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Ground Water in the Lake Basin Field and Adjacent Area

Herman Neibauer

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GROUND-WATER IN THE LAKE BASIN FIELD
AND ADJACENT AREA

A Thesis
Submitted to the Department of Geology in
Partial Fulfillment of the Requirements
for the Degree of Bachelor of Science
in Geological Engineering

by
Herman Neibauer

Montana School of Mines
Butte, Montana
May, 1941
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Description of Ground-Water Conditions in the Adjacent Area

General Statement

Descriptions by Townships

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Figure 1. Index map of area covered by this report.

Table 1. Table of geologic formations in the Lake Basin Field and adjacent area.
GROUND-WATER IN THE LAKE BASIN FIELD
AND ADJACENT AREA

Introduction

This thesis consists of studying the stratigraphic and structural features of the Lake Basin field and an adjacent area with special emphasis upon the ground-water conditions present. This region is located in south central Montana, as shown in Figure 1.

Figure 1. Index map of area covered by this report.

and is roughly 1500 square miles in area. It consists of portions of Golden Valley, Stillwater, Sweetgrass, Yellowstone, and Carbon counties. In this area the knowledge of ground-water conditions is very helpful to the farmer and rancher.

Many of the publications listed in the bibliography were consulted frequently. Dr. Eugene S. Perry of the Montana School of Mines assisted by offering suggestions and criticisms in connec-
tion with field work and preparation of the manuscript. Dr. Lawrence L. Sloss also gave helpful criticism at various times. The writer is very grateful to the Montana State Board of Health for the determination of the mineral content of various water samples.

Field work was done during the period from October 1, 1940 to January 1, 1941, when a total of twelve days was spent in the field collecting information. Farmers and ranchers were interviewed with reference to ground-water conditions upon their properties and information was obtained concerning the drilling of test wells for oil. Photographs were taken to show various geologic features, and at this time, water samples were taken to be later analyzed by the Montana State Board of Health.

General Description of Region

This region can be divided into two main portions: one can be called the Lake Basin field proper, and the other an adjacent area to the south.

The Lake Basin field lies north and northwest of the city of Billings. It is mainly a flat rolling upland with numerous shallow depressions which were former lakes, and it is from these depressions that the region receives its name. Various small towns, as shown in Plate 7, lie along railroads, which cross this country. In the eastern part of this region, irrigation is common, but with the exception of this portion, the Lake Basin field is unirrigated, and dry land farming and stock raising are the chief industries.

The area to the south of the Lake Basin field lies along the Yellowstone River Valley, and includes small hilly areas on either side of the valley lands. In the Yellowstone Valley, irrigation
is very common, and hence, the area is a productive farming country. Important cities and towns are located on the Northern Pacific Railroad which follows the Yellowstone River.

Earlier Work

Portions of the area has been surveyed by the United States Geological Survey at different times. Hancock's paper deals chiefly with the stratigraphic and structural relations of the various rocks with reference to the possibilities of oil and gas. Knappen and Moulton mapped the geologic formations in the area along the Yellowstone River and southward. A water supply paper has been written by Hall and Howard on that portion of the area lying in Yellowstone county. Still earlier reports have been written on areas more distant. However, detailed descriptions of ground-water occurrence in the Lake Basin field proper have not been published.

General Geology

The rocks exposed at the surface in the region covered in this report consist of a series of upper Cretaceous strata essentially sandstone and shale with shale greatly predominating.

1 Hancock, E.T.; Geology and oil and gas prospects of the Lake Basin field, Montana; U.S. Geological Survey Bulletin 691-D.


An unusual geologic feature of the region is a line of faults which crosses the Lake Basin field in a northwest to southeast direction. Such faulting disturbs the ground-water conditions considerably. Several structural domes are found in the region, and these have been prospected for oil and gas. A small commercial field of oil and gas has been developed in the central part of the region.

The Big Snowy Mountains at the north, the Crazy Mountains to the west, the Bull Mountains to the east, and the Pryor Mountains to the south make the Lake Basin field appear as a region of depression. The geologic formations included in the series in this field are shown on the accompanying table. Pleistocene gravel caps some of the bench lands, and Quaternary alluvium is present along the lines of drainage. The shales in the series erode to form basins which are surrounded by a bold escarpment of more resistant sandstone. Two large depressions, Lake Basin and Comanche Flat, are the main reason why the region is known as the Lake Basin field.

The Ground-water Problem in Lake Basin

In the Lake Basin field, the farmers and ranchers must depend upon water generally from wells or springs for domestic and stock purposes. In the area to the south of the Lake Basin field, the same problem confronts the rancher and farmer with the exception of those who find it possible to get water from the Yellowstone River, its larger tributaries, or irrigation canals. Towns away from streams must depend chiefly upon ground-water. Some of these towns are Malt, Rapelje, Broadview, Aeton, and Comanche. The ground-water conditions at these towns, and for the nearby regions
are explained in detail under the township description of the township in which they lie. The geologic map and cross-sections shown on Plate 7 should further aid in the interpretation of ground-water conditions.

**Rock Formations and Ground-water Occurrence**

In Lake Basin field and the adjacent area the surface is underlain by shales and sandstone. The shales, if not dry, yield water, which is unfit for domestic purposes, and at times, also unfit for stock. The best source of water in shales is along coulees. The sandstones will generally yield water which is adequate for domestic and livestock purposes. The quantities of water in most cases are generally small, and are inadequate for irrigation purposes. Where the sandstone is covered by great thicknesses of shale, the prospects of encountering water which is unmineralized are very poor.

**Quaternary Alluvium**

In the irrigated lands along the north side of the Yellowstone River between Park City and Huntley, two types of Quaternary alluvium deposits are present. Immediately adjacent to the river lie flat bottom lands underlain by silts and clays. A few miles further north of the river, however, a low "bench" capped by gravel has been developed; these are the terrace deposits listed as Quaternary Alluvium by Hall and Howard.

* op. cit., page 32.
Table 1
Table of Geologic Formations in the
Lake Basin Field and Adjacent Area

<table>
<thead>
<tr>
<th>Geologic Age</th>
<th>Formation</th>
<th>Thickness in feet</th>
<th>Lithologic character</th>
<th>Water Supply</th>
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<tr>
<td></td>
<td>gravel</td>
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<tr>
<td>Tertiary</td>
<td>Fort Union</td>
<td>1000-2000</td>
<td>Interbedded sh. and yellow sandstone; ss. massive to fine-grained, porous, soft, concretionary. At base dark sh. (Lebo), 200-300' thick.</td>
<td>Ss. is water-bearing. Water moderately mineralized but good. Wells in Lebo sh. are usually weak and poor.</td>
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<td>(Eocene)</td>
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<td>U</td>
<td>Lance</td>
<td>+1500</td>
<td>Interbedded yellow to buff sandstone and sh. Coal in upper 1/2 (Tullock). Lower 3/4 (Hell Creek) consists of light greenish to yellow sh. with heavy beds of ss. and practically no coal.</td>
<td>Water-bearing in ss. Water in moderate amount fair to good. Sh. dry or water highly mineralized.</td>
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Bearpaw | ±1000 | Dark to black marine sh.; Sometimes dry. marine sh.; Water fit for both fossiliferous; domestic and stock concretionary. purposes.
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<tr>
<th>Geologic Age</th>
<th>Formation</th>
<th>Thickness in feet</th>
<th>Lithologic character</th>
<th>Water Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. Creek</td>
<td>Telegraph</td>
<td>±320</td>
<td>Heavy ss. at base, soft sh. Some highly mineralized water.</td>
<td></td>
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<tr>
<td>A. Colorado</td>
<td>Niobrara &amp;</td>
<td>±1550</td>
<td>Light gray and Poor water-bearer black sh. with even for livestock. Minor sandy beds.</td>
<td></td>
</tr>
<tr>
<td>E. Group</td>
<td>Carlile</td>
<td></td>
<td>Predominately Poor water-bearer ss. light colored, some sandy sh. and black sh.</td>
<td></td>
</tr>
<tr>
<td>O. Group</td>
<td>Frontier</td>
<td>±300</td>
<td>Predominately Poor water-bearer black sh. even for livestock. Some black ss. and streaks of lime.</td>
<td></td>
</tr>
<tr>
<td>U. Group</td>
<td>Mowry &amp;</td>
<td>±600</td>
<td>Sand, sandy sh. Poor water-bearer and sh. inter- even for livestock. bedded.</td>
<td></td>
</tr>
<tr>
<td>S. O.</td>
<td>Thermopolis</td>
<td></td>
<td>Predominately Poor water-bearer black sh. even for livestock. Some black ss. and streaks of lime.</td>
<td></td>
</tr>
<tr>
<td>L. Dakota</td>
<td></td>
<td>±100</td>
<td>Sand, sandy sh. Poor water-bearer and sh. inter- even for livestock. bedded.</td>
<td></td>
</tr>
<tr>
<td>Geologic Age</td>
<td>Formation</td>
<td>Thickness in feet</td>
<td>Lithologic Character</td>
<td>Water Supply</td>
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<tr>
<td>Lower Cretaceous</td>
<td>Kootenai (Lakota)</td>
<td>±500</td>
<td>Thick conglomerate, basal ss., deep holes for a middle zone of oil. Natural variegated sh., gas and hydrogen and upper zone of thin-bedded ss. and sandy sh.</td>
<td>Yields water in often present. Water is commonly soft.</td>
</tr>
</tbody>
</table>
The ground-water conditions are about the same in both types of deposits.

Fine sands and clays which may be classed as alluvium are found in the Commanche Flat region, and in the large depressions northwest of Molt. Both of these areas served as drainage basins for adjacent areas.

In the area of Quaternary alluvium near the Yellowstone River, an abundance of water which is usually hard occurs at shallow depth. However, most of the farmers in this region have cisterns which are filled with water from the irrigation ditches, or by hauling the water from the municipal system of a nearby town. The depth to water in the alluvium is seldom over 50 feet.

In the Commanche Flat region, the water from the Quaternary alluvium is used in many cases for domestic and stock purposes. It is generally quite hard and has a distinct taste. The depths to water is commonly from 20 to 35 feet. The alluvial deposits northwest of Molt are generally a source of poor water. In some cases, the water is even unfit for stock.

The water from the Quaternary alluvium as a whole contains approximately 2,000 parts per million of dissolved solids. The presence of a large quantity of Glauber's salt (sodium sulphate) gives the water a bitter taste, and it is generally only suitable for stock, but in some cases where better water cannot be procured it is used for domestic purposes. The surface topography has a great influence on the type of water in the alluvial material. Analyses of water are plotted on Plate 6.
Fort Union Formation

In the area studied by the writer, only the Lebo shale, the basal member of the Fort Union formation, was exposed, however, the upper portion of the formation is present over wide areas immediately west and northeast of the Lake Basin field.

In the Bull Mountains\(^1\) in the northeastern part of Yellowstone county, the Fort Union formation is 2,000 feet in thickness. Here it consists almost entirely of beds of sandstone and shale with numerous beds of coal. The Lebo member at the base is composed of 200 feet to 300 feet of black shale. If good water should be encountered, the well should be cased.

The Fort Union formation is an important source of water in eastern Montana. As inferred previously, it is difficult to tell what depth water can be expected in this formation. Hall and Howard\(^2\) state that dug wells in steep coulees or alluvial terraces should be attempted. The water in the Fort Union is generally fit for all ordinary uses. It is sometimes hard, due to the presence of considerable calcium and magnesium. Analyses of water from the Fort Union are plotted on Plate 6.

Lance Formation

The youngest formation of Cretaceous age is the Lance formation, which underlies the Fort Union formation. The Lance, exposed in several areas in the region covered in this report, is divided into an upper and lower member. The upper part, known as the Tullock

1 Hall, G.M. and Howard, C.S., op. cit., page 34.
2 Hall, G.M. and Howard, C.S., op. cit., page 35.
member, and comprising the upper fourth of the formation, consists of yellow to yellow-gray shale with abundant beds of yellow or brown sandstone, and many thin beds of coal. The lower three-fourths of the formation, known as the Hell Creek member, consists of light-greenish to yellow shale with many heavy beds of sandstone and practically no coal.

In the area covered in the field work by the writer, the Lance formation is a good producer of satisfactory water. The depth to water ranges from 45 to 200 feet. All wells should be cased due to the presence of shaly portions in the formation. Analyses of water from the Lance are plotted on Plate 6.

Lennep Sandstone

A series of sediments underlying the Lance formation are mapped as the Montana group of formations. The first member of this group is the Lennep formation. It consists of upper brown andesitic sandstone containing abundant tuffaceous material, and a lower massive light-colored sandstone. Some later writers include the Lennep in the overlying Lance formation, but Howard and Hall treat each of them as a distinct unit. The Lennep formation is more commonly known throughout eastern Montana as the Foxhills sandstone.

The Lennep, as a whole, has only been tested for water in a few localities, but where tested the water is suitable for domestic purposes. Springs commonly occur at the contact of the Lennep and the underlying Bearpaw formation. At Broadview water from the Lennep contains considerable iron and magnesium, but the water is adequate in volume and suitable in quality and sufficient in quantity to supply the domestic needs of the town.

1 Hall, G.M. and Howard, C.S., op. cit., page 36.
Plate 1

Figure A. Contrasting the topography of the Eagle sandstone and Colorado shale at Locomotive Butte in section 4, T4N, R18E.

Figure B. Typical escarpment of the Lennep sandstone overlying the Bearpaw shale in section 19, T4S, R18E.
Figure A. The Crazy Mountains west of Gibson, Montana in section 6, T3N, R16E.

Figure B. Contrasting the topography of the Claggett formation in the foreground and the Eagle sandstone in the background in section 1, T4N, R16E.
Plate 3

Figure A. Typical topography in faulted zone, section 34, T25, R26E.

Figure B. Outcrop of the Judith River formation west of Acton, Montana.
Figure A. Outcrop of the Lance formation overlying the Bearpaw shale northeast of Acton, Montana. (Lennef absent).

