CANADA

DEPARTMENT OF MINES

AND

TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 239

GROUND-WATER RESOURCES OF THE RURAL MUNICIPALITY OF PRAIRIE, NO. 408 SASKATCHEWAN

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

OTTAWA
1947

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MINES AND GEOLOGY BRANCH
BUREAU OF GEOLOGY AND TOPOGRAPHY

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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.	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 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 andn3,000 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 PRAIRIE, NO. 408, SASKATCHEWAN

Physical Features

Within this municipality the relief is more than 950 feet, from high hills on the southwest with an elevation above 2,450 feet to North Saskatchewan River in the northeast with an elevation below 1,500 feet. The land surface adjoining the river has been deeply dissected by streams and gullies, giving a local relief, in some areas, of 500 feet in less than a mile. Most of the slopes, however, away from the immediate vicinity of the gullies are gentle, due to the ease with which the bedrock formations beneath the mantle of glacial materials were eroded. An escarpment 200 to 300 feet high cuts across the north part of the municipality, dividing it into a lowland area, south of Battleford and west of North Saskatchewan River, and a highland south of the escarpment face. The escarpment is believed to be an erosion feature.

Geology

Owing to the wide variations in elevations throughout this municipality, several formations are represented in the bedrock beneath the mantle of glacial drift. On the lowland in front or north of the escarpment are outcrops of sands and shales believed to represent the Ribstone Creek formation. Grizzly Bear shales occur along the escarpment face, and are known from one outcrop on sec. 29, tp. 42, rge. 16, in a railroad cut northeast of Porter. To the south of the escarpment the strata are believed to dip southwesterly, so that successively higher beds stratigraphically outcrop in that direction. It is probable that near the escarpment only the equivalents of Variegated Beds are present, but these are overlain by Pale Beds to the southwest. However, no outcrops of these formations appear in this area, so that their character is unknown, though, as they are, apparently, products of continuous sedimentation, it is unlikely that outcrops would serve to distinguish them.

Water Supply

In this municipality the wells on the highland are almost entirely in sands and gravels in the glacial drift, whereas those on the lowland obtain their water almost exclusively from sands in the Ribstone Creek formation. This formation, about 120 feet thick in this area, contains many sand beds, one of the thickest and most massive lying near the top of the formation. The sands provide extensive aquifers, and in this area yield palatable but hard water. On the other hand, the water horizons in the glacial drift have little regularity, and though sand and gravel beds are widely scattered they are limited in extent and usually not thick. Abundant beds of this sort appear to be grouped into a zone probably near the base of the drift and at an average elevation in this municipality of 2,080 feet. A few wells have penetrated this zone without striking a water-bearing bed, but in most places such beds are present though at varying elevations within the zone.

Township 40, Range 16. That part of this township lying south of the Mosquito and Red Pheasant Indian Reserves is relatively elevated land for this part of the country. Some of it has an altitude above 2,400 feet. As wells are normally only sunk to the first aquifer where a supply of water is obtained the water-producing horizons in all the wells in this township are at high elevations. The records of the wells indicate an irregular distribution of sand and gravel beds in the drift, with no continuous aquifer. Under such conditions the discovery of a water-bearing sand or gravel bed is a matter of chance, and a well on NE. section 5 was bored 110 feet without striking an aquifer. Undoubtedly there are scattered gravel and sand beds below the level of the bottom of this well, but their elevations cannot be predicted. The thickness of the drift in this area is unknown, but the base of the drift might, as in other areas, provide a fairly continuous water-bearing horizon. The Pale and Variegated Beds beneath the drift would be expected also to contain water-bearing sands.

Township 40, Range 17. In the southeast part of this township the land slopes toward Keppel Lake which has an elevation of 2,195 feet. It is probable that this lake receives some water from springs from sand or gravel beds in the drift, as a well on NW. section 22 obtains water at an elevation of 2,196 feet; another, on NE. section 21, struck water at 2,202 feet; and a third, on SW. section 27, at 2,194 feet. This aquifer, however, is not widespread, as a well on NW. section 23 apparently penetrated the horizon without obtaining water. All wells in the township obtain water from aquifers irregularly distributed through the drift, but lower water-bearing beds, both in the drift and in the underlying Pale Beds, are undoubtedly present.

