly on the move, percolating toward 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 are too small for the water to percolate. The porosity of a material varies directly with the size and number of its interstices, which in turn depend chiefly upon the shape and arrangement and the degree of assortment of the constituent particles. A fine-grained rock such as shale, limestone, or dolomite may have such small interstices that the contained water will not flow readily and wells penetrating them may derive little or no water. Such rocks are considered impervious. More coarse-grained materials such as sand, gravel, or sandstone readily yield their water to wells and are called water-bearing beds or aquifers. A clean water-bearing gravel constitutes 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 between or below beds of more impervious material.

PRECIPITATION IN INCHES AT VARIOUS OBSERVATION STATIONS[1]

Station	Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Alliston	1947	1.0	2.4	1.5	2.9	5.6	4.2	2.6	0.5	4.3	1.3	1.8	3.5	31.6
	1948	2.8	1.4	1.8	2.4	2.8	2.0	1.8	1.7	2.2	0.7	-	1.9	--
	1949	1.9	1.8	3.1	2.6	1.1	1.5	1.8	4.1	2.1	1.6	4.0	1.0	26.6
Charlottetown	1947	4.0	3.1	2.2	4.1	5.8	5.2	2.6	1.3	4.7	1.2	4.5	4.7	43.4
	1948	2.8	2.0	2.6	3.2	3.5	3.1	3.4	3.4	3.7	3.2	5.6	3.7	41.2
	1949	3.2	4.3	4.5	3.3	2.5	2.8	1.7	4.2	4.5	2.3	4.3	2.8	40.4
Charlottetown Airport	1947	-	-	-	3.4	5.8	5.0	2.5	1.3	5.1	1.1	4.5	3.4	--
	1948	2.8	1.6	2.4	3.5	3.8	3.2	3.5	3.2	3.5	-	5.6	3.2	
	1949	2.5	4.2	5.7	4.2	2.9	2.0	2.1	5.0	4.4	2.2	4.4	2.9	42.5
Ellerslie	1947	3.6	4.5	1.5	3.3	3.6	5.1	1.4	1.9	4.8	-	3.0	-	
	1948	-	1.9	1.4	1.9	-	4.7	3.2	3.5	2.6	2.0	5.4	3.0	
	1949	2.9	3.0	7.2	3.2	2.4	4.1	-	-	4.6	-	-	2.1	
Summerside	1947	3.5	3.3	1.8	2.9	3.6	5.1	1.8	1.7	4.0	2.1	3.3	3.3	36.4
	1948	3.0	1.5	1.8	2.8	3.0	4.1	4.9	6.4	3.0	2.2	3.7	2.6	39.0
	1949	2.5	4.1	4.8	3.0	2.9	3.4	2.0	3.6	4.5	1.8	4.4	2.6	39.6
Summerside Airport	1947	2.5	3.1	1.5	2.4	3.5	4.4	1.1	2.0	4.0	2.2	2.8	2.8	32.3
	1948	-	-	-	-	3.3	4.3	4.9	6.3	3.1	2.4	-	2.9	
	1949	2.2	4.5	4.3	3.6	3.2	3.0	1.9	3.2	4.7	2.1	4.5	3.1	40.3

[1]Extracts from the Monthly Weather Map, Meteorological Service, Dominion of Canada

The most common wells and those that in drift-covered areas yield the largest aggregate supply of ground water are water-table wells that is, they derive their water from the zone of saturation. Many shallow water-table wells become dry during the late summer, winter, or 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 if the water-producing formations are of low permeability. When a well penetrates an aquifer confined by impervious beds, water flowing under pressure will rise in the well to a level equivalent to the hydrostatic pressure exerted at the point of its entrance into the aquifer. If the hydrostatic pressure is great enough to force the water to the surface, a flowing artesian well is formed.

Springs are formed by the water-table, or some aquifer containing water, outcropping at the surface of the ground. The water emerging from water-table springs is free water flowing down the gradient of the water-table. In many cases these springs occur as slow seeps along the lower edges of stream valleys. A large number in one area could maintain a swamp. A group of artesian 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 ANALYSES

The mineral content of ground water is of interest not only to consumers but also to industries seeking water of specific quality. Both the kind and quantity of mineral matter dissolved in a 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 Bureau of Mines, Department of Mines and Technical Surveys, Ottawa.

