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WATER SUPPLY PAPER No. 32

PRELIMINARY REPORT

GROUND-WATER RESOURCES OF THE RURAL MUNICIPALITY OF ..... NO. 20 SASKATCHEWAN

By

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

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GROUND WATER RESOURCES OF THE RURAL MUNICIPALITY OF NO. 20 SASKATCHEWAN

INTRODUCTION

Lack or 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 accesible. 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. 20 comprises an area of 324 square miles in southwestern Saskatchewan. The International Boundary forms the southern border of the area. The municipality consists of nine townships described as tps. 1, 2, and 3, ranges 22, 23, and 24, W. 3rd mer. The Valmarie branch of the Canadian Pacific railway extends in a northeast-southwest direction across the northern part of the municipality. The village of Claydon, situated on the railway, in sec. 9, tp. 3, range 22, is the largest settlement.

The relief of the land surface approximates 600 feet. Old Man on His Back plateau in the northwestern part of the municipality and Boundary plateau in the southeast corner form the two most prominent topographic features of the area and have elevations of over 3,400 feet. The intervening lowlands rise gradually from elevations of approximately 2,800 feet above sea-level in the bottoms of the coulées at the International Boundary in the southwestern part, to approximately 3,100 feet on the broad plain that occupies the central and northeastern parts of the municipality. A broad, shallow valley extends along the northern border of the lowlands from Claydon southwest to cross the western border of the municipality in sec. 18, tp. 2, range 24. To the northwest from the southern border of township 3, range 24, the ground surface rises rather abruptly to form the steep and, in places, almost precipitous scarps of Old Man on His Back plateau. In the southeastern half of the municipality the lowlands rise to the Boundary plateau. This upland is confined largely to township 1, range 22, and the eastern half of township 1, range 23, but extends a short distance southward across the International Boundary into the state of Montana. On the east and west sides of the Plateau the land rises rather abruptly from an elevation of about 3,000 feet in the coulée bottoms at the foot of the slopes to an elevation of

approximately 3,380 feet at the summit of the plateau in sec. 6, tp. 1, range 22. The general slope on the northern side is more gradual and the land surface, although irregular and deeply dissected by coulées, rises gradually from the lowland level.

In the area between the highlands and throughout most of the northeastern half of the municipality the surface is gently rolling. Drainage is poorly developed and the few small coulées existing in this part terminate in undrained depressions. The drainage of the southwestern half of the area is to the south and southwest. Many intermittent streams have their headwaters in the uplands to the north and east and converge to cross the International Boundary at an elevation of about 2,800 feet in the southeastern part of township 1, range 24 and join Milk river as a part of the Missouri drainage system in Montana.

The area has not been topographically mapped, so that no relief is shown on Figure 2 of the accompanying map. The elevations quoted in the report were determined as accurately as possible by means of aneroid barometers during the course of this investigation, but they must be regarded as only approximate as established elevation bench-marks are few, particularly in the northern part of the municipality.

The farming settlement is confined almost entirely to the central and northeastern parts. Owing to the rugged topography and generally poor farming conditions existing on the plateaux and throughout the southwestern townships these areas are given over largely to grazing.

Dams constructed to conserve surface water in the small coulées furnish water for stock in the range-land and supplement the supplies for stock at many places in the farming areas. The streams flow for only a few weeks in the early spring, but the impervious character of the subsoil would make it possible to retain by means of dams and dugouts large supplies of surface water through the dry seasons.

Although surface water is probably the most important source of water in this area, the Recent and glacial deposits and the bedrock formations either yield supplies of ground water or are potential sources throughout the area.

Water-bearing Horizons in the Unconsolidated Deposits

Recent deposits of silts and sands, interbedded in places with thin layers of gravel, cover the bottom of many of the coulées to depths generally not exceeding 20 feet. Wells sunk in these deposits usually find water, but the supply varies, depending principally upon the extent of the water-bearing bed and upon the gradient of the stream channel. Porous beds of sand or gravel that occur near the surface in stream channels of steep gradient lose their water supply by underground flow and surface evaporation soon after the stream ceases to flow. The water in porous beds buried under thick layers of impervious clay does not evaporate so rapidly, and if the stream gradient be low or the porous beds have no outlet water may be retained over long periods of drought. The quality of these waters varies from place to place. Where encountered in the small stream channels of this municipality the water is usually of good quality, and supplies from some wells are reported to be soft. The water from wells sunk in the larger stream channels and encountering water in fine sands or silts is in general more highly mineralized. This is probably due to the slow underground flow of these waters, which gives them a better opportunity of dissolving the soluble salts contained in the fine sediments. The greater part of the municipality is overlain by glacial drift. The drift was deposited by a great continental ice-sheet that many thousands of years ago moved in a general southwesterly direction over the province of Saskatchewan. The drift is composed chiefly of compact, blue-grey boulder clay that becomes light grey to yellowish brown on weathering. The thickness of the drift varies considerably in different parts of the municipality. It is generally thin over the steep slopes of the plateaux and is

absent in places on the slopes and in the larger coulées that have been cut down to bedrock. Wells sunk in the area intervening between the Boundary and Old Man on His Back plateaux, in township 2, range 23, and in the western half of township 2, range 22, pass through drift to depths ranging generally from 20 to 65 feet. Gravel thought to be of glacial origin, was encountered at the base of a 130-foot well in sec. 17, tp. 2, range 22, and in a few other wells at depths of 80 to 100 feet. If this interpretation is correct it suggests a great variation in the thickness of the drift within short distances. It is possible that these deeper occurrences of gravel represent places where channels had been cut in the surface of the bedrock by streams prior to the advance of the ice-sheet. With the deposition of the drift such channels would become completely filled, so that little or no evidence of their existence is to be found on the present land surface. In the northeast, central, and southwestern parts the drift is in the form of a blanket of boulder clay or glacial till and its thickness is apparently fairly uniform, averaging approximately 60 feet. In other places in the municipality the surface of the drift is much more irregular than it is on the till plain, being characterized by low knolls and hillocks and undrained depressions. Such areas, known as moraines, are thought to have been formed when the front of the ice-sheet remained stationary for a period of time during its retreat. Such moraines occur on the tops and over the higher slopes of the plateaux in the northwestern and southeastern parts of the municipality and in two, small, isolated areas, one occurring south of the railway between Claydon and Katherine, and the other extending over a narrow belt along the eastern border of township 3, range 22, approximately 3 miles east of Claydon. Southwest of Claydon the railway follows a dry stream course that marks the site of a drainage channel formed toward the end of the Glacial period. The lower and wider part of the valley in township 2, range 24, is overlain by a thin

layer of lake clay deposited in a glacial lake. To the northeast along the channel the clay becomes more sandy and hence more porous. Shallow wells sunk to the base of the clays have encountered gravel beds in several places, but it is improbable that they form a continuous water-bearing horizon throughout the entire valley.

Little if any water can be expected from the boulder clay that composes the greater part of the drift, as the clay is not sufficiently porous to form reservoirs for large supplies of water and does not readily yield water to wells. Wells sunk in the clay are usually situated beside dams or sloughs and derive their supply by seepage. They are dependable only when water remains in the reservoir and become dry during seasons of prolonged drought.

Two general water-bearing horizons are recognized in the glacial drift. The upper horizon consists of small pockets of water-bearing sands and gravels sparsely interspersed through the upper 25 feet of the boulder clay. These deposits are usually more numerous and are often of greater areal extent in the moraine-covered areas than in the till plain areas, but owing to the scarcity of wells in the moraines of this municipality little is known regarding their water-bearing properties. In places where the water-bearing pockets have been tapped by wells sunk into the till covering the lowlands, small to moderately large yields of drinkable water are usually obtained. Since these pockets are not present at all points and their occurrence is not generally indicated on the surface careful prospecting is required in many places before an adequate water supply is located.

