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MAR 15 1937

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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. 52 SASKATCHEWAN

BY

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

Water Supply Paper No. 113

OTTAWA

1936

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CONTENTS

	Page
Introduction	1
Glossary of terms used	5
Names and descriptions of geological formations referred to	8
Water-bearing horizons of the municipality	10
Water-bearing horizons in the unconsolidated deposits	12
Water-bearing horizons in the bedrock	14
Ground water conditions by townships:	
Township 4, Range 28, west of 3rd meridian	17
Township 4, Range 29, " " " "	19
Township 4, Range 30, " " " "	21
Township 5, Range 28, " " " "	22
Township 5, Range 29, " " " "	24
Township 5, Range 30, " " " "	26
Township 6, Range 28, " " " "	27
Township 6, Range 29, " " " "	29
Township 6, Range 30, " " " "	32
Statistical summary of well information	34
Analyses and quality of water	35
General statement	35
Table of analyses of water samples	39
Water from the unconsolidated deposits	40
Water from the bedrock	41
Well records	43

Illustrations

Map of the municipality:

Figure 1. Map showing surface and bedrock geology that affect the ground water supply.

Figure 2. Map showing relief and the location and types of wells.

GROUND WATER RESOURCES OF THE RURAL MUNICIPALITY OF No. 50 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 geologic 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 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. 52 occupies an area of approximately 294 square miles on the southern slope of the Cypress Hills uplands in the southwestern part of southern Saskatchewan. The Alberta-Saskatchewan boundary (the Fourth meridian) forms the western border of the area and the southern border lies 18 miles north of the International Boundary. The municipality consists of six full townships and three fractional townships, described as townships 4, 5, and 6, ranges 28, 29, and 30, W. 3rd mer. The fractional townships occur in range 30 adjacent to the Fourth meridian.

The greater part of the area consists of rangeland, the farming community being confined almost entirely to townships 4, ranges 28 and 29, and the southeastern half of township 5, range 28. The small village of Senate, situated on the Shaunavon branch of the Canadian Pacific railway in the southeastern part of township 4, range 28, is the chief trading centre of the area; a country store is located at West Plains post office in sec. 22, tp. 5, range 28.

As the area has not been topographically mapped, it has not been possible to indicate the relief by contour lines on Figure 2 of the map accompanying this report. The elevations quoted in the report were determined by aneroid barometer during the course of this investigation and, where possible, were checked by reference to railway and boundary survey bench-marks. As fairly large discrepancies in the barometric readings are bound to occur, the elevations must be regarded as only approximate.

The maximum relief of the area approximates 900 feet. The lowest surface elevations, ranging between 3,100 and 3,200 feet above sea-level, occur along the southern border of the area. From the southern boundary northward for about 6 miles, and for several miles farther on the eastern side, the undulating prairie

along the base of the Cypress Hills uplands rises gradually to an average elevation of about ,300 feet. From here in northerly and northwesterly directions the surface elevations rise more rapidly to attain a maximum elevation of slightly over 4,000 feet above sea-level in the northwestern part of the municipality. These uplands form part of the southern flank of Cypress Hills plateau. The surface of these slopes is a broadly rolling prairie land dissected by deep coulées and ravines and alternating in places with areas of wide and comparatively flat benchland.

A wide, flat-bottomed valley extends in an east-west direction through the central part of the municipality, cutting across the lower slopes of the uplands at an average elevation of about 3,300 feet above sea-level. Middle creek enters the municipality from the west through this valley, in sec. 20, tp. 5, range 30, and after running eastward for about 6 miles turns south to cross the southern border of the municipality in sec. 4, tp. 4, range 29. In the eastern part of the township the valley is occupied by Battle creek. This stream enters the municipality from the north through a deep coulée extending southward through range 29, and joins the main valley in the northern part of township 5, range 29. From here it flows eastward to cross the eastern border in sec. 1, tp. 6, range 28. Both streams are spring-fed and maintain a small but fairly constant flow. These streams are the chief sources of water supply for stock, although dams constructed in the small coulées conserve surface water for stock use in some parts of the area.

Ground water supplies of the municipality are obtained chiefly from wells sunk in the unconsolidated Recent deposits and the glacial drift. The bedrock formations are also a potential source of water supply in the northern upland parts of the area.

Water-bearing Horizons in the Unconsolidated Deposits

Stream deposits forming the broad flats along the bottoms of Middle Creek and Battle Creek valleys are regarded as a potential source of ground water supply at shallow depths. As the streams flow through land that is devoted largely to grazing the water resources of these deposits have been little developed. The stream deposits consist of clays, silts, and fine sands interspersed with, and in some places underlain by, coarser sands and gravels. The thickness of these deposits varies from place to place, but probably nowhere greatly exceeds 30 feet. Where wells have been put down to gravel aquifers abundant supplies of drinkable water have been obtained. The stream deposits may not be everywhere water bearing, however, particularly where the less porous clays and silts occur. As the water-bearing beds are usually buried under several feet of clay it may be necessary to sink several test holes or wells in one locality before a suitable water supply is encountered.

The glacial drift is the chief source of the present ground water supply in the municipality. These deposits were distributed unevenly over the surface of the bedrock 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 ice-sheet advanced over the municipality and, upon the melting of the ice, finally retreated to the northeast, it left a covering of drift distributed irregularly over the surface of the bedrock. In places the accumulation of drift is characterized by numerous low hills and intervening, undrained depressions, and these belts of drift have been formed where the retreating ice-sheet remained stationary for considerable periods of time. These deposits are referred to as moraines to distinguish them from the more level, drift-covered areas designated as till plains. The moraines in this municipality occur as irregular patches

distributed in a roughly northeast-southwest direction through the central part of the area. The largest of these areas occurs south of Battle creek in townships 4, ranges 28 and 29.

A small area of highland, extending over the northern part of township 6, range 30, at an elevation of about 4,000 feet above sea-level, is devoid of glacial drift and the surface deposits consist of a few feet of residual soil formed by weathering of the bedrock.

The glacial drift consists largely of boulder clay that in the weathered upper part is brown to yellowish grey, and grades into dark bluish grey clay below the zone of weathering at depths of 10 to 20 feet. Irregularly shaped pockets of sand and gravel occur sparsely interspersed through the upper 20 feet of the boulder clay. These pockets are a source of ground water in some parts of the area. They are often found beneath depressions and at the bases of steep slopes where material has washed down from the hills and higher slopes, and are generally more numerous in the moraine-covered areas than in the more level till plains. As the water-bearing beds are usually buried under several feet of boulder clay their presence is not always indicated by the character of the surface deposits. They may be readily located at a minimum expense by the use of test augers. Waters from these deposits are usually hard and not too highly mineralized to be unsuitable for use in the households.

