CANADA
DEPARTMENT OF MINES
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GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 302

GROUND-WATER RESOURCES OF TOWNSHIPS 7 TO 10, RANGES 14 TO 17, WEST OF PRINCIPAL MERIDIAN, MANITOBA

(CARBERRY AREA)

by

J. A. Elson

OTTAWA
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CONTENTS

Part 1

Part 11

Illustrations

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 failing 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:

<u>Silica</u> (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.

<u>Iron</u> (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.

<u>Calcium</u> (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.

<u>Magnesium</u>(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 ($MgSO_4$) 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.

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 7 TO 10, RANGES 14 TO 17, WEST PRINCIPAL MERIDIAN, MANITOBA

(Carberry Area)

Introduction

The Carberry area lies east of Brandon, and includes parts of the Rural Municipalities of North Cypress, South Cypress, Oakland, and Cornwallis. The principal communities are Carberry, Shilo, Wawanesa, and Glenboro. Information on ground-water resources was collected in the summer of 1948 by J. A. Elson, capably assisted by E. Hutney.

Physical Features

The area is a plain, which is quite flat around Carberry and Glenboro, but is elsewhere undulating to hilly. The hills for the most part are sand dunes, some of them 25 to 40 feet high, though usually much lower. In the southwest, the area borders on the Tiger Hills, which rise one or two hundred feet above the general level, and which represent a recessional moraine, formed during a pause in the retreat of the last ice-sheet. The central part of the area, composed of sand, has few valleys. Epinette Swamp and Epinette Creek lie in a southeast trending depression in the north-central part of the area. Assiniboine River enters the west side in the middle of the northwest quarter and flows southeast most of the way across the area. It turns to the northeast about midway of the southeast quadrant, and leaves the area about midway of its east side. The southeast-flowing section of the river lies parallel with the Epinette Swamp depression. Souris River enters the area in the southwest corner and flows northeast to Assiniboine River. In the west half of the area, south of the river, several small intermittent streams drain the land, mainly into Souris River. Above its confluence with the Souris, Assiniboine River Valley is in general less than 75 feet deep and in many places not much wider than the channel itself, there being few terraces. The valleys of the Souris, and of the Assiniboine below the mouth of the Souris, are about a mile wide and up to 150 feet deep, with numerous flat terraces between the channel and the tops of the valley sides. Both rivers meander on flat valley bottoms.

Altitudes vary from less than 1,050 feet, where the Assiniboine leaves the area, to 1,550 feet in the Tiger Hills in the southwest part of the area. The relief is variable, for the most part being less than 10 feet but increasing to 30 or 40 feet in the sand dunes in the east.

Geology

Table of Formations

Age	Formation	Character	Thickness (Feet)
Recent	Alluvium	Stream-laid mud, silt, sand and gravel	

Age	Formation	Character	Thickness (Feet)
Pleistocene	Lake deposits	Silty clays, fine sands and silts, duned sands, assorted sands and gravel in beaches and deltas	0-50
	Glacial drift	Till, clay, sand, gravel, boulders, assorted sand and gravel in outwash plains	0-400
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: <u>Pembina</u> (dark shale, numerous bentonite bands near base); <u>Boyne</u> (grey, calcareous shale, non-calcareous dark shale near base); and <u>Morden</u> (calcareous speckled shale, overlying dark grey, non-calcareous, blocky shale with thin partings of white sand)	60 ± 140 ± 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

In the south, the area is underlain by Upper Cretaceous shales of the Riding Mountain formation. North of townships 7, no information is available on the bedrock formations, and it is possible that the Upper Cretaceous deposits have been removed by erosion. The hard, upper (Odanah shale) part of the Riding Mountain formation underlies the area roughly south of a line drawn from the northwest corner of tp. 7, rge. 17, to the southeast corner of tp. 7, rge. 14. The area to the north of this line is underlain by the lower part of the Riding Mountain formation, a soft shale that is impervious and does not yield water. The harder 'Odanah shale' to the south yields water of a somewhat saline character. Its base lies at an altitude of about 1,100 feet, and if rock is not encountered in drilling down to that altitude, it is unlikely that a satisfactory water supply will be obtained from rocks below. However, water might be obtained in any unconsolidated deposits found below the altitude of the base of the 'Odanah shale'. Insufficient information prevents the drawing of the contact of the soft, lower Riding Mountain shale with the hard 'Odanah shale'.

