thickness of the deposits expected to be less than 30 metres. The Town of Provost obtains its municipal water from water supply wells completed in the sand and gravel aquifer associated with the buried valley near St. Lawrence Lake (Geoscience Consulting Ltd., 1977).

There are other linear bedrock lows shown on the bedrock topography map. All of these lows trend northwest to southeast in the M.D. and are indicated as being of meltwater origin. However, because sediments associated with the lower surficial deposits are indicated as being present in these linear bedrock lows, it is possible that the bedrock lows were originally tributaries to the Buried Bodo Valley drainage system.

The lower surficial deposits are composed mainly of fluvial and lacustrine deposits. Lower surficial deposits occur over approximately 20% of the Region, in association with linear bedrock lows. The total thickness of the lower surficial deposits is mainly less than 20 metres, but ranges from 10 to more than 30 metres in parts of the Buried Wainwright and Bodo valleys. The lowest part of the lower surficial deposits includes pre-glacial sand and gravel deposits. These deposits would generally be expected to directly overlie the bedrock surface in the Buried Wainwright and Bodo valleys. The lowest sand and gravel deposits are of fluvial origin and are usually less than 10 metres thick.

The upper surficial deposits are either directly or indirectly a result of glacial activity. The deposits include till plus sand and gravel deposits of meltwater origin. The thickness of the upper surficial deposits is mainly less than 40 metres. The greatest thickness of upper surficial deposits occurs mainly in association with the Buried Bodo Valley.

Sand and gravel deposits can occur throughout the entire unconsolidated section. The total thickness of sand and gravel deposits is generally less than 30 metres but can be more than 30 metres in the areas of the buried bedrock lows and meltwater channels.

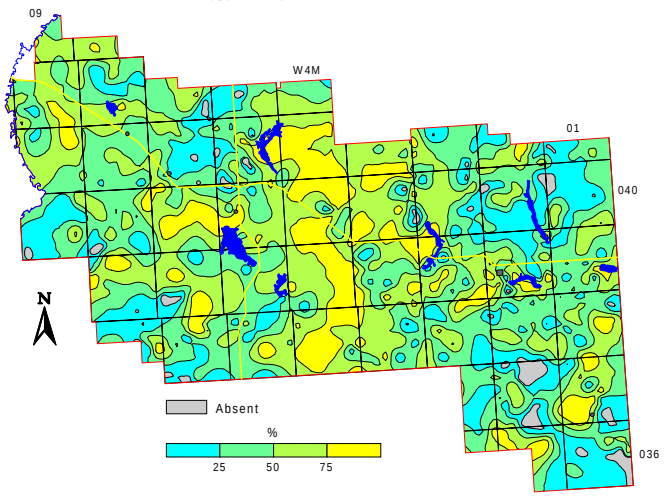

Figure 10. Amount of Sand and Gravel in Surficial Deposits

The combined thickness of all sand and gravel deposits has been determined as a function of the total thickness of the surficial deposits. Over approximately 40% of the M.D., the sand and gravel deposits are more than 50% of the total thickness of the surficial deposits. The main areas where the sand and gravel percentages are higher are in the north-central part of the M.D. and in association with linear bedrock lows. The other areas where sand and gravel deposits constitute more than 50% of the surficial deposits may be areas of meltwater channels or areas where linear bedrock lows exist but have not been identified due to a shortage of accurate bedrock control points.

5.2.2 Sand and Gravel Aquifer(s)

One source of groundwater in the M.D. includes aquifers in the surficial deposits. Since the sand and gravel aquifer(s) are not everywhere, the actual aquifer that is developed at a given location is usually dictated by the aquifer that is present. From the present hydrogeological analysis, 74 water wells are completed in aquifers in the lower surficial deposits and 1,112 are completed in aquifers in the upper surficial deposits. This situation occurs because of the limited areal extent of the lower surficial deposits. This number of 1,186 water wells completed in aquifers in the surficial deposits is more than double the number of water wells determined to be completed in aquifers in the surficial deposits based on lithology given on the water well drilling reports.

