64-7

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 64-7

GROUNDWATER RESOURCES OF THE EMERSON AREA, MANITOBA (TOWNSHIPS 1 TO 6, RANGES 1 TO 5 EAST OF PRINCIPAL MERIDIAN)

(Report and 13 figures)

J. E. Charron

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1965

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ABSTRACT

A groundwater study of the Emerson area was carried on during the summer of 1961. The area covered is south of Winnipeg and part of the Red River Basin, and encloses approximately 1,000 square miles.

Of geological interest are minor ridges in the form of swells in the lacustrine plain, which are described as ice-crack features.

The groundwater study shows clearly that the best aquifer is the limestone of the Red River Formation. In general the water from this aquifer is soft (approximately 100 ppm) with a total dissolved solids content of about 500 ppm. It is assumed that yields of 100,000 gallons per day are possible. This aquifer is without a doubt the best yet encountered in the Red River Basin.

GROUNDWATER RESOURCES OF THE EMERSON AREA, MANITOBA (TOWNSHIPS 1 TO 6, RANGES 1 TO 5 EAST OF PRINCIPAL MERIDIAN)

INTRODUCTION

The area covered by this report totals 1,080 square miles. It is bounded by the principal meridian (approximate longitude 97°28') and range 5 east (approximate longitude 96°46'), and the International Boundary and Township 6 (approximate latitude 49°31'). The report deals with the municipalities of Franklin, Montcalm, De Salaberry, the eastern part of Morris, the south-eastern part of Rhineland, and the west-central part of Hanover (Fig. 1).

Highways 75 and 59 cross the area from south to north, highway 23 crosses the area from the west as far east as highway 59. A well-developed network of gravel and earth roads make any part of the area (except the central eastern margin) easily accessible in dry weather. Two lines of the Canadian National Railways and one of the Canadian Pacific Railway also serve the Emerson area.

The economy of the region is almost entirely agricultural.

Water Supplies

The population of the area is approximately 17,000, of which 6,000 live in small towns or villages and the remainder on farms. The livestock consists of 20,500 cattle and hogs and 210,000 poultry.

Two towns, Morris (population 1,300[1]) and Emerson (population 900[1]), and also the village of Dominion City (population 600[1]) have waterworks systems supplying treated river water. The rest of the population of the area obtains water from wells, cisterns, dugouts, or by hauling.

Of the 2,040 homes visited by the author, 1,117 have wells. Of these 1,117 homes, 193 do not make use of their wells for

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[1]Economic Atlas of Manitoba; Manitoba Dept. Industry and Commerce (estimated population, 1960).

various reasons, and many of the other wells do not supply water all year round, especially at a time of drought, such as was experienced in the summer of 1961. Throughout the area cisterns and dugouts, as an alternative supply of water, are used extensively. In all, more than 1,127 homes use cisterns, plus an innumerable number of barrels, to collect rain-water or to store hauled water. More than 1,178 dugouts were counted.

Of the 923 homes without a well or a treated water supply, 696 obtain water by hauling from places such as Winnipeg, Emerson, St. Pierre, Dominion City, La Rochelle, Morris, St. Malo, Barkfield, and Ridgeville, or from the well of a more fortunate neighbour. One hundred and eleven more homes obtain water from wells at dugouts.

The cost of the water to be hauled can be as high as $ 1.50 per 1,000 gallons, or it may be free of charge if taken from municipal wells such as at Barkfield, St. Pierre, or Ridgeville. The cost of transporting the water varies with the distance hauled, and can be as high as $14.00 per 1,000 gallons.

These data show the lack of potable water in the Emerson area.

Well Construction

Most of the wells in the area are shallow dug wells. Such wells are generally 4 feet square if the crib is made of wood and about 3 feet in diameter if made of cement rings. The wells average 15 feet in depth.

Wells averaging 50 feet in depth are bored 1 foot to 2 feet in diameter and the crib consists of galvanized tin.

Deeper wells are drilled. The iron casing used in these wells varies from 2 to 6 inches in diameter.

In the Emerson area, pump tests and well-developing techniques (such as putting in screens, well-points, surging, or gravel-packing) are not commonly used, with the result that quantitative data are scarce and unreliable.

Soft Water

Even though the well water of the region is generally excessively hard, the use of water softeners is rare, because of the extensive use of cisterns to collect rain-water.

(Throughout this report and the accompanying maps, the word "potable" is used to describe water which the people of the area have been drinking for many years without any apparent ill effects, even though an analysis of the water in some cases might not permit its classification as "potable" by World Health Organization standards.)

Previous Work and Acknowledgments

The only previous groundwater study made in this area was that by Johnston (1934)[1]. His work was a general one, covering the greater part of southern Manitoba; it locates and describes some 33 wells, and outlines and explains the hydrology of a large flowing artesian basin which extends outside the Emerson area.

Appreciation is expressed to the residents of the area for their excellent cooperation, to the various authorities, municipal, provincial and federal, and to my able assistant Mr. D. Stinson.

PHYSICAL FEATURES AND GENERAL GEOLOGY

Topography and Drainage

The Emerson area can be divided into two parts: the western two thirds, west of the 800-foot contour, which is an extremely level lacustrine plain with relief only in the form of elongated swells and swales, and the eastern one third, east of the 800-foot contour, which is a gently undulating till plain. The elevation of the map-area ranges from 750 feet above sea-level in the lacustrine plain at Red River to 975 feet in the extreme south-eastern corner in the till plain.

The drainage normally is more than adequate, except in the central eastern margin of the map-area, where swamps occur. In general in the till the drainage flow is southeast to northwest and

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[1]Dates and/or names in parentheses refer to publications listed in the References.

all streams are intermittent. Apart from Roseau and Rat Rivers, these streams, at the times of high flow, are carried over the lacustrine plain to Red River in man-made drainage ditches. The principal river of the area is Red River, which meanders from south to north across the lacustrine plain (Fig. 1). Along the course of this river are numerous cut-offs and oxbow lakes. The land adjacent to Red River, throughout the Emerson area, has been the scene of many major spring floods.

The flatness of the area is basically due to the nearly horizontal bedrock underlying the till, and because of this flatness little erosion has taken place.

Underlying Rocks

As bedrock does not outcrop in the Emerson area, knowledge of the geologic formations under the thick surficial sediments is based on well logs. Figure 2 is a structure-contour map, which shows also isopachs of two of the various rock formations of the region.

The Precambrian rocks slope slightly south of west and form the base on which the other rock formations rest. The log of a well 1 mile north of the map-area, Township 7-4E, shows the top of the Precambrian to be 536 feet below ground level, whereas another well 1/2 mile west of the map-area, Township 5-1W, gives the top of the Precambrian as 951 feet below the surface, a drop of 415 feet in approximately 28 miles.

Overlying the Precambrian rocks are Ordovician rocks, the oldest of which are shale and sandstone of the Winnipeg Formation, ranging in thickness from 175 feet in the north to 75 feet in the southeastern corner of the area. The Red River Formation, ranging in thickness from 281 to 510 feet from east to west, overlaps the Winnipeg Formation, but only in the northern part of the map-area. To the south, rocks of Jurassic age, consisting of shale of the Amaranth Formation, occur in place of the limestone and dolomite of the Red River Formation found to the north. Ordovician shale of the Stony Mountain Formation overlaps the Red River beds only in the northwestern corner of the area.

The unconsolidated surficial deposits lie mainly on the beds of the Red River Formation in the northern part of the area and on the shale of the Amaranth Formation to the south (see Fig. 2).

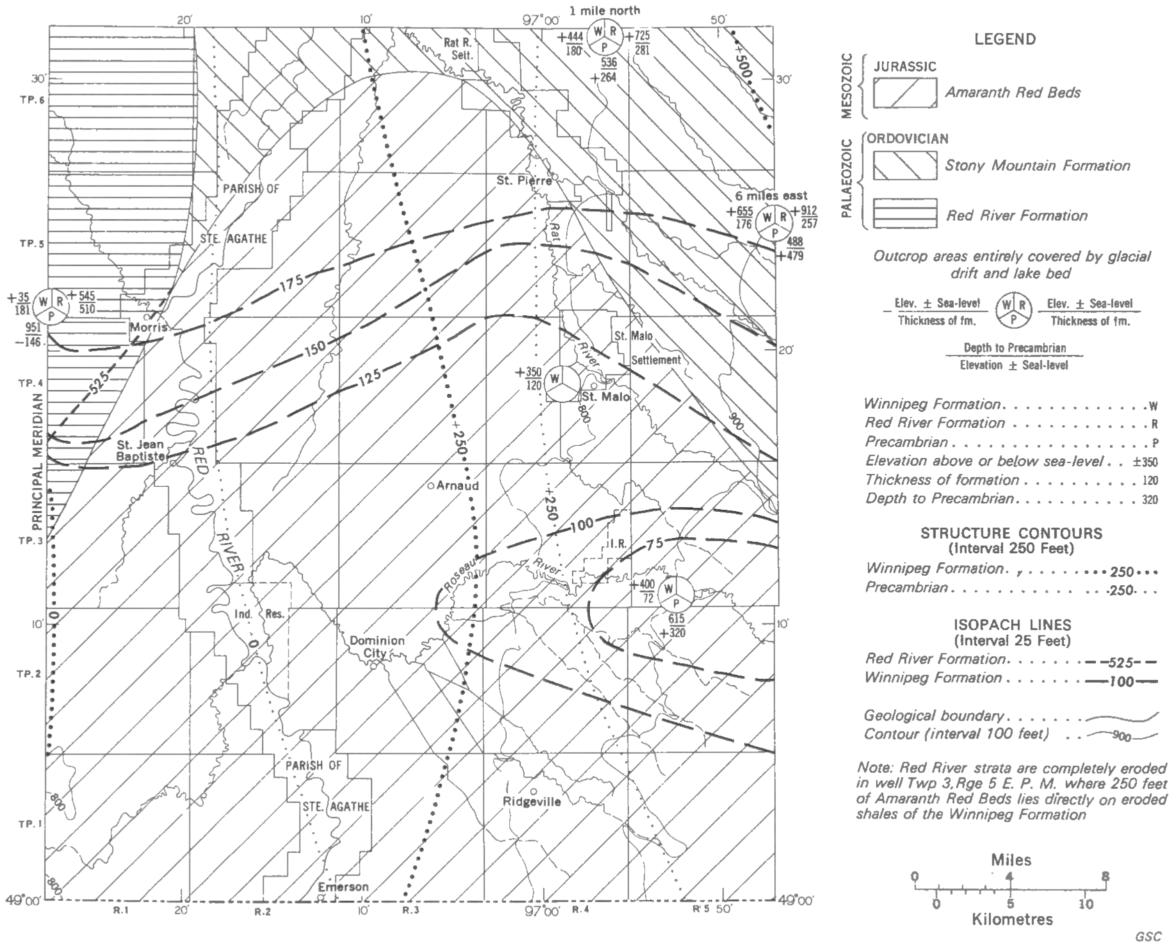

Figure 2. Structure contour and isopach map of Emerson area (from stratigraphic map series 10, 11, and 12, Manitoba Department of Mines, 1960).

Surficial Deposits

Glacial

During Pleistocene time, till was deposited by a continental glacier at more than one time, first upon the then exposed bedrock, then over previously laid till over the entire Emerson area. Presumably the till now under the lacustrine sediments was deposited principally as ground moraine. Till exists at the surface along the entire eastern margin of the area. Where exposed its thickness ranges from 70 feet in the north to more than 250 feet in the southern part. The till is thinner where overlapped by lacustrine sediments than it is where exposed, ranging in thickness from 50 feet and less in the north to a maximum of 100 feet in the south.

Where exposed at the surface the till has been in places reworked by the waters of glacial Lake Agassiz or had younger melt-water deposits laid over it. Therefore, features such as beaches, eskers, ground moraine, end moraine, and glacial outwash do exist in the area. Figure 1 shows many glacial features but does not differentiate them by their generic names.

The till in the map-area can be divided into two types: unconsolidated and consolidated. Where exposed at the surface the till is unconsolidated and granular. The particle sizes of this material vary from very fine to large boulders. Its thickness can range from 1 foot to more than 100 feet. Below the unconsolidated till is a highly cemented till, commonly known as "hardpan". The particle sizes of this consolidated till vary as in the other stratum, but the entire mass is cemented by a dry silty clay matrix. The thickness of this stratum varies commonly in the same proportion as in the unconsolidated till.

In addition to the till exposed at surface in the eastern third of the area, two small lenses of glacial outwash, occurring in the form of mounds, can be found at the surface among the lacustrine sediments, east of Red River in Townships 4-2E and 5-2E.

Economically, the exposed till is poor agricultural land, but the sand and gravel deposits derived from it are worked extensively for road aggregate.

Lacustrine

Lacustrine deposits of glacial Lake Agassiz, consisting of clay, overlie the till throughout the western two thirds of the Emerson area.

The clay immediately above the till is grey to blue-grey and is locally called "blue clay". It is moist, plastic, uniform, and contains very few small pebbles. Its thickness varies widely, but increases from north to south as well as from east to west, to a maximum of more than 100 feet in the southwestern corner of the area.

