CANADA

DEPARTMENT OF MINES

AND

TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 225

PRELIMINARY REPORT

GROUND-WATER RESOURCES OF THE RURAL MUNICIPALITY OF ..... NO. 81 SASKATCHEWAN

By

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

OTTAWA

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NOTE:

Because of difficulties involved in reproduction, the tables of well records referred to are not included with this report. Information regarding individual wells may be obtained by writing to the Director Geological Survey of Canada, Ottawa.

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GROUND WATER RESOURCES OF THE RURAL MUNICIPALITY OF NO. 81 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 find the approximate depth to a water-bearing horizon, he 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 age.

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 rests 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. 81 comprises an area of 324 square miles in the Cypress Hills uplands in the southwestern part of southern Saskatchewan. The municipality consists of nine townships described as tps. 7, 8, and 9, ranges 25, 26, and 27, W. 3rd mer. There are no towns and few improved roads in the area. The town of Maple Creek, situated on the main line of the Canadian Pacific railway, about 8 miles north of the municipality, serves as the chief trading centre, although a small store is located at Murrydale post office, and in Cypress Hills park a small summer resort flourishes during the camping season.

Townships 7 and 8, range 27, have not been topographically mapped in detail and, therefore, contour lines indicating variations in the surface elevations are shown only in the remaining townships of the area in Figure 2 of the accompanying map.

The three northern townships are situated on the steep northern slope of Cypress hills. The lowest elevation of about 2,800 feet above sea-level is in the valley of Gap creek in the northwestern part of township 9, range 27. From here southward and southeastward the deeply eroded and hillocky land surface rises rapidly to attain elevations of 4,000 to 4,100 feet above sea-level, in the highest part of the hills in the municipality in the northern part of township 8, ranges 25 and 26. Throughout the southern two-thirds of the municipality the surface slopes gently southward, forming a slightly rolling and in some places deeply eroded plain that extends across the southern border at elevations ranging between 3,400 and 3,600 feet above sea-level.

The southern part of the area is drained by Davis, Belanger, Sucker, and Oxarart creeks. All of these streams are spring-fed and maintain a fairly constant flow throughout the year. These streams occupy deep, steep-banked channels, the

bottoms of which lie at elevations of 100 to 200 feet below the bordering uplands, at the points where they cross the southern border of the municipality. Surface run-off on the northern slope is by way of a large number of small streams most of which are tributaries of Maple creek. These streams are also fed by springs and some of them flow throughout a large part of the year.

As most of the area consists of range-land, the small streams and springs are of great value as a source of water supply for stock. These supplies may be supplemented in a few places by artifically constructed dams and dugouts constructed in the coulée bottoms. Sloughs and small lakes provide some water for stock in the central and southwestern parts of the municipality, but elsewhere they are uncommon.

The ground water resources have been developed only in the farming communities in the northern and eastern townships, where wells have been put down in both the unconsolidated deposits and in the underlying bedrock formations.

Water-bearing Horizons in the Unconsolidated Deposits

The unconsolidated deposits consist of Recent sediments laid down by flood-waters in the bottoms of the stream channels and a mantle of glacial drift of irregularly varying thickness that covers the bedrock throughout the rest of the area.

In the stream deposits ground water is usually concentrated in the porous beds of sand and gravel that occur interspersed through the less pervious clays and silts. The small stream channels as a rule have steep gradients and their deposits consist largely of the coarser sediments thinly distributed over the valley floors. Such deposits are not likely to yield permanent water supplies to wells unless they are constantly replonished by springs seeping from the valley sides or by direct seepage from the stream.

In the larger stream channels, such as Davis creek, the gradient is less steep and the deposits consist of larger amounts of finer clays and silts washed down from the valley sides. These deposits are in some places interbedded with coarser sands and gravels that are usually water-bearing. Wells drawing water from the stream deposits are rarely over 20 feet deep, and their waters are nearly all reported to be quite satisfactory for domestic use.

The glacial drift that forms the surface deposits throughout the rest of the municipality consists essentially of boulder clay interspersed in some places with irregular pockets of well-sorted sands and gravels. The drift was deposited by a great continental ice-sheet that spread in a general southwesterly direction over the province of Saskatchewan many thousands of years ago. As the front of the ice-sheet retreated to the north due to the melting of the ice, it paused for considerable periods upon some of the upland areas, and there left more irregular and possibly greater accumulations of rock material than it did over other areas where the recession of the ice was more uniform. These unevenly surfaced areas, characterized by numerous, low drift hills and undrained depressions or sloughs, are known as moraines, as distinguished from the more evenly distributed boulder clay forming the till plains. The moraines in this municipality are confined to a narrow belt of about 2 miles in width extending along the western side of townships 7 and 8, range 27, and two small areas in the eastern part of township 8, range 26.

Ground water supplies in the drift are usually concentrated in the small pockets of sand and gravel that occur irregularly distributed through the less pervious boulder clay. The porous beds are not everywhere water-bearing, however, and owing to their erratic distribution residents in some parts of the area have failed to locate an adequate water supply, or when

it has been located it is in many cases inconveniently situated to farm buildings. The low depressions and draws between the ridges are usually regarded as being more favourable locations for the accumulation of these water supplies than are the ridges or level till plains.

