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WATER SUPPLY PAPER No. 297

# GROUND-WATER RESOURCES OF TOWNSHIPS 1 TO 6, RANGES 26 TO 29, WEST OF PRINCIPAL MERIDIAN, MANITOBA

(MELITA AREA)

by

E. C. Halstead, and J. A. Elson

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GEOLOGICAL SURVEY OF CANADA

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Preliminary map - Townships 1 to 6, ranges 26 to 29, west Principal meridian, Manitoba:

Figure 1. Map showing surface and bedrock geology;

2. Map showing topography and the location and types of wells.

# PART I

## INTRODUCTION

The present report is an attempt to assemble the data on ground-water resources in a form that will be useful to well drillers, farmers, municipal authorities, and others interested in obtaining adequate water supplies.

### Publication of Results

The essential information pertaining to ground-water conditions is being issued in reports that, in Manitoba, cover a square block of sixteen townships lying between the correction lines and beginning at the Saskatchewan boundary. The reports on the most southerly strip of the province include in addition the two townships lying north of the International Boundary. The secretary-treasurer of each municipality will be supplied with the information covering that municipality, and copies of the reports will also be available for study at offices of the Provincial and Federal Departments. Further assistance in interpreting the reports may be obtained by applying to the Chief Geologist, Geological Survey of Canada, Ottawa.

### How to Use the Report

Anyone desiring information concerning ground-water in any particular locality will find the available data listed in the well records, and other pertinent information on the maps of the area. For those unfamiliar with these reports it is, perhaps, advisable that that part dealing with the area as a whole be read first, so as to be in a better position to understand the more particular descriptions of each township that follow. Also, the map accompanying the report should prove a useful source of reference when reading the text.

The map consists of two figures. Figure I shows bedrock and surface geology. The water-bearing properties of the bedrock change from formation to formation, and are referred to in subsequent pages. The type of glacial deposit at the surface may be determined from the map, and its possibilities as an aquifer are also discussed in this report.

Figure 2 shows the location and types of wells in the area, the land relief (topography), and the drainage pattern. Not every well is plotted on the map, but most of those giving pertinent information are shown, and probably include 90 per cent of the wells in the area. Where ground water is not readily available, or carries too much dissolved salts to be used, dugouts often form the only means of supply. The topography is shown by contours, or lines of equal elevation, spaced at vertical intervals of 50 feet.

The well records are compiled from data obtained by interviewing farmers, and in many cases their accuracy depends upon the farmer's memory. Wherever possible data were checked by plumb-line measurement to the nearest foot. The wells are tabulated by townships and sections, and the total depth of the well, depths to the water level at high and low stages, and, where possible, the depth at which the water-bearing horizon occurs, are all listed. The general character of the water is stated, and the use to which it can be put. Wells from which samples were taken for analysis are indicated on the well-record sheets. An idea of how much water a well can be expected to yield is suggested by the number of stock (cattle and horses only) that can be watered at it. One head is assumed to consume between 8 and 10 gallons of water a day. Unless followed by the word "only"

the figure for the number of stock watered is not necessarily the maximum yield of the well, but simply the greatest amount that the present user has required. The word "only" indicates that the figure given is the maximum yield of the well. To obtain the position of an aquifer at any given point, the elevation of the point should be determined from the contours on Figure 2 of the map. Elevations of adjacent wells may be found in the well records and the depth to the aquifer can usually be determined from them. By comparing elevations the depth of the aquifer below the unknown point may be estimated. This method is particularly applicable to bedrock wells, but may not be successful where information is too limited, or where the glacial drift is thick and of an irregular character. In such instances a person searching for water should refer to the text for information on the nature of the deposits in that area.

## GLOSSARY OF TERMS USED

Alkaline. The term 'alkaline' or 'alkali' water has been applied rather loosely to waters having a peculiar and disagreeable taste, and commonly a laxative effect. The waters so described in the Prairie Provinces are those heavily charged with sulphates of magnesium and sodium (respectively Epsom salts and Glauber's salts) and are more correctly termed sulphate waters. Truly 'alkaline' waters owe that property to the presence of calcium carbonate and calcium bicarbonate. In this report an attempt to adhere to local terminology is made by referring to sulphate waters as 'alkali' in the well records, and the term 'alkaline' is avoided.

Alluvium. Deposits of clay, silt, sand, gravel, and other material in lake beds and in flood plains of modern streams. The term also includes the material in river terraces, which once formed part of the flood plain but are now above it.

Aquifer. A porous bed, lens, pocket, or deposit of material 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.

Bentonite and bentonitic clays have the property of swelling when water is added to them. They occur as white beds as much as 2 feet thick, but usually much thinner, and are probably formed by the weathering of volcanic ash.

Buried pre-Glacial Stream Channel. A channel eroded into the surface of the bedrock by a stream before the advance of the continental ice-sheet, and subsequently either partly or wholly filled in by sands, gravels, and boulder clay deposited by the ice-sheet or later agencies.

Coal Seam. The same as a coal bed. It is a deposit of carbonaceous material formed from the remains of plants by partial decomposition and burial.

Contour. A line on a map joining 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 relatively steep slope separating level or gently slopping areas.

Flood Plain. A flat part of a river valley ordinarily above water but submerged when the river is in flood. It is an area where silt and clay are being deposited.

Glacial Drift. A general term that includes all the loose, unconsolidated materials that were deposited by the ice-sheet, or by the waters associated with it. Clay containing boulders usually forms a large part of the glacial drift in an area, and is called glacial till or boulder clay, and is not to be confused with the more general term glacial drift, which occurs in the following 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) Ground Moraine. Boulder clay (till) laid down at the base of an ice-sheet. The topography may vary from flat to gently rolling.

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

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

Shoreline. A discontinuous escarpment, with intervening gravel beaches and bars, which indicates the former margin of a glacial lake.

Ground Water. The 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 in the well, namely, at the level of the aquifer.

Impervious or impermeable. Beds such as fine clays or shale are considered to be 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 in the case of sands and gravels.

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.

Sand Point or Driven Well. A sand point is a piece of perforated and screened pipe 2 or 3 feet long, which ends in a sharp point. It is fastened to lengths of ordinary pipe and forced down into surface deposits of a sandy or gravelly nature. The depth of such a well rarely exceeds 30 feet.

Unconsolidated Deposits. The mantle ~~or~~ covering of alluvium, ~~pre-glacial soils~~, and glacial drift ~~consisting~~ of loose, ~~uncemented material~~ that overlies the bedrock.

Variegated. Beds so described show different colours in alternating beds or lenses.

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. A water-table is said to be perched when a zone of saturated material is separated from the main water-table below by a zone or zones of unsaturated material.

