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DEPARTMENT OF MINES

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BUREAU OF ECONOMIC GEOLOGY

GEOLOGICAL SURVEY

PRELIMINARY REPORT

GROUND-WATER RESOURCES OF THE RURAL MUNICIPALITY OF .... No. 21 SASKATCHEWAN

BY

B. R. MacKay, H. H. Beach & D. P. Goodall

Water Supply Paper No. 109

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GROUND WATER RESOURCES OF THE RURAL MUNICIPALITY

OF NO. 21

SASKATCHEWAN

INTRODUCTION

Lack of rainfall during the years 1930 to 1934 over a large part of the Prairie Provinces brought about an acute shortage both in the larger supplies of surface water used for irrigation and the smaller supplies of ground water required for domestic purposes and for stock. In an effort to relieve the serious situation the Geological Survey began an extensive study of the problem from the standpoint of domestic uses and stock raising. During the field season of 1935 an area of 80,000 square miles, comprising all that part of Saskatchewan south of the north boundary of township 32, was systematically examined, records of approximately 60,000 wells were obtained, and 720 samples of water were collected for analyses. The facts obtained have been classified and the information pertaining to any well is readily accessible. The examination of so large an area and the interpretation of the data collected were possible because the bedrock geology and the Pleistocene deposits had been studied previously by McLearn, Warren, Rose Stansfield, Wickenden, Russell, and others of the Geological Survey. The Department of Natural Resources of Saskatchewan and local well drillers assisted considerably in supplying several hundred well records. The base maps used were supplied by the Topographical Surveys Branch of the Department of the Interior.

Publication of Results

The essential information pertaining to the ground water conditions is being published in reports, one being issued for each municipality. Copies of these reports are being sent to the secretary treasurers of the municipalities and to certain Provincial and Federal Departments, where they can be consulted by residents of the municipalities or by other persons, or they may be obtained by writing direct to the Director, Bureau of Economic Geology, Department of Mines, Ottawa. Should anyone require more detailed information than that contained in the reports such additional information as the Geological Survey possesses can be obtained on application to the director. In making such request the applicant should indicate the exact location of the area by giving the quarter section, township, range, and meridian concerning which further information is desired.

The reports are written principally for farm residents, municipal bodies, and well drillers who are either planning to sink new wells or to deepen existing wells. Technical terms used in the reports are defined in the glossary.

How to Use the Report

Anyone desiring information about ground water in any particular locality should read first the part dealing with the municipality as a whole in order to understand more fully the part of the report that deals with the place in which he is interested. At the same time he should study the two figures accompanying the report. Figure 1 shows the surface and bedrock geology as related to the ground water supply, and Figure 2 shows the relief and the location and type of water wells. Relief is shown by lines of equal elevation called "contours". The elevation above sea-level is given on some or all of the contour lines on the figure.

If one intends to sink a well and wishes to fine the approximate depth to a water-bearing horizon, be must learn: (1) the elevation of the site, and (2) the probable elevation of the water-bearing bed. The elevation of the well site is obtained by marking its position on the map, Figure 2, and estimating its elevation with respect to the two contour lines between which it lies and whose elevations are given on the figure. Where contour lines are not shown on the figure, the elevations of adjacent wells as indicated in the Table of Well Records accompanying each report can be used. The approximate elevation of the water-bearing horizon at the well-site can be obtained from the Table of Well Records by noting the elevation of the water-bearing horizon in surrounding wells and by estimating from these known elevations its elevation at the well-site.[1] If the water-bearing horizon is in bedrock the depth to water can be estimated fairly accurately in this way. If the water-bearing horizon is in unconsolidated deposits such as gravel, sand, clay, or glacial debris, however, the estimated elevation is less reliable, because the water-bearing horizon may be inclined, or may be in lenses or in sand beds which may lie at various horizons and may be of small lateral extent. In calculating the depth to water, care should be taken that the water-bearing horizons selected from the Table of Well Records be all in the same geological horizon either in the glacial drift or in the bedrock. From the data in the Table

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[1] If the well-site is near the edge of the municipality, the map and report dealing with the adjoining municipality should be consulted in order to obtain the needed information about nearby wells.

of Well Records it is also possible to form some idea of the quality and quantity of the water likely to be found in the proposed well.

GLOSSARY OF TERMS USED

Alkaline. The term "alkaline" has been applied rather loosely to some ground waters. In the Prairie Provinces a water is usually described as "alkaline" when it contains a large amount of salts, chiefly sodium sulphate and magnesium sulphate in solution. Water that tastes strongly of common salt is described as "salty". Many "alkaline" waters may be used for stock. Most of the so-called "alkaline" waters are more correctly termed "sulphate waters".

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 water-bearing bed, lens, or pocket in unconsolidated deposits or in bedrock.

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

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 struck.

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 the 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. These are called Flowing Artesian Wells.

(2) Wells in which the water is under pressure but does not rise to the surface. These wells are called Non-Flowing Artesian Wells.

(3) Wells in which the water does not rise above the water table. These wells are called Non-Artesian Wells.

NAMES AND DESCRIPTIONS OF GEOLOGICAL FORMATIONS, REFERRED TO IN THESE REPORTS

Wood Mountain Formation. The name given to a series of gravel and sand beds which have a maximum thickness of 50 feet, and which occur as isolated patches on the higher parts of Wood mountain. This is the youngest bedrock formation and, where present, overlies the Ravenscrag formation.

Cypress Hills Formation. The name given to a series of conglomerates and sand beds which occur in the southwest corner of Saskatchewan, and rest upon the Ravenscrag or older formations. The formation is 30 to 125 feet thick.

Ravenscrag Formation. The name given to a thick series of light-coloured sandstones and shales containing one or more thick lignite coal seams. This formation is 500 to 1,000 feet thick, and covers a large part of southern Saskatchewan. The principal coal deposits of the province occur in this formation.

Whitemud Formation. The name given to a series of white, grey, and buff coloured clays and sands. The formation is 10 to 75 feet thick. At its base this formation grades in places into coarse, limy sand beds having a maximum thickness of 40 feet.

Eastend Formation. The name given to a series of fine-grained sands and silts. It has been recognized at various localities over the southern part of the province, from the Alberta ~~boundary east~~ to the escarpment of Missouri coteau. The thickness of the formation seldom exceeds 40 feet.

Bearpaw Formation. The Bearpaw consists mostly of incoherent dark grey to dark brownish grey, partly bentonitic shales, weathering light grey, or, in places where much iron is present, buff. Beds of sand occur in places in the lower part of the formation. It forms the uppermost bedrock formation over much of western and southwestern Saskatchewan and has a maximum thickness of 700 feet or somewhat more.

Belly River Formation. The Belly River consists mostly of non-marine sand, shale, and coal, and underlies the Bearpaw in the western part of the area. It passes eastward and northeastward into marine shale. The principal area of transition is in the western half of the area where the Belly River is mostly thinner than it is to the west and includes marine zones. In the southwestern corner of the area it has a thickness of several hundred feet.

Marine Shale Series. This series of beds consists of dark grey to dark brownish grey, plastic shales, and underlies the central and northeastern parts of Saskatchewan. It includes beds equivalent to the Bearpaw, Belly River, and older formations that underlie the western part of the area.

WATER-BEARING HORIZONS OF THE MUNICIPALITY

Rural municipality No. 21 occupies an area of 324 square miles located in the southwestern part of Saskatchewan adjacent to the International Boundary. The municipality consists of nine townships described as tps. 1, 2, and 3, ranges 24, 25, and 26, W. 3rd mer. The Valmarie branch of the Canadian Pacific railway, on which are situated the sidings of Nashlyn, Supreme, and Arena, crosses the northern half of the municipality. The villages of Consul and Vidora, situated on the Lethbridge-Weyburn line 2 and 4 miles north of the area, form the chief trading centres for the community.

The land surface throughout the greater part of the area is a gently rolling to nearly level prairie land that rises gradually toward the north from an average elevation of about 2,850 feet above sea-level along the International Boundary to elevations averaging slightly more than 3,100 feet along the northern border. The highest elevation of about 3,500 feet is attained on the top of Old Man on His Back plateau, a prominent topographic feature that occupies a large part of township 3, range 25, in the northeastern part of the municipality. The plateau is characterized by steep slopes on its south and southwestern sides. Toward the north and northwest, however, slopes are more gentle and merge into the general prairie level along the northern border of the municipality at an elevation of about 3,150 feet above sea-level. As the area has not been topographically mapped the relief is not shown by contour lines on Figure 2 of the accompanying map. The elevations quoted in the report were determined by aneroid barometer readings and checked where possible during the course of the field investigation by reference to railway and Boundary survey benchmarks. As fairly large discrepancies in the barometric readings are bound to occur, the elevations given must be regarded as only approximate.