Wells drawing water from the boulder clay are usually situated beside sloughs or artifically constructed reservoirs and derive their supplies by seepage. This water is quite satisfactory for household use provided the water in the reservoir is not highly mineralized nor contaminated by sewage or other decaying organic matter. Shallow wells sunk in the drift remote from artificial reservoirs may yield only small supplies and are materially affected by prolonged drought conditions. The most

extensive and dependable sources of water supply in the drift are deposits of gravel and more rarely sand beds that immediately overlie the bedrock. An attempt is made by means of the "A" line on Figure 1, of the accompanying map, to outline the area in which these water-bearing gravels occur. Owing to the scarcity of wells along the borders of the areas, however, the extent of the gravels as outlined must be regarded as only approximate. The deposits are not believed to form any large, continuous horizon over the northern uplands.

Wells put down to this horizon range in depth from 50 to 135 feet, with an average depth of about 80 feet. The water supply obtained is adequate for the average farm requirements and the water is generally under sufficient hydrostatic pressure to cause it to rise in the wells 10 to 30 feet above the aquifer, and in some of the wells even greater heads are encountered. Water from the deepest well, situated in sec. 9, tp. 4, range 28, rises from a depth of 135 feet and flows at the surface. The aquifer supplying this flow of water is reported to be fine sand that lies at the base of the glacial drift. It is probable that water at this horizon percolates down from the northern uplands to the area of lower elevation. Such a condition would account for the pressure under which this water is found not only in this municipality but in the municipality to the east. In the absence of deep wells in the vicinity of the flowing well referred to above the areal extent of a possible artesian basin in the neighbourhood has not been determined.

Water-bearing Horizons in the Bedrock

Three bedrock formations, known as the Ravenscrag, Eastend, and Bearpaw formations underlie the unconsolidated deposits in different parts of the municipality. These formations at one time presumably extended over the entire area, the

Ravenscrag formation being underlain by the Eastend and it in turn by the Bearpaw. Extensive erosion that took place prior to and to a lesser degree after, the deposition of the glacial drift removed most of the upper formations, so that now the Ravenscrag occurs only in a small area extending over the northwestern uplands in the northwestern part of township 6, range 29, and the northern part of township 6, range 30. The Eastend formation lying below the Ravenscrag extends south and eastward through the remainder of the uplands and covers slightly more than the northern third of the municipality. The unconsolidated deposits throughout the rest of the municipality are immediately underlain by the Bearpaw formation.

The Ravenscrag formation consists of shales interbedded with thick beds of sand and sandstones, and occasionally thin seams of lignite coal. These beds are considered to be sufficiently porous to form reservoirs for water accumulation. No wells are reported to be yielding from these beds in the municipality, and owing to their isolated position on the highest part of the uplands they probably have little opportunity of retaining any large water supplies.

The Eastend formation is regarded as the best source of water supply in the bedrock of the area. These sediments consist largely of grey shales interspersed with lighter coloured, grey to buff-weathering silts and fine- to medium-grained sands and sandstones. The lower beds are more shaly and at depth gradually merge without any apparent break into the underlying Bearpaw formation.

The sandstone beds yield water to several wells in the municipality, and are expected to form a fairly continuous water-bearing horizon throughout the area underlain by this formation. Where obtained these waters are not highly mineralized and are reported to be quite suitable for drinking.

The upper part of the Bearpaw formation is probably only slightly less porous than the Eastend and contains thin beds of fine sand, interbedded with dark shales. At greater depths in the formation these porous beds are almost entirely replaced by shale. These shales may be readily distinguished in drilling from the boulder clays of the drift by their darker grey to almost black colour when wet, by their soapy feel, and by the small, roughly cubical fragments into which they break upon drying. They may be further distinguished by the absence in them of pebbles, stones, or boulders, and by the occasional occurrence of fossils. This formation is of wide areal extent and underlies the entire municipality. It may have a maximum thickness of about 700 feet in this municipality. As the upper, sandy beds have been removed by pre-glacial erosion over most of the southern half of the municipality the Bearpaw is not expected to be water bearing in this part of the area. This assumption is borne out by the results of a 635-foot dry hole drilled in the village of Senate. Here only dark grey shales are reported to have been penetrated to the base of the Bearpaw, which is at a depth of about 590 feet. Should water occur in the upper part of the Bearpaw in the central and northern part of the area it will probably be more highly mineralized than waters from the overlying Eastend, and may not be satisfactory for domestic use. Any small seepages that have been found in the compact shales comprising the middle and lower parts of the Bearpaw formation in adjoining municipalities are almost invariably too highly mineralized to be used even for watering stock. Residents are well advised to discontinue drilling when these compact shales are penetrated.

GROUND WATER CONDITIONS BY TOWNSHIPS

Township 4, Range 28

Water supplies of this township are obtained almost entirely from wells sunk in the unconsolidated deposits. A small tributary of Battle creek flows eastward through the southern sections, but it carries water only during flood seasons and cannot be depended upon for a permanent water supply. Part of the surface run-off might be conserved by constructing dams in the small coulées.

Recent deposits of silt, sand, and gravel that occur in the coulée bottoms are a source of ground water in the southern part of the area. Wells situated in sections 2, 5, and 10 are drawing their supplies from Recent sands at depths of 17 to 24 feet. The waters are reported to be noticeably mineralized, but are being used for domestic requirements. A better quality of water might be obtained by sinking wells in some of the smaller coulées or by digging seepage wells beside dams.

The glacial drift that mantles the township consists of boulder clay or till from which little water is obtainable at shallow depths. At several places wells have been put down beside sloughs, but the supplies obtained are not dependable during seasons of drought or during the winter months. The most reliable source of ground water is the gravel and sand beds that occur at or near the contact of the glacial drift with the underlying bedrock. Since the surface of the bedrock is uneven the depths to the water-bearing horizon vary considerably within short distances. This variation is particularly noticeable in sections 9, 17, and 20, where wells were put down to depths of 120 to 135 feet before water-bearing sand and gravel beds were encountered. The wells in sections 17 and 20 are apparently yielding from the same aquifer at a depth of 120 feet. The water

is under some hydrostatic pressure, as it rises in the wells 6 and 20 feet above the gravel bed. This water is moderately hard to soft, and is used for the domestic drinking supply. The well in section 9 struck water in quicksand. The pressure here is sufficient to raise the water 150 feet above the aquifer, or to a point 15 feet above the surface. The water is soft and drinkable. This well may derive its water from the upper part of the bedrock, but the evidence is not conclusive and the well has been tentatively listed as producing from an aquifer in the drift.

