CANADA
DEPARTMENT OF MINES
AND
TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

WATER SUPPLY PAPER No. 265

GROUND-WATER RESOURCES OF TOWNSHIPS 35 TO 38, RANGES 1 TO 4, WEST OF 4th. MERIDIAN, ALBERTA

Records collected and compiled by

G. S. Hume and C. O. Hage

OTTAWA
1947

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MINES AND GEOLOGY BRANCH
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INTRODUCTION

Information on the ground-water resources of east-central Alberta and western Saskatchewan was collected, mostly in 1935, during the progress of geological investigations for oil and gas. The region studied extends from Edmonton in the west to Battleford in the east, and from township 32 on the south to township 59 in central Alberta, township 63 in eastern Alberta, and in part as far north as township 56 in western Saskatchewan.

This region is crossed by North Saskatchewan and Battle Rivers, and includes other more or less permanent streams. Most of the lakes within the area, however, are alkaline, and water is obtained in wells from two sources, namely, from water-bearing sands in surface or glacial deposits, and from sands in the underlying bedrock.

A division has been made in the well records, in so far as possible, between glacial and bedrock water-bearing sands. In investigations for oil and gas, however, the bedrock wells were used to trace the lateral extent of geological formations, with the result that the records deal more particularly with this type of well. No detailed studies were made of the glacial materials in relation to the water supply, nor were the glacial deposits mapped adequately for this purpose. In almost all of the region investigated in Alberta, and in all but the northeast part of the region studied in Saskatchewan, water can be obtained from bedrock. In a few places, however, the water from the shallower bedrock sands is unsatisfactory, and deeper drilling may be necessary.

The water records were obtained mostly from the well owners, some of whom had acquired the land after the water supply had been found, and hence had no personal knowledge of the water-bearing beds that had been encountered in their wells. Also, the elevations of the wells were taken by aneroid barometer and are, consequently, only approximate. In spite of these defects, however, it is hoped that the publication of these water records may prove of value to farmers, town authorities, and drillers in their efforts to obtain water supplies adequate for their needs.

In collecting this information several parties were employed. These were under the direction of Professors R. L. Rutherford and P. S. Warren of the University of Alberta, C. H. Crickmay of Vancouver, and C. O. Hage, until recently a member of the Geological Survey. The oil and gas investigations of which these water records are a part were undertaken under the general supervision of G. S. Hume.

Publication of Results

The essential information pertaining to ground-water conditions is being issued in reports that in Saskatchewan cover each municipality, and in Alberta cover each square block of sixteen townships beginning at the 4th meridian and lying between the correction lines. The secretary treasurer of each municipality in Saskatchewan and Alberta will be supplied with the information covering that municipality. Copies of the reports will also be available for study at offices of the Provincial and Federal Government Departments. Further assistance in the interpretation of the reports may be obtained by applying to the Chief Geologist, Geological Survey, Ottawa. Technical terms used in the reports are defined in the glossary.

How to Use the Report

Anyone desiring information concerning ground water in any particular locality will find the available data listed in the well records. These should be consulted to see if a supply of water is likely to be found in shallow wells sunk in the glacial drift, or whether a better supply may be obtained at greater depth in the underlying bedrock formations. The wells in glacial drift commonly show no regional level, as the sands or gravels in which the water occurs are irregularly distributed and of limited extent. As the surface of the ground is uneven, the best means of comparing water wells is by the elevations of their water-bearing beds. For any particular well this elevation is obtained by subtracting the figure for the depth of the well to the water-bearing bed from that for the surface elevation at the well. For convenience, both the elevation of the wells and the elevation of the water-bearing bed or beds in each well are given in the well record tables. Where water is obtained from bedrock, the name of the formation in which the water-bearing sand occurs is also listed in these tables, and this information should be used in conjunction with that provided on bedrock formations, pages 4 to 11, which describes these formations and gives their thickness and sequence. Where the level of the water-bearing sand is known, its depth at any point can easily be calculated by subtracting its elevation, as given in the well record tables, from the elevation of the surface at that point.