Wells producing from the drift range in depth from 10 to 45 feet. The yields from the individual wells vary, but most of them are inadequate for more than household use and for a few head of stock. These waters also vary greatly as to their mineral salt concentrations. Although few wells are reported to yield water from the drift on the uplands, the mineral salt content there is expected to be low and these waters may all be suitable for drinking. Waters from the wells located on the lower slopes in the northern part of the municipality are, as a rule, much more highly mineralized, and although most of these waters are drinkable many of them contain appreciable amounts of the laxative acting salts in solution. Two wells are reported to yield water that is so highly mineralized as to be unfit even for stock use. "Sulphur" waters are also encountered at several places on these lowlands. The flowing springs that occur at many intervals along these slopes are nearly all issuing from drift or Recent gravels. Many of them may derive their water as seepages from the bedrock and find their way to the surface through the porous beds of the drift. These springs are listed in the table and are shown on the accompanying map, however, as being drift waters. The spring waters are nearly all satisfactory for domestic use and most of them are soft or only moderately hard in character.

Water-bearing Horizons in the Bedrock

Four bedrock formations, known as the Cypress Hills, Ravenscrag, Eastend, and Bearpaw formations, are known to immediately underlie the drift or Recent deposits in different parts of the

municipality. All of these formations at one time, presumably, extended over the entire area in the descending order given. Erosion, most of which took place before the deposition of the glacial drift, has reduced the original thickness of the upper formations in some parts of the area or entirely removed them, so that now only the lowest or Bearpaw formation underlies the entire area. The other formations occupy less extensive areas, the uppermost or Cypress Hills beds being confined to the uplands in range 25, and to two isolated areas in the central and south-central parts.

The Cypress Hills formation is composed essentially of alternating layers of medium- to coarse-grained sands and sandstones, and hard, cemented quartzite conglomerates. As these beds were laid down on an unevenly eroded surface, considerable variations in the thickness of the formation and in the elevation of its base occurs in different parts of the municipality. In the central parks area its base occurs at an elevation of about 4,000 feet above sea-level. It extends to much lower elevations, however, in the southern part of the area. Its thickness in most places probably does not greatly exceed 100 feet. The Cypress Hills formation is the principal source of water supply from the bedrock in the municipality. Water is encountered in wells sunk to depths ranging from 36 to 60 feet, although greater depths may be required in some localities. Where stream channels have cut through the Cypress Hills beds, springs are of common occurrence and are no doubt formed largely by seepages from these aquifers. Water from the Cypress Hills beds is almost invariably of good quality and in many places is reported to be soft, or only moderately hard.

The Ravenscrag formation is also known to be water-bearing, as evidenced by the occurrence of springs in most of the coulées cutting into the formation. No wells, however, are reported

to have been put down in these sediments. This formation consists chiefly of silts and soft shales, interbedded with variable thicknesses of sands and sandstones, and occasionally thin seams of lignite coal. The sands are usually grey to greenish grey, but weather to a light grey or buff on rock exposures. Colours of the shales range through a series of dark greys, greens, and browns, with the dark colours predominating, particularly in the lower beds. The sands and coal seams commonly form the aquifers, although the sandy shales may also be water bearing in some places. These waters are usually of good quality and do not differ essentially from water in the Cypress Hills formation.

The Ravenscrag formation, although it underlies most of the upland, is believed to be absent in the southwestern half of township 7, range 27, where the underlying Eastend formation occurs immediately beneath the drift deposits. The Ravenscrag is also absent on the lower slopes in the northwestern part of the area, at elevations lower than about 3,500 feet above sea-level.

The Eastend formation underlies the Ravenscrag and where the latter is absent underlies the unconsolidated deposits throughout the uplands and extends down the northern slopes beyond the borders of the Ravenscrag to an elevation of about 3,200 feet above sea-level. The position of its base is not definitely known, however, as it grades without apparent break into similar beds that form the upper part of the Bearpaw formation.

The Eastend formation is composed largely of soft grey clay, shales, and silts interbedded with a few layers of porous sands and sandstones. Both the Eastend and the upper beds of the Bearpaw formation are thought to be sufficiently porous to be water bearing. Several wells in the vicinity of Merryflat post office, located a few miles southwest of the municipality, are yielding adequate supplies of drinkable water from the Eastend sandstones. It seems reasonable to suppose that similar aquifers

underlie some parts of this municipality, although depths to water would probably exceed 100 feet at most places.