Figure B. The Big Snowy Mountains looking north from section 20, T6N, R18E.
Figure A. Claggett formation exposed in dissected area three miles south west of Acton, Montana.
Bearpaw Shale

Underlying the Lennop sandstone is approximately five hundred feet of marine shale, called the Bearpaw formation which is present at the surface throughout the central part of the mapped area. The formation decreases in thickness from the northwestern part of the Lake Basin field toward Billings. Various sandstones appear in certain horizons.

The Bearpaw shale is a poor source of water and many dry holes are drilled into this formation. If water fit for stock is not encountered at depths less than 100 feet, it is not advisable to drill deeper, unless it is possible to drill into the underlying Judith River sandstones at depths not greater than 200 feet.

The composition of the water in the Bearpaw is generally highly mineralized, and unfit for domestic purposes. The best hope for supplies of water is shallow dug wells in coulee. Analyses of water from the Bearpaw shale are plotted on plate 6.

Judith River Formation

The Judith River formation, underlying the Bearpaw shale, has a thickness of about 450 feet in the Lake Basin field, and consists of alternating beds of sandstone and shale, the sandstone predominating.

In the mapping of the Judith River formation, Hancock found it convenient, because of lithologic similarity, to include at the base of the Judith River formation, a sandstone which is approximately equivalent to a sandstone at the top of the Claggett southeast of Billings. The same procedure has been followed by the

1 Hancock, E.T.; Geology and oil and gas prospects of the Lake Basin field, Montana; U.S. Geological Survey Bulletin 691-D, 1916, page 120.
2 Hancock, E.T.; op. cit., page 117.
writer in preparing the map covering the area described in this report.

The Judith River formation is the best source of ground-water in the area covered in this report. There is generally an abundance of water suitable for domestic and stock purposes. (Analyses plotted on plate 6.). Farmers living in regions where the Colorado or Claggett shales are exposed commonly haul water from wells which have been drilled into the Judith River formation not far distant.

Claggett Formation

The Claggett formation in the Lake Basin field\(^1\) consists of belts of sandy shale alternating with those of thin-bedded sandstone, but the proportion of sand appears to decrease rapidly from southwest to northeast across the field. In a section measured along Canyon Creek in T1N, R23E, alternating shales and sandstones, gray in color, measure a total thickness of 567 feet. The Claggett often erodes to form a dissected region.

As a whole, the Claggett formation is not a good water-producer, and in places the water is so highly mineralized that it is unfit for stock. In areas where Claggett shale is exposed, it would be advisable to drill through the shale and into the underlying Eagle sandstone, if this sandstone is not too deeply covered by the Claggett. Water analyses are plotted on plate 6.

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1 Hancock, E.T.; op. cit., page 116.
Eagle Formation

The Eagle sandstone may be divided into three or more less distinct units.¹ In the type locality², along the Missouri, 40 miles below Fort Benton, the formation consists of an upper member of thin-bedded sandstone, a middle member of shale, and a lower member of massive ledge-making sandstone. The lower member is often called the Virgelle sandstone.

In the Lake Basin field¹ all three members are generally recognizable, however, the middle member does not, as a rule, contain much shale. It is ordinarily composed of belts of thin-bedded shale-like sandstone and a very sandy carbonaceous shale, but locally it is made up almost entirely of sandstone. The lower massive sandstone member varies considerably in thickness, but everywhere it forms a "rimrock" surrounding the basins and valleys that have been eroded out of the much softer underlying Colorado shale. A belt of carbonaceous shale in the middle member locally contains thin seams of coal. Small pebbles are also found on the top of the Eagle in various localities.

In a section along Canyon Creek, T1N, R23E, there are 51 feet of gray sandstone, locally thin-bedded, then sandstone with alternating beds of shale 101 feet thick, and then the lower member of massive gray bedded sandstone 91 feet thick, a prominent ridge former. The total thickness is 243 feet.

In another section measured in section 4, T4N, R19E, the beds are alternating sandstones and shales with a total thickness of 217½ feet.

¹ Hancock, E.T.; op. cit., page 114.
The Eagle in the Lake Basin field is generally a small producer of water. It was noticed that many of the wells were deeper than those in the other formations in this area. The water is hard, but satisfactory for drinking. Analyses of water from the Eagle sandstone are plotted on plate 6.

Colorado Group

In the Lake Basin field, the Colorado formation was mapped as one distinct unit, although Hancock\(^1\) discusses the various lithologic divisions. In the area not in the Lake Basin field proper, but covered in this report, Knappen\(^2\) shows the various divisions on the map of the area. For simplicity, the system used by Hancock will be employed in this report on the map covering both areas.

The Colorado group consists of about 2,400 feet of dark marine sandstone and shale. It is readily differentiated into the Thermopolis, Mowry, Frontier, Carlile, Miobrara, and Telegraph formations.

The Cloverly (Kootenai) formation, underlying the Colorado shales, passes upward into rusty sandy shale and interbedded black shale into the Thermopolis formation which is the lower member of the Colorado group. The Thermopolis and Mowry shales are logged in the Lake Basin field as ±600 feet of predominately black sand, and streaks of limestone.

Above the Mowry lies the Frontier member of the Colorado formation. In the Lake Basin field, it is mapped as ±300 feet thick predominately light colored sandstone with some sandy shale and black shale, the sandstone being capable of large gas production.

\(^1\) Hancock, E.T.; op cit., page 111.
\(^2\) Knappen, R.S, and Moulton, G.F.; Geology and mineral resources of parts of Carbon, Big Horn, Yellowstone, and Stillwater counties, Montana; U.S. Geological Survey, page 27.
The Niobrara and Carlile overlie the Frontier member. These upper formations are predominately light and dark shales with minor sandy beds. Their total thickness is 1550 feet.

At the base of the Montana group, overlying the Colorado shales, are beds of yellow sandy shale and sandstone which constitute the Telegraph Creek formation. It carries a mixed Montana and Colorado fauna, typically developed 10 miles southeast of Billings. Knappen\(^1\) after considering the opinions of other writers, places it in the Montana Group. Sloss\(^2\) says that the Telegraph Creek formation has now been definitely placed in the upper part of the Colorado Group.

The Colorado shales only produce a very small amount of water unfit for domestic purposes, and often also unfit for stock. The Sodium Sulfate is the main mineral present. It is unadvisable to drill a deep hole in the Colorado shale unless a sandstone member, such as the Frontier, can be encountered. Drilling is only recommended when this is possible. (Analyses plotted on plate)

**Kootenai Formation**

The Kootenai formation, underlying the Colorado groups, is not exposed in the area covered by this report, but being a good producer of water in other parts of Montana, it should be mentioned in the Lake Basin stratigraphy. This formation is known as the Cloverly formation in Wyoming, and the Dakota formation near the Black Hills. The name, Kootenai, is used by Hancock in

1 Knappen, op. cit., page 35.
2 Sloss, L.L.; oral communication.
describing the lithologic characteristics of this formation in the Lake Basin proper covered in this report. The term, Cloverly, is used Knappen and Moulton\(^1\) in describing the same formation. Perry\(^2\) says that because of the Kootenai's position well down in the stratigraphic column of Montana rocks (over 6,000 feet), it is only found in areas where it has been brought upward by major uplifts such as the Big Snowy or the Big Horn Mountains, and then exposed by erosion. In the Lake Basin field, it was struck at a depth of roughly 4000 feet. It is about 300 feet thick.

In the area covered by this report, the few wells that have been drilled into the Kootenai struck small amounts of water, which generally contained slight traces of oil and natural gas, it is too expensive to obtain water from the Kootenai formation in the Lake Basin field and adjacent areas. Analyses of water are plotted on plate 6.

Composition of Ground-Water

The ground-water in Lake Basin field and adjacent areas is derived mainly from wells less than 100 feet deep. From such wells there is a marked difference in the chemical composition of the water. In regard to this question, Perry\(^3\) says "the composition of shallow ground-water is dependent upon the character of surface or outcropping formation, that is, whether it be sandstone, shale, or soil. The range in chemical composition of

1 Knappen, R.S.; and Moulton, G.F.; op. cit.
2 Perry, E.S.; op. cit., page 47.
3 Perry, E.S.; op.cit., page 29.
shallow ground-water is from less than 500 parts per million\(^1\) to more than 6,000 parts per million, and the constituents are mainly the sulphates and carbonates of sodium, calcium, and magnesium. Calcium is always relatively high which causes this type of water to be hard. Sodium is a common and abundant constituent in certain 'alkali' waters coming from areas of shale and soil derived from shale, and water in such areas is generally high in the amount of dissolved solids present." The above statement is true for many of the water analyses plotted on Plate 6. Some iron and silica are also present in most water, but these are generally insignificant.

In sandstone areas the ground-water is considerably lower in mineral content than that found in shaly zones. This is due to the absence of soil from which dissolved mineral can be leached. Springs found at the contact of shales and overlying sandstone areas, although quite hard in character, produced water suited for domestic purposes. The lower mineral content is due to the "flushing-out" action of the spring over a considerable length of time. River waters are generally lower in mineral content than water from wells or springs.

Plate 6 shows graphically, by a diagramatic method commonly employed by the U.S. Geological Survey, the relationship between different water analyses. Each constituent is recalculated;

\(^1\) Parts per million is a common measure used by chemists in expressing the amount of dissolved solids in water. An amount of 10,000 parts per million equals one percent.
the parts per million of each constituent is multiplied by a factor, which is obtained by dividing the valence of each constituent by its molecular weight. Such a calculation converts parts per million into another figure, which designates the relative ability of the given amount of constituent to combine with any other constituent calculated in a similar manner. In other words, the height of a column of any one constituent in a particular analysis of that constituent in the analysis. Technically this figure is known as "milligram equivalent".

Effect of Dissolved Solids on Use of Water

The effect of the dissolved solids is not harmful to the human body unless the concentration is too great. The Montana State Board of Health in its Biennial Report states as follows: "All proposed standards for rating the quality of alkali water for human consumption should be regarded as tentative. However, it is possible to define standards that can be used as a general guide in interpreting analyses of alkali waters which generally occur in Montana. From observations of the properties and effects of water of known containing any of the following radicals in the amount specified would be unhealthful to most people.

- Bicarbonate (HCO₃) : 700 ppm
- Sulphate (SO₄) : 1600ppm
- Carbonate (CO₃) : 350 ppm
- Chloride (Cl) : 1600ppm
- Magnesium (Mg) : 175 ppm

"Water containing large amounts of two acid radicals make any application of standards more difficult, because it is hard to

1 Perry, E.S.; Ground-water Resources of Southeastern Montana; Bureau of Mines and Geology Memoir 14, 1935, page 31.
judge the combining effect of two substances. The standard based on total mineral content recommended below is offered as a tentative guide for classifying water for human consumption from the tabulated analyses of average Montana ground-water. The qualifying statements apply particularly to people not accustomed to alkali water for drinking.

<table>
<thead>
<tr>
<th>Good</th>
<th>0 to 500 ppm</th>
<th>No distinct taste as a rule. Can usually be recommended for drinking.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fair</td>
<td>500 to 1200 ppm</td>
<td>May have slight taste. Drinkable. Only few people offer objections. People using water under this class report no harmful effects.</td>
</tr>
<tr>
<td>Acceptable</td>
<td>1200 to 2000 ppm</td>
<td>Usually has a distinct taste. Drinkable for many people. Approaches limit of mineral content that should be tolerated. When found by experience to be objectionable, reduction of concentration of alkali by dilution through addition of water free from mineral matter, such as rain water, ice water, or distilled water, is recommended.</td>
</tr>
<tr>
<td>Poor</td>
<td>2000 to 2500 ppm</td>
<td>Distinct taste. Many waters in this class considered unfit for drinking by people using such water. Dilution recommended.</td>
</tr>
<tr>
<td>Unfit</td>
<td>3500 ppm &amp; above</td>
<td>Usually classed as unfit for any ordinary use.</td>
</tr>
</tbody>
</table>

"People who live for any considerable time in a region where alkali water abounds become accustomed to water of high mineral content and hold very different opinions on the effects and properties of alkaline waters from people who have no experience in
using these waters.

"Plants, in general, can survive under larger amounts of dissolved material. Irrigation with alkaline water should be practiced, so that there will be a minimum of evaporation. Good sub-surface irrigation is necessary."
Description of Ground-Water Conditions
in the Lake Basin Field

General Statement

The Lake Basin field consists of portions of Sweetgrass, Golden Valley, Stillwater, and Yellowstone counties (See plate 8). United States Geological Survey papers have been written on Golden Valley and Musselshell counties; and on Yellowstone and Treasure counties. These papers were consulted by the writer, and an attempt was made to compare the present ground-water conditions with those present when the Geological Survey studied the area.

Descriptions by Townships

T\&N - RI7E

The western half of the area lies outside of the Lake Basin field. The outcropping massive Lemno sandstone separates the eastern and western parts of this township.

The Lemno sandstone, approximately 315 feet thick, is considered a fair water-producer. In the northwest quarter of section 24, a spring flows with an abundant supply of good water.

The Bearpaw shale, from 20 to 300 feet thick underlying the Lance, is the rock formation present. This formation is generally a very poor water-producer.

1 Ellis, H. and Meinzer, O.E.; Ground-water in Musselshell and Golden Valley counties, Montana; Water Supply Paper 518, 1924.
2 Hall, G.H. and Howard, C.S.; Ground-water in Yellowstone and Treasure counties, Montana; Water Supply Paper 518, 1929.
The southern part of this township, (sections 25, 26, 27, 35 and 36), is in Stillwater County, while the rest of the township is in Sweetgrass County.

The oldest outcropping bed in the township is the Lennep sandstone. This formation is the source of water for a small town known as Gibson, located in the southwest quarter of section 8. The town, consisting mainly of a general store and a post-office, gets its supply of water from a well 117 feet deep. The resident, Charles Hoffman, states that there is an ample supply of good water which is used for both domestic and stock purposes.