A yellowish to tan clay overlaps the blue clay. It also is plastic, but is more silty than its counterpart below and therefore has a higher moisture content. The total thickness of this tan clay does not exceed 30 feet.

The top layer, called soil, is a dark organic silty clay ranging from a few inches to a foot or more in thickness. This is the rich agricultural land for which the entire Red River Valley is known.

The clays are as much as 30 per cent montmorillonite, which has a large concentration of alkaline sulphates and which also undergoes large volume changes with moisture changes. It is by far the most extensive unit exposed at surface in the entire area.

Other existing surficial deposits are the alluvium deposits found along the Red, Roseau, Rat, and Marais Rivers. The most extensive of these are found along Red River. In the case of Red and Marais Rivers, these deposits consist of a yellow silty clay which is deposited at times of high flow inside the meanders of these rivers. The thickness of these deposits is no more than 10 feet. Shallow deposits of sand and fine gravel occur in the clay along the river banks of Roseau and Rat Rivers, but for no more than a few miles from the till boundary.

Minor Ridges in the Clays of Lake Agassiz

Figure 1 shows numerous linear features over many parts of the clay plain, some of them intersecting one another. The greatest concentration occurs in the north-central part of the area. These lines actually represent ridges or swells in the clay. Both Horberg (1951) and Colton (1958) have defined these ridges as ice-crack features.

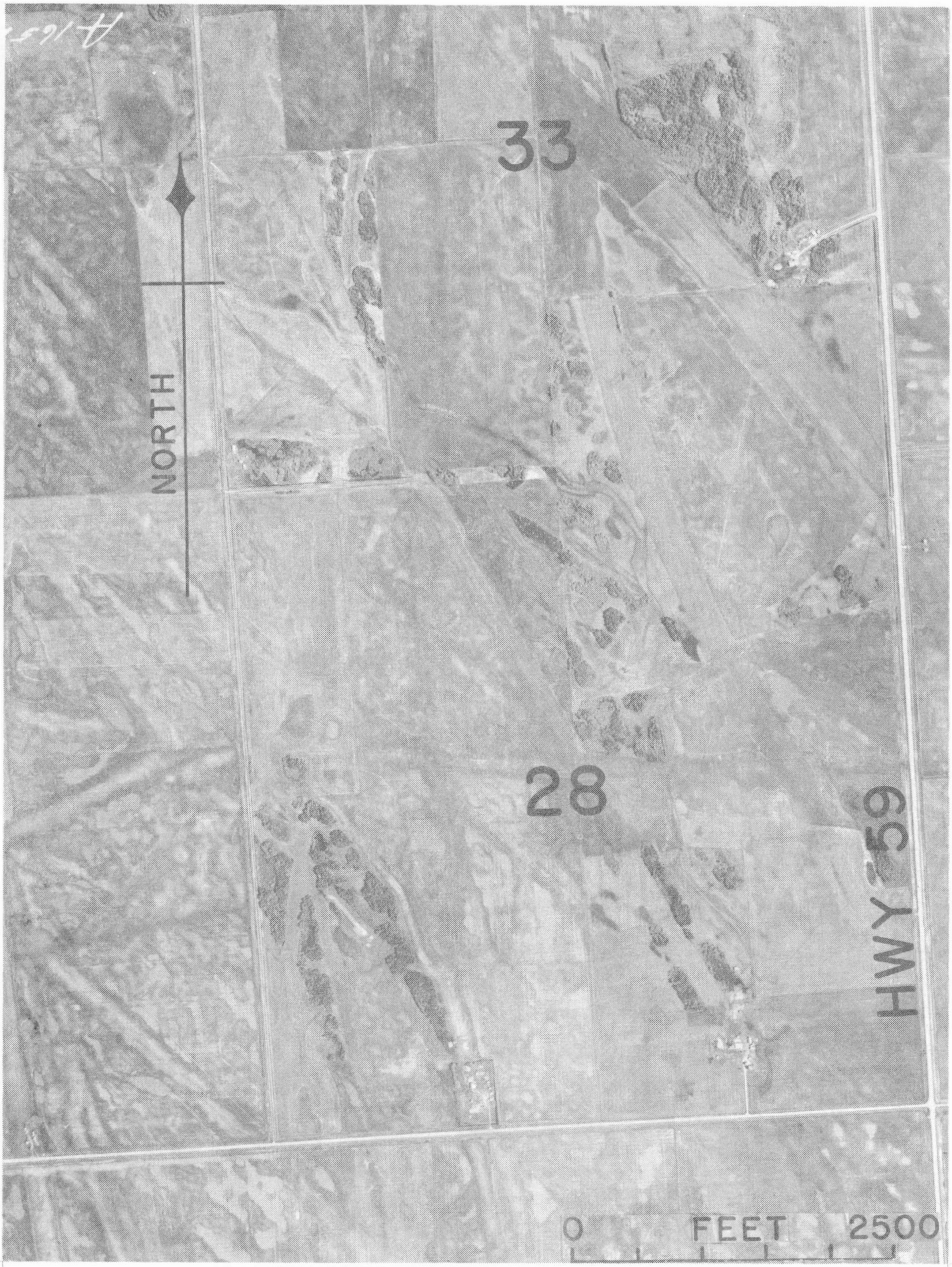

PLATE I - Aerial Photo #A-16521-177 showing ice-crack features. Location - township 6, range 4 east, sections 20, 21, 22, 27, 28, 29, 32, 33, 34.

The ridges or swells are 1 foot to 8 feet high, 40 to 400 feet wide and as much as 4 miles long. They form linear patterns that are easily seen on aerial photographs (Plate I), but which would generally pass unnoticed on the ground. On aerial photographs the ridges appear as light-coloured strips compared to the dark grey of the surrounding clay. The contrast results from the moisture and organic content of the soil.

Bore-holes drilled in a ridge along highway 59, in section 33-6-4E, show that the first 5 feet of the ridge consists of dry, fine, tan-coloured sand, which grades downward into 3 feet of silt, which in turn grades into blue clay similar to that in the surrounding land around the ridge.

These minor ridges were seen only on the lacustrine sediments; none were found to the east in the till plain of the Emerson area.

Climate

The data used here were obtained from the Economic Atlas of Manitoba, 1960.

The Emerson area has a continental-type climate with large seasonal temperature ranges. It is moderately dry much of the year.

Precipitation

Over a 30-year period (1921-1950) the average annual precipitation was 19 inches; the average annual snowfall was 45 inches[1]. More than 40 per cent of the total annual precipitation, 7.5 inches, falls from May to July, which are the critical months of the growing season.

Over 59 years, the rainfall in 10 per cent of the years was below normal (12 to 15 inches) and in 10 per cent of the years above normal (21 to 25 inches). During 66 per cent of the years rainfall varied from the normal by only 2 inches.

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[1] 10 inches of snow equals 1 inch of rain.

Although almost 70 per cent of the total precipitation falls during the growing season, May to August, most of it falls from thunderstorms and is lost, mostly as run-off. Hot humid air from the south meeting cool arctic air from the north causes an average of 15 to 20 thunderstorms in these months. The greater the contrast between the two air masses the more violent the storm.

According to Thornthwaite and Mather (1957) there is a net annual moisture deficiency in areas too dry to support deciduous forest cover. This is true at least in the clay plain of the Emerson area, where the potential evapotranspiration is 21.65 inches, the average moisture deficit is 3.94 inches, and the average moisture surplus is zero. This region, by Thornthwaite's classification, would be a transitional dry sub-humid region.

Temperature

For the 30-year period 1921-1950, the average annual range of temperature based on the difference between the January (2°F) and July (69°F) averages, was 67°F.

Mean monthly temperatures are below 32°F for five months, November to March, and are above 50°F from May to September. Therefore the transition from winter to summer is accomplished in one month, April, and from summer to winter during the month of October.

During the summer months an average of 20 tropical days may be expected during which the mean maximum temperature exceeds 86°F.

Because the soil in the Emerson area is mainly clayey, because the greater part of the annual precipitation falls as severe thunderstorms, and because a moisture deficit exists, very little of the total precipitation can percolate through the ground to eventually become groundwater.

GROUNDWATER SUPPLY

Figure 1 shows the location and extent of areas of potable water yielded by the different aquifers[1]. It also shows the location, depth, and type of well used to obtain the water, the various artesian flow zones, and a generalized columnar section of the various aquifers in the Emerson area. A table with references on each individual well shown on Figure 1 is kept on file by the Groundwater Section of the Geological Survey of Canada.

There are two types of aquifers in this area, unconfined and confined.

Unconfined Aquifers

This type exists near the surface of the ground. In every case the water is free and the level at which it is encountered is called the water table. Most wells in the Emerson area are sunk into this type of aquifer because they can be cheaply and easily dug as no great depths have to be reached. The unconfined aquifers of the Emerson area can be divided into three groups according to their geologic formation: (a) aquifers in alluvium, (b) aquifers in glacial outwash, and (c) aquifers in till.

In Alluvium

Unconfined aquifers in alluvium are found along the Marais, Rat, Red, and Roseau Rivers, but do not extend over wide areas. Wells in such aquifers are generally dug to an average depth of 15 feet.

Along Marais and Red Rivers the aquifer consists of a sandy silty clay. Therefore wells in this aquifer yield little water, ranging from 10 to 50 gallons per day. Because of this low yield the location of a permanent well site should be carefully chosen, generally on the information from test-holes. On most farms in the area the well is located in the farm yard close to the buildings, because more importance is given to the accessibility of the well than to the quantity and quality of the water.

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[1] Geologic formations or structures that transmit water in sufficient quantity to supply pumping wells, or natural springs, are called "aquifers".

Though lacking proof the writer believes that recharge of this aquifer along Marais and Red Rivers occurs mainly during the spring months, at times of strong run-off. The river beds are then full of water, and sometimes overflow. Because of this the groundwater flow in springtime is influent, that is, from the river to the adjacent ground, and bank storage occurs. During the dry summer months the direction of groundwater flow is reversed and gradually the water table in the wells goes down, so much so in fact, that at times of prolonged drought these wells go completely dry.

Along these rivers, in areas where wells are found, the establishment of small dams to hold back some of the spring run-off in the river bed would retard the lowering of the water table in this aquifer and increase recharge. Such dams would need to be constructed so that they would not cause greater flood problems in the springtime.

The aquifer along Rat and Roseau Rivers is sandier than the aquifer along Marais and Red Rivers. The sand is derived from the till plain to the east and is carried by the streams during spring run-off. These sandy deposits do not extend far into the clay plain. Most of the wells obtaining water from these sands are found a mile or so north of St. Malo, along Rat River.

The water from the unconfined aquifers in alluvium is potable and is used on farms for domestic and stock purposes.

At the present time fewer farms each year seem to derive their water from this type of aquifer, because of the low yield of the aquifer as well as the frequency with which wells in the aquifer go dry during times of drought.

In Glacial Outwash

The small glacial outwash deposit in the clay plain in Townships 5-2E and 4-2E (Fig. 1) is a good aquifer, although the quality of the water it yields is not too good (Table I, analysis #35). The aquifer is approximately 5 miles long, for it can be seen in a gravel pit in section 6-5-2E and it provides water to five wells in section 34-4-2E. Throughout this distance, however, it may be less than 200 yards wide. Wells are dug into it to a depth of 25 feet and water is encountered in sand and gravel. The static water level is 20 feet below the surface of the ground. As much as 10,000 gallons per day are being pumped from this aquifer from five wells situated on one farm.

Because the outwash deposit is at a slightly higher elevation than the country surrounding it, the tops of the wells dug into this aquifer are not submerged by floodwaters each spring, and the water in them, therefore, should not be contaminated. A constant yield has been supplied by wells in this aquifer even during the dry years of the 1930's.

Recharge is probably due to the annual average 19 inches of precipitation, but it is also possible that some recharge occurs in the springtime at flood level because the northernmost tip of the aquifer is within 1/2 mile of Red River.

Further study by resistivity methods and some drilling would permit outlining the exact extent of the aquifer and calculating its possible yield. It might also show that artificial recharging of this aquifer using Red River water is feasible, thus allowing for greater yields than are now available. Such a study could greatly benefit the town of Morris, which is situated across the Red River about a mile from the aquifer.

In Till

The largest unconfined aquifer in the Emerson area occurs in till and extends over the eastern third of the area (see Fig. 1).

Because the unconsolidated till that makes up this aquifer differs considerably in texture from place to place the amount of available water in the aquifer also differs considerably from place to place. This means that one farm may obtain enough water from one well, whereas another farm will need two or more wells to satisfy its needs. Hence the location of permanent well sites in the area underlain by this aquifer should be chosen carefully and on the basis of data obtained from several test-holes. Such careful selection may mean the difference of adequate or inadequate water supplies in very dry years.

All wells in this aquifer are shallow, averaging 15 feet in depth. The static water level is approximately 8 feet below the ground. Data are not available to plot a water-table contour map, but the writer believes that the water-table profile is parallel to the topographic profile and that groundwater flow is from southeast to northwest, parallel to the surface drainage.