The well-developed drainage system of Battle creek and its tributaries carries the surplus run-off of the central lowlands area southward to Milk river in Montana. Woodpile creek drains the western part, and East Fork creek the eastern part, of the southern half of the municipality. Both streams are tributaries of Battle creek and join the main stream a few miles south of the International Boundary. Although neither of these streams flows for more than a few weeks during the spring, they occupy deep, steep-sided valleys, the bottoms of which, in places, lie 60 to 100 feet below the bordering plains.

Battle creek crosses the northern border of the municipality in sec. 33, tp. 3, range 27, flows southeastward to the central part of the area, then south to cross the International Boundary in sec. 4, tp. 1, range 26. In the northern half of the municipality the stream flows through a wide flat or lowland area through which it has eroded a narrow, steep-sided trench in most places not exceeding 30 feet in depth. The channel becomes deeper toward the south, however, and where it crosses the International Boundary forms a coulée about a $\frac{1}{4}$ mile wide and 60 to 80 feet deep. Numerous deep tributary coulées also join Battle Creek valley in this part of the area. Although the small tributaries carry water only during the freshet in spring the main stream channel usually maintains its flow until midsummer.

Surface water forms the chief source of water in the municipality. The presence of numerous small coulées, generally of low gradient, offer splendid opportunities of conserving part of the spring run-off through the construction of dams. This method of conservation is widely used by the farmers and ranchers, and in some parts of the area is the only apparent source of drinking water. In these localities drinking water is obtained by sinking shallow seepage wells beside the dams or by storing ice during the winter to supply water for household use during the summer months.

Water-bearing Horizons in the Unconsolidated Deposits

Stream deposits that occur in narrow strips along the bottoms of the stream channels contribute most of the ground water supplies obtained in the municipality. Battle creek and some of its larger tributaries have a relatively low gradient; hence the flood-plain deposits in these channels consist largely of the finer sediments, clays, and silts such as would be carried away by swifter flowing streams. Owing to the fine texture of these sediments they are not particularly suitable for any large accumulations of ground water and do not readily yield water to wells. Small pockets of porous sands and gravels washed down from the coulée banks may occur, at some places, interbedded with the silts, along the edges of the coulée flats. Wells penetrating these porous beds can be expected to yield larger water supplies than those sunk in silt or clay, unless the latter derive water by direct seepage from the stream. Sand and gravel pockets are encountered more frequently in the smaller coulées where the run-off is rapid. Some of these deposits are thinly strewn over the surface and do not retain a permanent water supply. Wells sunk to sand or gravel pockets buried under several feet of clay are usually more dependable during dry seasons. As most of the southern half of the municipality is taken up by grazing leases, wells are confined largely to the northern half of the area. Here wells sunk in the stream deposits seldom exceed 20 feet in depth. Most of the waters obtained are hard and generally not highly mineralized, and are being used for the household drinking supply. Several wells situated in the northwestern part of the municipality yield slightly "alkaline" water, but this type of water is seldom encountered in the stream deposits in other parts of the area.

With the exception of the stream deposits, glacial drift forms the surface deposits throughout the municipality. The mantle of drift was laid down by the great continental ice-sheet that many thousands of years ago covered the province of Saskatchewan. These deposits consist mostly of compact grey boulder clay or till through which are interspersed a few isolated pockets of well sorted sands and gravels. Small areas of moraine, characterized by irregular hills and undrained depressions, occur in the central parts of townships 1 and 2, and along the eastern border of township 3, range 25. An extensive lowland area comprising about 13 square miles south of the railway in the vicinity of Nashlyn, in the northwestern part of the area, is overlain by glacial lake clay. Lake clay also overlies parts of sec. 12 and 13, tp. 2, range 25, on the eastern border of the municipality, and two small areas in the vicinity of the northwestern corner of this township are overlain by glacial lake sands and silts. The lake clay and sands probably overlie the boulder clay in these areas.

Well water is not obtained from the lake clay but several wells and flowing springs located in the northeastern part of township 2, and in the southeastern part of township 3, range 27, yield water from beds of fine sand occurring at the contact of the lake clay with the underlying boulder clay. The springs occur on the banks of Battle creek. The sand beds are apparently of small areal extent, as they have been encountered by wells at only a few isolated points. Depths of the wells penetrating these beds do not exceed 20 feet. These waters are hard and at some places contain appreciable quantities of mineral salts in solution, but are used for drinking.

Very little water is obtained from the boulder clay but a few wells have encountered water-bearing sand and gravel pockets that occur sparsely distributed through the clay. Depths of these wells range from 10 to 46 feet. Some of the deeper beds encountered may occur at the contact of the glacial drift and the underlying bedrock formations. A considerable variation is noted not only in the yield, but in the quality of waters derived from the glacial till. Some of the wells yield sufficient water for household use only. Most of them, however, yield sufficient water for 10 to 20 head of stock, and in a few places even larger yields are reported. Most of these waters are hard and at several places are reported to contain relatively large quantities of the laxative salts, rendering them unsuitable for domestic purposes. As these water supplies have been located at only a few isolated points in the municipality many farmers have found it necessary to conserve surface water or to haul water, in some places a distance of several miles.

Water-bearing Horizons in the Bedrock

Outcrops of five bedrock formations have been noted in this municipality. These are, in the descending order of their occurrence, the Ravenscrag, Eastend, Bearpaw, Belly River, and Pakowki formations, the names being derived from the districts in which the sediments comprising each formation were first studied. The areas within which each formation is considered to immediately underlie the glacial drift are indicated on Figure 1 of the map accompanying this report. The uppermost or Ravenscrag formation caps Old Man on his Back plateau in the southeastern corner of township 3, range 25. Outcrops of buff-weathering sandstones and grey shales of this formation occur along the south and southwestern upper slopes of the plateau at elevations between 3,300 and 3,400 feet above sea-level. As a large part of the plateau is range land, no wells are known to have been sunk to these sand beds although they are considered to be sufficiently porous to form a potential source of water.

The Eastend formation underlies the Ravenscrag and immediately underlies the glacial drift on the lower slopes of the plateau. As few outcrops of this formation occur in this vicinity the character of its sediments are not well known. The formation is thought to consist of beds of fine grey sand and silt interbedded with layers of dark shale in the upper part, to become more shaly toward the base, and to gradually merge into the upper part of the underlying Bearpaw formation. The beds of fine-grained sand occurring in the upper part of the Bearpaw may be water bearing, but no wells are known to have been sunk into them in this area. A dry hole sunk to a depth of 50 feet in sec. 21, tp. 3, range 25, encountered shale, however, in the lower part of the Eastend or possibly in the upper part of the Bearpaw formation.

The Bearpaw formation is thought to immediately underlie the glacial drift throughout the remainder of the municiaplity, with the exception of two small areas in townships 1, ranges 26 and 27, where the drift is underlain by older formations. The Bearpaw is composed almost entirely of grey to black shales interbedded with a few thin bands of ironstone, and occasionally fine-grained sandstones. Outcrops of the shales occur at intervals along the banks of Woodpile coulée in the southwestern part of the municipality.

No water-bearing horizons are known to occur in the Bearpaw formation in this municipality, but the upper beds of the formation yield water in the municipality to the east. Several dry holes, penetrating Bearpaw shale, have been sunk in the northern third of this municipality. The deepest of these, located on sec. 10, tp. 3, range 26, was put down to a depth of 190 feet. Should water occur in this formation it will probably be confined to the upper beds that occur on the lower slopes of the plateaus in the northeastern part of the area.

The Belly River formation underlies the Bearpaw formation and immediately underlies the drift in at least two small areas in the southern part of the municipality. This formation consists of alternating beds of medium- to fine-grained grey sandstone, light to dark grey and greenish grey shales, and a few seams of lignite coal. A fault or break in the bedrock extends in an east-west direction across the southern part of township 1, range 27, and has caused the beds immediately south of the break to be uptilted so that they are now sloping to the south at an approximate angle of 45 degrees. Woodpile coulée in cutting across this faulted zone in sections 8 and 9 has exposed the entire Belly River series and part of the underlying Pakowki shale bordering the fault. This disturbed belt, where exposed, is less than half a mile in width and may not extend beyond the east and west borders of this township. North and south of this belt the flat-lying Belly River beds may be buried under 100 feet or more of Bearpaw shale. Flat-lying beds of the Belly River formation are also exposed farther east in the valley of Battle creek in the central part of township 1, range 26, where erosion by the stream has removed the overlying Bearpaw. The structural conditions existing in this part of the area are not definitely known, but local disturbances of the strata undoubtedly occur, as the Belly River beds occur at a higher elevation in this creek than would be expected if they occurred in their normal, undisturbed position. Their presence here, however, may be due to an arching of the bedrock in this vicinity. In other parts of the municipality the Belly River formation may be overlain by a considerable thickness of Bearpaw shale, particularly in the northeastern part where the Bearpaw may have a thickness of 600 to 700 feet. The possibility of obtaining water from the porous sandstones and sandy shales of this formation is discussed in the sections of the report dealing with the townships in which these potential water-bearing beds may be encountered at moderate depths.

