CANADA

DEPARTMENT OF MINES

AND

TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 241

GROUND-WATER RESOURCES OF THE RURAL MUNICIPALITY OF ROUND VALLEY, NO. 410 SASKATCHEWAN

Records collected by C. O. Hage

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

OTTAWA

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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. Warren 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 concering 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 substracting 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 Cretaceious 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:

Formation	Character	Thickness 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.	050 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 Czar. 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 Paleland 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 Coulée 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 Coulée 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 Coulée, 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 Coulée 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 acquifer, 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 Coulée. 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 Coulée. 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 Coulée 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 Coulée 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 (SO4), 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 purposes[1]. Sodium sulphate is less

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

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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 soft, to very hard, and can be classified according to the following system[2]:

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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 degress 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 reaction[1].

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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:

Salts	SE. sec. 16, tp.38, rge. 21	NE. sec. 3, tp.39, rge. 25,	SW. sec. 7, tp.37, rge.24,	SE. sec. 21 tp. 38, rge.23
$CaCO_3$	73	18	53	35
$CaSO_4$	-	-	-	-
$MgCO_3$	52	14	45	38
$MgSO_4$	-	-	-	-
Na_2CO_3	297	679	464	562
Na_2SO_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_2CO_3	-	-	-
Na_2SO_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.sec10, tp.35, rge.20,
$CaCO_3$	73	73	73	198	108	90
$CaSO_4$	-	-	-	-	-	-
$MgCO_3$	38	38	38	52	69	52
$MgSO_4$	-	-	-	-	-	-

Na_2CO_3	129	119	129	11	106	125
Na_2SO_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 anlayses 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 illustratetsome of the different types of water from this formation:

Salts	Se.sec. 11, tp. 46, rge. 28	Ind.Agent Little Pine I.R.	SW.sec. 24, tp. 46, rge. 21	NE.sec. 36, tp. 43, rge. 18	Se.sec. 26. tp. 43, rge. 18	NE.sec. 36. tp. 41, rge. 24	NW.sec. 22. tp. 42. rge. 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_2CO_3	217	392	-	283	592	129	196
Na_2SO_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	1,230	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 ROUND VALLEY, NO. 410, SASKATCHEWAN

Physical Features

The eastern half of this municipality is flat prairie land, quite in contrast with the western part where areas of low relief are found around a number of lakes. At Fire and Farewell Lakes, elevations 1,895 and 1,911 feet respectively, a depressed area with flat bottom lands is surrounded by steep embankments as much as 250 feet high. Even at the lowest point in these embankments the elevation of any possible outlet for the lakes is more than 100 feet above the present lake levels, and no drainage course beyond is sufficiently low to have acted as an outlet. It is possible, however, that the original outlet has been dammed by glacial drift and that earlier drainage channels are now filled in. No satisfactory explanation can, however, be offered for such depressed areas as that in which Fire Lake occurs. Seagram Lake farther north is also at the relatively low elevation of 1,902 feet, and is bounded on the northeast by an escarpment 150 to 200 feet high. This escarpment marks the boundary between prairie land to the north and east and an area of sandy land and sand dunes to the southwest, in which the surface is very uneven and dotted with small lakes.

Geology

Although most of the municipality is covered by a thick mantle of drift, a few outcrops of Pale or Variegated Beds occur in the west on the embankments north of Fire Lake and southeast of Seagram Lake, and on the east side of the valley about half a mile west of Unity. Much information has also been acquired in drilling for oil and gas in the vicinity of Unity. The surface material in these wells is obviously drift, and water is found at several horizons, but particularly at depths of 234 and 253 feet in Vera Oilfields No. 2 well. These horizons are believed to occur in the Ribstone Creek formation, which may continue in the well to a depth of 295 feet. The thickness of the Ribstone Creek in this area is unknown, but is probably less than in the Ribstone area to the northwest, where it is thought to be about 180 feet. Also the thickness of Grizzly Bear shale, which overlies Ribstone Creek beds, is less than 100 feet. Consequently, the upper part of the well may have penetrated a few feet of Variegated Beds, with its basal sandstone equivalent of the Birch Lake formation, but it is probable that these strata have been replaced by glacial drift. Thus in the low area around Vera and to the northwest there are probably no Variegated or Pale Beds, although outcrops of these occur on the embankment to the southeast of Seagram Lake at an elevation of 1,984 feet. In a railroad cut a short distance east of Vera is a small, rather obscure outcrop of brownish sand and sandstone that may perhaps be Birch Lake beds, but this formation is apparently thinning out and may here be represented only by a sandstone at the base of the Variegated Beds. Very little information is available about this formation, as it has not been recognized in the Vera deep wells. It is concluded, therefore, that various formations may underlie the drift in different parts of this municipality.