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

GLOSSARY OF TERMS USED

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

BEDROCK FORMATIONS IN EAST-CENTRAL ALBERTA

The formations that outcrop in east-central Alberta are mainly of Upper Cretaceous age, but Tertiary beds occur to the southwest in the Red Deer area. These higher strata are sandstones and shales with thin coaly and carbonaceous beds. Commercial coal beds occur in the Upper Cretaceous Edmonton formation, but other thin coal seams are present, particularly in the Ribstone Creek formation and in the Pale and Variegated Beds. Carbonaceous beds also occur in the Bearpaw formation and are widely scattered through other formations. The Edmonton formation contains some harder sandstones, but almost the whole Upper Cretaceous succession consists of softer sands and sandstones alternating with shales in which ironstone nodules are commonly present. The succession, character, and estimated thickness of the formations are shown in the following table:

Age	Formation	Character	Thickness Feet
Tertiary	Paskapoo	Sandstones and shales with thin coal seams and carbonaceous beds; basal sandstones, massive and crossbedded; some siliceous limestone 150 to 200 feet above the base of the formation.	A few hundred feet thick in Red Deer area. The thickness increases to the south and west.

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

Paskapoo Formation

The Paskapoo formation was first named by Tyrrell from exposures of the lower part of the formation occurring along Blindman

River near its confluence with the Red Deer. It is composed essentially of sandstones and shales of freshwater deposition, and includes some thin coal seams and carbonaceous beds. The basal beds are massive, crossbedded sandstones that weather buff-yellow, and are in striking contrast to the underlying, light-coloured, bentonitic clays of the Edmonton formation. About 150 to 200 feet above the base of the formation are beds of siliceous limestones containing gastropods and pelecypods, but these beds are lenticular rather than continuous, although a zone of them appears widely distributed at about the same stratigraphic level.

Edmonton Formation

The name Edmonton formation was first applied to the beds containing coal in the Edmonton area, and later to the same beds in adjoining areas. The formation has a total thickness of 1,000 to 1,150 feet, but is bevelled off eastwards, and the east edge of the formation follows a northwest line from Coronation through Tofield to a point on North Saskatchewan River about midway between Edmonton and Fort Saskatchewan. No Edmonton beds occur northeast of this line, but the formation becomes progressively thicker to the southwest due to the fact that the beds dip in that direction and are bevelled across at the surface.

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

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

Bearpaw Formation

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

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

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

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

Pale and Variegated Beds

Underlying the Bearpaw formation is a succession of bentonitic sands, shales, and sandy shales containing a few coal seams. The upper part of this succession, due to the bentonitic content, is commonly light coloured and has been described as the Pale Beds, whereas the lower part is darker, and is known as Variegated Beds. In part, dark shales are present in both Pale and Variegated Beds; others are greenish, grey, brown, and dark chocolate carbonaceous types. The sands may also be yellow, but where bentonite is present it imparts a light colour to the beds. Both Pale and Variegated Beds are characterized by the presence of thin seams of ironstone, commonly dark reddish, but in part purplish. Selenite (gypsum) crystals are, in places, abundant in the shales.

The best sections of Pale Beds exposed in the region are in the Tit Hills, southwest of Czar. These hills carry a thin capping of Bearpaw shales, beneath which, and around Bruce Lake, more than 200 feet of Pale Beds are exposed. The total thickness of Pale and Variegated Beds in the Tit Hills area is about 970 feet. Variegated Beds outcrop near Hawkins on the Canadian National Railway west of Wainwright, but no area exposes the complete succession, which is considered to comprise about 200 feet of beds.

Records of wells drilled into the Pale and Variegated Beds do not, in general, indicate lateral persistence of sands for long distances, nor any uniform average depth to water-bearing sands in a local area. This points to the conclusion that the sands are mainly lenticular, but as such lenses are numerous few wells fail to obtain water. In the Cadogan area many flowing wells have been obtained from sands about midway in the succession. In western Saskatchewan, Pale and Variegated Beds occur over a wide area from Macklin and Kerrobert northeast through Wilkie to the Eagle Hills, south of Battleford. Numerous outcrops occur in the area south of Unity at Muddy Lake, but south and east around Biggar these beds are almost wholly concealed by glacial drift.

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

Birch Lake Formation

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

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

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

Grizzly Bear Formation

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

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

Ribstone Creek Formation

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

These marine shales in turn are overlain by a sandy zone about 20 feet thick containing oysters in the basal part. This sandy zone is the upper sand member of the Ribstone Creek formation. It thickens to the east and west from the Grizzly Bear area, but is probably at no place much more than 50 feet thick.