In the absence of accurate elevations at many of the well sites it has been difficult to determine the exact relationship existing among wells sunk to the lower part of the glacial drift. It is probable, however, that the gravel beds are fairly continuous over the northern and central parts, and occur at gradually decreasing elevations from north to south. Many local variations probably occur, due to irregularities in the surface of the bedrock upon which the gravels were deposited. Throughout the northern two-thirds of the township the water-bearing beds are generally encountered at depths ranging from 50 to 80 feet. At most places the water is under hydrostatic pressure and maintains a constant level in the well at points 30 to 40 feet above the aquifer. It is hard and tastes of iron. Some of the wells are also reported to produce water containing a relatively large amount of the sulphate salts that render the waters unsuitable for domestic use, but they are being used for watering stock. The southern extent of these contact deposits is not well defined. It was not encountered at the village of Senate in section 3, where a deep well was drilled into the bedrock, although it may extend through the southwestern sections. The "A" line shown on Figure 1, of the accompanying map, is situated only to outline

the probable southern boundary of the horizon, and its position should not be regarded as absolutely correct.

The Bearpaw formation is believed to immediately underlie the unconsolidated deposits in this township. This formation is composed almost entirely of compact shales and is not expected to contain beds sufficiently porous to permit of any large accumulations of water. A dry hole drilled at the village of Senate encountered Bearpaw shales at a depth of 105 feet and at a depth of 590 feet a seam of coal in what is probably the upper part of the underlying Belly River formation. The hole was terminated in the Belly River beds at a depth of 635 feet. The Belly River formation may have a thickness of 1,000 feet. It contains porous sands and sandy shales, and it may be water bearing. It is unfortunate that the 635-foot well at Senate was not continued some 50 or 100 feet deeper and thus provide more definite information regarding the water-bearing properties of the Belly River formation. Drilling to this formation is an expensive procedure and since water cannot be definitely assured residents are better advised to confine their search for water to the drift or to the drift-bedrock contact.

Township 4, Range 29

As a large part of this township consists of rangeland few wells have been put down for ground water supplies. Middle creek flowing southward through the township, from section 32 to section 4, provides a source of water for stock in its vicinity. In other places dams might be constructed in small coulées to conserve part of the run-off for stock use during the grazing season.

Recent deposits of sand and gravel that occur interspersed through the silts in the valley of Middle creek are probably the most reliable source of ground water at shallow depths.

Water from this type of deposit is usually drinkable, although it may contain relatively large amounts of salts in solution in some localities.

The glacial drift may also contain small water supplies at shallow depths, particularly in the moraine-covered area that extends southward through the north-central part of the township. Residents in search of water are advised to prospect with a small test auger in the depressions and small draws where pockets of sand or gravel may have formed from material washed down from the hillsides during glacial time. Such pockets are usually encountered at depths not exceeding 20 feet, and seldom produce more than sufficient water for a few head of stock and for household use. The water obtained is usually drinkable.

The chief source of ground water in the township is extensive gravel and sand beds that occur at or near the contact of the glacial drift and the underlying bedrock. The extent of these aquifers is not known, but they are believed to be present in most parts of the area, as no wells are reported to have been sunk through the drift without encountering an adequate yield of water at this horizon. At most places the water is under sufficient hydrostatic pressure to cause it to rise in the wells 15 to 35 feet above the water-bearing bed. The water is hard and contains appreciable amounts of the mineral salts, mostly sulphates in solution, but at all places it is reported to be suitable for stock use, and where better drinking water is not available it is being used for the domestic supply without imparting any apparent ill effects. A spring issuing from the bank of Middle creek, in section 9, may also have its source in these lower drift deposits. This and other smaller springs in the vicinity are reported to water 500 head of stock.

The Bearpaw formation is believed to form the bedrock immediately below the unconsolidated deposits throughout the township. Although no wells are known to have penetrated this formation in the township it is not expected to contain water in sufficient quantities to provide for the requirements of any large number of stock. Residents in the area are advised to confine their search for water to the overlying glacial drift or to the Recent stream deposits.

Township 4, Range 30

This fractional township lying adjacent to the Fourth meridian comprises about 26 square miles of rangeland. No wells are known to have been put down in the area. A large number of small dams constructed in coulées provide water for range stock.

Adequate supplies of ground water could probably be obtained by sinking wells to the base of the glacial drift at depths of 75 to 90 feet from the surface. Beds of water-bearing sands and gravels occurring at this horizon are a dependable source of water supply for residents situated throughout an extensive area to the east. These waters are usually hard and contain noticeable amounts of mineral salts in solution. They may not be everywhere suitable for household use, but there should be no difficulty in procuring suitable stock water supplies from this horizon in the township.

Water of better quality for domestic use could probably be obtained from shallow wells sunk to sand and gravel pockets that occur interspersed through the upper 20 feet of the drift. These pockets may be relatively scarce in some parts of the area. As their presence is not always indicated by the nature of the surface deposits careful prospecting may be required to locate a suitable water supply. The moraines and the irregularly rolling till plains are generally more favourable for this type of deposit.

Sand and gravel washed into the low depressions and draws may form porous beds sufficiently thick for the accumulation of fairly large ground water supplies. Wells drawing water from this source are generally affected by drought conditions and could not be depended upon to provide water during extended dry seasons.

The Bearpaw formation immediately underlying the glacial drift is not known to be water bearing in this vicinity.

Township 5, Range 28

Farms are confined to the southeastern half of this township, where the variation in surface relief is comparatively small. Toward the northwest the surface rises to form a steeply rolling upland that extends over most of the northwestern half of the township. This area is used only for grazing. Range stock obtain water from Battle creek and in a few places from a small spring located along the sides of the broad valley occupied by this stream.

Stream deposits, consisting largely of silts and fine sand, form extensive flats along the bottom of Battle Creek valley. Shallow wells sunk in these deposits should yield moderately large supplies of drinkable water, particularly if sand or gravel aquifers are encountered. These gravels usually underlie 10 to 15 feet of silt or clay, but they are not everywhere present and it may be necessary to sink several test holes before a suitable water supply is located.