Water Supply

East of the escarpment that marks the eastern boundary of the Seagram Lake depression, and to the south and east of the Fire Lake depression, many of the prairie wells obtain their water from sand or gravel beds in the glacial drift. In most areas these beds vary considerably in altitude, and the depth at which they will be encountered in any locality cannot be predicted. In many places where difficulty has been experienced in obtaining a sufficient supply of water from shallow wells, drilling has been carried down to the underlying bedrock formations. In the Unity area water has been found at several horizons within the Pale Beds, and to the northwest, in the Vera area, where the surface elevation is much lower, water in abundance has been found in the Ribstone Creek formation where the surface elevation is less than 2,000 feet. Several wells from this deeper horizon flow. Apparently there are two water horizons in the Ribstone Creek formation; these were encountered in Vera Oil fields No. 2 well, at depths of 234 and 253 feet respectively. Water from the upper of these horizons is fresh; that from the lower is too saline to be used for drinking. A flowing well, with gas, on NE. sec. 36, tp. 41, rge. 24, obtains water with a slight soda content, presumably from the upper of these two horizons. Gas also occurs in several springs along the edge of the embankment north of Seagram Lake. The lower, slightly salty water of the Ribstone Creek aquifer has also been reached by a well on SW. sec. 7, tp. 41, rge. 24. The inference that this salt water horizon is widespread would appear to be justified by the fact that flowing wells with gas have been obtained from it on SE. sec. 30, tp. 38, rge. 22, south of Muddy Lake, and on SE. sec. 10, tp. 35, rge. 20, at Tramping Lake Park.

Township 40, Range 22. In the northeast corner of this township a gravel bed has been encountered in wells on sections 24, 25, 34, and 36 between elevations of 2,100 and 2,110 feet. This is the continuation westward of a buried outwash sand and gravel deposit that occurs in the range to the east at elevations between 2,110 and 2,140 feet. It would appear that the outwash deposit thins out and disappears in this township, or that it may actually come to the surface owing to the lower altitude of the country to the west. Below it, at elevations principally from 2,040 to 2,090 feet, is a zone of sand deposits in the drift in which many wells obtain water. The sand bodies are, apparently, irregularly distributed but fairly abundant within this zone, so that there is a reasonable chance of striking one in any well. However, in places where no water is encountered in the drift, deeper wells into the underlying Pale Beds are almost certain to obtain water in quantity and, usually, soft in character. Several wells have been drilled into the Pale Beds, but appear to have found little uniformity in the elevations of the aquifers, a condition somewhat surprising in view of the fact that the water-bearing sands of the Pale Beds undoubtedly have considerable lateral extent. If the information on these wells is correct it means there are several aquifers in the Pale Beds in this township.

Township 40, Range 23. Two types of wells are present in this township, those that obtain water from the drift and those that obtain it from sands in the Pale Beds underlying the drift. Those in the drift occur at no particular level, but appear to be from irregularly distributed sand or gravel beds. The depth of the drift is unknown, but in one well, on SW. section 13, gravel occurs at a depth of 90 feet or an elevation of 2,049 feet. This is probably near the base of the drift, although definite information is lacking. Below the drift several wells have obtained water in the Pale Beds.

Township 40, Range 24. In this township Fire and Farewell Lakes occupy a deep depression, with outcrops of Pale Beds occurring on the steep banks on the northwest and south margins. The elevation of Fire Lake is 1,895 feet, whereas the elevation in the southeast part of the township is above 2,200 feet. Undoubtedly the water horizons above the level of the lakes are being drained, especially toward the edge of the depression, and hence some difficulty has been experienced in obtaining a water supply. At the southwest end of Fire Lake, on section 18, a spring issues from the Pale Beds at an elevation of 1,833 feet, and one well, 285 feet deep on SE. section 13, obtains water from the Pale Beds from the same level as Fire Lake. At a distance from the depressed area some wells obtain water from beds of glacial sand and gravel, but these, besides being irregularly distributed, are not as abundant in this township as elsewhere, and in SW. section 14 much difficulty has been experienced in obtaining an adeouate supply. The only hope of finding water at this location appears to be from wells drilled into the Pale Beds. As the elevation here is above 2,150 feet, it is 320 feet to the level of Fire Lake where the well on section 13 obtained its water supply. Some of the sands in the Pale Beds are very fine, and in a well 218 feet deep on NW. section 32, heaving sand plugged the well and prevented the water from entering the well casing. For such wells, therefore, the minimum casing should be 6 inches, although in many instances where no sand difficulty has been encountered wells have been successfully completed with 2-inch casing.