In any given area, an attempt is made to secure samples representative of the waters of all main 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 include all that are commonly found in natural waters in quantities sufficient to have any 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 from the feldspars. It is commonly determined in the analyses of water for use in steam boilers, as silica is classed as an objectionable encrustant.

Calcium (Ca) is derived originally to a great extent, from the decomposition of lime feldspars. The chief sources of calcium dissolved in ground water are from 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. Calcium carbonate is active in the formation of boiler scale.

Magnesium (Mg) is derived originally from many igneous rocks although its chief source for ground water is dolomite, a carbonate of calcium and magnesium. The sulphate of magnesium ($MgSO_4$) combines with water to form "Epsom salts" and renders the water unwholesome if present in large amounts.

Sodium (Na) is found in all natural waters in various combinations,although 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. Moderate quantities of these constituents have little effect upon the suitability of a water for ordinary uses, but water containing sodium in excess of about 100 parts per 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.

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 chemical analyses.

Iron (Fe) is almost invariably present in well waters, but rarely in large amounts. It is dissolved in combination from many rocks as well as from iron sulphide deposits with which 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 the iron separates as the hydrated oxide causing 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 potable if the iron content is more than 0.5 part per million.

Sulphates (SO_4). Deposits of gypsum constitute the principal source of sulphates dissolved in ground water. They occur chiefly as the salts of calcium, magnesium, and sodium. Sulphates cause permanent hardness in water and aid in the formation of injurious boiler scale. Sodium and magnesium sulphates are laxative when present in quantities of more than 900 parts per million.

Chloride (Cl) is nearly all either of organic origin or derived 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 any locally abnormal quantity in ground water suggests pollution from this source. However, in view of the many sources from which chlorides may be derived, such abnormal quantities should not, in themselves, be taken as positive proof of pollution. Chlorides impart a salty taste to water if present much in excess of 300 parts per million.

Nitrates (NO_3) are of minor importance in the study of ground water. Relatively large quantities in a water may represent pollution by sewage, or drainage from barnyards, or even 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. Water carrying carbonic acid in solution is the primary agent in rock decomposition. Carbonates are indicated in the table of analyses as alkalinity. Calcium and magnesium carbonate 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. The latter are decomposed by boiling the water, which changes them into insoluble carbonates that form a coating on the inside of cooking utensils.

Total Dissolved Solids (Residue on Evaporation). 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 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 those that carry much more than 1,000 parts per 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 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 larger quantities of sodium carbonate than calcium and magnesium compounds are soft, but if the latter compounds are more abundant the water is hard. The following table[1] may be used to indicate

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

the degree of hardness of a water:

Total Hardness

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

O'LEARY MAP-AREA, PRINCE COUNTY, PRINCE EDWARD ISLAND

PHYSICAL FEATURES

O'Leary map-area is located in the west part of Prince county on Prince Edward Island. It has an area of about 200 square miles. The village of O'Leary, the largest of several small communities within the area, is 75 miles northwest of the city of Charlottetown.

The surface of O'Leary map-area is relatively flat. A gently undulating to rolling effect in some parts is due chiefly to downcutting by streams since the retreat of the ice rather than to glaciation.

The central part of the map-area is covered mainly by clay till, and the largest deposits of sandy till occur along the west shore and in the southeast corner. All but a very small part of the shoreline is covered by Pleistocene marine deposits, which are most widespread in the eastern part where they extend farthest inland. A few small gravelly sandy till deposits are found throughout the central part of the map-area. Recent deposits of dune sand occur along the south shoreline.

A prominent topographic feature is a series of discontinuous ridges or bluffs that roughly parallel the present shoreline and can be traced intermittently throughout the map-area. These bluffs represent emerged marine shorelines. In general they follow the 25-, 50-, and 75-foot contours.

Surface elevations increase from sea-level to a maximum of 180 feet in the central and northern parts of the area, the increase being more gradual in the east.

The area is well drained by Pierre Jacques, Enmore, Trout, and Mill Rivers, as well as by numerous small creeks. Pierre Jacques River flows southerly across the west part of the area and Enmore River flows southwesterly across the east-central part. Trout and Mill Rivers flow easterly across the north part. Most of the streams are permanent, but do not carry much water. The source of much of the water is in wooded and swampy areas underlain by relatively impervious clay till. A few springs, some of which issue from sandstone, are scattered along stream valleys. Some streams have been dammed, and are utilized to operate small saw or grist mills. However, as more land is cleared and swamps drained, many of the permanent streams will become intermittent, and it will become increasingly difficult to operate such industries.

