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GEOLOGICAL SURVEY OF CANADA
WATER SUPPLY PAPER No. 230

GROUND-WATER RESOURCES
OF THE
RURAL MUNICIPALITY OF MARIPOSA
NO. 350
SASKATCHEWAN

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



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GEOLOGICAL SURVEY

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- Figure 1. Map showing bedrock geology;
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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 concerning ground water in any particular locality will find the available data listed in the well records. These should be consulted to see if a supply of water is likely to be found in shallow wells sunk in the glacial drift, or whether a better supply may be obtained at greater depth in the underlying bedrock formations. The wells in glacial drift commonly show no regional level, as the sands or gravels in which the water occurs are irregularly distributed and of limited extent. As the surface of the ground is uneven, the best means of comparing water wells is by the elevations of their water-bearing beds. For any particular well this elevation is obtained by subtracting the figure for the depth of the well to the water-bearing bed from that for the surface elevation at the well. For convenience both the elevation of the wells and the elevation of the water-bearing bed or beds in each well are given in the well record tables. Where water is obtained from bedrock, the name of the formation in which the water-bearing sand occurs is also listed in these tables, and this information should be used in conjunction with that provided on bedrock formations, pages 4 to 8, which describes these formations and gives their thickness and sequence. Where the level of the water-bearing sand is known, its depth at any point can easily be calculated by subtracting its elevation, as given in the well record tables, from the elevation of the surface at that point.

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

GLOSSARY OF TERMS USED

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

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

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

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

Bedrock. Bedrock, as here used, refers to partly or wholly consolidated deposits of gravel, sand, silt, clay, and marl that are older than the glacial drift.

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

Contour. A line on a map joining points that have the same elevation above sea-level.

Continental Ice-Sheet. The great ice-sheet that covered most of the surface of Canada many thousands of years ago.

Escarpment. A cliff or a relatively steep slope separating level or gently sloping areas.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Edmonton Formation

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

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

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

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

Bearpaw Formation

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

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

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

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

Pale and Variegated Beds

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

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

The best sections of Pale Beds exposed in the region are in the Tit Hills, southwest of 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 Pale and Variegated Beds occur over a wide area from Maclin and Kerrobert northeast through Wilkie to the Eagle Hills, south of Battleford. Numerous outcrops occur in the area south of Unity at Muddy Lake, but south and east around Biggar these beds are almost wholly concealed by glacial drift.

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

Birch Lake Formation

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

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

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

Grizzly Bear Formation

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

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

Ribstone Creek Formation

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

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

The lower sand member of the Ribstone Creek formation also varies in thickness from a minimum of about 25 feet. On the banks of Vermilion Creek, north of Mannville, the basal sand is at least 60, and may be 75, feet thick. It is overlain by shaly sand and sandy shale beds, which replace the shale beds in the central part of the formation as exposed at the mouth of Grizzly Bear Coulee. In the Wainwright area, where the formation has been drilled in deep wells, the basal sand is 60 feet thick, with the central part composed of shale containing sand streaks. The upper sand member is about 20 feet thick in this area. The total thickness of the formation in the Wainwright area is 160 to 200 feet, but this increases to the west and in the Viking area exceeds 300 feet.

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

Lea Park Formation

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

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

WATER ANALYSES

Introduction

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

Discussion of Chemical Determinations

The dissolved mineral constituents vary with the material encountered by the water in its migration to the reservoir bed. The mineral salts present are referred to as the total dissolved solids, and they represent the residue when the water is completely evaporated. This is expressed quantitatively as "parts per million", which refers to the proportion by weight in 1,000,000 parts of water. A salt when dissolved in water separates into two chemical units called "radicals", and these are expressed as such in the chemical analyses. In the one group is included the metallic elements of calcium (Ca), magnesium (Mg), and sodium (Na), and in the other group are the sulphate (SO₄), chloride (Cl), and carbonate (CO₃) 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 (CaCO₃) and calcium sulphate (CaSO₄).

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 (MgSO₄) 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 (Na₂SO₄) combines with water to form "Glauber's salt" and excessive amounts make the water unsuitable for drinking purposes. Sodium carbonate (Na₂CO₃) or "black alkali" waters are mostly soft, the degree of softness depending upon the ratio

of sodium carbonate to the calcium and magnesium salts. Waters containing sodium carbonate in excess of 200 parts per million are unsuitable for irrigation purposes¹. Sodium sulphate is less

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

harmful.