Township 40, Range 18. The land surface in the northwest of this township rises above 2,450 feet. The water horizons in the wells are mostly at high elevations, and the sands and gravels that provide the water are irregularly distributed through the drift. Lower water-bearing horizons are probably present both in the drift and in the underlying Pale and Variegated Beds, but no information is available to indicate at what levels such water-bearing beds occur.

Township 41, Range 15. Owing to the proximity of the land in this township to North Saskatchewan River, which lies at an elevation of less than 1,500 feet, the surface is deeply cut by streams and gullies, the maximum relief amounting to 750 feet. Drift covers the entire township, but in places is very thin and the formations underlying it range from Pale Beds at the higher elevations to Lea Park shales at river level. So far as the available records indicate, all the wells obtain their water from aquifers within the glacial drift. The well on NW. section 12 obtains water at a depth of 92 feet or an elevation of 2,083 feet from material reported as "black muck". This is evidently the same kind of material reported from a deep well on sec. 34, tp. 35, rge. 17, in Bushville municipality, at an elevation of 2,047 feet, and from NE. sec. 33, tp. 36, rge. 18, at an elevation of 2,079 feet, in Grandview municipality. These elevations suggest that the material occurs at a definite horizon, although the evidence is not conclusive. Owing to the great relief in the township, different bedrock horizons will be encountered below the drift in various localities, and no generalizations can be made in regard to the depth to possible water-bearing beds in the various formations. In certain areas however, the Ribstone Creek sands must occur at reasonable depths, and these elsewhere yield good supplies of water.

Township 41, Range 17. This is an area of prairie lands of low relief entirely covered by glacial materials in which there are irregularly distributed sand and gravel beds. No widespread aquifers are known within the range of present wells, all of which are less than 100 feet deep. It is highly probable, however, in this as in adjoining townships that other deeper water-bearing horizons occur both in the drift and underlying bedrock formations.

Township 41, Range 18. No well in this township has penetrated the drift, although one is 120 feet deep. The aquifers are discontinuous sand and gravel beds scattered irregularly through glacial clay, and, so far as is known, none of them has any considerable lateral extent. The occurrence of such aquifers is a matter of accident of deposition, and their elevations cannot be predicted. Some wells have, in fact, been drilled to considerable depths without striking any materials sufficiently porous to yield water. It is probable, however, that at greater depths other, water-bearing sands or gravels occur in the drift, the base of which may be nearly 100 feet below the deepest well. Beneath this again sands in the Pale and Variegated Beds should yield water, as they do in other areas.

Township 42, Range 15, Southwest of North Saskatchewan River. Very few records are available from this township, and, although the area is wholly covered by glacial materials, the relief is very considerable, as in the township to the south. Some of the wells obtain their water from sands in the glacial drift, whereas others may obtain it from sands in the bedrock. The information available, however, is too meagre to indicate any widespread uniformity of the aquifers. Two wells, one on NE. section 6 and the other on SE. section 17, get water in quicksand at elevations slightly above 1,900 feet, but it is not known if this is glacial or bedrock sand.

Township 42, Range 16. A northward-facing escarpment crosses the northern part of this township, and elevations to the north and south of it differ by about 300 feet. Sands and shales of probable Ribstone Creek age outcrop on the lowland in road-cuts north of Porter, in tp. 42, rge. 17, and shales containing marine micro-fossils and thought to be Grizzly Bear in age appear in a railroad cut on section 29 of this township. Thus the upland is probably underlain by Variegated and perhaps also Pale Beds, and these would be expected to contain sands capable of holding water, whereas the lowland is underlain by Ribstone Creek sands and shales, except in the northeast corner where these have been completely removed by erosion, leaving only Lea Park shales. The surface deposits, though, are mostly drift, probably thin on the lowland but attaining considerable thickness on the upland. Apparently all wells obtain their water from glacial drift, those on the lowland for the most part in shallow wells.