The Bearpaw shale underlies the Lennep sandstone. In the northwest quarter of section 4, on the property of Gailbert Opeland, a shallow well 36 feet deep produces water that is hard, containing some alkali salts. About one-half mile south in the same section, is a spring that produces a good supply of soft water. It appears to be located at the fault contact between the Bearpaw shale and the Lennep sandstone. Another well in the southeast quarter of section 23, the property of Conrad Fitchner, is said to produce soft water at a rate of one and one-half gallons per minute. A small fault crosses the area so that the water is probably coming from the underlying Judith River formation. In the northwest quarter of section 21, a well 60 feet deep in the Bearpaw produces an unlimited supply of good drinkable water. This well is on the property of Lloyd Bradbrook. The Judith River formation underlies the Bearpaw formation. On the southeast quarter of section 14, on the property of Conrad Fitchner, a well 60 feet deep produces an unlimited amount of good drinkable hard water.
The Lake Basin fault zone goes through the northern part of this township. The topography is too rough for farming and so stock raising is carried on. There should be some small springs along the fault contacts separating the Lennep, Lance, Judith River, and Bearpaw formations. In such a faulted area, the groundwater behavior may be very unusual.

T4N - R18E

The southern tier of sections in this township lies in Sweetgrass County, while the rest of the township lies in Golden Valley County.

The oldest exposed formation in this area is the Lance sandstone. This formation, approximately 270 feet thick, is exposed in the southwestern part of the township. The badly faulted area cutting across the Lake Basin field in a northwest and southeast direction is present here. The topography is rough due to the faulting and steeply inclined beds. The Lance is a good water-bearer at moderate depths, although no drilling has been done in it here.

The Lennep sandstone underlies the Lance formation. It occurs as a ridge forming showing prominent escarpments. The Lennep sandstone measured in section 29 is 314 feet thick. The formation is considered a good water-bearer. In the northwest quarter of section 30, on the property of R.H. Titeca, a spring is used for domestic purposes. This water is reported to be good.

Beneath the Lennep sandstone in this township, is the Bearpaw shale. This formation, about 500 feet thick, is only a fair producer of water, if the single well drilled in it may be used.

1 Hancock, E.T.; op. cit., page 125.
used as an example. On the property of Len Hanson in the southwest quarter of section 19, there is a well 54 feet deep. The water contains hydrogen sulphide, but the taste becomes less pronounced as the water is allowed to stand in a storage tank. The water is used for both livestock and domestic uses.

The Judith River formation, about 400 feet thick, overlies the Bearpaw shale. In the southeast quarter of section 4, on the property of F. V. Olhauer, a well 12 feet deep is producing good water. The well is in a small draw and is said to be able to produce considerable water. In the southwest quarter of section 4, a well 80 feet deep, on the property of Charles Olhauer, contains much water. It is said that the well cannot be pumped dry with the ordinary wind-driven pumps used in the country-side. The water is very good.

**T2N - R10E**

The southwest part of this township lies outside of the Lake Basin field proper. This boundary is made at the sharp uprisng of the Lommel formation lying above the Bearpaw shale.

The youngest rock exposed in this township in the Lake Basin proper is the Lommel sandstone. This sandstone is not used as a source of water in the part of this township in Lake Basin.

Below the Lommel sandstone is the Bearpaw shale. Being very soft, the resistant Lommel stands in cliffs. A well 301 feet deep drilled in the Bearpaw shale in the southeast quarter of section 4, is a good producer of water. This water is used for both livestock and household purposes. In section 17, however, on the property of Steve Caples, a dry hole was drilled to a depth of 224
feet. On the property of Reuben Bruce, in the southwest quarter of section 16, a well 25 feet deep produces good water. It is almost on the contact between the Lennop sandstone and the Bearpaw shale. The water is used for household and stock. In the northwest quarter of section 12, a well 70 feet deep on the property of Bill Clark also produces good water which is used for household and stock. The Bearpaw shale appears to yield an ample supply of water in some cases, and the contrary in others as shown by wells in this township.

In sections 1 and 2, there is an outcropping of Judith River formation. There has been no drilling, however, in the location cited. Quaternary alluvium has been deposited in parts of sections 3, 9, 10, and 16. This was evidently an old lake basin. In erosion basins of various other parts of this township, some small exposures of the Judith River formation can be seen.

T3N - R19E

The northern part of this township is very rugged due to extreme faulting. A small amount of Eagle sandstone in sections 1 and 3 is the oldest exposed rock. The faulting has disturbed the ground-water behavior considerably. The Bearpaw shale, in the northeast quarter of section 3, on the property of the Hines Motor Company, Billings, Montana, is a good source of water at a depth of 60 feet. In the southeast quarter of section 10, a spring occurs between the contact of Lance and Lennop formations. This water is said to be good. As a whole, the upper part of this township is only used for grazing, and therefore, only a few wells have been drilled.
In the southern part of the township, the oldest exposed rock is the Judith River formation. This formation is not used as a source of ground-water in this township. Where the Judith River formation is exposed, the area is being used mainly for grazing.

Six Shooter Creek, rising in the Judith River formation in T3N, R16E, flows to the southeast and enters T5N, R16E in section 19. Still in the Judith River formation, it flows east and encounters the gummy Bearpaw shale. Six Shooter Creek, as most creeks, only flows in periods of heavy precipitation.

The oldest exposed rock in the southern part of the township is the Bearpaw shale. This formation appears to be a fair source of water at moderate depths. In the southeast quarter of section 27, a well 54 feet deep supplies an ample amount of water. The water is used for both stock and household. In the northwest quarter of section 23, a well 55 feet deep in the Bearpaw shale is a good source of water. The same can be said for a well 55 feet deep in the northwest quarter of section 24. A well in the northwest quarter of section 34, 53 feet deep, was a fair supply of water, but this well now needs cleaning. In the northeast quarter of section 27, a well on the property of Lew Nygard, is a fair producer of water. This well is 46 feet deep. A resident at this time made a statement that in the Bearpaw shale in this township, a well from 50 to 75 feet deep should produce "plenty" of fair water.

T4N - R19E

North Fork Creek enters this township in the northwest corner
and flows to the northeast until it empties into Big Coulee Creek in section 8. The oldest exposed formation in this township is the Colorado shale. In a well drilled in section 35 of T5N, R19E, the Colorado measured a total thickness of 1,705 feet\(^1\) with evidence of erosion occurring. Only a few sources of water were being used from the Colorado shale in this township. On the property of George and Herman Webbler, in the northwest quarter of section 4, a spring contained fairly good water, while that in a shallow well nearby was not as good. These sources of water are in the dry creek bottom of Big Coulee Creek. In the northeast quarter of the same section, on the property of Mrs. Ketchum, a shallow well supplies a small amount of fair water.

Overlying the Colorado shale is the Eagle sandstone. In the northwest quarter of section 28, a 65 foot well on the property of L. H. Lumarine has a good supply of fair water. This well is almost on the contact between the Eagle sandstone and the Claggett formation. In the southeast quarter of section 28, on the property of Tom Heder, a 70 foot well supplies good water. On section 20, there is a spring which is said to be fairly good.

The Claggett, Judith River, and Bearpaw formations are exposed in the southeast quarter of this township, but are not a source of ground-water. In the extreme southeast and southwest corners the Lake Basin faulting can be seen.

T5N - R19E

The Colorado shale is the oldest exposed formation in this township. It is overlain by the Eagle sandstone with the exception

\(^1\) Hancock, E.T.; op. cit., plate 17.
of a small area of alluvium along Big Coulee Creek. The Geological Survey\(^1\) water supply paper states that a well drilled by the Seventy-nine Oil Company shows that the Colorado shale here is nearly 2,000 feet thick, and is very unpromising as a source of water. Small supplies of water can probably be developed by digging shallow wells in the alluvium along Big Coulee Creek.

The Eagle sandstone, overlying the Colorado shale, is reported by the Geological Survey to yield water at moderate depths. The Claggett shale overlies the Eagle sandstone in the western part of the township. It should be possible to drill through this formation into the underlying Eagle sandstone, which should supply potable supplies of water.

T9N - R19E

The northern two tiers of this township lie outside of the Lake Basin field. Only two formations, the Eagle sandstone and Claggett formation, are at the surface. The Eagle sandstone should yield fair amounts of potable water. It is unadvisable to drill into the Claggett formation unless it is possible to encounter the underlying Eagle sandstone at moderate depth.

T1N - R20E

Only the western part of this township is in Lake Basin proper. The Lennei sandstone again is the boundary former. A well in the Lennei sandstone in the southwest quarter of section 6, 33 feet deep, contains very good water, but not a large quantity. Another well about one hundred yards away along a creek

\(^1\) Ellis, H. and Heinzler, O.E., op. cit. page 49
bottom supplies plenty water for stock.

The Bearpaw shale, underlying the Lennep sandstone, is being used as a source of water by two wells, 12 and 18-feet deep, on the property of Mrs. Johnson in the northeast quarter of section 12. The water in the 12-foot well is good, but the 18-foot well contains water which is quite alkaline.

T2N - R20E

The topography of this township is typical of a lake basin country. Many small depressions occur which were formerly fresh water basins, but have now dried up. The vegetation consists mainly of sagebrush.

The youngest exposed rock in the township is a large hill of Lennep sandstone in section 35, lying in the Bearpaw shale below it. No drilling has been done in the Lennep.

The Bearpaw shale has been drilled in many places as a source of water in this township. In the southwest quarter of section 35, a well drilled to a depth of sixty-five feet on the property of John H. Zylstra serves as a supply of a considerable quantity of water. In the northwest quarter of section 20, two wells have been drilled. A 95-foot well was drilled, and good water encountered. Another well was put down to 130-feet because no water was hit previous to this. The water was good, but only enough for 15 head of stock. In the northwest quarter of section 21, a 50-foot well has been drilled which supplies water somewhat alkaline in composition. In the southeast quarter of section 28, on the property of George Sylde, a well 32-feet deep supplied "alkaline" water. This well is not being
used at the present time. In the southwest quarter of section 24, on the property of Robert Roebuck, two wells 60 and 70-feet deep are used for stock and for the washing of clothes. Water is being hauled for drinking purposes. In the northeast quarter of section 5, a well 70-feet deep on the property of Clarence Kirchner, supplies good water, but goes dry at times. A government well in the northwest quarter of section 4 supplies a large amount of water which can be used for domestic and stock purposes. The 175-foot well is probably getting its water supply from the underlying Judith River formation.

In the southwest quarter of section 2, on the property of Theo Geor, a well 31-feet deep in the Quaternary alluvium supplies water only in a sufficient amount for household use. The water contains 2535.0 parts per million of dissolved salts which make it moderately hard.

T3N - R20E

T3N, R20E is characterized by the presence of the Colorado shale in the north-eastern part of the township, by extreme faulting in the north central part, and by the presence of Bearpaw shale to the south.

The Colorado shale is the oldest exposed rock in this township, as can be seen in a depression known as Hailstone Basin. In the northeast quarter of section 14, a dug well 15-feet deep has water, but the water supply is going down. This well is on the property of John Brinkel. A well in the south east quarter of section 2 has a supply of water which is fairly good. This water is being used for both stock and household.
The sharply tilting fault zone of the Lake Basin field forms the southwestern boundary of the Hailstone Basin. The formations from the Nemont down to the Colorado have been disturbed by the faulting. No wells have been drilled in the Eagle sandstone or Claggett formation which are only exposed in the faulted zone. A well, 100-feet deep, in this faulted zone in the southwest quarter of section 8, on the property of Albert Christenson, provides a supply of good water from the Judith River formation.

The Judith River formation is exposed mainly in sections 21 and 22, and in parts of sections 16, 17, 20, and 23. In the northeast quarter of section 20, a well 26-feet deep in the Judith River formation, gives a moderate supply of fair water. This well is on the property of C. C. Clements of Rapelje, Montana. Another well, 60-feet deep, in the southeast quarter of section 20, provides a poor supply of water. This water is probably coming out of the Bearpaw, however. In the northeast quarter of section 22, a well in the Judith River formation provides water sufficient for 30 head of stock. The Bearpaw shale, the formation covering the greatest areal extent in T3N, R20E, has a well 40-feet deep, which supplies enough water for household purposes. Residents say that the water is good. In the southwest half of section 32, a well 80-feet deep provides water which has a smell of hydrogen sulphide. Five years previous to this, a spring ran at about the same location as the present well. The water table appears to have dropped. In the northeast quarter of section 32, a well 27 feet deep, on the property of Albert Christenson, provides a limited amount of good water. In the northwest quarter of section 33, the Northern Pacific Railroad has a spring which provides water.
for locomotives. This water is said to be fairly good. In the southeast quarter of section 32, a well 60 feet deep, on the property of Fred Sheets, provides water which is somewhat hard. Good water is obtained in the northwest quarter of section 31 at a depth of 50 feet, on the property of Lloyd Bradbrook. On the southeast quarter of the same section, a well 31 feet deep provides a supply of water of good quality. In the southeast quarter of section 19, a well in the Bearpaw shale provides water from a horizon at 20 feet and another at 35 feet. The total depth of the well is 56 feet. The water is said to be good. On the property of Mrs. Hemphill in section 29, a well has the following log: sandstone, 25 feet; shale water at 33 feet; shale water at 55 feet; total depth, 60 feet. The water is good.

Quaternary alluvium is exposed in sections 25 and 36. No drilling has been done here. These sections are in low-lying depressions in which sagebrush is the common plant growth. Water should be expected at moderate depth. This water should be good for livestock.

T4N - R20E

In this township, the Eagle sandstone stands in cliffs above the underlying non-resistant Colorado shale. The two formations are the only formations present in this township.