Water-worked Till. Glacial till or boulder clay that has been subjected to water action, usually near the margins of glacial lakes, so that the fine clay has been washed out and a deposit that may be composed mainly of sand and gravel is left behind.

Wells. The term refers to any hole sunk in the ground by any means for the purpose of obtaining water. If 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 (Sub-artesian) Wells. Wells in which the water is under sufficient hydrostatic pressure 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.

## 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 into 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. 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~~.

In some areas of relatively steep slopes, valleys have been partly filled with sand and gravel, which, in turn, have been covered with impervious clay and silt. ~~These circumstances commonly~~ give rise ~~to artesian~~ conditions in the lower part of the valley.

## DISCUSSION OF WATER ANALYSES

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 Department of Health and Public Welfare, Winnipeg, and by the Bureau of Mines, Department of Mines and Resources, Ottawa.

As the ground-water survey of Manitoba progresses an effort is made to secure samples representative of each major aquifer encountered; the purpose of this is to compare the chemical characteristics of waters from the various geological horizons and, thereby, assist in making correlations of the strata in which the waters occur. The mineral content of natural waters is also of interest to the consumers, though the effects of the constituents are usually already apparent. 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. A salt when dissolved in water separates into two chemical units called 'radicals', and these are expressed as such in the chemical analyses. In one group are included the metallic elements of calcium (Ca), magnesium (Mg), sodium (Na), and iron (Fe), and in the other group are the sulphate ($SO_4$), chloride (Cl), bicarbonate ($HCO_3$), carbonate ($CO_3$), and nitrate ($NO_3$) radicals. The radicals listed in the analyses tabulated in the second part of this report can be combined to give the actual quantity of the particular salts present in the water, but this is not done here as the radicals alone give enough information to identify the water types. In fact, the sulphate, chloride, and carbonate radicals, plus the hardness, serve to identify a water, and crude field tests on the basis of these constituents were used in some areas to outline more completely zones of the various water types.

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 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 straining on porcelain or enamelled ware, and renders the water unsuitable for laundry purposes. Water is usually considered not potable if the iron content is more than 0.5 part per million.

Calcium (Ca) in the water comes from mineral particles present in the surface deposits, the chief sources being limestone, gypsum, and dolomite. Fossil shells provide a source of calcium, as does also the decomposition of igneous rocks. The common compounds of calcium are calcium carbonate ($CaCO_3$) and calcium sulphate ($CaSO_4$), neither of which have injurious effects on the consumer, but both of which cause hardness.

Magnesium (Mg) is a common constituent of many igneous rocks and, therefore, very prevalent in ground water. Dolomite, a carbonate of calcium and magnesium, is also a source of the element. The sulphate of

magnesia ($M_gSO_4$) combines with water to form 'Epsom salts,' and renders the water unwholesome if present in large amounts.

Sodium(Na) is derived from a number of the important rock-forming minerals, so that sodium sulphate and carbonate are very common in ground waters. Sodium sulphate ($Na_2SO_4$) combines with water to form 'Glauber's salt' and excessive amounts make the water unsuitable for drinking purposes. Sodium carbonate ($Na_2CO_3$) or 'black alkali' waters are mostly soft, the degree of softness depending upon the ratio of sodium carbonate to the calcium and magnesium salts. Waters containing sodium carbonate in excess of 200 parts per million are unsuitable for irrigation purposes[1]. Sodium sulphate is less harmful.

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[1]"The extreme limit of salts for irrigation is taken to be 70 parts per 100,000, but plants will not tolerate more than 10 to 20 parts per 100,000 of black alkali (alkaline carbonates and bicarbonates)". Frank Dixey, in 'A Practical Handbook of Water Supply', Thos. Murby & Co., 1931, p. 254.

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Sulphates ($SO_4$) referred to in this report are those of calcium, magnesium, and sodium, and have been mentioned above in referring to these radicals. They are also formed by oxidation of iron sulphides, and, hence, it is not uncommon to find iron in sulphate waters. Sulphates cause permanent hardness in water, and injurious boiler scale. Sodium and magnesium sulphates are laxative when present in quantities of more than 900 parts per million. The writers found that acclimatized people could drink water containing as much as 2,000 parts per million of all three of the principal sulphates, but that when all were present in quantities over 1,500 parts per million the water was commonly laxative to those not accustomed to it.

Chloride (Cl) is a constituent of all natural waters and is dissolved in small quantities from rocks. Waters from wells that penetrate brines or salt deposits contain large quantities of chloride, usually as sodium chloride (common salt) and less commonly as calcium chloride and magnesium chloride. Sodium 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 if present much in excess of 500 parts per million. In southwestern Manitoba waters with as much as 3,000 parts per million of chloride are used domestically, though more than 1,500 parts per million is generally considered undesirable. The following figures apply to chlorides: stock will require less salt if the water bears 2,000 parts per million; more than 5,000 parts per million is unfit for human consumption; more than 8,000 parts per million is unfit for horses; more than 9,500 parts per million is too much for cattle; and more than 15,500 parts per million is excessive for sheep. Magnesium chloride, less common than sodium chloride, is very corrosive to metal plumbing.

Nitrates($NO_3$) found in ground water are decomposition products of organic materials; they are not harmful in themselves, but they do point to probable pollution. It is recommended that a bacterial test be made on water showing an appreciable nitrate content, if it is to be used for domestic purposes.

Carbonates ($CO_3$) in water are indicated in the table of analyses as 'alkalinity'. Calcium and magnesium carbonate cause hardness in water, which may be partly removed by boiling. Sodium carbonate causes softness in waters, and is ~~referred to under 'Sodium' above.~~

Bicarbonates ($HCO_3$). 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 to insoluble carbonates.

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, 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 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] may

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

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 above table gives the generally accepted figures for hardness, but the people of southwestern Manitoba have become accustomed to harder waters, and the following table, based on about 800 field determinations of hardness, by the soap method, is more applicable:

| Parts per million | Character |
|---|---|
| 0-100 | Very soft |
| 100-150 | Soft |
| 150-250 | Moderately hard |
| 250-350 | Hard |
| 350-500 | Very hard |
| 500+ | Excessively hard |

Waters having a hardness of up to 300 parts per million are commonly used for laundry purposes. In southwestern Manitoba, hardness ranges from less than 50 parts per million to more than 2,500 parts per million.

## PART II

### TOWNSHIPS 1 to 6, RANGES 26 to 29, WEST PRINCIPAL MERIDIAN, MANITOBA (Molita Area)

### Introduction

The Molita area occupies the extreme southwest corner of Manitoba, and includes the Rural Municipalities of Edward, Arthur, and Albert. Information on its ground-water resources was collected in the summer of 1946 by E.C. Halstead, assisted by E. Hall, and in the 1947 season by J.A. Elson, assisted by J.S. Langford.