GEOLOGY AND WATER SUPPLY

Bedrock Formations and Their Water-bearing Properties

The entire province of Prince Edward Island is underlain by Upper Carboniferous or possibly Permian formations. They consist of soft, dark red sandstone, soft, thin-bedded, red shale, hard pebble-conglomerate, and irregular beds of impure limestone containing pebbles of bright red shale. These latter are described locally as limy conglomerates.

Sandstone, because of its relatively high porosity, constitutes the most satisfactory bedrock source of ground water. E. D. Ingall[1] notes that in most instances ground water was

[1]Ingall, E. D.: Boring on Prince Edward Island; Geol. Surv., Canada, Sum. Rept. 1909, p. 30.

encountered in sandstone during the drilling of five deep holes under the direction of the Geological Survey of Canada in 1908-9. Where sandstone was located under beds of less permeable shale, the water was sometimes under pressure and rose a considerable distance in the well. The greatest depth at which fresh water was encountered in these holes was at 1,560 feet in well No. 4, 1¼ miles from Little Sands, Kings county. Below the fresh water horizons, the water was increasingly brackish and finally quite saline. In holes drilled adjacent to the sea-coast, the water encountered rose in the casing to an elevation corresponding to that of the sea water, and the rise and fall of the tides produced a direct effect upon it.

Although soft, red shales are not a satisfactory source of ground water in themselves, their location in bedrock suggests the possible presence of aquifers containing ground water under pressure as ground water located beneath such a shale bed will generally rise a considerable distance in the well from the point where it was first encountered. The presence of impermeable shale beds near the surface may result in the creation of perched water-tables. Because of the limited extent of these shale beds, shallow wells deriving their water from above the shale in such localities are not satisfactory and will go dry rapidly during drought.

Beds of limestone and conglomerate are not extensive and are unimportant as sources of ground water. Their relative impermeability causes them to behave like the shale beds in that ground water occurring immediately below is under pressure and will rise in the well when encountered.

O'Leary map-area is well supplied with ground water for both domestic and stock purposes. Over 92 per cent of the wells in the area are bored and 74 per cent obtain their water from depths of 40 feet or less. A survey of the well records shows that over 97 per cent of the wells have a permanent water supply. The chief sources of ground water in O'Leary map-area are bedrock formations, and of these the sandstone only is of any importance. Of the 1,342 wells and springs in the area about 61 per cent are known to have their aquifers in sandstone. Although the character of the bedrock in 37 per cent of the wells is unknown it is, without doubt, sandstone as no other type of bedrock was found to be a favourable source of ground water. The term "unknown" is used when the information of the owner is scanty in regard to the character of the aquifer, or when the well was bored during a previous owner's occupancy. The information regarding the character of the aquifer was derived solely from the statements of the owners and the drillers.

All drilled wells in the area obtain their water from sandstone but, according to drillers' reports, various thicknesses of shale are encountered between the sandstone beds. This is clearly shown by the four deep wells drilled at Mount Pleasant Airport. The impervious shale beds prevent the water in the sandstone from rising to a higher level or from percolating downward.

When the shale is penetrated by drilling, water is encountered in nearly all underlying sandstone beds. The yield of these four drilled wells at the Airport is as follows: No. 1 — 40-60 gallons a minute; No. 2 — 70-80; No. 3 — 90-100; No. 4 — 30-40. The compilation of these wells is as shown:

No.	Elevation	Depth	Depth to water	Aquifer	Quality of water
1	108	240	-15	Sandstone	Slightly hard, clear
2	105	290	-12	"	" " "
3	94	350	-25	"	" " "
4	91	150	-9	"	" " "

In the case of bored wells, sandstone is also the principal aquifer. In boring wells it is necessary in many cases to drill through the limy conglomerate or the pebble-conglomerate before a satisfactory supply of water is obtained. Many owners report that after the drill has penetrated a layer of hard rock it drops from 3 to 6 inches into water. According to information received from well drillers the apparent "drop" is the result of the hand drill passing through the relatively hard pebble-conglomerate or limy conglomerate into the softer sandstone. The contrast between the different types of rock is all the more apparent if the sandstone is saturated with water.