Waters from the lower part of the Eastend and the upper part of the Bearpaw formations are usually more highly mineralized than waters from the Ravenscrag and Cypress Hills formations. On the lowlands in the northwestern part of the area, where the Bearpaw underlies the drift, the bedrock waters may be too highly mineralized for household use. At greater depths the Bearpaw formation is thought to be composed largely of compact, dark grey to black shales. Such shales yield only small supplies of water in which the dissolved mineral content renders the water unfit for domestic use or for stock. For this reason deep drilling in the lowlands is of questionable value in seeking a water supply

GROUND WATER CONDITIONS BY TOWNSHIPS

Township 7, Range 25

The ground surface of this township is quite irregularly rolling, particularly in the northern and western parts. In the central and southwestern parts the land in some sections is nearly level or is characterized by gentle slopes. In general, the land surface rises in a northerly direction from elevations ranging from about 3,400 to 3,500 feet in the south, to elevations slightly greater than 3,800 feet above sea-level, along the northern border. Drainage of the area is southward through Davis and Belanger creeks. Both streams are spring-fed and maintain a fairly constant flow.

As most of the township consists of range-land, the ground water resources have been little developed to date. Range stock obtain water from flowing springs and from the creeks.

Recent stream deposits consisting essentially of clays and silts, interbedded with more porous sands and gravels, floor the coulée bottoms to depths usually less than 20 feet. These deposits are regarded as the best potential source of water supply in the unconsolidated deposits. They are little used, however, as most of the farm buildings are situated on the uplands remote from the stream channels and the few residents situated in the valleys use spring water in the household. Wells put down in stream gravels in sections 12 and 15 are reported to yield adequate supplies of soft drinkable water, and it is expected that similar supplies might be obtainable in these sediments in other parts of the township.

Water is not so readily obtained from the glacial drift. The drift is composed largely of compact clay, in which occur a few isolated pockets of more porous sands and gravels. These pockets are water bearing in some places, and have been tapped by two wells

in section 16. The water is not noticeably mineralized and is reported to be of excellent quality for household use. Residents in search of these water supplies are advised to prospect locations with a test auger before undergoing the labour and expense of sinking a well, as the drift aquifers are erratic in their distribution and may be absent in many sections of the township.

The unconsolidated deposits are underlain by the Cypress Hills formation throughout the township, with the exception of a narrow belt along the valley of Davis creek, and on the western side and the valley of Belanger creek. Here the Ravenscrag formation underlies the drift. The creek valleys in their lower reaches near the southern border may possibly have been eroded down to the Eastend beds that underlie the Ravenscrag formation.

The Cypress Hills formation is a source of water in other townships bordering on the north and east and is regarded as a potential source of water in this township. The thickness of the formation probably does not greatly exceed 100 feet in any part of the area. A dry hole put down to a depth of 64 feet in section 20 may not have reached the lower beds of the formation where water is most likely to occur, and cannot be regarded as proof that water does not occur in this formation in this township. Waters from the Cypress Hills beds are usually well suited to all farm requirements.

The Ravenscrag formation is also thought to be water-bearing, and may be the source of some of the springs that are reported to occur in the lower reaches of Belanger creek. Ravenscrag waters are usually contained in sand beds or coal seams, and where encountered in other townships to the east are reported to be of good quality. Depths to water in the Ravenscrag beds will probably range between 100 and 200 feet, in most parts of the township.

The Eastend formation occurs at depths generally greater than 200 feet. This formation also contains sandstone beds that are regarded as potential sources of drinkable water. It is doubtful, however, if it would be necessary to sink wells to this formation in places where the Eastend is overlain by the younger formations.

Township 7, Range 26

This township consists almost entirely of range-land. It has an irregular land surface, particularly in the northern part. Surface elevations range from an average of about 3,500 feet above sea-level, along the southern border, to slightly over 3,900 feet in the northern sections. Drainage is carried southeastward by Sucker and Weaver creeks, and by Lonepine and other tributaries of Belanger creek.

As the township consists chiefly of grazing land its ground water resources have not been developed. Range stock obtain water from the creeks, most of which are spring-fed and maintain a fairly constant flow. Some of the springs are also reported to flow continuously throughout the year.

Although the Recent stream deposits that occur in the coulée bottoms are possibly the best potential source of ground water supply at shallow depths, there is little need of prospecting them as the streams and springs at most places provide an adequate water supply. Should greater supplies be required, however, it is quite possible that drinkable water in sufficient quantity for domestic use might be located at depths generally less than 20 feet, in most of the large stream valleys, particularly if sand or gravel beds are encountered.

The glacial drift forming the unconsolidated deposits throughout the rest of the township is also a potential source of shallow water supplies. The drift consists largely of boulder clay,

interspersed with more porous sand and gravel pockets. The sands and gravels may be water bearing in some places, particularly if they are underlain by less pervious clays and shales. Careful prospecting may be required to locate these water supplies, and settlers are advised to prospect first the depressions between the ridges and the bases of steep slopes in preference to the hills and areas of local till plains. Such waters as may be obtained from the drift are not expected to be highly mineralized and should be quite suitable for the domestic drinking supply.

The Cypress Hills formation is regarded as the most reliable source of water supply in the bedrock in this region. This formation is thought to immediately underlie the drift throughout most of the southern third of the township, and it may cap the uplands of highest elevation in the northern part. These sands, conglomerates, and gravels usually yield water at depths of less than 150 feet. The water is as a rule of good quality and is commonly reported to be soft.