### Physical Features

The general character of the topography is that of a level to undulating plain. Extending diagonally across the map-area from southwest to northeast is a level belt about 12 miles wide that was formerly part of the basin of glacial Lake Souris. Small areas of duned sand, in the northeast, border an undulating plain that extends to the northwest. Many minor, undrained depressions (sloughs) from 2 to 6 feet deep and as much as several acres in area are scattered over this plain. They hold water for much of the year, and are naturally surrounded by small poplar trees and brush. In the southeast part of the map-area the terrain varies from that of a small, rolling, knob and kettle area, along the central part of the east side, to a gently undulating to level plain in the south. The southeastern part is separated from the central lake basin by the valley of Souris River with its ramifications. This valley has a nearly level bottom, with escarpment-like sides, and averages about 1 mile in width and 50 to 100 feet in depth.

Elevations vary from less than 1,400 feet above sea-level, at the lower part of Souris River, to more than 1,700 feet in the extreme northwest corner of the area. Relief is perhaps 100 feet at some points along Souris Valley, but in the roughest parts of the plains is less than 25 feet, and probably would average 3 to 6 feet in the slough areas of the northwest.

The map-area is drained by five principal streams, four of which empty into Souris River. Drainage is from the west and northwest across the central plain to Souris River on the east.

The principal streams, from north to south, are: Stony Creek, which disappears in the sandy area in the northeast; Jackson and Graham Creeks, which go dry almost every year and drain the northwest part of the map-area; Gainsborough Creek, which also dries up, and which, with the more permanent Antler River, drains the southwestern part of the map-area.

### Geology

Table of Formations

| Age | Formation | Character | Thickness (Feet) |
|---|---|---|---|
| Recent | Alluvium | Stream-laid mud, silt, sand and gravel | |
| Pleistocene | Lake deposits | Silty clays, fine sands and silts, duned sands, assorted sands and gravel in beaches and deltas | 0-50 |

| Age | Formation | Character | Thickness (Feet) |
|---|---|---|---|
| | Glacial drift | Till, clay, sand, gravel, boulders, assorted sand and gravel in outwash plains | 0-400 |
| Upper Cretaceous and Paleocene | Turtle Mountain<br>Ravenscrag | Soft shale, lignite beds, fine-grained white to yellowish sand and sandstone | 300-400 |
| | Boissevain | Greenish grey sandstone and sand. | 100 |
| Upper Cretaceous | Riding Mountain | Upper beds of medium to light grey, hard, siliceous shales (Odanah shale), with some thin layers of fine, blue sand and bentonite beds; lower beds of slippery clay shale that tends to slump | 1,000 + |
| | Vermilion River | Dark grey and black shale; comprising three members: Pembina (dark shale, numerous bentonite bands near base); | 80 ± |
| | | Boyne (grey, calcareous shale, non-calcareous dark shale near base); | 140 ± |
| | | and Morden (calcareous speckled shale, overlying dark grey, non-calcareous, blocky shale with thin partings of white sand) | 190 ± |
| | Favel | Grey shale with white calcareous material; some bands of limestone; some bentonite | 150 ± |
| Lower and Upper Cretaceous | Ashville | Dark grey to black shales with silt and sands | 40 ± |

| Age | Formation | Character | Thickness (Feet) |
|---|---|---|---|
| Lower Cretaceous | Swan River | White to green sandstone, black shale and silt | 50 + |
| Jurassic | | Light grey to red shale, calcareous sandstone, grey to buff to brown shales, light grey limestone and sandstone | 380 ± |
| Jurassic or earlier | Amaranth | Red beds and gypsum | 220 |

The area mapped is underlain by Upper Cretaceous shales of the Riding Mountain formation, with the possible exception of the southwest corner where the bedrock may be the Ravenscrag formation of Paleocene age (See Map). Locally, considerable amounts of highly mineralized water are obtained from layers of sand in the Upper Cretaceous rocks, and in localities underlain by the Ravenscrag formation moderate amounts of good to poor water are contained in the sandstone and lignite beds. At the northwest corner of sec. 31, tp. 2, rge. 29, shale is the underlying rock at a depth of 309 feet, but 1 mile west an artesian well, said to be 350 feet deep, may derive its water from the Ravenscrag formation, which yields artesian water in adjacent parts of Saskatchewan. A well in sec. 2, tp. 1, rge. 26, obtains water from about 50 feet below the surface of the Riding Mountain shale, and several wells in tp. 3, rges. 26 and 27, obtain water from the upper, fractured and weathered zone of this shale. Water is also obtained from deeper wells in the shale in tp. 3, rge. 26. A well 380 feet deep in sec. 35, tp. 6, rge. 27, derives salty but potable water from the upper 20 feet of the shale. The Swan River formation, which underlies the map-area at a depth of 2,400 feet or less, is a possible source of saline, highly mineralized water in large quantities under artesian pressures.

The glacial drift varies in thickness from little or nothing to about 400 feet in the central part of the north end of the map-area. It is less than 35 feet thick along the upper part of the Souris channel and in most of tp. 3, rge. 26, but thickens from there to the west and north. The average thickness in the northwest part of the area is about 300 feet; in the southeast, 50 feet.

By far the greatest part of the glacial drift is composed of till, and two types are in evidence: a greyish buff, sandy clay till varying in thickness from 10 to 20 feet and overlying a more compact blue-grey till. Neither of these tills is appreciably permeable, but both contain irregularly distributed lenses and pockets of sand and gravel that commonly yield highly mineralized water. Southeast trending, gravelly ridges rest on the lower till and are partly buried by the upper till. These yield good water, and may represent the courses of streams that flowed along the ice front during pauses in the retreat of the glacier.

A recessional moraine in tps. 2 and 3, rge. 26, is a local source of water, but bedrock is close to the surface and the surrounding till is relatively impervious.

The deposits in the basin of glacial Lake Souris grade from fine, clayey silts to fairly coarse sands, and vary in thickness from less than 10 feet to more than 50 feet. In the northeast part, sand dunes up to 30 feet high have been formed by the wind. Ground water forms no problem in this district, which includes parts of tps. 5 and 6, rge. 26. To the south and west the sands become finer, and silts and silty clays are found locally. Water is more difficult to obtain from such silts and is of poor quality. At some localities in the south the glacial-lake deposits are clay-like, and dugouts supply most of the water.

Around the margins of glacial Lake Souris are deposits of deltaic gravels. Where those gravels are 10 feet or more in thickness they form good aquifers.

Till, modified by the action of water, is shown on the map along the valleys of the present streams. The gravel ridges left in the valleys usually form good aquifers with plenty of water at depths of 20 to 30 feet below their crests.