Township 42, Range 17. The same east-trending escarpment present in tp. 42, rge. 16, also cuts across the central part of this township, dividing it into a northern lowland and a southern upland. The conditions in regard to bedrock beneath the drift are similar to those in tp. 42, rge. 16. It is probable that the water in most of the wells on the lowland comes from sands in the Ribstone Creek formation, whereas it is believed that all the wells on the upland obtain water from irregularly distributed sands in the drift. The thickness of the drift on the upland surface is unknown, but in some parts is probably at least 100 feet deep and may be considerably deeper. A fairly persistent water-bearing horizon appears to occur at elevations of 2,080 to 2,100 feet, and it is possible this is close to the base of the drift.

<u>Township 42, Range 18.</u> The escarpment mentioned in tp. 42, rge. 17, cuts across the northeast corner of tp. 42, rge. 18, leaving a small lowland area within it. Conditions in the township are the same as in the range immediately to the east where the wells obtain water mostly from sands believed to be within the Ribstone Creek formation. On the upland the wells are all in drift materials in which the water-bearing sands and gravels are widely scattered at various elevations. Several wells, however, obtain water from a zone of aquifers between elevations of 2,050 and 2,095 feet, and this zone, as previously mentioned, may have some persistence although the individual aquifers in it are probably quite limited in lateral extent and not very thick. It forms a zone in which water-bearing sands may be expected to occur, but this does not preclude the possibility that in places within it no aquifers may be present. At greater depths water-bearing sands may be expected to occur in the Pale and Variegated Beds.

ANALYSES OF WATER SAMPLES FROM RURAL MUNICIPALITY OF PRAIRIE; No. 408, SASKATCHEWAN

No.	¼ Sec.	Tp.	Rge.	Depth in feet	Elev. of Aquifer	Total dissolved solids	Constituents as Analysed: Ca	Mg	Na	SO_4	Cl.	Alk.	Total Hardness	Constituents as Calculated in assumed Combinations: $CaCO_3$	$CaSO_4$	$MgCO_3$	$MgSO_4$	Na_2CO_3	Na_2SO_4	NaCl.	Source of Water
118	NW 23	40	17	100	2133	2060	336	135	43	943	27	470	1900	470	503		668		80	44	Glacial drift
117	NE 33	40	18	130	2265	2280	358	142	143	1015	24	700	2200	700	265		704		392	40	do
29	NE 34	41	17	35	2154	880	157	52	61	324	7	390	800	390	3		257		173	12	Glacial drift
26	SW 2	42	16	88	2180	520	129	57	55	180	7	480	500	323		132	94		155	12	do
27	SE 9	42	16	80	2104	1260	236	105	4	549	9	450	1200	450	190		519			10	Glacial drift
28	NE 17	42	16	106	2046	1420	265	107	27	595	12	525	1400	525	187		530		59	20	Glacial drift
25	NW 21	42	17	Spring		1260	172	100	77	574	11	395	1200	395	48		495		215	18	do
23	NW 27	42	17	22	1766	11040	365	1020	1025	6367	160	475	3000 +	475	595		5049		2839	264	Glacial clay above shale
24	NW 28	42	17	75	1730	1940	93	33	742	564	168	585	320	233		115		228	1098	277	Ribstone Creek
30	SW 4	42	18	60	2095	2360	293	161	179	1328	36	350	2300	350	520		797		481	59	Glacial drift
20	NW 36	42	18	42	1801	880	64	39	192	262	20	435	500	160		135		121	388	33	Ribstone Creek