The unconsolidated deposits vary in thickness from the south, where bedrock may in places be reached at 10 feet, to the north, where their thickness is unknown but probably very great. Most of these deposits are formed of sand, originally deposited in a glacial lake by the ancestor of the present Assiniboine River. The river entered the lake near the northwest corner of the area, where the coarser material was left in extensive gravel deposits (tps. 9 and 10, rge. 17). Farther out in the lake then lying to the east, sand was deposited. After the lake was first drained, the ancestral Assiniboine flowed in a course now occupied by Epinette Swamp, later moving south to its present position. Before being mantled by vegetation, large areas of sands were blown by the wind, giving the rough, irregular, dune topography of the central part of the area. The thickness of the sand is greater than 85 feet at Shilo and may be several hundred feet there and farther east. In general the water-table stands within 50 feet of the surface, and plenty of good quality water can be easily obtained.

The main unconsolidated deposits in tps. 7 and 8, rge. 17, are fine silt and glacial till. Three layers of till are present, and lenses of water-bearing gravel commonly occur between the middle and uppermost tills at depths of the order of 25 feet. The water may be saline and short in supply. In secs. 4 to 9, tp. 8, rge. 17, a supply of water can be obtained from a sub-artesian aquifer, which has an altitude of about 1,185 feet. Its altitude is probably greater to the west; its full extent is not known. A typical section of the unconsolidated deposits in the vicinity of Wawanesa is given in the section dealing with tp. 7, rge. 17. There the outlook for obtaining adequate water from wells is not bright, and dugouts must frequently be used. The areas of water-worked till and of glacial-lake silt are not much better aquifers than the till itself, in this vicinity. Adequate supplies are usually obtained from the alluvium of the valley floors at shallow depths.

Water Supply

Except around Wawanesa, there is an abundant supply of water in the Carberry area, and the quality is good. Sandpoints are used at depths varying from 10 to 60 feet. In the south, some wells obtain water from the bedrock. A discussion of the water supply in each township follows.

Township 7, Range 14. This township is a plain having an elevation of about 1,225 feet in the southern part. The northern third is occupied by an area of sand dunes with local relief of up to 50 feet. The valley of Assiniboine River passes through sections 31, 32, 29, 28, 33, and 34, where the elevation of the lower, broadest terrace varies from 1,040 to 1,100 feet above sea-level.

Except for the terraces of Assiniboine River, which are formed of clay, the entire township is occupied by sand and silty sand deposits laid down in waters of a glacial lake. In the northern part of the township no particular bedding or sorting is apparent in the sands. Water is easily available everywhere at depths of from 8 to 40 feet depending on the topographic location of the well. Any well reaching below an elevation of about 1,170 feet will obtain an abundant supply of water, though it is not always necessary to go this deep. The sands of the southern part of the township (south of sections 19 to 24) are either interbedded with sandy clay, or else have had clayey layers formed by the transportation of fine particles down to the water-table where they were deposited as the downward movement of infiltrating water stopped. Below the village of Glenboro two such layers occur, one at 15 feet being about 3 feet thick and another at 20 feet about 4 feet thick. Between the two layers is a sand too fine to give satisfaction with sandpoints; the coarser, most satisfactory sand is reached at about 26 feet. West of Glenboro, thinner, more numerous layers of clay are thought to occur, but no open excavations exist, and the deposits have not been observed. In the southern part of the township water is reached at about 15 feet, at an elevation of about 1,215 feet.

The quality of water is good except in section 1 where the sulphate content is excessive for human consumption. Elsewhere in the township the water is clear and potable, and varies from soft to slightly hard. Sulphates and chlorides are very low. There is enough iron in the water to give it a slightly disagreeable taste and, in many cases, to stain vessels brown. The iron is not very noticeable in the waters of the sand-dune area in the north of the township.