Alluvial deposits are found in the valleys of Souris River, Antler River, and the lower few miles of Gainsborough and Graham Creeks. The alluvium is mainly of a silty nature, except in the lower part of Souris Valley where it is gravel. Few wells have been dug in the alluvium, and its water-bearing characteristics and depth are not known.

## Water Supply

Water supply forms an acute problem in several parts of this area, either because of its scarcity, as in the northwest, or because of its unsatisfactory mineral content. Most of the wells in the area are dug wells, 4 feet square and commonly deeper than 20 feet, with wood casing. These are sunk into surface deposits of sand and gravel until the rapid entry of water into the well makes further digging too difficult. Many of the wells dug in a wet season go dry because the water-table falls below the bottom of the well, but deepening by several feet will restore the supply. Wells less than 10 feet deep may freeze to the bottom in winter unless protected by straw insulation. In the northeast, sand points driven less than 20 feet into the lake deposits provide an adequate supply of water. Sand points are not successful in the areas of fine sand and silt, because the screens permit the silt to enter and clog the pipe, or else are plugged themselves by it. Producing wells drilled into bedrock vary from depths of 400 feet in the north to 60 feet in the southeast, and yield mineralized water that is sometimes potable, but is usually fit only for stock. Many dry wells have been drilled into the bedrock. One artesian well in the west is 350 feet deep, but information as to its aquifer is limited, though it seems to be of glacial origin. In general, except for the deposits in and associated with the bed of glacial Lake Souris, the aquifers of the Melita area are rather irregular in distribution and extent, both on and below the surface of the ground. Areas with acute water-supply problems are located in the northwest, where aquifers are narrow, and in the southeast, where the glacial drift does not supply water and water from the bedrock is scarce or not usable.

Township 1, Range 26. Only a few scattered areas provide potable water in this township, as the glacial drift is mostly clay with little sand and gravel. Many wells have been dug, bored, and drilled without results or have obtained only a small supply of alkali water. In the northeast part of the township, water is obtained from wells 10 to 25 feet deep, the water-bearing zone being yellow clay with some admixed gravel. Several bored and drilled wells have yielded very alkali water. Drilled wells in sections 2, 4, and 31 reached bedrock at depths of 100, 260, and 135 feet respectively without finding water. In section 15, a well bored to a depth of 30 feet obtained water from a thin bed of gravel

in yellow clay, but the supply gradually decreased and the well is now dry. Bored wells, 85 and 50 feet deep respectively, in sections 13 and 26, have yielded a small supply of very alkali water. A dug well 20 feet deep in a sand pocket in section 35 yields an abundant supply of potable water, which is hauled to Waskada for domestic use. It has proved almost impossible to obtain an adequate supply of potable water in this township, so the farmers have abandoned digging and drilling and now depend on the surface water collected in dugouts.

Townships 1, Range 27. There are two water-bearing zones in this township. The upper zone is formed of sand and gravel lenses scattered through the glacial drift and glacial-lake deposits. In many places several wells were dug before a gravel pocket was located, and in most wells the yield was alkali water. Many of these wells are dry in winter, and water must be hauled from Coulter or Souris River. Dugouts have now been excavated to assure a winter supply for stock. The lower, water-bearing zone lies within 90 to 120 feet of the surface, and is reached by bored and drilled wells. The zone is formed of sand, gravel, and till, below the silty glacial-lake deposits. The water is alkali, and a sample sent for analysis from a well in section 22 was reported unfit for use. A few of the wells yield only a small supply and are often dry, probably because of the thin beds and uneven deposition of the sand at the base of the lake deposits. In section 25, two wells were bored to bedrock at an elevation of about 1,420 feet, and a moderate supply of alkali water was obtained.

Township 1, Range 28. Water supply is obtained from one water-bearing zone within 20 feet of the surface, or at an average elevation of 1,497 feet. The water-bearing beds are lenses of sand in lake-bed silts or glacial drift. Blue clay lies at an average depth of 18 feet and serves as a reservoir for the supply of many wells dug 2 or 3 feet into it. Water from the yellow clay, which overlies the blue clay, or where the lenses of sand are very narrow, is alkali. Along Antler River, in the southern part of the township, deposits of alluvium carry abundant potable water within 8 feet of the surface. Dug wells in glacial drift supply the damand for water in the village of Lyleton. Wells dug to the base of the lake-bed deposits of silt should provide an adequate supply of water, but it would probably carry much dissolved alkaline salts. Seventeen dugouts have been excavated in the township to provide a sufficient supply for stock needs.

Township 1, Range 29. One water-bearing zone is known in the glacial drift of the township. It is composed of lenses and pockets of sand and gravel that occur locally in the glacial drift. An abundant supply of water can be obtained at a shallow depth and approximate elevation of 1,535 feet. In NE$\frac{1}{4}$ section 10 is a dry hole 18 feet deep. In the SW$\frac{1}{4}$ of the same section a dug well, 12 feet deep, encountered an abundant supply in a narrow, water-bearing sand lens between yellow and blue clay.

Glacial outwash deposits of the northern half of the section should produce an excellent supply of water even though the area has proved unfavourable for agricultural use. As a sufficient supply has been obtained from the glacial drift, it has been unnecessary to drill deep wells. Dugouts have been excavated for the storage of surface water where a greater supply is necessary for stock needs.

Township 2, Range 26. The township is underlain by glacial drift and lake-bed deposits of silt, which are very compact and impervious. Many wells have been dug, drilled, and bored, but no adequate supply has been found, as pockets of sand or gravel are widely separated and difficult to locate. Wells have been dug to depths of 11 to 39 feet, but the supply is insufficient in most cases. Bored wells have either been dry or have yielded a small supply of water too alkali for use. Most drilled wells, 72 to 900 feet deep, have been dry, but one in section 17 at a depth of 230 feet and another in section 10 at a depth of 72 feet are yielding a sufficient supply of potable water. Indiscriminate drilling and digging have proved unsuccessful, so the farmers rely on dugouts, of which there are thirty-five townships.

Township 2, Range 27. Two water-bearing zones are present in the township. The upper zone lies within 20 feet of the surface, and the water occurs in lenses of sand and gravel in the yellow clay of the lake-bed deposits. Along Gainsborough Creek deposits of glacial drift modified by wave action afford an adequate supply of hard, potable water. A similar deposit is present east of Souris River where sufficient water is obtained from dug wells 12 to 22 feet deep. The township is crossed by Souris and Antler Rivers and Gainsborough Creek, which supply abundant water for stock. The lower, water-bearing zone is composed of narrow seams of quicksand below, and scattered through, the blue clay. This zone is reached by wells bored to 60 and 80 feet. Such wells, in sections 2, 3, 9, and 32, are commonly dry during the winter months and yield an inadequate supply of hard, alkali water.