RECORD OF WELLS IN RURAL MUNICIPALITY OF PRAIRIE, NO. 408, 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	SW. 1	40	16	3	Dug	14	2350			14	2336	Glacial gravel	Soft	D.S.	Sufficient
2	S.E. 4	40	16	3	Bored	75	2345	-40	2305	75	2270	" sand	Hard	"	"
3	N.W. 5	40	16	3	"	110	2370								Dry Hole
4	S.E.10	40	16	3	"	75	2380			75	2305	"	Hard	"	Limited
5	S.W.14	40	16	3	"	56	2431	-46	2385	56	2375	" sand	"	"	Sufficient
6	S.E.16	40	16	3	"	90	2410	-60	2350	90	2320	" "	"	"	"
7	N.W.16	40	16	3	Dug	12	2400	-8	2392	12	2388	" gravel	"	"	"
8	N.W.19	40	16	3	"	28	2365			28	2337	" "	"	"	"
9	S.E.19	40	16	3	"	22	2375			22	2353	"	" (Alk.)	"	Limited
10	N.E.20	40	16	3	Bored	55	2385	-15	2370	55	2330	" sand	" "	"	Sufficient
12	S.W.23	40	16	3	"	50	2433			50	2383	" "	"	"	"
11	S.W.22	40	16	3	Dug	30	2440			30	2410	" "	"	"	"
1	N.W. 7	40	17	3	Dug	40	2249			40	2209	" gravel	"	"	"
2	S.W.18	40	17	3	Bored	100	2299	-60	2239	100	2199	" sand	"	"	"
3	N.E.21	40	17	3	"	95	2297	-20	2277	95	2202	" "	"	"	"
4	N.W.22	40	17	3	"	95	2291	-25	2266	95	2196	" "	"	"	"
5	N.W.23	40	17	3	"	100	2233	-27	2206	100	2133	" "	"	"	"
6	S.W.23	40	17	3	"	75	2325	-20	2305	75	2250	" "	"	"	"
7	S.W.27	40	17	3	"	95	2289	-23	2266	95	2194	" "	"	"	"
8	S.W.28	40	17	3	Dug	4	2290	+1	2291	4	2286	" gravel	"	"	"
9	S.W.31	40	17	3	Bored	57	2240	-32	2208	32	2208	" sand	"	"	"
10	N.W.33	40	17	3	Dug	21	2331	-14	2317	18	2313	" gravel	"	"	"
11	N.E.34	40	17	3	Bored	67	2266	-9	2257	66	2200	" sand	"	"	"
1	N.E. 1	40	18	3	Dug	20	2225			20	2205	" sand	"	"	"
2	N.E. 4	40	18	3	"	25	2265	-19	2246	25	2240	" "	"	"	"
3	S.W. 6	40	18	3	Bored	50	2205			50	2155	" gravel	"	"	"
4	N.E. 7	40	18	3	Dug	28	2255	-20	2235	28	2227	"	"	"	"
5	N.W.10	40	18	3	Bored	49	2300	-20	2280	49	2251	" "	"	"	"
6	N.E.16	40	18	3	Dug	10	2343	-7	2336	10	2333	"	"	"	"
7	N.W.30	40	18	3	Bored	104	2340	-70	2270	104	2236	" sand	"	"	"
8	S.W.30	40	18	3	"	107	2338			107	2231	"	"	"	"

x.- D.- Domestic, S.- Stock.