The lower water-bearing horizon occurs in beds of gravel and more rarely sand lying at the contact between the glacial drift and the bedrock. A large number of wells have tapped this horizon in an area that extends from the northeastern corner of the municipality in a southwesterly direction through most of township 3, range 22, and a few sections in the northern part of township 2, range 22, and through the east-central part of township 3, range 23. Farther south these

gravel beds appear to occur discontinuously, but they have been encountered in a few isolated points in township 2, range 23, and in the western half of township 2, range 22. In this area they probably lie in depressions or buried stream channels that were carved into the bedrock prior to the advance of the ice-sheet. The depths of wells necessary to reach this horizon range from 45 to 70 feet. Where encountered the water is usually under hydrostatic pressure and maintains a constant level in the wells at points 10 to 25 feet above the aquifer. The quality of the water varies in different wells and does not seem to show any particular variation with depth. Some wells yield soft, to moderately hard, drinkable water. Other waters are reported to contain appreciable amounts of mineral salts in solution and several wells situated near the north and western borders of the area yield water that is too highly mineralized to be used for drinking. The water is not too highly mineralized, however, to be used for stock.

Water-bearing Horizons in the Bedrock

Four bedrock formations, known as the Ravenscrag, Whitemud, Eastend, and Bearpaw formations, immediately underlie the glacial drift in different parts of the municipality. The order in which the formations are given is the order in which they would be penetrated by a deep well drilled on the highest point in the municipality. The uppermost or Ravenscrag formation caps the Boundary plateau at elevations greater than about 3,250 feet above sea-level. It may also occur at approximately the same elevation in a smaller area on the southwestern corner of township 3, range 24, on the top of Old Man on His Back plateau. This formation consists chiefly of fine to medium coarse-grained, buff-weathering sands and dark brownish grey shales and thin seams of lignite coal. Little is known as to the ground water conditions existing in this formation owing to the paucity of wells located in the areas in which it is known to occur. The porous sands and coal seams are expected to be water-bearing in at least part of this area.

The Ravenscrag formation along the western slopes of the Boundary plateau is underlain by light grey to white clays and fine sands of the Whitemud formation. These deposits form a conspicuous outcrop on the hill-side in this area, but are not known to occur elsewhere in the municipality. The Whitemud beds are probably too fine grained to yield any large supply of ground water.

The Eastend formation underlies the Whitemud beds on Boundary plateau and may immediately underlie the drift in a belt 1 to 2 miles wide on the lower slopes of this upland at elevations between about 3,250 to 3,100 feet above sea-level as indicated on Figure 1 of the accompanying geological map. This formation is also thought to underlie Old Man on His Back plateau in a few sections of township 2, range 24, most of township 3, range 24, and the northwestern half of township 3, range 23. It is also known to occur beneath the drift in a small, elevated area lying between the plateaux in the central part of township 2, range 23.

The upper beds of the Eastend formation consist largely of sands and silts interbedded with grey shales, and are considered to be of brackish or freshwater origin. The lower beds are much more shaly, are of marine origin, and grade imperceptibly into the shales of the underlying Bearpaw formation. Wells sunk to depths of 21 to 105 feet on the northern side of Boundary plateau encounter water of a good quality in this formation. Other wells in the central area and on Old Man on His Back plateau also yield water from this formation, although some of these waters particularly those from the lower more shaly parts of the formation, are more highly mineralized. For a more detailed description of these water supplies the reader is referred to later sections of this report dealing with the individual townships in which this formation occurs.

The Bearpaw formation underlies the Eastend at all places where the Eastend is present, and throughout the remainder of the municipality occurs immediately beneath the glacial drift. A few sandy

beds are present in the upper 200 feet of the Bearpaw, but the greater part of the formation is composed almost entirely of dark grey marine shale interbedded at intervals with bands of hard ironstone. Where encountered in drill holes the shale is locally referred to as "soapstone". It is recognized by the dark grey appearance and soapy feel when wet, and by the small, roughly cubical fragments into which it crumbles upon drying. Outcrops of the shale are quite numerous in coulées in the vicinity of the southwestern corner of townships 2, range 23, and at a few isolated points in other parts of the municipality as indicated on the accompanying geological map (Figure 1). The exact thickness of this formation is not known as no wells have been sunk to its base in the municipality. It may, however, extend to a depth of 700 to 800 feet in the lowlands part of this area as is indicated by a deep well sunk in the village of Climax about 20 miles east of this municipality.

Little if any water can be expected from the shale in the middle and lower parts of the formation. The upper sandy zone, occurring immediately beneath the Eastend or fringing the lower slopes of the uplands, is, however, water-bearing and yields moderate to large supplies to wells sunk in the central and mid-eastern part of the municipality. Wells that have encountered these aquifers range in depth from about 50 feet to 210 feet. The lowest water-bearing bed was encountered at an elevation of approximately 2,784 feet in sec. 28, tp. 2, range 22. Although an adequate supply of soft, drinkable water is reported to have been encountered at a depth of 210 feet or at the elevation stated above, drilling was continued to a depth of 435 feet without finding additional supplies. The individual aquifers encountered by other wells in the area are apparently erratic in their distribution and of limited areal extent, as no two wells are definitely known to have tapped the same aquifer. The quality of the waters also varies from place to place. Wells sunk in shale in the SW. $\frac{1}{4}$, sec. 13, the

NE. $\frac{1}{4}$, sec. 33, tp. 2, range 23, and in the SW. $\frac{1}{4}$, sec. 1, tp. 3, range 23, yield water that is reported to be too highly mineralized to be used for drinking. Water from a well in the SE. $\frac{1}{4}$, sec. 25, tp. 3, range 22, is considered unsuitable even for stock. Other waters obtained at shallower depths in the Bearpaw are reported to be drinakble, although several of these contain noticeable amounts of salts in solution. The yields obtained from these aquifers also vary. Most of the wells, however, produce an adequate supply for the average farm requirements of 25 to 40 head of stock. Those obtaining small yields are sunk to depths of 100 feet or less and are situated in localities where better yields are expected to occur at slightly greater depths. No wells are known to have been sunk to the Bearpaw shale in the southwestern part of the municipality. The possibility of locating water in the bedrock of this area is less favourable, as a large part of the upper sandy zone is thought to have been removed by erosion.

GROUND WATER CONDITIONS BY TOWNSHIPS

Township 1, Range 22

All of this township is occupied by Boundary plateau. Both the northern and southern parts are overlain by moraine, the irregular surface of which has been dissected by deep coulées. The highest elevation of about 3,380 feet is in section 6. From this point the surface falls off gradually toward the north and east down to an average elevation of about 3,200 feet above sea-level along the northern border. Toward the east, however, the slopes are more abrupt and are interrupted by stream channels, some of which have been cut down to elevations of about 3,100 feet.

Owing to the irregular topography of the township it is not being farmed and as only one well was recorded in the area little is known regarding the ground water possibilities. Water is obtained for range stock by impounding surface water behind dams in the coulées. No springs are reported in this area, although they probably do occur in some of the deeper coulées along the central and in the eastern part of the township.

The depth of the glacial drift is not known, but it no doubt varies greatly in different parts of the township. Wells sunk in the uplands in the townships bordering on the north and west encountered the bedrock at depths of 20 to 60 feet. Even greater thicknesses of drift may occur in the moraine-covered lower part of this township, but it is judged to be thin on the steeper slopes and on the points of highest elevation in the southwestern part of the township. Scattered pockets and discontinuous beds of water-bearing sands and gravels no doubt occur interspersed through the boulder clay, but it will probably be necessary to sink a number of test-holes before a suitable water supply is located. Greater accumulations of gravel are expected to occur in the coulée bottoms and at places where the valley gradient flattens off they may contain large supplies of

water. A 47-foot well, situated in the SE. $\frac{1}{4}$, section 5, yields hard, drinkable water from this type of deposit.

The bedrock was not observed to outcrop in this township, but observations made in the township to the west indicate that the Ravenscrag formation occurs there and probably underlies most of the western half of the township under discussion. It may extend down to an approximate elevation of 3,250 feet, that is down to depths of about 130 feet on the highest point on the plateau. A thin bed of white, sandy clay representing the Whitemud formation, although probably not overywhere present, occurs below the base of the Ravenscrag. These clays are in turn underlain by some 100 to 150 feet of fine, grey sands, silts, and dark grey shales designated the Eastend formation. The base of this formation lies at an approximate elevation of 3,100 feet above sea-level and immediately underlies the drift in a narrow belt extending along the lower slopes of the plateau in the eastern and northern parts of the township as outlined in Figure 1 of the accompanying geological map. The Bearpaw formation is thought to underlie the drift at elevations below 3,100 feet in a belt of variable width along the eastern border of the township.