The Pakowki formation is composed of shale greatly resembling the shale of the Bearpaw formation. It is probably too compact to form a source of water in the faulted zone. Its occurrence below the Belly River formation throughout the remainder of the municipality limits the search for water in this area to the Belly River and overlying formations.

GROUND WATER CONDITIONS BY TOWNSHIPS

Township 1, Range 25

The surface of this township is undulating to moderately rolling, with elevations rising from about 2,800 to 2,900 feet above sea-level along the International Boundary to 2,975 to 3,000 feet along the northern border. The principal stream of the area is an eastern branch of Battle creek. Several tributary coulées join the main stream, which flows southward through the eastern third of the township. Although these valleys carry water only during the period of spring run-off or in exceptionally wet seasons the streams have excavated deep, steep-sided coulées, the bottoms of which lie in some places 60 feet below the bordering prairies.

As most of the township is used only for grazing the ground water resources are developed in only a few isolated localities. Water is obtained for range stock by constructing dams in the small coulees, thus conserving part of the spring run-off. Small depressions in the gravel bed of the main stream also retain water for stock throughout part of the dry seasons.

The stream deposits that occur along the coulée bottoms are probably the best potential source of ground water in the township, but a few isolated pockets of water-bearing sand or gravel may occur interspersed through boulder clay in the upper 25 feet of the glacial drift. Only three wells are reported as having been sunk in this township, all of which obtain water from shallow depths of 20 feet or less. Consequently, little is known regarding the ground water conditions existing in the lower part of the glacial drift or in the underlying bedrock formation. The quantity of water occurring in the stream deposits will probably vary considerably in different localities, depending upon the nature and extent of the source beds. The water is drinkable, and one well situated in a valley in section 2 yields moderately soft water. Although adequate yields are obtained from the few wells sunk in these deposits they may not be representative of water conditions existing in other parts of the area. Small coulées and draws that are floored by only a thin layer of alluvium are less likely to produce permanent water supplies than the thicker accumulations of sediments in the large coulées. Where encountered, however, the waters are expected to carry relatively small amounts of salts in solution. Wells sunk beside dams and deriving their water supply by seepage also form sources of drinking water at a few points in the district.

A few isolated pockets of sand or gravel may occur in the upper 25 feet of the glacial drift, especially at the base of slopes or in undrained depressions. Wells sunk to these deposits should encounter small yields of drinkable water. Due to the irregularity of occurrence of these pockets it may be necessary in most instances to sink a number of test holes before locating water. Little if any water can be expected from the compact boulder clay that forms the greater part of the glacial drift, but beds of sand and gravel that may occur at the base of the glacial drift form another possible source of water in the township. These water-bearing beds, if they occur, are expected to be of small areal extent and erratic in their distribution. The thickness of the drift will no doubt vary, but probably does not greatly exceed 60 feet.

The impervious grey shales of the Bearpaw formation are thought to immediately underlie the glacial drift throughout the entire township. This formation is not known to be water bearing in this vicinity and residents are advised to confine their search for water to the unconsolidated alluvium and drift deposits rather than to sink deep wells in the bedrock, from which an adequate water supply cannot be assured.

The Belly River formation is believed to underlie the Bearpaw formation. Since no wells have penetrated the shales the depth to the lower formation has not been determined, but it will probably be encountered within 350 feet of the surface at any point in the township. The Belly River contains much more sand than the Bearpaw and hence will probably be water bearing.

Township 1, Range 26

The surface of the township is deeply dissected by Battle creek and its numerous tributary coulées. The general slope of the land is to the south from an average elevation of about 2,950 feet above sea-level in the northern part of the township to elevations ranging from 2,880 to 2,740 feet at the International Boundary. The lowest elevation is in the valley of Battle creek where it crosses the International Boundary in section 4. Throughout most of the township the streams occupy steep-sided coulées, the bottoms of which are 40 to 60 feet below the general prairie level.

The ground water resources of the township have not been developed, as the entire area is devoted to grazing. Stock obtain water from Battle creek and its tributaries. Although the streams seldom maintain their flow throughout the year there is always sufficient water remaining in deeper parts of the channel to water stock during periods of drought. These supplies may be increased at some places by the construction of dams.

The stream deposits are probably the best potential source of ground water in this area. Battle Creek valley and most of the tributary coulées are floored by fairly thick deposits of silts and fine sands, interbedded in places by irregular pockets of gravel. Wells sunk to depths of 25 feet or less in these sediments may encounter moderate to large supplies of drinkable water, especially if the well be located near the main stream channel in the lower part of the valley bottom. The upper 25 feet of the glacial drift covering the uplands may also contain small pockets of porous sands and gravels, especially at the base of steep slopes and in depressions where accumulations of hill wash materials have been deposited. As the glacial drift is composed mostly of boulder clays and fine silts little if any water can be expected by sinking shallow wells on the ridges or in areas of the level till plain. A few thin, irregularly distributed beds of sand or gravel may occur, however, at the base of the drift and overlying the bedrock. Where such beds occur they are expected to be water bearing.

The glacial drift is thought to be underlain throughout most of the area by the Bearpaw formation. So far as known these shales are non-water-bearing. The exact thickness of this formation is not known, but it probably varies in different parts, the greatest thickness occurring in the eastern side of the township. In the valley of Battle creek in the central part of the township the Belly River beds are exposed in several places, indicating a relatively thin layer of Bearpaw, probably not greater than 40 feet, in the vicinity of the creek.

The possibility of large supplies of water occurring in the porous sands and coal seams of the Belly River formation is quite favourable, although drilling to depths of 200 feet or more may be required in some localities, especially in areas of relatively high elevation. For a more detailed description of this latter formation the reader is referred to an earlier section of the report dealing with the municipality as a whole.

Township 1, Range 27

The surface of this township is moderately rolling to nearly level prairie sloping gently to the southward from an average elevation of about 3,000 feet in the north to elevations ranging between 2,800 to 2,900 feet above sea-level in the southern part. The lowest elevation of 2,760 feet is attained in the bed of Woodpile creek where it crosses the International Boundary in the southwestern corner of section 3. This creek drains the western half of the township; the eastern half is drained by several, small, southeasterly flowing tributaries of Battle creek which join the main stream south of the border.

The ground water resources of the township are undeveloped as the entire area is given over to community grazing leases. None of the creeks maintain a permanent flow, but sufficient water for the range stock usually remains in deeper parts of the channels during the summer. These supplies are supplemented in a few places by dams constructed in small coulées.

The stream deposits are probably the best potential source of ground water in the township. These deposits may occur to depths of 25 to 30 feet in the bed of Woodpile coulée, but are judged to be thin in most of the smaller stream channels. They are composed mostly of fine sands, silts, and, more rarely, gravel, and are similar to those occurring in Battle creek as described in the preceding section dealing with township 1, range 26.

The depth of the glacial drift no doubt varies considerably in different parts of the township, owing principally to the removal of part of this deposit by stream erosion. Woodpile creek has cut its channel down to bedrock along its full length within the township, exposing thicknesses of 30 to 40 feet of drift in some places. A few isolated pockets of sand and gravel may occur interbedded with the boulder clay at depths of 20 feet or less. Wells sunk to these porous beds, however, are not expected to yield large or permanent water supplies, but probably will yield sufficient water for household requirements.

The glacial drift is immediately underlain throughout most of the township by shale of the Bearpaw formation. Although few wells have penetrated these shales it is improbable that they will prove to be water bearing in this area. In Woodpile coulée, in the vicinity of section 9, the Belly River and even a lower marine shale formation known as the Pakowki are exposed in a narrow faulted area nearly one-half mile in width. This belt of uptilted beds may extend in an east-west direction across the township from section 7 to section 12. The uppermost of these beds comprising the Belly River formation are thought to be overlain by 100 feet or more of Bearpaw shale throughout the township to the north and south of this disturbed belt. The Imperial Oil Company's well in the SW. $\frac{1}{4}$, section 9, encountered water in the Belly River formation at depths of 240 and 535 feet, and other flows were encountered in lower formations at depths of 925, 1,600, and 1,705 feet. These flows are all reported to be small. Another well was drilled for oil to a depth of about 1,100 feet in section 15, but no log of this well is available and it is not known if water was encountered. Owing to the unusual structural conditions existing in the bedrock at these locations the findings cannot be taken as indicative of water conditions in the bedrock in other parts of the township. It is probable, however, that fairly large supplies of water occur in the Belly River beds, although it may be necessary to sink wells to depths of at least 200 feet before the top of this formation is encountered.

