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CANADA
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GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 258

GROUND-WATER RESOURCES
OF THE
RURAL MUNICIPALITY OF BRITANNIA
NO. 502
SASKATCHEWAN

Records Collected by C. O. Hage

Compilation by G. S. Hume and C. O. Hage



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DEPARTMENT OF MINES AND RESOURCES

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INTRODUCTION

Information on the ground-water resources of east-central Alberta and western Saskatchewan was collected, mostly in 1935, during the progress of geological investigations for oil and gas. The region studied extends from Edmonton in the west to Battleford in the east, and from township 32 on the south to township 59 in western Alberta, township 63 in eastern Alberta, and in part as far north as township 56 in western Saskatchewan.

This region is crossed by North Saskatchewan and Battle Rivers, and includes other more or less permanent streams. Most of the lakes within the area, however, are alkaline, and water is obtained in wells from two sources, namely, from water-bearing sands in surface or glacial deposits, and from sands in the underlying bedrock.

A division has been made in the well records, in so far as possible, between glacial and bedrock water-bearing sands. In investigations for oil and gas, however, the bedrock wells were used to trace the lateral extent of geological formations, with the result that the records deal more particularly with this type of well. No detailed studies were made of the glacial materials in relation to the water-supply. nor were the glacial deposits mapped adequately for this purpose. In almost all of the region investigated in Alberta, and in all but the northeast part of the region studied in Saskatchewan, water can be obtained from bedrock. In a few places, however, the water from the shallower bedrock sands is unsatisfactory, and deeper drilling may be necessary.

The water records were obtained mostly from the well owners, some of whom had acquired the land after the water supply had been found, and hence had no personal knowledge of the water-bearing beds that had been encountered in their wells. Also the elevations of the wells were taken by aneroid barometer and are, consequently, only approximate. In spite of these defects, however, it is hoped that the publication of these water records may prove of value to farmers, town authorities, and drillers in their efforts to obtain water supplies adequate for their needs.

In collecting this information several field parties were employed. These were under the direction of Professors R. L. Rutherford and P. S. Wairén of the University of Alberta, C. H. Crickmay of Vancouver, and C. O. Hage, until recently a member of the Geological Survey. The oil and gas investigations of which these water records are a part were undertaken under the general supervision of G. S. Hume.

Publication of Results

The essential information pertaining to ground-water conditions is being issued in reports that in Saskatchewan cover each municipality, and in Alberta cover each square block of sixteen townships beginning at the 4th meridian and lying between the correction lines. The secretary Treasurer of each municipality in Saskatchewan and Alberta will be supplied with the information covering that municipality. Copies of the reports will also be available for study at offices of the Provincial and Federal Government Departments. Further assistance in the interpretation of the reports may be obtained by applying to the Chief Geologist, Geological Survey, Ottawa. Technical terms used in the reports are defined in the glossary.

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. These should be consulted to see if a supply of water is likely to be found in shallow wells sunk in the glacial drift, or whether a better supply may be obtained at greater depth in the underlying bedrock formations. The wells in glacial drift commonly show no regional level, as the sands or gravels in which the water occurs are irregularly distributed and of limited extent. As the surface of the ground is uneven, the best means of comparing water wells is by the elevations of their water-bearing beds. For any particular well this elevation is obtained by subtracting the figure for the depth of the well to the water-bearing bed from that for the surface elevation at the well. For convenience both the elevation of the wells and the elevation of the water-bearing bed or beds in each well are given in the well record tables. Where water is obtained from bedrock, the name of the formation in which the water-bearing sand occurs is also listed in these tables, and this information should be used in conjunction with that provided on bedrock formations, pages 4 to 8, which describes these formations and gives their thickness and sequence. Where the level of the water-bearing sand is known, its depth at any point can easily be calculated by subtracting its elevation, as given in the well record tables, from the elevation of the surface at that point.

With each report is a map consisting of two figures. Figure 1 shows the bedrock formations that will be encountered beneath the unconsolidated surface deposits. Figure 2 shows the position of all wells for which records are available, the class of well at each location, and the contour line or lines of equal surface elevation. The elevation at any location can thus be roughly judged from the nearest contour line, and the records of the wells show at what levels water is likely to be encountered. The depth of the well can then be calculated, and some information on the character and quantity of water can be obtained from a study of the records of surrounding wells.

GLOSSARY OF TERMS USED

Alkaline. The term "alkaline" has been applied rather loosely to some ground waters that have a peculiar and disagreeable taste. In the Prairie Provinces, water that is commonly described as alkaline usually contains a large amount of sodium sulphate and magnesium sulphate, the principal constituents of Glauber's salt and Epsom salts respectively. Most of the so called alkaline waters are more correctly termed sulphate waters, many of which may be used for stock without ill effect. Water that tastes strongly of common salt is described as salty.

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

Aquifer or Water-bearing Horizon. A porous bed, lens, or pocket in unconsolidated deposits or in bedrock that carries water.

Buried pre-Glacial Stream Channels. A channel carved into 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.

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.

Coal Seam. The same as a coal bed. 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 a relatively steep slope separating level or gently sloping areas.

Flood Plain. A flat part in a river valley ordinarily above water but covered by water when the river is in flood.

Glacial Drift. The loose, unconsolidated surface deposits of sand, gravel, and clay, or a mixture of these, that were deposited by the continental ice-sheet. Clay containing boulders forms part of the drift and is referred to as glacial till or boulder clay. The glacial drift occurs in several forms.

(1) Ground Moraine. A boulder clay or till plain (includes areas where the glacial drift is very thin and the surface uneven).

(2) Terminal Moraine or Moraine. A hilly tract of country formed by glacial drift that was laid down at the margin of the continental ice-sheet during its retreat. The surface is characterized by irregular hills and undrained basins.

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

(4) Glacial Lake Deposits. Sand and clay plains formed in glacial lakes during the retreat of the ice-sheet.

Ground Water. Sub-surface water, or water that occurs below the surface of the land.

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

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

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

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

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

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

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

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

(1) Wells in which the water is under sufficient pressure to flow above the surface of the ground.

(2) Wells in which the water is under pressure but does not rise to the surface.

(3) Wells in which the water does not rise above the water table.

BEDROCK FORMATIONS OF WEST-CENTRAL SASKATCHEWAN AND EAST-CENTRAL ALBERTA

The formations that outcrop in west-central Saskatchewan are an extension of similar formations that occur in east-central Alberta. They are of Upper Cretaceous age, and consist entirely of relatively soft shales and sands, with some bands of hard sandstone and layers of ironstone nodules. The succession, character, and estimated thickness of the formations are shown in the following table:

<u>Formation</u>	<u>Character</u>	<u>Thickness</u> Feet
Edmonton	Grey to white, bentonitic sands and sandstones with grey and greenish shales; coal seams prominent in some areas, as at Castor, Alberta.	1,000 to 1,150
Bearpaw	Dark shales, green sands with smooth black chert pebbles; partly non-marine, with white bentonitic sands, carbonaceous shales or thin coal seams similar to those in Pale Beds; shales at certain horizons contain lobster claw nodules and marine fossils; at other horizons are abundant selenite crystals.	300 to 600 thins rapidly to the north-west
Pale and Variegated Beds	Light grey sands with bentonite; soft, dark grey and light grey shales with selenite and ironstone; carbonaceous shales and coal seams; abundant selenite crystals in certain layers.	950 to 1,000 in Czar-Tit Hills area; may be thinner elsewhere
Birch Lake	Grey sand and sandstone in upper part; middle part of shales and sandy shales, thinly laminated; lower part with grey and yellow weathering sands; oyster bed commonly at base.	100 in west, but less to east and south
Grizzly Bear	Mostly dark grey shale of marine origin, with a few minor sand horizons; selenite crystals and nodules up to 6 or 8 inches in diameter	Maximum, 100
Ribstone Creek	Grey sands and sandstones at the top and bottom, with intermediate sands and shales; thin coal seam in the vicinity of Wainwright; mostly non-marine, but middle shale in some areas is marine.	Maximum, 325 at Viking; thins eastward
Lea Park	Dark grey shales and sandy shales with nodules of ironstone; a sand 70 feet thick 110 feet below the top of the formation in the Ribstone area, Alberta.	950 to 1,100

Edmonton Formation

The name Edmonton formation was first applied to the beds containing coal in the Edmonton area, and later to the same beds in adjoining areas. The formation has a total thickness of 1,000 to 1,150 feet, but is bevelled off eastward and the east edge of the formation

follows a northwest line from Coronation through Tofield to a point on North Saskatchewan River about midway between Edmonton and Fort Saskatchewan. No Edmonton beds occur northeast of this line, but the formation becomes progressively thicker to the southwest due to the fact that the beds incline in that direction and the surface bevels across them.

The Edmonton formation consists of poorly bedded grey and greenish clay shales, coal seams, and sands and sandstones that contain clay and a white material known as bentonite. This material when wet is very sticky and swells greatly in volume, and when dry tends to give a white appearance to the beds containing it. Such beds are relatively impervious to water, and at the surface produce the "burns" of barren ground where vegetation is scanty or absent.

Water is relatively abundant in the Edmonton formation, which contains much sand, commonly in the form of isolated lenses distributed irregularly through the formation. Consequently, there is little uniformity in the depth of wells even within a small area. Water also occurs commonly with coal seams and, unlike the sand lenses, these beds are much more regular and persistent. In contrast with the water from the bentonitic sands, which is generally "soft", water from the coal seams, as the water from the shallow surface deposits, may be "hard". The basal beds of the Edmonton formation usually contain fresh water, but this may become brackish locally where the underlying Bearpaw beds contain highly alkaline or salty water.

Bearpaw Formation

In southern Alberta, where the Bearpaw formation is thickest, the beds composing it are mainly shales that have been deposited in sea water. In the area north of township 32 the formation thins to the northwest and becomes a shoreline deposit composed of shales containing bentonite, impure sands, and thin coal seams. In some areas, as at Ryley and near Monitor, and in the Neutral Hills, the Bearpaw contains pebble beds. At Ryley these are consolidated into a conglomerate, but mostly the pebbles are loosely distributed in shale or sandy beds.

In the area immediately north of township 32 the Bearpaw occupies a widespread belt beneath the glacial drift, but farther northwest the belt narrows, and at Ryley and northwestward it is only a few miles wide. This belt crosses North Saskatchewan River about midway between Edmonton and Fort Saskatchewan. Bearpaw beds form the main bedrock deposits of the Neutral Hills. Farther south, where they have an exposed thickness of at least 400 feet, they contain green sands, and beds of marine shale interfinger with the bentonitic shales and sands of the underlying formation. To the north, on the banks of North Saskatchewan River, the division between the Bearpaw and the overlying and underlying formations is indefinite, and the thickness of beds of Bearpaw age is relatively small.

The water in the Ryley area is from the Bearpaw formation, and is salty. In other areas to the south the marine Bearpaw formation carries green sand beds that yield fresh water, but commonly a much better supply is found by drilling through the Bearpaw into the underlying Pale Beds.

In Saskatchewan, Bearpaw beds occur southeast of Maclin and south of Luseland and Kerrobert. Only the basal beds are present, and these contain green sands that are commonly water-bearing.

Pale and Variegated Beds

Underlying the Bearpaw formation is a succession of bentonitic sands, shales, and sandy shales containing a few coal seams. The upper part of this succession, due to the bentonitic content, is commonly light coloured and has been described as the Pale Beds, whereas the lower

part is darker, and is known as Variegated Beds. In part, dark shales are present in both Pale and Variegated Beds; others are greenish, grey, brown, and dark chocolate, carbonaceous types. The sands may also be yellow, but where bentonite is present it imparts a light colour to the beds. Both Pale and Variegated Beds are characterized by the presence of thin seams of ironstone, commonly dark reddish, but in part purplish, Selenite (gypsum) crystals are, in places, abundant in the shales.

The best sections of Pale Beds exposed in the region are in the Tit Hills, southwest of Ocar. These hills carry a thin capping of Bearpaw shales, beneath which, and around Bruce Lake, more than 200 feet of Pale Beds are exposed. The total thickness of Pale and Variegated Beds in the Tit Hills area is about 970 feet. Variegated Beds outcrop near Hawkins on the Canadian National Railway west of Wainwright, but no area exposes the complete succession, which is considered to comprise about 200 feet of beds,

Records of wells drilled into the Pale and Variegated Beds do not, in general, indicate lateral persistence of sands for long distances, nor any uniform average depth to water-bearing sands in a local area. This points to the conclusion that the sands are mainly local lenses, but as such lenses are numerous, few wells fail to obtain water. In the Cadogan area many flowing wells have been obtained from sands about midway in the succession. In western Saskatchewan Pale and Variegated Beds occur over a wide area from Maclin and Kerrobert northeast through Wilkie to the Eagle Hills, south of Battleford. Numerous outcrops occur in the area south of Unity at Muddy Lake, but south and east around Biggar these beds are almost wholly concealed by glacial drift.

The water from the sands of the Pale and Variegated Beds is generally soft. The supply, apparently, is dependent in part on the size of the sand body that contains the water and in part on the ease with which water may be replenished in the sand. Small sand lenses surrounded by shales may be filled with water that has infiltrated into them, but when tapped by a well the supply may be very slowly replenished. In many instances such wells yield only a small supply, although this is commonly persistent and regular.