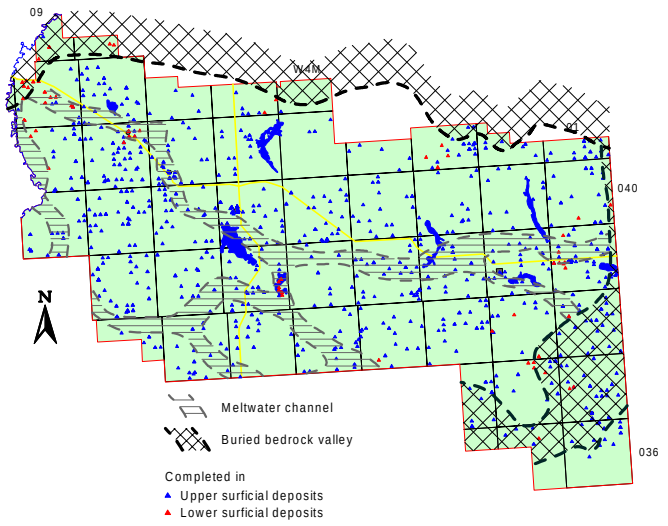

Figure 11. Water Wells Completed in Surficial Deposits

The water wells completed in the upper surficial deposits are located throughout the M.D., as shown in Figure 11. The majority of the water wells completed in the lower surficial deposits are located along the Buried Wainwright and Bodo valleys and bedrock lows of meltwater origin.

The adjacent map shows water well yields that are expected in the M.D., based on surficial aquifers that have been developed by existing water wells. These data show that water wells with yields of more than 100 m³/day from sand and gravel aquifer(s) can be expected in more than 30% of the M.D. The most notable areas where yields of more than 100 m³/day are expected are mainly in or adjacent to the areas of linear bedrock lows. Over the majority of the M.D., water wells completed in the sand and gravel aquifer(s) would be expected to mainly have long-term yields of less than 100 m³/day.

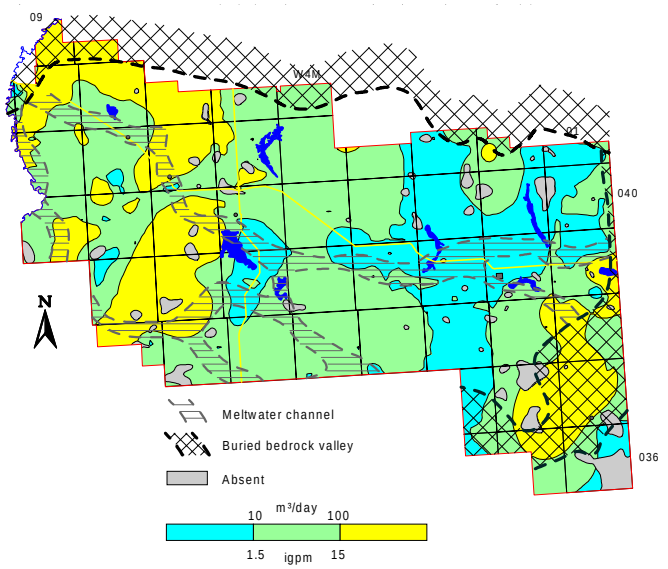

Figure 12. Apparent Yield for Water Wells Completed through Sand and Gravel Aquifer(s)

5.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

The chemical analysis results of groundwaters from the surficial deposits have not been differentiated based on aquifers in the upper or lower surficial deposits. The main reason for not separating the chemical analysis results into the different aquifers is the lack of control. Because of the limited areal extent of the lower surficial deposits, almost all of the analysis results are from the upper surficial deposits.

The other justification for not separating the analyses was that there appeared to be no major chemical difference between groundwaters from the upper or lower sand and gravel aquifers. The groundwaters from these aquifers are generally chemically hard and high in dissolved iron.

The groundwaters from the surficial deposits are mainly calcium-magnesium-bicarbonate-type waters, with 65% of groundwaters having a TDS of less than 1,000 mg/L. The groundwaters with a TDS of more than 1,500 mg/L occur mainly in the eastern part of the M.D. Groundwaters from the surficial deposits are expected to have dissolved iron concentrations of greater than 1 mg/L. Groundwater from the Town of Provost water supply wells completed in the Upper Sand and Gravel Aquifer has a TDS of approximately 500 mg/L and a hardness of less than 400 mg/L. Chloride concentrations were mainly below the detection limit (Geoscience Consulting Ltd., 1977).