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

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

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

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

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

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

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

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

1

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

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

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

WATER ANALYSES IN RELATION TO GEOLOGY

Glacial Drift

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

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

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

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

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

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

Bearpaw Formation

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

Pale Beds

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

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 ₂ CO ₃	297	679	464	562
Na ₂ SO ₄	297	158	266	437

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

Variegated Beds

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

Salts	NW. sec. 21, tp.41,rge.26	NW. sec. 3, tp.41,rge.28	SE. sec. 28, tp.40,rge.26
CaCO ₃	250	375	125
CaSO ₄	-	-	-
MgCO ₃	1109	80	155
MgSO ₄	149	104	69
Na ₂ CO ₃	-	-	-
Na ₂ SO ₄	98	132	386
NaCl	12	12	18
Total solids	640	640	780
Hardness	600	600	500

Ribstone Creek Formation

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

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

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

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

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

	Se.sec. 11, tp. 46, rge.	Ind.Agent Little Pine I.R.	SW.sec. 24, tp. 46, rge.	NE.sec. 36, tp. 43, rge.	Se.sec. 26, tp. 43, rge.	NE.sec. 36, tp. 41, rge.	NW.sec. 22, tp. 42, rge.
Salts	28		21	18	18	24	23
CaCO ₃	90	90	410	73	35	73	125
CaSO ₄	-	-	-	-	-	-	-
MgCO ₃	97	59	168	38	31	38	97
MgSO ₄	-	-	64	-	-	-	-
Na ₂ CO ₃	217	392	-	243	592	129	196
Na ₂ SO ₄	1,644	777	2,518	225	522	61	1,541
NaCl	249	63	76	12	83	2,690	71
Total solids	2,220	1,340	3,000	620	1,260	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 MARIPOSA, NO. 350, SASKATCHEWAN

Physical Features

Mariposa municipality is bounded on the east by the deep depression occupied by Tramping Lake, which has an elevation of 2,018 feet and above which the land rises abruptly 100 to 150 feet. A deep ravine, now without a stream, trends easterly across the municipality to Tramping Lake, and probably represents a former drainage course for glacial waters. A moraine, with a characteristic northwest trend, lies in the vicinity of Breadacres, and is in part covered by lake clays. North of Breadacres are two hills, known as Ear Hills by reason of their prominence. They are composed of bedded sands with a small amount of gravel, and are believed to be kames that accumulated in a crevice in the glacial ice or at the junction of two ice fronts. In front of the moraine previously mentioned are lake silts and clays. The whole municipality is a gently rolling drift plain.

Geology

The surface of the municipality is covered by a deposit of glacial material that in places on the east is 200 feet thick, but thins to the west. Several wells penetrate the drift to the underlying Pale Beds, which, from regional information, are known to be present everywhere in the municipality.

Water Supply

The water supply comes mainly from wells that encounter sand or gravel beds in the drift, but a few wells penetrate the drift and obtain their supply from sands within the Pale Beds. In the areas covered by lake clays the wells are deep, and, as the clay is sufficiently impervious to prevent downward percolation of rain-water, the underlying sand and gravel beds of the drift do not yield as abundantly as elsewhere. Hence many wells in these areas have had to be drilled to the Pale Beds for their supply. In a sandy area in the southwest part of the municipality water is obtained from shallow wells. This is rain-water that has accumulated in the sand where it rests on more impervious beds.

West Half Township 34, Range 20. In this area water is obtained both from the drift and from the underlying Pale Beds. Many of the wells in the drift are exceptionally deep, up to 210 feet, but the deepest of them does not reach the level of Tramping Lake. Probably the gravels from which the water is derived in these wells is near the base of the drift. The absence here of shallow, water-bearing sand and gravel precludes the possibility of shallow wells. Two deeper zones, one at an elevation of about 2,040 feet and the other 150 feet deeper, are both considered to be in the Pale Beds, although the information with respect to the upper one is not conclusive. This upper zone has only been reported from two wells, one on NW. section 30 at a depth of 245 feet, and the other on SE. section 20 at a depth of 230 feet, and at both places yields hard water. In SE. section 20, however, the yield was not sufficient, and the well was deepened to 383 feet where a further supply was obtained. This water, as is that from a well 300 feet deep on SE. section 4, is soft.