Birch Lake Formation

The Birch Lake formation underlies the Variegated Beds, but in many areas the division is not sharp. The type area of the formation is along the north shore of Birch Lake south of Innisfree, where a section 65 feet thick, composed mostly of sand, is exposed. The total thickness of the formation in this area is about 100 feet, and although this is dominantly sand a central part is composed of alternating thin sand and shale beds. At the base of the formation, in a number of places, is an oyster bed, and this is exposed in a road cut in a section 73 feet thick on the east side of Buffalo Coulee in sec. 3, tp. 47, rge. 7, W. 4th mer. In both upper and lower parts of the formation the sand is commonly massive and outcrops tend to consolidate into hard, nodular masses from a foot to a few feet in diameter. Apparently these are formed through the deposition of salts from the water that finds an outlet at the outcrops. In fact, in some areas the sand may be traced along the side of a hill by the presence of small springs or nodular masses of sandstone,

The Birch Lake formation occurs under the drift and in outcrops in a large area south of North Saskatchewan River and northeast of a line from Willingdon to Innisfree and Minburn. East of this area the southwest boundary is more irregular, but outcrops are persistent on the banks of Battle River from a few miles north of Hardisty to and beyond the mouth of Grizzly Bear Coulee in tp. 47, rge. 5. It is believed, too, that a large area near Edgerton and Chauvin is underlain by the Birch Lake formation and that it extends southeastward into Saskatchewan around Manitou Lake and southeast to Vera.

It is thought that the Birch Lake formation thins eastward from its type section at Birch Lake, and that it loses its identity in western Saskatchewan. Deep wells drilled at Czar, Castor, and elsewhere no longer show the Birch Lake as a clearly recognizable sand formation, so that its southern limit beneath younger formations is unknown. Wherever it occurs as a sand, however, it is water-bearing, although in some areas the sand is apparently too fine to yield any considerable volume of water. In other areas, however, it persistently yields good wells. There is no apparent uniformity in the character of the water, which is either hard or soft in different wells in the same general area. Direct contact with surface waters that contain calcium sulphates may in time change a "soft" water well to a "hard" water well, and many wells are not sufficiently cased to prevent the percolation of water from surface sands into the well, and hence into the deeper, soft water producing sands. In part this accounts for the change in character of the water in a well, a feature that has been noticed by many well owners.

Grizzly Bear Formation

The type locality for the Grizzly Bear formation, which underlies the Birch Lake beds, is near the mouth of Grizzly Bear Coulee, a tributary of Battle River with outlet in tp. 47, rge. 5. The formation is mainly composed of dark shales that were deposited in sea water. At the mouth of Grizzly Bear Coulee two shale sections, each about 100 feet thick, are separated by a zone of thin sand beds. It is now recognized that the upper section is the Grizzly Bear shale, and that the lower one, very similar in character and also deposited in sea water, occurs in the next lower formation, the Ribstone Creek. The Grizzly Bear shale contains a thin nodular zone about 50 feet above the base, that is, at about the centre of the formation. This zone is sandy, and is believed to yield water in various wells. Other thin sands, in places water-bearing, are also present. The impervious nature of the Grizzly Bear shales makes the overlying Birch Lake sand a strong aquifer, as water collects in the sand above the shale. The contact of the Birch Lake and Grizzly Bear formations can be traced in some places by the occurrence of springs issuing from the base of the Birch Lake sand even where this is not exposed.

Grizzly Bear shales occur in a road cut on the south side of Battle River near the highway bridge at Fabyan. The shales in this area are about 100 feet thick. It is thought they extend as far west as the Viking gas field, where they have been recognized in samples from deep wells. It is probable, however, that the shales thin westward and thicken eastward so that their general form is a wedge between both higher and lower sand beds. The position of the thin edge of the wedge to the west is unknown, but evidently the Grizzly Bear marine shale underlies a large area in east-central Alberta extending into Saskatchewan mainly in the area south of Battle River.

Ribstone Creek Formation

The type area of the Ribstone Creek formation is on Ribstone Creek near its junction with Battle River in tp. 45, rge. 1, W. 4th mer. At this place the lower sand beds of the formation are well exposed. The upper part of the lower sand member of this formation outcrops on the north side of Battle River, in the northeast part of sec. 26, tp. 47, rge. 5, near the mouth of Grizzly Bear Coulee. Above it, higher on the bank and at a short distance from the river, there is a 12 foot zone of carbonaceous and coaly beds in two layers, each about 2 feet thick, separated by 8 feet of shale. Above this are 90 feet of dark shales that are thought to have been deposited in sea water, that is, they are marine shales. These marine shales in turn are overlain by a sandy zone about 20 feet thick containing oysters in the basal part. This sandy zone is the upper sand member of the Ribstone Creek formation.

It thickens to the east and west from the Grizzly Bear area but is probably at no place much more than 50 feet thick.

The lower sand member of the Ribstone Creek formation also varies in thickness from a minimum of about 25 feet. On the banks of Vermilion Creek, north of Mannville, the basal sand is at least 60, and may be 75, feet thick. It is overlain by shaly sand and sandy shale beds, which replace the shale beds in the central part of the formation as exposed at the mouth of Grizzly Bear Coulee. In the Wainwright area, where the formation has been drilled in deep wells, the basal sand is 60 feet thick, with the central part composed of shale containing sand streaks. The upper sand member is about 20 feet thick in this area. The total thickness of the formation in the Wainwright area is 180 to 200 feet, but this increases to the west and in the Viking area exceeds 300 feet.

The Ribstone Creek formation is widely exposed in a northwest-trending belt in east-central Alberta. The southwest boundary of this northwest-trending belt passes through the mouth of Grizzly Bear Coulee in tp. 47, rge. 5, and beyond to the Two Hills area in tp. 54, rge. 12, whereas the northeast boundary crosses North Saskatchewan River southwest of Elk Point and extends northwest to include an area slightly north of St. Paul des Metis and Vilna to tp. 60, rge. 14. Within this belt water wells are common in the Ribstone Creek sands, which are almost without exception water-bearing in some part of the formation. The limits of the belt to the northeast determine the limits of water from this source, but to the southwest of the belt, as here outlined, water may be obtained in this formation by drilling through the younger beds that overlie it. The Ribstone Creek sands are a prolific source of water in many places and hence the distribution of this formation is of considerable economic importance. Where the formation consists of upper and lower sands with a central shale zone only the sands are water-bearing, although thin sand members may occur in the shale. Where the formation is largely sand the distribution of water may be in any part of the formation, although the upper and lower sands are perhaps the better aquifers. To the east of Alberta, along Battle River and Big Coulee in Saskatchewan, the Ribstone Creek sands are marine. Marine conditions apparently become more prevalent to the southeast and it is believed that in this direction the sands are gradually replaced by marine shales. Thus at some distance southeast of Battleford the Ribstone Creek formation loses its identity and its equivalents are shales in a marine succession.

Lea Park Formation

The Lea Park formation is largely a marine shale, and only in the upper 180 feet is there any water. In the Dina area south of Lloydminster the upper beds of the Lea Park consist of silty shales about 110 feet thick underlain by silty sands 70 feet thick. Below these sands are marine shales only, and these yield no fresh water either in east-central Alberta or west-central Saskatchewan. The sand in the upper Lea Park formation is thus the lowest freshwater aquifer within a very large area. The extent of this sand in the Lea Park, particularly to the northeast, is not known, but as the strata in east-central Alberta have a southwest inclination, progressively lower beds occur at the surface to the northeast. Thus at a short distance beyond the northeast boundary of the Ribstone Creek formation, as previously outlined, the sand in the upper Lea Park reaches the surface, and represents the last bedrock aquifer in that direction. Farther northeast water must be obtained from glacial or surface deposits only. In Alberta this area without fresh water in the bedrock includes the country north of North Saskatchewan River in the vicinity of Frog Lake and a large area extending to and beyond Beaver River. In this area, however, more fresh water streams are present than farther south, and bush lands

help to retain the surface waters. The area northeast of North Saskatchewan River in Saskatchewan is almost wholly within the Lea Park formation, where water can be found only in surface deposits.

WATER ANALYSES

Introduction

Analyses were made of water samples collected from a large number of wells in west-central Saskatchewan. Their purpose was to determine the chemical characteristics of the waters from different geological horizons, and thereby assist in making correlations of the strata in which the waters occur. Although this was the main objective of the analyses, it was also realized that a knowledge of the mineral content of the water is of interest and value to the consumer. The analyses were all made in the laboratory of the Water Supply and Borings Section of the Geological Survey, Ottawa.

Discussion of Chemical Determinations

The dissolved mineral constituents vary with the material encountered by the water in its migration to the reservoir bed. The mineral salts present are referred to as the total dissolved solids, and they represent the residue when the water is completely evaporated. This is expressed quantitatively as "parts per million", which refers to the proportion by weight 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 the one group is included the metallic elements of calcium (Ca), magnesium (Mg), and sodium (Na), and in the other group are the sulphate (SO_4), chloride (Cl), and carbonate (CO_3) radicals.

The analyses indicate only the amounts of the previously mentioned radicals, thus neglecting any silica, alumina, potash, or iron that may be present. It will be noticed that in most instances the total solids are accounted for by the sum total of the radicals as shown by the analyses. Actually, the residue when the water is completely evaporated still retains some combined water of crystallization, so that the figures for the "total solids" are higher than the sum total of the radicals as determined. These radicals are also "calculated in assumed combinations" to indicate the theoretical amounts of different salts present in the water. The same method was followed in each analysis, so that the table presents a consistent record of the different compounds present.

Mineral Constituents Present

Calcium. Calcium (Ca) in the water comes from mineral particles present in the surface deposits, the chief source 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).

Magnesium. 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 mineral. The sulphate of magnesia (MgSO_4) combines with water to form "Epsom salts" and renders the water unwholesome if present in large amounts.

Sodium. 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 purposes¹. Sodium sulphate is less

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.

harmful.

Sulphates. The sulphate (SO_4) salts referred to in these analyses are calcium sulphate (CaSO_4), magnesium sulphate (MgSO_4), and sodium sulphate (Na_2SO_4).

Chloride. Chlorine (Cl) is with a few exceptions, expressed as sodium chloride (NaCl), that is, common table salt. It is found in all of the analyses, most of the waters containing less than 200 parts per million, but some as much as 2,000 or 3,000 parts. These waters have a brackish taste.

Alkalinity. The alkalinity determined in these water analyses is based on the assumption that the only salts present in the samples that will neutralize acids are carbonates, and that, consequently, the degree of alkalinity is proportional to the amount of the carbonate radical (CO_3) present.

Hardness. The hardness of water is the total hardness, and has been determined by the amount of a standard soap solution required to form a lather that will stand up (persist) for 2 minutes. Hardness is of two kinds, temporary and permanent. Temporary hardness is caused by calcium and magnesium bicarbonates, which are soluble in water but are precipitated as insoluble normal carbonates by boiling, as shown by the scale that forms in teakettles. Permanent hardness is caused by the presence of calcium and magnesium sulphates, and is not removed by boiling. The two forms of hardness are not distinguished in the water analyses. Waters grade from very soft₂ to very hard, and can be classified according to the following system²:

² The "Examination of Waters and Water Supplies", Thresh & Beale, page 21, Fourth Ed. 1933.

- A water under 50 degrees (that is, parts per million) of hardness may be said to be very soft.
- A water with 50 to 100 degrees of hardness may be said to be moderately soft.
- A water with 100 to 150 degrees of hardness may be said to be moderately hard.
- A water with more than 200 and less than 300 degrees of hardness may be said to be hard.
- A water with more than 300 degrees of hardness may be said to be very hard.

Hard waters are usually high in calcium carbonate. Almost all of the waters from the glacial drift are of this type, especially those ~~not~~ associated with sand and gravel deposits that come close to the surface.

In soft water the calcium carbonate has been replaced by sodium carbonate, due to natural reagents present in the sand and clays. Bentonite and glauconite are two such reagents known to be present. Montmorillinite, one of the clay-forming minerals, has the same property of softening water, owing to the absorbed sodium that is available for chemical reaction¹.

1

Piper, A. M. "Ground Water in Southwestern Pennsylvania", Penn. Geol. Surv., 4th series.

If surface water reaches the lower sands by percolating through the higher beds it may be highly charged with calcium salts before reaching the bedrock formations containing bentonite or glauconite. The completeness of the exchange of calcium carbonate for sodium carbonate will, therefore, depend upon the length of time that the water is in contact with the softening reagent, and also upon the amount of this material present. The rate of movement of underground water will, consequently, be a factor in determining the extent of the reaction.

The amount of iron present in the water was not determined, owing to the possibilities of contamination from the iron casings in the wells. Iron is present in most waters, but the amount may be small. Upon exposure to air a red precipitate forms, the water becomes acid, and, hence, has a corrosive action. When iron is present in large amounts the water has an inky taste.

WATER ANALYSES IN RELATION TO GEOLOGY

Glacial Drift

The quality of the water from glacial drift depends largely on the nature of the deposit from which it comes and on the depth of the aquifer below the surface. Glacial deposits may be divided roughly into three types.

- (1). Sand and gravel beds that form the surface deposit, such as outwash material and glacial lake sands.
- (2). Buried outwash and interglacial deposits between two tills of boulder clay.
- (3). Pockets or lenses of sand and gravel irregularly distributed through the till.

Water from surface sand deposits is normally low in dissolved salts, the total being generally less than 1,000 parts per million. Where large amounts of limestone occur in the glacial sand and gravel beds a characteristic constituent of the glacial water is calcium carbonate, the amount present varying from 300 to 700 parts per million.