The Ravenscrag formation constitutes the uppermost bedrock throughout the rest of the township, with the possible exception of the valley of Sucker creek in the southeastern corner. It is also expected to be water bearing. The base of this formation probably lies at an elevation of about 3,400 feet above sea-level. The formation consists of sandy shales interbedded with sands and sandstones, and possibly a few thin coal seams. Most of the springs that are reported to occur along the banks of the stream channels are believed to originate in the porous Ravenscrag beds. The springs were not examined and consequently their exact locations are not recorded on the map or in the table of wells accompanying this report. Their waters, however, are reported to be of good quality. Wells sunk to these aquifers on the uplands between the stream channels should yield an adequate supply of water for the

average farm requirements, although no prediction can be made as to the depth it will be necessary to go.

The Eastend formation underlying the Ravenscrag is also a potential source of water. This formation may underlie the stream deposits in the lower valley of Sucker creek, in section 1, at elevations lower than 3,400 feet above sea-level. As these beds occur at depths of 100 to 300 feet, throughout most of the township, it is improbable that it will be found necessary to sink wells of a sufficient depth to penetrate this formation before water is found.

Township 7, Range 27

The land surface in the western half of this township is characterized by numerous, low, irregular hills, with intervening undrained depressions or sloughs, and is typical glacial moraine topography. The eastern half, although irregular to steeply rolling, is well drained by the southward-flowing Oxarart creek, and smaller tributary streams.

As the entire area consists of range-land its ground water resources have not been developed. Range stock obtain water from sloughs, and from the creeks and the springs that flow from their banks.

Ground water may be obtained at shallow depths by sinking wells in the stream deposits that floor the bottoms of Oxarart creek and its tributaries. Although wells are reported to have been sunk in these deposits the sediments are believed to resemble stream deposits occurring in the Cypress Hills uplands and consist largely of sands and gravels, interbedded, and usually overlain, by less pervious clays and silts. Since the gravel and sand aquifers obtain their water chiefly by seepage from the stream and from springs, their waters should be quite suitable for household use.

The thickness of the glacial drift that mantles the rest of the area is not expected to exceed 50 feet, and in many places is undoubtedly much thinner. The drift is thought to be water bearing, particularly in the moraine-covered western half of the township. The water may be concentrated in small, irregularly shaped pockets of sand and gravel such as usually occur interspersed through the less pervious bouldor clay. As the presence of these pockets is not readily detected at the surface, careful prospecting may be required in some localities before a suitable water supply is located. The low depressions and draws are usually regarded as the most favourable location for wells in the glacial drift. The drift waters are not expected to be highly mineralized, and should be satisfactory for domestic use.

Three bedrock formations are considered to immediately underlie the unconsolidated deposits in different parts of the township.

The Cypress Hills formation may be present only in the eastern part of sections 1 and 12. These beds may be water bearing, although no prediction can be made as to the yield to be expected. Waters from this source are, however, nearly always suitable for domestic use.

The Ravenscrag formation, underlying the Cypress Hills beds, is thought to extend below the drift throughout the rest of the northeastern half of the township. The Ravenscrag coal seams, and sand or sandstone beds, are also regarded as potential sources of water supply. Some of the springs that are reported to occur near the headwaters of Oxarart creek are probably formed by seepage from these beds. Depths to which it will be necessary to sink wells in the Ravenscrag may vary considerably with difference in surface relief, but they are not expected to exceed 150 feet.

These waters are nearly always satisfactory for use in the household.

The Eastend formation occurs below the Ravenscrag and extends southward, underlying the unconsolidated deposits throughout the rest of the township. The Eastend consists largely of shales, but it is interbedded with thick beds of sandstone that are capable of retaining large supplies of water. In the township lying to the southwest, wells sunk to these sandstone beds yield an adequate water supply for the farms on which they are located. Similar aquifers are expected to occur in this township. Depth to water may vary, but it is not expected to exceed 200 feet, in any part of the area. Hence water is to be expected in all parts of the township, providing wells are sunk sufficiently deep.

Township 8, Range 25

The northeastern part of this township is fairly flat-lying, with an average surface elevation of about 3,950 feet above sea-level. Davis creek flows southward through a wide valley that extends through the central part to cross the southern border of the township in section 3 at an elevation of about 3,650 feet. West of Davis Creek valley, particularly in the southwestern part of the township, the surface is irregular and in some places deeply eroded by the main valley of Belanger creek, and its tributary streams.

Farms in the township are confined largely to the more level northeastern part. The rest of the area is given over to ranch land.

Stream deposits are possibly the most reliable source of ground water supply at shallow depth. These deposits, consisting largely of silts and clay, interbedded with sands and gravels, floor the coulée bottoms to depths probably not exceeding 20 feet. Few wells are reported to have been put down in these sediments, as

springs on the valley sides and the creeks supply ample water for range stock. Waters contained in the valley sediments should be of good quality, however, and may form an addition to the water supplies of residents located in the valleys.