The glacial drift overlying the remainder of the township has an average thickness of about 75 feet. An irregular area of moraine extends across the uplands south of Battle creek from the central part of the township westward to sections 7 and 18. Several smaller moraine-covered areas occur along the northern border. The surface deposits throughout the rest of the township consist of an undulating to moderately rolling till plain.

As most of the wells are located on the till plains in the southeastern half of the township the ground water conditions existing in the moraine are not well known. It seems probable, however, that water-bearing sand and gravel pockets may occur interspersed at shallow depths through the boulder clays. Such pockets are more likely to occur in the depressions between the hills than on the steep slopes and ridges, and hence are expected to be more plentiful in the moraine-covered areas than in the more level till plains.

Gravel and sand beds lying at or near the base of the glacial drift are the most reliable source of water supply in the southeastern half of the township. These beds may extend westward in some places beyond the "A" line, as shown on Figure 1 of the accompanying map, as extensive gravel beds occupying the same relative position in the drift are exposed in some places on the lower banks of Battle Creek valley.

The depths of wells drawing water from these beds range from 54 to 98 feet. Most of the wells maintain a fairly high water-level and yield an adequate water supply for the farm requirements. The water varies in character from moderately soft to hard. From only one well is the water reported to be "alkaline", and at all places it is used for the domestic drinking supply as well as for stock use.

No water is obtained from the bedrock formations in the township. The Eastend formation underlying the drift may extend from the northern border southward to the banks of Battle creek. The Eastend formation generally contains thin, porous sand beds interspersed through the clays and shales and may yield water at some places in the northwestern part of the township. In the absence of any drilling in the vicinity to date no prediction can be made as to the quality or quantity of water to be expected from these potential source beds. Battle Creek valley and the

part of the township lying south of the valley is thought to be underlain by the Bearpaw formation.

The Bearpaw formation is not known to be water bearing in this municipality or vicinity. A dry hole put down to a depth of 150 feet in section 5 encountered the Bearpaw shales at a depth of 112 feet. Deep drilling in these shales is not recommended.

Township 5, Range 29

The land surface of this township is steeply rolling, with variations in relief of about 100 to 150 feet. Battle creek enters the township from the north in section 33, and flows southeastward to cross the eastern border in section 24. Middle creek enters the township from the west, then flows southward to cross the southern border in section 5. Both streams occupy wide, flat-bottomed valleys, the bottoms of which lie at elevations of 50 to 150 feet below the bordering uplands. A wide flat joining Battle Creek and Middle Creek valleys in the northwestern part of the township at one time formed part of this drainage system, but is now dry.

As the township is devoted largely to grazing the ground water resources are little developed to date. Surface waters in the creek and possibly a few springs provide water for stock. These supplies may be supplemented in some places by constructing dams in the small coulées.

Flood-plain deposits that occur in the valley bottoms are possibly the best potential source of ground water supply at shallow depths. These deposits consist chiefly of silts and fine sands that are underlain by or interbedded in some places with coarser sands and gravels. Wells encountering the coarser sediments can be expected to provide moderately large supplies of drinkable water. These aquifers may be easily located with a test auger, as they seldom occur at depths greater than 20 feet from the surface.

Water-bearing pockets of sand and gravel may occur sparsely interspersed through the upper 20 feet of the drift deposits. These porous beds are usually concentrated in the depressions in the land surface where sands and gravels have been washed in from the bordering ridges or hills. The irregular, moraine-covered areas in the eastern two-thirds of the township are possibly the most favourable for the occurrence of water in this type of deposit. The shallow drift waters are usually drinkable, although the yield from the individual aquifers may be small.

The glacial drift forming the surface deposits over the other parts of the township may have a variable thickness. Two wells situated in sections 2 and 4 encountered water in gravel beds at what is probably the base of the drift, at depths of 88 and 114 feet, respectively. The water is under sufficient pressure here to cause it to rise in the wells approximately 40 feet above the water-bearing bed. It is not highly mineralized, and is reported to be quite suitable for drinking. As these are the only wells listed from this township the northward extension of the deep gravel horizon is undetermined. Although it probably does not underlie the entire township it may have a much wider distribution than indicated by the "A" line on Figure 1 of the map accompanying this report.

The bedrock formations underlying the township and their ground water conditions are presumably the same as those described in the preceding section dealing with the township bordering on the east. Here also the Eastend formation occurs only on the uplands along the northern border and the Bearpaw formation forms the bedrock throughout the rest of the township.

Township 5, Range 30

This fractional township lying adjacent to the Fourth meridian consists entirely of range-land. Middle creek flows in an easterly direction across the northern part of the area and provides water for stock in its vicinity.

Stream deposits consisting chiefly of silts and fine sands form extensive flats along the bottom of Middle Creek valley. These are underlain by or interbedded in some places with water-bearing gravels. A 19-foot well, put down in section 24, encountered an abundant supply of water in one of these aquifers. The gravel here is buried under about 18 feet of clay. The water is under a slight hydrostatic pressure and rises in the well to within 15 feet of the surface. It is hard and is reported to be quite suitable for drinking. Similar water supplies may occur at other places in the valley flats and in some of the small tributary coulées.

No wells are reported to have been sunk in the glacial drift. Small, irregular-shaped pockets of sand or gravel are expected to occur sparsely interspersed through the upper 20 feet of the boulder clay. These may in some places be water bearing. Gravel and sand beds occurring at the base of the drift may form a more reliable source of water. This potential horizon is expected to have a fairly wide distribution throughout the township, particularly in the southern half. In the townships to the east and southeast wells drawing water from these aquifers range in depth from 60 to 100 feet. Depths to this horizon in this township are not expected to be much greater. The quality of these waters varies, depending upon the amounts of sulphate salts in solution, but the waters are usually suitable for drinking.

The Bearpaw formation is believed to immediately underlie the unconsolidated deposits throughout the entire township.

Outcrops of these shales occur at several places in the lower banks of Middle creek, in section 25. As the Bearpaw is not generally water bearing in this part of the province residents are advised to confine their search for water to the unconsolidated Recent and glacial deposits.

Township 6, Range 28

This township is characterized by high, steeply rolling hills and ridges. The lowest elevation of approximately 3,250 feet above sea-level occurs in the bottom of Battle Creek valley in the southeastern corner of the area. From the valley bottom northward the land surface rises abruptly to form a steeply rolling upland, with elevations ranging from about 3,500 to 3,700 feet above sea-level.