Township 41, Range 22. An outwash, glacial sand and gravel deposit, now buried in the drift, occurs in the southwest of this township at elevations of 2,100 and 2,110 feet, the same as in the township immediately south. This deposit probably rises to the northeast, but data were not collected on many wells in this township owing to the fact that they are all too shallow to reach the bedrock beneath the drift. This outwash deposit, however, has proved the source of water supply for many wells. Above it and below it, scattered irregularly through the drift, are local beds of sand and gravel that supply water to a number of wells. These beds show no uniformity of level, but within certain elevations in this area, 2,030 to 2,090 feet, seem to be more abundant than elsewhere. Their presence, however, cannot be predicted at any specific location, and the amount of yield must be dependent to a large extent on the size and porosity of the sand bed encountered.

Township 41, Range 23. Nearly all wells in this township, of which records were collected, obtain their water from sand and gravel beds that occur in a zone in a drift between elevations of 2,060 and 2,090 feet. Other water-bearing sands are irregularly distributed through the drift at higher elevations, and water is obtained from these in some wells. Only one well, 285 feet deep on NE. section 4, is known to have reached the Pale Beds and obtains water from a sand in these beds at an elevation of 1,908 feet. As this well is only a mile from Akerlund Lake, which has a surface elevation of 1,912 feet, no other, higher aquifers in the Pale Beds would be expected to be productive, especially in proximity to the escarpment, in some places 200 feet high, that cuts across the west and southwest part of the township. Other wells far from the escarpment face might obtain water at higher elevations in the Pale Beds, although it is difficult to predict to what extent sands in the Pale Beds are sealed by a cover of glacial materials along the face of the escarpment. It would appear that there is an abundant water supply in sands in the Pale Beds, but, presumably, wells will need to be 250 to 300 feet deep to obtain it.

Township 41, Range 24. In this township, south of Vera, several deep wells were drilled for oil and gas, and all of them struck slightly salty, artesian water. In Vera Oilfields No. 2 well fresh water was encountered at a depth of 234 feet, or an elevation of 1,700 feet, and salty water at a depth of 253 feet, elevation 1,681 feet. Southwest of these deep wells, and covering a central area of the township in a northeasterly direction, the land surface is sandy, and in part is occupied by sand dunes. It is probable that shallow wells to the base of this sand would give water, if such wells were needed. Most of the land, however, is unsuited for agriculture. In the extreme southwest of the township the land is less sandy and is farmed. A well on SW. section 7 was drilled to a depth of 535 feet and apparently encountered the same salty water horizon as is present in the Vera deep wells. It is very improbable, however, that this water comes from the bottom of the well at an elevation of 1,572 feet, as the elevation of the similar water horizon at Vera is 1,681 feet. It is thought that the well encountered the water at some distance above the bottom, as regional evidence does not support the amount of southwest dip that otherwise would be indicated.

Another well, on NE. section 36, drilled to a depth of 248 feet, obtains flowing water with gas at an elevation of 1,704 feet. The water contains some soda and is not salty. It probably comes from an horizon corresponding to the depth of 234 feet in Vera Oilfields No. 2 well, and as such is believed to be derived from a sand in the Ribstone Creek formation.

In the well owned by Mr. Davidson, on SW. section 7, the water rises to an elevation of 2,007 feet. In the well on the farm of Mr. Gathie, on NE. section 36, it is known that the water will rise at least 40 feet above the surface, or to an elevation of at least 1,992 feet, with the extreme limit not determined. It is probable that 2,007 feet, the elevation to which the water rises in Mr. Davidson's well on SW. section 7, would be about the limit. Consequently, any well with surface elevation less than 2,000 feet in this area and drilled to the same water horizon should flow.