The northwestern part of Hailstone Basin is included in this township. The Colorado shale exposed here is considered a poor producer of water. However, wells put down in creek bottoms a short distance from the Eagle sandstone will often strike water of fairly good quality. A well in the southwest quarter of sec-
tion 34, produces good stock water. In the northeastern part of
the township, Painted Robe Creek has its head waters. This creek
cuts down deeply through the Eagle sandstone overlying the Colo-
rado shale. On the property of Jack Mellenbrook in the southwest
quarter of section 14, a spring flows from the Eagle sandstone on-
to the Colorado shale. This water is transported in a pipe line
for a short distance to the ranch houses, where it is used for
livestock and household. The water is very good, although slight-
ly hard, according to the user. In the southwest quarter of sec-
tion 12, on the property of Oliver Richard, a well 20 feet deep
has been drilled in the creek bottom. There is a considerable am-
count of water which is used for household and stock.

The Eagle sandstone overlies the Colorado shale. There seems
to be an abundance of water in the Eagle sandstone. In the north-
west quarter of section 26, a 60-foot well, on the property of Wm.
Zeuchner, produces an abundance of good water. Analysis shows
only 445 parts per million of dissolved salts; analyses plotted on
plate 6. This is remarkable for water found in the Eagle sandstone.
A well, 60 feet deep, on the property of Charles Zeuchner in the
southeast quarter of section 22, has considerable water, but it
contains iron in large amounts. The Eagle appears to be a good
source of ground-water in this township. The wells may have to be
deeper than in other formations, but a good supply of water should
be attained. A well 60 feet deep in the northeast quarter of sec-
tion 28 produces an abundance of water. In the northwest part of
the township, the Colorado shale is again exposed. Various ranches
are located along the creek bottoms. Wells drilled here should
provide a fair amount of water that may be quite hard.
The Colorado shale about 2,000 feet thick is at the surface over most of this township. At the best, only small amounts of poor water can be expected. Big Coulee Creek runs through the northeastern part of this township. It should be possible to obtain small amounts of water in the alluvium of the creek bottom. The Eagle sandstone overlies the Colorado shale, and where the sandstone is not too thin or near the steep outcrop of this formation over the Colorado shale, it should be possible to obtain small amounts of hard water.

The northeastern part of this township is not included in the Lake Basin field. In the northwestern part of the township, the Claggett formation is at the surface. Drilling is not recommended, into this formation, except where it is possible to encounter the Eagle sandstone at moderated depths.

The Claggett formation is underlain by the Eagle sandstone. The Eagle sandstone should yield small amounts of water at moderate depths. The Geological Survey\(^1\) reported two wells in the Eagle sandstone in this township, which yielded water fit for domestic uses.

The topography of this township consists mainly of flats and rolling hills due to the erosion of Bearpaw shale. The Bearpaw shale is the only rock exposed in this township with the excep-

\(^1\) Ellis, H., and Meinzer, O.E., op. cit., page 52.
tion of a small outcrop of Lensep sandstone in section 31, which is on the southwest boundary of Lake Basin proper.

The water in the Bearpaw shale in this township is almost always unsatisfactory for human consumption. A well, 65-feet deep, in the southeast quarter of section 4, on the property of Jim Wilson, contains 4275 parts per million of dissolved solids (analyses plotted on plate 6). The owner of the ranch says that cattle object somewhat to this water, but it is being used for stock purposes. A spring in the northeast quarter of section 9 is used for human consumption. This spring is located near the bottom of a creek. In the northeast quarter of section 4, a well, 65-feet deep on the property of A. Richer, provides fair water for human consumption. A well, 70-feet deep in the northwest quarter of section 4 on the same property, also provides fair water. A dug well, 64-feet deep on the property of A. H. Edwards in the northwest quarter of section 6, supplies water slightly salty which is used for domestic and stock. In the northwest quarter of section 8, a well, 60 feet deep on the property of Mr. Luther, provides very poor water. In the northwest quarter of section 5 on the property of Mr. Luther, a well 100-feet deep furnishes only good stock water. In the northeast quarter of section 21 on the property of Henry Keating, two wells each 20-feet deep drilled in a depression supply fair water. As can be seen by the well reports the water from the Bearpaw shale in this township is generally unsatisfactory.

T28N - R21E

This township is mainly a large lake basin covered with
Quaternary alluvium. The Bearpaw shale forms a slight rim for the basin.

The oldest exposed rock in this township is the Claggett formation in the extreme northeast quarter of section 1. The Lake Basin fault zone appears here. The Judith River formation is also exposed. No drilling, however, has been done in either formation. The Judith River should be a good source of water at moderate depths.

The Bearpaw shale is being used as a source of water by many farmers. Nick Schuman, in the southwest quarter of section 26, has a well 80-feet deep which supplies good stock water. A well, 35-feet deep on the property of John Isaacson in the southeast quarter of section 34, provides only good stock water. Claude Marsh, in the southwest quarter of section 30, has a 27-foot deep well which also is only stock water. A well, 70-feet deep, at Wheat Basin, in the northeast quarter of section 23, supplies very poor water. The analysis shows 12.0 parts per million of iron. The total dissolved solids are 2520.0 parts per million, (analysis plotted on plate 6). The resident says that the well is not cased all of the way down and therefore, the water is probably coming in from near the surface. On the property of E. I. Laken in the northwest quarter of section 28, a well 23-feet deep supplies fair stock water. The Bearpaw shale in this township is a source of only fair stock water.

The quaternary alluvium is in the central part of the large basin in this township. This basin was a lake not many years ago. Even at the present time, during a wet season, water tends to collect here. Two wells, each 14-feet deep, in the Quaternary
alluvium in section 20 on the property of E. I. Laken, is a source of good stock water. A well, 50 feet deep, in the northwest quarter of section 18, on the property of Mr. Jackson, is a source of water used for domestic and stock purposes. This well is on the contact between the Bearpaw shale and the Quaternary alluvium.

A shallow well, drilled just south of Half Breed Lake in the southwest quarter of section 4, is used for domestic and stock purposes.

T3N - R21E

The Colorado shale is at the surface in the north eastern part of this township. It is exposed in two districts, in the eastern part of Hailstone Basin and in a small depression called Little Basin. The rise of Eagle sandstone cliffs mark the boundaries for both regions.

The Colorado shale in Hailstone Basin is considered a source of very poor water. A resident in the area stated that the water table appeared to be dropping. The water is generally at best only usable for stock. In the northwest quarter of section 4, on the property of Harry Ray, a well 30 feet deep supplies water only usable for stock. Springs occurring at the base of the Eagle are used as a household water supply.

The Eagle sandstone has been drilled in this township. In the southeast quarter of section 1, a well 40 feet deep used to be a good producer. This well is on the property of Ralph Sawyer. In section 11, a well 150 feet deep on the property of Guy Alke supplies water which is bitter. This well may have gone through the Eagle sandstone into the underlying Colorado shale. The Eagle sandstone is a fair producer of water in most cases. A well, on
the property of Harry Ray in section 26, struck water at 55 feet after penetrating the sandstone capping. Upon deeper drilling, water was again struck at 155 feet. This water is said to be of excellent quality. The total depth of the well is 150 feet. Numerous springs generally supply water which can be used for domestic purposes.

In the southern and southwestern part of this township, the Lake Basin faulting occurs. The formations from the Colorado shale up the geologic column through the Bearpaw shale have been disturbed. This region is very rugged due to the faulting, and therefore, is used mainly for grazing. Consequently, many of the formations have not been investigated for ground-water possibilities. The Claggett formation is generally a poor source of water. The Judith River, however, is considered a good source. In the southeast quarter of section 28, a well, 102 feet deep on the property of Chris Kettleson, provides an ample supply of clear soda water used for domestic and stock purposes. The water in this well rose to a height of 70 feet from the surface. Another well, 70 feet deep, in the southeast quarter of section 28, is also a source of good water, although not of a large quantity. Sufficient water is present for 60 head of stock and domestic uses. This well is on the property of Louis Marsh.

The Bearpaw shale has not been drilled in this area. Drilling in this formation is not recommended if a source of water for domestic purposes is desired.
northwestern part of this township has cut through the Eagle sandstone to expose the underlying Colorado shale. The creek, generally dry, has eroded to form a sharp deep canyon.

The Colorado shale is the oldest formation at the surface in this township. In the Painted Robe district no wells have been drilled, but water in the coulees should be within 15 feet of the surface. Springs at the outcrop of the Eagle sandstone should provide water at the mentioned depth in the coulees. The northern part of Hailstone Basin is in the southern part of this township. The Colorado shale, exposed at the surface, has been drilled as source of water in the Lake Basin field. In the southwestern quarter of section 34, two wells, 35 and 86-feet deep, contain water which is hard. The wells, on the property of Wm. E. Hoagland, only provide enough water for 5 head of hogs and 17 head of cattle. Water for domestic purposes is obtained from a spring at the Eagle sandstone and Colorado shale contact in the northwest corner of section 30, on the property of Orlando Hoagland, a well 60-feet deep is a source of stock water in considerable quantities. The analysis of the water shows a total of dissolved solids of 4275 parts per million of which 2616 parts per million are the sulphate radical. This water is unsatisfactory for human consumption. (Analysis plotted on plate 6).

The Eagle sandstone overlies the Colorado shale. This sandstone has been drilled in several localities. The composition of the water in this formation seems to vary considerably. A well, 80 feet deep in the northeast quarter of section 36, is a source of soft water for domestic and stock purposes. This is rather unusual as water in the Eagle is generally hard. On the property of Harry Ray in the southwest of section 36, a 120-foot well is a
source of stock water. This well is on the property of John Hennesy.

The Claggett formation, overlying the Eagle sandstone, is exposed on the surface in section 12. In this section, a well 40 feet deep is a source of water satisfactory for stock and domestic purposes. The water horizon was struck at 20 feet. This well is the only one in the Claggett formation in this township.

T5N - R21E

The oldest formation at the surface is the Colorado shale exposed along a creek bottom in the southern part of the township. Small springs may be found at the contact of this formation and the overlying Eagle sandstone. It is advisable to drill a deep hole into the Colorado shale.

The Eagle sandstone is exposed over most of this township. It should be possible to obtain small amounts of water fit for domestic purposes from this formation.

The northeastern part of this township is not in Lake Basin field. In the central part of the township, the Claggett formation overlies the Eagle formation. Unless it is possible to drill into the underlying Eagle sandstone, it is advisable to attempt to drill a deep well into the Claggett shales in search of good water.

T1N - R22E

The oldest outcropping formation is the Claggett. It overlies the Eagle sandstone, and is at the surface in small strips in the southern eastern part of the township. An intermittent stream
Canyon Creek, has its headwaters here. The Claggett due to its numerous sandstones weathers to a rather rough topography.

The Judith River formation, overlying the Claggett formation, weathers to forma rolling farming country with a chocolate-brown soil. The town of Molt is located in the southeast quarter of section 1. The town has no public water-works, and consequently, private wells are the common occurrence. On the property of R.C. Slavens in the southeast quarter of section 1, a well 60 feet deep provides a considerable supply of water. This water contains 1250 parts per million of totally dissolved salts. (Analysis plotted on plate 6). About 100 yards to the northwest of this well, a well 70 feet deep owned by H. B. Slavens, supplies water which is considerably more alkaline. The total parts per million of dissolved solids is 2420. (Analysis plotted on plate 6). In the northeast quarter of section 14, a well 90 feet deep supplies hard water. This well is not being used at the present time. A well 58 feet deep in the southeast quarter of section 20 on the property of J. H. Coles provides a small quantity of good water. Springs may also be found at the contact of the Judith River formation and the underlying Claggett formation. In the southeast quarter of section 34, such a spring occurs on the property of Earl Linger. This well is used for domestic and stock purposes. A well, in the northeast quarter of section 15, on the property of J. H. Brooks, is a source of good water. George Eastbeck, in the southwest quarter of section 2, has a well 80 feet deep which is a source of good water sufficient for domestic and stock purposes.

The Bearpaw shale overlies the Judith River formation in the
western part of this township. The water from this formation in T1N, R22E appears to be fairly good. On the property of Albert Leuthold, in the southwest quarter of section 30, a well 15 feet deep provides water for domestic purposes. Another well, 15 feet deep, provides water for stock. A spring also occurs which provides good water. The owner of the farm said that the water was good.

Quaternary alluvium is on the surface in sections 5, 4, 5, and in parts of various other sections. In section 6, an arm of a lake occurred during only recent times. This is part of the large body of water known as Big Lake. In the vicinity of Big Lake, the topography is exceedingly flat. The vegetation consists mostly of sagebrush. Quaternary alluvium is a poor source of water. In section 4, a well 85 feet deep is a source of water unfit for domestic or stock purposes. The well has the following log: 40 feet of clay, 45 feet of sand. In section 3, a well 84 feet deep supplies water of fairly good quality. The water is slightly blue in color due to the presence of a shale at 83 feet.

T2N - R22E

The strong Lake Basin faulting occurs in the northern part of this township. This district is used for grazing due to the rough topography.

The oldest formation at the surface in T2N, R22E is the Claggett shale and subordinate sandstones. No drilling has been done in it in this township.

The Judith River formation overlies the Claggett formation. The Judith River sandstones and shales are at the surface in the
faulted area in the northern part of the township, and in a fairly prosperous farming community in the southeastern part. Its areal extent is greater than any other formation. The Judith River formation is generally considered a good producer of fair water. This is generally substantiated by drilling. On the property of C. J. Earls in the southwest quarter of section 6, a well 90 feet deep produces water for domestic and stock purposes. In the southeast quarter of section 22, a well 60 feet deep on the property of A. C. Wanless is a source of good water in large quantities. Mrs. Thielbar in the southwest quarter of section 23 also has a well 60 feet deep which yields a good supply of water used for domestic and stock purposes. Shallow wells, 12 feet deep, have been dug in a creek bottom in the southwest quarter of section 23. These produce a water of good quality. In the southeast quarter of section 26, two wells, 43 feet deep, yield a supply of water used for domestic and stock purposes. The Judith River in this township yields a considerable quantity of water of good quality.