A broad lowland basin, known as Merryflat, extends over several sections on the western side of the township at an average elevation of about 3,600 feet above sea-level. Several farms are located in this area. The remainder of the township is devoted almost entirely to grazing.

Range stock water at Battle creek. Further supplies could be made available by constructing dams in the small coulées to conserve the surface run-off from the uplands. Springs may also provide some water for stock.

No wells in the township are reported to be drawing water from the unconsolidated deposits. Battle Creek flats in the southeastern part of the area are formed by Recent flood-plain deposits, consisting chiefly of silts and fine sands. These sediments are probably interbedded with, or underlain by, in some places, coarser sands and gravels. Wells sunk in the valley deposits should encounter water within 20 feet of the surface, although the yield will depend upon the thickness, porosity, and areal extent of the aquifer tapped. Waters from

the sediments in this stream channel are generally suitable for drinking.

Surface deposits throughout the rest of the township consist of boulder clay. Moraine of irregular outline covers a belt about $1\frac{1}{2}$ miles wide extending from the southwestern to the central part of the area. Small, isolated patches of moraine also occur in the northeastern corner and along the southern boundary. The rest of the township is overlain by a moderately rolling till plain which in some places is deeply dissected by small ravines and coulées. Small, discontinuous pockets of porous sands and gravels occur interspersed at irregular intervals through the boulder clay. These deposits are generally more plentiful in the moraine deposits, but they may also occur in the more evenly distributed glacial till. The ground water in the drift is usually concentrated in these porous beds. Owing, however, to their irregular distribution it may be necessary in some places to sink a number of test holes before a suitable water supply is located. Residents in search of water at depths of 20 feet or less are advised to sink wells in the depressions and at the bases of steep slopes in preference to the hills or ridges. The presence of deeper sand and gravel deposits, particularly those occurring at the contact of the glacial drift with the underlying bedrock, is not generally indicated by the character of the land surface and they may be of wide areal extent. Owing to variations in the thickness of the drift the depth to this potential horizon cannot be predicted for any one locality. It is not expected to exceed 100 feet, however, and it may be much less in some parts of the township.

Only two wells are reported to have been sunk in the township, and these are both drawing their water from the underlying bedrock. The Eastend formation forms the uppermost bedrock under the drift throughout the uplands. The flood-plain deposits

in the bottom of Battle creek in the southeastern and eastern part of the area are underlain by the Bearpaw formation.

The Eastend formation consists chiefly of shales, but it contains some thick beds of sandstone and sandy shales that are sufficiently porous to permit ground water accumulation. A well situated in section 18 struck water in Eastend sandstone at a depth of 36 feet. The drift here is reported to be only 10 feet thick. The water is of good quality and is being used for the domestic and stock requirements. A similar water supply is obtained from a bed of soft sandstone in a 78-foot well situated on section 20. The water in these aquifers is under little or no hydrostatic pressure, but the yield from the wells is adequate for the farms on which they are located. These or similar sandstone aquifers of the Eastend formation are yielding water to several wells in the township bordering on the west. The areal extent of the water-bearing beds in this township has not been determined beyond the above-mentioned locations in sections 18 and 20. They are expected, however, to occur elsewhere in the area underlain by the Eastend formation, although possibly at much greater depths in some of the localities where higher surface elevations prevail.

The Bearpaw shale underlying the Eastend, or in its absence the unconsolidated deposits, contains few sand beds and is not considered to be a source of ground water supply.

Township 6, Range 29

The maximum surface relief in this township approximates 450 feet. Drainage is to the south through Battle creek. This stream occupies a wide, steep-banked coulée that extends southward through the central part of the area, at an average elevation of about 3,450 feet above sea-level. A small tributary also enters the township through a wide coulée from the northeast

and joins Battle creek in the central part of the area. The eastern and western parts of the township consist of high, steeply rolling areas grading in places to fairly level prairie land, with surface elevations ranging from about 3,600 to 3,850 feet above sea-level.

The farms of the township are confined largely to Battle Creek valley and to a wide, comparatively level area extending east of Battle creek through the east-central part in the vicinity of Merryflat post office. The remainder of the township consists of range-land.

Battle creek and a few springs that occur in the coulée banks supply most of the water for range stock, although dams could be constructed at some places for the conservation of surface waters.

The valleys of Battle creek and its tributaries are underlain by flood-plain deposits consisting of silts and sands interbedded with, and in some places underlain by, coarser sands and gravels. Wells sunk in these valley sediments can generally be expected to yield adequate supplies, particularly if sand or gravel aquifers are encountered. A 12-foot well, situated in section 9, is producing a good supply of hard, drinkable water from one of these gravel aquifers. The depth to water in other parts of the valley is not expected to exceed 20 feet.

The glacial drift consists mainly of boulder clay of variable thickness, probably not exceeding 60 feet in most places. Small, irregular-shaped areas in the southern part of the township are overlain by moraine. The rest of the uplands, with the possible exception of part of section 31, is covered with a more evenly distributed till plain.

In section 31 drift was either never deposited or has been entirely removed by erosion. The drift is also thin on the valley sides where much of it has been removed or reworked by stream action.

No wells are reported to be drawing water from the drift deposits in the township. It seems probable, however, that water-bearing sand and gravel beds may occur interspersed through the drift in many parts of the area. As there is frequently no indication of the presence of these water supplies at the surface it may be necessary in most places to sink several test holes before a suitable aquifer is located. In putting down test holes in search of shallow aquifers the depressions and valleys between the ridges are generally the more favourable locations. Water from the glacial drift in this township is expected to be of good quality.

The Ravenscrag formation occurs only in the driftless area in the northwestern corner of the township. It probably contains porous sands and sandy shales, but owing to its isolated position on the edge of the uplands it may have little opportunity of retaining any large quantities of ground water.

The Eastend formation underlies the unconsolidated deposits throughout the rest of the township, with the possible exception of the lower reaches of Battle Creek valley in section 4, where the Bearpaw formation is thought to immediately underlie the Recent sediments. The Eastend formation is known to be water bearing in the vicinity of Merryflat where three wells have been put down to depths of 21, 30, and 50 feet. Water was obtained from sandstone at all three locations. The water is hard and is reported to be suitable for household use, and the supply is adequate for the stock requirements of the individual farms on which the wells are located. Similar water-bearing sands are expected to occur in the Eastend in other parts of the township, although it may be necessary in some places to sink wells to depths of 100 to 200 feet before water is obtained.