Township 42, Range 22. All wells for which records are available in this township obtain their water from sand and gravel beds irregularly scattered through the drift. It is probable that at greater depth water can be obtained from sand of the underlying Pale Beds, although the drift is probably more than 170 feet deep, as one well, on NE. section 4, bored to a depth of 146 feet did not penetrate it and was still considerably above the base, according to information from other wells. It is probable, however, in this as in other areas, that toward the base of the drift there will be a zone containing many sand or gravel beds at elevations ranging from 2,030 to 2,090 feet, and that most of the wells drilled to these depths will find a sufficient supply of water.

Township 42, Range 23. All wells in this township, as indicated by available records, obtain their water at what is thought to be a considerable distance above the base of the drift. The latter contains many sand and, less commonly, gravel beds widely scattered at various elevations, so that at any location the prospects of encountering one of these beds in a well are fairly good. It is probable though that here, as in the range immediately east, there is a lower zone of porous beds of a similar type that would yield water if the upper part of the drift failed to do so. Probably the well on SW. section 17, which reaches the aquifer at an elevation of 2,089 feet, is in the top of this zone, which, from regional information, is believed to be about 60 feet thick, with its base at approximately the base of the drift. As in this township surface elevations reach 2,250 feet, it may be that the drift in these higher places is more than 200 feet thick. Wells drilled below it into the sands of the underlying Pale Beds would be expected to yield water.

Township 42, Range 24. In this township Seagram Lake, with an elevation of 1,902 feet, occupies a considerable area. To the north and east of it, within this township, is an embankment 150 to 200 feet high, along the edge of which, north of Seagram Lake, there are several springs with gas seepages. The springs issue at elevations slightly below 2,000 feet from what may be the base of the drift, as outcrops of Pale or Variegated Beds along this same embankment, on NE. sec. 25, tp. 41, rge. 24, occur at an elevation of 1,984 feet. On the prairie level above the embankment the wells obtain their water from sands irregularly scattered through the drift, several wells obtaining their supply within a zone of sands between elevations of 2,070 and 2,100 feet. One dry hole, 70 feet deep, on NW. section 35, did not reach this level. The artesian water found in a well on NE. sec. 36, tp. 41, rge. 24, is undoubtedly present throughout this township, but wells drilled to it would not be apt to flow unless the surface elevation was less than 2,000 feet.

ANALYSES OF WATER SAMPLES FROM RURAL MUNICIPALITY OF ROUND VALLEY, NO. 410, SASKATCHEWAN

No.	¼ Sec.	Tp.	Rge.	Depth in feet	Elev. of Aquifer	Total dissolved solids	Constituents as Analysed						Total Hardness	Constituents as Calculated in assumed Combinations							Source of Water
							Ca	Mg	Na	SO_4	Cl.	Alk.		$CaCO_3$	$CaSO_4$	$MgCO_3$	$MgSO_4$	Na_2CO_3	Na_2SO_4	NaCl.	
115	NE 18	40	22	160	1966	1040	7	7	376	16	125	670	30	18		24		660	24	206	Pale Beds
116	SW 25	40	23	220	1926	1640	7	7	436	406	71	470	30	18		24		448	602	117	Pale Beds
114	SW 3	40	24	300	1977	1660	222	76	231	730	21	580	1050	555		21	346		668	35	Variegated Beds ?
113	NE 18	40	24	Spring	1933	1760	93	52	436	554	29	775	560	232		180		348	820	48	Pale Beds
58	SW 7	41	24	535	1572	3200	79	15	1153	41	1735	270	100	198		52		11	61	2863	Ribstone Creek ?
54	SE 22	41	24	253	1681	3460	29	11	1266	37	1840	230	90	73		38		119	55	3036	do
53	SE 25	41	24	272	1680	3840	29	11	1228	37	1775	240	135	73		38		129	55	2929	do
55	NE 36	41	24	248	1704	3120	29	11	1136	41	1360	240	110	73		38		129	61	2690	do
52	NE 4	41	23	285	1908	1420	207	89	133	611	15	515	1100	515	3		441		380	25	Glacial Drift?
35	SW 13	42	22	108	2065	2240	336	144	138	1205	17	475	2100	475	496		712		422	28	Glacial Drift
56	NW 22	42	23	554	1690	1900	50	28	613	1041	43	425	600	125		97		196	1541	71	Ribstone Creek
57	SW 22	42	24	Spring	1955	700	157	59	11	189	9	440	600	393		39	223		16	15	Variegated Beds?