Water from buried outwash deposits contains more dissolved salts than the surface sands, as the water in order to reach them has to percolate through overlying till. Rain water contains carbonic acid, which acts as a solvent and dissolves a great deal of calcium, magnesium, and sodium from the rock-forming minerals. Sulphate salts are commonly present, though their proportions vary greatly in the different waters. The shales that are incorporated in the drift are high in calcium sulphate, so that the amount of shale present will modify the quality of the water. The oxidized upper part of the drift contains less sulphate than the deeper, less oxidized boulder clay. The character of the water in the buried outwash deposits will, therefore, depend largely on the composition and amount of till that overlies it.

Water from irregularly distributed sand and gravel beds will vary in its content of dissolved salts depending upon the character of the material surrounding the reservoir beds. As the water in this type of deposit does not flow to any marked extent, it is apt to be more highly impregnated with soluble salts than where the underground movement is more rapid. Soft water in the drift is mostly confined to shallow wells in sands low in calcium carbonate. Waters from glacial lake clays are sometimes high in soluble salts.

The sample from a well in glacial lake clay on N.W. $\frac{1}{4}$ sec. 27, tp. 42, rge. 17, has 11,040 parts per million of soluble salts, largely magnesium sulphate and sodium sulphate. The sample from SE. $\frac{1}{4}$ sec. 13, tp. 42, rge. 16, which is believed to come from glacial lake silts, has a very different composition. The total solids in it are only 440 parts per million, of which 250 are calcium carbonate. The great difference in these waters is due to the high soluble salt content that is associated with the lake clays but absent in the silts. Average drift water contains between 1,000 and 3,000 parts per million of dissolved mineral salts.

Bearpaw Formation

The Bearpaw formation consists of dark marine shales and beds of green sand. Water from these sands has a total solid count ranging from 300 to 1,600 parts per million and a hardness of more than 300 degrees. Calcium carbonate is very marked in all samples, due, perhaps, to the proximity of the water sands to the glacial drift. Sodium sulphate is the chief salt present, followed by calcium carbonate, magnesium sulphate, magnesium carbonate, and sodium chloride in decreasing amounts. These waters are distinguished from the overlying drift waters by being relatively low in total dissolved solids, and in containing no calcium sulphate and only moderate amounts of sodium sulphate, magnesium sulphate, and magnesium carbonate.

Pale Beds

Pale Beds underlie the Bearpaw formation. Total solids in waters from these beds vary from 700 to 1,300 parts per million. The water is, in most instances, soft, as it contains sodium carbonate in excess of calcium and magnesium carbonates, but when mixed with surface water high in calcium carbonate, it will become hard. The high concentration of sodium salts, especially sodium carbonate, in contrast with the calcium and magnesium salts distinguishes this water from that in Bearpaw sands. The Pale Beds include much bentonite, and it is this mineral that acts as a water softener within the formation. The following analyses are typical of waters from the Pale Beds:

	SE. sec. 16, NE. sec. 3, SW. sec. 7, SE. sec. 21	tp.38, rge. 21	tp.39, rge. 25,	tp.37, rge.24,	tp. 38,rge.23
Salts					
CaCO ₃	73	18	53	35	
CaSO ₄	-	-	-	-	
MgCO ₃	52	14	45	38	
MgSO ₄	-	-	-	-	
Na ₂ CO ₃	297	679	464	562	
Na ₂ SO ₄	297	158	266	437	

NaCl	31	45	46	130
Total solids	760	1,020	940	1,260
Hardness	100	20	30	75

Variegated Beds

In Senlac Rural Municipality, Saskatchewan, are a number of wells that have water very similar in character to that found in the Bearpaw formation. These wells tap an horizon that corresponds with the Variegated Beds in Alberta, although they have not been separated from the Pale Beds. They are less bentonitic than the Pale Beds and darker in colour. The water is hard and has a low dissolved solid content. The three analyses given below show a great deal of similarity and suggest a common horizon.

Salts	NW. sec. 21, tp.41,rge.26	NW. sec. 3, tp.41,rge.28	SE. sec. 28, tp.40,rge.28
CaCO ₃	250	305	125
CaSO ₄	-	-	-
MgCO ₃	1109	80	155
MgSO ₄	149	104	69
Na ₂ CO ₃	-	-	-
Na ₂ SO ₄	98	132	386
NaCl	12	12	18
Total solids	640	640	780
Hardness	600	600	500

Ribstone Creek Formation

Chemical analyses of water from the Ribstone Creek formation vary more than in the Pale Beds, the reason being that at several different horizons the sediments show considerable lateral variation. The formation includes both marine and non-marine beds, thin coal seams being present in the basal part of the formation around Paynton, whereas south of Lashburn, on Battle River, marine fossils were found in strata considered to be at approximately the same horizon. The water analyses show similarities within limited areas, but long distance correlations cannot be made safely except for the saline waters that occur in the flowing wells at Vera, Muddy Lake, and at the south end of Tramping Lake. Analyses of these waters are given in the following table:

Salts	SE. sec. 25, tp.41,rge.24	SE. sec. 22, tp.41,rge.24	NE. sec. 36, tp.41,rge.24	SW. sec. 7, tp.41,rge.24	SE. sec. 30, tp.38, rge.22	SW. sec. 10, tp.35, rge.20
CaCO ₃	73	73	73	198	108	90
CaSO ₄	-	-	-	-	m-	-
MgCO ₃	38	38	38	52	69	52
MgSO ₄	-	-	-	-	-	-

Na ₂ CO ₃	129	119	129	11	106	125
Na ₂ SO ₄	55	55	61	61	49	43
NaCl	2,929	3,036	2,690	2,863	3,531	3,861
Total solids	3,840	3,460	3,120	3,200	3,860	4,460
Hardness	135	90	110	100	130	130

The similarity in these analyses suggests a common source bed. The distance between the Tramping Lake well and the Vera wells is about 40 miles. This water, which is thought to come from the basal sand of the Ribstone Creek formation, is not typical of water from the same stratigraphical horizon in the vicinity of Battle River, one reason being, possibly, that at Battle River the stream has cut through the Ribstone Creek formation exposing the sand members along its banks. This may cause a more rapid movement of the underground water in this area than farther south, and it is known that the rate of flow is a controlling factor that governs the change of calcium carbonate to sodium carbonate when the softening reagents of bentonite or glauconite are present in the sand.

Some of the soft waters from the Ribstone Creek formation cannot be distinguished from those of the Pale Beds, whereas others are quite different. The following analyses illustrate some of the different types of water from this formation:

	Se.sec. 11, tp. 46, rge.	Ind.Agent Little Pine I.R.	SW.sec. 24, tp. 46, rge.	NE.sec. 36, tp. 43, rge.	Se.sec. 26, tp. 43, rge.	NE.sec. 36, tp. 41, rge.	NW.sec. 22, tp. 42, rge.
Salts	28		21	18	18	24	23
CaCO ₃	90	90	410	73	35	73	125
CaSO ₄	-	-	-	-	-	-	-
MgCO ₃	97	59	168	38	31	38	97
MgSO ₄	-	-	64	-	-	-	-
Na ₂ CO ₃	217	392	-	283	592	129	196
Na ₂ SO ₄	1,644	777	2,518	225	522	61	1,541
NaCl	249	63	76	12	83	2,690	71
Total solids	2,220	1,340	3,000	620	1,240	3,120	1,900
Hardness	280	160	750	110	35	110	600

The above chemical analyses show such a wide range in the dissolved salts present in the different waters in the Ribstone Creek formation that they cannot be used for correlation purposes over a large area.

Conclusions

- (1) In most instances water from glacial drift is quite different from water from bedrock.
- (2) Some of the bedrock horizons carry waters that show definite chemical characteristics.
- (3) Most waters from glacial till carry total solids amounting to between 1,000 and 3,000 parts per million.

(4) Bedrock waters are commonly low in dissolved salts. Exceptions to this are to be found in water from the Ribstone Creek formation.

(5) Water from the Bearpaw formation is hard. An average of ten wells gave a total solid content of 1,100 parts per million.

(6) Water from the Variegated Beds resembles that from the Bearpaw formation.

(7) Waters from the Pale Beds is mostly soft. An average of ten wells gave a total solid of 1,000 parts per million.

(8) All soft waters contain sodium carbonate (Na_2CO_3), which is present in water from the Pale Beds and Ribstone Creek formations but absent from the Bearpaw formation and Variegated Beds.

RURAL MUNICIPALITY OF BRITANNIA, NO. 502,
SASKATCHEWAN

Physical Features

Saskatchewan River forms the northern boundary of this municipality. The stream bed completely fills the bottom of the valley, which is nearly 200 feet deep. The south bank is bush covered, but the north bank is essentially treeless except in the small, tributary gullies. The valley slopes are broken by a series of hillocks caused by sliding or slumping where the banks have been undercut by the river. This is more evident where the river has cut below a thin drift cover into the shales of the Lea Park formation, which contains thin layers of bentonitic material that act as a lubricant and greatly facilitate slumping. The river flows in general southeasterly, but on sec. 5, tp. 53, rge. 26, it turns sharply to the northeast for several miles before resuming its winding southeast course. This sharp turn is caused by a large recessional moraine, which has blocked the ancient channel of the river. Elsewhere these morainal hills parallel the river across the municipality, and the larger ones, including Gumbo Hill to the northwest, Patmores Hill north of Greenstreet Lake, and the long ridge east of the town of Hillmond, appear to form a broken ridge. These hills are covered with boulder till, but information obtained from well records indicates bedrock at no great depth beneath. The hills, consequently, were in existence before the advance of the continental glacier, and are thus drift-covered erosional remnants. Other hills of similar appearance may have a similar origin.

Big Gully Creek cuts across the southwest part of the municipality. Only a small stream now flows down this deep valley, which was eroded by a large stream from the melting ice of the retreating continental glacier. These glacial waters are also responsible for the large area of sand that extends from Greenstreet Lake southwest to Sandy Lake and Big Gully Creek. This sand was laid down in the shallow waters of a lake that was later drained by Big Gully Creek, and has since been blown into dunes, leaving a rolling surface. South of the gully is a ground-moraine deposit, and to the north the country is hilly and exhibits definite morainal characteristics. The sandy plain around Tangleflags is due in part to the early erosional action of Saskatchewan River, which formed a number of terraces along its banks.

Numerous small lakes occupy the undrained basins between the larger hills, the largest being Greenstreet and Sandy Lakes. Many of the shallower basins dry up during the summer, leaving a white alkaline coating.

Geology

The surface deposits of the municipality consist of boulder till, sand, and sandy soil. The two drainage channels, those of Saskatchewan River and Big Gully Creek, cut through the surface deposits into the underlying sedimentary strata of shale and sand exposing outcrops of these beds at several places. The highest of these, stratigraphically, are the sandy beds of the Ribstone Creek

formation, which underlies almost all of the area south of Big Gully Creek and also a strip on the north side, estimated to be about 4 miles wide, extending southeast from the sandy area parallel to Big Gully Creek. Below the Ribstone Creek sand and in areas where it has been removed by erosion is the Lea Park shale, a very fine-grained, greenish grey clay that is impervious to water. These shales are exposed along Saskatchewan River and in railroad cuts at Hillmond. They have been encountered in many wells, and, except in the higher hills, underlie the northern half of the municipality.

Water Supply

The water supply in Britannia municipality is obtained principally from the drift, but in those areas underlain by the Ribstone Creek formation several wells obtain water in the bedrock. It is impossible from a study of the surface features to accurately outline the northern limit of the Ribstone Creek formation, and the boundaries shown on the map have been sketched in tentatively.

The Ribstone Creek sands are finer in texture than they are farther south, and, consequently, do not afford the same possibilities for water. The underlying Lea Park shales are relatively impervious, and their investigation by test wells is not recommended.

The drift material will continue to be the main source of supply, as impervious shales underlie the drift over the northern half of the municipality. In the sandy area the water supply affords no serious problem as the water-table is less than 30 feet from the surface. Owing to the porous nature of the soil much of the annual precipitation enters the ground and percolates downward to where the sands overlie an impervious bed of clay or shale. A decrease in the annual rainfall is reflected by slight lowering of the water-table. In the morainal areas on the north and east sides of the municipality most of the water is obtained within 30 feet of the surface, and the relatively few dry holes indicate a large amount of sand and gravel in the upper part of the drift.

Township 50, Range 25. Most of this township lies within the boundaries of a large moraine that parallels Saskatchewan River. The remaining part, comprising from 6 to 8 square miles in the southwest corner, is a gently rolling ground moraine. Within the area of the large moraine the country is extremely hilly, and numerous small lakes occupy the larger depressions. Many of these lakes dry up during the summer, leaving basins covered with white alkaline salts. The land is, consequently, more suitable for grazing stock than for grain farming.

No bedrock is exposed within this area of thick glacial deposits, but to the south, along the banks of Big Gully Creek, outcrops of Ribstone Creek sandstone appear at an elevation of about 1,900 feet. The sandstone is also encountered in wells drilled south and west of this township at an elevation of 1,880 feet. These sands have a limited areal extent northward, but due to the thick overburden their boundary cannot be exactly defined. However, as they are not present at Hillmont they must be eroded in that direction,

and are thus limited to the areas of higher land. Their northern boundary cuts diagonally across the township from the northwest to the southeast corner, beyond which the country is underlain by the fine-grained shales of the Lea Park formation.

The water supply in this township is obtained from relatively shallow wells, believed to be in glacial drift. These wells comprise two groups: in one the aquifers have elevations between 1,957 and 1,974 feet, and in the other group they lie between 2,000 and 2,045 feet. The higher aquifers are restricted to a belt 2 miles wide across the southern part of the township, whereas the lower water-bearing zone is encountered elsewhere in the township, except in the well on SE. section 16. As the wells that tap this lower zone are located at widely separate points on a rolling surface and obtain water at nearly the same elevations, it appears that there is considerable sand in the drift at this level and that possibilities for water elsewhere in this part of the township are very good. A lower water-bearing zone may also occur in the drift in the southern part of the township, as the usual gravel deposits associated with a moraine have not been reported in the wells in this belt but may be found at greater depths.