Township 2, Range 25

The southern slope of Old Man on his Back plateau forms a steep escarpment extending along the northern border of the township from section 36 to section 33. The highest elevation of about 3,500 feet above sea-level is attained on the top of the plateau at the northeast corner of section 34. From the base of the escarpment at an average elevation of about 3,200 feet the surface slopes more gradually to the south and west to merge into the general prairie level at an average elevation of about 3,000 feet in the central part of the township. From the vicinity of the railway southward through the southern half of the township and along the western border the surface is gently undulating to nearly level. The drainage of the area is to the south through the east fork of Battle creek and its small tributaries, and southwest through another tributary that joins the main branch of Battle creek in township 1, range 26.

The entire township is overlain by glacial drift of variable thickness. On the steep southern slopes of the plateau these deposits are quite thin and the bedrock is exposed in numerous places. On the lowland areas, however, the drift may extend to a depth of 60 feet or possibly more in some localities. A small area of irregularly rolling moraine covers nearly three sections in the central part of the township. The areal extent of a now dried up glacial lake is indicated in sections 12, 13, and 24, on the eastern side, by a layer of glacial lake clay. A narrow belt extending northeastward from section 19 to the NW. $\frac{1}{4}$, section 28, is overlain by a thin blanket of flood-plain deposits consisting mostly of clays, silts, and fine sands. Similar deposits also cover a small area in the northwestern corner of the township. With these exceptions, and the thin beds forming the stream deposits that occur in the coulée bottoms, the surface throughout the remainder of the area is covered by till or boulder clay.

Most of the township is range land and the ground water resources have been little developed. The stream deposits probably offer the best potential source of ground water at shallow depths. Where encountered in other parts of the municipality waters from this source usually contain only small amounts of salts in solution, and are apparently quite suitable for domestic use. Yields from wells sunk in this type of deposit are generally intermittent unless extensive gravel or sand beds are encountered or the water is derived by seepage from permanent bodies of water such as may be retained behind dams or in pools in the creek bottom.

Small, discontinuous pockets of well-sorted sands and gravels occur interspersed through the upper part of the glacial drift; these porous beds are likely to occur more frequently in and around the edges of the moraine-covered area and in depressions along the base and lower slopes of the plateau. Two wells sunk to depths of

14 and 21 feet, in section 21, encountered adequate water supplies in this type of deposit. The water from the deeper well is hard and drinkable, but the shallower well is reported to yield "alkaline" water which is used only for stock. Scattered beds of sand and gravel that occur at or near the base of the glacial drift are also a potential source of water in the township. Only one well is reported to have been sunk to a sufficient depth to tap this horizon. This well, situated on section 18, struck water in gravel at a depth of 46 feet. Owing to faulty cribbing the well is not used although the quality and supply of the water are reported to be satisfactory for domestic and stock use.

Little is known regarding the ground water conditions existing in the underlying bedrock formations. The Ravenscrag formation is known to be water-bearing on the plateau in the township to the north. As this formation is confined to the upper hill slopes in a very narrow band extending along the eastern part of the northern border of this township it cannot be considered as an important source of water, but springs may occur at points where the massive sandstones are exposed.

Small to moderate yields of water may be obtainable from the fine sands and sandstones in the Eastend and upper beds of the Bearpaw formation that underlie the southern slope of the plateau in the north-central to the northeastern part of the township. As these beds are composed almost entirely of marine sediments the waters derived from them may contain fairly large quantities of sulphate salts in solution. Little if any water can be expected from the Bearpaw shale that is thought to underlie the drift throughout the lowland area in the southern half and along the western border of the township. Residents who contemplate sinking wells in this area are advised to confine their search for water to the unconsolidated drift and Recent deposits. Extensive prospecting by means of test borings, directed to cover as large an area as possible, is advisable to sinking wells deeper than 50 to 60 feet in these parts of the area.

Township 2, Range 26

Battle creek and its numerous tributary coulées form a fairly well-developed drainage system throughout this township. The land surface is level to undualting with the exception of some areas where stream erosion has excavated deep coulées. In general, surface elevations range from about 2,950 to 3,000 feet above sea-level. Farming is confined largely to a few sections in the northern third of the township the rest of the area being used as range land.

Water for stock is obtained largely from Battle creek and by constructing dams in the small coulées. As most of the coulées have a low stream gradient and fairly high banks they afford splendid opportunities for conserving surface water. Drinking water is obtained by sinking shallow wells in the creek bottoms or beside dams. The low gradient of the stream channels has also made possible the accumulation of flood-plain deposits composed mostly of clays and fine silts which would be carried away by swifter flowing streams. Wells sunk in these fine sediments produce only small supplies of water; usually in quantities barely sufficient for household use. Slightly larger yields may be obtainable from pockets of sand or gravel interbedded with the clays, especially in the swifter flowing tributary stream channels, although few of these deposits have been prospected to date.

Glacial drift composed mostly of boulder clay forms the surface deposits throughout the entire township except where they are covered by the narrow strips of Recent sediments in the coulée bottoms, and by two small areas of glacial lake clay in section 24 and section 36, and a narrow belt of glacial lake clay in the vicinity of Battle creek, in the northwestern corner of the township.

A few small, isolated pockets of sand or gravel may occur, interspersed through the upper 20 feet of the boulder clays. As these porous beds may be dry or entirely absent in many sections of the township residents who contemplate sinking wells in the glacial drift are advised to thoroughly prospect their location with a test auger before going to the expense of sinking a well.

Small, discontinuous beds of sand or gravel occurring at the base of the drift and immediately overlying the bedrock are also a potential source of water in the township. A bed of water-bearing sand, one foot in thickness, was reported to overlie bedrock in a 41-foot well sunk on section 10. The water obtained from it is soft, but the yield is not known as the well has been abandoned for several years. These beds appear to be present as isolated deposits rather than as extensive water-bearing horizons. This is indicated by the thinness of the sand deposit encountered at this location, and by the fact that several dry holes were sunk into bedrock without encountering any sand whatsoever in the northern part of this township or in the southern part of the township adjoining on the north.

The Bearpaw shale is thought to form the bedrock immediately underlying the drift throughout this township. Little or no water can be expected from this formation but the underlying Belly River formation may prove to be water bearing. No prediction can be made as to the quality of water to be expected or as to the depths necessary to sink wells in order to obtain water within this latter formation. The base of the Bearpaw or top of the Belly River formation may occur at depths of 100 to 200 feet in the south-central part of the township. Owing to a north or northeasterly dip of these beds it may be necessary to drill wells to depths of 500 feet or more in the northern sections before encountering the Bearpaw-Belly River contact. Just how far wells will have to be extended into the grey sand and shale beds of the Belly River formation before water is obtained has not been determined. Extensive prospecting in stream valleys and in and at the base of the drift is advisable to sinking wells into the shale unless deep drilling into the Belly River formation is contemplated.

Township 2, Range 27

The farming settlement of this township is confined almost entirely to a few sections along the northern border. The rest of the area is devoted to grazing. The land surface is comparatively level with elevations ranging from 2,950 feet to slightly more than 3,000 feet above sea-level. The drainage of the northeastern half of the township is to east and southeast through Battle creek and its tributaries. The southwestern half is drained by the southerly flowing Woodpile creek.

Dams constructed in the coulées conserve surface water for stock. Supplies of drinking water are obtained by sinking shallow wells in the unconsolidated Recent or glacial deposits.

Stream deposits, consisting mostly of fine sands, silts, and occasional thin beds of gravel, are probably the best potential sources of ground water in the area. An 18-foot well, situated in a coulée in section 7, encountered a moderate yield of hard, drinkable water in gravel. Although water-bearing gravels have not been encountered elsewhere in the township they may be fairly abundant in many of the small tributaries of Battle and Woodpile creeks. In the valley of Battle creek in the northern part of the township only fine sands and silts or clay have been encountered. These deposits are not extensive as the creek in this vicinity traverses a glacial lake bed the clay of which forms high banks that rise abruptly from the creek bed.

Glacial lake clay overlies a narrow belt of land slightly more than half a mile in width extending along the northern border of the township from section 33 to section 36. The remainder of the township is overlain by glacial till. Thin, discontinuous beds of fine sand are known to occur at or near the base of the lake clay at depths of about 20 feet. A small spring on the bank of Battle creek in the SW. $\frac{1}{4}$, section 36, is thought to have its origin in these sands.

This water is hard and is used for the domestic drinking supply.

Owing to the scarcity of wells sunk in the glacial drift that mantles all other parts of the township little is known as to the ground water resources existing in these deposits. A 25-foot well sunk in sandy clay in section 31 yields a small supply of hard, drinkable water in sufficient quantity only for household use. Large yields are not to be expected from these deposits, although small domestic supplies may be procurable from isolated pockets of porous sands or gravels interspersed through the boulder clay.