Numerous springs along the streams that cut through the till flow only during years of normal or above-normal precipitation. A few spring wells exist in Township 2, ranges 4 and 5E. These 2-inch wells are driven to a depth of 14 feet in sand and gravel. The flow of one such well, situated in section 16-2-5E, was measured as 3 gallons per minute in the month of June. Even though the summer of 1961 was an extremely dry one the same well still yielded 1 gallon per minute in September of the same year.

To the east of Emerson map-area drainage is poor and large swamp areas exist, which constantly recharge this till aquifer. For this reason the water table is fairly constant and the most productive wells in the aquifer supply water at all times. Nevertheless it must be kept in mind that the yield from this aquifer is only sufficient for farm use.

One well in this aquifer, situated in SW16-1-4E, is operated by the rural municipality of Franklin and is used by the inhabitants in the clay plain in that vicinity.

A greater use of sand-points in well construction would seem justified for this aquifer. Sand-points cannot and should not be used everywhere, but where the water table is high and where the aquifer is made up of clean coarse sand or gravel, greater use of them could be made. The cost of a sand-point is similar to the cost of the material used in a dug well, but the time spent in driving in a sand-point is much less than the time spent in digging a well of the same depth.

Confined Aquifers

In this map-area a confined aquifer can be found underneath the lacustrine clay or below the till. Therefore greater depths have to be reached to encounter a confined aquifer than are required to find an unconfined aquifer. If a well pierces a confined aquifer the water in the well will rise because it is under pressure. The level to which the water rises may lie below or above the water table and it may even rise above the ground surface.

Figure 1 does not show each confined aquifer in its entirety, but only the area where its water is considered potable.

The recharge area of these aquifers is east of the map-area at an elevation between 1,100 and 1,300 feet above sea-level, which makes it 300 to 400 feet higher than the surface at St. Pierre, which in turn is approximately 800 feet above sea-level. The elevation of the confined aquifers near St. Pierre varies between 450 and 700 feet above sea-level and the water rises from that depth up to and above ground level.

In the Emerson area confined aquifers can be divided into two groups, aquifers in till and aquifers in bedrock.

In Till

Confined aquifers in till are of two types: one is an extension of the unconfined aquifer where the unconsolidated till is overlapped by the lacustrine clay, and the other consists of sand and gravel lenses or deposits within the consolidated till.

Water obtained from the confined aquifer in the unconsolidated till beneath the lacustrine clay as seen on Figure 1 is, with rare exception, not potable. The water level in the wells can vary from 40 feet below ground level to 1 foot above it. The yield of such wells is approximately 500 gallons per day and will suffice only for farm use. Therefore because of its low yield and generally poor-quality water, this is not considered a good aquifer, and its use, in general, is mainly to supply water for livestock.

The consolidated till in itself is not an aquifer. The aquifers are the lenses or deposits of sand and/or gravel which are found in it, especially at the till-bedrock contact. In Township 6-4E this type of confined aquifer is encountered at 80 to 100 feet in depth whereas to the south in Township 1-4E it has been struck as deep as 245 feet. Along the eastern part of the map-area the water from this aquifer is potable whereas west of a line almost wholly within the margins of range 4E, the water is too salty for human consumption.

In general the water in wells in this aquifer rises to within 15 feet of the surface, but where the water is obtained from the till and bedrock contact it rises 1 foot or more above the ground level. Various places where the water obtained from this aquifer rises above the ground are shown on Figure 1.

This aquifer is used extensively for water supplies in the northeastern part of the Emerson area, but its yield to wells is small. The measured maximum natural flow of one well in it was 5 gallons a minute. Therefore the amount of water derived from the aquifer is only sufficient to supply individual farms. Where the water from the aquifer is salty, as in the western part of the map-area, it is used only for livestock.

Because the drilling of a well to the confined till horizon is expensive and often discouraging, the following suggestions are offered for regions of probable salty water. The top half of the till is the best part from which to obtain potable water, for there is less chance of salty contamination from below because the hardpan acts as an almost impermeable layer. Therefore, once a sand or gravel lens is encountered that yields potable water, drilling should be stopped. Also, slow continuous pumping is preferable to fast irregular pumping, to minimize again the infiltration of salty water from the bedrock below.

In Bedrock

Bedrock aquifers exist beneath the till over the entire map-area. As in the till, a transitional zone running in a northwestern-southeastern direction defines the fresh-water, salt-water limits of these aquifers from east to west. Figure 1 shows that the water from a bedrock aquifer is potable only in the northeastern corner of the Emerson area.

Except for wells near the village of Grunthal, all wells drilled to bedrock in this area have flowed or still flow at surface.

There are two bedrock formations that can be called aquifers in the Emerson area: a limestone member of the Red River Formation, and a sandstone member of the Winnipeg Formation. The most important and interesting aquifer is the limestone aquifer, which is encountered throughout the northern half of the map-area. The biggest concentration of wells obtaining water from this limestone aquifer is in the St. Pierre village region; there, good water which is considered soft (approximately 100 ppm) for this part of the country, is available. Within 144 square miles some 169 wells were counted, which together yielded a natural flow of more than a million gallons of water per day. The minimum measured flow in any well was only 1 gallon a minute, whereas the maximum measured flow was 16 gallons a minute.

At St. Pierre the Red River Formation is between 250 and 300 feet thick, and the limestone aquifer zone in it is approximately 150 feet thick. The water is probably available from fissures, joints, and openings in the limestone. The average depth to water is 325 feet, and the water rises to the maximum measured height of 16 feet above ground level. The municipality of De Salaberry operates one such well in the village, which is used by anyone willing to haul the water at his own expense. The village has no main water-distribution system. Instead, individuals have formed groups or cooperatives, which share the cost of a well and then they all connect to it. One such well supplies nineteen families. Within the village limits of St. Pierre, 23 flowing wells were counted.

Most wells in this aquifer are 5 inches in diameter. Casing is used to bedrock and no pumping is required to deliver the water. The unused surplus of the water from all wells tapping this aquifer is left flowing at all times. The tremendous loss of unrecoverable groundwater through the flow of these wells, through the years, is considerable, for some wells have been flowing since 1916. Therefore there is depletion of the aquifer, a lowering in the pressure, and consequently a lowering of the piezometric surface. Many of the older inhabitants affirm that the flow of water from these wells in the area has decreased. In some wells the flow has ceased completely and the wells now have to be pumped. No excessive pumping has yet occurred in the area, but if more wells are drilled and pumping is increased it is easy to predict that most or all wells in the region will stop flowing. To keep the wells flowing and at the same time conserve this limestone aquifer for many years (pressure will also increase if consumption of water remains the same) all the wells should be prevented from flowing freely, thereby curtailing the unnecessary wastage of water.

Little is known about the second bedrock aquifer of this area, which consists of the sandstone of the Winnipeg Formation. West of the map-area in Township 1 this aquifer is known to yield very salty water, whereas east of the map-area in Township 5 fresh water is available from the same aquifer. In both places the water is under artesian pressure and flows at surface. Within the Emerson area itself one hole drilled at Arnaud many years ago to a depth of 710 feet yielded salt water, probably from the sandstone of the Winnipeg Formation. The author believes that the 480-foot-deep municipal well in the village of St. Malo may also be tap water from the sandstone of the Winnipeg Formation rather than from the limestone of the Red River Formation, as is commonly believed, or from a sandstone of the Stony Mountain Formation, as was suggested by Johnston (1934).

If the general trend is followed by this aquifer as was the case in the other aquifers found in the Emerson area, it should yield more and better-quality water towards the east, especially east of the map-area.

No pump tests have been carried out to establish the productivity of these bedrock aquifers. Evidence to date indicates that the limestone aquifer near St. Pierre is capable of supplying small industries, if not large ones. Because of this, a drilling program with a properly conducted pump test is required to determine the coefficients of transmissibility and storage of the aquifer. Furthermore, the St. Pierre region is only about 35 miles south of Winnipeg and the aquifer may extend northward, closer to Winnipeg.

CHEMISTRY OF THE GROUNDWATER

Forty-two groundwater samples taken from representative wells in the various aquifers in the Emerson area were analyzed by the Industrial Minerals Division of the Mines Branch, Department of Mines and Technical Surveys, Ottawa. The analyses show the dissolved mineral content of the waters, but do not indicate whether a water that is reported to be chemically potable is bacteriologically safe. The results of the analyses are given in Table I. From the figures given at the end of the table a comparison can be made between the analyses and the established standards. For the Emerson area, water with a sum of constituents less than 500 parts per million can be considered as excellent water; less than 1,000 ppm can be considered as good water; and less than 1,500 ppm as fair water. Water containing more than 1,500 ppm cannot be considered as potable water, although it is being used as such in many places.

From these forty-two analyses the following generalities are derived: (1) the groundwater is hard, in places extremely hard, except in the limestone aquifer; (2) it is high in iron; (3) the pH indicates the water is alkaline; (4) a high fluoride content exists in the limestone aquifer along the west of Rat River (Fig. 3), whereas abnormally low sulphates are found east of Rat River in the north-eastern corner of the map-area; and (5) the chloride content and the total sum of constituents of the groundwater in the confined aquifers increases from east to west, that is as the distance increases from the recharge area (Figs. 10 and 11).

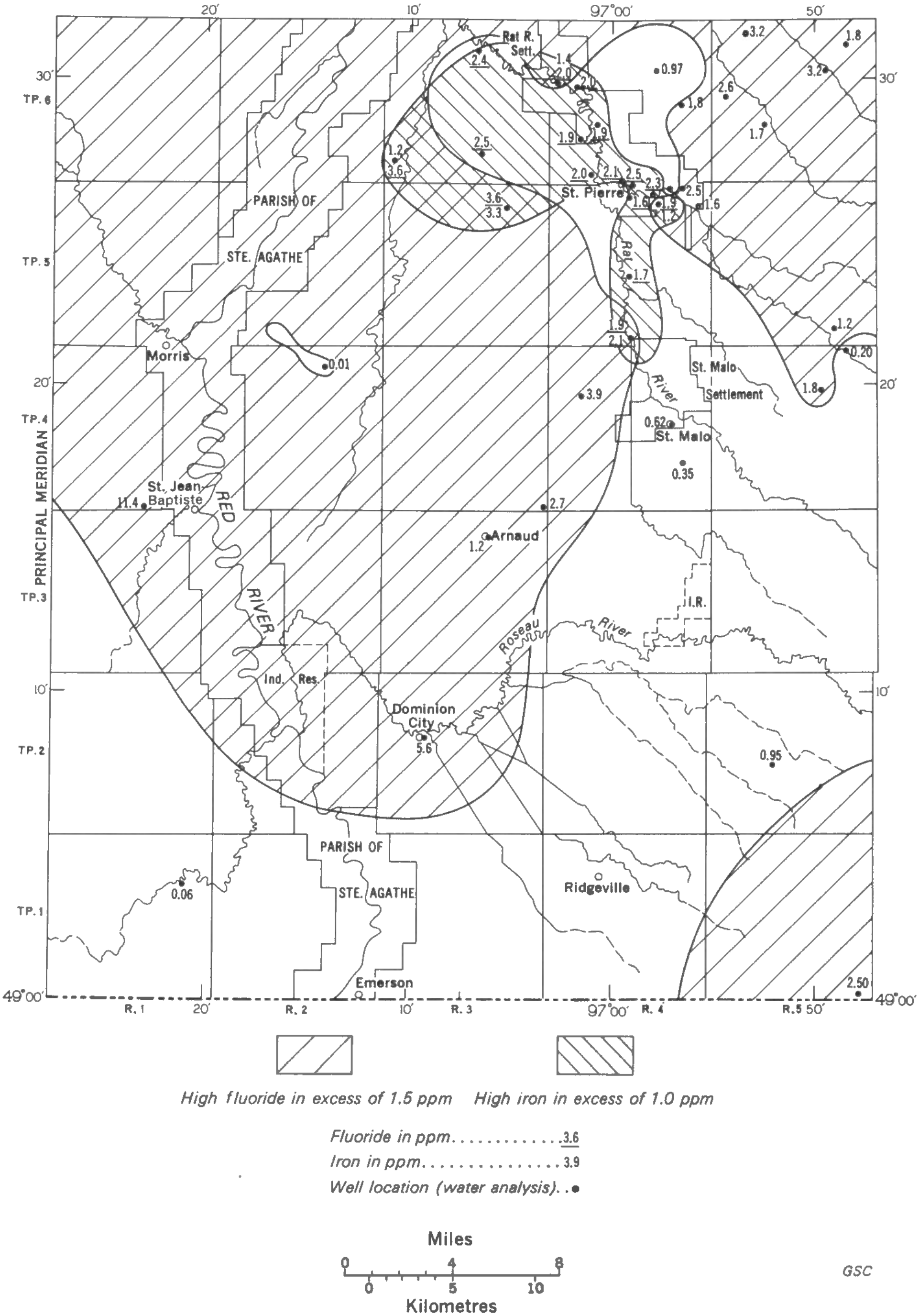


Figure 3. Areas of high fluoride and high iron concentration.