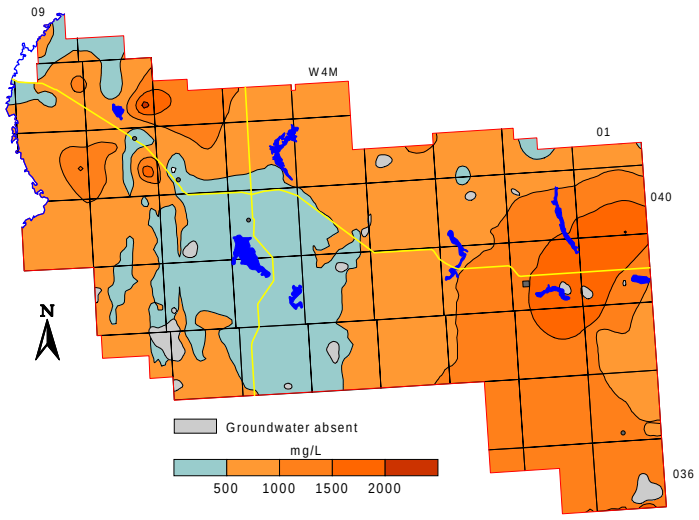

Figure 13. Total Dissolved Solids in Groundwater from Surficial Deposits

Although the majority of the groundwaters are calcium-magnesium-bicarbonate-type waters, there are groundwaters from the surficial deposits with sodium as the main cation; there are also groundwaters with significant concentrations of the sulfate ion. The groundwaters with elevated levels of sulfate occur in areas where there are elevated levels of total dissolved solids. There are very few groundwaters from the surficial deposits with appreciable concentrations of the chloride ion and in most of the M.D., the chloride ion concentration is less than 100 mg/L.

5.2.3 Upper Sand and Gravel Aquifer

The Upper Sand and Gravel Aquifer includes saturated sand and gravel deposits in the upper surficial deposits. These aquifers typically occur above an elevation of 650 metres AMSL. Saturated sand and gravel deposits are not continuous but are expected over approximately 95% of the M.D.

5.2.3.1 Aquifer Thickness

The thickness of the Upper Sand and Gravel Aquifer is in part a function of the elevation of the non-pumping water-level surface associated with the upper surficial deposits and in part a result of the depth to the bedrock surface. Since the non-pumping water-level surface in the surficial deposits tends to be a subdued replica of the bedrock surface, the thickness of the Upper Sand and Gravel Aquifer tends to be directly proportional to the thickness of the surficial deposits.

While the sand and gravel deposits in the upper surficial deposits are not continuous, the Upper Sand and Gravel Aquifer includes all of the aquifers present in the upper surficial deposits. The Upper Sand and Gravel Aquifer is more than 30 metres thick in a few areas, but over the majority of the M.D., is less than ten metres thick; over 5% of the M.D., the Aquifer is absent. Most of the greater thickness in the Upper Sand and Gravel Aquifer occurs in the areas of linear bedrock lows.

5.2.3.2 Apparent Yield

The permeability of the Upper Sand and Gravel Aquifer can be high. The high permeability combined with significant thickness leads to an extrapolation of water wells with high yields; however, because the sand and gravel deposits occur mainly as hydraulically discontinuous pockets, the long-term yields of the water wells are limited. The apparent yields for water wells completed in this Aquifer are expected to be mainly less than 100 m³/day. Where the Upper Sand and Gravel Aquifer is absent and where the yields are low, the development of water wells for the domestic needs of single families may not be possible.

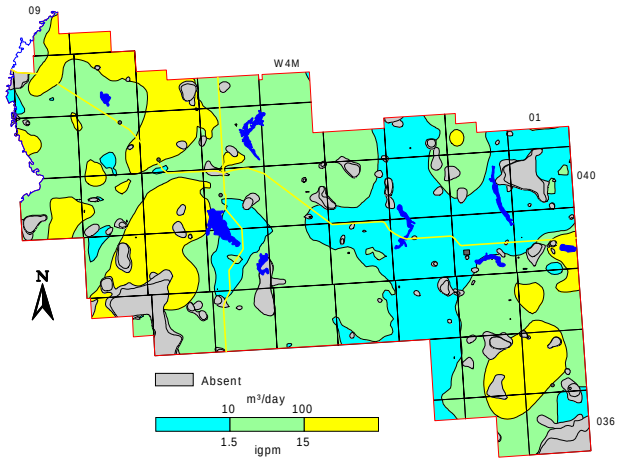

Figure 14. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

The highest yield from surficial deposits that has been developed in the M.D. is for the Town of Provost. The Town uses the Upper Sand and Gravel Aquifer associated with the Buried Bodo Valley in township 039, range 01, W4M. Extensive studies of this aquifer in 1966 by V.G. Beckie of J.D. Mollard & Associates indicated a long-term supply of in the order of 1,000 m³/day (Geoscience Consulting Ltd., 1977). A water test hole was completed in the Upper Sand and Gravel Aquifer associated with a bedrock low of meltwater origin for the Provost & District Golf Club in township 039, range 02, W4M. Studies of this aquifer indicated a long-term yield of 135 m³/day (Hydrogeological Consultants Ltd., November 1994).