Township 2, Range 28. The township is floored by lake-bed and flood-plain deposits, the northern half being sandy and the southern half silty. One water-bearing zone is reached by shallow, dug wells, many of which bottom in blue clay about 16 feet below the surface. The water enters the wells at the contact of sand and blue clay. Some wells were dug to depths of 30 feet, but as they penetrated blue clay with only narrow seams of sand, the water supply was negligible. Most of such wells contain alkali water unfit for domestic use. Several wells reach quicksand so fine that it plugs the wells. The wells in the sandy, glacial-lake deposits of the northern half of the township are shallow and are invariably dry in winter, so that residents owning much stock rely on dugouts for a continuous supply.

Township 2, Range 29. One water-bearing zone is known in the glacial drift of this township. It occurs, locally as lenses of sand or pockets of gravel distributed throughout the glacial drift at an elevation of approximately 1,534 feet. Along the southern edge of the township, in sections 1 to 6 and 10 to 12 inclusive, all wells are dug wells with an average depth of 10 feet. They are in glacial or glacial-lake sands, and during rainy seasons carry an abundant supply of potable water. The supply depends entirely on the amount of rainfall, and during dry seasons the wells are dry. As many of the wells are dry in winter, the landowners excavate dugouts to assure a sufficient supply. The remainder of the township gets a supply of water from shallow dug wells that tap lenses of sand or gravel distributed locally through the glacial drift. The wells are about 16 feet deep and bottom in blue clay. Sand points are used along the northern border of the township. The water in this area is potable, but the supply is not sufficient. In NW$\frac{1}{4}$ section 31 a well was drilled to a depth of 350 feet. Formerly, it obtained a good water supply but is now dry. No driller's log was available, but it is believed that the well was drilled to the Ravenscrag formation, and as this formation is discontinuous in this area, the water supply obtainable from it was soon depleted.

Township 3, Range 26. The glacial drift is less than 30 feet thick in the greater part of this township, and several wells obtain a supply from the shale below, at depths of from 60 to 65 feet in sections 23 and 28, where the water is soft, to 125 feet in section 10, and 150 feet in section 14, where the water is hard and suitable only for stock. The drift is thicker in section 1, where water suitable for stock is obtained from shale at 150 feet. Most of the wells in the township are in glacial drift and are less than 30 feet deep. In the south and east they are dug into local pockets of sand and gravel in the till. In the west and north parts of the township are shallow, water-laid deposits and water-worked till overlying shallow till and bedrock. Here water is obtained at depths of 6 to 20 feet. An area of glacial gravels is found in sections 29 and 32, and good water is obtained at 30 feet. Throughout the north and west parts of the township the quality of the near-surface water is satisfactory, although the wells can be polluted easily. The quality of the water varies from fair to bad in the southeastern till wells, and in the vicinity of sections 4 and 10 dugouts furnish a more satisfactory supply.

Township 3, Range 27. This township is completely occupied by glacial-lake deposits, alluvium, and water-worked till with its associated sand and gravel. For most of the area, water of good quality is obtained from wells less than 18 feet deep. Two deep wells have been sunk into the till, one in section 20 is 90 feet deep and yields a poor supply of alkali water, and the other, in section 16, was drilled 250 feet and was dry. In section 14, the township's only bedrock well, 80 feet deep (bedrock at 75 feet), produces water suitable only for stock. The depth to bedrock in the area increases from about 25 feet in the east and south to about 300 feet in the northwest corner. There is reason to believe that a buried escarpment extends diagonally across the township from northeast to southwest, with the low side to the northwest. Souris Valley, a mile wide, separates the surface lake deposits of the west and central part of the township from the water-worked till and shallow water-laid deposits of the southeast. In the vicinity of sections 20 and 21 the underlying till rises to near the surface, thinning out the lake sediments and causing the ground water to move away through these porous deposits. Here the till yields a little water, but neither the quality nor the quantity is satisfactory.

Township 3, Range 28. All but the western fourth of this township is occupied by glacial-lake deposits. In the northwest are deltaic deposits and, in the southwest, water-worked till. Graham Creek cuts through the northeast quarter of the township. The water-laid deposits are almost everywhere thick enough to form an aquifer. No wells are deeper than 20 feet, and about half of them are less than 10 feet deep. In most of the few places where water supply is a problem, deepening the wells a few feet would make the supply adequate. The use of sand points is applicable in the coarse sands and gravels. The glacial drift is probably 200 feet thick in the southeast part of the township, and may thicken to 350 feet in the northeast. No bedrock wells are known.

Township 3, Range 29. Most of this township is occupied by a slough-pitted plain of yellow-brown clay till, which contains numerous pockets of sand and gravel. Post-glacial drainage valleys containing gravels that are good aquifers extend from section 32 south-southeast to section 3, and from section 34 south-southeast to section 13; and water-worked till, with considerable gravel deposited locally, is found in sections 4, 12, 13, 25, and 26. The wells in the area are all shallow, with one exception, and most of them are less than 15 feet deep. The outwash and water-worked deposits are the most dependable aquifers and yield the best water. Wells in the gravelly pockets and lenses in the till generally give potable water, but tend to be alkali, and they must be several feet deeper than the other wells or they may go dry in summer. Sand points are used successfully in many places. In the western part, water may be difficult to obtain from the till. The one deep well is in section 6. It is a flowing-artesian well 350 feet deep, and so far as is known, derives its water supply from glacial deposits. The water is alkali, and rises about 3 feet above the surface of the ground.

Township 4, Range 26. This township is covered by lake-bed deposits, reworked gravels, water-worked till, and alluvium. All but the alluvium produce water of fair to good quality from wells that average 12 feet in depth and rarely exceed 20 feet. A well was drilled 125 feet in SW.$\frac{1}{4}$ section 12 but the water obtained was saline and of poorer quality than that from surface deposits. A hole drilled on the road allowance at the northeast corner of section 23 showed about 30 feet of clay and sand and gravel (alluvium), then 10 feet of blue till, with bedrock at 40 feet. The surface of the bedrock slopes to the west and north, and the depth of drift increases from 25 feet in section 1 to an estimated 150 feet in section 31.

Township 4, Range 27. This township is occupied by lacustrine deposits mainly of a silty and sandy character. Gravel occurs in section 1 and some alluvium is found along Graham Creek in sections 1 and 2. Local clayey areas are found in the centre of the township. All wells are less than 20 feet deep and average about 14 feet. The few wells that give an inadequate supply could be improved by deepening them a few feet during a dry season. In general the water is of satisfactory quality for domestic use. The thickness of drift increases from about 125 feet in the southeast of section 1 to an estimated 225 feet in section 31, and an estimated 325 feet in section 6. The general slope of the bedrock surface is to the west and south.