Table I

Chemical Analyses of Groundwaters in the Emerson Area, Manitoba

(Analyzed by the Industrial Minerals Division, Mines Branch, Department of Mines and Technical Surveys)

								Chemical Constituents in Parts per Million														
								Hardness as $CaCO_3$														
Sample No.	Location	Type of Aquifer	Temperature (°F)	Colour (Hazen unit)	pH	Carbon Dioxide (CO_2)	Conductance (micromhos at 25°C)	Non-Carbonate	Total	Total Alkalinity as $CaCO_3$	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Iron (Fe)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Silica (SiO_2)	Sum of Constituents	% Sodium
1	SW 16-2-5E	U	44	5	7.7	14	746	25	350	325	72.0	41.5	28.0	4.6	0.95	396	73.0	10.3	0.5	0.0	24	448	15
2	NE 35-4-5E	C	45	5	7.8	13	692	0	265	372	49.5	34.4	51.5	6.2	0.20	453	1.2	8.5	0.6	0.1	15	390	29
3	SE 17-6-5E	C	47	5	7.8	12	660	0	307	368	61.0	37.5	28.0	4.8	1.70	449	1.1	3.2	0.4	0.0	15	372	16
4	SW 19-6-5E	C	45	10	7.9	9	631	0	296	350	56.5	37.6	26.0	4.8	2.60	427	1.1	4.8	0.3	0.0	14	356	16
5	NW 32-6-5E	C	44	5	7.8	10	616	0	260	320	50.1	32.8	35.0	5.1	3.20	390	1.3	13.3	0.4	3.1	12	345	22
6	SW 26-6-5E	C	56	5	7.8	11	626	0	314	347	65.4	36.5	17.0	3.4	3.20	423	1.3	1.5	0.3	0.1	15	349	10
7	SE 27-6-4E	C	44	10	7.8	11	648	0	226	328	40.9	30.0	54.0	6.8	0.97	400	1.3	18.5	0.7	0.0	11	360	33
8	SE 20-2-3E	C	47	5	7.5	11	10322	2676	2855	179	573.0	346.0	1120.0	17.4	5.60	219	355.0	3410.0	0.7	0.0	22	5951	46
9	NE 27-3-3E	C	44	5	7.5	23	1696	298	652	354	145.0	70.4	99.4	7.1	1.20	432	154.0	246.0	0.3	4.0	27	965	25
10	SE 1-4-3E	C	44	5	7.5	16	3345	947	1207	261	222.0	159.0	240.0	7.9	2.70	318	403.0	769.0	0.5	4.0	19	1980	30
11	SW 29-4-4E	C	44	5	7.5	12	7776	2255	2449	195	577.0	245.0	860.0	10.5	3.90	238	1316.0	2030.0	1.1	8.4	20	5185	43
12	NE 11-4-4E	U	52	10	7.8	12	830	51	424	363	102.0	40.9	13.5	3.1	0.35	442	46.3	28.6	0.2	3.0	13	468	6
13	Lot E-SMS	C	60	10	8.1	5	1443	0	256	317	59.5	26.2	215.0	13.0	0.62	387	191.0	145.0	1.2	0.1	7	849	63
14	Lot 82-SMS	C	46	10	7.9	8	1647	0	173	301	38.7	18.6	290.0	13.0	2.10	367	172.0	243.0	1.9	0.1	7	964	77
15	NE 16-5-4E	C	47	5	8.0	6	1079	0	147	294	30.9	16.8	180.0	10.5	0.63	358	94.0	112.0	1.7	0.1	8	630	71
16	NE 14-6-4E	C	52	10	7.7	14	666	0	151	322	31.7	17.4	86.0	13.0	1.80	392	0.0	21.9	0.7	5.0	22	391	53
17	SE 23-6-4E	C	48	10	7.8	10	1315	0	153	311	27.5	20.6	225.0	9.7	0.12	380	7.0	233.0	1.0	0.1	8	719	75
18	SE 35-6-5E	C	44	10	7.9	9	610	0	274	328	52.3	34.7	28.5	4.4	1.80	400	0.0	7.4	0.4	2.8	12	339	18
19	SW 35-5-4E	C	53	10	8.4	2	1349	0	76	285	12.8	10.6	270.0	10.0	1.20	344	0.5	263.0	1.9	0.1	5	745	87
20	Lot 50-RRS	C	45	5	8.1	5	750	0	173	300	32.9	22.1	95.0	9.2	2.50	366	16.1	50.4	1.0	0.5	10	417	53
21	Lot 48-RRS	C	47	5	8.2	3	716	0	99	263	15.2	14.8	118.0	9.3	0.53	320	0.3	70.6	1.4	1.4	6	395	70

22	Lot 42-RRS	C	60	5	8.1	4	1952	0	133	249	23.3	18.1	364.0	12.0	0.41	303	165.0	371.0	2.3	0.5	6	1112	84
23	Lot 28-RRS	C	43	5	8.0	6	1861	0	90	283	16.6	11.7	370.0	11.0	0.44	344	36.0	407.0	2.5	0.1	6	1030	89
24	Lot 30-RRS	C	48	10	8.0	6	783	0	109	277	20.9	13.8	127.0	9.1	0.47	337	17.1	70.8	1.6	0.1	8	434	70
25	Lot 29-RRS	C	48	5	8.1	5	810	0	117	279	21.3	15.6	130.0	9.4	0.64	340	30.1	70.2	1.5	0.0	8	453	69
26	SE 5-6-4E	C	48	5	7.8	10	1624	0	166	288	36.1	18.5	300.0	11.5	0.44	351	127.0	282.0	2.0	0.4	7	957	78
27	Lot 16-RRS	C	48	5	8.2	4	1945	0	126	283	24.9	15.4	370.0	11.5	0.23	344	56.8	417.0	1.9	0.1	7	1074	85
28	Lot 11-RRS	C	46	5	7.9	7	1065	0	78	270	14.8	10.0	205.0	10.0	0.23	329	13.9	170.0	1.9	0.0	7	594	83
29	Lot 1-RRS	C	45	5	7.9	7	1547	0	95	268	17.2	12.6	295.0	9.5	0.23	326	46.0	303.0	2.0	0.0	9	855	86
30	Lot I-RRS	C	52	5	8.3	3	1602	0	102	261	20.0	12.6	305.0	9.8	1.40	318	56.2	316.0	2.0	0.0	11	889	85
31	NW 27-6-3E	C	48	5	7.9	7	3352	0	196	268	44.7	20.5	650.0	2.3	1.00	327	189.0	809.0	2.4	0.8	7	1886	88
32	SE 10-6-3E	C	54	5	7.9	8	2553	0	173	293	39.7	17.9	475.0	2.1	0.40	357	173.0	531.0	2.5	0.1	7	1423	86
33	SW 35-5-3E	C	56	0	7.9	7	6713	343	588	245	133.0	62.2	1392.0	28.6	3.30	299	1424.0	1356.0	3.6	0.4	6	4553	83
34	NW 6-6-3E	C	50	0	7.5	12	5542	1440	1643	203	571.0	52.9	741.0	24.8	1.20	248	1772.0	871.0	3.6	0.0	8	4166	49
35	SE 34-4-2E	U	50	5	7.5	23	2402	698	1064	366	214.0	129.0	106.0	8.4	0.01	446	237.0	378.0	0.4	206.0	26	1523	18
36	SW 3-4-1E	C	46	5	7.4	18	4600	1287	1509	222	339.0	161.0	367.0	12.5	11.40	271	302.0	1302.0	0.5	1.1	20	2639	34
37	SW 26-1-1E	U	48	10	7.8	20	2675	899	1524	626	407.0	123.0	10.8	7.7	0.06	763	183.0	219.0	0.3	490.0	31	1845	2
38	Lot 25-RRS	C	47	5	8.1	5	2028	0	120	290	24.9	14.0	393.0	12.6	0.87	353	40.8	448.0	2.1	0.3	7	1116	86
39	Lot 53-RRS	C	45	5	8.2	4	614	0	155	286	27.9	20.7	72.0	8.7	1.60	348	3.2	27.3	1.0	0.1	9	341	49
40	NW 2-5-5E	C	48	10	7.8	12	686	0	267	368	49.9	34.6	50.0	6.3	1.20	449	0.0	9.2	0.6	5.0	15	391	28
41	SE 27-4-5E	C	46	5	7.8	9	1079	21	330	309	71.6	36.6	115.0	10.3	1.80	376	213.0	41.6	1.0	0.1	11	685	42
42	SW 1-1-5E	C	58	20	7.4	17	408	0	131	203	23.9	17.2	33.5	12.0	2.50	248	0.7	6.7	0.6	1.4	12	230	33
U-Aquifer average			49	8	7.7	17	1663	418	841	420	198.8	83.6	39.6	6.0	0.34	512	134.8	159.0	0.4	174.8	24	1071	10
C-Aquifer average			48	10	7.9	9	2036	244	433	288	96.4	46.8	284.0	10.0	1.75	351	194.3	406.8	1.4	1.1	11	1224	56
Standards	Permissible		-	5	6.5 to 9.2	-	-	-	150*	125	75.0	50.0	250.0	-	0.30	180	200.0	200.0	0.5	40.0	-	500	
	Excessive		-	50		-	-	-		-	200.0	150.0	-	-	1.00	360	400.0	600.0	1.5	100.0	-	1500	60

U - unconfined.
C - confined.
SMS - St. Malo settlement.
RRS - Rat River settlement.

Permissible - Good potable water.
Excessive - Beyond this range water is not considered potable.

*Hard water.

Date of collection of samples - Sept. 2,6,7,8, 1961.

Temperature

The average temperature of the groundwater at the time of sampling was 48.5°F. Water from the limestone of the Red River Formation is as cool as 43°F. It can be used for cooling dairy products and air-conditioning.

Colour

The average degree of colour of the groundwater is nine Hazen units, which puts it well within the range of normal water.

pH

The lowest pH of groundwater in the Emerson area is 7.4, the highest is 8.4, and the average is 7.8. The pH is slightly higher (7.9) in confined aquifers than in unconfined aquifers (7.7). The groundwater of the limestone of the Red River Formation has a pH above 8.0 along Rat River, whereas the groundwater obtained from the consolidated till underneath the clay plain (Fig. 4) has a low pH.

Hardness

Of the forty-two samples analyzed (Table I), twenty show that the hardness of the water exceeds 200 ppm; in eight of the twenty it is greater than 500 ppm. Therefore, except in the vicinity of St. Pierre, water obtained from future wells can be expected to be hard water. Nevertheless where the iron content of the groundwater is less than 1.0 ppm, water softeners could be employed with difficulty.

The softest groundwater found in the Red River Basin is that derived from the limestone of the Red River Formation near St. Pierre. The lowest total hardness figure obtained is 76 parts per million (Sample No. 19, Table I). In every analysis from this aquifer near St. Pierre the water has very little or no non-carbonate hardness because mineralization is mainly due to bicarbonates of calcium and magnesium. In turn the low calcium and magnesium values are due to the low free CO_2 value. This free CO_2, as carbonic acid, causes solution of the calcium and magnesium thus producing carbonate hardness in the waters of this aquifer. West of St. Pierre, however, the groundwater in this aquifer is high in sodium chloride (NaCl) and is high in non-carbonate hardness.