Although no wells have been sunk into the bedrock all of these formations as represented in this area are considered to be sufficiently porous to form reservoirs for the accumulation of ground water. Little difficulty should be experienced in obtaining fairly large supplies of drinkable water from wells less than 150 feet in depth throughout the area underlain by the Ravenscrag and Eastend formations. The Bearpaw cannot be expected to be as porous as the other formations, but as the upper and more sandy phase of the formation occurs immediately beneath the drift in this area it should prove to be water bearing at moderate depths.

Township 1, Range 23

The ground surface of this township rises to the north and northeast from elevations of approximately 2,800 feet above sea-level in the bottom of the small, southwesterly flowing creek where it crosses the International Boundary in section 6, to elevations of approximately 3,050 feet in section 31, and 3,250 feet in section 36. Toward the eastern border the land rises abruptly to form the steep, western slopes of the Boundary plateau and in section 1 reaches its highest elevation in the township of approximately 3,380 feet.

The land surface in the southwestern and southeastern parts of the township is steeply rolling and deeply dissected in many places by narrow stream valleys. Since this part of the township is unsuited to farming the principal ground water requirements are for stock. The streams rarely carry water for more than a short period during the spring or during exceptionally wet seasons, as the gradient is high and the run-off is correspondingly rapid. Part of the run-off is conserved for range stock by means of dams in the coulées.

The stream deposits are possibly the most reliable source of ground water in the unconsolidated deposits of this township. These deposits are composed mostly of fine silts and clays, but discontinuous beds of porous sands and gravels no doubt occur interbedded with the clays, and these may contain, in places, large supplies of water. One well in a coulée situated in section 32 yields a small supply of highly mineralized water from a depth of about 10 feet. This water is used for stock, but cannot be used for drinking. The Bearpaw shale outcrops in the creek valley in this vicinity and it is quite probable that the highly "alkaline" character of the water found in the stream deposits is due to seepages from the shale. Farther down stream the bedrock is covered and water of better quality is to be expected.

The mantle of glacial drift overlying the bedrock consists largely of compact, grey boulder clay. Very little, if any, water can

be expected from wells sunk in this clay. Larger supplies of water will probably be obtained by sinking wells either to the base of the drift or into the bedrock than from water-bearing pockets at shallow depths in the boulder clay.

Thin beds of sands and gravels washed down from the highlands and spread over the bedrock surface along the lower hill slopes prior to the advance of the continental ice-sheet probably form small, irregular deposits at the base of the drift in the northern and north-eastern sections of the township. Since few wells have been sunk in the township the areal extent of such beds is undetermined.

The series of grey sands, brown clays and shales, and occasional coal seams comprising the Ravenscrag formation form the uplands along the eastern border of the township. These beds are in turn underlain by a few feet of buff to white clays and sands designated the Whitemud formation. These Whitemud beds are exposed along the sides of the valley in sections 13 and 14 and may extend beneath the Ravenscrag over a considerable area. The Eastend formation occurs at still lower elevations and extends beneath the Ravenscrag (or Whitemud), and where these formations are absent, beneath the glacial drift over the greater part of the eastern half of the township. It is shaly at its base and grades downward imperceptibly into the Bearpaw formation which underlies the drift throughout the western lowland part of the township.

No wells are known to be deriving water from the Ravenscrag, but it appears to be sufficiently porous at the places where it is exposed to yield moderately large supplies at depths probably nowhere exceeding 150 feet. As this formation is confined to the uplands it has a smaller catchment area than the underlying formations and hence may prove to be only sparingly productive particularly near the top of the plateau.

Two wells located on sections 24 and 25 probably penetrated a few feet of Ravenscrag before entering the underlying Eastend where

water was found. It is possible that the upper formation is thin in these areas and hence does not yield an appreciable supply of water.

Four wells in the northeast corner of the township are deriving water from the Eastend formation. Although the elevations of the well sites as determined by aneroid cannot be considered accurate, it seems probable that the 160-foot well on section 24, and the 105- and 120-foot wells on section 35, tap a common aquifer near the base of the formation at elevations of 3,177 to 3,100 feet above sea-level. These wells yield a soft, drinkable water in sufficient quantities for local requirements. The fourth well, situated in section 25, produces a small supply of hard water from a slightly higher aquifer. This well, if extended to a depth of about 150 to 160 feet, should tap the soft water horizon. The part of the Bearpaw formation that underlies the drift throughout the western part of the township is considered to be sufficiently sandy to form a potential source of ground water at moderate depths. As only one well in this township derives water from this formation the general depth of wells or the quality and quantity of water to be expected have not been determined. Wells sunk to depths not exceeding 200 feet in the township to the north obtain adequate supplies of soft water at several horizons in the Bearpaw. The lowest of these occurs at an elevation of about 2,850 feet above sea-level.

Township 1, Range 24

The land surface of the eastern half of this township is steeply rolling and dissected by numerous southward trending coulées. The surface of the western half of the area is more gently rolling. In general the land surface slopes from an elevation of about 3,050 feet along the northern border in a southerly direction to 2,800 feet in the bottoms of the creeks where they cross the International Boundary. The run-off in this area is rapid and the streams maintain their flow

only during a few weeks in the spring or during exceptionally wet seasons. Dams constructed in the coulées conserve part of the run-off for range stock during periods of drought. Since the greater part of this township is devoted to grazing there has been little necessity to sink wells in search of water for household requirements.

Stream deposits are considered to be the most reliable source of ground water in the unconsolidated deposits. These sediments consist largely of silts and clays through which are interspersed a few pockets of more porous sands and gravels. Four wells, two of which are situated in sections 1 and 16, and the other two on the NE. $\frac{1}{4}$, section 35, obtain water from these deposits at depths of 16 to 25 feet. Water from the well in section 1 is reported to be hard and too highly mineralized for household use but is used for stock. The other wells yield soft to moderately hard, drinkable water.

The thickness of the glacial drift is not definitely known, but probably is not more than 50 feet throughout the greater part of this area. It is composed of grey boulder clay and silt containing very few beds sufficiently porous and thick to permit of any large accumulations of ground water. A few scattered beds of water-bearing sands or gravels may occur at or near the base of the glacial drift. Although no attempts have been made to locate such pockets it would probably be necessary to sink a number of test-holes before an adequate water supply from this source would be found.

The Bearpaw formation is believed to immediately underlie the glacial drift throughout the township. The ground water conditions of this formation are not well known as very few wells in this township or in the bordering townships have been sunk through the glacial drift. It is probable, however, that usable water will be found in sand beds in the upper 150 feet of the Bearpaw formation. Water is to be expected within 200 feet in the northern part of the township and at gradually lesser depths farther south. Drilling to depths greater than 150 feet

in the Bearpaw formation is not recommended as water is seldom encountered below the upper porous zone of the formation in this part of the province. The quality of the water to be expected can only be surmised. If extensive sand beds are encountered in the shales they should yield drinkable water, but if only shale is penetrated in drilling a more highly mineralized water probably will be found.

Township 2, Range 22

Ground water in this township is obtained mostly from wells sunk to gravel beds that occur near the base of the glacial drift and from sands and sandy shales in the underlying Eastend and Bearpaw formations.

Alluvial deposits are confined mostly to thin beds of silt, sand, and gravel in the coulée bottoms; and a more extensive area of flood-plain deposits consisting of silts and sandy clays occurs in sections 35 and 36. A 14-foot well in the NW. $\frac{1}{4}$, section 5, obtained a large yield of hard, drinkable water in a sand and gravel bed in a stream deposit, and it is probable that similar supplies occur elsewhere in the township, although none has been reported.

The thickness of the glacial drift varies considerably in different parts of the township, indicating that a very uneven bedrock surface existed prior to the deposition of the glacial drift. Gravel is reported to occur at 130 feet below the surface or at an elevation of 2,820 feet, in section 17, and probably marks the site of a preglacial stream channel cut into the bedrock. The direction or other characteristics of this buried channel are not known as no other wells in the area are sunk into it. Other wells in this part of the township encountered bedrock at depths of 20 to 60 feet. The average thickness of the drift over the greater part of the township, however, is apparently about 50 feet. It consists chiefly of compact boulder clay, yellowish to medium grey near the surface, but grading to dark

blue-grey clay below the zone of weathering at depths of 10 to 20 feet. Adequate supplies of water have not been found in the boulder clay, but wells situated in sections 13, 18, 32, 33, 34, and 36 encountered water-bearing gravels at the base of the drift at depths of 16 to 65 feet, and the above-mentioned well in section 17 tapped water-bearing gravels at a depth of 130 feet.