The Ribstone Creek formation underlies part of the township, and normally constitutes a good water horizon, the depth to it depending on the surface elevations. As this horizon lies at an elevation of about 1,880 feet, the drilling depths to it will vary from 200 to 250 feet. Marine shales occur below the Ribstone Creek sands, but drilling into them is not recommended as they contain no known water-bearing sands. It must be borne in mind, however, that the northern limit of the Ribstone Creek sands is only an assumed boundary, and that the formation may be either more or less extensive than shown. When shale is encountered below the drift at an elevation of about 1,850 feet, possibilities for a deeper supply of water are not good.

Township 50, Range 26. The main topographical feature of this township is the valley of Big Gully Creek. It was formed by the water that issued in great quantity from the retreating continental glacier that at one time covered this entire region. The strip of country paralleling the valley for several miles on either side is fairly well drained, and is a gently rolling ground moraine. To the north the country becomes very hilly, drainage is poor, small lakes occur in the larger depressions, and the morainal characteristics of the terrain are very pronounced. The general trend of the hills is northwest and southeast.

Natural outcrops of sandstone are found along Big Gully Creek. One, on section 5 on the east side of the gully, lies at an elevation of 1,880 feet, and may have slumped from a higher position as it is exposed on the edge of a terrace. On the west side of the gully along the main road a very similar sandstone is exposed at an elevation of 1,950 feet. The outcrop is small, but is almost certainly in place. It may be a higher sand stratigraphically than that on the east side of the valley. The valley floor is very flat, and is covered by a gravel deposit several feet

thick. The stream bed is here believed to have cut through the Ribstone Creek sands into the marine Lea Park shales, but elsewhere in the township Ribstone Creek sand will probably be encountered below the drift.

The thickness of the drift varies from 100 to 200 feet. The deepest well was drilled to a depth of 245 feet, and as it does not obtain a good supply of water at a higher level it is inferred that it penetrated mainly boulder till.

The water supply comes from wells that tap the sand and gravel lenses in the drift and the underlying bedrock sand of the Ribstone Creek formation. The wells in the drift have an average depth of 40 feet, the deepest one being 80 feet. A difference of 200 feet in the elevations of the glacial wells is due mainly to a difference in the surface levels rather than in the elevations of the aquifers, and because of this it is difficult to trace the lateral extent of the sand and gravel bodies. On section 32 are two wells in which the aquifers lie at elevations of 1,927 and 1,929 feet respectively, and as water occurs at the same elevations to the north and west it is probable that a continuous sand bed is represented. The well on SE. sec. 36, tp. 50, rge. 27, is reported to be in sandstone at a depth of 70 feet, or at an elevation of 1,929 feet, and if this is so it may be that the bedrock extends farther east than is shown on the map, in which case the other wells at this elevation are probably also in bedrock and the drift is less than 30 feet deep. The variability in the thickness of the surface deposit is proved by the fact that a sandstone bed 1 foot thick was encountered in a well on SW. section 24. It appears, therefore, that the hills though morainal in character may have a core of bedrock. Wells on NE. section 15, NW. section 22, and SW. section 32 report soft water at elevations of 1,930, 1,948, and 1,889 feet. The difference of 41 feet in these elevations seems too great to suggest a common aquifer, and the soft water may be caused by glauconite or other softening reagents occurring locally in the sands. The highest water-bearing zone occurs at elevations of from 2,025 to 2,060 feet, at depths ranging from 30 to 72 feet. It is limited to the strip of high land about 2 miles wide that parallels Big Gully Valley about 1 mile to the northeast.

The Ribstone Creek formation provides a sand that yields a good supply of hard water, and it is unfortunate that the overlying drift is so thick. The elevation of the bedrock aquifer is between 1,889 and 1,872 feet, and the wells that reach it are between 150 and 245 feet deep. This is thought to be the lowest sand in the Ribstone Creek formation, and drilling below it would not yield a further supply of water. With the exception of the wells previously mentioned, only hard water has been obtained from this aquifer, but it is possible that a higher aquifer within this formation may be represented in some of the shallower wells. On SE. section 1 a well 65 feet deep gives a good supply of water in black sand that is more typical of the Ribstone Creek formation than of the drift.

Township 50, Range 27. Long, narrow ridges, broken in places into small hills, mark small recessional moraines trending almost due east and west in this township.

Some of these ridges contain much gravel and resemble eskers. Small lakes fill the deeper depressions and the drainage, which is poorly developed, is towards Big Gully Creek. This creek lies in a large glacial drainage channel, and has cut through the mantle of glacial debris into the underlying bedrock, which is exposed at several places along the south bank.

The thickness of the glacial deposit varies somewhat from place to place. As shown by the samples from the deep wells drilled by the Lloydminster Oil and Gas Company on secs. 11 and 12, tp. 50, rge. 28, there is a great variation in the thickness of the drift. In No. 1 well the upper 90 feet is drift, and the sand immediately below is believed to represent the Ribstone Creek formation. In No. 2 well the total thickness of the drift is placed at 150 feet. Here it consists of boulder clay and two water-bearing sands, each 30 feet thick. Underlying the drift is the Ribstone Creek formation of alternating sands and shales. As the upper surface of the formation was exposed to erosion prior to glaciation, the part remaining varies in thickness at different places. Below the Ribstone Creek are the Lea Park and Alberta formations consisting of 1,500 feet of fine-grained impervious clay. These may contain sand lenses of limited lateral extent, but their occurrence cannot be predicted.

The water supply is obtained from wells that vary greatly in depth and that tap sand and gravel lenses in the drift as well as lower aquifers in the bedrock.

The wells are either in glacial drift or in bedrock, but in a few cases it is difficult to determine from which the water comes. Those from the glacial drift are from 10 to 55 feet deep, with an average depth of 30 feet, and the elevations of their aquifers range from 1,975 to 2,057 feet. The drift has an approximate thickness of 100 feet, and it appears that the upper 50 feet contains a considerable amount of gravel and sand except for an area of 12 square miles in the southwest and a strip about 1 mile wide along the north side of the township.

The large number of wells in the upper part of the drift indicates that sand and gravel deposits must be fairly continuous, but it is probable that they occur as separate lenses rather than as a single bed. Wells at intermediate depths, 80 to 98 feet, as in sections 4, 9, 15, and 16, obtain their water supply either at the base of the drift or in a high sand in the Ribstone Creek formation.

Outcrops of Ribstone Creek sandstone are found on the west bank of Big Gully Creek, and as no dry holes have been drilled in the township except on section 32 it seems certain that these bedrock sands underlie the entire township, except for a strip along the north. The elevation of the aquifer on SW. section 16 is 1,868 feet, which is 50 feet lower than the Ribstone Creek and Lea Park contact at Lloydminster. This is also lower than any known outcrop of sand along Big Gully Creek in this vicinity. On SE. section 34 a well drilled to a depth of 265 feet did not encounter any water below 130 feet, at an elevation of 1,953 feet. This was, therefore, taken to be the base of the

Ribstone Creek formation at that place. Also, a well, 160 feet deep, on NE. section 32 supplied water for several years from an horizon believed to be a Ribstone Creek sand. On NW. section 32 several dry holes were drilled to a depth of 196 feet, reporting shale, at the bottom at an elevation of 1,857 feet. There appears, therefore, to be a slight dip in the bedrock to the northeast from Lloydminster, followed by a rise towards Big Gully Creek. The well on SE. section 17 is said to have a layer of gravel 20 feet thick at the bottom, at an elevation of 1,895 feet. If this is actually gravel and not coarse sand it indicates drift at this elevation, but very little Ribstone Creek sand could be expected at greater depths. Along the north boundary of the township, especially in section 32 where dry holes have been drilled and a producing well has gone dry, the bedrock sand must be absent or very thin. As these sands are known to thin northward, owing to erosion prior to glaciation, it seems reasonable to expect to find places where they have been entirely removed. Their actual extent is difficult to determine, and can only be traced by test drilling. An outcrop of Ribstone Creek sandstone is found on the north side of the gully in section 9 in the township immediately to the north, at an elevation of 2,010 feet. The base of the formation is not known, but the formation itself must have a considerable thickness. The aquifers in the wells in the Ribstone Creek formation range in elevation from 1,868 to 1,957 feet, and in the southwest part of the township at least represent two horizons. The elevation of the aquifer on SW. section 5 is 1,912 feet, and on SE. section 6, 1,957 feet. Similarly, on section 8 the elevations are 1,933 and 1,941 feet, and on SE. section 16 the elevation is 1,868 feet. It is quite possible that some of the wells thought to occur at the base of the drift are in the higher horizon of the bedrock sand. Drilling depth to the lower sand is from 100 to 175 feet, depending on the surface elevation.

Township 50, Range 28. This is a part township 2 miles in width adjoining the 4th meridian. The town of Lloydminster lies in the extreme southwest corner. The country is mainly flat, but includes a few east-west ridges that represent small recessional moraines. The township is drift covered to a thickness of 100 feet or more, and no outcrops of the underlying bedrock are exposed in the area, but samples of the strata from two deep wells drilled for gas by Lloydminster Gas Company, Limited, are available for study. One of these wells, on SW. section 11, formerly produced gas from a depth of 1,970 feet.

Log of Upper part Lloydminster No. 1 Well

Location: SW. sec. 11, tp. 50, rge. 28, W. 3rd mer.

Elevation 2,117 feet

Depth (feet)

10-90 boulder clay.
100-150 pepper and salt sand, medium-grained, brown oxidation.
160-170 pepper and salt sand, greenish.
180-200 fine, silty sand.
210 sandy shale.
220 shale.

Log of Upper part of No. 2 Well

Location: SW. sec. 12, tp. 50, rge. 28, W. 3rd mer.

Elevation 2,105 feet.

Depth (feet)

0-60 brown drift mixed with sand.
60-90 pepper and salt sand, medium-grained.
90-120 clay mixed with sand, drift.
120-150 sand, medium-grained.
150-170 pepper and salt sand, medium-grained.
180 shale.

The thickness of the drift in No. 1 well is 90 feet and in No. 2 well 150 feet, as shown by the samples.

The possibilities for water at the different horizons are good, as indicated by the number of sands present. In No. 1 well water was struck at the base of the drift at 90 feet, elevation 2,027 feet, and again from 160 feet down to near the base of the Ribstone Creek formation. In No. 2 well two water-bearing sands were encountered in the drift at depths of 60 and 120 feet or at elevations of 2,045 and 1,985 feet respectively. The top of the basal Ribstone Creek sand, which is 20 feet thick, occurred at a depth of 150 feet. The Saskatchewan Cooperative Creamery well drilled 45 feet of sand and sandy shale at this same lower horizon, proof that the basal sands of the Ribstone Creek formation underlie the Lloydminster area. The same sands were also struck on NE. section 23 at an elevation of 1,879 feet, lower than at Lloydminster, and indicating a northern dip to the formation of 10 feet to the mile. It can, therefore, be stated that the Ribstone Creek sands offer a good aquifer for water at an average elevation of about 1,925 feet, the depth of the wells depending on the surface elevation and the distance that it is necessary to drill into the sand after it has been reached.

The glacial drift in this township carries much sorted material of sand and gravel, as shown by the samples from the wells drilled at Lloydminster. The deposit is about 100 feet thick, varying somewhat at different places, as was shown by the Lloydminster gas wells. The sands, however, seem to be restricted either to the upper 40 feet or at about 100 feet. These deeper sands are found on sections 11 and 14 at depths of 100 to 117 feet, and correspond to the water horizons in the deep gas wells previously mentioned. It seems, therefore, very reasonable to expect sorted material in varying amounts at the base of the drift in this vicinity. The possibilities of water at shallower depths are very good owing to the large amount of sand and gravel present in the upper part of the deposit.