The Judith River formation is overlain by the Bearpaw shale. In some wells, it appears that the Bearpaw shale may have been pierced and the well driven into the underlying Judith River formation. On the property of Nicholas Lesnick in the southwest of section 8, a well 85 feet deep supplies water fit for domestic and stock purposes. The surface exposure is the Bearpaw formation. In some wells in the Bearpaw, fairly good water is obtained, and in others dry holes are the result. In the southwest quarter of section 22, in a school house section, a dry hole, 90 feet deep, was drilled. A dry hole, 250 feet deep, was drilled in section 12 which is on the property of Robert McFarland.
T3N - R22E

The most outstanding features of this township are the extreme faulting in the southeastern part and the presence of a dome in the western part. This dome has been named the Broadview Dome after the town of Broadview about six miles to the northeast. Broadview is located in section 16, T4N, R23E. T3N, R22E is a very poor farming country.

The oldest formation at the surface in this township is the Eagle sandstone. It outcrops in sections 11, 12, 13, 14, 23, and 24, where it is part of the Broadview Dome, and also in sections 5, 6, 7, 8, 17, 18, 19, 20, 29, 30, 31, and 32. On the property of Robert Johnson, in the northeast quarter of section 8, a well 40 feet deep yields water fit for domestic and livestock purposes. The Eagle formation should be a source of at least good stock water in most cases. In the western part of the Broadview dome, difficulty in obtaining water is said to be true.

The Eagle sandstone is overlain by the Claggett shales and sandstones. This formation is a poor source of water. In section 5, a well 12 feet deep in the bottom of a creek supplies water for domestic and stock purposes. In most cases, it is only in such locations that water from the Claggett formation is satisfactory. On the property of Will Hagerman in the southeast quarter of section 21, a well 12 feet deep supplies hard water for stock purposes. Alkali is present on the sides of the water trough. The analysis of the water in the well shows 50, 100 parts per million. This is exceedingly high, (see analysis , page ).

In the northwest quarter of section 27, a well 20 feet deep supplies water high in the alkaline salts. This water is used for
stock only. In the southeast quarter of section 17, a well is used for stock purposes.

**T4N - R22E**

The Eagle sandstone outcropping of sections 5, 6, 7, 8, 17, 18, 19, 30, 31, and 32 is the oldest formation in the township.

By studying the various outcropping formations as shown on the map, it is apparent that a large structural dome has its apex somewhere in this region.

The Eagle sandstone in T4N, R22E is a source of water fit for domestic and stock purposes. In the southwest quarter of section 6, a spring yields water of good quality. In the northeast quarter of section 7, a spring also yields good water. In the northwest quarter of section 25, on the property of Les Heycox a well 60 feet deep yields water for domestic purposes. Considerable water is present. On the property of C. C. Biddle in the northeast quarter of section 20, a well produces good water. In the southwest quarter of section 17, on the Studebaker Ranch, a well 85 feet deep provides a large supply of soft water. In the northeast quarter of section 20, a well 90 feet deep, on the property of Carl Barnhart, hit hard water at 55 feet. This water is used for domestic and stock purposes. In section 22, a well on the property of Granek Benish supplies a fair amount of water. In the northeast quarter of section 24, a well 60 feet deep, on the property of James Eyers, yields a good supply of soft water. In the northeast quarter of section 23, on the property of Herbert Ries, a well 135 feet deep yields a large quantity of soft water. On the property of William Brinkel, in the southwest quarter of section 32, a well in the Eagle sandstone at a depth of 60 feet supplies a considerable amount of good drinking water.
The Claggett formation, overlying the Eagle sandstone, has been drilled for water in many places where exposed. In section 21, a well 35 feet deep, on the property of Mood McCollough, yields water of good quality. This well has been drilled in a creek bottom. On the property of A. C. Stiles, in the southwest quarter of section 20, a well originally drilled 110 feet deep supplied a small amount of soft water. Upon deeper drilling to 160 feet, the water became unfit for human consumption and is even being rejected by stock. The analysis shows 2540 parts per million of dissolved solids, (see analysis, page ). In the southwest quarter of section 7, a well 175 feet deep, on the property of J. B. Gotgen, struck water at 90 feet and at 175 feet. The well yields a large quantity of water used for domestic and stock purposes. This water may be coming out from the underlying Eagle sandstone. In the southwest quarter of section 10, a well 94 feet deep, on the property of W. S. Hanser, supplies an adequate amount of good stock water. In the southwest quarter of section 9, also the property of W. S. Hanser, two wells have been drilled. The first well, 245 feet, struck a small amount of water at 30 feet. Upon deeper drilling to 245 feet, no water was encountered. The well was given up as a dry hole at this depth. The second well was drilled to 160 feet, and it also was a dry hole. In the southwest quarter of section 15, on the property of Frank Benish, a well 100 feet deep yields poor stock water. In the northwest quarter of section 21, a well 40 feet deep, on the property of R. P. Johnson, yields a limited supply of poor water. Water is hauled from wells to the east in the Judith River formation. The groundwater in the Claggett formation in T4N, R22E is generally unsatis-
factory. The geologic cross-sections show that it is unadvisable to drill in this formation except in the western edge of the outcrop in this township. Here it is possible to drill through the Claggett shales and into the underlying Eagle sandstone at moderate depths.

The Claggett formation in the northeastern part of this township is overlain by the Judith River formation. The wells in the Judith River formation show that it is an excellent source of water. On the property of J. S. Drosse in the northeast quarter of section 14, a well 65 feet deep yields water which is used for domestic and stock purposes. This well has been an excellent producer of water since 1913. Many farmers living in the region where the Claggett formation is at the surface, haul water from this well for household uses. In the northeast quarter of section 23, on the property of R. H. Drosse, a well 65 feet deep yields water fit for domestic and stock purposes. The Judith River formation should yield water of good quality at less than 100 feet in depth.

T1N - R23E

The western tier of sections in T1N, R23E lies in Stillwater County and the rest of the township in Yellowstone County.

The oldest exposed formation is the Colorado shale which underlies the Eagle sandstone in the canyons near the south end of the township. The Colorado shale is approximately 2,250 feet thick. A few springs will probably be found near the Eagle sandstone and Colorado shale contact. The shale will probably be only a poor source of highly mineralized water.

The Eagle sandstone is not a good source of water in this
township\(^1\) as in some other parts of the county. Farmers are reported to have experienced some difficulty in sections 33 to 36 in obtaining adequate supplies by drilling. In the northwest quarter of section 35 on the property of John Wold, a spring flows with a small quantity of water is used for domestic purposes. The water deposits some "white alkali" around the spring.

The Claggett formation overlies the Eagle sandstone and is at the surface in a broad belt extending across the township. Owing to numerous sandstones, the surface has been eroded to form a rough topography unsuitable for farming. Hence, there has not been much drilling into the Claggett in this township. Many of the ranch houses have been abandoned. The water, if found, will probably be in sandstone, but probably of poor quality.

The Judith River formation overlies the northern part of this township and forms elevated rolling farm country with chocolate-brown soil. It is probably the best water-bearing formation in the township, and will yield supplies satisfactory for household purposes to wells drilled to a depth of about 100 feet. In the southeast quarter of section 1, on the property of Leonard Burme, a good spring yields water satisfactory for domestic and livestock purposes. This well was also reported by the U. S. Geological Survey. In the southeast quarter of section 3, on the property of the Malt Estate, a well 20 feet deep supplies water which is being used for stock. An adequate supply is present. In section 19, on

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the property of Mr. Shawhan, a well 250 feet deep was drilled. The water is hard but is usable for stock. At this depth, it appears that the well may have gone into the underlying Claggett formation. In the northeast quarter of section 30, two wells were drilled on the property of B. J. Coles. In one well, 60 feet deep, a small supply of water usable for household consumption was found. This water rose to within 30 feet of the surface. Another well, dry, 200 feet deep, was drilled about 100 yards to the southwest of the 60-foot well. The log of the well shows 20 feet of sandstone on the top, and 180 feet of marine shale below. It appears that the Claggett shale was penetrated by the well.

In the northeast quarter of section 18, a well 65 feet deep on the property of Joseph Wagner yields an adequate supply of water which can be used for all purposes. No soda can be detected by the human taste. The Geological Survey water supply paper reports that wells 21 feet to 92 feet deep in sections 10, 11, 19, and 20 produce adequate supplies of usable water. Small springs are also found in sections 8, 9, 10, 11, 12, and 16.

T2N–R23E

The Western tier of sections in T2N, R23E lies in Stillwater County. The Claggett is the oldest formation cropping out in this township, and the areal extent is small. Erosion has exposed the Claggett in only a few coulees. The Geological Survey reports that in the northeast quarter of section 36, on the property of C. H. Nickils, a dug well 30 feet deep in a coulee yields water of poor quality. It ordinarily produces enough water for 11 head of stock, but goes dry at times in the winter. The Geological Sur-
vey also reports that a well in section 36, 220 feet deep, was drilled through 50 feet of Judith River, and about 170 feet of Claggett. This well yields only a small quantity of water reported to have a "soda" taste. Springs are found at places along the Judith River-Claggett contact, but they frequently go dry in hot summers. Drilling in the Claggett formation would not be recommended.

The Judith River formation, which overlies the Claggett formation, is at the surface over the entire township except in a few small areas. In the northwest quarter of section 21, a well 85 feet deep, on the property of William Hiken, produces a large quantity of water used for household and stock purposes. In the northeast quarter of section 19, springs supply water of good quality. These springs are on the property of Carl Thompson. The Geological Survey reports that in the northeast quarter of section 24, on the property of W. F. Wall, there is a 6-inch drilled well about 285 feet deep which draws its supply from a sandy stratum about 60 feet below the surface. The water is hard and contains 1,393 parts per million of totally dissolved solids. The Geological Survey reports various other wells in this township ranging from 10 feet to 220 feet in depth. Generally where the Judith River formation is not too thin, it will yield fairly abundant supplies of good water to wells 150 feet or less in depth. In a faulted zone in the southeast quarter of section 6, a well 253 feet deep was dry. The groundwater behavior is very unusual in this disturbed area.

The Bearpaw shale rests on the Judith River formation in sections 2, 3, 4, 5, and 6. It is exceedingly unsatisfactory as a
source of water.

In the northern row of sections the Judith River formations is covered by Quaternary alluvium. In the southeast quarter of section 3, a well 30 feet deep supplies water which is even poor for livestock. The Geological Survey reports that in the southeast quarter of section 2, on the property of Mrs. Rose Ballard, a dug well 42 feet deep produces considerable water which is unfit for household use. This water contains 5,586 parts per million of dissolved solids consisting chiefly of sodium sulphate, (Glauber's salt). The writer observed a well in section 4 that supplies water not given to livestock if any source of water is present.

In the northeast quarter of section 10, a well 30 feet deep, on the property of M. T. Cole, supplies water which is unsatisfactory for household purposes. In the northwest quarter of the same section, there used to be a good well, but it has not been used in recent years. In the southwest quarter of section 10, there was a well, 25 feet deep supplying fairly good water, but "alkali" waters have ruined it. In the southeast quarter of the same section, the well was also ruined. The Judith River formation is present at the surface at the location of the two wells, but the waters from the Quaternary alluvium must have worked their way to them.

T3N - R23E

The most prominent single feature in this township is the outcropping Eagle sandstone on the east half of the structural dome in sections 6 and 7, the Geological Survey reports that wells are found in the sandstone, but that in the western half of the dome in Stillwater County well drillers have trouble in obtaining water
from it.

The Clagget formation overlies the Eagle sandstone and is found in areas around the prominent dome. This country is dissected considerably, and consequently, few attempts have been made to obtain water from it. This formation is unsatisfactory as a source of water. The Geological Survey reports a spring, in the northeast quarter of section 20, flows a few gallons a minute. The water is used for stock.

The Judith River formation, which is immediately above the Clagget formation, covers a considerable area in the township, and is a good water-bearing formation. The Geological Survey reports that in the southwest quarter of section 4, on the property of William Reamer, a 6-inch drilled well 60 feet deep produces an adequate supply for household purposes, but the water is slightly salty. Various other wells have been drilled in the Judith River at depths of less than 75 feet and the water has been found satisfactory. Some springs have also been found which supply small amounts of good water.

The Bearpaw shale, overlying the Judith River formation, is at the surface in only a small area, and is unpromising as a source of water. It is not advisable to drill into this formation to reach the Judith River beds, where it is necessary to drill through the entire 800 feet of the Bearpaw. Small supplies may be obtained locally by digging shallow wells in the coulees.

In the eastern part of the township, the Quaternary alluvium of the Comanche Flat is well developed. The Geological Survey reports that most of the wells sunk in this alluvium are successful as to quantity, but not to quality of water obtained. The
ground-water character may be variable. It is not advisable to
drill through the Quaternary alluvium except in those areas where
the Judith River or Lance underlies the alluvium, and in such
areas great care must be taken to case out alluvial waters.

Faulting in the southwest quarter of the township complicates
ground-water conditions.

In a deep well, 2440 feet deep, drilled by Charles Hurry in
the southwest quarter of section 7, obtained water containing 18,
820 parts per million of total dissolved solids from one of the
sandier beds in the Colorado shale. This water is unusual in
that it contains 10,992 parts per million of chloride.

The Lance formation, consisting of sandstone and shale,
epresents the northeastern part of the township. In the southeast
quarter of section 3, on the property of Dave Turner, a well 50
feet deep struck a water horizon at 54 feet. This water is used
for domestic and livestock purposes. In the northeast quarter of
section 9, a well 60 feet deep yields soft water. On the prop-
erty of William Spindel in section 1, a well 60 feet deep produces
good water. In the northeast quarter of section 10, on the prop-
erty of N. D. Turner, a well 60 feet deep yields water for house-
hold purposes. The analysis shows 1415 parts per million of dis-
solved solids. (Analysis plotted on plate 6). The amounts of
sodium and sulfate present is typical of the Lance formation. A
40-foot well in the southeast quarter of section 3 supplies a
large quantity of water used for stock. In the northeast quarter
of section 14, a well 131 feet deep yields water for domestic and
stock purposes. This water has a "soda" taste. In the southwest
quarter of section 11, a well 150 feet deep supplies fair water.
This well is beginning to cave in the lower part. The Geological Survey\(^1\) water supply paper recommends that all wells in the Lance and Fort Union should be cased. The wells in this formation yield an adequate supply of water moderately mineralized, which may contain considerable quantities of sulphate, bicarbonate, and sodium. The analysis verifies this statement. The wells, observed by the writer of this report, have the same general characteristics as those listed by the Geological Survey.