Township 34, Range 21. Most of the wells in this township obtain their water from sands and gravels in the glacial drift between elevations of 2,110 and 2,190 feet. There is no continuous, widespread aquifer, so that neither the depth to nor the presence of

water-bearing beds can be predicted, but, due to their prevalence, very little difficulty has been experienced in reaching one at any location. An exception is the well on SW. section 26, which, because of the high surface elevation, did not go sufficiently deep to reach the top of this zone. A few wells obtain water in the Pale Beds underlying the drift. Those do not show as marked a regularity of elevation as might be expected, due probably to the methods of drilling whereby the aquifer is not recognized when encountered. In a well on SE. section 14 an aquifer was encountered at a depth of 275 feet at an altitude of 2,036 feet, but the well was continued to a second aquifer at a depth of 400 feet and an elevation of 1,911 feet. The upper aquifer is probably the same as that recorded at 2,040 feet in the township to the east, and which in that area did not give a sufficient supply in one well. In a well on SW. section 14 neither of the two aquifers reported from SE. section 14 is recorded, and a lower one at a depth of 496 feet or an elevation of 1,819 feet was reached. This well was plugged with fine sand, and it would appear from the records that it must have passed through two or possibly three water-bearing zones before reaching its final depth.

Township 34, Range 22. The water supply of this township is for the most part from glacial drift, but a few wells reach aquifers in the underlying Pale Beds. There is no regularity to the altitude of the water-bearing beds in the drift, which occur at elevations of 2,100 to 2,175 feet. In a well on NE. section 6, at 137 feet depth or an elevation of 2,078 feet, brown soft water was encountered. Brown water usually results from contact with carbonaceous materials, and in this well the aquifer may thus be in the Pale Beds, although conclusive evidence of this is lacking. The Kerrobert town well, on NE. section 18, flows at a depth of 220 feet or an elevation of 1,945 feet. Gravel is reported to have been encountered in it almost at the bottom. To the west, on the highway west of Kerrobert, Bearpaw or Pale Beds outcrop at an elevation of about 2,300 feet. It may be, therefore, that the top of the bedrock slopes steeply east from Kerrobert into a deep glacial valley where the Kerrobert town well was drilled. This would account for the flowing well, in that a considerable head would be provided by the higher area to the west. In the range to the west one well drilled on NW. section 9 to a depth of 450 feet obtained water that rose 300 feet to an elevation of 2,206 feet, which is above the level of the surface at the Kerrobert well. This well was undoubtedly in Pale Beds, and it seems possible, therefore, that flowing wells may be obtained from these beds in this area where the surface elevation is less than 2,200 feet. The factors that control the height to which water will rise from the Pale Beds are not well understood, as the water-bearing sands are presumed to be lenticular and in many places the source of water is not known.

Township 35, Range 20, West of Tramping Lake. Only the records of a few wells are available in this area. These show that water can be obtained both in the drift and in the underlying Pale Beds. On the west side of Tramping Lake, just above lake level on section 4, are springs, but the position of the aquifer from which these come is unknown. Water occurs, however, in a number of wells in the drift between elevations of 2,050 and 2,085 feet, and this zone may be fairly constant, although the individual sands from which the water comes may not be extensive. Water was encountered beneath the drift in a well on NW. section 19 at a depth of 194 feet, or an elevation of 1,965 feet. This does not appear, however, to be a persistent water-bearing bed, as two wells, one on NW. section 17 and the other on SW. section 20, passed through this aquifer to another about 90 feet deeper. Thus under the whole area there is reason to expect a supply of water in the Pale Beds. In all three wells from the Pale Beds in this township the water is soft.

Township 35, Range 21. The drift in this township appears to be 150 to 200 feet thick, and, as a result, no outcrops of the underlying Pale Beds are known even in the ravine 100 feet or so deep that cuts across the southern part of the township. The gravel and sand beds in the drift vary greatly in elevation, and there are no recognizable, widespread aquifers to which the depth at any specific location can be predicted. A well on NE. section 35 is reported to have encountered an inch of coal at a depth of 80 feet, or an elevation of 2,112 feet. It does not seem probable that this is in the Pale Beds, as in this area gravel is reported on NE. section 13 at a depth of 2,056 feet. Thus the only well that is known with certainty to have penetrated the drift is on NE. section 15 where, at a depth of 365 feet or an elevation of 1,835 feet, soft water was obtained and rose to 70 feet from the surface.