5.2.4 Lower Sand and Gravel Aquifer

The Lower Sand and Gravel Aquifer is a saturated sand and gravel deposit that occurs at or near the base of the surficial deposits in the deepest part of the pre-glacial linear bedrock lows. The Lower Sand and Gravel Aquifer may be a continuous aquifer in the Buried Wainwright Valley, where the thickness of the sand and gravel deposits is mainly between 10 and 30 metres. The Lower Sand and Gravel Aquifer is mostly restricted to the Buried Wainwright and Bodo valleys in the M.D.

5.2.4.1 Apparent Yield

Water wells completed in the Lower Sand and Gravel Aquifer may have yields in excess of 100 m³/day. The highest yields are expected in the Buried Wainwright Valley in the northwestern part of the M.D.

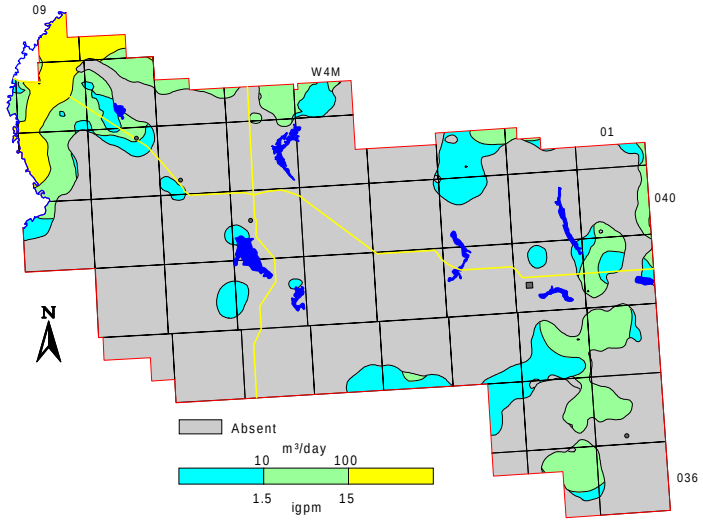

Figure 15. Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer

5.3 Bedrock

5.3.1 Geological Characteristics

The upper bedrock in the M.D. includes the Bearpaw Formation and the Belly River Group. The Lea Park Formation underlies the Belly River Group.

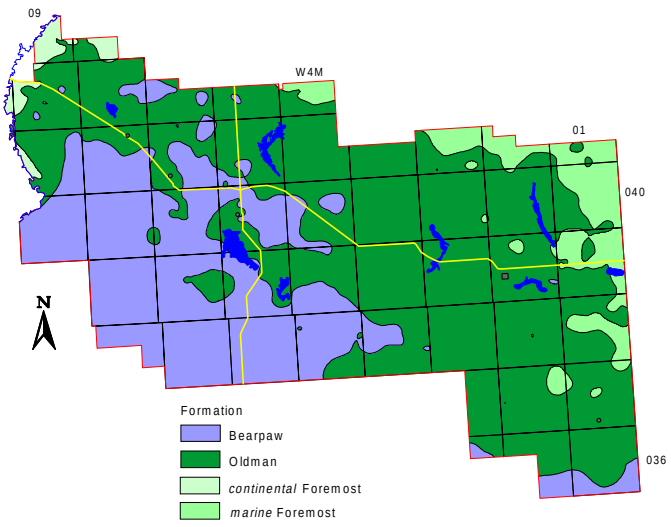

Figure 16. Bedrock Geology

The Bearpaw Formation is the upper bedrock mainly in the southwestern part of the M.D. and has been eroded in the northeastern half of the M.D. There are also subcrops of the Bearpaw Formation that occur as outliers within the area of the Oldman Formation. The Bearpaw Formation is generally less than 100 metres thick in the M.D. "The Bearpaw Formation consists of marine shale, siltstone and minor sandstone, and represents the final widespread marine unit in the Western Canada Foreland Basin" (Catuneanu, Miall and Sweet, 1997). The border between the bottom of the Bearpaw Formation and the uppermost part of the Belly River Group was used as a geological marker in the e-log interpretation. In the M.D., the Bearpaw Formation is composed mainly of shale and as such is a regional aquitard.

The Belly River Group in the M.D. has a maximum thickness of 250 metres, and includes the Oldman Formation and both the *continental* and *marine* facies of the Foremost Formation.