The underlying Bearpaw formation may also be water bearing in its upper part. This formation, however, becomes more

shaly at depth and at depths greater than 100 feet there probably occurs few sand beds sufficiently porous for ground water accumulation.

Township 6, Range 30

The surface of this township rises in a northerly direction from an average elevation of about 3,600 feet above sea-level in the south to elevations slightly greater than 4,000 feet along the northern border. The land is steeply rolling in some parts with intervening areas of fairly flat benchland. There are no permanent streams or lakes in the township, although a few springs may provide water for stock. As the entire township is range-land the ground water resources are little developed.

The glacial drift is probably the best potential source of ground water supply at shallow depths. These deposits consist chiefly of boulder clay in which occur sandy clays and irregular pockets or lenses of well-sorted sands and gravels. A narrow belt of moraine extends across the southeastern part of the township. There is no evidence of drift having been deposited on the uplands in the northern sections; the few feet of soil present consists largely of material formed by the weathering of the underlying bedrock.

Ground water supplies in the unconsolidated deposits are likely to be concentrated in the porous pockets of sand and gravel such as commonly occur in the depressions between the hills and in the bottoms of the coulées. These supplies generally occur at depths not exceeding 25 feet. Owing to their erratic distribution, however, it may be necessary to sink several test holes before locating a suitable water supply. Such waters as occur in the drift are not expected to be highly mineralized and may be used for drinking.

The Ravenscrag formation forms the uppermost bedrock only in the uplands that extend along the northern border of the township. This formation is known to contain sand and sandstone beds that are sufficiently porous to retain large supplies of ground water. Water from these sands are, as a rule, quite satisfactory for domestic use.

The Eastend formation, consisting of shale and sandstones, underlies the Ravenscrag and is immediately beneath the drift in an area extending for about a mile south of the southern boundary of the Ravenscrag. One well, situated in section 10, is probably drawing its water supply from these beds. Water was struck in a soft sandstone immediately underlying the glacial clays at a depth of 35 feet. An abundant yield of hard, drinkable water was obtained. Similar aquifers probably occur in the Eastend beds within reasonable depths at other places in the southern half of the township.

The Eastend is believed to be absent on the lower slopes along the southern border of the area, and the drift here is underlain by the Bearpaw formation. A few thin beds of water-bearing sand may occur in the upper part of this formation, but at depth the formation is composed almost entirely of shales from which little or no water can be expected.

STATISTICAL SUMMARY OF WELL INFORMATION IN RURAL MUNICIPALITY No.52, SASKATCHEWAN

Township	4	4	4	5	5	5	6	6	6	Total No. in municipality
West of 3rd mer. Range	28	29	30	28	29	30	28	29	30	
Total No. of Wells in Township	24	11	0	20	2	1	2	4	1	65
No. of wells in bedrock	2	0	0	4	0	0	2	3	1	12
No. of wells in glacial drift	21	11	0	16	2	0	0	1	0	51
No. of wells in alluvium	1	0	0	0	0	1	0	0	0	2
Permanency of Water Supply										
No. with permanent supply	20	11	0	15	2	1	2	4	1	56
No. with intermittent supply	1	0	0	0	0	0	0	0	0	1
No. dry holes	3	0	0	5	0	0	0	0	0	8
Types of Wells										
No. of flowing artesian wells	1	0	0	0	0	0	0	0	0	1
No. of non-flowing artesian wells	12	6	0	8	2	0	0	0	1	29
No. of non-artesian wells	8	5	0	7	0	1	2	4	0	27
Quality of Water										
No. with hard water	17	11	0	10	1	1	2	4	1	47
No. with soft water	4	0	0	5	1	0	0	0	0	10
No. with salty water	0	0	0	0	0	0	0	0	0	0
No. with "alkaline" water	9	6	0	1	0	0	0	0	0	16
Depths of Wells										
No. from 0 to 50 feet deep	11	5	0	7	0	1	1	4	1	30
No. from 51 to 100 feet deep	9	6	0	12	1	0	1	0	0	29
No. from 101 to 150 feet deep	3	0	0	1	1	0	0	0	0	5
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	1	0	0	0	0	0	0	0	0	1
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	18	8	0	15	2	1	2	4	1	51
No. not usable for domestic purposes	3	3	0	0	0	0	0	0	0	6
No. usable for stock	21	10	0	15	2	1	2	4	1	56
No. not usable for stock	0	1	0	0	0	0	0	0	0	1
Sufficiency of Water Supply										
No. sufficient for domestic needs	20	11	0	15	2	1	2	4	1	56
No. insufficient for domestic needs	1	0	0	0	0	0	0	0	0	1
No. sufficient for stock needs	18	10	0	11	2	1	2	3	1	48
No. insufficient for stock needs	3	1	0	4	0	0	0	1	0	9

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. Resident

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 differance between the total hardness and the permanent hardness and represents the amount of mineral salts that ban 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.

Analyses of Water Samples from the Municipality No. 52, Saskatchewan

LOCATION						Depth of Well, Ft.	Total dis'vd solids	HARDNESS			CONSTITUENTS AS ANALYSED						CONSTITUENTS AS CALCULATED IN ASSUMED COMBINATIONS									Source of Water
No.	Qtr.	Sec.	Tp.	Rge.	Mer.			Total	Perm.	Temp.	Cl.	Alkalinity	CaO	MgO	SO_4	Na_2O	Solids	$CaCO_3$	$CaSO_4$	$MgCO_3$	$MgSO_4$	Na_2CO_3	Na_2SO_4	NaCl	$MgCl_2$	
1	NE.	3	5	28	3	13	280	200	80	120	8	270	90	29	8	34	285	161		61		38	12	13		*1
2	NW.	13	6	29	3	21	1,180	800	750	50	122	430	30	248	70	0	628	54		318	88			12	156	*2

Water samples indicated thus, *1, are from glacial drift.
Water samples indicated thus, *2, are from bedrock, Eastend formation.
Hardness is the soap hardness expressed as calcium carbonate ($CaCO_3$).
For interpretation of this table read the section on Analyses and Quality of Water.