RECORD OF WELLS IN RURAL MUNICIPALITY OF ROUND VALLEY, NO. 410, SASKATCHEWAN

Well No.	LOCATION ¼ Sec.	Tp.	Rge.	Mer.	Type of Well	Depth of Well Ft.	Altitude of Well	WATER LEVEL Above (+) or Below (-) Surface	Elev. Above Sea Level	PRINCIPAL WATER-BEARING BED Depth Ft.	Elev.	Geol. Horizon	Character of Water	Use to which Water is put.[x]	Yield & Remarks
1	N.W. 5	40	22	3	Bored	45	2093	-30	2063	45	2048	Pale beds	Hard	D.S.	Good supply, coal at 40'.
2	S.E. 7	40	22	3	"	20	2085			20	2065	Fine sand	"	D.	Poor " dry hole 80'.
3	N.W.10	40	22	3	Drilled	120	2130	-50	2080	120	2010	(Pale Beds			Sand trouble.
4	N.W.11	40	22	3	Dug	36	2118	-33	2085	36	2082	(Sand	Soft	D.S.	Sufficient
5	S.W.13	40	22	3	"	30	2113		Low	30	2083	Glacial Clay	Hard Alk	D.	"
6	S.E.16	40	28	3	"	18	2082	-15	2067	18	2064			D.S.	"
7	N.W.17	40	22	3	Bored	70	2090	-30	2060	70	2020		Hard	"	"
8	S.E.18	40	22	3	Drilled	185	2100			185	1915	Pale beds	Soft		Abundant, Unity Power House.
9	N.E.18	40	22	3	"	328	2088	-20	2068	254	1834	" "	" dark	D.	" Unity School
10	N.E.18	40	22	3	"	123	2089	-60	2029	123	1966	" "	Hard	D.S.	Sufficient
11	N.E.20	40	22	3	Bored	80	2130	-40	2090	80	2050	Clay		S.	Poor supply
12	S.W.24	40	22	3	Dug	25	2128		Low	25	2103	Glacial sand	Hard	D.	" "
13	N.W.25	40	22	3	"	22	2127	-10	2117	22	2105	" gravel	"	D.S.	Waters 30 head stock.
14	N.E.30	40	22	3	Bored	128	2126			128	1998	Pale beds	Soft	"	Good supply Coal above water
15	N.E.31	40	22	3	"	45	2120	-28	2092	45	2075		Hard	"	Sufficient
16	S.E.32	40	22	3	Dug	35	2119	-30	2089	35	2084	Glacial sand	"	"	"
17	N.W.33	40	22	3	"	30	2126			30	2096	" "	"	D.	Good supply
18	S.W.34	40	22	3	"	22	2127	-19	2108	22	2105	" gravel	"	D.S.	Sufficient
19	S.W.36	40	22	3	Bored	38	2146	-25	2121	38	2108	" "	"	"	Good supply
1	S.W. 3	40	23	3	Bored	105	2150	-50	2100	105	2045		Hard	D.	Sufficient
2	S.E. 5	40	23	3	"	60	2223			60	2163	Glacial sand	"	D.S.	Limited
3	N.E. 5	40	23	3	"	35	2196	-25	2171	35	2161	" "	"	"	Sufficient
4	N.W. 7	40	23	3	Bored	62	2198	-47	2151	62	2136	Gl. gravel	Hard	D.S.	Good supply
5	N.E.13	40	23	3	Drilled	140	2096	-14	2082	98	1998	Pale beds	Soft	D.(Hospital)"	" mud spring 98 - 140'
6	S.W.13	40	23	3	Bored	90	2139	-60	2079	90	2049	Glacial gravel	Hard	D.S.	Sufficient
7	N.E.20	40	23	3	Dug	12	2146	- 9	2137	9	2137	"	"	"	"
8	S.W.24	40	23	3	"	40	2101			40	2061	" clay	"	"	Good supply
9	S.W.25	40	23	3	Drilled	220	2146	-100	2046	220	1926	Pale beds	Soft	"	Sufficient
10	S.E.26	40	23	3	"	210	2117	-70	2047	210	1907	" "	"	"	Waters 95 head stock

x.- D.- Domestic, S.- Stock, Alk.- Alkaline, Fe.- Iron.