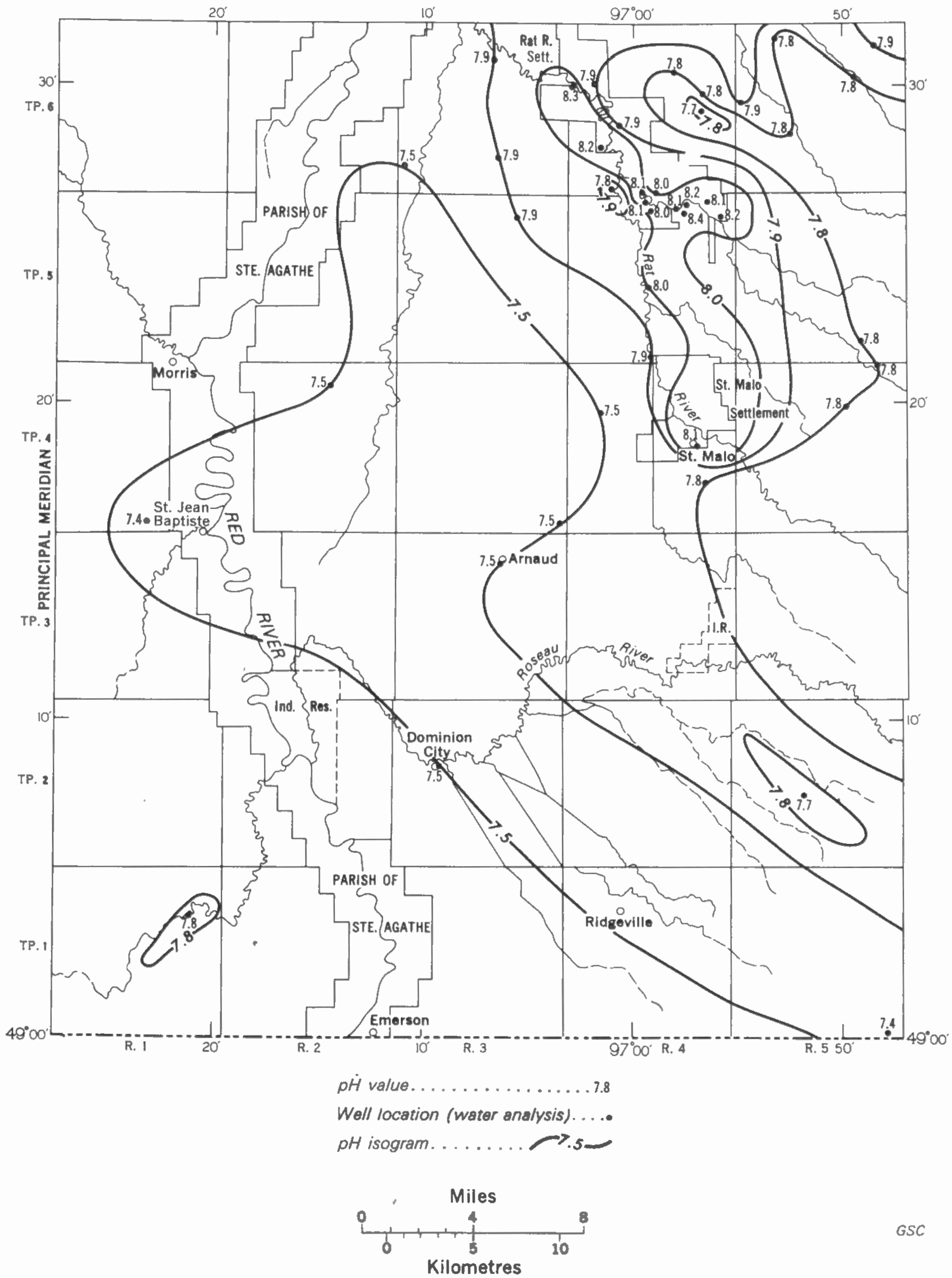


Figure 4. Isogram of pH, Emerson area.

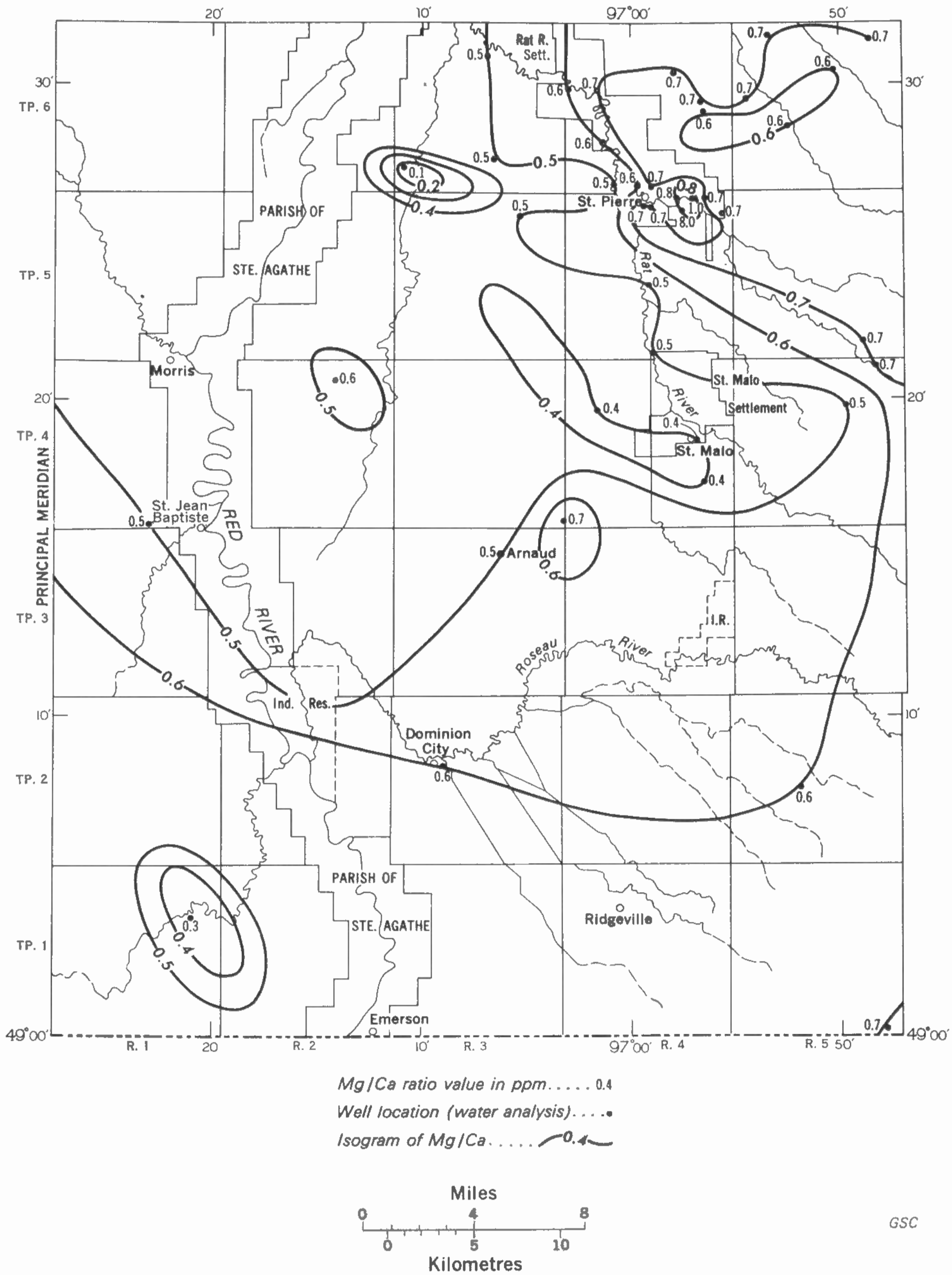


Figure 5. Isogram of Mg/Ca ratios, Emerson area.

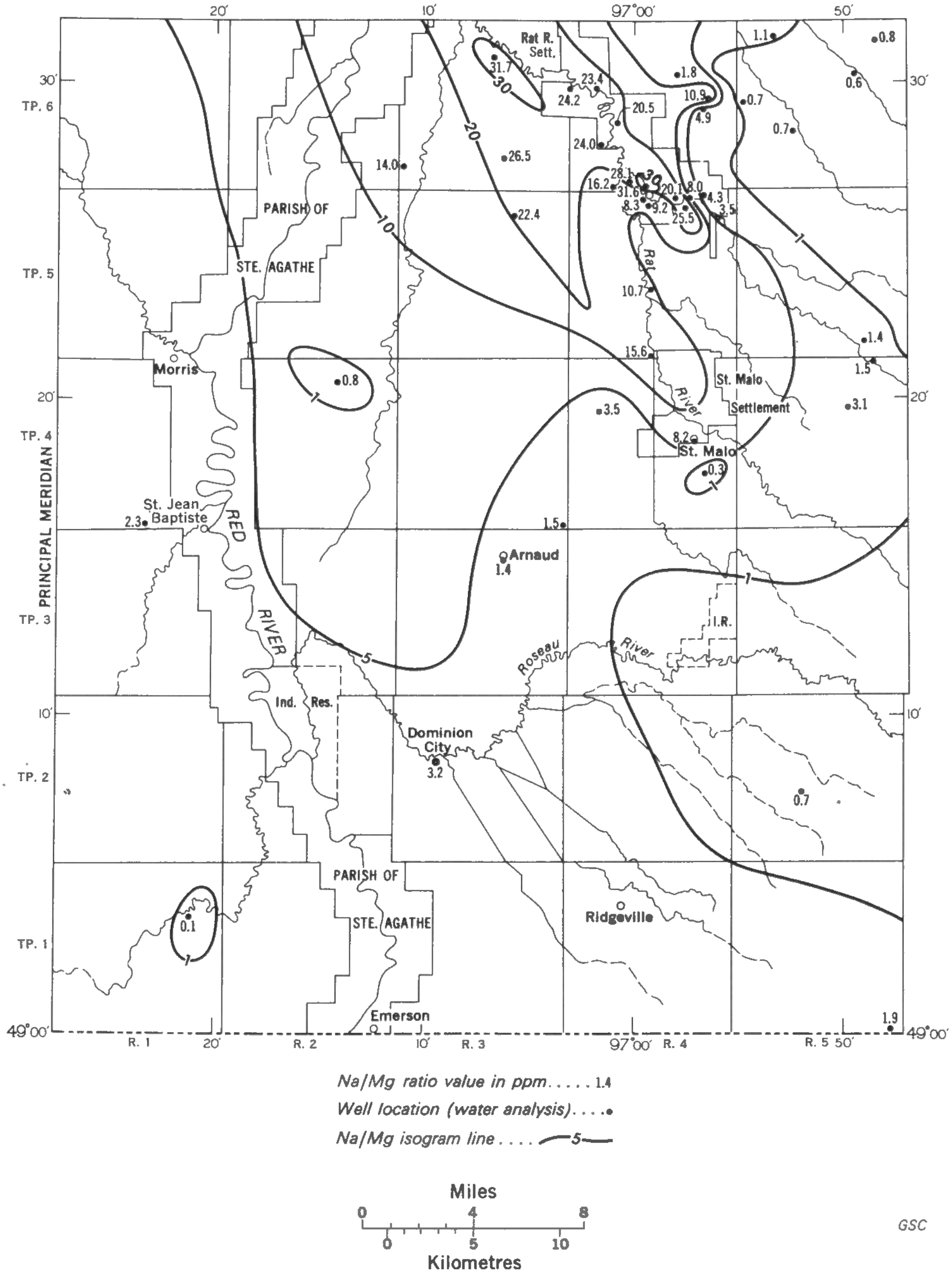


Figure 6. Isogram of Na/Mg ratios, Emerson area.

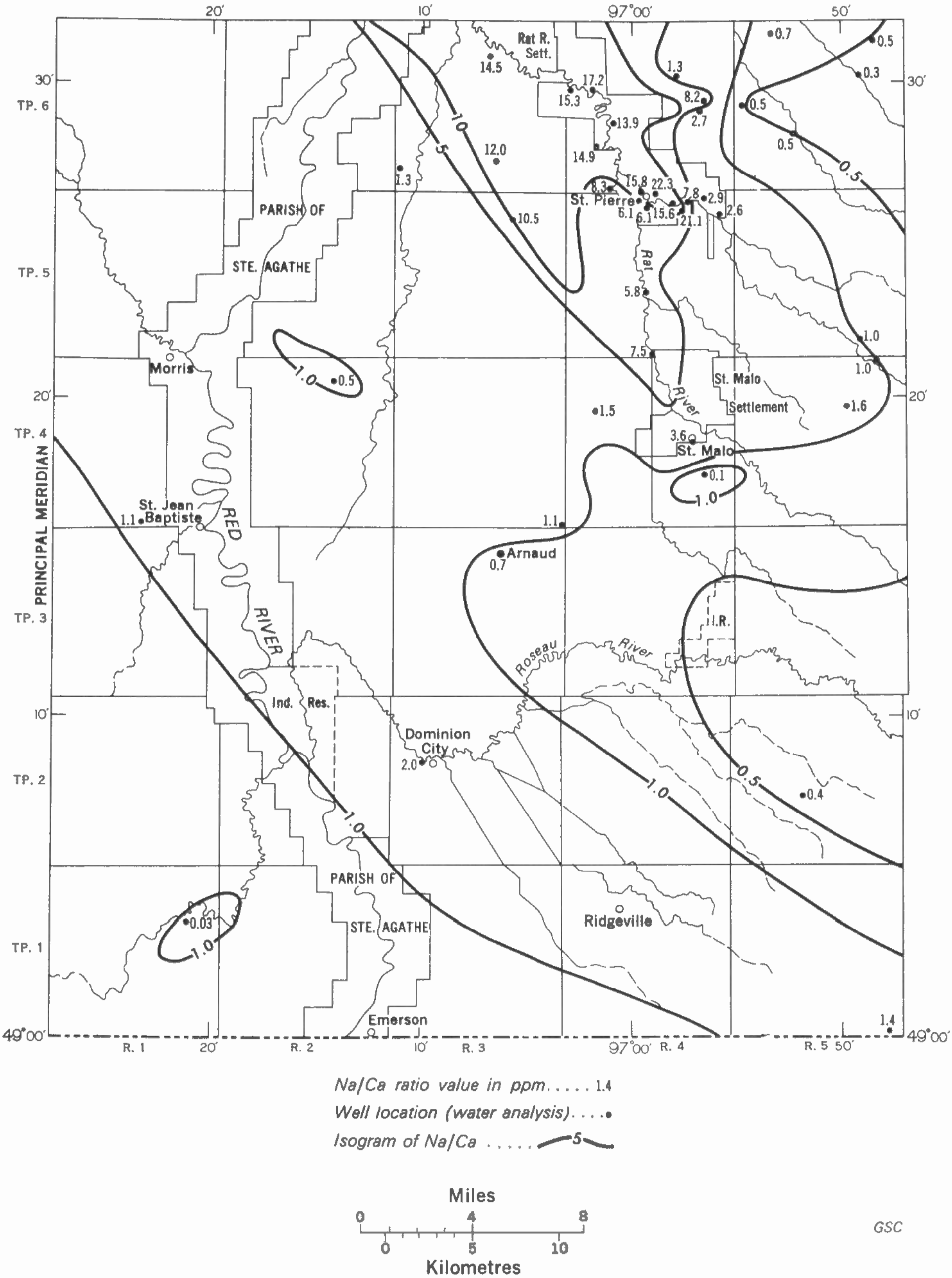


Figure 7. Isogram of Na/Ca ratios, Emerson area.