Township 4, Range 28. Except for three sections in the west where the surface deposit is glacial till, this township is occupied by deltaic and lake-bed deposits, represented by sand and silt in the southeast and assorted gravel elsewhere. The township is drained by Jackson Creek in the north and by Graham Creek in the south. The wells vary between 8 and 24 feet in depth, most of the water being obtained between 15 and 20 feet. Sand points are used effectively. Some difficulty is caused by quicksand, which is fine enough to plug sand point screens and commonly limits the depths of wells by making digging conditions very difficult. The exact thickness of glacial drift is uncertain as no bedrock wells are known, but probably varies between 225 and 400 feet, with the bedrock surface sloping west and south.

Township 4, Range 29. This township is mainly occupied by glacial till pitted with numerous sloughs. A deposit of deltaic gravel covers parts of sections 1, 2, 10, and 11. Bands of outwash gravel and water-worked till associated with the present drainage system extend through sections 8 and 5; from sections 33 and 34 to sections 3 and 4; and from section 36 to section 13. The second of these bands is in the valley of Jackson Creek, which is the only permanent stream in the township. All the wells in the township are shallow, varying between 6 and 22 feet in depth, and averaging about 12 feet. The deltaic deposits and water-worked till with outwash gravels yield adequate quantities of good water. Most wells dug in pockets of sand and gravel in the till yield a sufficient supply, but the water may be too alkali for use. Depth to bedrock is estimated to be about 400 feet in this township.

Township 5, Range 26. This township is occupied by lake-bed deposits, with considerable areas of deltaic gravels in the west and southeast. The sands are duned in sections 23, 24, 25, and 26. Water is easily obtained from the surface deposits by shallow dug wells and sand points. The wells vary in depth from 7 to 28 feet, with an average of about 12 feet. The water varies from mederately soft to quite hard, and the content of undesirable salts is low. A well at Bernice supplies the Canadian Pacific Railway with water for steam. No bedrock wells are known in the township, but the depth to bedrock varies from 50 feet in the southeast to about 200 feet in the northwest corner.

Township 5, Range 27. The northern and western parts of this township are occupied by slough-pitted glacial till; the remainder is floored principally by assorted deltaic gravel deposits, with some water-worked till in sections 7 and 18, and a strip of sandy lake deposits in the south and east. The general slope of the land is to the east, and the township is drained by Jackson Creek in the south, and by Stony Creek in the central and northeast parts. The wells are all shallow, water being obtained between depths of 10 and 15 feet on the average. Dug wells are used, many of them supplemented by sand points. The water is generally of a satisfactory quality, and varies from moderately soft to very hard. Nowhere does the sulphate content appear to be excessive. One dry well was drilled 210 feet to bedrock in section 18. The thickness of drift probably varies from 150 feet in section 1 to 250 feet in section 31.

Township 5, Range 28. Parts of this township on the south and east are occupied by deltaic gravel deposits, the two areas being separated by till

and water-worked till. Ground moraine is found in the west half of the township and the northeast. Water-worked till of glacio-fluvial origin is found in sections 28, 32, 33, and 34. In the last two sections these deposits are in the valley of Stony Creek, which flows southeast across the northeast quarter of the township. Jackson Creek drains the southern part. The wells in the township are all shallow, varying between 6 and 24 feet in depth and averaging from 10 to 15 feet. Most of the water is obtained from gravel associated with deltaic deposits, or with water-worked till. The ground moraine itself is not an aquifer, but pockets of sand and gravel in it produce potable water. All the water is of a generally satisfactory character and varies from soft to very hard. One deep hole was drilled in section 13 but did not reach bedrock. From indirect evidence the bedrock appears to be covered by about 250 feet of drift in the east of the township and by 400 feet or more in the west.

Township 5, Range 29. This township is an undulating plain pitted by many sloughs up to 10 feet in depth, and slopes generally to the east and south. It is drained by Graham Creek, which flows south through the centre of the township, and by Jackson Creek, which flows south-southeast through the eastern part. The valleys of these creeks are shallow and their slopes smooth and gentle. Deltaic gravel occurs in section 1, but most of the superficial material is ground moraine, with water-worked till occurring along the two valleys named above and extending south as a narrow band from section 31 to section 6. Gravel ridges occur almost continuously along Graham Creek and along considerable lengths of Jackson Creek. Pockets and nearly buried ridges of gravel and sand are found in the ground moraine at irregular intervals. The bedrock, Riding Mountain shale, is buried by about 350 feet of glacial drift in the west and probably more than 400 feet in the east. Most of the wells are dug to depths of 10 or 15 feet, with some sand points extending about 5 feet deeper. The best sources of water are the gravel ridges along the creeks, which yield plenty of good water. Water from pockets of sand and gravel in the till is often high in sulphate (especially in dry seasons) and iron. The supply from such wells is frequently inadequate, and must be supplemented by a dugout. All the water in the township is hard. Several deep wells are said to have been drilled in the southwestern part of the township, but all are dry. No exact information on these is available.

Township 6, Range 26. This township occupies an almost level plain broken by ridges where wind-blown sand has been deposited along fences. In the east, notably in section 13, the sand has formed dunes 20 to 30 feet high. Most of these dunes are anchored by vegetation. The township is drained through the sand rather than by surface channels, and the only stream, Stony Creek, flows east and north before disappearing in the sand. Though most of the area is glacial-lake sand and silt, deltaic gravel is found in the west, with ground moraine occurring in sections 8, 18, and 19. The depth to bedrock varies from about 125 feet in the southeast of section 1 to an estimated 350 feet in section 31. The wells are principally dug, ranging from 9 to 30 feet in depth, with an average of 10 to 15 feet. The depth to water below the surface of the ground fluctuates with the season, and was about 10 feet in 1947. In general, plenty of potable water is available, its character varying from soft to hard, and not high in dissolved solids. Sand points are in common use, although in some sections, as in the vicinity of section 10, the fine sand and silt will plug the screens.

Township 6, Range 27. This township is a gently undulating plain pitted with numerous sloughs and sloping to the east at a rate of about 16 feet to the mile. Drainage is to the east through shallow, gravel-filled valleys locally known as 'runs', many of which have topographic expression by way of surface channels. The 'runs' pass through a till area and join deltaic gravels in the northeast and southeast. The two chief runs pass from section 32 to section 26 and from section 30 southeast to section 1. Other minor runs are located in sections 6 and 7, section 4, and section 3. Except for those runs the township is ground moraine. The glacial drift increases in thickness from about 200 feet in the southeast of the township to an estimated 400 feet in the northwest.