These gravels are not continuous over the entire township, but individual beds or pockets are thought to be fairly extensive in the northern and northeastern sections. Their occurrence in sections 17 and 18 may possibly be of only local extent as they have not been found in other wells in this vicinity. Where they have been encountered, the water supplies obtained from them are adequate for the average farm requirements. Several of the wells maintain a constant water-level of 10 to 15 feet above the water-bearing bed. The quality of the waters varies considerably. The water from wells in sections 32 and 33 is reported to be soft; from others it is hard and two wells yield slightly "alkaline" water, but all the waters are used for drinking.

Wells situated in section 6 obtain large yields of soft, drinkable water at depths of 66 and 21 feet or at an elevation of about 3,108 and 3,128 feet respectively. The water occurs in a red sandstone in what is probably the Eastend formation. A 90-foot dry hole situated in the NE. $\frac{1}{4}$, section 5, also encountered several similar beds of red sandstone before drilling was suspended at an elevation of about 3,129 feet. The possibility of finding water at greater depths at this location is quite favourable as a few miles north and west of this locality sandy shales and sandstones in the upper part of the Bearpaw are known to be water-bearing.

These red sandstone beds of the Eastend formation have not been encountered elsewhere in the township and probably do not extend north of the geological boundary as outlined in the accompanying map (Figure 1). The Bearpaw formation is thought to underlie the drift

throughout the remainder of the township. Wells situated in sections 20 and 28 tap a water-bearing sand in the Bearpaw formation at depths of 180 and 210 feet, or at an average elevation of about 2,793 feet above sea-level. The water is under hydrostatic pressure and rises over 100 feet above the water-bearing sand. Water from the well in section 28 is reported to be soft, whereas water from the well on section 20 is hard and slightly "alkaline". Both waters are suitable for household use. The areal extent of this horizon is not known, but the fact that the water in these wells is under pressure suggests a fairly wide distribution for this horizon. A shallower horizon has been encountered by wells sunk to depths of 48 to 121 feet in sections 13 and 14. Adequate supplies of hard to moderately soft water are obtained from these wells at elevations ranging from about 2,925 to 2,970 feet above sea-level. The water is reported to occur in clay, but is more probably in sandy shale. This horizon has not been encountered elsewhere and is probably confined to this locality.

There is no apparent scarcity of water-bearing beds in this township providing wells are sunk to the required depths, usually not exceeding 200 feet. Drilling to greater depths can not be expected to yield water suitable for farm use.

Township 2, Range 23

This township is situated between the Boundary plateau on the southeast and Old Man on His Back plateau on the northwest. The small drainage that exists in the area is to the southwest through sections 17, 8, and 5.

Ground water is obtained in this township partly from the Recent stream deposits in the coulée bottoms partly from sand and gravel beds occurring at the base of the glacial drift that covers the uplands, and partly from the underlying bedrock formations. Many of the settlers also conserve surface water for stock by constructing small

dams in the coulée bottoms.

The stream deposits consist largely of clays and silts, but these beds contain in places discontinuous beds or pockets of sand or gravel enclosed in the less porous sediments. Wells obtaining water from these sand or gravel pockets are usually not over 30 feet deep. The quality of the water varies in different localities. A well situated in a wide valley that extends through sections 31 and 32 south of the railway line yields highly mineralized water that is used only for stock. Other wells located in the smaller stream channels produce drinkable water containing variable amounts of mineral salts.

The thickness of the glacial drift varies greatly from place to place, and in several places along the southern creeks the drift has been entirely eroded away, exposing the shale of the Bearpaw formation. The variation in thickness is in part due to irregularities in the surface of the underlying bedrock which have been filled in so that their areal extent is undeterminable except by test drilling. Two wells situated on section 13 illustrate this variation. Although the surface elevations at these well sites are about the same, the shale bedrock was encountered at a depth of about 25 feet in the southwest quarter and at a depth of about 110 feet in the northwest quarter. A variation of about 60 feet in thickness of these deposits is also reported in wells situated on the NW. $\frac{1}{4}$ and the NE. $\frac{1}{4}$ of section 34. It seems probable, however, that should careful prospecting in the upper 30 feet of the drift fail to yield an adequate supply of water fairly good possibilities exist of finding water either at the base of the drift or in the upper few feet of the underlying shale at depths of 75 to 100 feet. Waters from existing wells tapping this horizon vary in quality from soft to hard and are highly mineralized. The yield from individual wells is usually sufficient for the domestic and stock requirements. Sandy shale beds, which may represent the basal part of the Eastend formation, occur

immediately beneath the drift in the southeastern corner of the township and over a small area in the central parts, but the fact that these deposits are similar to the underlying Bearpaw suggests a corresponding similarity in ground water conditions.

Wells sunk to the bedrock usually yield large supplies of water. Depths of the wells vary from 30 to 182 feet depending upon the thickness of the drift. Individual water-bearing horizons are apparently of small areal extent and occur as thin, discontinuous beds of fine sand or sandy shale in the upper part of the bedrock. Two distinct types of water are obtained from the Bearpaw formation. Most of the wells yield soft water that is reported to be quite suitable for drinking, although it may contain a relatively high concentration of dissolved solids consisting chiefly of sodium salts; the soft character of the water is due to the absence of calcium and magnesium salts. A highly mineralized water that is reported to be laxative in character is obtained from the Bearpaw shale in the SW. $\frac{1}{4}$, section 13, and in the NE. $\frac{1}{4}$, section 33. This water is used for stock, but is reported to be unsuitable for household use. Although the information obtained regarding the material penetrated in these wells is incomplete it is evident that the water is derived largely from shale and, therefore, can be expected to be more highly mineralized than the water derived from wells that have tapped extensive sand beds interbedded with shale. Dry holes have been sunk on sections 14 and 35 to approximately the same depth in the shale at which water was reported on sections 13 and 33. Due to the irregularity of occurrence of producing aquifers in the Bearpaw, deeper drilling may not find water in spite of the fact that productive beds have been penetrated in the Bearpaw at a lower horizon on sections 2 and 3. However, deepening the well on section 14 some 60 to 75 feet, or down to an approximate elevation of 2,850 feet above sea-level, seems a worth-while procedure. No evidence has been obtained as to the possibility of finding water below an

elevation of 3,000 feet above sea-level in the northern sections, but water was found in section 15, at a depth of 100 feet, or at 2,967 feet above sea-level; in section 13 at a depth of 160 feet, or at 2,852 feet above sea-level; and in section 16 at a depth of 182 feet, or at an elevation of 2,813 feet above sea-level.

Township 2, Range 24

This township is situated on the southern slope from Old Man on His Back plateau. Drainage of the area is to the south and southwest by way of several, small, intermittent streams, the largest of which extends along the eastern side of the township. The coulée bottoms are underlain by thin layers of alluvium consisting of clay and silt, through which are interspersed pockets of sands and gravels. Shallow wells sunk to these pockets are the chief source of drinking water for the few residents located in the township. Water is obtained for stock by constructing dams in the coulées, thus conserving part of the spring run-off. Glacial drift, consisting largely of light to medium dark grey boulder clay overlies the bedrock to a depth ranging from a few feet in the northwestern part of the township to 50 feet and possibly more in the south and southeastern parts. A broad valley trends southwestward across the township from the north half of section 25 to section 19. This area is overlain by light bluish grey glacial lake clay.

Probably little if any water can be obtained from the fine-textured lake clay, but two wells situated in sections 19 and 27 struck water in beds of sand and gravel that occur below the clay at depths of 14 and 41 feet, respectively. These waters are reported to be soft and quite suitable for household use. Little is known as to the ground water conditions in the glacial drift throughout the remainder of the township, but it is probable that sands and gravels overlie bedrock or occur in buried stream channels that extend southward from the uplands in the northern part.