Water from the Unconsolidated Deposits

No water samples were taken for analysis from the stream deposits in this municipality. Such analyses as have been made of waters from these deposits in other municipalities to the east generally show a wide variation in the total dissolved solids and in the relative abundance of the individual salts present. The thin stream sediments are derived chiefly from the boulder clays of the glacial drift, and in the large valleys from the lower bedrock formations. Such sediments contain a relatively large amount of readily soluble salts. The porosity of the stream beds also has an important bearing on the eventual concentration of the dissolved salts. Water contained in the stream sediments is derived chiefly as seepage from the stream or from direct run-off from the uplands and upon first entering the sediments contains relatively small amounts of the dissolved salts. Slow circulation of the ground waters through fine sands or silts allows ample opportunity for any soluble salts present to be taken into solution. The coarser sands and gravels generally contain less soluble salts and allow for more rapid circulation, hence their waters are, as a rule, not highly mineralized. Surface evaporation may also concentrate the salts in solution to such an extent that waters found at shallow depths on the wider flats may, in some places, be unfit for drinking.

Waters obtained from deposits in the glacial drift also vary greatly from place to place, since the character of the sediments themselves vary greatly in character even within limited areas. Waters obtained from the shallow drift deposits do not differ essentially from waters obtained from the stream sediments. They are usually hard, but do not contain large amounts of the objectionable sulphate salts of sodium and magnesium, and are generally drinkable. The first analysis given on the accompanying

table is of water from a sand pocket in the upper part of the drift. This analysis shows an exceptionally low concentration of solids in solution, and is believed to represent a water of better quality than is obtainable from sandy phases of the boulder clay or from the compact clay itself. The total hardness of 200 parts per million is sufficient to term the water moderately hard. A large part of the hardness is temporary, however, and is removable by boiling. The deeper sand and gravel aquifers lying at the base of the drift, as a rule, yield waters containing a greater concentration of mineral salts. They are generally hard and most of them contain an excess of 1,000 parts per million of dissolved solids. The sulphates of sodium (Na_2SO_4) and magnesium ($MgSO_4$) usually predominate in these waters, with sodium sulphate in the greater concentration. Sodium sulphate (Glauber's salt) is nearly tasteless, but has a laxative effect when taken in large amounts. Magnesium sulphate or "Epsom salts" has a bitter taste and a laxative effect of about twice that of sodium sulphate. It also contributes to the hardness of the water. Combined concentrations of about 1,000 parts per million for these salts is usually considered to be the upper limit of safe usage for humans, although waters containing greater concentrations are frequently used with no apparent ill effects. Stock are less affected by highly mineralized waters and have been reported to thrive on waters containing an excess of 3,000 parts per million providing the proportion of magnesium sulphate is not too large.

Water from the Bedrock

Only one sample of water from the bedrock in the municipality was taken for analysis. As few wells in this, or in adjoining municipalities, are yielding water from the bedrock formations only broad generalizations regarding the character of these waters can be given.

The Ravenscrag waters are variable in character. Their total dissolved solid content may range from 300 to 1,800 parts per million within short distances, due to lateral variations in the character of the sediments forming the aquifers. In general, waters obtained from the coal seams and from the fine sands or sandy shales are more highly mineralized than water from the thick sand beds. Sulphate salts are present in solution, although they are not usually in sufficient quantity to render the water unfit for domestic use.

Waters obtained from the Eastend formation also vary greatly in character in different localities and at different horizons. The sulphate salts are usually present, with sodium sulphate in the greatest abundance. Sodium carbonate is also a common constituent of these waters. They are frequently soft and the total dissolved salt content is usually not sufficient to render them undrinkable. The second sample listed in the table of water analysis differs essentially from the usual type obtained from the Eastend formation. The total dissolved solid content is low, most of which is composed of the comparatively harmless carbonates and chlorides of magnesium. These salts render the water excessively hard, and the hardness being mostly permanent is not removable by boiling.

Waters from the upper part of the Bearpaw formation are, as a rule, similar to the Eastend waters as regards the relative amount of the salts usually found in solution, although sodium chloride may be present in sufficient amounts to give the water a distinctly salty taste. The average concentration of the salts in the Bearpaw waters is, however, slightly greater. Although waters obtained from the upper sandy shales at greater depths in the formation may be drinkable, the concentration of sodium sulphate and common salt may exceed 3,000 parts per million, rendering the water unfit for drinking and probably unfit for stock.

WELL RECORDS—Rural Municipality of NO. 52, 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	SE.	2	4	28	3	Bored	23	3,120	− 5	3,115	5	3,115	Recent sand	Soft, clear, "alkaline"		D, S	Sufficient for local needs only during the summer season.
2	NE.	3	"	"	"	Drilled	635	3,177									Dry hole; base in Belly River formation.
3	SW.	5	"	"	"	Bored	35	3,101	− 20	3,081	35	3,066	Glacial gravel	Hard, clear, "alkaline", iron		S	Sufficient supply; use a seepage well for domestic supply.
4	NE.	5	"	"	"	Dug	24	3,100	− 14	3,086	20	3,080	Glacial sand	Hard, clear, "alkaline", iron		D, S	Sufficient for local needs.
5	NE.	9	"	"	"	Drilled	135	3,170	+ 15	3,185	135	3,035	Glacial sand	Soft, clear		D, S	Sufficient supply; also a 100-foot dry hole; base in Bearpaw shale.
6	SE.	10	"	"	"	Bored	17	3,106	− 12	3,094	12	3,094	Glacial sand	Hard, clear, iron, "alkaline"		D, S	Sufficient for local needs.
7	NE.	17	"	"	"	Bored	120	3,073	−114	2,959	120	2,953	Glacial gravel	Hard, clear		D, S	Sufficient for local needs.
8	SW.	19	"	"	"	Spring		3,050	0	3,050	0	3,050	Glacial gravel	Hard, clear		S	Sufficient for local needs.
9	NW.	20	"	"	"	Dug	120	3,090	−100	2,990	120	2,970	Glacial gravel	Soft, clear		D, S	Sufficient for local needs.
10	SE.	21	"	"	"	Bored	68	3,198	− 40	3,158	68	3,130	Glacial gravel	Hard, clear, iron		D, S	Sufficient for local needs.
11	SW.	22	"	"	"	Bored	78	3,215	− 48	3,167	78	3,137	Glacial gravel	Hard, clear, iron		D, S	Sufficient for local needs.
12	SE.	23	"	"	"	Bored	75	3,220	− 48	3,172	75	3,145	Glacial gravel	Hard, clear, iron		D, S	Sufficient for local needs.
13	SW.	24	"	"	"	Bored	76	3,225	− 47	3,178	76	3,149	Glacial gravel	Hard, clear, iron		D, S	Sufficient for local needs.
14	SE.	27	"	"	"	Bored	72	3,220	− 35	3,185	72	3,148	Glacial gravel	Hard, clear, "alkaline", iron		S	Sufficient for stock needs; hauls drinking water.
15	SW.	28	"	"	"	Bored	16	3,222	− 4	3,218	8	3,214	Glacial gravel	Hard, clear, "alkaline"		D, S	Also a 25-foot dry hole.
16	SW.	30	"	"	"	Bored	70	3,285	− 40	3,245	70	3,215	Glacial gravel	Hard, cloudy, "alkaline"		S	Sufficient for stock needs; haul drinking water.
17	NE.	32	"	"	"	Bored	90	3,275	− 30	3,245	90	3,185	Glacial drift	Hard, clear, iron		D, S	Sufficient for local needs.
18	NW.	32	"	"	"	Dug	18	3,297	− 2	3,295			Glacial drift	Hard, clear, "alkaline"		D, S	Intermittent supply.
19	NW.	34	"	"	"	Bored	50	3,240	− 22	3,218	50	3,190	Glacial sand	Hard, clear, iron		D, S	Sufficient for local needs.
20	NW.	35	"	"	"	Dug	20	3,213	− 17	3,196			Glacial sand	Hard, clear, iron		D, S	Sufficient for local needs.
21	NE.	36	"	"	"	Bored	80	3,233	− 64	3,169	80	3,153	Glacial gravel	Soft, clear, "alkaline"		D, S	Sufficient for local needs.
1	SE.	4	4	29	3	Bored	98	3,110	− 80	3,030	98	3,012	Glacial sand	Hard, clear, "alkaline"		N	Sufficient supply; but not used at present.
2	SW.	9	"	"	"	Spring		3,105	0	3,105	0	3,105	Glacial drift	Hard, clear		S	Sufficient for 500 head stock; also three other springs.
3	SW.	12	"	"	"	Bored	66	3,263	− 50	3,213	66	3,197	Glacial gravel	Hard, clear, "alkaline", iron		S	Sufficient supply; a 20-foot well is used for domestic purposes.