Township 51, Range 25. The rolling topography of this township is distinctly morainal in character. Small lakes partly fill the larger depressions between the hills. In late summer many of these dry up leaving a white alkaline deposit covering the surface. Some of the larger hills, however, may have a core of bedrock and are thus erosional remnants of a pre-Glacial land surface. This is thought to

be true of the long hill that trends northwest from section 2 diagonally across the township and northwest of section 31. The slopes of the hills are grass covered, and as few wells have been sunk from the top of the hill the character of the underlying bedrock is uncertain. Marine shales are exposed in the railroad cuts east and west of the town of Hillmont on sec. 25, tp. 51, rge. 26, W. 3rd mer. They were also encountered in a shallow well dug by Rutherford Brothers in Hillmont, thus indicating that the drift is very thin in this vicinity. In a gravel pit southwest of town and on the same section are abundant fragments of sandstone resembling the Ribstone Creek formation. The top of the shale at Hillmont is at an elevation of about 1,880 feet, but in places there is evidence of the presence of Ribstone Creek sand above the shale. On NE. section 33 a dug well 60 feet deep encountered 20 feet of sand with water below a shale in which a marine fossil was found. The elevation of the bottom of the well is 1,881 feet. The sand thus overlies the shale at Hillmont and is, therefore, considered to be part of the Ribstone Creek formation, and shales above this sand would, consequently, be of Ribstone Creek age. These shales also are known to carry a marine fauna in the vicinity of Lloydminster. The only other well that has possibly penetrated the drift is a shallow well 18 feet deep on NW. section 21 at an elevation of 1,936 feet. Some of the material from this well had the appearance of shale, but definite proof of its geological age is lacking. Ribstone Creek sandstone is, therefore, believed to underlie the surface deposits on the high ridge east of Hillmont extending from section 2 northwest to section 31 and beyond. Lea Park shale underlies the drift elsewhere in the township. This shale is a very fine clay, contains very little sand, and thus is impervious to water. No water horizons are known in it, but water usually occurs at its contact with the drift, especially when sand or gravel is present. The thickness of the drift varies greatly. The well on SE. section 14, which is both the deepest and lowest well in the township, apparently did not penetrate the drift at a depth of 82 feet. The well on NW. section 27 reveals glacial lake clays at a depth of less than 75 feet or an elevation of 1,890 feet. No relationship exists between the water horizon in this well and that on section 33, as the material from the two wells was examined and found to be different, and the extent of the glacial-lake clay deposit was not traced beyond the one well. Available well records do not seem to indicate much uniformity in the level of the water-table, so it is concluded that the sand deposits are irregularly distributed. Water is found in sufficient quantity in the drift to supply the needs of the farmers, and except on the high ridge where Ribstone Creek sands occur deep drilling should not be undertaken. Where the drift is thin it may be difficult to find a suitable aquifer. As the shale surface was exposed to erosion prior to glaciation its surface will be irregular, much like the present topography, and, as the shale is impervious, seepages of water will tend to collect in depressions on this surface, saturating any sands and gravels that may be present. In such places a good supply of water may be obtained on top of the shale. Where the drift is thin the shale surface may roughly parallel the surface topography, and the best seepage wells will be found in low-lying areas. Test holes are of great value in locating these areas.

Township 51, Range 26. The topography of this township is definitely morainal in character. In the south the hills are higher and more rugged and pronounced than they are in the north. Some of the larger hills have gentle slopes, and in appearance resemble those that elsewhere are known to have a core of bedrock. One such hill trends northeast across section 18. To the north of it the country is lower but still rolling, the hills becoming more pronounced again along the northern side of the township. The long ridge east of Hillmont cuts across section 36.

The township is everywhere covered by drift varying in thickness from a few feet, as at Hillmont, to more than 90 feet on SW. section 6. Wells at Hillmont have encountered a fine-grained impervious shale below the boulder till. These shales belong to the Lea Park formation and are exposed in railroad cuts both east and west of town. From regional information it is believed that the Ribstone Creek formation, which overlies the Lea Park shale, is present on the higher land, and as it contains several sand members it is an important source of good water. The exact position of the boundary between these two formations has not been defined, but it follows an approximate diagonal line from section 19 to section 1. The Ribstone Creek sands may also underlie section 36 to the northeast, and, if so, the elevation of the contact between the two formations is about 1,880 feet and prospects of encountering this sand in the southwest part of the township are, therefore, very good.

The water supply is derived principally from wells in the glacial drift. Their depths vary from 10 to 92 feet, with only one more than 45 feet deep. The elevations of the water horizons on the higher land to the south range from 1,919 to 1,946 feet. As this area is very hilly, and the surface deposits are morainal, and as the wells are shallow it is not possible that the aquifer is continuous, but, nevertheless, chances of finding water elsewhere in the area at the same elevation are reasonably good. Furthermore, as this is the area underlain by the Ribstone Creek sand a lower horizon in this formation may serve as a good aquifer should a larger supply of water be required. Nothing is known of the texture of the sand, however, and the supply will greatly depend upon its effective porosity.

To the north of this area the water supply must come from the drift. The land here is lower, and so are the elevations of the aquifers. At Hillmont, where the drift is thin, water is obtained in a gravel overlying Lea Park shale at a depth of 10 feet. A well dug by Rutherford Brothers at Hillmont is reported to yield a good supply of water at 37 feet, at an elevation of 1,825 feet. To the west the drift is thicker, and the chances for water are much better. The contact between the drift and shale should not be overlooked as a possible water source owing to the impervious nature of the shale. The spring on NW. section 32 at an elevation of 1,875 feet may indicate the base of the drift at this point.

Township 51, Range 27. The main topographic feature in this area is Big Gully Creek, which trends diagonally across the township from the northwest corner. Southwest of this valley the country is a gently rolling plain marked by several east-west ridges, indicating small

recessional moraines. Northeast of the valley the typical morainal topography of the township to the east continues as far west as section 14. Here the hills of boulder till end, and to the north and west sand, now blown into dunes, forms a plain that occupies a considerable area.

Beneath the glacial deposits of sand, silt, clay, and boulder till is the bedrock, consisting of flat-lying beds of fine sedimentary clays and sands. The latter are part of the Ribstone Creek formation, which is underlain by the fine clays or shales of the Lea Park formation. Erosion prior to glaciation removed the sandy beds from most of the township, leaving only remnants of the lower beds on the higher land. The only natural outcrop in the township is one of sandstone exposed on the north side of the valley in section 9 at an elevation of 2,010 feet. As sandstone outcrops on the north bank, it seems logical to expect that it underlies the drift on the south bank, especially as the valley is glacial to post-glacial in origin. This, however, is not true for the whole area, as several dry holes have been drilled on section 4 indicating an absence of sand below the drift. This may infer a narrow drainage channel cut through into the shale or it may be due to the lack of sand in a fairly large area south of the gully. It is thought, however, that Ribstone Creek sand underlies almost the entire area south of the valley and on the north side as far west as section 14, including sections 10, 11, 12, 13, and 24. The remaining part to the northwest is underlain by shale, and is roughly outlined by the sandy area.

The water supply within the township is obtained chiefly from sands and gravels of glacial origin. In the morainal district to the southeast the wells are shallow, with two exceptions, and a good supply is obtained at a depth of less than 45 feet between elevations of 1,930 and 1,960 feet. Two wells, on sections 23 and 24, drilled a thick deposit of glacial-lake clays and silts, and encountered water in a sand presumably also of lake origin at elevations of 1,907 and 1,909 feet respectively. Owing to the thickness of the lake deposits in these two wells it is suspected that the lake in which these sediments were laid down occupied a fairly large area. The lake deposits are covered by a later boulder till, which may contain sand or gravel aquifers on the higher land to the south where otherwise the Ribstone Creek sands have been eroded away. To the west and north the land surface is lower, and the boulder till is not the most important source of water.

In the sandy area north of Big Gully Creek Valley water is obtained in sand at depths of less than 30 feet. The aquifers occur at elevations of from 1,854 to 1,906 feet, depending largely on the surface elevation of the well. Boulder till underlies the sand on the east side. Where the till is mostly clay water may be found in the sand above it, but as the surface of the till is irregular it may be necessary to sink several test holes before a good well is located in a depression where the waters in the sand can accumulate. As previously stated, shale probably underlies the glacial deposits, and digging or drilling into it is not recommended. However, there should be no need for deep drilling, as shallow wells should yield the necessary supply. In a sandy area such as this the run-off is small, and a large part of the precipitation enters the water-bearing sands.

On the south side of the valley the water supply constitutes a serious problem for some of the farmers. Several holes have been drilled on section 4 without striking a water-bearing sand. The drift deposit does not offer the same possibilities as it does on the north side of the gully, and it, therefore, becomes necessary to seek water at depth, and a knowledge of the underlying strata becomes very useful. On section 6 water is obtained in the Ribstone Creek sand at elevations of 1,886 and 1,876 feet. This sand is known to thin in this direction, so that the depth to the contact with underlying shale is probably not much lower. On section 18 water occurs at elevations of 1,792, 1,798, and 1,894 feet in what may be two horizons of the same Ribstone Creek sand, but it seems probable that the lower sand bed occurs in the Lea Park shale about 90 feet below the top of the formation. The well drilled on SW. section 4 to a depth of 400 feet did not encounter this sand, which, therefore, appears to be a local deposit and not a continuous aquifer. The higher aquifer, namely at 1,894 feet, probably corresponds to that found to the south at 1,886 feet, and it seems reasonable to expect good possibilities for water at this horizon within the limits defined for the Ribstone Creek formation. Beyond the limits of these sand beds the contact between the Lea Park shale and drift may yield sufficient water, especially if there happens to be some sand or gravel present in the glacial deposits. The higher aquifers in the drift have very limited lateral extent, and for this reason it is almost impossible to predict their occurrence and water possibilities.

Township 51, Range 28. This township is a strip of country about three-quarters mile wide adjoining the meridian. Records are limited to only three wells, two of which obtain their water from glacial material, and the third from Ribstone Creek sand. Water conditions are very similar to those in the township immediately to the east, but the deep well on section 12 has a somewhat higher elevation than similar wells to the south and north. This may be due to a greater thickness of the sand than in the other localities. The sand is very fine and causes some trouble, as it runs freely into the well and plugs it.

Township 52, Range 25. Saskatchewan River forms the eastern boundary of the municipality in this township. It has a valley about 200 feet deep in which the floor is almost entirely occupied by the stream bed. The upper banks of drift are fairly steep, whereas the lower parts, or those where the channel has cut into bedrock shale, are formed of a series of slumps or slides. Bentonite layers in the shale act as gliding surfaces and thereby prevent the formation of steep banks. Terraces, many of which are covered with a silt deposit, are well developed along certain sections of the river. A deep ravine cuts across sections 19, 20, and 21, and provides drainage from an area east of Greenstreet Lake. It was formed by the overflow waters from this lake shortly after the retreat of the ice. In the southwest part of the township the large northwest-trending ridge covered with boulder till occupies about 4 square miles. The rest of the area is covered with a light sandy soil. The origin of these light soils can be attributed to the early waters of Saskatchewan River, which left a deposit of silt on its terraces and flood-plains, and also to deposition from the

glacial waters that formed the outwash plain to the north. Boulder till underlies these light sandy soils of fluvio-glacial origin. The surface deposit of drift is underlain by the Lea Park shale except in the high area to the southwest where Ribstone Creek sands are thought to be present. The contact between the two formations is at an elevation of about 1,880 feet, and as all the land to the north is at a lower elevation than this there is very little probability of the Ribstone Creek sand being present. On section 2 a well struck shale at an elevation of about 1,800 feet. The thickness of the drift here is 50 feet, which may be a fair average for the flat stretch of land along the river.

The water supply for the township is obtained from wells less than 24 feet deep and averaging 15 feet, and the elevations of their aquifers vary from 1,812 to 1,850 feet, with one well on section 5 at 1,918 feet. This well is on the higher ridge of boulder clay and within the area mapped as underlain by Ribstone Creek sand. Owing to the shallow nature of the wells and lack of complete logs, it does not seem advisable to try to correlate them on the elevations of their aquifers alone, although, within local areas, the elevations of the water-table have definite limits. In the northwest part of the township these elevations range from 1,834 to 1,847 feet; in the central part, in sections 9, 10, 14, and 16, they range from 1,812 to 1,825 feet; and in sections 2 and 3 they rise again to 1,840 and 1,852 feet.

As the drift is underlain by impervious bedrock shale, water must be located in the drift. Owing to the sandy nature of the surface soil and the large amount of sand in the upper 25 feet of drift, it seems reasonable to expect that a good supply of water will be obtained within this depth as long as the annual rainfall remains normal, and deeper digging may reveal other water horizons in the glacial deposits. Drilling into the underlying shale is not recommended.

In the southwest corner of the township, where Ribstone Creek sand is believed to underlie the drift, deeper wells are recommended, and water should be encountered above an elevation of 1,880 feet.

Township 52, Range 26. Greenstreet Lake now occupies a depression in the southwest corner of the township, and it is thought to have had an outlet to Saskatchewan River through a broad valley to the northeast. This valley cuts across a long, large ridge that parallels the Saskatchewan and separates Patmores Hill on the north from the ridge to the south. The ridge to the south is covered with a morainal deposit, but is thought to have a core of bedrock. This may also be true of Patmores Hill, but with it is associated a large amount of outwash gravels and smaller hills that have definite morainal characteristics. These hills, trending west and northwest from the main hill, formed a barrier large enough to cause a large north bend in Saskatchewan River.

The land in the vicinity of Greenstreet Lake and along the low land to the northeast is light to sandy. To the east of Patmores Hill, on sections 27, 34, and 35, are coarser deposits of outwash sands and gravels that have been deposited by stream action, and that seem to grade into the finer sands and silts of the flat country to the south. The

higher land both north and south of the valley previously referred to is covered with a boulder till that, in places, is extremely rocky, especially in the northwest part of the township.

The water supply is obtained mainly from shallow wells in the glacial drift. A well on section 36, drilled to a depth of 168 feet, obtained a good supply of water at 108 feet, but has been abandoned owing to the poor quality of its water. As no sand lens is known to occur in the bedrock shale at this elevation it is possible that the water comes from an horizon at the base of the drift. Most of the wells obtain water in the upper part of the drift, but the possibilities of encountering a lower water-bearing horizon at greater depth are good. On the sandy area adjoining Greenstreet Lake and the valley to the east the wells are in a surface deposit of sand. The water is not under pressure, and a lowering of the water-table will thus be reflected in the wells. The outwash gravel deposits on sections 25, 26, 35, and 36 grade into sand deposits to the south and likewise form a good water horizon at shallow depths. In section 36 the elevation of the aquifer is 1,864 feet, and on section 24 it is 1,845 feet. The slope of these outwash sands and gravels is, therefore, to the southeast. The water possibilities to the northwest and southeast are not as easily predicted because there are no known extensive sand deposits in the glacial drift. The thickness of the drift may be greater, but the sand and gravel beds occur as irregular deposits at various horizons, and in many places may be missed altogether in digging a well. The wells dug in this area to date are shallow and water has been obtained with considerable ease, indicating that there is considerable sand and gravel in the upper part of the morainal deposit, and other sand beds may be encountered at various levels down to the base of the drift. Drilling into the underlying shale is, however, not recommended. A water-bearing sand in the bedrock may overlie the shale on the high ridge south of the valley, and, if present, should be encountered at an elevation of about 1,800 feet.