The wells vary in depth from 7 to 17 feet and average about 12 feet. Most of them are found in the 'runs', which yield adequate quantities of potable water varying from moderately soft to hard. Some wells, dug in gravel pockets in till, yield water high in sulphates though many obtain an insufficient supply and must be supplemented by dugouts. One well was drilled in section 35 to a depth of 400 feet. Bedrock was reached at 380 feet, and a good supply of hard, clear, salty water, sufficient for at least 100 head of stock, was obtained from the Odanah shale (Riding Mountain formation).

Township 6, Range 28. This township is a gently undulating, slough-pitted plain sloping to the east and south and drained to the south by Stony Creek. Except for the shallow, mile-wide valley of Stony Creek and an adjoining strip of water-worked till, in sections 7, 8, and 5, the entire township is occupied by ground moraine. Its thickness is not definitely known, but indirect evidence suggests that the glacial drift is more than 400 feet thick in the centre of the township, about 400 feet in the northwest, and 300 feet in the southeast. Good water is obtained from the water-worked till in Stony Creek Valley and the adjoining 'run'. Water is also obtained from sand and gravel pockets in the till, but in such places is commonly high in sulphates and short in supply, and the wells must be supplemented by dugouts. The wells of this township range from 6 to 18 feet in depth, but average 10 to 15 feet. The character of the water ranges from moderately soft to hard.

Township 6, Range 29. This township is a plain pitted by a great many sloughs, and it slopes to the east and south. Drainage is to the south by Graham Creek in the west and Jackson Creek in the centre. The entire township is occupied by ground moraine, with the exception of the water-worked till along the stream valleys and elsewhere as described below. Bands of water-worked till, ½ to 1 mile in width, extend from section 30 south to sections 5 and 6; from sections 32 and 33 south to sections 2 and 3; and from sections 35 and 36 south to section 13. All of these provide adequate quantities of potable water, the best supplies being from the longitudinal gravel ridges in the two stream valleys. The water varies from soft to hard. Elsewhere wells dug in sand and gravel pockets in the till supply inadequate quantities of water apt to be high in sulphates, and the wells must be supplemented by dugouts. The glacial drift is probably about 300 feet thick in the northwest of the township and increases to more than 400 feet in the southeast.

## Analyses of Water Samples

### Discussion of Analyses

Many tests for the hardness of waters and their sulphate and chloride content were made in the field, and on the basis of these tests certain samples, nineteen in all, were selected for analysis by the Bureau of Mines at Ottawa. The results of these final analyses are tabulated at the end of this discussion. Not all the constituents determined are listed, because some are of little significance to the public, and because the accuracy of others may be impaired through the lapse of time between collection and analysis. Omitted from the tables are: hydrogen ion concentration (pH), colour, silica, iron, nitrites, and potassium.

All samples, with one exception, were taken during the summer of 1947. The quantity of any or all constituents varies from season to season depending on the amount of water present, especially in near-surface aquifers. The proportion of one constituent to another is fairly constant, but may be changed if the water is polluted by organic matter, making it more acid and, therefore, more capable of dissolving solids. Each sample is actually representative of only a small locality and may not be truly representative of an aquifer. Limited facilities do not permit enough analyses to determine the true nature of all waters.

The first sample, No. 1275, was taken from the artesian well west of Pierson near the Manitoba-Saskatchewan boundary. The well is 350 feet deep, and the water is said to come from glacial deposits. This water is high in dissolved solids, mostly carbonates. The water contains a large quantity of bicarbonate. The amount of common salt (sodium chloride) is not enough to be objectionable.

Sample No. 1859, from SW sec. 3, tp. 2, rge. 27, was taken from a bed of gravel overlain by glacial till, and resting on bedrock. The water is fairly high in magnesium sulphates (Epsom salts), and might be laxative if drunk in excess, although it would not be so with ordinary consumption. Total solids are high, typical of water from the deeper aquifers, and bicarbonate is also high. The latter, together with magnesium sulphate and calcium carbonate, makes the water excessively hard.

Sample No. 1896, taken from a well dug in silty sand, serves the community of Lyleton, and shows no very great excess of any constituent. The water is very hard because of the carbonates and bicarbonates present in it.

Sample No. 1577 was taken from the 'small end' of a 'run'. Being confined laterally though not longitudinally, the water in this aquifer has picked up more sulphates than it would in a larger run, as shown below. The bicarbonates are also high, making the water very hard. Other constituents are not excessive.

Samples Nos. 1580, 1588, 1587, and 1585 form a series taken at the lower end of a run and in the area where this particular run discharges its water. The first sample was taken near the lower end of the run where the water is confined laterally by till, although there is free longitudinal movement through the gravel. The run is a fairly large one, and extends northwest through Reston for at least 8 miles above the point where the sample was taken. The water is hard, due to carbonates and bicarbonates, and the sulphates and nitrates are noticeably higher than in the succeeding two samples. The second in the series, No. 1588, is quite low in all constituents, hardness being chiefly due to bicarbonates. Such water would become quite soft when boiled. The sample came from a point in the glacial-lake delta where water could move freely in all directions, and where the water-table is quickly affected by rainfall. Sample 1587 was obtained nearer the 'mouth' of the run, and shows higher amounts of all constituents than does the second one of the series. The fourth sample, No. 1585, was taken from a silty sand area farther out in the old bed of glacial Lake Souris. Here the rain-water entering the ground can move less freely than in the gravel and dissolves more of the mineral constituents. The total dissolved solids is far above that of the other samples from the gravels. This water is excessively hard. The most noticeable increase of any constituent is in the nitrates, indicating probably pollution from a barnyard or outhouse or, possibly, from a fertilized field. In a sandy area the nitrates are carried down to the water-table, but as lateral movement of water below the water-table is relatively slow in such sand, as compared with gravel, the nitrate is not diluted and carried off as rapidly as it would be in a gravel deposit. This water cannot be condemned for human use on the basis of nitrates alone, but a bacterial count is highly advisable.

Another series of samples, Nos. 1579, 1584, and 1583, demonstrates the effects of decreasing grain size in the deltaic aquifer in the vicinity of Broomhill and Bede. As the grain size decreases from gravel to sand to sandy silt the total dissolved solids increased from 370.0 to 1,827.5 parts per million, and all the constituents increase more or less proportionately. The water in the finest material is excessively hard, largely due to a considerable concentration of sulphates.

The next three samples, 1578, 1581, and 1582, represent water from sand and gravel pockets in ground moraine. All are fairly high in dissolved solids, and all are excessively hard. As these sand and gravel pockets have no apparent outlet such increase of any constituent is accumulative. Sample No. 1581, is alarmingly high in nitrates. Concentrations of 1,200 parts per million have been known to be fatal to humans who used it over a period of years, in the United States. The magnesium sulphate content of this water is also high, and might have a laxative effect if used in excess.