The glacial drift overlying the rest of the township consists chiefly of boulder clay or till. Should water occur in the boulder clay it will probably be concentrated in small, irregular pockets of sand or gravel that occur interspersed at various horizons through the clay. No wells are reported to be drawing their water supplies from these sediments, although several wells in the northeastern part of the township have been sunk through the drift to the underlying bedrock. Such waters as may occur in the drift are expected to be satisfactory for household use, although it is doubtful if many large yields are obtainable from this type of deposit.

Most ground water supplies of the township are obtained from the Cypress Hills bedrock formation. These beds immediately underlie the unconsolidated deposits throughout the township with the exception of a lowlands along the western side, where in the absence of the Cypress Hills beds the Ravenscrag underlies the drift.

The water occurs in beds of gravel and conglomerate, and has been tapped by wells ranging in depth from 40 to 75 feet. The individual aquifers may be of small areal extent, but all of them together should form a fairly continuous horizon throughout the area where this formation occurs. The waters encountered in the wells are reported to be soft and are satisfactory for domestic use.

The Ravenscrag formation underlying the Cypress Hills beds is also thought to be water bearing and may be the source of some of the springs that are known to occur in the western part of the township. Depths to these aquifers in most places will be

greater than 100 feet from the surface, but are not expected to exceed 200 feet.

Township 8, Range 26

The surface of this township is, for the most part, steeply rolling and in places is deeply dissected by steep-banked coulées. The highest part, with an elevation of about 4,100 feet above sea-level, lies on the western side of the township within the Cypress Hills Forest Reserve. On the eastern side elevations range in general between 3,700 and 3,800 feet above sea-level. Most of the area drains southward through Belanger creek and its tributaries, although several small streams in the north-central part flow across the northern border in sections 33 and 34. As the entire area consists of range-land, the ground water resources have not been developed. Range stock obtain water from the creeks and sloughs, and from springs that commonly occur on the coulée banks.

The stream deposits are a source of water supply at shallow depths. These consist chiefly of gravels and sands interbedded with clay and silts. Although no wells are known to have been sunk in the township, these deposits could be expected to form a source of water supply for summer campers in the Cypress Hills Park and Forest Reserve, in the west-central parts.

On the uplands, the glacial deposits are also regarded as potential source of water, particularly in the eastern part of the township, where the underlying bedrock is less pervious than that underlying the western uplands. Small, moraine-covered areas that occur in sections 11, 23, and 26 are particularly promising, since this type of glacial drift usually contains pockets of porous sands and gravels that are capable of retaining moderate supplies of drinkable water.

The Cypress Hills formation is possibly the most reliable source of ground water in the bedrock. This formation overlies the uplands throughout most of the western half of the township and extends down to an elevation of about 4,000 feet above sea-level. Wells put down in these beds should strike water at a depth less than 100 feet.

The Ravenscrag formation occurs below the Cypress Hills beds and extends beneath the drift throughout the rest of the township. This formation is thought to contain the source beds of many of the flowing springs that occur at intervals along the banks of most of the coulées and supply water for the summer resort in Cypress park. The spring waters are moderately soft to hard, and are of excellent quality for drinking. These aquifers are expected to occur in other parts of the township and should be encountered in wells at depths less than 200 feet.

Township 8, Range 27

Relief of the township is not less than 700 feet. The lowest elevation, of about 3,300 feet above sea-level, occurs in section 31. The surface of the western half of the township is very irregular, with surface elevations ranging in general from 3,500 to 3,700 feet above sea-level. Toward the east the surface rises rapidly to attain a maximum elevation of slightly greater than 4,150 feet, on the western side of the township. No wells are recorded from the township as the land is devoted almost entirely to ranching. Small creeks and springs, and possibly a few sloughs, provide water for range stock.

Stream deposits, consisting largely of sands and gravels, floor the bottoms of the coulées. These are regarded as a source of ground water, particularly for residents who are in search of household supplies at shallow depths of less than 20 feet. As the water in the sand and gravel beds is derived chiefly

from springs and by seepage from the streams, the water should be quite suitable for drinking.

The glacial drift forming the surface deposits throughout the rest of the township is also a potential source of water at shallow depths. The thickness of the drift is undetermined, but it probably does not exceed 50 feet, and it is no doubt much thinner on the steeper hill-sides and on the uplands in the eastern part of the area. The drift consists chiefly of till, interspersed with irregular pockets of well-sorted sands and gravels. The porous beds may be more numerous in the irregular, moraine-covered area that extends southward through the southwestern part of the township, and at the bases of slopes or in the draws where materials may have washed down from the hill-sides. Owing to the irregular distribution of the water-bearing beds in the drift it is usually necessary to sink several wells before locating a water supply. The drift waters in this township are expected to be satisfactory for domestic use.

The bedrock formations underlying the unconsolidated deposits in this township are also thought to be water bearing. The uplands, including most of the eastern third of the township, is underlain by the Cypress Hills formation, outcrops of which are quite common on the steeper slopes. These beds are usually water bearing at depths ranging from 40 to 150 feet. Waters obtained from the formations in other parts of the municipality are reported to be soft and are satisfactory for domestic use.