The lower sand member of the Ribstone Creek formation also varies in thickness from a minimum of about 25 feet. On the banks of Vermilion Creek, north of Mannville, the basal sand is at least 60, and may be 75, feet thick. It is overlain by shaly sand and sandy shale beds, which replace the shale beds in the central part of the formation as exposed at the mouth of Grizzly Bear Coulée. In the Wainwright area, where the formation has been drilled in deep wells, the basal sand is 60 feet thick, with the central part composed of shale containing sand streaks. The upper sand member is about 20 feet thick in this area. The total thickness of the formation in the Wainwright area is 180 to 200 feet, but this increases to the west and in the Viking area exceeds 300 feet.

The Ribstone Creek formation is widely exposed in a northwest-trending belt in east-central Alberta. The southern boundary on the Alberta-Saskatchewan meridian is in the south part of township 44, south of Battle River, whereas the northern boundary is in township 51, a few miles north of Lloydminster. The southwest boundary of this northwest-trending belt passes through the mouth of Grizzly Bear Coulée in tp. 47, rge. 5, and beyond to the Tit Hills area in tp. 54, rge. 12, whereas the northeast boundary crosses North Saskatchewan River southwest of Elk Point and extends northwest to include an area only slightly north of St. Paul des Metis and Vilna to tp. 60, rge. 14. Within this belt water wells are common in the Ribstone Creek sands, which are almost without exception water-bearing in some part of the formation. The limits of the belt to the northeast determine the limits of water from this source, but to the southwest of the belt, as here outlined, water may be obtained in this formation by drilling through the younger beds that overlie it. The Ribstone Creek sands are a prolific source of water in many places, and hence the distribution of this formation is of considerable economic importance. Where the formation consists of upper and lower sands with a central shale zone only the sands are water-bearing, although thin sand members may occur in the shale. Where the formation is largely sand the distribution of water may be in any part of the formation, although the upper and lower sands are perhaps the better aquifers. To the east of Alberta along Battle River and Big Coulée in Saskatchewan the Ribstone Creek sands are marine. Marine conditions apparently become more prevalent to the southeast, and it is believed that in this direction the sands are gradually replaced by marine shales. Thus at some distance southeast of Battleford the Ribstone Creek formation loses its identity and its equivalents are shales in a marine succession.

Lea Park Formation

The Lea Park formation is largely a marine shale, and only in the upper 180 feet is there any water. In the Dina area south of Lloydminster the upper beds of the Lea Park consist of silty shales about 110 feet thick underlain by silty sands 70 feet thick. Below these sands are marine shales only, and these yield no fresh water either in east-central Alberta or west-central

Saskatchewan. The sand in the upper Lea Park formation is thus the lowest freshwater aquifer within a very large area. The extent of this sand in the Lea Park, particularly to the northeast, is not known, but as the strata in east-central Alberta have a southwest inclination, progressively lower beds occur at the surface to the northeast. Consequently, at a short distance beyond the northeast boundary of the Ribstone Creek formation, as previously outlined, the sand in the upper Lea Park reaches the surface, and represents the last bedrock aquifer in that direction. Farther northeast water must be obtained from glacial or surface deposits only. In Alberta this area without fresh water in the bedrock includes the country north of North Saskatchewan River in the vicinity of Frog Lake and a large area extending to and beyond Beaver River. In this area, however, more freshwater streams are present than farther south, and bush lands help to retain the surface waters. The area northeast of North Saskatchewan River in Saskatchewan is almost wholly within the Lea Park formation, where water can be found only in surface deposits.

TOWNSHIPS 35 TO 38, RANGES 1 TO 4,
WEST OF FOURTH MERIDIAN, ALBERTA

Physical Features

The prominent physiographic features of this area are the eastward extension of Neutral Hills and the large shallow body of alkaline water of Sounding Lake. For the most part Neutral Hills lie to the northwest of Monitor, but only a few miles northeast of this town they are broken by the valley of Sounding Creek east of which they again re-appear and extend to the Alberta-Saskatchewan boundary. They rise to a maximum elevation of 2,800 feet, or about 650 feet above Sounding Lake, and their abrupt rise is in sharp contrast with the level plain that in this area bounds them on the north. Sounding Lake drains northeastward through Eyehill Creek, a stream that is intermittent in flow according to the season and in general has a wide low valley. Sounding Lake is the southern limit of the natural tree belt of the plains, and only in the northwest corner of this area is there a sparse development of scrub poplar on a sandy plain. Neutral Hills have no trees except in small gullies, and are almost wholly composed of grassy, sloping lands used only for grazing purposes.