Two bedrock formations are known to immediately underlie the drift in different parts of the township. Eastend beds outcrop on the slope from the plateau in the northwestern corner of the township, and probably extend southward for about 2 miles as outlined by the geological boundary on Figure 1 of the accompanying map. The remainder of the township is underlain by the Bearpaw formation.

No wells are recorded as definitely having derived water from the bedrock in this township. One well in the NW. ¼, section 27, bored 122 feet deep to an approximate elevation of 2,950 feet above sea-level, obtained soft soda-bearing water at a depth of 41 feet, from what is considered to be the contact of the glacial drift and the Bearpaw formation. No information was obtained regarding the character of the sediments passed through in the 42-foot dry hole in the valley on section 12. In the absence of further information regarding ground water conditions in this township or in the township to the west accurate generalizations cannot be made. It is probable, however, that conditions found in the township to the east will prevail in this township and that fairly large supplies of water may be obtained from the bedrock at depths of 100 to 200 feet.

Township 3, Range 22

Glacial drift mantles the bedrock in this township to a fairly uniform depth of about 60 feet. Stream or flood-plain deposits consisting essentially of fine sand, silt, and clay occur in a small area in the southern part of sections 1, 2, and 18, and in the bottoms of the shallow coulées that extend southward through the western half of the township. These deposits overlie the glacial drift and probably nowhere exceed 20 feet in thickness. Moraine covers parts of sections 5, 6, and 7 in the southwestern corner of the township and forms a narrow belt along the eastern border of the township from section 1 to section 24. The remainder of the township

consists of a gently undulating to level till plain.

Ground water supplies in the township are obtained almost entirely from wells sunk in the unconsolidated deposits. These supplies occur at two different horizons. The upper horizon consists of isolated pockets of fine sand in the stream deposits and in sand pockets interspersed in the less pervious clays in the upper 20 feet of the drift. Wells encountering these aquifers are usually situated in depressions or in the coulée bottoms. Individual aquifers are usually of small areal extent and in many places it is necessary to sink several test holes before a suitable water supply is located. Most of these waters are reported to be soft and are quite suitable for domestic use but the quantity obtained is often inadequate for the stock requirements.

Several settlers who have failed to locate an adequate water supply in the upper horizon have sunk wells to a lower water-bearing horizon that occurs at the base of the glacial drift. Depths of wells to this horizon range from 47 to 98 feet. The water occurs in sand or gravel beds and is usually under sufficient hydrostatic pressure to cause it to rise in the wells 10 to 30 feet above the aquifer. The quality of the water varies, but most of it contains appreciable amounts of mineral salts in solution, and one well situated in the SE. $\frac{1}{4}$, section 34, is reported to yield water so highly mineralized that it is used only for stock. Owing to the abandonment of a number of the farms prior to 1935 the survey of these wells is incomplete. The distribution of the lower water-bearing beds, however, is apparently fairly uniform throughout the township, as they have been encountered in the surrounding township.

Little is known regarding ground water conditions in the Bearpaw formation which is thought to underlie the glacial drift throughout this township. A 90-foot well, situated in the SE. $\frac{1}{4}$, section 25, probably taps a water-bearing horizon in the Bearpaw. The water is reported to occur in shale, but it is found in thin

layers of fine sand interbedded with the shale. The hydrostatic pressure is sufficient to cause the water to rise in the well 60 feet above the aquifer. The water contains a high concentration of mineral salts and, therefore, is not used. Highly mineralized waters are obtained from shale aquifers in the Bearpaw formation in the townships lying to the north and west and this suggests that this type of water occurs in the shale throughout the township. Wells sunk to beds of sand or sandstone in this formation usually yield water with a lower mineral salt content than that from the sandy shale. As described in an earlier section of this report, water-bearing sands are encountered in the Bearpaw formation in secs, 20 and 28, tp. 2, range 22, at depths of 180 and 210 feet. Water is also obtained from a bed of sandstone in the Bearpaw formation at a depth of 305 feet in section 17 in the township to the north. It is improbable that these aquifers form continuous horizons but similar aquifers may occur in parts of this township at depths of 200 to 300 feet.

Township 3, Range 23

A wide valley extends diagonally across the southern half of this township from section 13 to section 4. The bottom of the valley is overlain by clay, silt, and fine sand distributed through which occur a few scattered pockets of gravel. The area lying south of the valley is covered by moraine having an uneven surface. A more extensive moraine-covered area extends across the northwestern corner of the township. The remainder of the township consists of fairly level to undulating till plain.

Ground water is obtained from two horizons in the unconsolidated stream and drift deposits. The upper horizon consists of isolated pockets of sand and gravel that occur in the upper 20 feet of the glacial drift and at similar depths in the coulée bottoms. These water-bearing beds are erratic in their distribution and in many

places it is necessary to sink several test holes before water is found. Where obtained, however, these waters are generally of fair quality, although the yield is seldom sufficient for more than the household requirements. Larger yields may be expected in the moraine-covered areas, as these deposits are usually more porous than the till. Few wells have been sunk in these areas in this township.

The second water-bearing horizon occurs at or near the base of the glacial drift at depths of 32 to 60 feet. The water occurs in beds of sand and gravel and generally contains a fairly high concentration of mineral salts. Two wells 32 and 46 feet deep, situated in the NW. $\frac{1}{4}$, and SW. $\frac{1}{4}$, section 23, yield water that is reported to be too highly mineralized for drinking, but is being used for stock. A 60-foot well, on section 12, produces a less highly mineralized water that is drinkable. As no other wells in the township have encountered this horizon its western limits are unknown.

Two bedrock formations are thought to underlie the glacial drift in different parts of the township. The upper or Eastend formation is known to underlie the drift on Old Man on His Back plateau and probably extends through the northwestern half of this township at elevations above 3,100 feet above sea-level. The southeastern half of the township, most of which lies at elevations below 3,100 feet, is underlain by the Bearpaw formation.

Both of these formations probably are water-bearing, but little information is available as to the depths or the areal extent of individual aquifers. In township 2, ranges 22 and 23, large yields of drinkable water are obtained from the Eastend and upper 200 feet of the Bearpaw formation. Similar water-bearing horizons probably extend northwest through this township. Depths to which it will be necessary to sink wells will no doubt vary considerably, but are not expected to exceed 200 feet. The results of sinking two wells

to bedrock in section 1 and 34 in this township are not encouraging, but this cannot be taken as indicative of ground water conditions in other parts of the township or at greater depths at these locations. A well situated in section 34 was sunk to a depth of 84 feet where a small seepage of drinkable water was encountered in red sand that probably represents the lower part of the Eastend formation. This water is not used as the supply is reported to be insufficient even for household use. A well situated in section 1 obtained a small yield of highly mineralized water from Bearpaw shale at a depth of 70 feet. This water is reported to be unsuitable for drinking, but is used for stock. Larger yields are to be expected at greater depths at both of these locations although no prediction can be made as to the quality of the water.

Township 3, Range 24

The greater part of this township is occupied by Old Man on His Back plateau. The land surface for the most part is rolling moraine that slopes gradually to the north and northeast from a maximum elevation of about 3,400 in section 6 to elevations ranging from 3,050 feet to 3,200 feet along the north and eastern borders of the township. Only in the southeast corner is the ground surface sufficiently level to be farmed. All other parts of the area are used as range land.

Small dams constructed in the coulées retain water for stock. These surface supplies are supplemented in a few places by shallow wells sunk to water-bearing sand and gravel beds in the coulée bottoms and in one instance by a deeper well bored to the bedrock.

Stream deposits along the coulées are probably thin in this area as most of the coulées have a fair gradient, so that extensive alluvial deposits have not been found. Wells sunk in this type of deposit in sections 11 and 21 yield soft, drinkable

water from quicksand at depths of 21 and 14 feet, respectively. Sand flows into the well on section 11 and reduces the yield to such an extent that it is inadequate for the stock requirements. The well on section 21 is reported to yield an adequate supply for both stock and household use. A well situated on the SW. $\frac{1}{4}$, section 13, may also obtain its water supply from a stream deposit. This well yields a large supply of soft, slightly "alkaline" water from a gravel aquifer at a depth of 22 feet. The water is used for drinking and for stock. Water-bearing sand and gravel deposits of a similar character probably occur in the lower parts of the slopes and in the depressions between the hills in the moraine-covered area in the northern half of the township.