The Ravenscrag formation occurring below the Cypress Hills beds may extend down to an elevation of about 3,600 feet above sea-level. It extends beyond the borders of the Cypress Hills formation and is present throughout the rest of the township with the exception of the northwestern slopes and part of section 6, where surface elevations range lower than 3,600 feet. The sand beds

and coal seams of this formation are believed to be the source of some of the springs that are reported to occur on the coulée banks. These aquifers should be encountered in wells at depths less than 200 feet in places underlain by the Ravenscrag.

The Eastend formation is also regarded as a potential source of water. This formation, consisting largely of shales interbedded with fine- to medium-grained sands and sandstones, underlies the Ravenscrag, or in the absence of the Ravenscrag underlies the drift deposits throughout the township, with the exception of a small area in sections 31 and 32. Here the Bearpaw formation underlies the drift at elevations lower than about 3,350 above sea-level. It is quite probable that the Eastend sands may form aquifers containing drinkable waters, although the depth to the aquifers and the quality of water obtainable are expected to vary considerably in different localities.

The Bearpaw formation occurs at too great depths in most parts of the area to be regarded as a practical source of water supply. It may contain water-bearing sand beds in its upper part, but these waters are usually fairly highly mineralized and in some places may be undrinkable.

Township 9, Range 25

Most of the southeastern half of this township consists of high-level benchland, with an average elevation of about 4,000 feet above sea-level. The northwestern half is situated on the northern slope of Cypress hills, with surface elevations ranging from 4,000 feet on the edge of the benchland to an elevation of 5,200 feet above sea-level, in the vicinity of the northwestern corner of the township. The steep slopes are irregular to hillocky and are partly covered by a growth of poplar and willow. These areas are not satisfactory for cultivation and are used largely for grazing. Sections 24, 25, and the NE.$\frac{1}{4}$, section 26,

form the Maple Creek Indian Reserve. A few sections in the flat benchland in the southeastern part are farmed.

Springs are the chief source of water supply in the township. They occur at irregular intervals along the northern slopes at elevations ranging from about 3,280 to 4,000 feet above sea-level. At all places they are reported to flow from the glacial drift, although many of them, particularly those on the upper slopes, are believed to have their origin in the underlying bedrock aquifers. The spring waters are all reported to be satisfactory for stock and domestic requirements.

The glacial drift forming the surface deposits on the northern slopes is composed chiefly of silts and clays that have been partly reworked by stream action. Pockets and thin beds of well-sorted sands and gravels have been washed into the stream channels and depressions, between the ridges. These porous beds may be water bearing in some places, particularly if they are sealed at their lower end by impervious clay. Wells encountering these supplies are not expected to exceed 20 feet in depth, and their waters should not differ greatly from the spring waters. Water-bearing sand and gravel pockets may be relatively scarce in the drift mantling the southeastern benchland, and residents are advised to extend wells into the underlying bedrock formations. The bedrock throughout the uplands consists of porous sand and gravel beds of the Cypress Hills formation and offers little resistance to the downward flow of the ground waters.

Wells sunk through the drift encounter the underlying Cypress Hills Beds at an average depth of about 40 feet. Water was struck in two of these wells, located in sections 12 and 15, at depths of 55 and 60 feet. A third well put down to a depth of 65 feet, in section 14, failed to encounter water. Other aquifers, however, are expected to occur at greater depth, down to the base

of the formation at a depth of about 150 feet. Where encountered, the water is reported to be soft and the supply is sufficient for the requirements of the farms on which the wells are located.

The Ravenscrag formation underlying the Cypress Hills beds may also underlie the unconsolidated deposits on the northern slope down to an elevation of about 3,400 feet above sea-level. The rest of the township, including slightly more than sections 31, 32, and 33, is underlain by the Eastend formation.

Both these formations are believed to consist of shales that are interbedded with sands and sandstones and are regarded as a potential source of water supply that should be made available by sinking wells nowhere greatly exceeding 100 feet in depth.

Township 9, Range 26

This township is located on the northern slope of the Cypress Hills uplands. Elevations range from an average of about 3,000 feet above sea-level on the northern border to a maximum of about 4,000 feet on the top of the upland in section 6. The surface is irregular and deeply carved by numerous, small stream channels through which small streams flow down the slope to the north. Owing to the steep gradient the run-off in the streams is rapid, but since part of the water is derived from springs some of the streams maintain a fairly constant flow.

With the exception of the springs the stream deposits are probably the most reliable source of ground water at shallow depth. These deposits floor the coulée bottoms and consist chiefly of sands and gravels interbedded with the less pervious silts. Wells sunk in the sand and gravel beds usually strike water at depths of less than 20 feet. The water is reported to be hard and drinkable.

The glacial drift is the immediate source of the springs that occur on the coulée banks, although these waters may originally

have come as seepage from the underlying bedrock. Most of the spring waters are hard, but at only a few places are they reported to contain any appreciable amounts of mineral salts in solution.