Well No.															
11	S.E.30	40	23	3	Dug	30	2143	-28	2115	30	2113	Glacial sand	Hard	D.S.	Poor supply
12	N.W.34	40	23	3	Bored	46	2171	-26	2145	46	2125	" "	"		
1	S.E. 1	40	24	3	Bored	120	2269	-95	2174	120	2149	Glacial sand	Hard	D.S.	Sufficient
2	S.W. 3	40	24	3	Drilled	300	2217			240	1977	Pale beds	Soft	"	
3	S.E.13	40	24	3	"	285	2180			285	1895	" "			Sand trouble
4	S.W.14	40	24	3	Bored	115	2157			113	2044	Clay			Supply exhausted
5	N.E.18	40	24	3	Spring		1933					Pale beds	Soft	D.S.	Good supply
6	S.E.24	40	24	3	Bored	107	2157	-60	2097	100	2057	Glacial gravel	"	"	Waters 60 head
7	N.W.29	40	24	3	Dug	24	2148	- 6	2142	24	2124	Sand		"	Sufficient
9	N.W.32	40	24	3	Drilled	218	2143			175	1968	Pale beds			
										218	1925	" "			Plugged with sand
8	S.E.31	40	24	3	Dug	24	2045	-23	2022	24	2021	Clay	Hard	D.S.	Poor supply
1	S.W. 5	41	22	3	Dug	30	2138			30	2108	Glacial clay	Hard	D.S.	Waters 75 head stock
2	S.E. 6	41	22	3	"	44	2118	-20	2098	20	2098	" "	" Fe.	"	
3	S.W.17	41	22	3	Bored	75	2178			75	2103	Blue clay	" Alk.	S.	Sufficient
4	N.E.18	41	22	3	"	85	2174	-60	2114	85	2089	Sand	" Fe.	D.S.	"
5	S.E.24	41	22	3	"	35	2250	-30	2220	35	2215	Glacial sand	"	"	"
6	S.E.25	41	22	3	Dug	41	2256	-35	2221	41	2215	" "	"	"	"
7	S.W.29	41	22	3	"	20	2201			20	2181		Soft		
8	N.E.31	41	22	3	Bored	90	2232±								Dry hole Gl. material
	" "	41	22	3	"	70	2232±			70	2162	Glacial sand	Hard	D.S.	Waters 150 head
9	N.W.32	41	22	3	"	71	2241	-35	2206	71	2170	" "	"	"	
10	N.W.33	41	22	3	Dug	42	2229	-30	2199	42	2187	Coarse sand	" Alk.	S.	
1	N.E. 4	41	23	3	Drilled	285	2193	-40	2153	285	1908	Pale beds	Hard	D.S.	Abundant supply
2	S.W. 9	41	23	3	Bored	40	2203			40	2163	Glacial sand	"	"	Sufficient
3	N.E.10	41	23	3	"	60	2163	-40	2123	60	2103	Blue clay	" Fe.	"	"
4	S.W.14	41	23	3	"	70	2160	-30	2130	70	2090	Clay	" Alk.	S.	Good supply
5	N.W.21	41	23	3	"	100	2190			100	2090	Glacial gravel	"	D.S.	" "
6	N.W.23	41	23	3	"	25	2174	- 6	2168	25	2149	" "	"	"	Sufficient
7	N.E.32	41	23	3	"	70	2138			70	2068	Clay & sand	" Fe.	"	Limited
8	S.E.32	41	23	3	"	66	2162	-44	2118	66	2096	Coarse gravel	"	"	Spring 68' below well
9	S.E.34	41	23	3	"	108	2200	-50	2150	108	2092	Sand	"	"	Waters 160 head stock
1	N.E. 5	41	24	3	Dug	16	2045	- 8	2037	14	2031	Black soil	Hard	D.S.	Sufficient
2	W. 7	41	24	3	Drilled	535	2107	-100	2007	200	1907	Gravel			Small supply
										535	1572		Soft & Salty	D.S.	Water in fine sand.