The unproductive Bearpaw shale is thought to form the bedrock underlying the glacial drift throughout the entire township. Residents are advised to confine their search for water to the Recent stream deposits and to the thin mantle of glacial drift rather than undergo the expense of sinking deep wells in the bedrock. Deep drilling to depths of 250 to 300 feet will penetrate the sandy beds of the Belly River formation. In the absence of any deep wells in the area, however, the yield or quality of water to be expected from this formation in this township has not been determined.

Township 3, Range 25

Old Man on his Back plateau occupies the northeastern and southeastern parts of the township. The highest point, about 3,500 feet above sea-level, is attained in section 1, in the southeastern corner of the township. The western side of the plateau declines abruptly to an elevation of about 3,100 feet in section 4, then more gradually to an elevation of 3,000 feet in the southwestern corner of the township. Towards the north and northwest the uplands have a fairly even slope to an average elevation of about 3,150 feet on the northern border of the township. Most of the run-off of the area is carried south through a tributary of Battle creek extending along the western side of the township. The water supply of the area is obtained chiefly by means of dams constructed in the coulée bottoms and from shallow wells sunk in the unconsolidated Recent deposits and glacial drift. Although the underlying bedrock formations are also a potential source of water few wells have penetrated them to date.

Stream deposits consisting mostly of silts and fine sand interbedded with irregular pockets of coarser sands and gravels occur in the coulée bottoms. Wells sunk in these deposits and encountering sand or gravel aquifers usually yield small to moderately large supplies of water that is reported to be suitable for household use. Water obtained from the finer silts, although drinkable, usually contains appreicable amounts of dissolved sulphate salts unless the well derives its water by direct seepage from a dam or reservoir, in which case the water may be only slightly mineralized.

Glacial drift forms the surface deposits throughout the township remote from the stream channels. The drift varies in thickness from only a few feet of top soil on the summit and on the steeper slopes of the plateau to 40 feet or possibly more at the northern and western borders of the township. The drift is composed essentially of compact, bluish grey boulder clay. Due to weathering the upper few feet of the clay is generally lighter grey to yellow-buff. Interspersed through the clay with no apparent regularity either of depth or individual areal extent are beds and lenses of well-sorted gravels which are generally water bearing.

In the southwestern corner of the township a wide flat extending through four sections is overlain by glacial lake deposits consisting mostly of silts and fine sands. These sediments are probably underlain by glacial till.

The ground water resources of the drift deposits in the uplands or plateau area are little developed as farming is confined mostly to the lowlands along the north and western borders of the township. A 12-foot well situated in the glacial lake bed in the NW. $\frac{1}{4}$, section 5, yields a small supply of slightly "alkaline" water from sandy clay. Elsewhere in the township water is obtained from scattered gravel pockets in the boulder clay. As most of the wells are located in valleys or at the base of steep slopes the gravels may, in a few cases, be of more recent accumulation. The waters obtained from them are, however, generally similar in character to supplies from gravel pockets in the drift, being usually soft to moderately hard and suitable for drinking. Productive beds are generally encountered within 25 feet of the surface, although one well situated in section 35 was sunk to a depth of 38 feet before a gravel aquifer was reached. As these aquifers are apparently of small areal extent they may be entirely absent in some localities. They are expected to be fairly numerous, however, in and along the border of the moraine that extends along the eastern boundary of the township.

Three bedrock formations are thought to immediately underlie the glacial drift in different parts of the township. The uppermost, or Ravenscrag, formation caps the plateau in the southeastern corner of the township. The approximate area covered by this formation is shown on the accompanying geological map (Figure 1). This formation is composed essentially of shale and medium- to fine-grained, grey to buff sands and sandstones. A well situated in the SE. $\frac{1}{4}$, section 2, encountered a large supply of soft, drinkable water at a depth of 8 feet in this formation. The water is reported to occur in shale, but this occurrence cannot be considered as indicative of water conditions existing in the shale throughout the area. This water probably seeps along the contact between the drift and bedrock from a point of higher elevation to the east and occurs only in the upper few feet of the shale in this locality. The porous sands of the Ravenscrag are expected to contain small to moderately large supplies of water, however, although the depths of wells to these aquifers will no doubt vary considerably owing to the irregular thickness of the overlying drift and to the rough, rolling topography in this part of the township. The exact position of the base of the Ravenscrag has not been determined, but it probably lies at an elevation of about 3,300 feet.

The Eastend formation underlies the Ravenscrag where it occurs and also underlies the drift elsewhere in the township, with the exception of several sections in the southwestern corner where surface elevations are lower than 3,150 feet and the drift is probably underlain by the Bearpaw formation. No wells in the township are known to yield water from the Eastend or Bearpaw formations although a few feet of shale in the lower part of the Eastend formation may have been penetrated by a dry hole sunk to a depth of 50 feet in section 21. The Eastend formation and the upper part of the Bearpaw yield adequate supplies of water over an extensive area southeast of the plateau in township 2, range 23. They may, however, contain less porous zones in this township, although at least the upper part of the Eastend is considered worthy of prospecting. Deeper drilling into the Bearpaw formation will not likely yield a satisfactory supply of water.

Township 3, Range 26

The land surface of this township is moderately rolling to undulating, and rises gradually from a minimum elevation of about 2,950 feet above sea-level in the southwestern corner to elevations exceeding 3,175 feet in the northeast corner. A few, small, southerly trending tributaries of Battle creek constitute the only drainage features of the area.

Dams constructed in the coulées and small draws supply most of the water necessary for the stock in the area. Drinking water is obtained chiefly from shallow wells sunk in the Recent stream deposits or beside dams or reservoirs.

Stream deposits are confined largely to the bed of a tributary of Battle creek that flows southward through the central part of the township. These deposits consist mostly of fine sands and silts in which are interspersed a few pockets of gravel. Water is encountered at depths of 10 to 20 feet. Although the supply obtained is not always sufficient for the farm requirements it may be supplemented by digging several wells in the same locality. The water from this source is seldom highly mineralized and is reported to be quite suitable for household use.

The glacial drift overlying the greater part of the township is composed almost entirely of boulder clay or glacial till. The till is covered by a bed of glacial lake clay in a small area extending through section 6 and part of section 7. Little if any water is obtainable from the lake clay although thin beds of fine sand may occur immediately below it. Several springs occur on the banks of Battle creek in this vicinity and probably have their source in these sands.

Although test holes have been sunk in the glacial drift in different parts of the townships very few have struck water. Porous beds of sand or gravel are apparently sparsely distributed through the drift and where encountered are usually near the surface and almost entirely non-water bearing. Only two wells are known to yield water from the drift in this township. One of these wells, situated in section 33, produces a moderate supply of "alkali" water that is used only for stock. The other well, also in the northern part of the township in section 35, yields water that is reported to be too highly mineralized even for stock use. Elsewhere in the township the residents have found it necessary to haul water from wells in the creek bottoms or sink shallow seepage wells beside dams or reservoirs.

Unfortunately, the underlying bedrock is also thought to be non-water bearing in this area. Bearpaw shale is believed to underlie the drift throughout the township, with the exception of a small area in the northeastern corner where the Bearpaw may be overlain by similar marine shale of the lower part of the Eastend formation. Dry holes have penetrated the Bearpaw shale to depths of 70 and 90 feet in section 1 and to a depth of 190 feet in section 10.

Dry holes have also been sunk to depths of 120 and 150 feet in this formation in the township to the west. A test has been made of the Eastend formation in a location less than a mile north of this township, in sec. 1, tp. 4, range 26. This holé sunk to a depth of 96 feet encountered grey shale below the glacial drift and no water was obtained.

Deeper drilling in the bedrock of this township is not recommended unless the driller is prepared to sink a well to the Belly River formation in which conditions are more favourable for ground water accumulation. Depths to this formation are not expected to exceed 700 feet, and may be even less toward the western side of the township. Since no wells have reached this formation in this or adjoining areas the yield or quality of water to be expected is not known.

Township 3, Range 27

This township is drained by Battle creek and its tributaries. The main stream flows southeast through a now extinct lake basin that extends through the central and southeastern part of the township at an average elevation of about 2,975 feet above sea-level. West and northeast of the lake basin the land is moderately rolling and rises gradually to elevations exceeding 3,100 feet in some places along the east and western borders of the township.

The lake basin is overlain by 10 to 20 feet of glacial lake clay. The remainder of the township is blanketed by glacial till with the exception of the coulee bottoms, in which the till is overlain by irregularly occurring deposits of Recent alluvium.

Surface water collected behind dams and in dugouts is the chief source of water in the township. Battle creek, although not here a permanent stream maintains its flow in some years until midsummer. Some of the residents store ice during the winter for their summer drinking water supply.

Recent deposits that occur in the coulée bottoms are the chief source of ground water in the western half of the township. Wells sunk in these deposits are generally less than 20 feet in depth. The water occurs in sand or gravel, which is generally buried under several feet of yellow clay. The yield from individual wells varies, but it is reported to be in most instances sufficient for domestic requirements and for a few head of stock. Most of these waters are hard and "alkaline" and are used only where better drinking water supplies are not available.