Township 35, Range 22. The southwestern part of this township is covered by glacial lake sands in which wells obtain water at shallow depths. The water has accumulated wholly from the annual precipitation, as the sand is underlain by relatively impervious clays. Most of the wells, however, obtain their water from sand and gravel beds at various elevations in the drift. These beds are mostly of local occurrence, but one zone, at an elevation of 2,110 to 2,120 feet, appears to be more widespread, yielding water in sections 23, 24, 30, and 32. The elevation of the base of the drift is not definitely known. A well on NW. section 22 obtains water at a depth of 90 feet, or an elevation of 2,067 feet. This may be in the drift, but is more probably within the Pale Beds, although wells that have penetrated to deeper horizons in the Pale Beds did not, as might be expected from a formational sand, encounter water at this level. Several wells obtain soft water from the Pale Beds, although the level from which this water comes is different in each well. It is not known whether this indicates a number of horizons or inaccuracy of information, but it is probable that the water-bearing sands are fairly continuous. It is certain, however, that water can be obtained in this area from the Pale Beds at an elevation of about 1,850 to 2,000 feet.

Township 36, Ranges 20 and 21, West of Tramping Lake. Most of the wells in this area obtain their water supply from sand and gravel deposits in the glacial drift at depths up to 118 feet. A fairly continuous aquifer at elevations between 2,140 and 2,160 feet is indicated by the records. In some places this is not far below surface elevation, and the wells are relatively shallow; in other places wells appear to have passed through this upper zone without obtaining water. A still less constant aquifer occurs at elevations of 2,080 to 2,100 feet, probably indicating a zone of sand and gravel beds at this level rather than any continuous single bed. The log of the Canadian Pacific Railway Tramping Lake well seems to indicate that the base of this zone closely corresponds to the base of the drift, although the information available is not conclusive. Below the drift, in the Pale Beds, one water-bearing zone is indicated at an elevation of 1,910 to 1,920 feet, and another is reported about 70 feet lower, perhaps in Variegated Beds. The water from these zones is soft. These formational, water-bearing sands undoubtedly underlie the entire area.

Township 36, Range 22. Many of the wells in this township obtain their water supply from sand and gravel deposits in the glacial drift. Very little regularity, however, is shown by these deposits, their distribution being through at least 140 feet of drift.

The approximate base of the drift is probably indicated by the poor water horizon at an elevation of 2,061 feet in the well on NE. section 21. Several wells have been sunk below this level and obtain soft water in the Pale Beds or, in the case of one well on NE. section 18, probably from the still deeper Variegated Beds at an elevation of 1,709 feet. Again, as in some of the other areas where water has been obtained in the Pale Beds, the aquifers are difficult to correlate. This indicates that the water-bearing sands are either lenticular and numerous, or that the records of the levels at which water was encountered have not been accurately noted.

ANALYSES OF WATER SAMPLES FROM RURAL MUNICIPALITY OF MARIPOSA NO. 350, SASKATCHEWAN.

No.	¼ Sec.	Tp.	Rge.	Depth in feet	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 ₂ CO ₃	Na ₂ SO ₄		NaCl.
1	NE 35	34	21	446	1720	43	20	556	746	41	560	210	108		69		392	1104	68	Pale Beds
2	NE 18	34	22	220	1040	14	9	357	156	130	500	60	35		31		454	231	215	" "
3	SW 6	35	22	260	3320	21	11	1212	234	1340	595	65	53		38		527	346	2211	Pale Beds (?) High NaCl.
4	NE 25	35	22	429	1680	21	11	572	681	153	415	30	53		38		336	1008	252	Pale Beds
5	SW 36	35	22	316	1360	14	7	490	410	17	675	30	35		24		648	607	28	" "
6	NE 15	35	21	365	2040	64	13	663	1017	104	445	220	160		45		245	1505	172	" "
7	NW 17	35	20	336	1740	50	22	549	828	54	470	240	125		70		270	1225	89	" "
8	SW 27	36	21	288	1940	29	7	669	935	30	535	60	73		24		459	1384	50	" "
9	SW 5	36	21	360	1440	50	26	435	599	26	515	280	125		90		300	886	43	" "
10	NW 5	36	22	420	1280	50	15	395	496	48	460	180	125		52		289	734	79	" "
11	NE 18	36	22	546	1700	14	9	576	627	69	570	30	35		31		528	928	114	" "

RECORD OF WELLS IN RURAL MUNICIPALITY OF MARIPOSA NO. 350, SASKATCHEWAN.