Geology

In this, as in many parts of the Plains the bedrock is largely concealed, but such outcrops as do occur belong to either the Pale Beds or the Bearpaw formation. It is obvious, although outcrops are few, that Neutral Hills are erosion remnants of the Bearpaw formation, with only a thin mantle of glacial drift, and that outcrops of Pale Beds are confined to the plains and valley slopes.

The Bearpaw consists of dark shales and green sands, and contains in its lower part an abundance of smoothly polished chert pebbles, mostly black as in the outcrop on SW. sec. 2, tp. 36, rge. 4. So far as known, however, these pebbles are never consolidated into a conglomerate, but in certain areas they are exceedingly numerous. They are commonly flat and up to 2 inches in diameter, but the average size is much smaller. The Bearpaw shales in certain places, as on SW. sec. 21 and NE. sec. 20, tp. 35, rge. 4, contain many grey nodules 1 inch to 1½ inches in diameter, each of which when broken invariably contains a lobster claw. The underlying Pale Beds are lithologically distinct from the Bearpaw and consist of white bentonitic sands with greenish or brown shales and commonly carbonaceous bands including thin coal seams. In spite of this, however, the division between the Pale Beds and Bearpaw is arbitrarily drawn as the two formations interfinger and typical Bearpaw outcrops composed of greenish sand and grey shale with lobster claw nodules and smooth chert pebbles, as on NE. sec. 22, tp. 35, rge. 4, at an elevation of 2,210 feet, are below typical Pale Beds on secs. 26, 27, and 35, tp. 35, rge. 4, at an elevation of 2,310 to 2,345 feet, and these in turn occur below Bearpaw beds with marine fossils at an elevation of 2,365 feet. The fact that Pale Beds occur higher than a finger of Bearpaw is also shown by the outcrops of Pale Beds on secs. 6 and 7, tp. 35, rge. 3, at an elevation of 2,320 feet, in comparison with the Bearpaw on sec. 22, tp. 35, rge. 4. The interfingering of the Pale Beds and the Bearpaw is in harmony with the gradual change from non-marine conditions, as represented by the Pale Beds, to marine conditions in Bearpaw time, and is only an indication of oscillations in the position of the shoreline as the change was effected.

Water Supply

In this area water occurs in both the drift and underlying bedrock. The indefinite boundary between the Pale Beds and Bearpaw makes it difficult to determine the source of the water where it is found close to the contact. Some of the water from the Bearpaw is hard and alkaline, but where it is derived from green sand it is generally soft, as is also the water from the Pale Beds, which contain bentonite. Contamination by higher waters, either from the drift or from the higher Bearpaw strata, may in time affect the character of the water from deeper beds, and wells that originally produced soft water may gradually change to hard water. Also, the Bearpaw shales where present are relatively impervious, and although the Pale Beds are generally a source of abundant water supply, they may be dry where overlain by Bearpaw shales, as in a well 375 feet deep on NW. sec. 28, tp. 35, rge. 2. It is presumed that approximately 175 feet of Pale Beds were present in the lower part of this well. Elsewhere these same beds, without a Bearpaw cover, are water-bearing, and many sands are present in at least the upper 500 feet.

<u>Township 35, Range 1.</u> On SW. section 16 is a shallow well from which green sand with nodules was dug. The nodules contained several species of marine Bearpaw fossils. It is not known from what depth in the well the fossils were obtained, but the elevation is about 2,400 feet. It is quite probable that the thickness of glacial materials varies widely in this township, as in section 17 it is presumably 60 feet thick and on section 6 it is at least 45 feet. Many of the wells undoubtedly obtain their water from glacial gravels and sand scattered through the drift, and a few, as for example that on SE. section 7, may be in the Pale Beds.