Calcium, Magnesium, and Sodium

The Mg/Ca ratio (Fig. 5) decreases slightly towards the northwest, while the Na/Mg and Na/Ca ratios (Figs. 6 and 7) increase from the southeast to the northwest along a line that parallels Rat River.

Iron

Only seven analyses are below the established standards of 0.3 ppm iron. Therefore, all groundwater except in the southeastern corner of the Emerson area (Fig. 3) can be said to be high in iron. Twenty analyses have less than 1.0 ppm iron, which means that for almost half of the water analyzed the use of water softeners is possible without the use of iron filters. The limestone aquifer of the Red River Formation, along Rat River, yields water that has an iron content of less than 1.0 ppm.

Bicarbonate, Sulphate, and Chloride

The HCO_3 (bicarbonate) content is generally fairly constant, for though it ranges between a low of 219 ppm and a high of 763 ppm, thirty-two of the forty-two analyses contain 400 ppm or less. It is to be noted that when there is a high concentration of SO_4 (sulphate) there is a lowering effect on the HCO_3.

The most striking thing about the analyses is the abnormally low concentration of SO_4 in the northeast and possibly southeast corners of the area (Fig. 8). Schoeller (1955) explained this fact by saying that groundwater as it flows underground changes in chemical composition by means of reduction, base exchanges, and concentration.

The most important elements affected by reduction are the sulphates. The low SO_4 content is always associated with the presence of organic matter. In the groundwater study of the Emerson area the peat bogs to the east near the area of recharge satisfy this condition. The reduction of the sulphates is not brought about by the organic matter itself but by a very specific anaerobic micro-organism. The reduction is accompanied by oxidation of the organic compounds, by the production of CO_2, which in turn will produce large quantities of HCO_3 ions and H_2S. A slight H_2S odour was discernible in some wells in the St. Pierre area. On the other hand the high concentration of SO_4 shown in analyses Nos. 11, 33, and 34 is probably due to the dissolution of gypsum (Fig. 8).

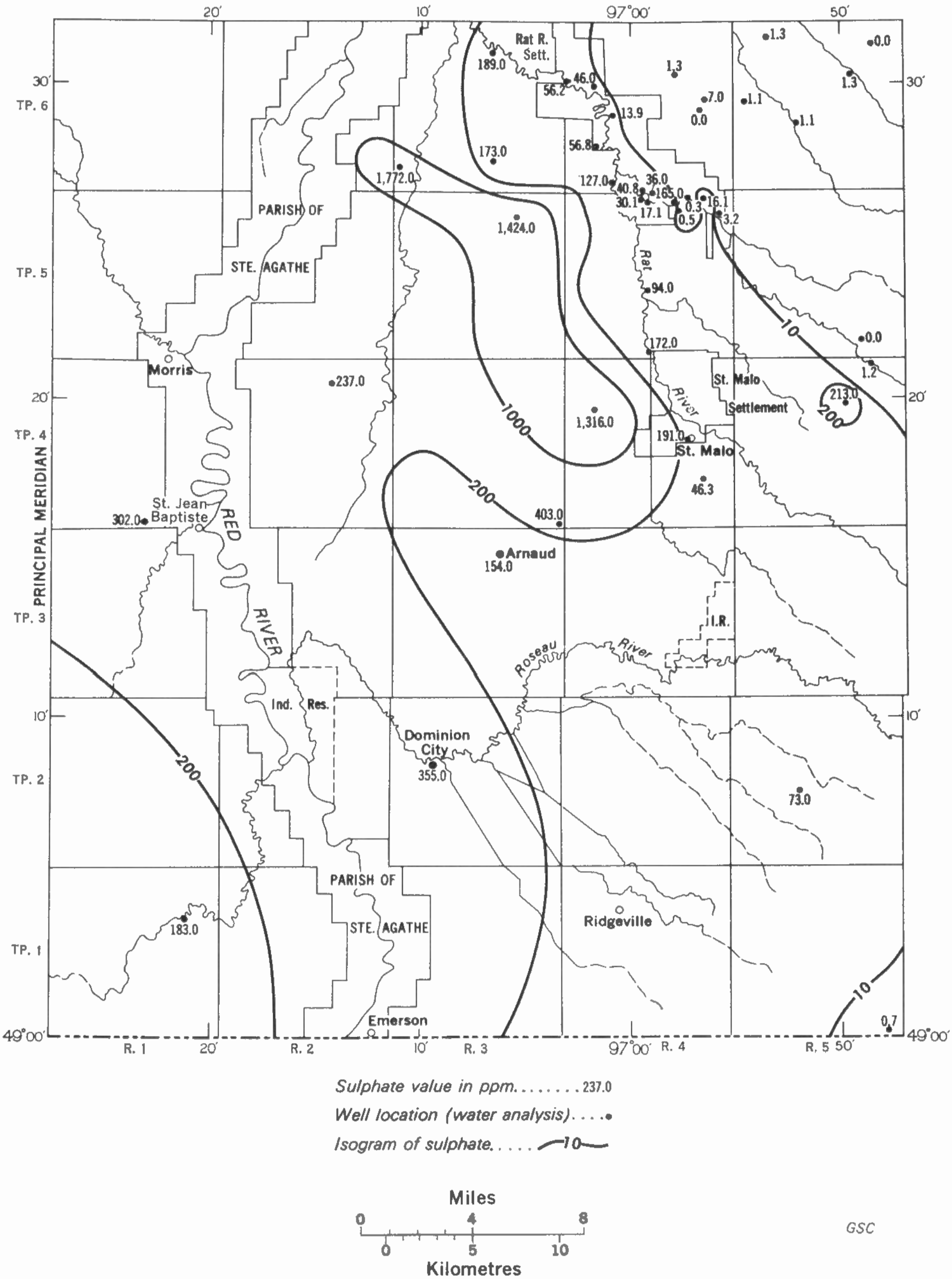


Figure 8. Isogram of SO_4, Emerson area.

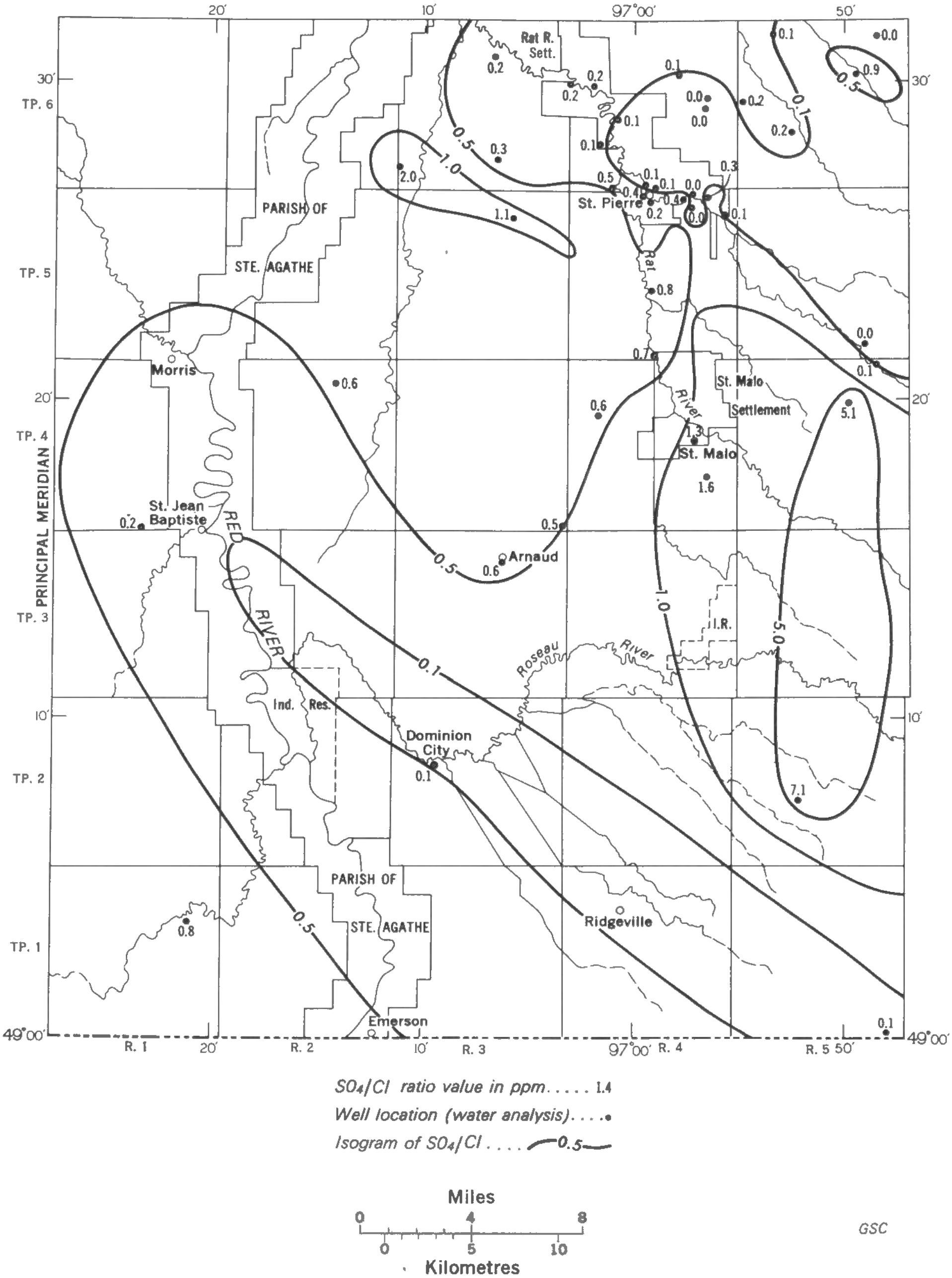


Figure 9. Isogram of SO_4/Cl ratios, Emerson area.

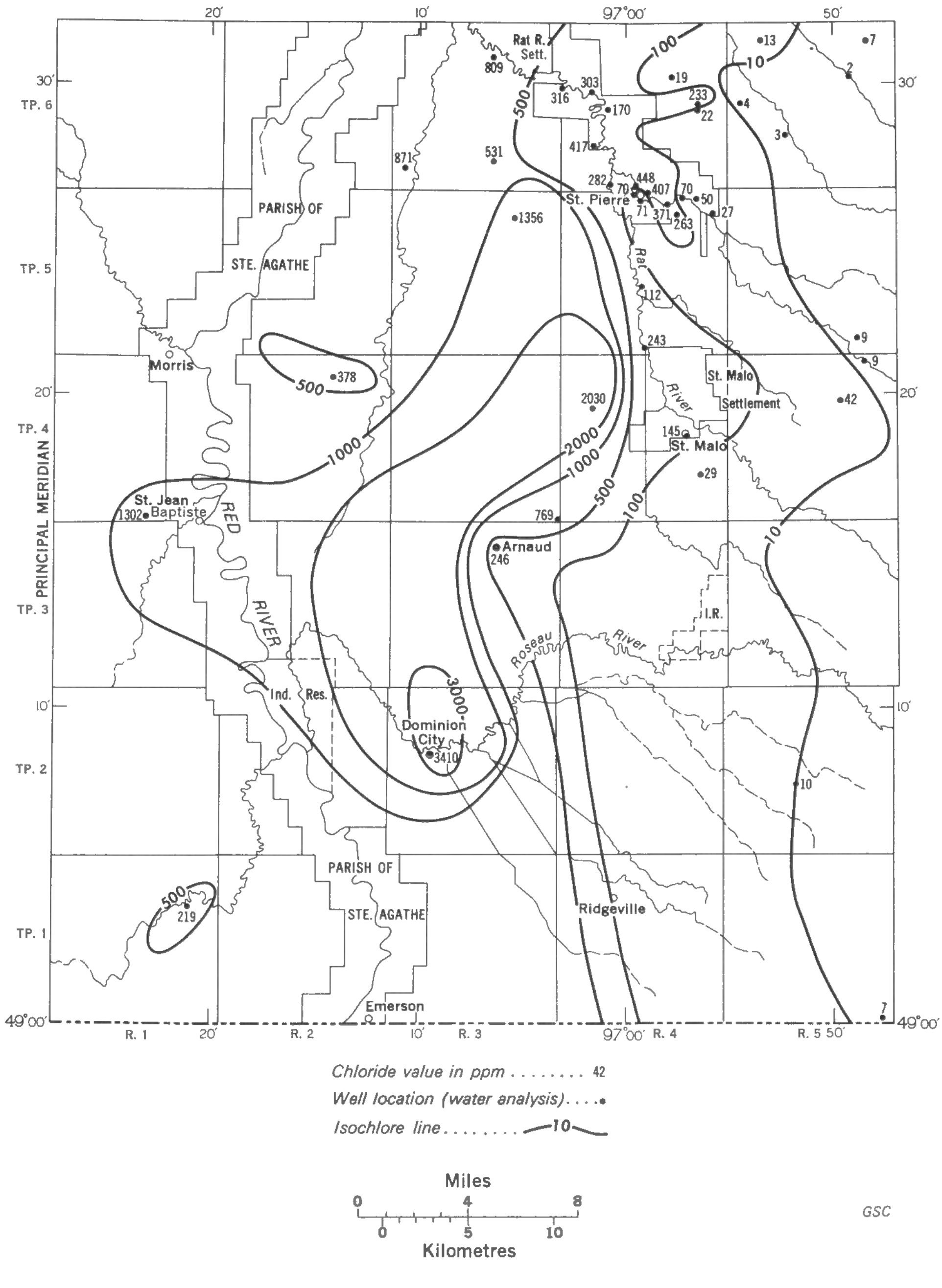


Figure 10. Isochlores (ppm), Emerson, area.