Well No.	LOCATION				Type of Well	Depth of Well	Altitude of Well	WATER LEVEL		PRINCIPAL WATER-BEARING BED			Character of Water	Use to Which Water Is Put x	Yield & Remarks	
	Sec.	Tp.	Rge.	Mer.				Above (+) or Below (-) Surface	Elev. Above Sea Level	Depth Ft.	Elev.	Geol. Horizon				
1	S.E.	4	34	20	3	Drilled	300			300	1836	Pale Beds	Soft	D.S.	Sufficient	
2	N.E.	5	34	20	3	Dug	130	2236	-120	2116	130	2106	Sand	Hard Fe.	D.S.	Sufficient

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

Well No.	Section	Area	Depth	Method	Top	Bottom	Dist	Top	Bottom	Material	Notes	Remarks	
3	N.W.	6 34	20	3 Dug	160	2283	-100	2183	160	2183	Sand	Hard Fe.	D.S. Sufficient
4	S.E.	6 "	"	"	125	2290	-115	2175	125	2165	"	" "	" Limited supply
5	S.W.	7 "	"	"	210	2274	-205	2069	210	2064	Glacial gravel	"	" Poor
6	S.W.	7 "	"	Drilled	400	2274			400	1874	Pale beds	Soft	" Coal at 388
7	N.E.	9 "	"	"	262	2278	-140	2138	262	2016	Blue sand	Hard	D.S. Sufficient
8	S.E.	16 "	"	"	385	2282	-100	2182	385	1897	Pale beds	Soft	"
9	S.W.	17 "	"	Dug	180	2295	-150	2145	180	2115	Glacial gravel	Hard Fe.	" Limited
10	S.E.	20 "	"	Drilled	383	2274	-160	2114	230	2044			
									383	1891	Pale beds	Soft	" Sufficient
11	N.E.	20 "	"	Bored	115	2273			115	2158		Hard	"
12	N.W.	30 "	"	Drilled	245	2286	-140	2146	245	2041	Pale Beds (?) Sand	"	"
13	S.E.	30 "	"	"	236	2284	-136	2148	236	2048	"	"	"
14	N.W.	32 "	"	Bored	80	2210							"
													Dry Sand at 80 Feet
1	N.E.	2 34	21	3 Bored	135	2250			135	2115	Glacial Sand	Hard	D.S. Sufficient supply
2	S.W.	2 "	"	"	86	2234			86	2148	" gravel	"	"
3	N.E.	4 "	"	"	90	2225	-80	2165	90	2135		" Fe.	"
4	N.W.	4 "	"	"	120	2180							"
5	N.W.	9 "	"	"	60	2212	-50	2162	60	2152	Glacial Sand	Hard	Dry Hole.
6	S.E.	14 "	"	Drilled	400	2311	-120	2191	190	2121	Sand	" Fe.	Limited
									275	2036	Pale beds	Soft	Sufficient
									400	1911	"	"	"
7	S.W.	14 "	"	Drilled	496	2315			496	1819	"	"	"
													Abandoned Sand trouble.
8	S.E.	15 "	"	"	406	2279	-100	2179	406	1873	"	"	"
9	S.E.	16 "	"	Bored	75	2213			75	2136	Sand	Hard	Sufficient
10	N.W.	20 "	"	"	50	2229	-40	2189	50	2179	Glacial Gravel	"	"
11	S.W.	21 "	"	"	110	2220	-90	2130	110	2110	" sand	" Fe.	"
12	S.E.	24 "	"	Dug	170	2276	-150	2126	170	2106	"	"	"
13	S.W.	24 "	"	"	30	2269	-23	2246	30	2239	"	"	"
14	S.W.	28 "	"	Bored	80	2301						Soft	"
15	N.W.	28 "	"	"	83	2233	-70	2163	83	2150	Glacial sand.	Hard	Dry Hole
16	S.E.	28 "	"	"	160	2267	-140	2127	160	2087	"	"	D.S. Sufficient supply
17	N.W.	30 "	"	"	30	2190			30	2160	"	"	"
18	S.E.	30 "	"	"	60	2219	-50	2169	60	2159	" gravel	"	"
19	N.E.	32 "	"	"	152	2263	-120	2143	152	2111	"	"	D.S. " "
20	S.W.	32 "	"	Dug	30	2220	-16	2204	30	2190	" sand	"	"
21	N.E.	35 "	"	Drilled	446	2269	-200	2069	446	1843	Pale beds	Soft	"