Wells put down in the drift encounter water that is more variable and usually more highly mineralized than the spring water. Several wells situated in sections 14 and 16 are reported to yield water that is "alkaline" and "sulphur" bearing. In one well on the latter section the mineral salt concentration in the water was so great that stock would not drink it. As few wells have been put down in the glacial drift in other parts of the township it is not known if this type of water is common at shallow depths in the drift in other parts of the area. It is probable, however, that apart from the shallow sand and gravel pockets that usually occur interbedded with the clay at the bases of steep slopes, little water may be obtained from the drift. Residents in search of water in the unconsolidated deposits are advised to sink wells in the draws and coulée bottoms in preference to the ridges.

The Cypress Hills, Ravenscrag, Eastend, and Bearpaw formations occur below the drift in descending order down the slope to the north. The Cypress Hills beds occur only in the highest uplands in the southeast and southwestern parts at elevations greater than about 3,800 feet above sea-level. A large spring that occurs in the SW.$\frac{1}{4}$, section 6, although flowing from the drift, may have its origin in the base of this formation. The water is reported to be hard and clear and can be used for domestic purposes.

The Ravenscrag formation may extend down to an elevation of about 3,500 feet above sea-level, and is confined largely to the southern and southwestern sections of the township. Sand beds, and possibly coal seams in this formation, may be water-bearing,

although depths to the productive beds will not doubt vary owing to the great range in surface elevations in different parts of the area.

The Eastend formation occurring below the Ravenscrag may extend down to an elevation of about 3,200 feet above sea-level and underlies the mantle of drift throughout most of the southern two-thirds of the township. Since springs are reported to be flowing from the drift in areas underlain by Eastend beds it is presumed that some of these are caused by seepage from the bedrock and that these aquifers might be penetrated by sinking wells. No prediction can be made as to the depth to the water-bearing beds, however, owing to irregularities in the topography and to the variable thicknesses of the overlying drift.

The Bearpaw formation is regarded as the least favourable of the bedrock formations for the occurrence of water. Porous sands are usually scarce in the Bearpaw and its waters where encountered are as a rule highly mineralized, rendering them in some places unsuitable for drinking. Residents situated in the northern part of the township where this formation forms the uppermost formation are advised to confine their search for water to the unconsolidated deposits.

Township 9, Range 27

Elevations in this township range from about 2,800 feet in the valley of Gap creek in section 32, in the northern part, to slightly greater than 3,800 feet above sea-level on the highest point in the southeastern corner of the area. The land surface is quite irregular and is dissected by the numerous, small, northward-flowing tributaries of Gap and McShane creeks.

Ground water supplies of the township are obtained at the present time entirely from shallow wells sunk in the unconsolidated deposits. The glacial drift consists largely of boulder clay

and silt of variable thickness. The upper part of the drift has been reworked by stream action, so that now fairly thick deposits of well-sorted sands and silts may occur at some places in the northern part of the township where the stream gradient is less steep. These flood-plain deposits are the chief source of water supply, as most of the wells are situated in the draws and creek bottoms. They do not usually exceed 16 feet in thickness. The water occurs at nearly all places in beds of gravel buried under several feet of clay or silt. The mineral salt concentration of the water varies widely from place to place, so that no prediction can be made as to the type of water to be expected at any well location. Only one well, situated on section 10, is reported to yield water that is so highly mineralized as to be undrinkable. This well was put down to a depth of 80 feet, but it is thought to obtain most of its water supply from a gravel bed at a depth of 10 feet. This is the only deep well recorded from the township. It seems probable, however, that at many places water-bearing gravels might occur at the contact of the glacial drift and the underlying bedrock. The presence of these beds can only be ascertained by sinking wells to the bedrock. This undertaking is recommended only in places where the shallow drift and Recent stream deposits have proved unproductive.

The bedrock formations may be water bearing only in the southeastern half of the township. The Ravenscrag beds immediately underlie the drift only in section 1 and in the southern parts of section 2 at elevations greater than about 3,600 feet above sea-level. The Eastend formation occurring below the Ravenscrag extends farther down the slope to an elevation of about 3,300 feet. Both these formations are known to contain porous sands and sandstones that are capable of retaining ground water. No generalizations can be made regarding the depth of well required to penetrate

these beds, however, due to the great variations in the surface relief from place to place.

The Bearpaw formation underlies the unconsolidated deposits throughout the lowland part of the township at elevations lower than 3,300 feet above sea-level and is not expected to yield any large supplies of drinkable water. Residents in this part of the area are advised to confine their search for water to the overlying unconsolidated stream deposits and glacial drift.