Township 7, Range 15. This township is a plain with a general slope from the southwest, where the elevation is about 1,270 feet above sea-level, to the valley of Assiniboine River in the north. The valley is from ½ to 1 mile wide, terraced, and is bounded by escarpments about 100 feet high; the river has an elevation of about 1,170 feet above sea-level. The south half of the township is level to gently undulating, whereas much of the north half is a rolling area of sand dunes with a relief of 10 to 40 feet. Drainage of the north part is by Assiniboine River, which trends east, and drainage of the south part is by Oak Creek and its tributaries, the main stream flowing to the northwest.

Three distinct types of deposits occur in the township: in sections 4, 5, and 6, water-worked till, the surface of which is strewn with boulders, has a thickness of up to 15 feet and overlies the hard, grey 'Odanah shale' of the Riding Mountain formation. The central plain of the township is composed of sand, and the description of the sand deposits in townships 7 to 14 is applicable. The thickness of the sand is unknown, but exceeds 70 feet. The southern part of the sand area is smooth to gently undulating, whereas the northern part, separated from the south by a winding escarpment 10 to 30 feet high, is composed of sand dunes. The alluvial deposits of Assiniboine River in the north of the township are composed principally of light grey to white clay, with irregularly distributed gravel, sand, and silt.

In the area of water-worked till, in sections 4, 5, 6, and 7, water is obtained from wells bored more than 50 feet deep in shale, in quantities sufficient for 40 of 50 head of stock but of a quality too poor for domestic use. Water for domestic use is obtained, in quantities barely sufficient, from wells less than 20 feet deep. Water from the deeper wells contains soda, salt, and alkali, and is often very laxative to humans. The shallower wells give water low in mineral content.

In the sand plain, which forms the greater part of the township, water is obtained by driving sandpoints to a depth of about 25 feet; the depth varies from 8 to 40 feet in the sand dunes of the north. The supply obtained from these wells is adequate for maximum farm requirements, and the water varies from moderately soft to slightly hard. Throughout most of the area there is sufficient iron in the water to give a slight taste to the water and to cause some staining of water vessels.

On the alluvial terraces of the Assiniboine, water can usually be easily obtained by sandpoints, though the depths at which it is obtained vary more than in the sand plains, and the aquifers may be clay, sand, or gravel. The water supply is adequate for farm use, of moderately soft to slightly soft character, and very low in iron content.

Township 7, Range 16. The southwestern part of this township is a rolling area of knobs and kettles with a relief of as much as 75 feet. The northwestern corner is occupied by Souris River Valley, which has precipitous slopes and is about a mile wide and as deep as 130 feet. The remainder of the township is a plain of rather uniform elevation with a gently undulating to level surface, except in the northeast where sand dunes have a relief of up to 30 feet. The township is drained to the north by Oak Creek and its tributaries, and by Souris River.

The hummocky area in the south and west is a recessional moraine composed of sandy and gravelly clay till. Some of the knobs may have cores of broken bedrock that has been shoved out of its former position by glacial action. This moraine occupies all or part of sections 2 to 11, and adequate supplies of water are obtained principally from wells bored as deep as 95 feet into a shale aquifer. Most of the water obtained from depths greater than 20 feet is alkali and rather laxative to persons unaccustomed to it. Domestic water of good quality is often obtained at depths less than 16 feet.

All or parts of sections 1, 2, 7, 8, 10, 11, 12, 17, 18, 19, and 20 are occupied by relatively shallow deposits of lake clay and silt or water-worked till. These deposits yield only poor supplies of alkali water or no water at all. Adequate supplies of water (alkali) for stock are obtained by boring or drilling into the hard 'Odanah shale' to depths of up to 72 feet. Some pockets of gravel and sand yield satisfactory domestic water. In this belt, shale lies within 10 feet of the surface on the east side of the township, but is buried under about 50 feet of drift on the west side.

Good water in abundant supply is usually obtained from the alluvial deposits along the rivers at shallow depths.