The thickness of the glacial drift in this township is not known, but it is probably quite thin near the summit of the plateau in the southwestern corner of the township. In the northern parts, however, it may have a thickness of 50 feet or more in some places. Little is known as to ground water conditions in the glacial drift as only the previously mentioned wells are reported from this area, and few wells have been sunk in the area of range land bordering the township on the north and west. Moderate to large amounts of water probably occur in pockets of well-sorted sands and gravel interspersed through the boulder clay in the moraine. These waters are not expected to be so highly mineralized as to be undrinkable. Discontinuous beds of sand and gravel may also occur at the contact of the drift and the underlying bedrock in some places in the northern part of the township, although careful prospecting may be necessary to locate them.

The glacial drift is thought to be underlain by the Eastend formation throughout most of the township, although the Ravenscrag formation probably overlies the Eastend in a small area on the summit of the plateau in the southwestern corner of the township at elevations exceeding 3,250 feet above sea-level. Medium to fine-grained, buff-weathering sands and grey shales that outcrop on the southern

escarpment of the plateau in the vicinity of the southern border of section 6, although not positively identified as such, may form the basal beds of the Ravenscrag formation. Should these beds extend northward at the same elevation they may be encountered in section 6 and parts of sections 5, 7, and 8 by sinking wells to depths of less than 100 feet and can be expected to be water-bearing in at least part of this area.

The Eastend formation is also a potential source of ground water in this township. A 76-foot well bored in section 2 is reported to yield an adequate supply of hard and slightly "alkaline" water from the Eastend shale. Although no other bedrock wells are known to have been sunk in the township it is quite probable that water of similar or even better quality may occur in other localities at depths of less than 150 feet. At greater depths the upper part of the Bearpaw formation underlying the Eastend may also be water-bearing, but many of the waters from this source contain a higher concentration of mineral salts in solution.

STATISTICAL SUMMARY OF WELL INFORMATION IN RURAL MUNICIPALITY OF NO. 20, SASKATCHEWAN

West of 3rd meridian — Township	1	1	1	2	2	2	3	3	3	Total No. in municipality
Range	22	23	24	22	23	24	22	23	24	
Total No. of wells in Township	1	5	4	18	23	8	15	14	4	92
No. of wells in bedrock	0	4	0	9	12	0	1	3	1	30
No. of wells in glacial drift	1	1	4	8	11	7	14	11	1	58
No. of wells in alluvium	0	0	0	1	0	1	0	0	2	4
Permanency of Water Supply										
No. with permanent supply	1	5	4	17	21	7	15	13	4	87
No. with intermittent supply	0	0	0	0	0	0	0	0	0	0
No. dry holes	0	0	0	1	2	1	0	1	0	5
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	1	0	10	8	1	8	0	1	29
No. of non-artesian wells	1	4	4	7	13	6	7	13	3	58
Quality of Water										
No. with hard water	1	2	2	11	8	5	11	7	1	48
No. with soft water	0	3	2	6	13	2	4	6	3	39
No. with salty water	0	1	0	0	0	1	0	0	0	2
No. with "alkaline" water	0	0	1	3	8	2	6	7	2	29
Depths of Wells										
No. from 0 to 50 feet deep	1	1	4	7	8	7	7	10	3	48
No. from 51 to 100 feet deep	[illegible]	1	0	6	9	0	8	4	1	29
No. from 101 to 150 feet deep	0	3	0	2	3	1	0	0	0	9
No. from 151 to 200 feet deep	0	0	0	1	3	0	0	0	0	4
No. from 201 to 500 feet deep	0	0	0	2	0	0	0	0	0	2
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	1	5	3	16	17	6	12	8	4	72
No. not usable for domestic purposes	0	0	1	1	4	1	3	5	0	15
No. usable for stock	1	5	4	16	21	6	14	13	4	84
No. not usable for stock	0	0	0	1	0	1	1	0	0	3
Sufficiency of Water Supply										
No. sufficient for domestic needs	1	5	4	16	21	7	15	12	4	85
No. insufficient for domestic needs	0	0	0	1	0	0	0	1	0	2
No. sufficient for stock needs	0	3	2	16	15	7	12	5	3	63
No. insufficient for stock needs	1	2	2	1	6	0	3	8	1	24

ANALYSES AND QUALITY OF WATER

General Statement

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

Total Dissolved Mineral Solids

The term "total dissolved mineral solids" as here used refers to the residue remaining when a sample of water is evaporated to dryness. It is generally considered that waters that have less than 1,000 parts per million of dissolved solids are suitable for ordinary uses, but in the Prairie Provinces this figure is often exceeded. Nearly all waters that contain more than 1,000 parts per million of total solids have a taste due to the dissolved mineral matter. Residents

accustomed to the waters may use those that have much more than 1,000 parts per million of dissolved solids without any marked inconvenience, although most persons not used to highly mineralized water would find such waters highly objectionable.

Mineral Substances Present

Calcium and Magnesium

The calcium (Ca) and magnesium (Mg) content of water is dissolved from rocks and soils, but mostly from limestone, dolomite, and gypsum. The calcium and magnesium salts impart hardness to water. The magnesium salts are laxative, especially magnesium sulphate (Epsom salts, $MgSO_4$), and they are more detrimental to health than the lime or calcium salts. The calcium salts have no laxative or other deleterious effects. The scale found on the inside of steam 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. The following generalizations regarding the character of the ground water found in the various types of sediments are based upon observations at the well sites, opinions of residents, and the results of analyses of waters from adjoining municipalities in which the source beds are similar.

Waters obtained from the stream deposits that occur in the small coulées and depressions are generally not highly mineralized, and if not contaminated by sewage or other decaying organic materials are suitable for domestic use. Waters from the beds of fine sands and silts that occur in the bottoms of the larger stream channels and some of the undrained depressions generally contain a higher concentration of salts in solution. The fine texture of these sediments and the consequent slowness with which water percolates through them lends to this greater concentration. Surface evaporation is a further cause of concentrations of mineral salts, particularly in extensive flats such as occur on the south and southeastern slopes from Old Man on His Back plateau and at the edge of the moraine east of Claydon. Similar factors determine the mineral salt concentration of waters found at shallow depth in the drift. As these waters are obtained mostly from coarse sand and gravel they are, as a rule, not highly mineralized. Some of the shallow wells yield only slightly mineralized, soft water, whereas from others the water contains appreciable amounts of sodium and magnesium sulphates in solution. Nearly all the waters found at shallow depths are reported to be drinkable. The compact, bluish grey boulder clay that forms the greater part of the drift is generally regarded as being the main source of the sulphate salts that render the water laxative. Even shallow wells deriving their water by seepage from the clay yield a bitter, undrinkable water. Water derived from sand

and gravel beds at the base of the glacial drift are more variable in character. Many of these waters probably contain a concentration of salts in excess of 1,000 parts per million and in some the concentration possibly exceeds 3,000 parts per million. 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 in solution, but waters containing any large amount of it have a laxative effect upon humans. Waters containing magnesium sulphate (Epsom salt) have a bitter taste, and strong laxative effect. This salt also contributes to the hardness of the water. Waters containing both these salts in a combined concentration exceeding 1,000 parts per million are usually considered as being unsuitable for human consumption, but in many places in the Prairie Provinces waters containing higher concentrations are being used with no apparent ill effects. Stock are apparently less affected by highly mineralized waters and have been reported to thrive on waters containing concentrations of sulphate salts amounting to 3,000 parts per million or somewhat more. During winter months when stock are fed on dry fodder a slight laxative effect of the water cannot be regarded as injurious.

Wells sunk in the boulder clay are usually situated beside dams or artificially constructed reservoirs and derive their water by seepage. The clay acts as a filter to the water in the reservoir and if the water is not contaminated by sewage or does not contain a high concentration of mineral salts due to evaporation such water will be suitable for drinking.