STATISTICAL SUMMARY OF WELL INFORMATION IN RURAL MUNICIPALITY OF NO.81, SASKATCHEWAN

	Township	7	7	7	8	8	8	9	9	9	Total No. in muni-
West of 3rd meridian	Range	28	29	30	28	29	30	28	29	30	cipality
Total No. of Wells in Township		7	0	0	11	0	0	32	29	18	97
No. of wells in bedrock		1	0	0	4	0	0	3	0	0	8
No. of wells in glacial drift		4	0	0	3	0	0	29	24	12	72
No. of wells in alluvium		2	0	0	4	0	0	0	5	6	17
Permanency of Water Supply											
No. with permanent supply		5	0	0	11	0	0	29	23	15	83
No. with intermittent supply		0	0	0	0	0	0	1	4	3	8
No. dry holes		2	0	0	0	0	0	2	2	0	6
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	0	0	0	0	0	1	1
No. of non-artesian wells		5	0	0	11	0	0	30	27	17	90
Quality of Water											
No. with hard water		0	0	0	0	0	0	7	27	16	50
No. with soft water		5	0	0	11	0	0	23	0	2	41
No. with salty water		0	0	0	0	0	0	0	0	0	0
No. with "alkaline" water		0	0	0	0	0	0	0	4	10	14
Depths of Wells											
No. from 0 to 50 feet deep		6	0	0	9	0	0	28	28	17	88
No. from 51 to 100 feet deep		1	0	0	2	0	0	4	1	1	9
No. from 101 to 150 feet deep		0	0	0	0	0	0	0	0	0	0
No. from 151 to 200 feet deep		0	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0
How the Water is Used											
No. usable for domestic purposes		5	0	0	11	0	0	26	16	16	74
No. not usable for domestic purposes		0	0	0	0	0	0	4	11	2	17
No. usable for stock		5	0	0	11	0	0	30	26	17	89
No. not usable for stock		0	0	0	0	0	0	0	1	1	2
Sufficiency of Water Supply											
No. sufficient for domestic needs		5	0	0	10	0	0	28	23	14	80
No. insufficient for domestic needs		0	0	0	1	0	0	2	4	4	11
No. sufficient for stock needs		4	0	0	10	0	0	26	17	5	62
No. insufficient for stock needs		1	0	0	1	0	0	4	10	13	29

ANALYSES AIT 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 boilders 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 hardness 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 analysis from this municipality by the Geological Survey. The following discussion of the general characteristics of these waters is based upon opinions of the residents and upon analyses of waters taken from adjoining municipalities where the source beds show close similarities.

Nearly all the waters obtained from the stream deposits apparently contain only small concentrations of mineral salts in solution. Most of them are soft or moderately hard. This type of water is expected to be of fairly general occurrence in the coarse sediments flooring coulées or scattered along the lower hill slopes. The aquifers consist largely of well-sorted gravels and hence the waters contain only small amounts of salts in solution. The spring waters that seep from the bedrock on the sides of the coulées are the source of at least part of the water found in these sediments. These waters contain only small concentrations of mineral salts in solution and owing to their fairly rapid circulation through the gravels they are afforded little opportunity of dissolving additional salts. In the northwestern part of the area, the stream sediments are derived partly by erosion of the marine shales of the Bearpaw and Eastend formations. The salts inherent in these shales may be taken into solution in some places in sufficient quantity to render the water unsuitable for household use.

The boulder clay comprising much of the glacial drift contains inherently large amounts of readily soluble mineral salts, and hence waters from the drift in this part of the municipality may be highly mineralized. The so-called "alkali" waters usually contain sodium sulphate (Na_2SO_4), magnesium sulphate ($MgSO_4$), calcium carbonate ($CaCO_3$), and common salt (NaCl). These salts are

listed in the decreasing order of their relative abundance. The sulphates of sodium and magnesium are the most harmful salts present. Waters containing in excess of 1,000 parts per million of both these salts tend to have a laxative effect when drunk by persons unaccustomed to highly mineralized waters, although waters containing concentrations of nearly twice this amount are in many places used for drinking in different parts of the province without imparting any noticeable ill effects.

The drift waters encountered on the uplands are remarkably free from any large mineral salt concentration. The drift here is more porous than that commonly found on the lower plains. The underlying bedrock is also porous at most places and allows a free downward percolation of ground water and thus the greater part of the readily soluble salts has been removed.

Water from the Bedrock

Waters obtained from the Cypress Hills formation contain very low mineral salt concentrations. The Cypress Hills sediments are composed largely of quartzite pebbles and sand grains, firmly cemented in places by lime carbonate. The carbonates are the only readily soluble salts present, and form the chief constituents in waters from this formation. The carbonates of calcium ($CaCO_3$), and magnesium ($MgCO_3$), are usually present in the greatest abundance, with calcium carbonate forming the predominant salt. These compounds are tasteless, and are regarded as harmless, but they contribute to the hardness of the water. A large part of this hardness is temporary, and may be removed by boiling the water.

As no wells are reported to yield water from the Ravenscrag formation, the quality of its waters is not known so well as that of the waters from the Cypress Hills formation. The waters may contain a slightly higher average mineral salt concentration, although it is doubtful if at any place they are too

highly mineralized for domestic use.

The Eastend and Bearpaw formations in many cases yield water containing large amounts of the laxative sulphate salts. Their waters are so variable, however, that it is difficult to predict the type of water that may be expected in any one locality. In general, the sandstone beds in the upper part of the Bearpaw and in the Eastend formations yield drinkable waters. Supplies from the sandy shales and fine silts are more highly mineralized. The concentration of dissolved sodium sulphate and sodium chloride (common salt) may increase with depth in the Bearpaw formation to such an extent that waters obtained at horizons more than 200 feet below the top of the formation may be unfit even for stock watering.