In the north and east part of the township, composed of sandy lake deposits, water is obtained from dug wells and sandpoints at depths of from 6 to 40 feet. The water-table lies lowest along Oak Creek, and apparently rises gradually to the south and west. Water from these deposits is of good quality and abundant in supply.

Township 7, Range 17. Though the general slope of the land is to the northeast, this township is dissected from southwest to northeast by Souris River and the adjacent land slopes towards it. Souris Valley has precipitous sides, and the land on its margins appears to be flat. At various points along the valley wall and in the stream bed, Riding Mountain shale is exposed, and good sections of the glacial deposits may be seen in sections 15, 16, and 23. From the surface down, the succession in section 15 is as follows:

Character	Thickness (Rough average) Feet
Silt....................................	15
Compact, sandy till......................	5
(Lenses of gravel, sand, and silt)........	0-1
Compact till with shale fragments.........	13
Compact till with broken shale............	8

The base of the deposit contains more shale, and grades into underlying hard shale. The hard shale (Odanah) is about 50 feet thick here, and contains a few thin bentonite beds that might produce water; it is underlain by soft, greenish grey shale (the lower part of the Riding Mountain formation), which is impervious, has little jointing, and is unlikely to bear water; its thickness here is unknown, but is probably several hundred feet.

This is the section that one might expect to encounter on drilling a well in this vicinity. There is a chance of obtaining water in the sandy beds at about 20 feet, and some chance of getting fair to poor quality water in the shale between 45 and 100 feet. This would probably apply for a mile or two on each side of the valley.

Sections 1 and 2, and parts of 3, 4, 5, 11, and 12, are occupied by recessional moraine. Water is obtained from local pockets of sand and gravel in it at a depth of less than 20 feet, or by drilling a few feet into the bedrock, which lies as much as 60 feet below the surface.

In the areas of water-worked till in and adjacent to sections 3 to 8, and also townships 28 to 33, water is obtained in pockets and lenses of gravel in the till at depths of up to 45 feet. It is commonly too saline for human consumption, but usually fit, and adequate, for at least a few stock. Similar conditions prevail in the ground moraine of section 31.

The sections not already mentioned are occupied in part by glacial-lake silts and clay. Water is not obtained from the silts but is found at depths varying from 17 to 40 feet in local pockets of sand and gravel in the till below. The water is high in alkali content and is commonly difficult to find without digging many test holes. Good water is available at shallow depths in the alluvium lying in the bottom of the smaller valleys passing through this area. In the valley of Souris River, many of the terraces are cut into till and are unlikely to be water-bearing, though where bands of gravel are in evidence on the surface, as in the bottom lands, water should be easily obtained.

Where the terraces were originally cut into shale that has weathered into broken fragments, as in the lower part of the town of Wawanesa, water is readily obtained at depths no greater than 35 feet.

Township 8, Range 14. The greater part of this township is occupied by sand and uninhabited. Along the alluvial flats and terraces of Assiniboine River, water of good quality is obtained within 30 feet of the surface in sands and gravels. One well in section 1 derives water from 'black' sand at a depth of 70 feet. Most of the wells are sandpoints, and water could probably be obtained even in the uninhabited parts at less than 40 feet. The quality of the water is good.

Township 8, Range 15. This township has few dwellings, being mostly occupied by sand dunes. Along and in Assiniboine Valley, water is obtained from dug wells and sandpoints at depths of up to 40 feet. Those wells in the valley are deeper than those on the plains above, the latter averaging about 12 feet.

Township 8, Range 16. The township is occupied by sand (mostly dunes), alluvium of Souris and Assiniboine Rivers, and some water-worked till. Water is obtained from sandpoints varying in depth from 10 to 40 feet, most being less than 20 feet. The water lies somewhat deeper in the sand dunes on the north side of the township. Water is generally of good quality, commonly iron bearing, and the quantities obtained are adequate. It is unlikely that water would be obtained from the bedrock in this township, which is the lower, soft, impervious shale of the Riding Mountain formation (sometimes referred to colloquially as soapstone). This lies beneath about 100 feet of unconsolidated deposits in the south of the township, and its thickness increases to the north.