T4N-R23E

The Claggett formation lies at the surface in the southwest of T4N, R2 3E. It contains some sandy beds that may yield water, but the topography is rougher than in most of the rest of Yellowstone County.

The Judith River formation underlies much of the western part of the township and is a good source of water. Strong springs are present in the sections 20 and 21, which furnished the municipal supply of Broadview. These springs have decreased in flow so that now in the northeast part of section 20, three wells 80 feet deep have been drilled. The wells supplied a total of 15 gallons per minute. The analysis of the water from the springs showed that it was hard, containing 638 parts per million, essentially lime bicarbonate. A well, 240 feet deep, was drilled 100 feet west of the three wells just mentioned, but bad water at a rate of 10 gallons per minute was encountered. Another well, 190 feet deep, to the north in the same section also supplies water unfit for human consumption. These wells evidently hit a shaly portion of the Judith River formation. Other wells, to be men-

\(^1\) Hall, G. M. and Howard, C. S., op. cit. p 36
tioned later, have been drilled in the Lennep sandstone to the east of Broadview in the search for a municipal water supply.

The Bearpaw shale forms a depression in which the town of Broadview is situated. This shale is unpromising for water, and practically all wells drilled into it are dry, according to the Geological Survey report. One very deep, but dry, hole was drilled in this shale in Broadview.

The Lennep sandstone is a rather thin formation. In the northeast quarter of section 16, two wells have been drilled into this formation in search of water for the municipal supply of Broadview. In the first well, water was struck at 107 feet, lost at 110 feet, and recovered at 150 feet. The well produces hard water at the rate of 24½ gallons per minute. The water also contains some iron. In a second well, 200 feet to the east of the first well, water was struck at 207 feet, but the well was continued to 313 feet. The water is said to be fair, and flows at the rate of 8 gallons per minute. At the present time, these wells are supplying the entire domestic needs of the town of Broadview. The water, from latest information, is hard with a considerable content of magnesium and iron.

T1N - R24E

The oldest exposed formation is the Colorado shale in the southeastern part of this township. The Geological Survey states that where the Colorado shale is not covered with terrace gravel, it is almost useless to drill for supplies of water. Some wells have been reported, but the water is unfit for any purpose.

The Eagle sandstone overlies the Colorado shale in a large area, but is not, according to the Geological Survey report, a good source of water. A few springs may occur at the contact of the Eagle sandstone and the overlying Claggett formation.

1. Hall, G. M. and Howard, C. S. op. cit. p 67
The Claggett formation, with its unusual number of sandstone beds, erodes to a rough topography. Very little farming is done in this area. In section 5, a recent well 100 feet deep supplies fair water at a rate of 3/4 of a gallon per minute. This well is on the property of Clinton McFarland. Various wells from 60 to 143 feet deep have been reported by the Geological Survey\(^1\) in the Claggett formation. The water is generally satisfactory for domestic purposes.

The Judith River formation, in the northwestern part of the township, is reported to be a good water-bearer. Wells in section 6, from 50 to 140 feet deep, are reported by the Geological Survey to produce moderate amounts of water suitable for domestic use.

T2H - R24E

The oldest exposed rock in this township is the Claggett formation which erodes to depressions. In the center of section 14 on the property of Herman Schroeder, a spring, at the contact of the Judith River and Claggett formation, provides water which is stored in a tank. The water is used for both domestic and livestock purposes. In the center of section 17, also on the property of Herman Schroeder, a well 14 feet deep yields fair water. In the water supply paper for this area it was stated that a dug well about 60 feet deep in a sculee supplied water used for domestic purposes. It appears that the water table is higher now than at that time. Shallow wells in the Claggett in this section are said to be common. Many other wells were reported by the Geological Survey\(^2\) in the exposures of the Claggett in various other sections. Many of the farms have now been abandoned in this area, and hence, many of the former wells are not being used at the present time.

Springs are quite common at the contact of the Judith River and Claggett formations. A well, 120 feet deep on the property of John

\(^1\) Hall, G. M. and Howard, C. S., op. cit. p. 67
\(^2\) Hall, G. M. and Howard, C. S., op. cit. p. 68
Radmacher in the southwest quarter of section 34, yields a little poor water. It is not being used for any purposes. Another well, 92 feet deep on the property of H. Popelka in the southwest quarter of section 32, supplied hard water, but is now dry. The Geological Survey's water supply paper in this area states that the quantity and quality of water obtained from the Claggett is variable, but in this township drilled wells should be successful at depths of less than 200 feet and dug wells in coulees at depths of not more than 35 feet. All wells will not yield water that is usable for domestic purposes.

The Judith River formation overlies the Claggett formation. In the northeast quarter of section 16, on the property of Ben Uhrich, a well 22 feet deep in a coulee furnishes water for stock which is blue in color. In the northwest quarter of section 10, a well 52 feet deep used to be a source of good water. It was used for drinking, but now it kills stock. In the southeast quarter of section 10, on the property of John Uhrich, a well 260 feet deep is used for domestic and stock purposes. This water has 4505 parts per million of total dissolved solids. The water is salty here due to an excess of sodium chloride. In the northwest of section 10, a test well 16 feet deep was drilled and showed a total of 4506 parts per million of total dissolved salt. The mineral in excess is sodium sulphate. In the northeast quarter of section 10, a well 20 feet deep was drilled. The water contained a total of 10,180 parts per million of dissolved solids, which is extremely high. The concentration of the sulphate radical was very predominant. The preceding were analyses extremely high in total mineral content for water from the Judith River formation. In the northeast quarter of section 26, on the property of Henry Popelka, a well

1. Hall, G. M. and Howard, G.S. op. cit. p. 68
65 feet deep yields an adequate supply of fair drinking water.

A spring in the southwest quarter of section 26 supplies good water. This spring is probably at the contact of the Judith River and Claggett formations. The water from the Judith River in this township is not as good as that found in other townships. It appears that the ground-water conditions in the Judith River formations are not too satisfactory. In general, wells less than 200 feet deep should be successful for at least stock purposes. The water will be variable in composition. Springs are the best source for domestic purposes.

The Bearpaw Shale, according to the Geological Survey, is a poor source of water in T2N, R24E. The town of Acton, on the Great Northern Railroad, is situated on the Bearpaw, and the wells around the town yield poor water, so that almost all water for domestic purposes must be hauled to town from wells and springs. The inhabitants at the present time are using water from a railroad well in the northwest quarter of section 19, T2N, R25E. Quaternary alluvium is found in the northern row of sections, which are part of the Comanche Flat. The ground-water conditions here have not changed a great deal. A well 35 feet deep in the southwest quarter of section 3, on the property of R. Mainwaring, contains considerable water which is sufficient for 140 head of stock. In the southwest quarter of section 8, on the property of R. Mainwaring, a dug well 28 feet deep yields water which is used for domestic and stock purposes. The Geological Survey reported the same well in their report. At that time it was being used for domestic purposes.

T3N - R24E

This township is characterized by the presence of Quaternary

1. Hall, C. M. and Howard, C. S., op. cit., p. 69
2. Hall, C. M. and Howard, C. S., op. cit., p. 70
alluvium in a large area known as Comanche Flat. The Lance, Lonnep and Bearpaw crop out in the eastern part of the township.

The Comanche Flat is covered with alluvium consisting of sand, silt, and gravel ranging in depth from only a few inches at the edge to 75 feet or more in places. In the northeast quarter of section of 34, a well 16 feet deep on the property of O. H. Oswald provides water for domestic and stock purposes. Fred Dreeses, in the center of section 35, has a shallow well which yields a large supply of water. The Geological Survey reported a well 15 feet deep in the northeast quarter of section 34 which yielded an adequate supply of fairly good but hard water. The ground-water conditions have not changed to any large extent except for slight lowering of the water table. Comanche, a small town on the Great Northern Railroad, has no municipal water works. The inhabitants still get their water from dug wells from 20 to 32 feet deep. This water, somewhat hard, is used for domestic and livestock purposes. The 32 foot well in section 26, belonging to the Great Northern Railroad, is still being used by the inhabitants of Comanche as a source of water. This water was reported by the Geological Survey to be highly mineralized. The Geological Survey reported a well 12 feet deep, in the northwest quarter of section 26, on the property of A. Kruger. This water contained 16,471 parts per million of total dissolved salts. At the time of the former survey, this well was used for stock, but at the present time, the well is not being used for any purpose. The alluvium in most cases should yield water at shallow depths, but the quality of water is generally not too satisfactory. The quality of water in a small area may vary considerably.

The Bearpaw shale is exposed in only a small area. The ground-

1. Hell, C. M. and Howard, C. S., op. cit. p. 70
water in this should be only in small amounts, and of poor quality.

The Lennep sandstone appears as a narrow ridge in the northeast part of the township. It has not been investigated because the overlying Lance is fairly productive. The Lennep sandstone, however, was shown to contain water near Broadview, hence it is possible that fair water should be struck at less than 200 feet in this formation in T3N, R24E.

The Lance formation, consisting of lenticular masses of sandstone and shale, should be a fair producer of water. In the southwest half, a well 79 feet deep in the Lance yields an adequate supply of fairly soft water. This well is on the property of W. L. Adams.

In the northeast quarter of section 10, a well 145 feet deep yields a large quantity of soft water. The Geological Survey\(^1\) reports also wells in the same section at depths of about 100 feet. The Geological Survey\(^1\) reports two wells, 98 feet and 45 feet deep, in section 15. These same wells are still being used for stock purposes.

It can be said that the Lance formation is a source of water that is satisfactory. It should not be necessary to drill deeper than 200 feet.

**T4N - R24E**

The oldest surface formation in this township is the Lance formation which consists of lenticular masses of sandstone and shale. Most of the ground-water comes from the sandstone, and many of the larger supplies, according to the Geological Survey\(^2\), comes from sandstone underlain by impervious shale. In the southeast quarter of section 4, on the property of M. P. Corps, a well 106 feet deep supplies a small quantity of water used for household and stock purposes. Another well 100 feet east of the 106 foot well was drilled to a depth of 200 feet. No water was struck. Blue shale

1. Hall, G. M. and Howard, C. S., op. cit. p. 70
2. Hall, G. M. and Howard, C. S., op. cit. p. 71
was present in its entire depth. In the southwest quarter of section 4, from the water supply paper, a well 165 feet deep on the property of C. E. Barr, drawing its water from a bed 152 feet below the surface, yields an adequate supply of fairly good water, which rises within 47 feet of the surface. A well, observed by the writer, in the southwest quarter of section 2, yields an adequate supply of stock water. This well is on the property of Robert Johnson. Two wells, 60 and 80 feet deep, on the property of Tony Bucher in the northwest quarter of section 28, supply air water. The 60 foot well can be pumped dry. The Geological Survey reports two wells in the northeast quarter of section 28. These wells, 110 and 90 feet deep, yield soft water of fair quality. The Geological Survey also reports a dug well 19 feet deep in the southeast quarter of this section. This 19 foot well still provides a small amount of water. In the southeast quarter of section 22, on the property of Will Jensen, a well 80 feet deep yields water of fair quality. The water is in considerable amounts. In the northwest quarter of section 34, a well 40 feet deep yields an adequate supply of soft water. This well is on the property of Charles Bensky. As a whole, in comparison with ground-water conditions as given by the Geological Survey, it can be said that only minor changes have occurred in the ground-water in the Lance formations in this township. The Lance is a good source of water at depths of less than 200 feet and the water obtained may be very hard or very soft. Supplies for large herds may be hard to secure.

The Lebo shale, a member of the Fort Union rocks, overlies the Lance formation. The formation is exposed in the northeastern part of the township. It is unadvised to drill in this formation for ground-water. The water is of poor quality, according to the Geo-

1. Hall, G. M. and Howard, C. S., op. cit. p. 71
2. Hall, G. M. and Howard, C. S., op. cit. p. 72

(68)
ological Survey. The Lebo shale consists mainly of a bluish shale which erodes to a flat plain.

Quaternary alluvium is on the surface in the southwestern part of this township. A resident said that wells at a depth of 30 feet in the alluvium yield water which is sometimes fairly good, and which at other times is quite salty. The water is generally only suitable for stock.

T1N - R25E

The colorado shale in the southern part of this township lies in Yellowstone Valley. Wells are not common in this part. A few may have been dug for stock, but where no terrace gravel exists, the water should be unsatisfactory. The Eastern Montana Normal School, the Billings Polytechnic Institute, and the Billings Airport, and residences in this vicinity get their water from the Billings municipal water system. Many people have cisterns which are filled from irrigation ditches.

The Eagle sandstone outcrops over most of the township. It stands in high vertical cliffs. In section 4, a well 240 feet deep supplies water of fair quality. In the southeast quarter of section 12, a well 90 feet deep on the property of A. J. Muscleman supplies a large amount of water used for domestic purposes. This well was pumped for eight hours and the water was still 30 feet from the collar. A spring existed at the present location, but this spring went dry. A. J. Muscleman stated at this time that springs occur on the west side of Alkali Creek, but never on the east side. Springs are said to occur from section 3 southeastward to where Alkali Creek empties into the Yellowstone River. A very recent well was drilled on the property of R. J. Rehberg in section 14.
This well is 210 feet deep, and furnishes a fair amount of water, but has very little pressure to force the water up the well. The water is typically Eagle, that is, moderately hard. A well in the southwest quarter of section 4, 80 feet deep, and containing 1549 parts per million of total dissolved salts, is classed as hard. This analysis, plotted on plate 6, will be taken as a representative of the Eagle water in this district. In the northeast quarter of section 23, a well 300 feet deep supplies a very small amount of fair quality water. In the northeast of section 27, a well 150 feet deep struck a large amount of water. Two wells were also drilled in section 18. One is 90 feet and the other 250 feet deep. In the northwest quarter of section 17, a well 140 feet deep contains water which rose to 90 feet of the surface. The water from the last three wells is probably moderately hard.