Township 52, Range 27. The topography of this township is characterized by fairly large hills with small lakes occupying the depressions. The largest of these hills is several miles long, extending through sections 17 and 20. It, as well as the smaller hills to the north, is covered with boulder till. The sandy area that extends west from Greenstreet Lake is on the whole very hilly, the hills there being composed of bedded sands and silts, part of which are wind blown. Some of the larger hills may be remnants of a much more extensive sandy deposit that now occurs in a basin extending south and west from Greenstreet Lake. The chain of lakes in the southwest part of the township has an outlet at high water into Big Gully Creek, and represents the only well-developed drainage system in the township.

The township is divisible roughly into two areas covered with surface deposits of different types. Boulder till forms the large hill in sections 17 and 20 and occupies a strip about 2 miles wide across the northern part of the township. This represents a moraine, and has the characteristic features of such a deposit. The other area lies to the south

and occupies the rest of the township. The surface deposit here is a sand and sandy soil. The sand was at one time laid down under water, either as a shallow water deposit in a lake or as a delta deposit, and has since been modified greatly by wind action. It is very probable that boulder clay underlies the sand, as indicated by some of the well records. The drift deposit is believed to be underlain by the marine shales of the Lea Park formation, except in the long ridge in sections 17 and 20 where sands of Ribstone Creek age are thought to occur. This exception is based on the record of one well on SW. section 20, where black sand was encountered at a depth of 104 feet.

Shallow wells, of which only two are deeper than 30 feet, yield the water supply. In the northern part of the township the elevations of the aquifers are between 1,857 and 1,888 feet, which is relatively uniform for a morainal topography. The presence of water in these wells at a uniform level indicates considerable sand and gravel in the upper part of the boulder till. On the north-south ridge extending from sections 17 and 20 the elevations of the aquifers are higher, except for the deep well on SW. section 20, which is believed to be in the Ribstone Creek sand. On NW. section 18 in a well with a depth of 32 feet, shale was encountered at a depth of 28 feet or an elevation of 1,907 feet. Near by a dry hole was bored to a depth of 136 feet. At 100 feet a granitic boulder was encountered above bedrock shale. The bottom of the drift in this hole is at an elevation of 1,835 feet, which is below the water horizon on section 20. If the information cited above is correct, a water sand should be found at an elevation of 1,875 feet where the bedrock is present above this level. The possibilities of a water horizon in this sand lie within an area as outlined by the slope of the hill.

In the sandy area to the south the water-table lies at a very shallow depth. The wells are less than 30 feet deep and have elevations between 1,861 and 1,874 feet. In section 22 the elevations are somewhat lower at 1,838 and 1,832 feet. Lower horizons will undoubtedly be found at the base of the glacial drift.

Township 52, Range 28. This is a very narrow strip east of the 4th meridian. The same conditions exist here as in the west part of tp. 53, rge. 27.

Township 53, Range 25. The part of this township lying within Britannia municipality is an area of about 8 square miles west and south of the bend in Saskatchewan River. This stream is in a valley more than 200 feet deep and occupies the floor except on section 9 where there is a large flat terrace on the west side about 25 feet above water level. On either side of the river banks the country is rolling and boulders are numerous, especially on the ridges. It appears that the morainal deposit of boulder clay has suffered erosion, thereby concentrating the boulders on the surface.

So far as can be determined all wells obtain their water supply from surface materials. The wells range in depth from a few feet to 22 feet, except for one 100 feet deep on SE. section 17, which is also in glacial drift. The two wells on section 5 have about the same water level, at

1,832 and 1,838 feet respectively. The spring on SE. section 5, at an elevation of 1,852 feet, is reported to emerge from the top of the blue clay. Several springs farther north along the river bank are at about the same elevation, so that there appears to be an eastern slope to the underlying impervious bed. It does not seem at all probable that this impervious bed is shale, as a well on SE. section 17 at an elevation of 1,757 feet is believed to be in glacial material. From this information the following generalizations can be made: the upper 25 feet of drift contains sand beds that yield a fair amount of hard water; about 80 feet below this horizon there is the possibility of another water-bearing bed; and the prospects of obtaining water in the shale are so uncertain that drilling deeply into it is not recommended.

Township 53, Range 26. The part of this township in Britannia municipality lies to the south and east of a large bend in Saskatchewan River. The deflexion of the stream was caused by a thick, hilly deposit that blocked the former course of the river. The deposit trends northerly and forms part of the large moraine that parallels the river. East of this northern extension of the moraine is an outwash deposit of considerable size, on sections 2 and 3. River terracing is shown in the double bend of the river. On sections 5 and 6 a fairly large flat, formed during the early stages of the river, is now about 100 feet above the present stream bed, and on sections 22 and 23 an old stream channel connected with the Saskatchewan appears to mark an early watercourse of the river.

The water supply is obtained from shallow dug wells, only two of which are more than 30 feet deep. These wells are in glacial drift, which contains the only water-bearing material above the impervious shale of the Lea Park formation. The thickness of the drift is not known, but is thought to be in excess of 100 feet.

The levels of the aquifers in this township vary with the nature of the deposit in which they occur, the only area that can be expected to show any uniformity being that of the outwash plain on sections 1, 2, and 3. The aquifers of the two wells on section 3 have elevations of 1,867 and 1,862 feet at depths of 30 and 25 feet respectively. Elsewhere in this plain the water level is expected to vary only slightly from these elevations, except for a gradual dip to the east. Pockets of sand and gravel may be encountered at shallow depths on the moraine to the west, but the distribution is probably irregular and the supply of water obtained will be in direct proportion to the size of the sand body. On section 15 water was struck below blue clay at a depth of 40 feet and elevation of 1,857 feet. This level corresponds very closely with that of the school well on section 13, and it appears probable that the morainal country paralleling the river has a sand horizon at about this level that should prove to be a good source of water. On the river terraces previously referred to water will be obtained at shallow depths in sands and gravels laid down by the river, but owing to the greater depth of erosion on these terraces the drift and river deposits are comparatively thin and the wells themselves will be shallow, as no water is to be expected in the underlying shales.

The spring on SE. section 24 at an elevation of 1,736 feet may indicate the top of the shale at that locality.

Township 53, Range 27. This township is a triangular area of rolling country south of North Saskatchewan River. Gumbo Hill, which is one of the larger hills south of the river, has its eastern end in sections 7 and 8. It is an erosional remnant, as higher beds stratigraphically are present in the hill than beneath the surrounding plain. Drift is not thick on the hill, and ledges of sandstone are exposed on the southern side towards the western end in Alberta. The other hills paralleling the river are part of a small recessional moraine.

The drift is underlain by Lea Park shale, except at the eastern end of Gumbo Hill in section 7 where the higher Ribstone Creek sands are believed to be present. No outcrops of the sandstone were noticed on this hill in Saskatchewan, but in Alberta a sandstone ledge has an elevation of approximately 1,950 feet. This ledge is believed to be near the base of the Ribstone Creek formation, and if so only that part of the ridge where the bedrock surface is above 1,950 feet in elevation can be expected to yield water in the bedrock sand. The drift does not appear to be thick as several wells have reached bedrock shale at depths ranging from 25 to 40 feet. On SE. section 6 a well encountered a deposit of lake clay that closely resembled shale but was separated from the water-bearing sand by a layer of boulder clay. The elevation of the aquifer is 1,938 feet, and so far as can be determined it is in glacial material. The extent of this lake deposit is difficult to determine, as it is overlain by boulder till and other more recent deposits.

The water supply in this area is not as good as it is farther south, for the drift thins towards the river and lacks suitable sands. Digging into the shale, below an elevation of 1,875 feet, is not considered advisable, and prospecting for water should be confined to the sand and gravel deposits in the drift. Important seepage supplies may also collect at the contact between the drift and the shale, especially where sand or gravel deposits immediately overlie the shale and where depressions in the shale surface permit the accumulation of water.

Township 53, Range 28. This is a narrow strip cut off on the west by the 4th meridian. Conditions are the same as the west side of Tp. 53, rge. 27.

ANALYSES OF WATER SAMPLES FROM RURAL MUNICIPALITY OF BRITANNIA NO. 502, SASKATCHEWAN.

No.	1/4 Sec.	Tp.	Rge.	Depth in feet	Total dis- solved solids	Constituents as Analysed					Total Hardness	Constituents as Calculated in assumed Combinations					Source of Water		
						Ca	Mg	Na	SO4	Cl.		Alk.	CaCO3	CaSO4	MgCO3	MgSO4		Na2CO3	Na2SO4
1	SW 2	50	26	245	1220	107	59	256	484	43	505	268		199	10		705	71	Ribstone Creek
2	NW 5	50	26	160	1880	222	111	200	910	21	470	470	115		550		676	35	" "
3	SE 30	50	26	74	760	114	48	91	193	13	465	285		151	25		256	21	" "
4	SW 2	50	28	185	1300	64	55	317	697	68	255	160		80	158		844	112	" "
5	NW 24	51	26	44	1420	179	100	128	488	53	555	447		91	366		289	87	Lea Park
6	NE 12	51	28	155	1740	200	74	274	771	17	575	500		63	277		813	28	Ribstone Creek
7	SE 2	52	25	74	7240	243	155	1775	4543	61	285	285	439		758		5350	100	Lea Park
8	NW 20	52	26	32	1180	150	100	62	574	28	285	285	122		495		136	46	Glacial
9	SW 20	52	27	104	960	29	15	297	271	23	465	73		52		350	401	38	Ribstone Creek

4695

WELL RECORDS—Rural Municipality of Britannia No. 502, Saskatchewan.

WELL No.	LOCATION					TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE		PRINCIPAL WATER-BEARING BED			CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
	¼	Sec.	Tp.	Rge.	Mer.				Above (+) Below (-) Surface	Elev.	Depth	Elev.	Geological Horizon				
1	NW	3	50	25	3	dug	12	2037	- 10	2026	12	2025	glacial	soft		D.	Poor supply in sand
2	SW	4				"	12	2052	- 4	2048	12	2040	"	hard		D.	Poor supply
3	NE	5				bored	48	2041	- 47	1994	48	1993	"	"		D.	Poor supply in sand
4	SW	5				dug	30	2072			30	2042	"	"		D.S.	Good supply in sand
5	NE	6				"	12	2014	- 8	2006	12	2002	"	"		D.S.	Good supply in clay
6	SW	7					50	2125	- 47	2078	50	2075	"	"		D.	Good supply in sand
7	NW	10				drilled	80	2082			80	2002	"	"		D.S.	Good supply
8	SW	16				dug	40	1997	- 22	1975	40	1957	"	soft		D.S.	Good supply in clay
9	SE	16				"	18	2027	- 15	2012	18	2009	"	hard		D.S.	Good supply in sand
10	SW	20				bored	20	1980	- 16	1964	20	1960	"	"		D.S.	Good supply in sand
11	SE	25					27	2001	- 21	1980	27	1974	"	"		D.S.	Good supply in sand
12	NW	32				drilled	84	2048	- 64	1984	84	1964	"	"		S.	Poor supply in sand
1	NE	1	50	26	3	drilled	232	2090			232	1858	Ribstone Creek	hard		D.S.	Good supply
2	SE	1				"	65	2111	- 27	2084	65	2046	"	"		D.S.	Good supply in black sand
3	SW	2				"	245	2119	-225	1894	245	1874	"	"		D.S.	Good supply in black sand
4	SE	3				"	234	2136	-223	1913	234	1902	"	"		D.S.	Good supply in black sand
5	NW	3				"	238	2115			238	1877	"	"		D.S.	Good supply
6	NE	4					30	2109	- 26	2083	30	2079	glacial	"		D.S.	Good supply
7	NW	5				drilled	160	2032			160	1872	Ribstone Creek	"		D.S.	Good supply in black sand
8	SW	5				"	140	2017	-137	1880	140	1877	"	"		D.S.	Good supply
9	NE	6				"	150	2027			150	1877	"	"		D.S.	Good supply
10	SE	6				bored	35	2023	- 23	2000	35	1988	glacial	"		D.S.	Good supply
11	NW	9				drilled	72	2123			72	2051	"	"		D.S.	sufficient
12	SW	10				"	243	2135			243	1892	Ribstone Creek	"		D.S.	Good supply
13	SW	15				dug	35	2095	- 23	2072	35	2060	glacial	"		D.S.	Good supply
14	SE	15					35	2014	- 33	1981	35	1979	"	"		D.S.	Good supply
15	NE	15					80	2010	- 60	1950	80	1930	"	soft		D.S.	Insufficient
16	SE	16					30	2069	- 26	2043	30	2039	"	hard		D.S.	Good supply
17	SW	16					50	2096	- 46	2050	50	2046	"	"		D.S.	Good supply
18	SW	17					30	2055	- 26	2029	30	2025	"	"		D.S.	Sufficient
19	SE	17				drilled	200	2082			200	1882	Ribstone Creek	"		D.S.	Good supply
20	NE	18				bored	37	2038			37	2001	glacial	"		D.	Good supply
21	SE	18					25	1890			25	1865	"	"		D.S.	Good supply
22	NE	19					30	1937			30	1907	"	"		D.S.	Good supply in silty sand
23	NE	20				bored	30	1911	- 27	1884	30	1881	"	"		D.S.	Good supply
24	SW	20				dug	30	1957			30	1927	"	"		D.	Good supply
25	SW	21				bored	60	1975	- 30	1945	60	1915	"	"		D.S.	Good supply in gravel
26	NW	22				"	30	1978	- 15	1963	30	1948	"	"		S.	Good supply
27	SW	24				dug	12	1977	- 6	1971	12	1965	Ribstone Creek	hard		D.S.	Good supply in sandstone 1 foot thick
28	SE	30				"	74	1960			74	1886	"	"		D.S.	Good supply
29	NW	32				"	30	1959			30	1929	glacial	"		D.S.	Good supply
30	SW	32				drilled	66	1955			66	1889	"	soft		D.S.	Good supply
31	NE	32					24	1951			24	1927	"	hard		D.S.	Good supply

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WELL RECORDS—Rural Municipality of Britannia No. 502, Saskatchewan.