Very little water is obtainable from the stream deposits in the eastern half of the township. Battle creek is floored throughout most of its length by silts and clays from which only seepage water from the creek or dams is available. These supplies can be depended upon only when water remains in the creek or reservoir.

Most of the wells sunk in the glacial drift are also situated beside dams and derive their water by seepage. Thin beds of sand and gravel are interbedded in the upper few feet of the boulder clay, but only one well, situated in section 5, encountered an adequate water supply in this type of deposit. At this location 2 feet of gravel occurs below 10 feet of clay. The water obtained, although drinkable, is reported to contain appreciable amounts of mineral salts in solution and would probably have a laxative effect on persons not accustomed to the use of "alkaline" waters.

Difficulty has also been experienced in obtaining a suitable ground water supply in the glacial lake basin that occupies slightly more than the southeastern quarter of the township. Generally only very small seepages of water are procurable from the fine-textured grey clay that overlies this area. A few scattered pockets or thin beds of fine-grained, water-bearing sands occur interbedded in the lower part or possibly at the base of, the clays in the southern part of the area. Water from these sands has been obtained in wells sunk to depths of 15 to 19 feet in sections 1, 2, and 3. Several small springs that occur on the banks of Battle creek in this vicinity may also derive water from these sands. The individual sand beds are apparently of small areal extent as they are not known to occur elsewhere in the lake basin and have been encountered at only a few isolated points in the above-mentioned sections. The water from this source is hard. A well situated in the SE. $\frac{1}{4}$, section 3, yields water that has the odour of hydrogen sulphide and contains iron. It is, however, being used for drinking. It is probable that such conditions are local and are not characteristic of all supplies found in this region. Other wells in this area have been abandoned for several years and the quality of their waters is not known. A flowing spring in the SE. $\frac{1}{4}$, section 2, is reported to be slightly "alkaline", but drinkable.

Beds of sand occur in places at the contact of the glacial drift with the underlying Bearpaw formation and may be a potential source of water in some parts of the township. Wells sunk to depths of 60 to 120 feet in the townships to the north and northwest encounter large yields of water both in a gravel bed at the base of the drift and in the weathered upper few feet of the underlying bedrock at this horizon. Should the sand bed extend southward into this township it will probably be of small areal extent and occur as narrow strips in buried stream channels or depressions in the old bedrock land surface. Drilling for these water supplies is a very uncertain undertaking and is not recommended if other sources of water are available.

The depth at which the top of the Bearpaw formation lies below the surface varies in different parts of the township but is not expected to exceed 100 feet throughout most of the area. The impervious character of the shale comprising the greater part of this formation is not favourable for ground water accumulation so that the possibility of locating suitable water supplies in it is quite remote. No wells are known to have been sunk through the Bearpaw formation, but dry holes sunk to a depth of 150 feet in section 23 and 120 feet in section 30 no doubt penetrated the upper part of the shale. Water may exist in the porous sand beds of the Belly River formation, but probably drillling to depths of 600 feet would be necessary before a productive horizon is encountered. Extensive prospecting at shallow depths in the drift or the construction of dams and dugouts seem preferable to deep drilling, as no definite assurance can be given that the Belly River formation will be productive.

STATISTICAL SUMMARY OF WELL INFORMATION IN RURAL MUNICIPALITY NO. 21, SASKATCHEWAN

West of 3rd mer. Township / Range	1 / 25	1 / 26	1 / 27	2 / 25	2 / 26	2 / 27	3 / 25	3 / 26	3 / 27	Total No. in Municipality
Total No. of Wells in Township	3	0	2	4	6	3	13	32	29	92
No. of wells in bedrock	0	0	2	0	1	0	2	3	3	11
No. of wells in glacial drift	1	0	0	4	4	2	6	17	22	56
No. of wells in alluvium	2	0	0	0	1	1	5	12	4	25
Permanency of Water Supply										
No. with permanent supply	3	0	2	4	3	3	11	18	13	57
No. with intermittent supply	0	0	0	0	1	0	1	0	2	4
No. dry holes	0	0	0	0	2	0	1	14	14	31
Types of Wells										
No. of flowing artesian wells	0	0	0	0	0	0	0	0	0	0
No. of non-flowing artesian wells	0	0	0	3	0	0	2	0	0	5
No. of non-artesian wells	3	0	2	1	4	3	10	18	15	56
Quality of Water										
No. with hard water	1	0	2	2	2	3	7	16	13	46
No. with soft water	2	0	0	2	2	0	5	2	2	15
No. with salty water	0	0	0	0	0	0	0	0	0	0
No. with "alkaline" water	1	0	0	1	2	0	3	4	10	21
Depths of Wells										
No. from 0 to 50 feet deep	3	0	0	4	5	3	13	29	26	83
No. from 51 to 100 feet deep	0	0	0	0	1	0	0	2	0	3
No. from 101 to 150 feet deep	0	0	0	0	0	0	0	0	3	3
No. from 151 to 200 feet deep	0	0	0	0	0	0	0	1	0	1
No. from 201 to 500 feet deep	0	0	0	0	0	0	0	0	0	0
No. from 501 to 1,000 feet deep	0	0	0	0	0	0	0	0	0	0
No. over 1,000 feet deep	0	0	2	0	0	0	0	0	0	2
How the Water is Used										
No. usable for domestic purposes	3	0	0	2	3	3	12	11	9	43
No. not usable for domestic purposes	0	0	2	2	1	0	0	7	6	18
No. usable for stock	3	0	0	3	3	3	12	12	15	51
No. not usable for stock	0	0	2	1	1	0	0	6	0	10
Sufficiency of Water Supply										
No. sufficient for domestic needs	3	0	0	4	2	2	11	18	11	51
No. insufficient for domestic needs	0	0	2	0	2	1	1	0	4	10
No. sufficient for stock needs	3	0	0	4	0	1	8	18	8	42
No. insufficient for stock needs	0	0	2	0	4	2	4	0	7	19

ANALYSES AND QUALITY OF WATER

General Statement

Samples of water from representative wells in surface deposits and bedrock were taken for analyses. Except as otherwise stated in the table of analyses the samples were analysed in the laboratory of the Borings Division of the Geological Survey by the usual standard methods. The quantities of the following constituents were determined; total dissolved mineral solids, calcium oxide, magnesium oxide, sodium oxide by difference, sulphate, chloride, and alkalinity. The alkalinity referred to here is the calcium carbonate equivalent of all acid used in neutralizing the carbonates of sodium, calcium, and magnesium. The results of the analyses are given in parts per million--that is, parts by weight of the constituents in 1,000,000 parts of water; for example, 1 ounce of material dissolved in 10 gallons of water is equal to 625 parts per million. The samples were not examined for bacteria, and thus a water that may be termed suitable for use on the basis of its mineral salt content might be condemned on account of its bacteria content. Waters that are high in bacteria content have usually been polluted by surface waters.

Total Dissolved Mineral Solids

The term "total dissolved mineral solids" as here used refers to the residue remaining when a sample of water is evaporated to dryness. It is generally considered that waters that have less than 1,000 parts per million of dissolved solids are suitable for ordinary uses, but in the Prairie Provinces this figure is often exceeded. Nearly all waters that contain more than 1,000 parts per million of total solids have a taste due to the dissolved mineral matter. Residents accustomed to the waters may use those that have much more than 1,000 parts per million of dissolved solids without any marked inconvenience, although most persons not used to highly mineralized water would find such waters highly objectionable.

Mineral Substances Present

Calcium and Magnesium

The calcium (Ca) and magnesium (Mg) content of water is dissolved from rocks and soils, but mostly from limestone, dolomite, and gypsum. The calcium and magnesium salts impart hardness to water. The magnesium salts are laxative, especially magnesium sulphate (Epsom salts, $MgSO_4$), and they are more detrimental to health than the lime or calcium salts. The calcium salts have no laxative or other deleterious effects. The scale found on the inside of steam boilers and tea-kettles is formed from these mineral salts.

Sodium

The salts of sodium are next in importance to those of calcium and magnesium. Of these, sodium sulphate (Glauber's salt, Na_2SO_4) is usually in excess of sodium chloride (common salt, NaCl). These sodium salts are dissolved from rocks and soils. When there is a large amount of sodium sulphate present the water is laxative and unfit for domestic use. Sodium carbonate (Na_2CO_3) "black alkali", sodium sulphate "white alkali", and sodium chloride are injurious to vegetation.

Sulphates

Sulphates (SO_4) are one of the common constituents of natural water. The sulphate salts most commonly found are sodium sulphate, magnesium sulphate, and calcium sulphate ($CaSO_4$). When the water contains large quantities of the sulphate of sodium it is injurious to vegetation.