A few wells are dug through the overlying unconsolidated deposits to sandstone, from which water is obtained. Most of these wells are shallow, as the sandstone is fairly close to the surface and lies directly below the surface deposits without any intervening shale or conglomerate zones.

Springs generally occur where porous lenses or beds are exposed by natural slopes, cliff faces, or stream valleys. Some springs used for domestic and stock purposes obtain their water from sandstone. The best illustration of bedrock springs is to be found along the cliffs of the present shoreline. Here the water seeps downward through porous layers of rock until some impervious shale zone is reached. The water then flows along the top of the shale layer, following the hydraulic gradient, and issues at the face of the cliff. Some of these springs are under sufficient hydrostatic pressure to flow as steady streams from the rock, but most are merely slow seeps where the water-table outcrops at the surface.

Unconsolidated Deposits and Their Water-bearing Properties

During the Pleistocene or glacial epoch, great accumulations of ice formed at one or more centres in northern Canada. This ice moved out in all directions and covered large regions with what has been called the Continental Ice-sheet. As the ice advanced, it picked up, transported, and redeposited great quantities of loose rock debris. This material is unconsolidated and is commonly called glacial drift. The ice-sheet advanced and retreated several times and after each retreat left an accumulation of drift on the surface over which it had passed.

This drift, together with dune sand, stream flood plain deposits of alluvium, and swamp deposits of muck and peat, constitute, to a large extent, the unconsolidated deposits on the Island.

Most of the glacial drift consists of boulders and pebbles of various sizes, some foreign, but predominantly of Island bedrock, embedded in a matrix of clay or sandy clay. This material is known as a till. The following are the more important types of unconsolidated deposits with their water-bearing properties that occur in O'Leary map-area: (1) glacial deposits; (2) marine deposits; (3) marine beach deposits; (4) glacio-fluvial deposits; (5) recent deposits, consisting of beach sand and gravel, dune sand, stream alluvium, and muck and peat.

Only 2 per cent of the total number of wells obtain their water from these unconsolidated deposits.

Glacial Deposits. This type consists of glacial drift varying chiefly from a clay till to a sandy till in different parts of the area. Gravelly, sandy till is not extensive and is not an important source of ground water. Although the zone of saturation with its accompanying water-table exists in clay till, the interstices in the till are extremely small and much of the contained water is not recoverable by wells. Swamp conditions are common in clay till areas. Sandy till yields a more satisfactory supply of water, but is not sufficiently extensive in the area to form an important source. No wells were found to draw their water solely from the glacial deposits.

Marine Deposits. These deposits consist chiefly of silt and sand with a few scattered interbeds of clay. They are very porous and yield their water freely to shallow dug wells. Perched water, although not common, is present in these areas. Such localities cannot be expected to yield a satisfactory supply of ground water unless the well passes through the perched zone and enters the true zone of saturation.

Areas overlain by glacio-fluvial and marine beach deposits are of relatively small extent and, although they consist of well stratified silt, sand, and gravel that are very porous and should yield good supplies of water, do not constitute important sources of ground water.

There are no drilled or bored wells in these marine deposits. All the dug wells are shallow, but the yield is fairly consistent. Half the total number of springs listed as the sole source of water supply of a farm are found in these sand and gravel deposits. The greatest number of wells with this type of aquifer are located in lot 8.

The water-bearing properties of alluvial deposits are variable, but in general such deposits form favourable aquifers.

Dune sand deposits are very porous and should yield satisfactory supplies of ground water to wells that penetrate the water-table. They provide the water supply for the fishing community of West Point, from shallow dug wells. Although the supply is not great, the water level appears to remain fairly constant and no well is known to become intermittent.

The possibilities of obtaining flowing-artesian wells in O'Leary map-area are not good. The porous sandstone beds as well as the deposits of Pleistocene marine sand and gravel provide an excellent intake area for ground water, but the relief is so slight there is very little possibility of the ground water eventually returning to the surface at lower elevations in flowing artesian wells.

Springs occur throughout the area, but only those springs are shown on the map which constitute the sole source of water supply of a farm.

WATER SUPPLY OF THE VILLAGE OF O'LEARY AND OTHER COMMUNITIES

All communities in O'Leary map-area obtain their water from privately owned wells. With the exception of West Point the supply comes mainly from sandstone. All wells have a permanent supply of water.