<u>Township 35, Range 2.</u> Mostly this township is a hilly morainal area, but the large hill in the north has a bedrock core of Bearpaw strata. Records of only a few wells are available, and these indicate that the water is derived mainly from glacial sands and gravels. An exception is the well on NW. section 28, which at a depth of 375 feet had not encountered water. At this depth the well was undoubtedly in Pale Beds, but these are probably overlain by Bearpaw shales, and from information obtained in other areas it is known that these shales commonly form an impervious barrier to the downward percolation of rain water, which is apparently the source of the water in the sands of the Pale Beds. Thus the prospects of obtaining water beneath the Bearpaw are not nearly as good as where the drift rests directly on Pale Beds.

<u>Township 35, Range 3.</u> In sec. 1, tp. 36, rge. 3, close to tp. 35, on the north side of a large east-west trending hill, there is a small outcrop of white sand, grey shale, and brown, carbonaceous shale, resembling Pale Beds in lithology and carrying plant remains. Above these beds is a small thickness of dark shales containing small, lobster-claw nodules up to 2 inches in

diameter, such as commonly occur in the Bearpaw formation. It would appear, therefore, that here, at an elevation of about 2,400 feet, is the contact of the Pale Beds and Bearpaw formation and that the wells in tp. 35, rge. 3, that reach bedrock below 2,400 feet are probably in Pale Beds. As the glacial materials may be thick there are undoubtedly places where little or no Bearpaw lies between the glacial materials and the Pale Beds, thus permitting the downward percolation of surface water to Pale Beds sands unimpeded by impervious Bearpaw shales. From present information, therefore, the Pale Beds of this area are a likely source of water for most of the township owing to the relatively thin cover of Bearpaw shales. Gravel and sand beds that carry water are found in the drift and are productive in several wells.

Township 35, Range 4. Sounding Creek Valley crosses this township and is relatively poor land, so that the farming area is mostly confined to the slopes on either side. Few well records are available, but these show that the Pale Beds beneath the thin mantle of drift contain several water horizons, the deepest of which was found at an elevation of 1,946 feet in the Monitor Creamery well at a depth of about 300 feet. The water from the Pale Beds is mostly soft where infiltration of other water has not occurred. Many outcrops of Pale Beds are exposed on the flanks of the hills adjoining Sounding Creek, but above an elevation of 2,400 feet shales contain an abundance of lobster-claw nodules characteristic of the Bearpaw formation.

Township 36, Range 1. Most of the shallow wells in this township obtain water from glacial sands. These show little or no uniformity of level. The drift is known to be thick, and below it several wells 200 or more feet deep have obtained water from sands in the Pale Beds. It is probable that the deepest sand encountered, at an elevation of 1,900 feet, is a fairly conti... aquifer. It was reached in wells on section 9 at 390 feet, on section 18 at 422 feet, and on section 20 at 374 feet. Other water-bearing sands in the Pale Beds occur up to an elevation of 2,100 feet, but these are not extensive as indicated by their presence only in shallow wells, deeper wells passing through them without obtaining an adequate supply. The water from the Pale Beds is soft.

Township 36, Range 2. In this township, as in the one to the east, a number of shallow wells obtain water from beds of glacial sand and gravel. These sands show no uniformity of level, and apparently have no great lateral continuity or thickness. Below them are Pale Beds with several water-bearing sands, although the deep sand encountered in wells in tp. 36, rge. 1, has not been reached here. The water-bearing sand in section 27, reached at a depth of 311 feet, or an elevation of 2,008 feet, is the same as that in tp. 36, rge. 1, reached at 300 feet in a well on SW. section 21. Also the sand at an elevation of 1,979 feet in the well 270 feet deep on NE. sec. 15, tp. 36, rge. 1. is the same as that encountered in the wells on NE. section 22 at 310 feet and on NE. sec. 26, rge. 2, at 320 feet. The southern part of this township is occupied by a large east-trending ridge, the eastern extension of Neutral Hills. It is possible that the spring on NW. section 5 issues at about the contact of the Bearpaw formation with the underlying Pale Beds.