Well No.	Section	Area	Depth	Method	Top	Bottom	Flow	Top	Bottom	Material	Quality	Notes	Supply
1	N.W. 2	34 22	3	Bored	50	2145	-40	2105	50	2095	Sand	Soft	D.S. Sufficient supply
2	S.E. 4	" "	"	Dug	30	2150			30	2120	Glacial sand	Hard	" " "
3	N. E. 6	" "	"	Bored	137	2215	-60	2155	137	2078	Pale Beds Sand	Soft br.	" " "
4	S.E. 6	" "	"	"	112	2212	-80	2132	112	2100	Sand	"	" " "
5	N.E.10	" "	"	Dug	10	2140			10	2130	"	"	" " "
6	N.E.18	" "	"	Drilled	220	2165	Flows	2165	220	1945	Pale Beds	"	D.S.M. Kerrobertown well
7	N.E.18	" "	"	Dug	30	2165	-25	2140	30	2135	Glacial Sand	Hard	D.S. Sufficient supply
8	N.W.19	" "	"	Bored	50	2189	-40	2149	50	2139	" "	"	" " "
9	S.E.20	" "	"	Dug	15	2140			15	2125	" "	"	S. " "
10	N.E.22	" "	"	"	8	2167	- 6	2161	8	2159	" "	Soft	D.S. " "
11	N.E.24	" "	"	Bored	88	2196	-40	2156	82	2114	" sand grav.	Hard	" " "
12	S.E.24	" "	"	"	30	2190			30	2160	"	"	Limited " "
13	N.E.26	" "	"	"	90	2180	-50	2130	90	2090	Sand	"	" Sufficient " "
14	N.E.28	" "	"	Dug	40	2165	-35	2130	40	2125	Glacial sand	"	" " "
15	S.E.28	" "	"	"	40	2158	-30	2128	40	2118	" "	"	" " "
16	S.E.30	" "	"	Bored	50	2178	-40	2138	50	2128	" "	"	" " "
17	S.W.30	" "	"	"	60	2205	-40	2165	60	2145	" "	"	" " "
18	N.W.30	" "	"	"	40	2215	-35	2180	40	2175	" "	"	" " "
19	S.E.31	" "	"	"	40	2190	-30	2160	40	2150	" blue clay	Soft	" Limited " "
20	S.W.36	" "	"	Dug	30	2185			30	2155	" sand F.	Hard	" Sufficient
1	N.E. 7	35 20	3	Bored	44	2128	-34	2094	44	2084	Glacial sand	Hard	D.S. Limited supply
2	N.W.17	" "	"	Drilled	336	2186		High	336	1850	Pale Beds	Soft	" Sufficient
3	S.E.19	" "	"	Bored	112	2168	-100	2068	112	2056	Green sand	Hard	" " "
4	N.W.19	" "	"	"	194	2159	-150	2009	194	1965	Pale Beds	Soft	" " "
5	S.W.20	" "	"	Drilled	345	2202	-130	2072	345	1857	" " sand	"	" " "
6	S.W.30	" "	"	Bored	80	2155	-50	2105	80	2075	Glacial sand	"	" " "
7	S.E.30	" "	"	"	72	2157	-63	2094	72	2085	" "	Hard	" Limited
1	S.W. 3	35 21	3	Bored	73	2154	-69	2085	73	2081	Sand	Hard Fe.	D.S. Limited supply
2	S.E. 4	" "	"	"	148	2263		Low	148	2115	Glacial sand	" "	" " supply
3	S.E. 6	" "	"	"	50	2181	-42	2139	50	2131	" "	"	" Sufficient supply
4	N.W. 8	" "	"	"	30	2212		Low	30	2182	Glacial	"	" Limited "
5	N.E. 9	" "	"	"	36	2229	-24	2205	36	2193	" clay	"	" " "
6	N.W.10	" "	"	"	110	2247	-80	2167	110	2137	Glacial	Bad Fe.	" Sufficient "
7	N.E.12	" "	"	"	120	2303		Low	120	2183	"	Hard	" Poor "
8	N.E.13	" "	"	"	160	2216			160	2056	" gravel	"	S. " "