The last sample, No. 1586, was taken from a cistern, and is not a true representative of the water from an aquifer. It had been pumped into a cistern and may have been diluted by rain-water. The well water came from the Riding Mountain shale at a depth of 380 feet. Most of the constituents are low, and hardness is not excessive for such a water. It is not as salty as most waters from such depths, and the sulphate content is low. Bicarbonates are probably higher than represented, because carbon dioxide is given off from the water as it is pumped and the atmospheric pressure on it decreases. Though not used for human consumption this water might be potable, the bicarbonate being the only constituent present in quantities that might be disagreeable.

ANALYSES OF WELL WATERS FROM Townships 1 to 6 Ranges 26 to 29 W. Principal Meridian, Manitoba.

| Sample Number | ¼ | Section | Township | Range | Meridian | Owner | | Depth of well (feet) | Aquifer | Total dissolved solids (parts per million) | Constituents as Analysed (parts per million) 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 | Mg hardness | Total hardness |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1275 | SW | 6 | 3 | 29 | P | Rusk | 1 | 350 | T | 1735.5 | 53.8 | 25.7 | 580.9 | 41.2 | 324.3 | 132.8 | 1276.9 | 1046.6 | 134.2 | 105.8 | 240.0 |
| 1895 | SW | 3 | 2 | 27 | P | K. Miller | 2 | 69 | GB | 1860 | 144.0 | 210.5 | 91.5 | 811.0 | 30.0 | | 602.7 | 494.0 | 359.3 | 866.2 | 1225.5 |
| 1896 | SW | 28 | 1 | 28 | P | Lyleton Community | 3 | 15 | SSl | 406.0 | 60.0 | 45.0 | 19.7 | 90.5 | 13.9 | | 264.0 | 216.4 | 150.0 | 184.5 | 334.5 |
| 1577 | SE | 19 | 6 | 27 | P | | 4 | 7 | G | 617.0 | 90.7 | 59.7 | 13.3 | 152.3 | 19.9 | 12.3 | 346.5 | 284.0 | 226.3 | 245.7 | 472.0 |
| 1580 | SW | 34 | 6 | 27 | P | H.H. Harper | 5 | 11 | G | 489.5 | 69.6 | 46.8 | 12.0 | 99.2 | 6.8 | 44.3 | 287.2 | 235.4 | 173.7 | 192.6 | 366.3 |
| 1588 | NE | 32 | 6 | 26 | P | P. Bodobni | 6 | 14 | G | 318.0 | 65.7 | 24.0 | 3.9 | 58.9 | nil | 11.1 | 234.7 | 192.4 | 163.9 | 98.8 | 262.7 |
| 1587 | SE | 30 | 6 | 26 | P | J. Dodds | 7 | 12 | G | 516.5 | 96.0 | 29.1 | 9.4 | 81.1 | 15.2 | nil | 251.6 | 206.2 | 239.5 | 119.8 | 359.3 |
| 1585 | NW | 10 | 6 | 26 | P | T. Corbett | 8 | 9 | S | 1659.5 | 151.4 | 123.0 | 81.6 | 204.9 | 97.1 | 486.6 | 309.9 | 254.0 | 377.7 | 506.2 | 883.9 |
| 1579 | NW | 24 | 5 | 27 | P | J.L. Robinson | 9 | 10 | G | 370.0 | 61.3 | 35.0 | 6.8 | 57.2 | 2.5 | 39.8 | 251.3 | 206.0 | 153.0 | 144.0 | 297.0 |
| 1584 | NW | 27 | 5 | 26 | P | W. Hodgins | 10 | 12 | S | 559.0 | 80.0 | 43.7 | 42.4 | 70.0 | 20.7 | 8.0 | 378.7 | 310.4 | 199.6 | 179.8 | 379.4 |
| 1583 | NW | 8 | 5 | 26 | P | W.R. Holmes | 11 | 12 | SSl | 1827.5 | 223.0 | 133.3 | 86.5 | 763.0 | 27.0 | 124.0 | 389.4 | 319.2 | 556.4 | 548.5 | 1104.9 |
| 1578 | NE | 29 | 5 | 27 | P | G. Moore | 12 | 13 | T | 102 | 94.8 | 116.9 | 24.9 | 163.0 | 86.8 | 177.0 | 317.9 | 260.6 | 236.5 | 481.0 | 717.5 |

Symbols used for aquifers T / Till GB-Gravel on bedrock S-sand
SSl-sandy silt G-gravel

NO. 669

ANALYSES OF WELL WATERS FROM **Townships 1 to 6, Ranges 26 to 29, West Principal Meridian, Manitoba**

| Sample Number | ¼ | Section | Township | Range | Meridian | Owner | Depth of well (feet) | * Aquifer | Total dissolved solids (parts per million) | Constituents as Analysed (parts per million) 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 | Mg hardness | Total hardness |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1581 | SE | 22 | 6 | 27 | P | T.S.Fersythe 13 | 15 | T | 4373.5 | 255.8 | 503.5 | | 791.E | 176.7 | 1593.7 | 287.9 | 236.0 | 638.2 | 2071.9 | 2710.1 |
| 1582 | SE | 33 | 5 | 27 | P | N.J. Halls 14 | 10 | T | 746.5 | 109.0 | 50.3 | 14.9 | 79.4 | 35.7 | 194.3 | 245.0 | 200.8 | 272.0 | 207.0 | 479.0 |
| 1586 | NE | 35 | 6 | 27 | P | J. Sinkbeil 19 | 400 | RMS | 465.0 | 76.6 | 33.7 | 38.5 | 74.5 | 30.0 | 15.5 | 348.9 | 286.0 | 191.1 | 138.7 | 329.8 |

* Symbols used for aquifers T/till G-gravel RMS-Riding Mountain Shale

NO. 669

## Record of Wells

The well records of this area follow in tabulated form. A commentary on these has been made on page 3 of this report.

As a general rule the depth to the 'Principal Water-bearing Bed' has been taken as the total depth of the well, and its elevation is given as such. This commonly applies to wells drilled in bedrock or in wells obtaining water from a sub-artesian or artesian aquifer in glacial or bedrock formations; digging or drilling is continued until a good supply of water is obtained and then operations are stopped. In shallow surface deposits (up to 30 feet deep), however, wells are usually dug a short distance below the water-table during a dry season, and thereafter water may enter and leave the well at any point below the water-table. The level of the water-table changes about 2½ foot each year in near-surface deposits of wide extent, but may rise or fall as much as 8 feet during a wet to dry 10-year cycle. Hence, the figures on the elevations of the bottom of wells in these deposits are of doubtful value, and have been omitted from the last eight townships in the tabulation.

Only those dugouts are recorded where a supply supplementary to the wells is needed. The symbol 'D' used on the map (Figure 2) indicates sections where dugouts mainly are used for supply.

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