WELL No.	LOCATION					TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE		PRINCIPAL WATER-BEARING BED			CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
	¼	Sec.	Tp.	Rge.	Mer.				Above (+) Below (−) Surface	Elev.	Depth	Elev.	Geological Horizon				
1	SW	1	50	27	3	bored	130	2020	- 50	1970	130	1890	Ribstone Creek	soft		D.S.	Good supply
2	NE	4				drilled	80	2012			80	1932	glacial	hard		D.	Insufficient, water in fine sand
3	SW	5				bored	125	2037	- 75	1962	125	1912	Ribstone Creek	"		D.S.	Good supply
4	SW	6				dug	55	2055	- 20	2035	55	2000	glacial	"		D.S.	Good supply
5	SE	6				bored	100	2057	- 70	1987	100	1957	Ribstone Creek	"		D.S.	Good supply
6	SW	8				"	100	2033	- 70	1963	100	1933	" "	"		D.S.	Good supply
7	NW	8				"	97	2038	- 57	1981	97	1941	" "	"		D.S.	Good supply
8	SE	9				"	50	2023	- 46	1977	50	1973	glacial	"		D.S.	Good supply
9	NE	10				"	47	2051	- 39	2012	47	2004	" "	"		D.S.	Good supply
10	NW	10				"	90	2037	- 40	1997	90	1947	" ?	"		D.S.	Good supply
11	SW	10				"	50	2037	- 24	2013	50	1987	" "	"		D.S.	Good supply
12	NE	11				"	34	2049			34	2015	" "	"		D.S.	Good supply
13	NW	13				dug	18	2019	- 17	2002	18	2001	" "	soft		D.	Good supply
14	SW	13				"	10	1985	- 8	1977	10	1975	" "	"		D.	Good supply
15	SW	14				"	35	2035			35	2000	" "	hard		D.S.	Good supply
16	NE	15				"	28	2054	- 14	2040	28	2026	" "	"		D.S.	Good supply
17	SW	15				bored	93	2042			93	1949	" ?	"		D.S.	Good supply
18	SE	16				drilled	120	2046			120	1926	Ribstone Creek	"		D.S.	Good supply in sand
19	SW	16				"	175	2043	- 40	2003	175	1868	" "	"		D.S.	Sufficient
20	SE	17				"	145	2040	- 40	2000	145	1895	" "	"		D.S.	Good supply
21	SW	17				dug	12	2033	- 10	2023	12	2021	glacial	soft		D.S.	Good supply
22	NW	19				"	34	2053	- 24	2029	34	2019	" "	hard		D.	Good supply
23	SW	19				"	18	2017	- 12	2005	18	1999	" "	soft		D.S.	Good supply
24	NE	19				drilled	90	2046	- 60	1986	90	1956	glacial ?	hard		D.S.	Good supply
25	NW	21				dug	30	2058	- 18	2040	30	2028	" "	"		D.S.	Good supply
26	NE	22				"	28	2058			28	2030	" "	"		D.S.	Good supply
27	NE	23				dug	30	2080	- 26	2054	30	2050	" "	"		D.S.	Good supply
28	SW	23				"	22	2079	- 15	2064	22	2057	" "	"		D.S.	Good supply
29	NW	23				bored	50	2062	- 30	2032	50	2012	glacial	hard		D.S.	Good supply. Water in silty sand
30	SE	24				dug	13	1994	- 10	1984	13	1981	" "	"		D.S.	Good supply
31	NW	24				bored	36	2028	- 30	1998	36	1992	" "	"		D.S.	Good supply
32	SE	26				"	48	2070			48	2022	" "	"		D.S.	Good supply
33	NW	26				dug	40	2028	- 35	1993	40	1988	" "	"		D.S.	Good supply. Water in gravel
34	NW	26				"	40	2050	- 37	2013	40	2010	" "	"		D.S.	Good supply
35	NW	28				"	35	2031	- 32	1999	35	1996	" "	"		D.S.	Good supply
36	SW	28				drilled	98	2079	- 70	2009	98	1981	" "	"		D.	Limited supply in sand
37	NE	28				bored	35	2058	- 32	2026	35	2023	" "	"		D.S.	Good supply in gravel
38	SE	29				drilled	110	2049	-107	1942	110	1939	Ribstone Creek	"		D.	Good supply in gravel
39	SW	30				dug	20	2044	- 19	2025	20	2024	glacial	"		D.	Sufficient
40	NE	32				drilled	200	2032			160	1872	Ribstone Creek	"		D.S.	Limited supply
41	NW	32				bored	86	2003			86	1917	glacial	"		D.S.	Present supply small. Shallow well 18' gives main supply.
42	NW	32				drilled	196	2053						"		D.S.	Good supply in fine sand
43	NW	32				"	146	2053						"			Dry hole in shale. Bottom 1857.
44	SE	34				"	265	2083						"			Dry hole. Bottom in shale at 1907.
45	SE	35				dug	16	1895	- 10	1885	16	1879	Ribstone Creek	hard		D.S.	Good supply. Shale below 130 feet.
46	SE	36				bored	70	1999	- 60	1939	70	1929	Ribstone Creek	"		D.S.	Good supply. Shale below 130 feet.

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(#) Sample taken for analysis.

WELL RECORDS—Rural Municipality of Britannia No. 502., Saskatchewan.

WELL No.	LOCATION					TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE		PRINCIPAL WATER-BEARING BED			CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
	¼	Sec.	Tp.	Rge.	Mer.				Above (+) Below (−) Surface	Elev.	Depth	Elev.	Geological Horizon				
1	SW	1	50	28	3	drilled	90	2088	- 60	2028	90	1998	Ribstone Creek	hard		D.S.	Good supply
2	SW	2				"	185	2115			185	1930	" "	"		D.	Good supply. Sask. Co-op. Creamery
3	NE	11				"	90	2111	- 60	2051	90	2021	glacial	"		D.S.	Good supply.
4	SW	11				"	1970	2117			160	1957	Ribstone Creek	soft		N.	Water also at 94 feet. Lloydminster Oil and Gas Co. Well No. 1.
5	NW	11				"	117	2111	- 80	2031	117	1994	glacial	hard		D.S.	Water also at 94 feet. Lloydminster Oil and Gas Co. Well No. 1.
6	SW	12				"	2005+	2105			160	1945	Ribstone Creek			N.	Water also at 65 feet. Lloydminster Oil and Gas Co. Well No. 2.
7	NW	13				dug	18	2053	- 16	2037	18	2035	glacial	hard		D.	Limited supply in sand
8	NW	14				drilled	103	2108	- 60	2048	103	2005	"	"		D.S.	Good supply in sand
9	SE	15				"	100	2106	- 60	2046	100	2006	"	"		D.S.	Good supply in gravel
10	NE	23				"	185	2064	- 26	2038	185	1879	Ribstone Creek	"		D.S.	Good supply in sand
11	NW	25				"	120	2069	- 30	2039	120	1949	" "	"		D.	Good supply
12	SE	25				dug	30	2047	- 29	2018	30	2017	glacial	"		D.S.	Sufficient in gravel
13	NE	27				bored	128	2086	- 60	2026	128	1958	"	"		D.S.	Good supply in gravel
14	SE	35				dug	40	2063	- 36	2027	40	2023	"	"		D.S.	Good supply
15	NE	36				"	35	2062	- 31	2031	35	2027	"	alkaline		D.	Good supply
1	SE	1	51	25	3	dug	10	1928	7	1921	10	1918	glacial	hard		D.S.	Good supply
2	SE	2				"	12	1894	10	1884	12	1882	"	"		D.S.	" "
3	SE	14				"	82	1906	68	1838	82	1824	"	"		D.S.	" "
4	NW	18				"	30	1908	25	1883	30	1878	"	"		D.S.	Good supply in fine sand
5	NW	21				"	18	1954	15	1939	18	1936	glacial sand	soft		D.S.	Good supply of water in sand
6	NW	22				"	16	1855	8	1847	16	1839	" "	soft		D.S.	Good supply
7	NW	27				bored	75	1965	70	1895	75	1890	" "	"		D.S.	Glacial lake clay above sand
8	SE	28				"	28	1880			28	1852	" "	hard		D.	Indian Creek School
9	NE	33				dug	60	1941	58	1883	60	1881	Ribstone Creek	soft		N.	Well abandoned due to poor casing.
1	SE	4	51	26	3	dug	24	1952			24	1928	glacial	hard		D.S.	Good supply
2	SW	6				bored	92	2014	- 70	1944	92	1922	glacial gravel	"		D.S.	Good supply. Some water at 16 feet
3	NW	7				dug	33	1979	- 30	1949	33	1946	glacial	"		D.S.	Limited supply in fine sand
4	NW	8				"	24	1964	- 20	1944	20	1944	"	"		D.S.	Good supply in fine sand
5	SW	9				"	18	1941	- 14	1927	18	1923	"	"		D.S.	Good supply in sand and silt
6	SE	8				"	20	1940	- 15	1925	20	1920	"	"		D.S.	Limited supply
7	NW	10				"	22	1955			22	1933	"	"		D.S.	Limited supply in sand
8	NE	13				"	30	1911	- 17	1894	30	1881	" sand	"		D.S.	Good supply. Small amount of water at 20-
9	NW	14				"	18	1938			18	1920	" gravel	"		D.S.	Good supply.
10	NW	18				"	20	1921	- 16	1905	20	1901	" sand	"		D.S.	Good supply.
11	SE	21				"	18	1894			18	1876	" sand	"		D.S.	Good supply
12	NE	22				"	30	1928	- 25	1903	30	1898	" gravel	"		D.S.	Limited supply
13	NW	22				"	40	1900	- 28	1872	40	1860	" "	"		D.S.	Good supply. Blue clay below gravel
14	SE	22				"	20	1939	- 15	1924	20	1919	" sand	"		D.S.	Good supply. Blue clay below gravel
15	NW	24				"	44	1902	- 40	1862	44	1858	Lea Park Shale	"		D.S.	Soakage through and on top of Lea Park Shale.
16	SW	25				"	35	1862									Digging in Lea Park Shale, not completed. Small soakage at 20 feet.
17	SW	28				"	40	1911			40	1871	glacial sand	"		N.	Good supply from well 12' deep in sand.
18	SE	30				"	10	1914	- 8	1906	10	1904	" "	"		D.S.	Good supply. Dry hole 40' in blue clay
19	NW	32				"	10	1885			10	1875	" "	"		D.S.	Good supply. Spring close to buildings
20	NW	34				"	21	1874	- 11	1863	21	1853	glacial	"		D.S.	Good supply.
21	SW	36				"	12	1925	- 9	1916	12	1913	glacial sand	"		D.S.	Good supply

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WELL RECORDS—Rural Municipality of Britannia No. 502, Saskatchewan.