Well No.	Section	35	21	3	Drilled	365	2200	-70	2130	365	1835	Pale Beds bl. sand	Soft	D.S.	Sufficient
9	N.E.15	"	"	"	Dug	24	2131	-18	2113	24	2107	Glacial	Hard	"	Limited
10	N.W.16	"	"	"	"	30	2139	-27	2112	30	2109	" sand	"	S.	"
11	S.E.18	"	"	"	Bored	82	2225	-40	2185	82	2143	" clay	"	D.S.	Waters 10 head stock
12	N.E.19	"	"	"	"	40	2292		Low	40	2252	"	"	"	" 9 " " "
13	S.W.21	"	"	"	"	52	2233	-14	2219	52	2181	" sand	"	"	Good supply
14	N.E.21	"	"	"	"	50	2254	-42	2212	50	2204	" gravel	"	"	Limited
15	N.W.22	"	"	"	"	104	2180	-70	2110	104	2076	" sand	"	"	"
16	N.W.23	"	"	"	"	100	2250	-50	2200	100	2150	"	"	"	Sufficient
17	S.W.28	"	"	"	"	120	2249		Low	120	2129	" gravel	"	"	Limited
18	N.W.29	"	"	"	Dug	60	2263	-55	2208	60	2203	"	"	"	"
19	S.E.32	"	"	"	Bored	40	2138	-37	2101	40	2098	" sand F.	"	"	Sufficient
20	N.W.34	"	"	"	"	90	2192	-70	2122	90	2102	Sand	"	"	" 1" Coal at 80'
21	N.E.35	"	"	"	"	40	2094	-30	2084	40	2054	"	Soft	"	"
22	S.E.35	"	"	"	"	45	2170	-12	2158	45	2125	Glacial gravel	Hard	"	"
23	N.E.36	"	"	"	"										
1	S.E. 1	35	22	3	Bored	35	2190	-30	2160	35	2155	Glacial sand	Hard	D.S.	Limited supply
2	S.W. 3	"	"	"	Dug	12	2137	- 9	2148	12	2145	" "	Soft	"	Sufficient
3	S. W. 5	"	"	"	Bored	60	2200			60	2140	"	Hard	"	Limited supply
4	S.W. 6	"	"	"	Drilled	260	2258			260	1998	Pale Beds	Soft	"	Abundant
5	N.W.10	"	"	"	Dug	9	2160	- 6	2154	9	2151	Glacial sand	"	"	Sufficient
6	N.E.12	"	"	"	Bored	65	2286	-60	2226	65	2221	" "	Hard	"	Poor
7	S.E.14	"	"	"	"	40	2136	-35	2131	40	2126	Glacial	"	"	Limited
8	N.E.15	"	"	"	"	52	2186	-25	2161	52	2134	" sand	"	"	Waters 75 head
9	N.W.22	"	"	"	"	90	2157	-50	2107	90	2067	Blue sand	"	S.	" 12 "
10	S.W.23	"	"	"	"	50	2160	-40	2120	50	2110	Glacial clay	" Fe.	D.S.	" 40 "
11	S.E.24	"	"	"	"	110	2225	-107	2118	110	2115	Sand fine	"	"	" 4 horses.
12	S.W.24	"	"	"	"	100	2215	-90	2125	100	2115	Glacial gravel	"	"	Limited supply
13	N.E.25	"	"	"	Drilled	429	2242	-120	2122	399	1843	Pale Beds sand	Soft	"	Sufficient
14	N.E.28	"	"	"	Dug	48	2146	-30	2116	48	2098	Glacial	Hard Fe.	"	"
15	N.E.30	"	"	"	"	25	2143	-20	2123	25	2118	"	Hard	"	Limited
16	S.E.32	"	"	"	Bored	40	2158	-25	2133	40	2118	"	"	"	Abundant
17	S.E.34	"	"	"	Dug	15	2195	-10	2185	15	2180	" sand	"	"	Sufficient
18	S.W.36	"	"	"	Drilled	316	2267	-126	2141	316	1951	Pale beds	Soft	"	"
19	N.E.36	"	"	"	Bored	65	2200	-30	2170	65	2135	Glacial sand	Hard	"	"



Well No.