The Claggett formation is exposed only in section 1. It is usually a poor source of water. The best chance for water is in the coulees.

T1N, R25E is mainly a grazing country. Most of the information for this district was received from O. B. Johnson and W. E. Anderson, a well driller.

T2N - R25E

In this section, the Lake Basin faulting is very prominent. This township is mainly used for grazing. Many of the former farm houses have now been abandoned.

The Eagle is the oldest formation outcropping in this township. In the southeast quarter of section 22 on the property of O. B. Johnson, a well 120 feet deep supplies a large quantity of water which is said to be fair in quality. The Geological Survey reported a...

1. Hall, O. M. and Howard, C. S., op. cit. p. 75
drilled well 125 feet deep in the southwest quarter of section 22 which drew a large supply of hard water from a sandstone 100 feet below the surface. The water, used for irrigating a garden, contained 1,329 parts per million of total dissolved salts. An old well, 3,300 feet deep, hit water at a depth of 180 feet in the southeast quarter of section 22. The writer observed a well in the southwest quarter of section 34 which was 65 feet deep. The latest reports said that when the water was being used, it was very good. A well, reported by the Geological Survey in this same location, contained only 470 parts per million of total dissolved salts. Another well in the middle of section 21, 2,500 feet deep, encountered no water.

The Claggett formation overlies the Eagle. It can be recognized in the valleys in the faulted zone, between resistant material. In section 22, a well 140 feet deep produces water. The Geological Survey reports several other wells between 140 and 165 feet deep in the Claggett. Ordinarily this formation is a poor source of water.

The Judith River formation overlies the Claggett formation. A well, 317 feet deep, was reported by the Geological Survey to have been drilled in the northwest quarter of section 19, on the property of the Great Northern Railroad Company. At that time the well produced large quantities of soft water used for domestic purposes. The same quantity and quality of water is persisting at the present time. Various other wells have been reported by the Geological Survey, and the behavior of the ground-water is rather peculiar. Some of the wells in the Judith River supply good water, while others are highly mineralized.

The Bearpaw shale is exposed at the surface in the northern

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1. Hall, G. M. and Howard, C. S., op. cit., p. 75
part of the township. It appears in a sort of valley between the faulted zone to the south and the cliff-forming Lance to the north. In the southeast of section 9, on the property of Glen Wheatley, a well 80 feet deep supplies a large amount of water which has an unpleasant taste. In sections 1 to 6, small springs are said to occur between the contact of the Lance sandstone and the underlying Bearpaw shale. As a whole, drilling in the Bearpaw is not advisable. The holes may be dry or the water useless.

There has been no drilling in the cliff-forming Lance in this township.

**T1N - R26E**

The northern part of the city of Billings is located in sections 32 and 33. The Yellowstone River has cut through the Eagle sandstone which forms the rimrock.

The Colorado shale is the oldest formation at the surface in this township. The city of Billings is located on river gravels. Most of the residents in this area get their water from the municipal water supply of Billings. Those residents in the vicinity of Billings should be able to get an abundance of stock water from the river terraces. A large irrigation canal, known as the Billings Land and Irrigation Ditch, crosses through the northern part of Billings. Many farmers in the adjacent areas fill cisterns for domestic purposes. The water is obtained by hauling it from the municipal supply at Billings, or from the irrigation canal. It would be necessary to drill through to the underlying Cloverly at a depth of about 2,000 to 2,250 feet. The Geological Survey\(^1\) states that the water in the Cloverly would be unfit for domestic uses.

The Eagle sandstone overlies the Colorado Shale. The lowest

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1. Hall, G. M. and Howard, C. S., op. cit. p. 79
member, the Vergelle sandstone, forms the conspicuous rimrock. The Geological Survey reports several wells in the area. The water is generally poor. At times, even the stock do not like the water.

A new well, in the southwest quarter of section 10, on the property of J. Pemberton, was drilled through 100 feet of Claggett into the underlying Eagle. The water, rising to the surface, is soft, but is unfit for human consumption. In the southeast quarter of section 18, a well 96 feet deep in the Eagle supplies hard water.

In Alkali Creek, the Eagle is overlain by a very thin layer of Quaternary alluvium. In the southeast quarter of section 16, on the property of C. B. Johnson, the water in the alluvium is within four feet of the surface. The water appears to lay in a sheet. It is being used for household and livestock purposes.

Another well, 20 feet deep in the creek bottom, is said to supply considerable water. This water is not being used because of surface refuse which probably contaminates the water. Springs are said to occur on the west side of Alkali Creek in various parts of sections 12, 16, 20, and 28.

The Claggett formation in this district, according to the Geological Survey, consists predominately of dense gray shale and very subordinate sandstone. Wells drilled through the overlying terrace deposits will probably be dry, or only yield small quantities of unusable water. Dug wells in coulees would be advisable. The Billings Land and Irrigation Ditch goes through sections in which the Claggett is exposed. Due to heavy irrigation in many areas, the water table should be very close to the surface. In section 23, two wells 55 feet deep were drilled about 20 years ago. These wells supplied fair amounts of water used for stock. At the present

1. Hall, G. M. and Howard, C. S., op. cit. p. 79
2. Hall, G. M. and Howard, C. S., op. cit. p. 80
time, the water table is about 15 feet from the surface. Many sub-
surface ditches have been laid out in this area to prevent the ru-
ination of the land. The water generally deposits some "white alkali",
that can be used for stock. Most of the farmers have cisterns which
are filled with water from the municipal supply at Billings.

The Judith River, overlying the Claggett, is exposed in the
northeastern part of the township. Again terrace deposits are pre-
sent. Water in such deposits should be found at depths less than
50 feet. The water should be usable for stock.

A little Quaternary alluvium is found in areas along the river.
As a whole, little drilling is done, because water can be hauled
from the river.

T2N - R26E

The most prominent topographic features of this township are
in the zone of faulting that crosses the southern part of the town-
ship.

The Eagle sandstone is the oldest formation at the surface in
this township. This sandstone should supply small quantities of
hard water when drilled into.

The Claggett formation overlies the Eagle sandstone, and is
generally found in valleys between the more resistant Judith River
and Eagle formations. It would be unadvisable to drill for water
in this formation. Dug wells in coulees would be the best place
to find water. The water in the deeper wells would probably be
usable.

The Judith River formation, overlying the Claggett formation,
is a good source of water in this township. In the northwest quar-
ter of section 23, on the property of Henry Barsh, a well 60 feet
deep supplies good soft water used for domestic and stock purposes. In a creek bottom in the same section, a well 40 feet deep supplies water used for stock. In the southeast quarter of section 14, a spring on the property of Bill Peters, supplies a large quantity of very good water. In the southwest quarter of section 23, on the property of C. J. Hindt, two wells have been drilled, one 50 feet deep and the other 100 feet deep. The 50 foot well can be pumped dry in five minutes. Both wells contain good soft water that can be used for domestic and stock purposes. In the southwest quarter of section 10, on the property of S. Ballek, a well 130 feet deep supplies water for household and stock purposes. The water is said to contain considerable "soda". Various other wells have been reported in the Judith River in this area by the Geological Survey. Most of the wells, as those at the present time, contained water fit for human consumption. The water is generally soft in the Judith River in this township.

The Bearpaw shale, overlying the Judith River formation, is exposed in the northern part of the township. This area at the present time is being used mainly for grazing. Drilling for good water in the Bearpaw is unadvisable. A well, 80 feet deep in the northwest quarter of section 10, on the property of Steve Ballek, was abandoned, because the water was too bitter for human consumption. This well substantiated the report on the other wells in the area as given by the Geological Survey. If a dry hole is not drilled, the water that is generally present is highly unsatisfactory for use.

TIN - R27S

The Yellowstone River crosses the northeastern part of TIN.

1. Hall, G. M. and Howard, C. S., op. cit. p. 82
R27E. This part of the township north of the river is in Lake Basin proper.

The oldest formation in the township north of the river is the Judith River formation. In this area, irrigation is very common, and consequently, a high water table persists. Dug wells at shallow depths should be successful as a source of water for stock purposes. Springs should be quite common.

Quaternary alluvium is exposed on the flat river bottom. Considerable quantities of water should be present at shallow depths. Most of the farmers find the river water more accessible.

T2N - R27E

The southeastern part of this township is out of Lake Basin proper. The Yellowstone River forms the boundary of Lake Basin field in this area. The town of Huntley, in the southwest quarter of section 26, has no municipal water supply, and most of the people get their water from the Northern Pacific Railroad water tank, which is filled from the Yellowstone River. The village of Shepherd, in the northern part of the township, also has no municipal water supply. Wells and cisterns filled with ditch water are used for livestock and domestic purposes.

The exposure of the Claggett formation, the oldest formation in this township, is on the southeast side of the Yellowstone River in the northeast quarter of section 36. Much water was encountered at a depth of 120 feet in this hole. This well, drilled by the Gladys Belle Oil Company, and described by the Geological Survey, shows that the Colorado shale was struck at a depth of 160 feet after passing through three very thin sandstones, showing the rapid disappearance of the Eagle sandstone to the north and east. No water

1. Hall, G. M. and Howard, C. S., op. cit. p. 86
was encountered below 160 feet.

The Claggett is overlain by the Judith River. Recently, several wells have been drilled down through the Bearpaw shale into the underlying Judith River formation. In the northeast quarter of section 17, on the property of Harold Huntz, a well 340 feet deep went down into the Judith River formation. This water, in large quantities, is being used for stock. It contains too much soda for human consumption. In the northwest quarter of section 16, a well 290 feet deep was drilled on the property of Jake Ellers. This water in the well was at first very salty, but at the present time, it is said to be soft. The water is being used for livestock and domestic purposes. On the property of Bill Clayton, in the northwest quarter of section 20, a well 340 feet deep encountered water sands at 331 feet. This water is said to be good.

In the southeast quarter of section 30, a well in the Judith River, on the property of J. Pingle, supplies good water.

The Bearpaw shale overlies the Judith River formation. Evidently the water in the Bearpaw shale, if any, is unusable. This is why the previously-mentioned wells, as stated, went through the Bearpaw shale into the Judith River formation. The Bearpaw shale, a very gummy mass when wet, is covered with terrace deposits.

In the town of Shepherd, the water level is said to be within 20 feet of the surface. Surrounding swampy lands verify this statement. Dug wells for stock purposes are common. Cisterns filled from irrigation ditches are used for domestic purposes. The Montana Power Company has considerable difficulty in this area in setting power line posts because of the high water table. In the southeast quarter of section 2, a dug well hit water at 7 feet. This water is being used for livestock. In the northeast quarter of section 16, a dug well 10 feet deep is being used for livestock purposes. In the northeast quarter of section 22, on the property
of A. J. Horton, a dug well 4 feet deep supplies water for livestock. Mr. Horton stated that water was seeping out of the terraces near the edge of the river to the south. It appears that the whole area is water-logged.
DESCRIPTION OF GROUND-WATER CONDITIONS
IN THE ADJACENT AREA

This area consists of portions of Yellowstone, Stillwater, and Carbon counties. The portion in Yellowstone County has been described previously by the United States Geological Survey. No actual field work was done by the writer in any part of the area with the exception of correspondence with some of the residents and with a well driller of this region.

Description of Townships

T13 - R20E

The Lance and Lennep formations are at the surface in this township. These formations are generally a source of satisfactory water at depths less than 200 feet. The wells in the Lance may have to be cased due to the presence of a blue shale which tends to crumble in a short time.

T2S - R20E

The town of Columbus with a municipal water supply is located in the south central part of this township. The water is pumped from the Yellowstone River, which flows across the township in a southeasterly direction. The Stillwater River, flowing in a north-easterly direction, empties its water into the Yellowstone River about one-half a mile southwest from the town of Columbus.

1 Hall, G.M. and Howard, C.S.; Ground-water in Yellowstone and Treasure counties, Montana; Water Supply Paper 599, 1929.
The oldest exposed formation at the surface in this township is the Bearpaw shale a few miles north of Columbus. A well 200 feet deep in section 8, on the property of Dr. Payne, supplies water fit for general ranch purposes. The water flows at the rate of 2 gallons per minute.

The Lance and Lennep formations are exposed at the surface in both areas north and south of the Yellowstone River. In the areas north of the river, drilling should supply water sufficient for domestic and livestock purposes. In the high bluffs south of the river, more difficulty will be encountered due to the drainage of the ground-water to lower levels.

Quaternary alluvium is found on the "bottom lands" near the Yellowstone River. It should not be necessary to drill deeper than 50 feet to assure a supply of water sufficient for stock purposes.

T13 - R21E

The Lennep sandstone stands in sharp relief above the Bearpaw shale in the north part of this township. The Judith River formation, found further to the east, covers the largest area in the township. The Lance formation is at the surface in the western part of the township. The Judith River formation should be a good producer of water at depths not more than about 100 feet. This water should be fit for domestic and livestock purposes.

The Bearpaw shale, overlying the Judith River formation, is probably the poorest source of ground-water in the township. Wells deeper than 200 feet should not be drilled unless the Judith River
formation can be hit at this depth. The water in the Judith River may be mineralized due to the overlying Bearpaw shale.

The Lennep sandstone is reported to yield small amounts of water which should be generally satisfactory for domestic purposes. The overlying Lance formation should also yield sufficient water for domestic and stock purposes.