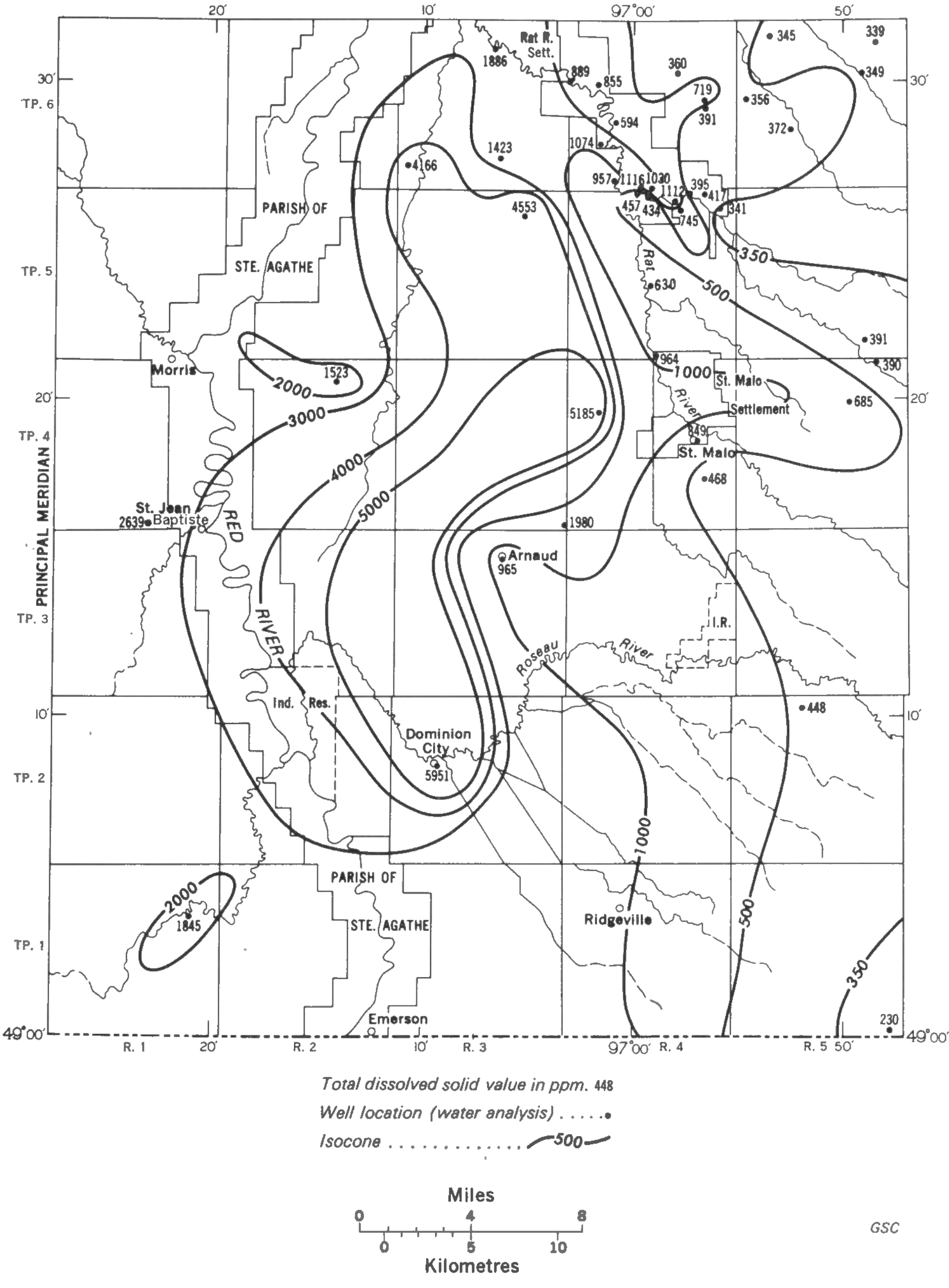


Figure 11. Isocones (ppm), Emerson area.

In general, the SO_4/Cl ratio decreases from the recharge area downstream, but in the Emerson area there is no such definite trend (Fig. 9).

The chloride content is greater from east to west, and is at a maximum near the centre of the map-area (Fig. 10). In general the greater the distance from the area of recharge, the longer the contact of the water with the salt-bearing formations, and the slower the rate of flow of water — the higher will be the chloride concentration. In the Emerson area these facts are well established. Analyses Nos. 16 and 17 show the difference in chloride concentration between two adjacent wells of different depths. The general line of demarcation between what can be called salt water and fresh water, that can be obtained from the limestone of the Red River Formation, is that line formed by Rat River. In general east of the line the water is potable and west it is too salty for domestic use, although it can still be used for watering stock.

Fluoride

Fluoride, which some authorities regard as important for the prevention of tooth decay, is found in high concentrations — more than 1.5 ppm in sixteen of the analyses. It is deficient, less than 0.5 ppm, in nine analyses. No explanation is available for the high fluoride content near St. Malo, St. Pierre, and Otterburne. It is a known fact, however, that appreciable amounts of fluoride are found in soft sodium-bicarbonate waters in many places throughout the United States (Cederstrom, 1945). The groundwater of the 16 analyses containing a high fluoride content is the softest in the Emerson area, with the sole exception of analysis No. 34. However, it is not just a sodium-bicarbonate water, but also a sodium-chloride water.

In all but one of the analyses with a fluoride content of 1.5 ppm or more, the per cent sodium of the water exceeds 60 per cent. Again the one exception is analysis No. 34, which may be explained by the fact that the groundwater of this sample is derived from the till aquifer and not from bedrock. In general, all groundwater in the Emerson area that is derived from the limestone aquifer of the Red River Formation and which has a fluoride content of 1.5 ppm or more will also have sodium exceeding 60 per cent, which means it cannot be used for irrigation.

Nitrate

The nitrate content of the confined aquifers is low, less than 8.4 ppm, which shows that very little contamination of the wells occurs, even though most are near or in barns. On the other hand, shallow wells in unconfined aquifers show, in two analyses out of four, very high concentrations of nitrate, the highest being 490 ppm. In both cases the high nitrate content can be attributed directly to the proximity of the wells to the barn. The two wells in which it is low are farther away from the barn.

Per Cent Sodium

The per cent sodium is equivalent to the SAR (sodium absorption ratio), which is used as an index for the usage of water in irrigation. Waters with up to 60 per cent sodium can be used for irrigation, whereas those over the 60 per cent mark are not recommended.

Interpretation of Chemical Analyses by Patterns

Chemical analyses patterns are employed to correlate various types of groundwater.

The patterns formed by the forty-two analyses (Fig. 12) show that the groundwater from unconfined aquifers, which is basically bicarbonate in character, (analyses Nos. 1, 12, 35, and 37) is the same chemically as the groundwater from confined aquifers close to or at the area of recharge (analyses Nos. 2, 3, 4, 5, 6, 18, etc.). Also in some places, because the water from confined aquifers is under artesian pressure, the water of a top aquifer is chemically the same as the water of the aquifer below it, owing to some slow infiltration (analyses Nos. 33 and 34). Finally the confined till aquifer yields water consistently high in sodium chloride and sulphate (analyses Nos. 8, 10, 11, 34, and 36). The last statement is also in complete agreement with the work of previous years in the same basin (Charron, 1960, 1964).

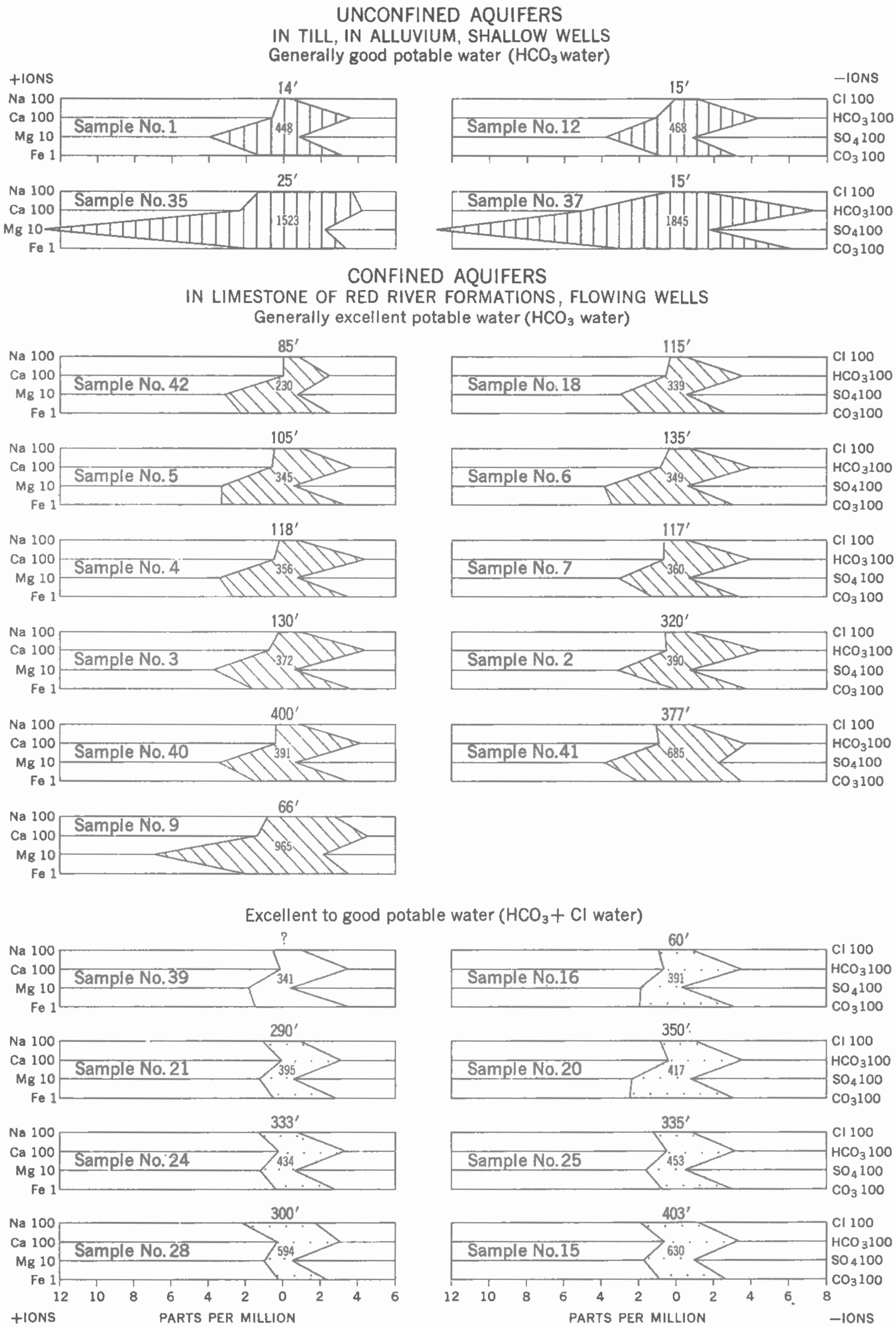
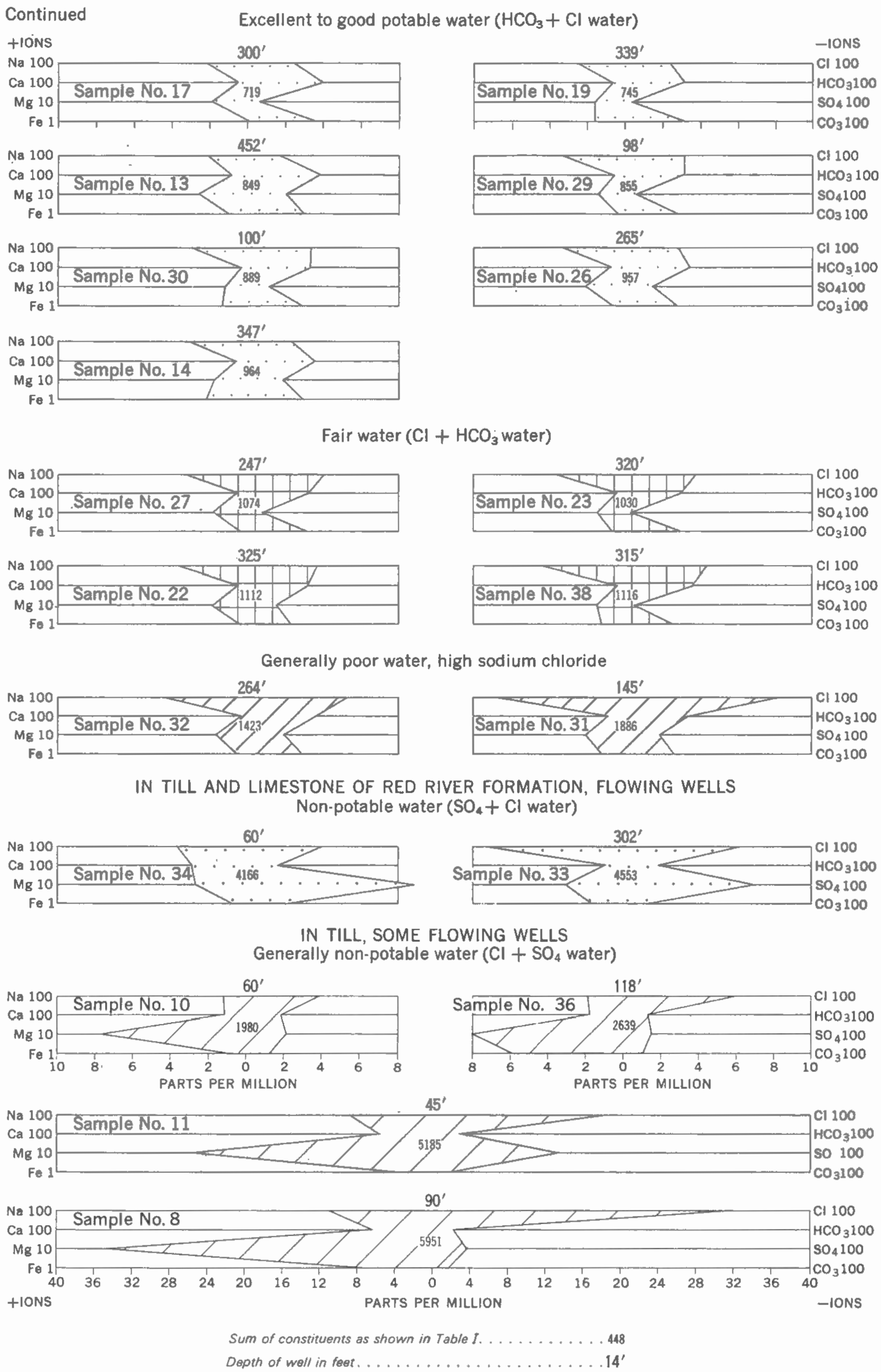