O'Leary

O'Leary, the largest of all the communities, has sixty-six wells. All but three of these wells are of the bored type. Over 65 per cent obtain their water from depths of from 21 to 40 feet. All known aquifers are sandstone, and although the aquifer is not listed for fifty wells, it is presumed also to be sandstone. The average depth of clay till in O'Leary is 13 feet.

St. Chrysostom

St. Chrysostom has twenty-eight wells. Twenty-seven of these wells are bored and twenty-one obtain their water from depths of 40 feet or less. All known aquifers are sandstone.

Coleman

There are fourteen wells in Coleman. All but one of these wells are bored, and nine receive their water from between depths of 21 and 40 feet. All known aquifers are sandstone. The average depth of clay till in Coleman is 15 feet.

West Point

West Point has eleven wells. With one exception all wells are dug. Depths are mainly less than 20 feet. Recent dune sand is the source of water of all dug wells.

Portage

Portage has seven wells, five of which are bored. Depths range from 18 to 120 feet. The known aquifer is sandstone.

ANALYSES OF WATER SAMPLES

Thirty-one samples of well waters from O'Leary map-area were analysed for their mineral content by the Bureau of Mines. The samples were taken from depths of from 0 to 138 feet, and nearly all are from sandstone. All waters were found to be suitable for domestic and farm use.

Amounts (in parts per million) of dissolved mineral matter in waters collected in O'Leary map-area:

Constituent	Quantity		
	Maximum	Average	Minimum
Total dissolved solids	357.0	177.4	80.0
Silica	21.2	8.9	2.0
Calcium	57.9	32.0	2.7
Magnesium	22.5	7.2	1.1
Alkalis (sodium and potassium).	44.0	14.8	6.9
Sulphate	37.9	9.8	2.9
Chloride	43.2	17.1	0.0
Nitrate	32.8	10.3	0.0
Bicarbonate	219.8	127.7	48.8
Total hardness	191.6	109.5	14.1

Conclusions

This investigation warrants the following conclusions:

1. Ground-water supplies of O'Leary map-area are abundant for domestic, stock, and field uses. Most farms have wells in their pastures and potato fields, which supplement the water supply for cattle as well as providing an adequate supply for irrigation of field crops.

2. Precipitation appears sufficient to ensure adequate supplies of ground water.

3. The chief source of ground water is sandstone. The sandstone is soft and allows penetration by hand drills. In order to reach water in sandstone, it is often necessary to bore through overlying hard limy conglomerate and (or) pebble-conglomerate.

4. A few wells are dug in marine sands and gravels

5. Dune sand deposits provide an ample water supply for the community of West Point.

6. No suitable aquifers for ground water are present in glacial till areas.

7. Conditions that produce flowing-artesian wells are not present in the map-area.

8. All villages and communities in O'Leary map-area have an abundant and permanent water supply.

9. The quality of ground water derived from ~~sandstone is~~ quite suitable for domestic and farm use.

10. The presence of large forested areas are of vital importance in maintaining a sufficient supply of ground water. It was noted that the forests in the map-area are gradually being depleted and very little effort is being made toward reforestation. It is suggested that, wherever possible, some plan of reforestation be carried out. This would undoubtedly ensure an abundant supply of ground water for the future.