Township 8, Range 17. The northeastern half of this township is underlain by deposits of sand and gravel. In them water of good quality is usually available at depths of from 8 to 30 feet. Most of the southwest half of the township is occupied by silt and water-worked till, which is underlain by till. Water supply is frequently a problem here, but can often be obtained from pockets of sand and gravel in the till. The wells obtaining water from these pockets are from 25 to 60 feet deep. In the vicinity of sections 7, 8, and 9 is a sub-artesian aquifer at an elevation of about 1,185 feet that supplies adequate water of a quality satisfactory for stock. This aquifer may extend over a larger area, especially to the west. For further discussion of this aquifer and others like it nearby, See Sample 2230 under 'Analyses of Water Samples' which follows. In the terminal moraine in section 1, water suitable for stock is obtained at various depths from pockets of sand and gravel in the till.

Township 9, Range 14. The entire township is occupied by sand, mostly in the form of dunes. Several dwellings in the centre of the township obtain ample supplies of iron-bearing, but generally satisfactory, water.

The water-table in the centre of the township is very sensitive to changes of the level of Epinette Creek, and has been known to rise and fall as small dams were built or removed. This rapid response is indicative of the great porosity of the sands.

Township 9, Ranges 15 and 16. This township is uninhabited, and is composed of duned sands and swamp. Water can probably be obtained anywhere in it by use of a sandpoint, at depths of less than 40 feet.

Township 9, Range 17. Except for section 6, this township is underlain by sand and gravel deposits that yield an abundant supply of potable water at depths of less than 30 feet. On the western margin of the township, south of Assiniboine River, alkali water is obtained at depths of from 25 to 50 feet from pockets and lenses of sand and gravel in till. The depth to bedrock is not known here, but it is probable that any wells drilled to bedrock would encounter the lower soft shale of the Riding Mountain formation, which is impervious rock, unlikely to be water-bearing.

Township 10, Range 14. Sections 15 to 27 and 29 to 32 of this Township form a rather level plain, composed of sand, whereas the remaining sections, also sand, are duned, the highest dunes being in the eastern part of the township. Water is easily obtained everywhere, sandpoints being used throughout the area. In the east, these must be as deep as 40 to 50 feet to ensure a supply in the dry seasons. To the west, at Carberry, 25 feet is usually deep enough, and to the south 20 feet is adequate. In the south, the water may contain iron, but everywhere it is potable and abundant. Beds of sandy silt or silty clay up to 1 foot thick occur at various depths, and sandpoints should be driven clear of these. One occurs at about 15 feet and others at various depths up to at least 60 feet. An example of the amount of water available is the four sandpoint wells at the Carberry air station, which can supply 100,000 gallons a day.

Township 10, Range 15. The southwestern part is composed largely of swamps, and much of the township is not inhabited. The sandy deposits are similar to those in tp. 10, rge. 14. Water is obtained from 25- to 30-foot sandpoints in the northeast, but lies closer to the surface in the southwest.

Township 10, Range 16. The central part of the township is occupied by a swamp and the remainder by sand deposits similar to those described in the preceding townships. In section 35, ample water is obtained with a 16-foot sandpoint.

Township 10, Range 17. Except for till on the north side of section 31, this township is occupied by sands, gravels, and swamp. The sands increase in degree of coarseness from east to west, where medium gravels suitable for road metal and concrete work are found. Over most of the area, water of good quality is obtained at depths of 30 feet or less. In section 2, one of the wells supplying Shilo Camp has been driven to 85 feet, first encountering the water-table at about 25 feet. This well supplies about 50,000 gallons a day. A well being dug in the till on section 31 was not completed at the time of investigation.

Analyses of Water Samples

Discussion of Samples

Eight samples of water from the Carberry area were analysed by the Bureau of Mines at Ottawa. Most of them were selected as being representative of aquifers of different types and in different areas.

Not all the constituents determined are listed in the table that follows, silica and potassium having been omitted. The numbers attached to the samples are for laboratory identification only and have no special significance.