Chlorides

Chlorides are common constituents of all natural water and are dissolved in small quantities from rocks. They usually occur as sodium chloride and if the quantity of salt is much over 400 parts per million the water has a brackish taste.

Iron

Iron (Fe) is dissolved from many rocks and the surface deposits derived from them, and also from well casings, water pipes, and other fixtures. More than 0.1 part per million of iron in solution will settle as a red precipitate upon exposure to the air. A water that contains a considerable amount of iron will stain porcelain, enamelled ware, and clothing that is washed in it, and when used for drinking purposes has a tendency to cause constipation, but the iron can be almost completely removed by aeration and filtration of the water.

Hardness

Calcium and magnesium salts impart hardness to water. Hardness of water is commonly recognized by its soap-destroying powers as shown by the difficulty of obtaining lather with soap. The total hardness of a water is the hardness of the water in its original state. Total hardness is divided into "permanent hardness" and "temporary hardness". Permanent hardness is the hardness of the water remaining after the sample has been boiled and it represents the amount of mineral salts that cannot be removed by boiling. Temporary hardness is the difference between the total hardness and the permanent hardness and represents the amount of mineral salts that can be removed by boiling. Temporary hardness is due mainly to the bicarbonates of calcium and magnesium and iron, and permanent harness to the sulphates and chlorides of calcium and magnesium. The permanent hardness can be partly eliminated by adding simple chemical softeners such as ammonia or sodium carbonate, or many prepared softeners. Water that contains a large amount of sodium carbonate and small amounts of calcium and magnesium salts is soft, but if the calcium and magnesium salts are present in large amounts the water is hard. Water that has a total hardness of 300 parts per million or more is usually classed as excessively hard. Many of the Saskatchewan water samples have a total hardness greatly in excess of 300 parts per million; when the total hardness exceeded 3,000 parts per million no exact hardness determination was made. Also no determination for temporary hardness was made on waters having a total hardness less than 50 parts per million. As the determinations of the soap hardness in some cases were made after the samples had been stored for some time, the temporary hardness of some of the waters as they come from the wells probably is higher than that given in the table of analyses.

Water from the Unconsolidated Deposits

No samples of water were taken for analyses from this municipality. Hence the following generalizations regarding the quality of waters from the different types of deposits are based upon observations at the well sites, opinions of residents, and analyses of waters from other municipalities in this part of the province in which the source beds are apparently similar.

Creek water contains a relatively low mineral salt content, but is more liable to contamination by organic material than water obtained from wells. Ice obtained from the surface water is, however, fairly free from contamination, and if stored for summer use provides a pure drinking water supply throughout the dry season.

In this municipality water obtained from the stream sands and gravels that occur in the small coulées and depressions, with a few exceptions, contains relatively small quantities of mineral salts in solution and is quite suitable for drinking provided it is not contaminated by sewage or other decaying organic materials.

Water obtained from the fine sands and silts that commonly occur in the bottoms of the larger stream channels such as Battle creek and from the glacial lake beds that occur south and west of Old Man on his Back plateau generally contain a higher concentration of salts in solution, but few of these waters are reported to be unpalatable.

Variations in the quality of the water from the stream deposits may be attributed to several factors. Gravel and coarse sand beds contain inherently only minor amounts of readily soluble mineral salts and because of their porosity permit the water to circulate freely rather than to become stagnant. Silts and fine sands in valley and coulée bottoms are derived by erosion of the materials forming the uplands. Larger amounts of dissolvable mineral salts are present in this material, and since its fine texture does not allow water to pass through it rapidly ample opportunity for the taking of these salts into solution is afforded. A water of much poorer quality is thus generally found in the silt beds. Surface evaporation plays an important part in concentrating the mineral salt solutions over the lowland flats.

Somewhat analogous conditions prevail in the glacial deposits. The water derived from porous sand and gravel beds near the surface is generally soft or only moderately hard and is quite satisfactory for domestic use. The blue-grey boulder clay is considered to be the source of the objectionable mineral salts that contaminate many of the waters from the drift. Hence wells sunk entirely in boulder clay yield small seepages of water that is highly charged with mineral salts. Such water is generally undrinkable due to its laxative effect, and may not be satisfactory for stock use. Similarly, wells deriving water from small pockets of sands covered by any large thickness of boulder clay yield water of poor quality. The waters are hard and many of them may contain a concentration of salts in excess of 1,000 parts per million. The sulphates of sodium (Na_2SO_4) and magnesium ($MgSO_4$) usually predominate in these waters, with sodium sulphate in excess of magnesium sulphate. Sodium sulphate, or "Glauber's salt" is nearly tasteless, but has a laxative effect when drunk in large amounts. Magnesium sulphate or "Epsom salts" has a bitter taste, has a laxative effect of about twice that of sodium sulphate, and contributes to the hardness of the water. Concentration of about 1,000 parts per million for both these salts is usually considered as the upper limit of safe usage for humans, although waters containing greater concentrations are frequently used with no apparent ill effects. Stock are apparently less affected by highly mineralized waters and have been reported to thrive on waters containing concentrations of sulphate salts somewhat in excess of 3,000 parts per million. Sodium chloride (NaCl) or common salt is seldom present in noticeable amounts in drift waters. Calcium sulphate ($CaSO_4$) and calcium carbonate ($CaCO_3$) are usually present. These compounds, although harmless for drinking, contribute to the hardness of the water.

Water from the Bedrock

Water supplies from the bedrock have been of little importance in this municipality, as only one shallow well is known to yield water from an aquifer not in the unconsolidated deposits. This well is thought to be in the Ravenscrag or possibly upper Eastend beds. In other municipalities to the north and northwest the Ravenscrag waters are seldom found to be too highly mineralized for household use. Water of good quality is frequently obtained, also, from the Eastend formation. Water obtained from the Bearpaw formation is more variable in character, and frequently contains large amounts of sodium and magnesium sulphate and common salt. The upper few feet of this formation is generally sufficiently porous and weathered to form a source of water which, although appreciably mineralized, can still be used for drinking. At greater depths in the shale the quantity of dissolved mineral salts present in the water increases markedly, and such waters are unsuited to domestic use and may even tend to cause scour in stock. Total dissolved solid contents exceeding 3,000 or even 4,000 parts per million are not uncommon in the water from depth in the shale. Water from the Belly River formation is usually soft owing to an excess of sodium carbonate (Na_2CO_3), and the absence of calcium and magnesium. Water of this type has a flat taste and although drinkable is inferior for household use to water from porous beds in the upper part of the glacial drift. Sodium carbonate (black alkali) has an injurious effect upon vegetation and hence the water from the Belly River formation may not be suitable for garden irrigation. No wells are known to be deriving their supply from the Pakowki formation lying at the surface in the narrow, faulted zone. Since the sediments comprising this formation are similar to the shale of the Bearpaw formation it is presumable that they will yield water of a similar poor quality.