O'Leary Map-Area

Summary of Wells and Springs Used as a Source of Water Supply

lls and Springs	Lots 5	6	7	8	9	10	11	12	13	14	15	O'L.	St.C.	C.	W.PT.	P.	Total No. in Area	% of Total
Total number	49	256	155	232	181	84	51	44	107	37	20	66	28	14	11	7	1342	
Bored	45	249	143	200	172	80	44	37	106	36	20	63	27	13	0	5	1240	92.4
Dug	1	5	8	28	7	2	6	1	0	0	0	0	1	1	10	0	70	5.2
Drilled	1	2	3	2	1	0	1	5	0	0	0	3	0	0	1	2	21	1.6
Springs	2	0	1	2	1	2	0	1	1	1	0	0	0	0	0	0	11	0.8
Wells 0 - 20 feet deep	2	23	15	42	24	12	17	11	43	8	6	1	8	1	10	1	224	16.7
21 - 40	28	168	66	133	113	59	30	24	50	23	9	43	13	9	0	1	769	57.4
41 - 60	11	48	42	45	36	8	1	2	9	3	4	15	5	4	0	2	235	17.5
61 - 80	6	13	23	10	7	5	0	2	5	3	1	4	2	0	0	0	81	6.0
81 - 100	2	4	6	1	1	0	1	0	0	0	0	1	0	0	0	1	17	1.3
101 - 120	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	2	5	0.4
over 120	0	0	1	0	0	0	1	4	0	0	0	1	0	0	0	0	7	0.5
depth unknown	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	4	0.2
Wells that yield hard water	32	172	114	215	154	71	33	25	70	23	17	44	19	6	1	7	1003	74.8
Soft water	17	84	41	17	27	13	18	19	37	14	3	21	8	8	9	0	336	25.0
Salty water	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	3	0.2
Wells with aquifer in sandstone	28	183	98	125	118	50	36	31	73	24	10	16	12	7	1	4	816	60.8
In marine sand or gravel	0	0	0	12	1	2	2	1	1	0	0	0	0	0	0	0	19	1.4
In recent sand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	10	0.7
Unknown	21	73	57	95	62	32	13	12	33	13	10	50	16	7	0	3	497	37.1
Non-artesian wells	46	254	151	228	169	82	50	38	106	36	20	63	28	14	10	5	1310	97.6
Non-flowing artesian wells	1	2	3	2	1	0	1	5	0	0	0	3	0	0	1	2	21	1.6
Springs	2	0	1	2	1	2	0	1	1	1	0	0	0	0	0	0	11	0.8
Wells with permanent supply	45	253	151	223	170	81	50	44	105	37	19	66	28	14	11	7	1304	97.2
Wells with non-permanent supply	4	3	4	9	11	3	1	0	2	0	1	0	0	0	0	0	38	2.8

O'L. -- O'Leary
St.C.-- St. Chrysostom
C. -- Coleman
W.Pt.---West Point
P. -- Portage

ANALYSES OF WELL WATERS FROM..O'Leary...... MAP-AREA...Prince...... COUNTY P.E.I.

Sample Number	Owner	Lot	Concession	Depth of well (Feet)	Aquifer	Total dissolved solids parts per million	Constituents as Analysed (parts per million): Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Alkalis (as Na)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Bicarbonate (HCO_3)	Alkalinity (as $CaCO_3$)	Hardness as $CaCO_3$ (pts. per million): Ca hardness (as $CaCO_3$)	Mg hardness (as $CaCO_3$)	Total hardness (as $CaCO_3$)
1	P.W. Pate	O'Leary		29	Ss	236	8.9		42.6	16.5	16.4	3.7	30.7	0.0	219.8	180.2	106.3	67.9	174.2
2	M. Kennedy	O'Leary		38	?	201	9.4		35.5	14.4	13.1	12.3	17.1	31.0	127.6	104.6	88.8	59.0	147.8
3	R. Smallman	O'Leary		37	Ss	357	11.6		41.9	18.4	10.8	37.9	22.0	1.8	156.2	128.0	104.8	75.4	180.2
4	Champion Electric Co.	O'Leary		138	Ss	317	15.0		39.7	22.5	9.4	13.2	15.6	0.4	161.0	156.0	99.3	92.3	191.6
5	A. Craswell	5		92	?	183	8.2		27.8	19.4	9.3	10.7	16.8	32.8	117.1	96.0	69.5	79.5	149.0
6	A. Webb	6		65	Ss	157	12.6		27.0	17.7	7.8	9.1	11.2	0.7	124.9	120.0	67.5	72.6	140.1
7	[illegible]. Jeffrey	10		75	Ss	243	21.2		40.3	8.1	14.0	21.4	23.2	9.8	119.6	106.0	100.5	33.3	133.8
8	Gharbell	Portage		50	Ss	278	12.8		57.9	4.6	19.0	8.2	17.7	0.0	197.6	182.0	144.5	18.9	163.4
9	Sharbell	Portage		120	Ss	192	20.0		41.8	3.3	10.8	6.6	8.7	0.0	146.4	137.6	104.3	13.6	117.9
10	J. McFadden	11		22	Ss	144	9.2		31.5	1.7	8.1	12.3	12.5	0.0	102.7	84.2	78.6	7.0	85.6
11	E. Adams	10		Sp.	S	160	11.0		37.0	11.4	7.1	14.8	8.4	2.7	136.4	120.6	92.3	46.9	139.2
12	E. Moore	13		33	?	130	7.2		29.2	1.7	11.2	9.5	14.2	0.0	92.7	76.0	72.9	7.0	79.9
	Sp-spring	Ss-sandstone S -sand																	