Well No.																
9	S.E.24	40	18	3	Bored	80	2288	-73	2215	80	2208	Glacial gravel	Hard	D.S.	Limited	
10	N.W.24	40	18	3	"	92	2331	-88	2243	92	2239	"	"	"	Sufficient	
11	S.W.27	40	18	3	"	65	2347	-40	2307	65	2282	" sand	"	"	"	
12	S.E.28	40	18	3	"	71	2365	-45	2320	71	2294	" "	"	"	"	
13	S.E.30	40	18	3	Dug	15	2332			15	2317	"	"	"	"	
14	N.E.33	40	18	3	Bored	120	2385			120	2265	" gravel	H_2S odour	S.	"	
15	N.W.33	40	18	3	"	120	2405	-100	2305	120	2285	" "	Hard	D.S.	"	
1	N.W.12	41	15	3	Bored	92	2175	-62	2113	92	2083		Hard	D.S.	Sufficient	
2	N.W.20	41	15	3	Dug	10	2195	- 7	2188	10	2185	Gl.	"	" "	"	
3	S.E.28	41	15	3	"	23	2223	-20	2203	23	2200	" gravel	"	" "	"	
4	S.E.31	41	15	3	"	48	2163	-45	2118	48	2115	" sand	"	D.	Poor supply	
5	S.W.34	41	15	3	"	67	2080	-57	2023	65	2015	" gravel	"	D.S.	Sufficient	
1	N.W. 3	41	17	3	Bored	80	2281			80	2201	Glacial gravel	Hard	D.S.		
2	S.E. 4	41	17	3	"	50	2331		Low	50	2281	" "	"	"	Sufficient	
3	S.E. 6	41	17	3	"	68	2249	-64	2185	64	2185	" sand	"	"	"	
4	S.W. 6	41	17	3	"	84	2375			80	2295	"	"		Gas.	
5	S.E. 9	41	17	3	"	45	2369	-27	2342	38	2331	" sand	"	D.S.	Sufficient	
6	S.W.15	41	17	3	Dug	24	2250	-20	2230	24	2226	Blue Clay	Soft	"	Poor supply	
7	S.E.16	41	17	3	Bored	48	2240			32	2208	Glacial sand	Hard	"	Sufficient	
8	N.E.18	41	17	3	"	32	2231		Low	16	2215	" "	"	S.	Poor supply	Dry Hole 90'.
9	S.E.20	41	17	3	"	27	2277	-22	2255	27	2250	" gravel	"	D.S.	Limited	
10	N.W.22	41	17	3	Dug	33	2234	-28	2206	32	2202	" clay	"	"	Sufficient	
11	N.E.27	41	17	3	Bored	62	2266	-56	2210	60	2206	" gravel	"	"	"	
12	S.E.29	41	17	3	Dug	8	2232	- 6	2226	6	2226	" sand	Soft	D.S.	Limited	
13	N.W.30	41	17	3	"	35	2225	-18	2207	35	2190	" gravel	Hard	"	Sufficient	
14	N.E.32	41	17	3	"	14	2222	-11	2211	14	2208	"	"	"	Limited	Dry Hole 90'.
15	N.W.33	41	17	3	Bored	80	2304	-76	2228	79	2225	" gravel	"	S.	Poor supply	
16	N.E.34	41	17	3	"	35	2187	-15	2172	33	2154		Soft	D.S.	Sufficient	
1	N.W. 2	41	18	3	Bored	75	2298			75	2223	Glacial gravel	Hard	D.S.	Limited	
2	S.W. 3	41	18	3	"	120	2318			120	2198	" "	"	"	Sufficient	
3	S.W. 4	41	18	3	"	97	2400	-90	2310	97	2303	" "	"	"	"	
4	S.E. 4	41	18	3	Dug	35	2385			35	2250	"	"	"	Poor supply	several dry holes.
5	N.E. 5	41	18	3	"	50	2311			50	2261	"	"	"	Sufficient	

Well No.															
6	N.W. 5	41	18	3	Bored	29	2310	-14	2296	29	2281	Glacial gravel	Hard	D.S.	Sufficient
7	N.W. 7	41	18	3	Dug	50	2284			50	2234	" "	"	"	"
8	N.E. 8	41	18	3	Bored	48	2255	-30	2225	48	2207	" clay	Soft	"	"
9	N.E.10	41	18	3	"	76	2245			76	2169	" "	Hard	"	Poor supply
10	N.W.12	41	18	3	"	60	2270			60	2210	"		"	" "
11	S.E.13	41	18	3	Dug	40	2268	-22	2246	40	2228	" clay	Hard	"	Good "
12	N.E.12	41	18	3	"	16	2235	- 3	2232	16	2219	" sand	Hard & Bit-ter	"	Sufficient
13	S.W.17	41	18	3	"	50	2275	-38	2237	50	2225	" gravel	Hard	"	"
14	S.W.17	41	18	3	"	15	2268			15	2253	" "	H_2S Odour		"
15	N.E.18	41	18	3	Bored	60	2268			60	2208	" "	Hard	D.S.	Poor supply
16	S.W.18	41	18	3	"	60	2267	-40	2227	60	2207	" sand	"	"	Sufficient
17	N.E.19	41	18	3	"	80	2223			80	2143	" gravel	H_2S Odour	"	"
18	S.E.22	41	18	3	"	66	2265		Low	66	2199	" sand	Hard	"	Poor supply
19	N.W.24	41	18	3	"	30	2229	-23	2206	24	2205	" gravel	Hard	"	Sufficient
20	S.E.26	41	18	3	Dug	48	2208	-16	2192	48	2160	Sandy clay	"	"	"
21	N.E.28	41	18	3	Bored	40	2184			40	2144	Glacial	"	"	"
22	N.W.28	41	18	3	"	80	2180								Dry Hole, Several Dry Holes.
23	N.E.30	41	18	3	Dug	13	2196			9	2187	Glacial	Soft	"	Good Supply
24	S.W.32	41	18	3	"	24	2196			24	2172	"		"	" "
25	S.W.34	41	18	3	Bored	42	2184	-31	2153	42	2142	"	Hard	"	Sufficient
26	N.E.36	41	18	3	Dug	35	2196	- 6	2190	35	2161	" sand	"	"	"
1	N.E. 6	42	15	3	Drilled	90	2020	-77	1943	90	1930	sand	Hard	D.S.	Sufficient
2	S.E.17	42	15	3	Dug	130	2040	-122	1918	130	1910	"	"	"	"
3	N.E.18	42	15	3	"	26	1987	-23	1964	26	1961	Blue clay	"	"	Limited
4	N.W.31	42	15	3	"	12	1727	-10	1717	12	1715	Glacial sand	Soft	"	Poor supply
1	S.W. 2	42	16	3	Bored	88	2262	-76	2186	82	2180	Glacial sand	Hard	D.S.	Sufficient
2	S.W. 3	42	16	3	"	65	2228	-55	2173	62	2166	" gravel	Soft	"	"
3	S.W. 4	42	16	3	Dug	36	2200	-30	2170	36	2164	Sandy clay	Hard	"	"
4	S.E. 9	42	16	3	"	80	2184	-75	2109	80	2104		"	"	"
5	S.W.15	42	16	3	"	12	2040	- 8	2032	12	2028	Sand	"	"	"
6	N.E.17	42	16	3	Bored	106	2106		Low	60	2046	Glacial sand	"	"	"
7	S.W.22	42	16	3	Dug	18	2077	-11	2066	18	2059	" "	Soft	"	" Dry Hole 87'.
8	N.W.28	42	16	3	Bored	35	2012	-25	1987	35	1977	Sand	Hard	"	"
9	S.E.30	42	16	3	Dug	18	1748	-16	1732	18	1730	Glacial gravel	"	"	"
10	N.E.32	42	16	3	"	12	1722	- 9	1713	12	1710	Sand	"	"	Limited Another Well 60' Deep.