Water from the Bedrock

No wells in the municipality are known to obtain water from the Ravenscrag formation. In the Cypress Hills uplands to the north and northeast of this municipality the sand beds and coal seams interbedded with the clays and shales of this formation form the chief source of ground-water throughout large areas. Analyses made of many

waters from this source show only a few to have a total solid content in excess of 1,000 parts per million and many to have a content less than 500 parts. Sodium sulphate and sodium carbonate are usually present in the greatest abundance, but the proportion of these to other compounds varies considerably. Two more or less distinct types of ground water are found in the beds of the Eastend and Bearpaw formations. The porous sand beds that form the greater part of the Eastend formation and occur interbedded with shale in the upper part of the Bearpaw formation yield a soft water. This softness is due to the absence of salts of magnesium and calcium in solution, but the water contains large quantities of sodium carbonate (or black alkali). These waters are generally drinkable, although the "soda" tends to give them a flat taste. If the soda content is large such waters should not be used for irrigating gardens, as this salt in solution tends to kill vegetation.

Waters derived from beds of shale either in the Eastend or the Bearpaw formation contain predominantly the sulphate salts of sodium and calcium and usually magnesium in solution. Such waters are exceedingly hard and the quantity of dissolved mineral salts may be sufficient to prohibit the use of the water in the household. In some places the water from the shales of the Bearpaw formation is unfit even for stock.

At greater depths in the more shaly parts of the Bearpaw formation the concentration of the sulphate salts will probably be found to increase, and appreciable amounts of common salt (NaCl) are also to be expected.

WELL RECORDS—Rural Municipality of NO. 20, 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.	5	1	22	3	Bored	47	3,238	- 43	3,195	43	3,195	Glacial gravel	Hard, clear	42	D	Insufficient supply.
1	NE.	24	1	23	3	Drilled	160	3,247	-100	3,147	160	3,087	Bearpaw shale	Soft, clear	43	D, S	Sufficient supply.
2	NW.	25	"	"	"	Dug	90	3,287	- 80	3,207	80	3,207	Eastend sand	Hard, clear	44	D, S	Insufficient supply.
3	NE.	32	"	"	"	Dug	12	3,047	- 10	3,037	10	3,037	Glacial sand and blue clay	Hard, salty, clear	43	S	Insufficient supply.
4	SE.	35	"	"	"	Dug	120	3,261	- 84	3,177	84	3,177	Eastend sandstone	Soft, clear	44	D, S	Sufficient supply.
5	NE.	35	"	"	"	Bored	105	3,257	- 97	3,160	97	3,160	Eastend	Soft, clear	43	D, S	Sufficient supply.
1	NW.	1	1	24	3	Dug	16	2,800	- 8	2,792	8	2,792	Stream deposits	Hard, clear, "alkaline"	45	S	Sufficient supply.
2	NW.	16	"	"	"	Dug	20	3,008	- 10	2,998	10	2,998	Glacial clay	Soft, clear	45	D, S	Sufficient supply.
3	NE.	35	"	"	"	Dug	20	3,068	- 14	3,054	14	3,054	Stream deposits	Hard, clear	45	D	Insufficient supply.
4	NE.	35	"	"	"	Dug	25	3,068	- 19	3,049	19	3,049	Stream deposits	Soft, clear	45	S	Insufficient supply.
1	NE.	5	2	22	3	Drilled	90	3,219									Dry hole in Eastend formation.
2	NW.	5	"	"	"	Dug	14	3,139	- 7	3,132	7	3,132	Recent Alluvium, gravel	Hard, clear	42	D, S	Sufficient supply.
3	NE.	6	"	"	"	Dug	21	3,149	- 13	3,136	21	3,128	Eastend sand	Soft, clear	42	D, S	Sufficient supply.
4	NW.	6	"	"	"	Dug	66	3,174	- 55	3,119	66	3,108	Eastend sand	Soft, clear	42	D, S	Sufficient supply.
5	SE.	7	"	"	"	Dug	28	2,989	- 8	2,981	28	2,961	Bearpaw	Soft, clear		D, S	Sufficient supply.
6	SE.	13	"	"	"	Bored	48	3,001	- 30	2,971	30	2,971	Bearpaw	Hard, clear	42	D, S	Sufficient supply.
7	NE.	13	"	"	"	Bored	34	2,990	- 60	2,930	60	2,930	Glacial sand and gravel	Hard, clear, "alkaline"	42	D, S	Sufficient supply.
8	SE.	14	"	"	"	Bored	121	3,015	- 61	2,954	61	2,954	Bearpaw	Hard, clear	42	D, S	Sufficient supply.
9	NE.	14	"	"	"	Bored	74	3,010	- 62	2,948	62	2,948	Bearpaw	Hard, clear	42	D, S	Sufficient supply.
10	NW.	17	"	"	"	Drilled	130	2,950	- 50	2,900			Glacial gravel	Hard, iron, "alkaline", red sediment	38	D, S	Probably sufficient supply; slightly laxative.
11	NE.	18	"	"	"	Drilled	180	3,019	- 60	2,959	60	2,959	Glacial gravel	Hard, clear	42	D, S	Sufficient supply.
12	NE.	18	"	"	"	Dug	30	3,070	- 20	3,050	20	3,050	Glacial drift	Hard		N	Abandoned farm.
13	NE.	20	"	"	"	Drilled	230	2,983	- 60	2,923	180	2,803	Bearpaw	Hard, cloudy, "alkaline"	42	D, S	Sufficient supply.
14	NE.	28	"	"	"	Drilled	435	2,994	- 35	2,959	210	2,784	Bearpaw coarse sand	Soft, clear	42	D, S	Sufficient supply.
15	NE.	32	"	"	"	Dug	16	2,988	- 6	2,982	16	2,972	Glacial gravel	Soft, clear	42	D, S	Sufficient supply.
16	NW.	33	"	"	"	Dug	65	2,997	- 45	2,952	65	2,932	Glacial gravel	Soft, clear	42	D, S	Sufficient supply.
17	NW.	34	"	"	"	Drilled	36	3,000	- 18	2,982	36	2,964	Glacial gravel	Hard, clear	42	D, S	Sufficient supply.

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

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(#) Sample taken for analysis.

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18	SE.	36	2	22	3	Bored	55	2,963	- 6	2,957	55	2,908	Glacial gravel	Hard, clear	42	D, S	Sufficient supply.
√1	SE.	2	2	23	3	Drilled	132	2,972	-118	2,854	118	2,854	Bearpaw	Soft, clear, slightly "alkaline"	43	D, S	Sufficient supply.
√2	NW.	3	"	"	"	Drilled	120	2,965	- 50	2,915	120	2,845	Bearpaw shale	Soft, clear	43	D, S	Sufficient supply.
3	SW.	4	"	"	"	Bored	74	3,024	- 47	2,977	74	2,950	Glacial sand and gravel	Soft, clear, "alkaline"	42	D, S	Sufficient supply.
4		5	"	"	"	Drilled	128	3,050			128	2,922	Bearpaw sand	Soft		D, S	Just sufficient supply.
√5	SE.	12	"	"	"	Bored	52	3,021	- 36	2,985	36	2,985	Bearpaw	Soft, clear	43	D, S	Sufficient supply.
6	NW.	12	"	"	"	Dug	8	2,990	0	2,990	8	2,982	Glacial gravel	Soft, clear	43	D, S	Sufficient supply.
√7	SW.	13	"	"	"	Bored	80	3,021	- 35	2,986	35	2,986	Bearpaw shale	Hard, clear, "alkaline"	42	S	Insufficient supply.
√8	NW.	13	"	"	"	Bored	160	3,012	- 80	2,932	160	2,852	Bearpaw shale	Soft, clear, "alkaline"	42	D, S	Sufficient supply.
9	SE.	14	"	"	"	Bored	90	3,012									Dry hole in Bearpaw shale.
10	SE.	14	"	"	"	Dug	20	3,012	- 18	2,996	16	2,996	Glacial quick-sand	Soft, clear	43	D	Insufficient supply.
11	SE.	15	"	"	"	Dug	15	2,994	- 13	2,981	13	2,981	Glacial sand and gravel	Soft, clear	43	D, S	Well not used at present.
√12	NE.	15	"	"	"	Bored	100	3,062	- 55	3,007	55	3,007	Bearpaw	Soft, clear	42	D, S	Sufficient supply.
13	SE.	16	"	"	"	Dug	16	3,035	- 7	3,028	16	3,019	Glacial clay	Hard, clear	43	D, S	Sufficient supply.
√14	NW.	16	"	"	"	Drilled	182	2,995	-160	2,835	182	2,813	Bearpaw sand	Soft, clear	43	D, S	Sufficient supply.
15	SE.	24	"	"	"	Drilled	98	2,989	- 38	2,951	98	2,891	Glacial drift	Soft, clear	42	D, S	Sufficient supply.
16	SW.	28	"	"	"	Dug	30	3,151	- 22	3,129	22	3,129	Eastend	Soft, clear	43	D, S	Sufficient supply.
17	SE.	30	"	"	"	Bored	190	3,167	-130	3,037	130	3,037	Glacial sand and gravel	Hard, clear, "alkaline"	43	D, S	Sufficient supply.
18	NE.	32	"	"	"	Dug	30	3,099	- 18	3,081	18	3,081	Glacial gravel	Hard, clear, "alkaline"	43	S	Insufficient supply.
19	NE.	33	"	"	"	Bored	84	3,199	- 74	3,125	84	3,115	Bearpaw shale	Hard, clear, "alkaline"	43	S	Insufficient at all times.
20	NW.	34	"	"	"	Bored	99	3,106	- 49	3,057	49	3,057	Glacial sand	Hard, clear, "alkaline"	43	S	Insufficient supply; a similar well for house use.
21	NE.	34	"	"	"	Dug	20	3,124	- 15	3,109	15	3,109	Glacial sand	Hard, clear	42	D, S	Sufficient supply.
22	NW.	35	"	"	"	Bored	100	3,119									Dry hole in Bearpaw shale; abandoned well filled in.
1	SW.	2	2	24	3	Dug	26	3,074	- 14	3,060	24	3,050	Glacial clay	Hard, clear, slightly "alkaline"	45	D, S	Sufficient supply.
2	NW.	7	"	"	"	Dug	47	3,150	- 31	3,119	31	3,119	Glacial sand	Salty		N	Water said to contain Epsom salts.
3	NW.	8	"	"	"	Dug	8	2,999	- 5	2,994	5	2,994	Glacial stream deposits	Hard, clear	45	D, S	Good supply.
4	NE.	12	"	"	"	Dug	42	3,209									Dry hole in glacial drift.
5	SW.	19	"	"	"	Dug	14	3,118	- 10	3,108	10	3,108	Glacial gravel	Soft, clear	45	D	Sufficient supply.