Figure 12. Chemical analyses patterns of groundwater in Emerson area.


Continued
Excellent to good potable water (HCO_3 + Cl water)
+IONS
—IONS
Na 100
Ca 100
Mg 10
Fe 1
Cl 100
HCO_3 100
SO_4 100
CO_3 100
300′
Sample No. 17
719
339′
Sample No. 19
745
452′
Sample No. 13
849
98′
Sample No. 29
855
100′
Sample No. 30
889
265′
Sample No. 26
957
347′
Sample No. 14
964
Fair water (Cl + HCO_3 water)
247′
Sample No. 27
1074
320′
Sample No. 23
1030
325′
Sample No. 22
1112
315′
Sample No. 38
1116
Generally poor water, high sodium chloride
264′
Sample No. 32
1423
145′
Sample No. 31
1886
IN TILL AND LIMESTONE OF RED RIVER FORMATION, FLOWING WELLS
Non-potable water (SO_4 + Cl water)
60′
Sample No. 34
4166
302′
Sample No. 33
4553
IN TILL, SOME FLOWING WELLS
Generally non-potable water (Cl + SO_4 water)
60′
Sample No. 10
1980
118′
Sample No. 36
2639
10 8 6 4 2 0 2 4 6 8
8 6 4 2 0 2 4 6 8 10
PARTS PER MILLION
45′
Sample No. 11
5185
90′
Sample No. 8
5951
40 36 32 28 24 20 16 12 8 4 0 4 8 12 16 20 24 28 32 36 40
PARTS PER MILLION
Sum of constituents as shown in Table I. 448
Depth of well in feet . . . . 14′

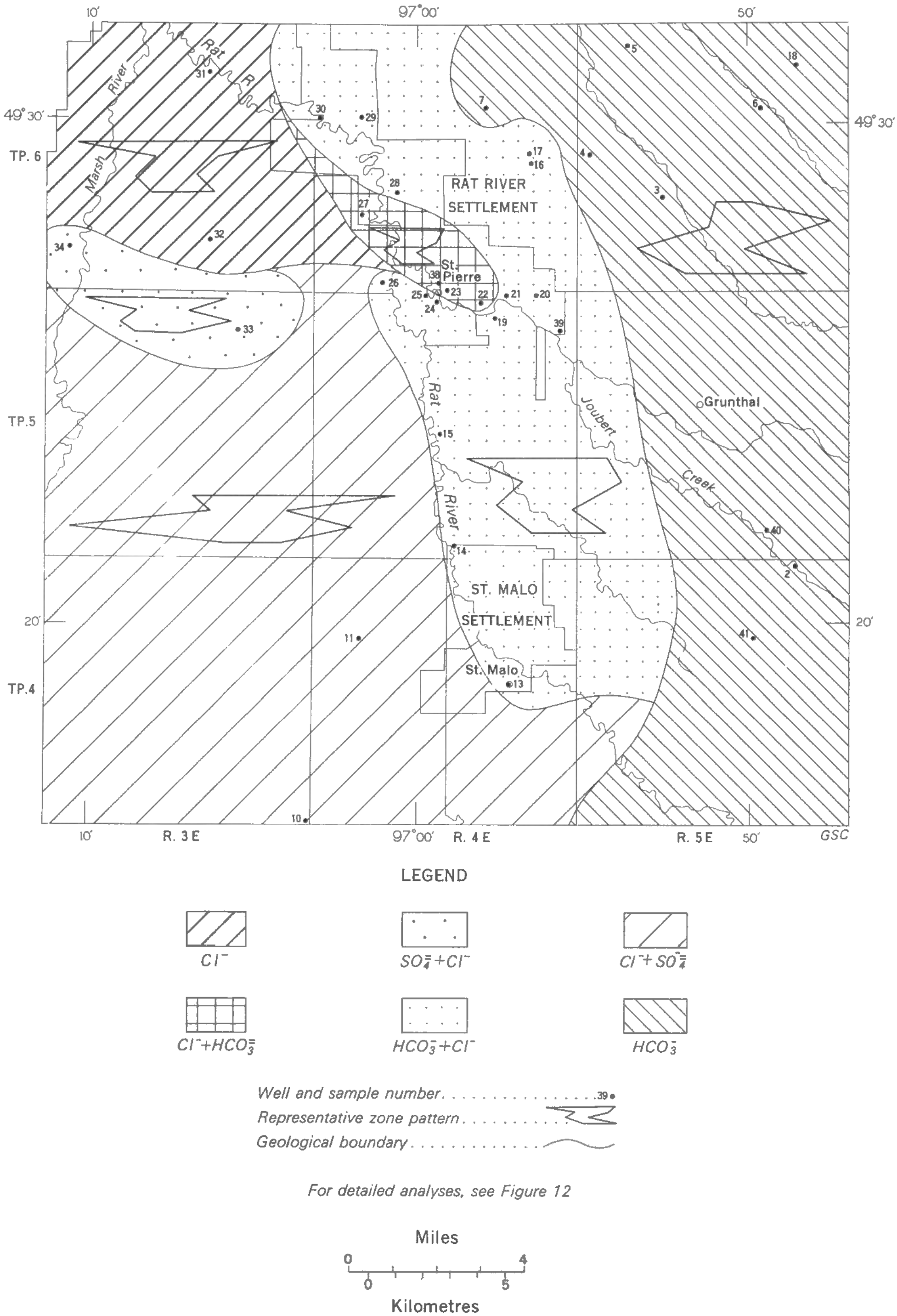


Figure 13. Zonations reflected in the chemical composition of groundwater from the limestone of the Red River Formation

Zonation of the Groundwater

Groundwater undergoes chemical change as it circulates. Greater depths, greater distance from the area of recharge, and slower rate of flow, all tend to increase the concentration of salt (Schoeller, 1955). The chemical change of the groundwater downstream follows the Chebotarev (1955) sequence: bicarbonate waters → bicarbonate-chloride waters → chloride-bicarbonate waters → chloride-sulphate or sulphate-chloride waters → sulphate waters → chloride waters.

The groundwater obtained from the limestone of the Red River Formation in the Emerson area follows the above sequence almost to the letter. On Figure 13 the patterns are used to show the different chemical zones of the groundwater of the limestone aquifer as they change downstream. Even though no piezometric contours are available the direction of flow of the groundwater is shown as being east-west. It would even seem that the direction of flow of the water is from the southeast towards the northwest up to and about a line approximating Red River. The northeastern corner of the map-area is the bicarbonate zone, which proves that even though the main area of recharge of the Red River Formation is some 25 miles to the east, some recharge does occur through till within or very near the eastern margin of the mapped area.

The chloride value is one of the most important indicators of the degree of stagnation of a body of groundwater (Schoeller, 1955). An increase in the chloride value reflects a decrease in the rate of flow, that is, an increase of the degree of stagnation. Therefore because the chloride content increases westward across the Emerson area (Fig. 10), the rate of flow of the groundwater in the limestone aquifer diminishes. In the till aquifer it is possible to suppose that the rate of flow has reached a state of quasi-stagnation, at least laterally, at a line approximating the path followed by Red River.

Conclusion

Quality

Excellent water (less than 500 ppm total dissolved solids) can be obtained from the limestone aquifer in the northeastern corner of the map-area (Fig. 11). It is also available in shallow wells along the entire eastern margin of the map-area. Westward, the quality of the groundwater deteriorates, so that beyond range 4 east the chances of obtaining potable water from any aquifer at any depth are not good.

Quantity

Very little is known on absolute values of the quantity of groundwater available from the various aquifers. The author thinks that yields of 100,000 gallons per day are possible from the limestone of the Red River Formation in the area around the village of St. Pierre, in the municipality of De Salaberry. Drilling and test-pumping would be essential prerequisites for any large-capacity wells planned for this area.

The northeastern corner of the Emerson area is much the best area for groundwater, both in quality and quantity.

REFERENCES

Cederstrom, D.J.
1945: Geology and groundwater resources of the coastal plain in southeastern Virginia; Geol. Surv. Virginia, Bull. 63, p. 276.

Charron, J.E.
1960: Groundwater resources of Plum Coulee area, Manitoba; Geol. Surv. Can., Paper 60-22.

1964: Groundwater resources of Fannystelle area, Manitoba; Geol. Surv. Can., Bull. 98.

Chebotarev, I.I.
1955: Metamorphism of natural waters in the crust weathering; Geochimica et Cosmochimica Acta, vol. 8, pp. 22-48, 137-170, 198-212.

Colton, Roger B.
1958: Note on intersecting minor ridges in the Lake Agassiz basin, North Dakota; Geol. Surv. North Dakota, Guidebook, 9th Ann. Field Conf., Misc. Ser. No. 10.

Horberg, Leland
1951: Intersecting minor ridges and periglacial features in the Lake Agassiz basin, North Dakota; J. Geol., vol. 59, No. 1, pp. 1-18.

Johnston, W.A.
1934: Surface deposits and groundwater supply of Winnipeg map-area, Manitoba; Geol. Surv. Can., Mem. 174.

Schoeller, H.
1955: Géochimie des eaux souterraines; applications aux eaux des gisements de pétrole; (Reprinted from Rev. Inst. Franc. Petrole Ann. Combust. Liquides, March, April, June, July, Aug., 1955).

Stiff, Henry A. Jr.
1951: Interpretation of chemical analyses of water by means of patterns; J. Pet. Technol., vol. 3, Oct.

Thornthwaite, C.W., and Mather, J.R.
1957: Instructions and tables for computing potential evapotranspiration and the water balance; Drexel Inst. Technol., Centerton, N. J.