T23 - R21E

The Yellowstone River cuts diagonally across the southwest corner of this township. The Judith River formation has been eroded and covered with alluvium along the bottom lands near the river.

The Judith River formation covers a large area in township 23, R21E. This formation should be a source of moderate amounts of water generally fit for domestic and livestock purposes.

The Bearpaw shale, overlying the Judith River formation, is exposed in the western part of this township. Drilling in this formation is not recommended unless it is possible to encounter the Judith River formation at depths less than 200 feet.

T13 - R22E

The Eagle sandstone is the oldest formation at the surface in this township. This formation is exposed in the extreme southern part of this township. Wells drilled in the Eagle sandstone will probably contain small quantities of mineralized water at depths less than 300 feet.

Overlying the Eagle sandstone is the Claggett formation. The
upper sandstone member of the Parkman, is reported by a well driller to contain good soft water. These wells often supply from 30 to 40 gallons a minute. Drilling into the underlying shales of the Claggett should be avoided because mineralized water is encountered. Along Valley Creek, which has its head-waters in this township, springs are found, but they often dry up during the summer.

The Judith River formation, overlying the Claggett shales and sandstone, should be a good source of ground-water. The total thickness of this formation is approximately 300 feet. An observation of the cross-section along the northern edge of this township should be of considerable value in determining the thickness of the various formations.

**T2S - R225**

The northeastern part of this township is underlain by the Eagle sandstone. The right fork of Valley Creek has its head-waters in the Eagle sandstone. In section 1, a well 225 feet deep, on the property of Adam Scheiner, supplies mineralized water at the rate of 1½ gallons a minute. This water is being used for general ranch purposes. The Eagle sandstone is reported to yield only small amounts of mineralized water in this township.

The Eagle sandstone is overlain by the Claggett formation. In this township, there is sharp contrast between the upper Parkman sandstone and the lower shaly zones of the Claggett formation. In the northeast quarter of section 28, on the property of L. Kober, a well 125 feet deep in the Parkman sandstone furnishes good soft water for
domestic and livestock purposes. In the southwest quarter of section 22, a well 85 feet deep also on the property of Lauerin Kober, is a good source of water. The well supplies good water at the rate of 3 gallons a minute from the Parkman sandstone. In the northeast quarter of section 23, on the property of J. Kober, a well 135 feet deep encountered a water horizon at 40 feet. The water, flowing at the rate of 30 gallons per minute, is soft with a sweetish taste and a bad odor. This water is evidently coming from the shales in the Claggett, and apparently the underlying Eagle sandstone contained little or no water.

Quaternary alluvium is at the surface in the southeastern part of this township. Water for stock should be encountered at depths not less than 50 feet.

T13 - R23E

The western two tiers of this township lie in Stillwater County, and the rest of the township in Yellowstone County. Most of the township is covered with the Judith River, Claggett, and Eagle formations, except for a small area of Colorado shale.

The Geological Survey\(^1\) reports that the Colorado shale in this area is a poor source of water. The Eagle is also reported to contain very little water. Springs, reported by the Geological Survey\(^1\) in section 22, flowed enough water for 2,000 head of stock.

Former ranches in this township have now been abandoned.

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1 Hall, G.M. and Howard, C.S.; op. cit. page 65.
T2S - R23E

Only part of T2S, R23E\(^1\) lies in Yellowstone County; the western tier of sections is in Stillwater County, and the part south of Yellowstone River is in Carbon County. The Eagle sandstone scarp runs through the northern tier of sections, dividing the river valley from rolling uplands.

The Colorado shale is again a poor source of ground-water as reported by the Geological Survey.\(^1\) The Geological Survey states that the small area underlain by the Eagle sandstone is badly dissected, and hence, the ground-water has all been drained.

In the irrigated region below the so-called Cave ditch the Geological Survey\(^1\) reports the land as being saturated with water. This condition still exists at the present time, although many sub-surface drains are being put in.

In the town of Park City, water from the river and irrigation canals is being put into cisterns. Many shallows wells drilled near this town yield water mainly for stock purposes. Most of the wells vary from 15 to 45 feet in depth. In section 32, on the property of John Sitzman, a well 30 feet deep supplies an abundance of water which is said to be excellent for human consumption. The water is coming from a bed of sandstone at the bottom of the well. Another well, 15 feet deep, also in section 32, on the property of George Banner, supplies water which is quite hard, but it is excellent for human consumption. The same bed of sandstone mentioned previously is again

\(^1\) Hall, G.M. and Howard, C.S.; op. cit. page 66.
the source of the water. The other wells in the area encountered
gravel to the depths drilled. Most of the water from the wells in
the terrace material is quite hard and is used for stock only.

The Geological Survey\(^1\) reports a well 2,235 feet deep in the
southwest quarter of section 12. This well, on the property of F.
W. Schauer, was drilled for oil, but was never a commercial producer.
The Claggett formation was evidently reached. The water analysis,
containing 1,194 parts per million of total dissolved solids, con-
sists chiefly of sodium and bicarbonate. The water is coming from
a fine-grained white sand at a depth of 1,930 feet to 1,955 feet
below the surface. Further details concerning this well can be found
in the ground-water paper of the Geological Survey\(^1\).

T1S - R24E

The Colorado shale, underlying the Eagle sandstone, is exposed
in most of T1S, R24E. This township is mainly under irrigation.

The Colorado shale is again a poor source of ground-water.
Near the outcrop of the Eagle sandstone, the Colorado shale is not
thoroughly covered with terrace material. In this area, drilling
into the Colorado is not recommended.

In the irrigated regions, the Geological Survey\(^1\) reports that
where sub-surface drainage is poor, the land is rapidly becoming
water-logged. At the present time, the same condition still exists,
and many "alkali spots" are present. In the southeast quarter of
section 6, on the property of William Rainis, the Geological Survey\(^1\)

\(^1\) Hall, G.M. and Howard, C.S.; op. cit. page 72.
reported a small spring on the bank of Canyon Creek which flows at the rate of a few gallons a minute. This water was hard, containing 2,415 parts per million of total dissolved salts. At the present time, this spring is flowing and the water is being used for human consumption.

The Eagle sandstone is exposed in the northern tier of this township. It is not advisable to drill near the rimrock, because the sandstone is well drained in such an area.

T2S - R24E

The town of Laurel, located in the northwestern part of this township, gets its municipal water supply from the Yellowstone River. The Clark Fork River flows into the Yellowstone River in section 24 of this township. Laurel is the division point of the branches of the Great Northern and Burlington Railroads, with the main line of the Northern Pacific. Section 32 and parts of sections 29 and 31 lie in Carbon County.

This township is underlain by the Colorado shale which is covered with terrace deposits with the exception of the high bluffs to the south of the river.

In the flat bottom lands near Laurel, the ground-water is very high in many areas. "White alkali" spots can be seen where evaporation is taking place. This area is under irrigation, and consequently, many sub-surface drains have been put in to lower the water table. In such areas the depth to water is sometimes not over 10 feet. There
is an abundance of water which can be used for stock. The Geological Survey\(^1\) reports a well drilled for oil in the southeast quarter of section 7. This well, 2,235 feet deep, on the property of F. W. Schauer, has never been a commercial producer of oil, and flows at the rate of about 10 gallons a minute. The Geological Survey\(^1\) reports large volumes of gas, a little oil, and some material like paraffin escaping with the water. The water from a Cloverley sandstone is not being used for stock, and contains 3,398 parts per million of total dissolved solids with large quantities of sodium bicarbonate, and chloride.

T13 - R29E

All of this township is underlain with Colorado shale. North of the Yellowstone River, in a densely populated farming district, the Colorado is covered with terrace material. The Geological Survey\(^2\) has reported many wells in this district which are 8 to 50 feet deep. Irrigation is very common, and due to the excess use, the water table almost coincides with the surface of the land. Water from drilled and dug wells in the various sections of this township north of the river should almost always be fit for stock. Cisterns are filled from irrigation ditches for household and drinking purposes. The writer has lived in this region for many years, and to his knowledge, most of the farmers have no difficulty in

1 Hall, G.M. and Howard, C.S.; op. cit., page 73.
2 Hall, G.M. and Howard, C.S.; op. cit., page 77.
obtaining water suitable for stock. The water is generally hard for household purposes. Many of the farmers are now putting in "water softening" devices so that it is possible to use the water from wells for household purposes.

South of the river, the people in the lowlands use river water. In the uplands, deep drilling in the Colorado is not recommended. The Geological Survey\(^1\) states that on the flat-topped hills, shallow wells dug to the sandy layer holding up the hill, supply small amounts of water.

T23 - R25E

This township is also underlain by the Colorado shale. The Yellowstone River cuts diagonally through the upper part of this township. The northwestern part of the township lies north of the Yellowstone, and is level lowland. The rest lies south of the river and is hilly upland.

In the lowlands north of the river, shallow dug wells are as common as they were in the other townships also covered with alluvium gravel.

South of the river, springs are common and are used for drinking purposes. Most of this area is only used for large scale wheat farming and consequently, wells are uncommon.

Duck Creek serves as a water course for the area south of the river. The Geological Survey\(^2\) reports so-called springs in the creek.

1 Hall, C.M. and Howard, C.S.; op. cit., page 77.
2 Hall, C.M. and Howard, C.S.; op. cit., page 78.
bottom. A well 24 feet deep in the southwest of section 13, reported by the Geological Survey, supplies a small amount of hard water for household uses.

The uplands are of Colorado shale, and consequently, deep drilling is not recommended.

T13 - R26E

The Yellowstone River cuts diagonally across this township forming two distinct topographic provinces, the river valley and the rolling uplands. The larger part of the city of Billings is in this township.

The Colorado shale is the oldest exposed formation in this township. North of the river, the formation is covered with terrace deposits. In this rich farming district, the depth to water in the terrace material is seldom over 50 feet. The depth to water at least fit for livestock can almost always be encountered in this terrace material. This water is hard, but is almost always fit for stock.

On the south side of the river, the Colorado forms rolling uplands. In this district, there are very few inhabitants. Good water is only found in creek valleys. The Geological Survey reports a drilled well 70 feet deep in the southeast quarter of section 13. The water, unfit for any use, contains 27,708 parts per million of total dissolved salts, consisting chiefly of sodium and sulphate.

1 Hall, G.M. and Howard, C.S.; op. cit., page 78.
2 Hall, G.M. and Howard, C.S.; op. cit., page 84.
In the southeast quarter of section 12, the Geological Survey reports a well 35 feet deep, which produces a small quantity of water used for domestic purposes. Springs are also found in this area, but they dry up during the summer.

The Eagle sandstone is exposed in a small area along the eastern edge of the township. The Eagle sandstone, a distance from the rimrock, should supply small quantities of hard usable water for domestic purposes.

The Claggett is exposed in a small area, but drilling is not recommended in this formation, unless it is possible to drill in the underlying Eagle sandstone. A few dug wells along creek bottoms have been reported by the Geological Survey to supply satisfactory water.

T23 - R26E

In this township, the Colorado formation is the only formation at the surface. Farmers and ranchers along Blue Creek have dug wells and springs that are used for domestic and livestock purposes. If water is not struck at shallow depths, less than 75 feet, deeper drilling is not recommended.

1 Hall, C.M. and Howard, C.S.; op. cit., page 84.
Condensed Summary of Ground-Water Occurrence

The generalized map, plate 7, and the following remarks with regard to each zone shown upon it is a short summary of the ground-water conditions found in the Lake Basin region.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Formation</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Fort Union</td>
<td>Much water in some wells. Others are dry due to the presence of shaly zones. Wells should be successful at depths of 300 feet or less. Water is hard, but good.</td>
</tr>
<tr>
<td>(2)</td>
<td>Lance</td>
<td>Most wells yield good water at depths of less than 200 feet. Numerous springs.</td>
</tr>
<tr>
<td>(3)</td>
<td>Bearpaw</td>
<td>Locally shallow wells down to 50 feet may be find moderate amounts of fair to poor water. Deep wells stopping in Bearpaw shale seldom if ever yield satisfactory water. The underlying Judith River sandstone is found at depths of 200 feet or less. Water is good from the Judith River formation.</td>
</tr>
<tr>
<td>(4)</td>
<td>Judith River</td>
<td>Most wells yield an abundance of good water. Depth about 100 feet.</td>
</tr>
<tr>
<td>(5)</td>
<td>Claggett</td>
<td>No wells find satisfactory water within the Claggett shales. Locally shallow wells in coulees find moderate amounts of fair water. The Eagle sandstone lies at a depth of approximately 200 feet. Numerous springs are found. Few wells drilled because of rough surface. Should yield fair to good water in wells drilled one or more miles from outcrop.</td>
</tr>
<tr>
<td>(6)</td>
<td>Eagle sandstone</td>
<td>No wells find satisfactory water within Colorado shales.</td>
</tr>
<tr>
<td>Zones</td>
<td>Formation</td>
<td>Explanation</td>
</tr>
<tr>
<td>-------</td>
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<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>(8)</td>
<td>Quaternary alluvium and terrace gravel</td>
<td>As shown on Plate 7, these deposits are found in the Yellowstone Valley. Wells should be successful at depths of 50 feet or less. Water is fit for stock.</td>
</tr>
<tr>
<td>(9)</td>
<td>Faulted zone</td>
<td>Rapidly changing geologic conditions. Fair to good water in sandstones of the Lance, Judith River, and Eagle formations. Numerous springs.</td>
</tr>
</tbody>
</table>

The writer believes that the preceding explanation is sufficient for generalized purposes, and that for further details, Plate 8 and the description of the townships of that certain district should be studied. A "successful well" is often the deciding factor between a good and poor farm or ranch.
Generalized Map of Lake Basin Region

Showing Zones of Ground-Water Occurrences
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GEOLOGIC MAP
OF THE
LAKE BASIN FIELD
AND
ADJACENT AREA
IN
MONTANA

Compiled from
U.S. Geol. Survey Bull. 691-D
U.S. Geol. Survey Bull. 822-A