Well No.																	
1	S.W. 1	42	17	3	Bored	50	2181			38	2143	Glacial sand	Hard		D.S.	Poor supply	Dry Hole 120' Deep.
2	S.W. 2	42	17	3	"	35	2146	-30	2116	31	2115	" gravel	"	Fe.	"	Sufficient	
3	N.E. 2	42	17	3	"	47	2146	-44	2102	42	2104	" "	Hard				
4	N.E. 3	42	17	3	Dug	14	2168	-11	2157	14	2154	" sand	"		"	"	
5	N.W. 3	42	17	3	Bored	72	2200	-50	2150	72	2128	" gravel	"		"	"	
6	N.E. 4	42	17	3	Dug	42	2188	-32	2156	42	2146	"	"		"	Poor supply	
7	S.W. 4	42	17	3	Bored	60	2312			59	2253	" gravel	"	Fe.	"	Sufficient	
8	N.E. 6	42	17	3	Dug	45	2232			42	2190	Sand	Hard		"	"	
9	N.E. 7	42	17	3	Bored	40	2200			40	2160	Glacial sand	"		"	"	
10	S.E.10	42	17	3	Dug	32	2182	-28	2154	32	2150	" gravel	"		"	"	
11	N.E.10	42	17	3	Bored	30	2161	-22	2139	30	2131	White sand	"		"		
12	N.W.12	42	17	3	Dug	22	2116	-20	2096	18	2098	Glacial gravel	"		"	Sufficient	
13	N.E.13	42	17	3	Dug	16	2016	-14	2002	16	2000	Glacial sand	Hard	Alk.		"	
14	N.E.14	42	17	3	Bored	72	2087	-67	2020	72	2015	Sand	Hard	Fe.	"	"	
15	S.E.14	42	17	3	"	41	2139	-37	2102	41	2098	White sand	Hard		"	"	
16	S.E.15	42	17	3	"	65	2161	-55	2106	65	2096	Glacial gravel	"		"	"	
17	N.E.15	42	17	3	Dug	40	2117	-36	2081	40	2077	Blue clay	"		"	Poor supply	
18	S.E.16	42	17	3	Bored	45	2177			45	2132	Glacial gravel				Sufficient	
19	S.W.19	42	17	3	Dug	18	1878			18	1860	Blue clay	Hard	Alk.	"	"	
20	N.W.21	42	17	3	"	22	1864			22	1842	Fine sand	Hard		D.	"	School Well.
21	N.W.21	42	17	3	"	23	1874	-20	1854	22	1852	" "	"	Fe.	D.S.	"	
22	S.E.25	42	17	3	Bored	80	1792	-50	1742	80	1712	Blue clay	Hard	Alk.	"	Limited	
23	N.W.27	42	17	3	Dug	22	1786			20	1766	Sand shale	"	"	"	Sufficient	
24	N.W.28	42	17	3	Bored	75	1804	-45	1759	74	1730	Gravel	"		"	"	
25	S.W.28	42	17	3	Dug	25	1823	-16	1807	16	1807	"	Soft		"	"	
26	S.W.32	42	17	3	"	22	1779			20	1759	Sand & Shale	Hard	Alk	D.S.	Sufficient	
27	N.E.32	42	17	3	"	25	1759	-20	1739	20	1739	Shale & Sand	"	"	"	"	
1	N.W. 2	42	18	3	Bored	50	2180	-38	2142	50	2130	Sand	Soft	S.	D.S.	Good Supply	
2	S.E. 2	42	18	3	"	70	2226	-65	2161	70	2156	Glacial gravel	Hard		D.S.	Sufficient	
3	N.E. 2	42	18	3	Dug	20	2205	-18	2187	20	2185	" sand	Soft		"	"	
4	N.E. 4	42	18	3	Bored	60	2150			60	2090	Sand	Hard		"	"	
5	S.W. 4	42	18	3	"	60	2155	-20	2135	60	2095	"	"	Alk.	"	"	
6	S.W. 6	42	18	3	Dug	30	2169	-28	2141	30	2139	Glacial gravel	Hard		"		
7	N.W. 7	42	18	3	Bored	45	2209	-25	2184	45	2164	" gravel	"		"	Sufficient	
8	S.W. 9	42	18	3	"	38	2162	-30	2132	38	2124	" sand	"	Alk.	"	"	
9	S.E.10	42	18	3	"	40	2170	-35	2135	40	2130	" "	"		"	"	
10	N.E.11	42	18	3	Dug	25	2211			25	2186	" "	Soft		"	"	