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6	NW.	27	2	24	3	Bored	122	3,075	- 41	3,034	41	3,034	Glacial sand	Soft		D, S	Sufficient supply.
7	SW.	34	"	"	"	Dug	13	3,100	- 0	3,100	13	3,087	Recent Alluvium, sand	Hard, clear	43	D, S	Sufficient supply.
8	SW.	34	"	"	"	Dug	18	3,204	- 13	3,191	13	3,191	Glacial gravel	"alkaline"		D, S	Water lowered 4 feet after 2 hours pumping.
1	NE.	5	3	22	3	Dug	98	3,065	- 60	3,005	60	3,005	Glacial gravel	Hard		N	Well used to be sufficient; abandoned and filled in now.
2	NE.	9	"	"	"	Drilled	78	2,992	- 40	2,952	78	2,914	Glacial gravel	Hard, clear, "alkaline"	42	D, S	Sufficient supply.
3	NW.	15	"	"	"	Drilled	60	3,024	- 32	2,992	60	2,964	Glacial gravel	Hard, clear, iron, slightly "alkaline"	42	D, S	Sufficient supply.
4	NW.	17	"	"	"	Drilled	57	2,998	- 47	2,951	57	2,941	Glacial sand	Hard, clear	42	D, S	Sufficient supply.
5	SE.	18	"	"	"	Dug	51	3,010	- 36	2,974	51	2,959	Glacial gravel	Soft, clear, "alkaline"	42	D, S	Sufficient supply.
6	SE.	21	"	"	"	Drilled	69	3,013	- 35	2,978	69	2,944	Glacial sand	Hard, clear, iron	42	D, S	Sufficient supply.
7	NE.	22	"	"	"	Dug	18	3,004	- 10	2,994	18	2,986	Glacial sandy clay	Soft, brown colour	42	D	Insufficient supply.
8	NE.	23	"	"	"	Dug	47	3,014	- 43	2,971	47	2,967	Glacial gravel	Hard, clear	42	D, S	Sufficient supply.
9	SE.	25	"	"	"	Bored	90	3,036	- 30	3,006	90	2,946	Bearpaw shale	Hard, clear, very "alkaline"	42	N	Sufficient supply.
10	NE.	25	"	"	"	Dug	15	3,033	- 8	3,025	8	3,025	Glacial stream deposits	Soft, clear	42	D, S	Sufficient supply.
11	NW.	27	"	"	"	Dug	10	3,006	- 4	3,002	4	3,002	Glacial stream deposits	Hard, clear, "alkaline"	42	S	Sufficient supply.
12		28	"	"	"	Dug	12	3,075	- 8	3,067	8	3,067	Glacial sand	Hard		D, S	Sufficient supply.
13	SE.	34	"	"	"	Dug	60	3,079	- 57	3,022	57	3,022	Glacial clay	Hard, clear, "alkaline"	42	S	Insufficient supply; an 8-foot seepage well supplies some water.
14	SE.	35	"	"	"	Dug	20	3,034	- 17	3,017	17	3,017	Glacial sand	Soft, clear	42	D, S	Sufficient supply.
1	SW.	1	3	23	3	Bored	100	3,124	- 70	3,054	70	3,054	Bearpaw shale	Hard, clear, "alkaline"	42	S	Insufficient supply; another well quite similar.
2	SW.	3	"	"	"	Dug	12	3,085	0	3,085	7	3,078	Glacial gravel	Hard, clear, "alkaline"	42	D, S	Insufficient supply.
3	NW.	10	"	"	"	Dug	12	3,000	- 7	2,993	7	2,993	Glacial sand	Soft, clear	42	D	Insufficient supply.
4	NE.	12	"	"	"	Dug	60	3,010	- 55	2,955	55	2,955	Glacial gravel	Soft, clear, "alkaline"	42	D, S	Sufficient supply.
5	NW.	14	"	"	"	Dug	16	3,000	- 11	2,989	11	2,989	Glacial gravel	Soft, clear, "alkaline"	42	D, S	Sufficient supply.
6	NW.	18	"	"	"	Dug	8	3,010	0	3,010	6	3,004	Glacial clay	Soft, clear	42	D	Insufficient supply.
7	NE.	20	"	"	"	Dug	6	3,000	- 3	3,997	3	2,997	Glacial sand	Hard, clear, iron, red sediment	43	S	Sufficient supply.
8	NW.	20	"	"	"	Drilled	50	3,010									Dry hole in glacial clay.

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9	SW.	23	3	23	3	Dug	46	3,010	- 42	2,968	42	2,968	Glacial sand	Hard, clear, "alkaline"	42	S	Sufficient supply.
10	NW.	23	"	"	"	Dug	32	3,000	- 30	2,970	30	2,970	Glacial sand	Hard, clear, "alkaline"	42	S	Insufficient supply.
11	NE.	23	"	"	"	Dug	17	3,004	- 11	2,993	11	2,993	Glacial quick-sand	Soft, clear	42	D, S	Sufficient supply.
12	SW.	34	"	"	"	Dug	84	3,120			80	3,040	Eastend sand	Hard, clear		N	Insufficient supply.
13	SW.	34	"	"	"	Dug	20	3,100	- 14	3,086	14	3,086	Glacial sand	Hard, clear	42	D	Sufficient supply.
1	NW.	2	3	24	3	Bored	76	3,246	- 67	3,179	67	3,179	Eastend	Hard, clear, slightly "alkaline"	43	D, S	Sufficient supply.
2	NW.	11	"	"	"	Dug	25	3,207	- 21	3,186	21	3,186	Recent Alluvium, quicksand	Soft, clear	43	S	Insufficient supply.
3	SW.	13	"	"	"	Dug	22	3,217	- 10	3,207	22	3,195	Stream deposits	Soft, clear, "alkaline"	43	D, S	Sufficient supply.
4	SE.	21	"	"	"	Dug	14	3,299	- 10	3,289	10	3,289	Recent Alluvium, quicksand	Soft, clear	43	D, S	Sufficient supply.

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.