Township 36, Range 3. The southwest corner of this township is crossed by a part of Neutral Hills rising to an elevation above 2,600 feet. On the south flank of this hill on section 6 a well bored to a depth of 150 feet reached a water-bearing sand at an elevation of 2,367 feet, and presumably is in the Pale Beds. This is the only well in this township for which a record is available that does not obtain water in relatively shallow glacial gravel and sand beds. It is probable that in the part of the township north of Neutral Hills water-bearing sands occur in the Pale Beds.

Township 36, Range 4. This township contains a considerable area of sand and sandy land south of Sounding Lake. Water can be obtained in this area mostly at shallow depths where it has accumulated in the sand overlying more impervious clays. Two wells, for which records are given, have been bored into glacial materials and obtain water in sand and gravel beds, and another well 275 feet deep, on NE. section 2, reached a soft-water horizon in the Pale Beds at an elevation of about 2,000 feet. In this township the Pale Beds underlie the drift in the valley of Sounding Creek and in the lower lying land immediately south of Sounding Lake. It is certain, however, that in the southwest and southeast corners of the township Bearpaw strata overlie the Pale Beds beneath the surface mantle of drift. Outcrops of shale and green sand are exposed on SW. section 1. These carry marine fossils and hence are considered to be of Bearpaw age. Also, dark shales on SW. section 2 contain an abundance of polished small chert pebbles that are characteristic of the lower part of the Bearpaw in this area. In both places the elevation of these outcrops is above 2,400 feet, which here is considered the approximate contact level of the Pale Beds and Bearpaw formation. The green sands are possible sources of water but the dark shales are mostly impervious.

Township 37, Range 1. The wells in this township vary in depth from a few feet to more than 200 feet. In some places the drift is not thick, as an outcrop of Pale Beds occurs on section 9 on the southeast side of Eyehill Creek. In other places, however, as on SE. section 23, gravel has been reported from a depth of 70 feet in a hill that is at least in part morainal in character and rises more than 100 feet above the level of Eyehill Valley. Where water has not been obtained in the drift deposits wells have been drilled to water-bearing sands of the Pale Beds. One of these sands occurs at an average elevation of 2,090 feet in wells on NE. section 19 at 197 feet, on SW. section 20 at 205 feet, on SW. section 28 at 160 feet, and on SE. section 31 at 190 feet. Another sand, at an elevation of 2,020 to 2,025 feet, occurs on NE. section 7 in a well 330 feet deep; on SW. section 17 in a well 225 feet deep; on NW. section 30 in a well 200 feet deep; and on NW. section 32 in a well 280 feet deep. The amount of water secured in these sands is undoubtedly controlled by their effective porosity, and in the well on NE. section 7 the yield at 225 feet was insufficient, so that the well was deepened to 330 feet reaching another water-bearing horizon at an elevation of 1,920 feet.

Township 37, Range 2. A few wells in this township obtain water in glacial materials, but many of the wells are 200 or more feet deep and obtain water from the Pale Beds. Apparently several sand zones yield water, but one between elevations of 1,955 and 1,995 feet is by far the most productive. It occurs in wells on sections 5, 9, 10, 12, 14, 16, 18, 20, 30, 32, and 34. In all cases it yields soft water, but in a few wells the water is brown due to association with carbonaceous layers.

Township 37, Range 3. Several wells in this township obtain water from the drift at depths of 15 to 30 feet. These are mostly in the west part of the township where the soil is sandy and water accumulates in the surface sand above more impervious clays. In the eastern part of the township there are a number of drilled wells in Pale Beds and water-bearing sands are reported at various elevations. The deepest well, on SE. section 24, at 350 feet or an elevation of 2,080 feet, struck a sand that probably is in the same sand zone that yields water in a well 180 feet deep on SW. section 14. In the well on SE. section 24, however, this sand failed to yield sufficient water, and the well was deepened to 550 feet or an elevation of 1,880 feet, where another sand was reached. Due to mechanical difficulties, however, the well had to be abandoned. This is not as low a stratigraphic level as that reached in tp. 37, rge. 2, where a well 500 feet deep on NE. section 13 reached a water-bearing bed at an elevation of 1,828 feet, but encountered difficulties at the bottom where fine sand shut off the water supply.