Well No.															
11	S.W.12	42	18	3	Bored	46	2234	-36	2198	42	2192	Glacial sand	Hard	D.S.	Sufficient
12	S.E.14	42	18	3	"	70	2196	-35	2161	70	2126	" gravel	" Fe.	"	"
13	S.E.19	42	18	3	"	60	2142	-40	2102	60	2082	" "	" Alk.	"	"
14	N.E.20	42	18	3	Dug	40	2120			40	2080	" "	"	"	"
15	N.E.24	42	18	3		35	1881			35	1846	Red gravel	"	"	"
16	S.W.27	42	18	3	Bored	72	2118	-62	2056	72	2046	Glacial gravel	"	"	"
17	S.W.30	42	18	3	Dug	30	2149	-13	2136	30	2119	" "	"	"	Good supply
18	N.W.30	42	18	3	Bored	60	2106			32	2074	Sand	"	"	Poor "
19	N.W.30	42	18	3	"	28	2086			28	2058	Glacial gravel	"	"	Good supply
20	N.W.32	42	18	3	Dug	18	2089	-15	2074	18	2071	" sand	"	"	Sufficient
21	N.E.32	42	18	3	"	23	2088			23	2065	" "	"	"	"
22	S.E.32	42	18	3	"	25	2081			20	2061	" "	"	"	"
23	S.W.34	42	18	3	"	50	2102	-35	2067	50	2052	" gravel	"	"	"
24	S.E.34	42	18	3	"	28	1872	-24	1848	28	1844	" "	"	"	"
25	N.W.35	42	18	3	"	15	1832			15	1817	Fine sand	" Alk.	"	"
26	S.W.36	42	18	3	Bored	52	1887								Dry Hole
27	N.W.36	42	18	3	Dug	42	1843	-40	1803	42	1801	Sand	"	"	Sufficient Top of Shale at 42'