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							Constituents as Analysed (parts per million)										Hardness as $CaCO_3$ (pts. per million)		
Sample Number	Owner	Lot	Concession	Depth of well (Feet)	Aquifer	Total dissolved solids parts per million	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Alkalis (as Na)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Bicarbonate (HCO_3)	Alkalinity (as $CaCO_3$)	Ca hardness (as $CaCO_3$)	Mg hardness (as $CaCO_3$)	Total hardness (as $CaCO_3$)
13	G. Gallant	14		18	Ss	178	7.8		41.4	2.5	16.4	4.9	23.0	9.7	120.8	99.0	103.3	10.3	113.6
14	F. Gallant	14		35	?	132	8.5		34.9	1.1	6.9	3.3	6.4	0.0	124.0	101.6	87.1	4.5	91.6
15	W. Gorrill	6		36	Ss	80	5.6		7.6	5.3	23.4	4.9	9.3	0.0	70.0	57.4	19.0	21.8	40.8
16	A. Phillips	12		26	Ss	222	6.6		30.1	3.8	36.1	18.5	43.2	20.4	95.2	78.0	75.1	15.6	90.7
17	W. Ford	12		Sp	S	154	7.3		41.9	1.5	8.9	9.5	0.0	0.0	144.4	118.4	104.5	6.2	110.7
18	W. MacIntosh	12		22	Ss	142	9.5		36.5	1.3	8.0	8.6	0.0	0.0	130.8	107.2	91.1	5.3	96.5
19	J. Buchanan	11		6	S	104	2.0	High	2.7	1.8	19.6	2.9	27.4	0.7	48.8	40.0	6.7	7.4	14.1
20	W. Shields	6		70	?	156	5.6		20.0	11.6	17.2	15.2	14.5	3.0	122.5	100.4	49.9	47.7	97.6
21	J. Arsenault	5		Sp	Ss	136	7.4		26.7	11.0	7.1	5.3	0.0	0.0	144.0	118.0	65.1	45.3	111.4
22	W. Stewart	7		30	Ss	120	5.0		29.5	1.5	10.1	7.0	14.0	0.0	95.6	78.4	73.6	6.2	79.8
23	R. Jones	7		42	?	226	6.7		53.5	4.0	24.0	4.1	25.8	0.0	204.5	167.6	133.5	16.5	150.0
24	Cape Wolfe School	7		75	Ss	122	6.2		22.7	1.8	11.8	8.6	19.5	0.0	70.5	57.8	56.6	7.4	64.0

Sp-spring

Ss-sandstone
S -sand

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ANALYSES OF WELL WATERS FROM....O'Leary.... MAP-AREA........

Sample Number	Owner	Lot	Concession	Depth of well (Feet)	Aquifer	Total dissolved solids parts per million	Constituents as Analysed (parts per million): Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Alkalis (as Na)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Bicarbonate (HCO_3)	Alkalinity (as $CaCO_3$)	Hardness as $CaCO_3$ (pts.per million): Ca hardness (as $CaCO_3$)	Mg hardness (as $CaCO_3$)	Total hardness (as $CaCO_3$)
25	A. McIntyre	8		27	?	242	10.3		35.0	2.7	44.0	2.5	14.3	0.0	215.0	176.4	87.3	11.1	98.4
26	J. Clements	8		31	SS	154	6.7		21.8	2.2	19.3	8.2	12.5	13.3	80.8	66.2	54.4	9.1	63.5
27	A. McDougall	7		50	Ss	150	6.4		38.5	1.5	10.4	4.5	8.1	0.0	134.2	110.0	96.1	6.2	102.3
28	F. Kilbride	11		30	Ss	200	6.2		47.2	2.2	16.0	9.9	21.6	16.8	134.4	110.2	117.8	9.1	126.9
29	J. Kelley	11		30	Ss	130	8.2		18.7	8.4	9.0	5.8	12.7	0.0	118.3	97.0	46.7	34.6	81.3
30	W. Duncan	6		20	Ss	98	6.2		12.3	8.0	9.5	7.0	6.4	0.0	85.4	70.0	31.2	32.9	64.1
31	J. W. Rayner	6		35	?	164	5.8		19.3	11.5	24.2	13.6	21.0	1.4	118.3	97.0	48.2	47.3	95.5

Ss-sandstone

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