Township 37, Range 4. This township lies north of Sounding Lake and is largely an area of sand or sandy soil within which the record of only one deep well is available. This well, on SW. section 4, reached a water-bearing sand in the Pale Beds at a depth of 140 feet or an elevation of 2,048 feet. This sand is undoubtedly at about the same horizon as in a well on NE. sec. 13, tp. 37, rge. 5, which at a depth of 180 feet encountered brown soft water at an elevation of 2,031 feet. It is thus reasonably certain that the Pale Beds are water-bearing everywhere within this township.

Township 38, Range 1. On SW. section 26 a well 130 feet deep is reported to have encountered water in glacial gravel. This is probably at the base of the drift, which undoubtedly varies widely in thickness from a few feet in the vicinity of Eyehill Creek to more than 100 feet in the morainal hills to the northwest. The Pale Beds have been encountered in many wells 200 to 350 feet deep, and a number of sands yield water. One of the most important sand zones is between elevations of 2,000 and 2,035 feet, and was encountered in wells on sections 2, 3, 4, 5, 9, 14, 15, 18, and 36. Another, the lowest reached in this township, lies at an elevation of 1,910 to 1,920 feet as indicated by wells on sections 13, 22, and 28, and still deeper water-bearing sands are known to occur in the Pale Beds.

Township 38, Range 2. In this township a few of the shallower wells obtain water from sands in glacial drift, but the greater number are drilled into the underlying Pale Beds where several sands have been found to be productive. The highest occurs at an elevation of 2,100 and 2,105 feet in two wells on section 28, but seems to have a limited lateral extent as many wells have penetrated below its level without, apparently, finding water. Another sand, nearly 100 feet deeper, at an elevation of 1,975 to 2,000 feet, occurs in wells on sections 2, 6, 12, 13, 14, 20, and 24. Another, still deeper sand, at an elevation of 1,920 to 1,940 feet, occurs in wells on sections 3, 4, 9, 10, 11, and 24. One well on NW. section 2 is reported to have found water in a sand at a depth of 365 feet, or an elevation of 1,895 feet. This is the deepest sand reported to have been reached and that was found to be water-bearing.

Township 38, Range 3. In this township a few wells obtain water from sand and gravel beds in the drift, but the greater number of wells have been drilled into the Pale Beds. The highest sand, as in the range to the east, is at an approximate elevation of 2,100 feet, and was reached in wells on sections 21, 24, and 26. Another, more indefinite zone of water-bearing sands occurs at elevations between 2,040 and 2,050 feet on sections 9, 16, and 32. The zone that in tp. 38, rge. 2, lies between elevations of 1,975 and 2,000 feet appears here to be at elevations of 2,000 to 2,015 feet, and wells on sections 11, 25, 32, and 35 obtain water from it. A still lower, but not very sharply defined, zone of water-bearing sands occurs between elevations of 1,940 and 1,960 feet on sections 12, 22, 23, and 28. The deepest producing horizon reported is in a well on NW. section 5 at a depth of 385 feet, or an elevation of 1,908 feet, and is possibly at about the same horizon as that of the deepest water-bearing bed in tp. 38, rge. 2.

Township 38, Range 4. In this township some relatively shallow wells get water in glacial sands, but the greater number are 120 to 300 feet deep and one is 400 feet deep. All of these are in Pale Beds and obtain water in sands at various levels. From a well 120 feet deep on SW. sec. 7 and another 140 feet deep on NW. sec. 25 the water flows, and is probably derived from the same sand at an elevation between 2,050 and 2,060 feet. In one well the water is reported to rise 4 feet above the surface or to an elevation of about 2,190 feet. In a well on SW. sec. 27 that reaches this same sand, at a depth of 275 feet, the water is reported to rise to 100 feet from the surface, or to an elevation of 2,224 feet. In a well on NE. sec. 15 the same sand was reached at a depth of 220 feet, and the water is reported to rise to an elevation of 2,245 feet. Wells above an elevation of 2,250 feet that tap this water horizon would not be expected to flow. The source of this water and the head that causes its rise in the wells are not known. Certain wells have been drilled through the sand from which the water in the flowing wells is derived without obtaining a water supply, so it is obvious that the sand does not have uniform widespread continuity. One well on SW. sec. 13 is 400 feet deep, and reaches sand at an elevation of 1,843 feet. It is the deepest in this township, and is believed to be wholly within the Pale Beds.

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