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. 52, 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
4	SE.	20	4	29	3	Dug	80	3,300	- 50	3,250	80	3,220	Glacial gravel	Hard, clear, "alkaline"		D, S	Sufficient for local needs.
5	SW.	22	"	"	"	Dug	85	3,290	- 50	3,240	85	3,205	Glacial gravel	Hard, clear, "alkaline"		D, S	Sufficient for local needs.
6	NW.	25	"	"	"	Bored	80	3,290	- 50	3,240	80	3,210	Glacial sand and gravel	Hard, clear, "alkaline"		D, S	Sufficient for local needs; also another similar well.
1	SE.	1	5	28	3	Bored	76	3,176	- 46	3,130	76	3,100	Glacial sand	Hard, clear, "alkaline"		D, S	Sufficient for local needs.
2	NE.	3	"	"	"	Dug	13	3,231	- 10	3,221	10	3,221	Glacial sand	Soft, clear		D, S	Sufficient for local needs; #.
3	NW.	3	"	"	"	Bored	82	3,229	- 22	3,207	82	3,147	Glacial gravel	Hard, clear		D, S, I	Sufficient for local needs.
4	NE.	5	"	"	"	Bored	150	3,273									Dry hole; base in Bearpaw shale; several other dry holes.
5	SW.	5	"	"	"	Dug	30	3,268	- 28	3,240	28	3,240	Glacial sand	Hard, clear		D, S	Insufficient for local needs; also two seepage wells are used.
6	NE.	9	"	"	"	Bored	98	3,276	- 28	3,248	98	3,178	Glacial gravel	Soft, clear, iron		D, S	Sufficient for local needs.
7	SE.	12	"	"	"	Bored	54	3,233	- 47	3,186	54	3,179	Glacial gravel	Hard, clear		D, S	Insufficient for local needs.
8	NW.	13	"	"	"	Bored	78	3,271	- 8	3,263	78	3,193	Glacial gravel	Soft, clear		D, S	Sufficient for local needs.
9	SE.	22	"	"	"	Bored	82	3,305	- 35	3,270	82	3,223	Glacial gravel	Hard, clear		D, S	Sufficient for 250 head stock; also a 95-foot dry hole.
10	SW.	2	"	"	"	Dug	13	3,294	- 13	3,281	13	3,281	Glacial gravel	Hard, clear		D, S	Sufficient supply; also another similar well.
11	NW.	24	"	"	"	Dug	69	3,298	- 55	3,243	69	3,229	Glacial gravel	Soft, clear		D, S	Sufficient for local needs.
12	SE.	24	"	"	"	Bored	64	3,256	- 34	3,222	64	3,192	Glacial gravel	Hard, clear		D, S	Sufficient for local needs.
13	NE.	24	"	"	"	Dug	15	3,287	- 11	3,276	11	3,276	Glacial sand	Soft, clear		D, S	Sufficient for local needs.
1	SW.	2	5	29	3	Bored	88	3,340	- 50	3,290	88	3,252	Glacial gravel	Hard, clear		D, S	Sufficient for local needs.
2	SW.	4	"	"	"	Dug	114	3,348	- 74	3,274	114	3,234	Glacial gravel	Soft, clear		D, S	Sufficient for local needs.
1	NW.	24	5	30	3	Dug	19	3,340	- 15	3,325	15	3,325	Recent gravel	Hard		D, S	Constant water-level.
1		18	6	28	3	Dug	36	3,600	- 30	3,570	30	3,570	Eastend sandstone	Hard, clear		D, S	Constant water-level.
2	NW.	20	"	"	"	Bored	78	3,605	- 73	3,532	73	3,532	Eastend sandstone	Hard, clear		D, S	Sufficient for local needs.
1	SE.	9	6	29	3	Dug	12	3,400	- 4	3,396	8	3,392	Glacial gravel	Hard, clear		D	Sufficient for domestic needs.
2	NW.	13	"	"	"	Dug	21	3,570	- 14	3,556	14	3,556	Eastend sandstone	Hard, clear		D, S	Sufficient for local needs; #.
3	SE.	23	"	"	"	Dug	30	3,568	- 20	3,548	20	3,548	Eastend sandstone	Hard, clear		D, S	Sufficient for local needs.
4	NE.	25	"	"	"	Dug	50	3,664	- 45	3,619	45	3,619	Eastend sandstone	Hard, clear		D, S	Sufficient for local needs.
1	NW.	10	6	30	3	Dug	35	3,700	- 20	3,680	35	3,665	Eastend sandstone	Hard		D, S	Constant water-level.

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.