WELL No.	LOCATION					TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE		PRINCIPAL WATER-BEARING BED			CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
	¼	Sec.	Tp.	Rge.	Mer.				Above (+) Below (-) Surface	Elev.	Depth	Elev.	Geological Horizon				
1	NE	1	51	27	3	dug	40	1978	- 30	1948	40	1938	glacial	hard		D.S.	Good supply in sand and gravel
2	SW	3				bored	96	2042			96	1946	"	"		D.S.	Yields 2 barrels per day.
3	SW	4				drilled	400	2044									Dry hole - Hauls water.
4	NW	4				bored	98	2040	- 90	1950	98	1942	Black sand	"		S.	Sufficient but comes in slowly
5	NW	6				dug	36	2074	- 32	2042	36	2038	Glacial sand	"		D.S.	Good supply. Another well 45 feet.
6	SW	6				drilled	100	1972			186	1886	Ribstone Creek	"		D.S.	Good supply
7	NE	6				"	100	1976			100	1876	Ribstone Creek	"		D.S.	Two dry holes 200' and 337 feet
8	SE	6				dug	27	1966	- 20	1946	27	1939	glacial	"		D.S.	Good supply
9	SW	9				bored	83	2046	- 50	1996	83	1963	Glacial sand	"		D.S.	Good supply
10	NW	10				"	58	2021			42	1979	glacial	"		D.S.	Limited supply. Water also at 28 feet
11	SW	10				dug	10	1936	- 4	1932	10	1926	Glacial sand	"		D.S.	Good supply
12	SW	11				"	40	1979	- 30	1949	40	1939	Glacial gravel	"		D.S.	Good supply
13	SW	12				"	30	1989	- 25	1964	30	1959	glacial	"		D.S.	Limited supply. Soakage well for additional supply.
14	SE	12				drilled	112	2035			112	1923	Ribstone Creek	"		D.S.	Limited supply in black sand
15	NE	13				bored	42	2012	- 38	1974	42	1970	Glacial sand	"		D.S.	Sufficient but supply limited
16	SW	14				dug	30	1960			30	1930	glacial	"		D.S.	Several similar wells necessary for total supply.
17	NW	18				bored	103	1968	- 30	1938	103	1865	Ribstone Creek	"		D.S.	Good supply
18	NW	18				drilled	249	1968	-120	1848	176	1792	Lea Park	"		N.	Limited. Casing thought to have shut off main flow.
19	NE	18				"	165	1954	-100	1854	165	1789	Lea Park	"		D.S.	Good supply - water soft when first dug
20	SE	18				bored	73	1954			60	1894	Ribstone Creek	"		D.S.	Good supply. Dry hole 200 feet.
21	NW	21				dug	25	1931	- 23	1908	25	1906	Glacial sand	soft		D.S.	Limited supply
22	NW	23				"	12	1918	- 7	1911	12	1906	Glacial sand	"		D.S.	Good supply
23	SW	24				"	40	1986	- 38	1948	40	1946	Glacial sand	hard		D.S.	Limited supply
24	NW	24				bored	30	1909	- 15	1894	30	1879	Ribstone Creek	"		D.S.	Good supply in sand
25	SW	25				dug	15	1896	- 5	1891	15	1881	Glacial sand	soft		D.S.	Good
26	SW	30				"	12	1973	- 10	1963	12	1961	glacial	soft		D.S.	Good
27	NE	31				"	36	1890	- 30	1860	36	1854	Glacial sand	"		D.	Stock watered in lake.
28	SW	31				"	30	1903	- 25	1878	30	1873	"	hard		D.S.	Good supply
29	NW	32				"	20	1877	- 17	1860	20	1857	Glacial sand	"		D.	2 barrels per day
30	NW	33				"	26	1903			26	1877	"	"		D.S.	2 barrels per day- Prov. Elev. Co.
31	SE	34				bored	40	1952	- 30	1922	29	1923	"	"		D.S.	Good supply
32	NW	35				dug	18	1904			18	1886	glacial	"		D.S.	Good supply
33	SE	35				"	45	1952	- 25	1927	45	1907	Glacial gravel	"		D.S.	Good supply
34	SW	36				bored	35	1944	- 11	1933	35	1909	Glacial sand	"		D.S.	Good supply in glacial lake. Silt and sand
1	NE	12	51	28	3	drilled	155	2082			155	1927	Ribstone Creek	hard		D.S.	Yields 4 bbls. for each pumping.
2	NW	24				bored	35	2048	- 20	2028	35	2013	glacial	"		D.S.	Original level reached in 15 minutes.
3	SW	36				dug	14	1918			14	1904	"	"		D.S.	Good supply in blue sand
																	Good supply in firm sand

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WELL RECORDS—Rural Municipality of Britannia No. 502, Saskatchewan.

WELL No.	LOCATION					TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE		PRINCIPAL WATER-BEARING BED			CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
	¼	Sec.	Tp.	Rge.	Mer.				Above (+) Below (-) Surface	Elev.	Depth	Elev.	Geological Horizon				
1	SE	2	52	25	3	dug	12	1852	10	1842	12	1840	Glacial	hard		D.S.	Good supply in sand and gravel
2	SE	2				bored	74	1852	44	1808	74	1778	Lea Park Shale	hard, alka.		N.	Very poor water. Not used
3	NE	3				dug	20	1870	10	1860	20	1850	Glacial sand	soft		D.S.	Good supply
4	SE	4				"	20	1834	15	1819	20	1814	Glacial sand	soft		D.S.	Good supply
5	NW	5				"	12	1930	10	1920	12	1918	Glacial	hard		D.S.	Good supply in sand and gravel. Stock watered in lake.
6	NW	9				"	12	1834	10	1824	12	1822	"	"		D.S.	Good supply. Soft when first dug.
7	SE	9				"	12	1836	10	1826	12	1824	Glacial sand	"		D.S.	Sufficient supply of water
8	NW	9				"	20	1832			20	1812	Glacial	"		D.	Poor supply. School well.
9	NE	10				"	12	1835	9	1826	12	1823	Glacial sand	"		D.S.	Good supply
10	NE	14				"	24	1849	20	1829	24	1825	Glacial	"		D.S.	Good supply in sand and gravel
11	SW	16				"	20	1840	16	1824	20	1820	"	"		D.S.	Good supply in sand and clay
12	SW	30				"	12	1859	9	1850	12	1847	Glacial sand	"		D.S.	Good supply. Sand point used for house well.
13	NE	30				"	22	1856			22	1834	Glacial	"		D.S.	Limited supply in sand
14	NE	31				"	8	1849	4	1845	8	1841	Glacial sand	soft		S.	Good supply
15	SE	32				"	12	1850	10	1840	12	1838	Glacial	hard		D.S.	Good supply in sand and gravel
16	SE	2	52	26	3	dug	27	2113	23	2090	27	2086	Glacial	hard		D.S.	Limited supply in sandy clay
17	NW	2				"	25	2109	15	2094	25	2084	"	"		S.	Good supply
18	NW	9				"	8	1823	6	1817	8	1815	"	"		D.S.	Good supply
19	NW	14				"	25	1790			25	1765	"	"		D.S.	Good supply - Reported hard pepper and sand above water.
20	NW	16				"	45	1970	30	1940	45	1925	Glacial	"		D.S.	Good supply in sand
21	NE	16				"	22	1865	10	1855	22	1843	"	"		D.S.	Good supply in sand
22	SW	18				"	12	1850			12	1838	"	"		D.	
23	SE	18				"	12	1840	10	1830	12	1828	"	"		D.S.	Good supply in sand
24	NW	20				bored	32	1938	20	1918	32	1906	"	"		D.S.	Good supply in sand and gravel
25	SE	20				dug	34	1952			34	1918	"	"		D.S.	Poor supply
26	NE	21				"	24	1878	12	1866	12	1866	"	"		D.	Limited supply in gravel. School well
27	NW	22				bored	30	1878	5	1873	30	1848	"	"		D.S.	Good supply
28	SW	22				dug	15	1865	12	1853	15	1850	"	"		D.S.	Good supply in gravel
29	NE	23				"	14	1869	10	1859	14	1855	"	soft		D.S.	Good supply in sand
30	NW	24				"	30	1875	28	1847	30	1845	"	hard		D.	Good supply in sand. Similar well for stock.
31	SE	28				"	8	1870	6	1864	8	1862	"	soft		D.S.	Good supply in sand.
32	SW	32				"	20	2063	9	2054	9	2054	"	hard		D.S.	Limited supply in gravel
33	NW	33				"	10	1785			10	1775	Lea Park	"		D.S.	Good supply in what appears to be Lea Park shale.
34	SW	33				"	22	1940	10	1930	22	1918	" "	"		D.S.	Good supply in sand
35	SW	34				"	25	1873	20	1853	25	1848	" "	"		D.S.	Good supply in sand
36	NE	36				"	168	1876			108	1768	" "	"		D.S.	Well abandoned due to poor quality of water. Present supply from 12' well.

NOTE—All depths, altitudes, heights and elevations given above are in feet.

(D) Domestic; (S) Stock; (I) Irrigation; (M) Municipality; (N) Not used.
(#) Sample taken for analysis.

WELL RECORDS—Rural Municipality of Britannia No. 502, Saskatchewan.

WELL No.	LOCATION					TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE		PRINCIPAL WATER-BEARING BED			CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
	¼	Sec.	Tp.	Rge.	Mer.				Above (+) Below (-) Surface	Elev.	Depth	Elev.	Geological Horizon				
1	SW	2	52	27	3	dug	30	1904			30	1874	glacial	hard		D.S.	Good supply in sand
2	NW	3				"	20	1896	- 4	1892	20	1876	"	"		D.S.	Good supply in gravel
3	SE	4				"	20	1887	- 16	1871	20	1867	"	soft		D.S.	Good supply in sand
4	NE	7				bored	20	1933	- 15	1918	20	1913	"	hard		D.S.	Limited supply in clay
5	SE	8				"	30	1941	- 28	1913	30	1911	"	"		D.S.	Limited supply in gravel. Dry hole 80' in blue clay.
6	NE	9				dug	25	1886			25	1861	"	soft		D.S.	Good supply in gravel
7	SW	16				"	28	1975	- 23	1952	28	1947	"	hard		D.	Good supply in gravel. Stock well 16 feet deep.
8	SE	17				"	27	1961	- 20	1941	20	1941	"	soft		D.S.	Limited supply above what appeared to be shale.
9	NW	18				bored	22	1935	- 16	1919	22	1913	"	"		D.S.	Limited supply above shale.
10	NW	18				"	36	1935									Dry hole, glacial boulder at 100 feet.
11	SW	20				"	104	1977	- 60	1917	104	1873	Ribstone Creek	"		D.S.	Good supply in black sand.
12	SE	20				"	30	1949	- 10	1939	30	1919	glacial	hard		D.S.	Good supply in sandy clay
13	NE	21				dug	20	1877	- 14	1863	20	1857	"	"		D.S.	Good supply in gravel
14	SW	22				"	25	1863	- 16	1847	25	1838	"	"		D.	Good supply. Stock watered in lake.
15	NE	22				"	16	1848	- 10	1838	16	1832	"	"		D.	Good supply. Stock watered in lake.
16	NE	28				"	30	1891	- 8	1883	30	1861	"	"		S.	Good supply
17	SE	31				"	30	1890	- 25	1865	30	1860	"	"		D.S.	Good supply in sand
18	NE	34				"	12	1900			12	1888	"	"		D.S.	Sufficient supply of water in clay.
19	SE	34				bored	66	1933	- 62	1871	66	1867	"	"		D.S.	Limited supply in sand and gravel
20	SW	36				dug	20	1893	- 18	1875	20	1873	"	"		D.S.	Limited supply in sandy clay.
	SW	25	52	28	3	dug	16	1851			16	1935	glacial	hard		D.S.	Limited supply in sand below blue clay.
	SE	5	53	25	3	dug	3	1835			3	1832	glacial	hard		D.S.	Spring. Flows continuously
	NW	5				"	22	1860			22	1838	"	"		D.S.	Good supply in sand.
	NE	6				"	16	1885			16	1869	"	soft		D.S.	Limited supply in sand.
	NW	9				"	16	1670	- 12	1658	16	1654	"	hard		D.S.	Good supply in sand.
	NW	16				"	12	1673	- 10	1663	12	1661	"	"		D.S.	Good supply in sandy clay
	SE	17				"	100	1857			100	1757	"	"		D.S.	Good supply.
	NW	17				"	18	1896			18	1878	"	"		D.S.	Good supply.
	NE	3	53	26	3	dug	25	1887	- 22	1865	25	1862	glacial	hard		D.S.	Good supply in gravel
	SW	3				"	30	1897	- 15	1882	30	1867	"	"		D.S.	Good supply in gravel and sand
	SE	4				"	14	1969	- 12	1957	14	1955	"	"		D.S.	Good supply in gravel and sand
	SW	5				"	30	1780	- 20	1760	30	1750	"	"		D.S.	Water supply in fine sand
	SW	13				"	60	1912			60	1852	Glacial sand	"		D.	Good supply. School well.
	NW	14				"	15	1832	- 12	1820	15	1817	glacial	"		D.S.	Limited supply in sand
	NE	15				"	40	1897	- 20	1877	40	1857	"	"		D.S.	Good supply
	SE	22				"	15	1839			15	1824	"	"		D.S.	Good supply in sand
	SE	24				"	4	1740			4	1736	"	"		D.S.	Spring, large continuous flow.

NOTE—All depths, altitudes, heights and elevations are in feet.

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(#) Sample taken for analysis.

WELL RECORDS—Rural Municipality of Britannia No. 502., Saskatchewan.

WELL No.	LOCATION					TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE		PRINCIPAL WATER-BEARING BED			CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
	¼	Sec.	Tp.	Rge.	Mer.				Above (+) Below (-) Surface	Elev.	Depth	Elev.	Geological Horizon				
	NW	3	53	27	3	dug	18	1913	- 13	1900	18	1895	glacial	hard		D.S.	Good supply in fine sand
	SW	3				"	18	1924	- 14	1910	18	1906	"	soft		D.S.	Good supply in sandy clay
	NW	5				"	25	1891			25	1866	"	hard		D.S.	Good supply on top of shale. Dry hole 102 feet in Lea Park shale.
	SE	5				"	12	1875	- 6	1869	12	1863	"	"		D.S.	Good supply in sand
	SE	6				"	32	1970			32	1938	"	"		D.S.	Limited supply in fine sand.
	SE	7				bored	57	1897	- 30	1867	57	1840	"	"		D.S.	Good supply in sand above shale.
	SW	7				dug	18	1914	- 14	1900	15	1899	"	"		D.S.	Good supply in sand veins in shale.
	NW	9				"	25	1934			25	1909	"	"		D.S.	Soakage on top of Lea Park shale.
	SE	9				"	16	1881	- 13	1868	16	1865	"	soft		D.S.	Good supply in sand
	SW	10				"	40	1899			40	1859	"	hard		D.S.	Limited supply of water on top of shale.
	SE	1	53	28	3	dug	12	2001			12	1989	glacial			D.S.	Limited supply. Dry hole over 100 feet
	NW	13				"	12	1870	- 10	1860	12	1858	"	soft		D.S.	Limited supply.

NOTE—All depths, altitudes, heights and elevations given above are in feet.

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(#) Sample taken for analysis.