Well No.																
3	S.E. 8	41	24	3	Dug	16	2034			16	2018	Glacial sand	Hard		S.	Poor supply
4	S.E.22	41	24	3	Drilled	1600	1934	-15	1919	58	1876	Sand				Vera Oilfields No. 2 Well
						Not Completed				140	1794	"	Soft			(drilled in 1935)
										234	1700	Ribstone Creek	Salty			Good supply. Base of Ribstone Creek at
								Flows		253	1681	" "				310 feet, elevation 1634 feet.
5	N.E.36	41	24	3	Drilled	248	1952	+40	1992	248	1704		Soft		D.S.	Large flow, considerable amount of gas.
1	N.E. 2	42	22	3	Dug	38	2200	-30	2170	38	2162	Glacial gravel	Hard		D.S.	Limited
2	S.E. 2	42	22	3	Bored	50	2210	-45	2165	50	2160	" "	"		"	Sufficient
3	S.E. 3	42	22	3	Dug	50	2231	-40	2191	50	2181	" sand	"		"	"
4	N.E. 4	42	22	3	Bored	146	2234									Dry hole in blue clay
5	" " 4	42	22	3	"	42	2234±	-12	2222	42	2192	Glacial gravel	Hard	Alk.	D.S.	Good supply
6	S.W.13	42	22	3	"	108	2173	-20	2153	108	2065	Black sand	"	Fe.	"	" "
7	S.E.14	42	22	3	"	54	2164	-30	2134	54	2110	Gl. sand	"	Alk.	"	Limited
8	S.E.19	42	22	3	"	55	2235	-50	2185	55	2180	" "	"			Poor supply
9	N.W.29	42	22	3	"	90	2203		High	90	2113	" "			S.	" water
10	N.E.36	42	22	3	Dug	25	2086	-10	2076	25	2061		"	Alk.	D.S.	Limited supply
1	S.E. 2	42	23	3	Bored	96	2207			96	2111	Glacial	Hard		D.S.	2 shallow wells at 45 & 50'
2	S.W.10	42	23	3	Dug	42	2180	-40	2140	42	2138	Glacial sand	"		"	Sufficient
3	S.W.15	42	23	3	Bored	80	2232			80	2152	White "	"		"	"
4	S.W.17	42	23	3		32	2121			32	2089		Soft		D.	Limited supply
5	S.E.18	42	23	3	Spring		2081						Hard		D.S.	Flow fills 6" pipe
6	N.W.19	42	23	3	Bored	67	2181	-35	2146	37	2144	Glacial clay	"		"	Waters 50 head of stock
7	N.W.20	42	23	3	Dug	20	2188			[illegible]	2168		"		D.	Poor supply
8	S.E.20	42	23	3	Bored	122	2232	-110	2122	122	2110	Glacial sand	"		D.S.	Sufficient
9	N.E.21	42	23	3	Dug	19	2160			19	2141	" "	"		"	"
10	N.W.22	42	23	3	Bored	103	2246	-34	2212	103	2143	" "	"	Fe.	"	Limited
11	N.W.27	42	23	3	"	90	2234			80	2154	" "	"		"	"
12	N.E.31	42	23	3	"	70	2282	-60	2222	70	2212	" "	"	Fe.	D.	Sufficient
13	N.E.31	42	23	3	"	100	2282			100	2182	" gravel			D.S.	Good supply
14	N.E.33	42	23	3	Bored	50	2171			50	2121	" sand	Hard	Alk.	"	Limited
1	N.W.10	42	24	3	Dug	18	1908	-12	1896	18	1890	Fine sand	Soft		D.S.	Sufficient
2	N.E.20	42	24	3	Bored	86	2160	-78	2082	86	2074		Hard			20 barrels per day
3	S.W.21	42	24	3	Dug	4	2003	0	2003	4	1999		"	Fe.	"	Good supply, Spring
4	S.W.22	42	24	3	"	15	1970	- 7	1963	15	1955	Glacial sand	"	"	"	Sufficient, Spring at 1988'

Well No.															
5	N.E.23	42	24	3	Bored	85	2188	-40	2148	85	2103		Hard	D.S.	Good supply
6	S.W.26	42	24	3	"	90	2186	-40	2146	90	2096	Fine sand	Soft	"	Sufficient. Sand trouble
7	S.E.27	42	24	3	"	107	2203	-80	2123	80	2123	Glacial sand	Hard	"	Limited, spring on farm
8	S.E.29	42	24	3	Dug	70	2147	-60	2087	70	2077	Fine "	Soft	"	Sufficient
9	N.W.34	42	24	3	Bored	50	2232			50	2182		Hard Alk.	"	Limited
10	N.W.35	42	24	3	"	70	2218								Dry hole with gas