Sample No. 2238 is from a sandpoint well in the centre of the village of Glenboro. The water is of good quality. Field tests showed iron in the water in an amount less than 0.5 parts per million. This gives the water a taste sometimes referred to as 'iodine'. The iron is harmless to humans, though it may stain porcelain-ware in time. Because iron precipitates from the water as an hydroxide when it is exposed to air, the test for iron must be made immediatedly after the sample is taken. Due to the long lapse of time between the collection of the sample and its analysis in the laboratory, no accurate tests for iron are made there.

Sample No. 2235 is representative of the water in the sands in the village of Stockton. The quality is good.

Sample No. 2232 was from a well dug in blue clay. The water corrodes aluminium ware rapidly. This is probably due to the bicarbonate, the only constituent present in unusual proportions.

Sample No. 2233 was taken from a shale aquifer in the lower part of the town of Wawanosa, and is of fairly good quality, though the bicarbonate content is high. This was indicated to the investigator as the type of water to be used in a hospital planned for the future. The water should be easily softened.

Sample No. 2231 was obtained from the gravel sub-artesian aquifer in sec. 7, tp. 8, rge. 17. The quantity of sulphate is excessive, and the water is laxative to people unaccustomed to alkali water.

Sample No. 2230 is from a sub-artesian sand aquifer in sec. 31, tp. 8, rge. 17. The water is rather hard, but otherwise of good quality. The aquifer is at an elevation of 1,215 feet. Because of the difference in elevation, the difference in sulphate content, and the difference in the ratio of sodium to potassium between this well and the one from which sample 2231 was taken, only 6 miles away, it is concluded that these aquifers are separate and distinct from each other. Both are probably formed of sands and gravels laid down in valleys that were covered by later glacial deposits, and they probably extend as long, narrow deposits towards the higher land to the west rather than as widespread sheets. The writer has noticed that many of these buried valleys lie, in a general way, underneath the shallower valleys now visible on the surface.

Sample No. 2229 is from a sandpoint well in the middle of the town of Carberry, and is representative of the area. The quality is quite satisfacotry.

Sample 2228 was taken from a well on the edge of the marshy sand district south of Carberry. The water was said to leave a varnish-like stain in vessels. The alkali (metals) content is very high for a sand area, and is composed principally of potassium (which has been included with sodium in the table, for the sake of uniformity). Whether this is responsible for the coating is uncertain. The potassium might be a result of contamination by fertilizers, not an unusual occurrence in sandy areas. However, the nitrate content is only average. There may be some source of contamination near the well.

ANALYSES OF WELL WATERS FROM Tps. 7 to 10, Rges. 14 to 17, W.Princ. mer. Man. (Carberry Area)

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
2238	NE	10	7	14	Pr	W.H.Carrothers	28	S	830	109.0	64.4	10.9	79.1	121.0	7.0	295.4	286.0	272.0	264.9	536.9
2235	NW	21	7	15		T. Brown	22	S	463	97.0	27.3	13.2	66.7	4.4	19.4	255.0	221.0	242.1	112.2	354.3
2232	SW	12	8	16			12	T	944	111.4	74.7	13.5	211.5	31.2	5.2	502.6	488	277.9	459.4	737.3
2233	SE	27	7	17			28	Sh	614	116.0	50.3	122.3	81.5	6.4	17.6	409.9	352	289.4	206.2	495.6
2231	NE	7	8	17			104	Gr	2874	255.0	224.2	188.4	921.0	162.0	124.0	351.4	344	636.2	922.6	1558.8
2230	NE	31	8	17			33	S	1378	173.0	126.3	54.8	227.2	85.4	132.9	353.8	330	431.6	519.7	951.3
2229	NE	30	10	14		Nelson Hotel	40	S	584	106.6	34.5	26.7	60.1	23.4	19.4	295.2	290	266.0	142.0	408.0
2228	SE	8	10	14		H.C. Watterson		S	582	122.4	47.6	387.7	12.3	12.0	12.4	490.4	442	305.4	195.9	501.3

* Symbols used for aquifers S = sand Gr = gravel T = till Sh = 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 1 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 $2\frac{1}{2}$ feet 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.