WELL RECORDS—Rural Municipality of NO. 21, SASKATCHEWAN

WELL No.	LOCATION ¼	Sec.	Tp.	Rge.	Mer.	TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE Above (+) Below (−) Surface	Elev.	PRINCIPAL WATER-BEARING BED Depth	Elev.	Geological Horizon	CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
1	SW.	2	1	25	3	Dug	22	2,840	- 8	2,832	8	2,832	Recent silt	Soft, clear	45	D, S	Sufficient for local needs.
2	SW.	13	"	"	"	Dug	13	2,897	- 7	2,890	7	2,890	Glacial gravel	Soft, clear	45	D, S	Sufficient for local needs.
3	NE.	19	"	"	"	Dug	22	2,892	- 15	2,877	15	2,877	Recent sand	Hard, clear, "alkaline"	45	D, S	Sufficient for local needs.
1	SW.	9	1	27	3	Drilled	3,960	2,936			240	2,696	Base in Madison limestone				Drilling was for oil; now abandoned.
2	SW.	15	"	"	"	Drilled	1,100	3,046					Base in bedrock				Drilling was for oil; now abandoned.
1	NE.	9	2	25	3	Dug	15	3,007	- 12	2,995	12	2,995	Glacial sand	Hard, clear	44	D, S	Sufficient for local needs.
2	SE.	18	"	"	"	Bored	46	3,011	- 23	2,988	46	2,965	Glacial gravel	Soft, clear	43	N	Cribbing faulty as a result the supply is very poor.
3	NW.	21	"	"	"	Dug	14	3,112	- 1	3,111	14	3,098	Glacial gravel	Soft, clear, "alkaline"	45	S	Sufficient for local needs.
4	NE.	21	"	"	"	Dug	21	3,115	- 6	3,109	21	3,094	Glacial sand and gravel	Hard, clear	45	D, S	Sufficient for local needs.
1	SW.	10	2	26	3	Dug	41	2,975	- 38	2,937	38	2,937	Glacial sand	Soft			This well is now abandoned.
2	NW.	32	"	"	"	Dug	18	2,964	- 16	2,948	16	2,948	Glacial clay	Hard, clear, "alkaline"	48	D, S	Well is not in use now.
3	SW.	34	"	"	"	Dug	3	2,969	- 2	2,967	2	2,967	Glacial clay	Hard, clear, "alkaline"	52	D	Intermittent supply.
4	SE.	35	"	"	"	Dug	14	2,990	- 11	2,979	11	2,979	Recent sand	Soft, clear	48	D	Insufficient for local needs.
5	NE.	35	"	"	"		70	3,000									2 dry holes, 14 feet and 70 feet deep; base in Bearpaw ? shale.
1	NW.	7	2	27	3	Dug	18	3,015	- 5	3,010	10	3,005	Recent gravel	Hard, clear, iron		D, S	Sufficient for local needs.
2	NE.	31	"	"	"	Dug	25	2,956	- 21	2,935	23	2,933	Glacial clay	Hard, clear	43	D	Insufficient for local needs.
3	SW.	36	"	"	"	Spring	3	2,940					Glacial sand	Hard, clear	46	D	Sufficient for local needs; a creek is used fo for stock needs.
1	SE.	2	3	25	3	Dug	8	3,335	- 3	3,332	3	3,332	Ravenscrag shale	Soft, clear	44	D, S	Sufficient for local needs.
2	NW.	5	"	"	"	Dug	12	3,105	0	3,105	0	3,105	Recent silt	Hard, clear, "alkaline"	44	D, S	Intermittent supply.
3	SE.	16	"	"	"	Dug	10	3,197	0	3,197	10	3,187	Recent gravel	Hard, clear, iron	44	D, S	Sufficient for local needs.
4	SW.	18	"	"	"	Dug	12	3,108	0	3,108	12	3,096	Glacial gravel	Hard, clear	44	D, S	Sufficient for local needs.
5	SW.	19	"	"	"	Dug	24	3,106	- 20	3,086	20	3,086	Glacial silt	Hard, clear, "alkaline"	44	D, S	Insufficient for local needs.
6	NE.	21	"	"	"	Bored	50	3,218									Dry hole; base in Eastend shale.
7	NW.	29	"	"	"	Dug	20	3,222	- 15	3,207	15	3,207	Glacial gravel	Hard, clear	44	D, S	Sufficient for local needs.
8	NE.	30	"	"	"	Dug	17	3,232	- 12	3,220	12	3,220	Recent gravel	Hard, clear, "alkaline"	44	D, S	Sufficient for local needs.
9	NE.	30	"	"	"	Dug	15	3,230	- 8	3,222	8	3,222	Recent gravel	Soft, clear	44	D, S	Insufficient for local needs.
10	SE.	31	"	"	"	Dug	10	3,276	- 3	3,273	3	3,273	Recent gravel	Soft, clear	44	D	Sufficient for local needs.

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

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

WELL RECORDS—Rural Municipality of NO.21, SASKATCHEWAN

WELL No.	LOCATION ¼	Sec.	Tp.	Rge.	Mer.	TYPE OF WELL	DEPTH OF WELL	ALTITUDE WELL (above sea level)	HEIGHT TO WHICH WATER WILL RISE Above (+) Below (−) Surface	Elev.	PRINCIPAL WATER-BEARING BED Depth	Elev.	Geological Horizon	CHARACTER OF WATER	TEMP. OF WATER (in °F.)	USE TO WHICH WATER IS PUT	YIELD AND REMARKS
11	NE.	34	3	25	3	Dug	22	3,148	- 19	3,129	19	3,129	Glacial gravel	Hard,clear	43	D, S	Sufficient for local needs.
12	NW.	35	"	"	"	Dug	42	3,159	- 38	3,121	38	3,121	Glacial gravel	Soft,clear	43	D, S	Sufficient for local needs.
13	NW.	36	"	"	"	Dug	25	3,159	- 7	3,152	20	3,139	Glacial gravel	Soft,clear	43	D, S	Sufficient for local needs.
1	SE.	1	3	26	3	Dug	20	3,020									Dry hole; base in glacial clay; two other dry holes 70 and 90 feet deep.
2	SE.	9	"	"	"	Dug	18	2,995	- 8	2,987			Recent sand	Soft,clear	48	D, S	Sufficient for local needs; five other wells, 18 feet deep are not used.
3	SE.	10	"	"	"	Drilled	190	3,048									Dry hole in Bearpaw shale.
4	SW.	10	"	"	"	Dug	16	2,995	- 8	2,987	8	2,987	Glacial clay	Hard,clear	48	D, S	Sufficient for local needs; another similar well.
5	SE.	16	"	"	"	Dug	10	3,033	- 6	3,027	6	3,027	Recent sand	Hard,clear	48	D, S	Sufficient for local needs; also used by neighbours. Two other similar wells.
6	SE.	21	"	"	"	Dug	12	3,045	- 6	3,039	6	3,039	Recent sand and gravel	Hard,clear	48	D, S	Sufficient for local needs; another similar well; three dry holes 12 to 18 feet deep.
7	NW.	23	"	"	"	Dug	26	3,000	- 10	2,990			Glacial clay	Soft,clear		D, S	Sufficient for local needs.
8	NW.	33	"	"	"	Dug	30	3,135	- 15	3,120	15	3,120	Glacial clay	Hard,clear, "alkaline"	46	S	Sufficient for local needs; also a dry hole 12 feet deep.
9	SE.	34	"	"	"	Dug	20	3,170	- 10	3,160	10	3,160	Recent sand and gravel	Hard,clear, "alkaline"	46	D, S	Sufficient for local needs; also several dry holes.
10	NW.	35	"	"	"	Bored	43	3,190	- 25	3,165	25	3,165	Glacial clay	Hard,clear, "alkaline"	46	N	Sufficient supply; but not fit for use.
11	NE.	35	"	"	"	Dug	25	3,175	- 17	3,158	17	3,158	Glacial clay	Hard,clear, "alkaline"	46	D, S	Sufficient for local needs; also a dry hole 10 feet deep.
1	NE.	1	3	27	3	Dug	19	2,950	- 11	2,939	11	2,939	Glacial clay	Hard		D, S	Well now filled in.
2	SE.	2	"	"	"	Spring		2,952	0	2,952	0	2,952	Glacial sand	Hard,clear, "alkaline"		S	Sufficient for local needs.
3	SE.	3	"	"	"	Dug	16	2,976	- 10	2,966	10	2,966	Glacial sand	Hard,clear, iron,sulphur	50	D, S	Sufficient for local needs; also dry holes to a depth of 20 feet.
4	NE.	3	"	"	"	Dug	15	3,020	- 10	3,010	10	3,010	Glacial drift	"Alkaline"		D, S	Well now filled in.
5	SE.	5	"	"	"	Dug	12	2,956	- 9	2,947	10	2,946	Glacial gravel	Hard,clear, "alkaline"	46	D, S	Sufficient for local needs.
6	NE.	9	"	"	"	Dug	12	3,130	0	3,130	9	3,121	Glacial sand	Soft,clear	48	S	Intermittent supply.
7	NW.	16	"	"	"	Dug	22	3,045	- 11	3,034	12	3,033	Glacial sand	Hard,clear, "alkaline"	48	D, S	Sufficient for local needs; ten dry holes 8 to 20 feet deep.
8	SE.	17	"	"	"	Dug	14	3,045	- 7	3,038	13	3,032	Recent gravel	Hard,clear, "alkaline"	48	D, S	Sufficient for local needs.
9	SE.	22	"	"	"	Dug	12	3,040					Glacial clay	Hard,clear, "alkaline"		D	Intermittent supply.
10	NE.	22	"	"	"	Spring		2,980	0	2,980	0	2,980	Glacial drift	Hard,clear, "alkaline"		D	Sufficient for local needs.
11	SE.	23	"	"	"	Dug	14	3,160	- 3	3,157	8	3,152	Glacial sand	Soft,clear	47	S	Sufficient for local needs; use creek water for drinking; a dry hole 150 feet deep.
12	SW.	27	"	"	"	Spring		2,982	0	2,982	0	2,982	Glacial drift	Hard,clear, "alkaline"	48	S	Sufficient for local needs.
13	NE.	30	"	"	"	Dug	13	3,155	- 4	3,151	10	3,145	Recent sand	Hard,clear		D, S	Sufficient for domestic needs only; two dry holes 120 feet deep.
14	NW.	30	"	"	"	Dug	15	3,130	0	3,130	5	3,125	Recent sand	Hard,clear, "alkaline"	47	S	Insufficient for local needs.
15	NE.	31	"	"	"	Dug	16	3,150	- 5	3,145	10	3,140	Recent sand	Hard,clear, "alkaline" iron	46	S	Sufficient for local needs.

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

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