1	S.E.18	36	20	3	Bored	110	2145										Dry Hole.
1	N.E. 1	36	21	3	Bored	60	2178	-20	2158	60	2118	Glacial gravel	Hard	S.	Limited supply		
2	N.E. 2	"	"	"	"	52	2190	-25	2165	52	2138	"	Soft	D.S.	Waters 50 head.		
3	S.E. 2	"	"	"	"	48	2188			48	2140	"	Hard	S.	"		
4	S.W. 4	"	"	"	Dug	20	2184	-16	2168	20	2164	Glacial gravel	Soft	D.S.	Limited		
5	S.W. 5	"	"	"	Drilled	360	2337			360	1877	Pale Beds	"	"	Abundant		
6	S.E. 7	"	"	"	Bored	38	2211	-28	2183	38	2173	Glacial sand	Hard	"	Limited		
7	S.W. 9	"	"	"	"	40	2180			40	2140	"	"	S.	Poor supply		
8	N.E.10	"	"	"	"	118	2199	-100	2099	118	2081	"	"	"	Sufficient		
9	N.W.10	"	"	"	"	48	2210	-40	2170	48	2162	" gravel	"	"	"		
10	N.E.12	"	"	"	"	25	2191	-5	2186	25	2166	" sand	"	D.S.	Abundant		
11	S.E.12	"	"	"	"	60	2187	-57	2130	60	2127	Glacial	"	S.	Limited supply		
12	N.E.13	"	"	"	"	25	2168	-20	2148	25	2143	" sand	"	D.S.	"		
13	N.E.15	"	"	"	"	108	2209	-98	2111	108	2101	"	"	S.	Sufficient		
14	S.W.16	"	"	"	"	74	2218	-54	2168	74	2144	Glacial sand	"	D.S.	"		
15	N.W.20	"	"	"	"	28	2175			28	2147	Blue "	"	"	Abundant		
16	S.E.25	"	"	"	"	80	2165			80	2085	Sand	"	S.	Waters 10 head.		
17	S.W.27	"	"	"	Drilled	288	2200	-88	2112	288	1912	Pale Beds	Soft	D.S.	Sufficient supply		
18	N.W.27	"	"	"	"	240	2206	-160	2046	240	1966	"	"	"	"		
19	N.E.30	"	"	"	Bored	60	2209			60	2149	Glacial	Hard	S.	Limited other shallow		
20	N.W.30	"	"	"	"	35	2189	-10	2179	35	2154	"	Soft	D.S.	Abundant supply		
21	S.W.30	"	"	"	"	44	2195	-14	2181	44	2151	" gravel	Hard	"	Sufficient		
22	S.E.32	"	"	"	Dug	20	2174	-10	2164	20	2154	" sand	"	"	"		
23	N.W.33	"	"	"	Drilled	272	2191			272	1919	Pale Beds	"	"	"		
24	S.W.36	"	"	"	"	333	2177	-80	2097	333	1844	Pale or Variegated	Soft	D.S.	Plugged with sand		
										83	2094	Glacial	Hard	"	Sufficient supply		
25	S.E.36	"	"	"	Bored	74	2158	-44	2114	74	2084	Glacial sand	"	"	"		
1	S.W. 3	36	22	3	Drilled	390	2244	-100	2144	390	1854	Pale Beds sand	Soft	D.S.	Sufficient		
										250	1994	" "	"	"	Limited		
2	S.E. 3	"	"	"	"	398	2234	-90	2144	245	1989	" "	"	"	Sufficient		
										398	1836	" "	"	"	"		
3	S.W. 4	"	"	"	Dug	30	2240	-24	2216	30	2210	Glacial sand	"	"	Poor supply		

Well

Lake

Well No.															
4	N.W. 5	36	22	3	Drilled	420	2253	-70	2183	420	1833	Pale Beds	Soft	D.S.	Abundant
5	S.E. 8	"	"	"	Bored	114	2245	-25	2220	114	2131	Glacial gravel	Hard	"	Sufficient
-6	N.E. 8	"	"	"	"	54	2240	-44	2196	54	2186	"	"	"	Waters 40 head
7	N.W. 8	"	"	"	"	85	2266	-45	2221	85	2181	"	"	"	Sufficient
8	S.E.10	"	"	"	Drilled	256	2223	-80	2143	256	1967	Pale Beds	Soft	"	"
9	N.W.10	"	"	"	Bored	52	2250	-43	2207	52	2198	Glacial sand	Hard	"	Waters 15 head
10	S.W.13	"	"	"	"	50	2212	-10	2202	50	2162	Glacial	"	"	"
11	N.E.18	"	"	"	Drilled	546	2255	-90	2165	546	1709	Variegated Beds ?	Soft	"	Sufficient
12	N.W.19	"	"	"	Bored	70	2223	-20	2203	70	2153	Glacial	Hard	"	Waters 60 head
13	N.W.20	"	"	"	"	135	2196	-50	2148	135	2063	Sand-C.	"	"	Sufficient
14	N.E.20	"	"	"	"	85	2215	-82	2133	85	2130	Glacial sand F.	"	"	Poor, other dry holes 100' Deep.
15	N.L.21	"	"	"	Drilled	480	2261	-100	2161	200	2061		"		Poor
16	S.W.22	"	"	"	Bored	45	2214			480	1781	Pale Beds (soda)	Soft	D.S.	Abundant supply
17	N.E.30	"	"	"	"	63	2185	-43	2142	45	2169	Glacial	Hard	"	"
18	N.W.32	"	"	"	"	90	2201	-60	2121	63	2122	Glacial sand	"	"	Waters 125 head
19	N.W.33	"	"	"	"	140	2158	-20	2138	90	2111	Glacial	"	"	Sufficient
20	S.E.34	"	"	"	"	145	2150	-100	2050	140	2018	Pale Beds ?	Soft	"	Sufficient
										145	2005	Pale Beds ?	"	"	Waters 50 head of stock.