The uppermost part of the Belly River Group is the Oldman Formation. This Formation is the upper bedrock in the majority of the northeastern two-thirds of the M.D. The Oldman Formation has a maximum thickness of 100 metres within the M.D. and is composed of sandstone, siltstone, shale, and coal deposited in a continental environment. The Oldman Formation is composed of three parts: the Comrey, the Upper Siltstone and the Dinosaur members. The uppermost part of the Dinosaur Member is the Lethbridge Coal Zone. Sandstone is predominant in the Comrey Member, the Upper Siltstone is mainly siltstone, and the Dinosaur Member includes shale and coal deposits.

The *continental* Foremost Formation underlies the Oldman Formation and subcrops under the surficial deposits in the northwestern part of the M.D. The *continental* Foremost Formation has a maximum thickness of 140 metres within the M.D. The *continental* Foremost Formation, a backshore deposit, consists mainly of shale deposits with minor amounts of sandstone present. Coal zones occur within the *continental* Foremost Formation, with the main ones referred to as the McKay and the Taber Coal Zones. There are also minor amounts of ironstone, a chemical deposit, in the *continental* Foremost Formation. Where the *continental* Foremost Formation is close to the bedrock surface, it can be fractured or weathered and can have significant local permeability.

The *marine* Foremost Formation has a maximum thickness of 200 metres within the M.D. and underlies the *continental* Foremost Formation. The *marine* Foremost Formation can be separated into individual sandstone and shale members in parts of the M.D. The sandstone units from top to bottom are as follows: Birch Lake, Ribstone Creek, Victoria, and Brosseau members. In the northwestern part of the M.D., the sandstones making up the *marine* Foremost Formation cannot always be separated into individual members. This situation occurs because the sandstone members of the *marine* Foremost Formation thicken and the intervening shale layers thin toward the western edge of the *marine* facies. With this change, distinguishing between the individual sandstone members is not possible. The upper part of the *marine* Foremost Formation is present in the northwestern part of the M.D. Even though the individual members cannot be distinguished, the sandstone occurrence can be a significant aquifer and has been designated the “Milan Aquifer”. The top of the Milan Aquifer extends up to 10 metres into the overlying *continental* Foremost Formation and can occupy the upper 40 metres of the *marine* Foremost Formation. The westward extent of the Milan Aquifer coincides with the position where the Basal Belly River Sand can be distinguished. The Milan Aquifer is present under the *continental* Foremost Formation in the northwestern part of the M.D. but does not subcrop anywhere in the M.D.

The Lea Park Formation is mostly composed of shale, with only minor amounts of bentonitic sandstone present in some areas. Regionally, the Lea Park Formation is an aquitard.

5.3.2 Aquifers

Of the 2,980 water wells in the database, 732 were defined as being completed in bedrock aquifers. This designation is based on the top of the completion interval being below the bedrock surface. The completion depth is available for the majority of water wells. In order to make use of additional information within the groundwater database, it was statistically determined that water wells typically have completion intervals equivalent to one quarter of their completed depth. This relationship was used to increase the number of water wells identified as completed in bedrock aquifers to 1,909 from 732. With the use of geological surfaces that were determined from the interpretation of geophysical logs, it has been possible to assign the water wells completed in bedrock aquifers to specific aquifers based on their completion intervals. Of the 1,909 bedrock water wells, 1,406 could be assigned a specific aquifer. The bedrock water wells are mainly completed in the Oldman and the *marine* Foremost aquifers as shown in the table above. The total given for the number of water wells completed in the *marine* Foremost Aquifer does not include water wells completed in the individual members of the *marine* Foremost Aquifer; however, the 415 water wells do include water wells completed through more than one member. The discussions related to specific aquifers, later in this report, do not include the Bearpaw, Milan or Lea Park aquifers due to the paucity of data available in the M.D. However, maps associated with these aquifers are included on the CD-ROM.

Bedrock Aquifer	No. of Water Wells
Bearpaw	76
Oldman	809
Continental Foremost	46
Milan	9
Marine Foremost	415
Birch Lake Member	18
Ribstone Creek Member	17
Victoria Member	16
Brosseau Member	0
Lea Park	0

Table 3. Completion Aquifer

There are 505 records for bedrock water wells that have apparent yield values. In the M.D., water well yields can be expected to be mainly less than 100 m³/day. The areas of higher yields that are indicated on the adjacent figure are mainly in the northern and eastern parts of the M.D. These higher yields may be a result of increased permeability that has resulted from the weathering process.

There are 490 apparent yield values that can be assigned to a specific bedrock aquifer. The majority of the water wells completed in the bedrock aquifers have apparent yields that range from 10 to 100 m³/day, as shown in the table below.

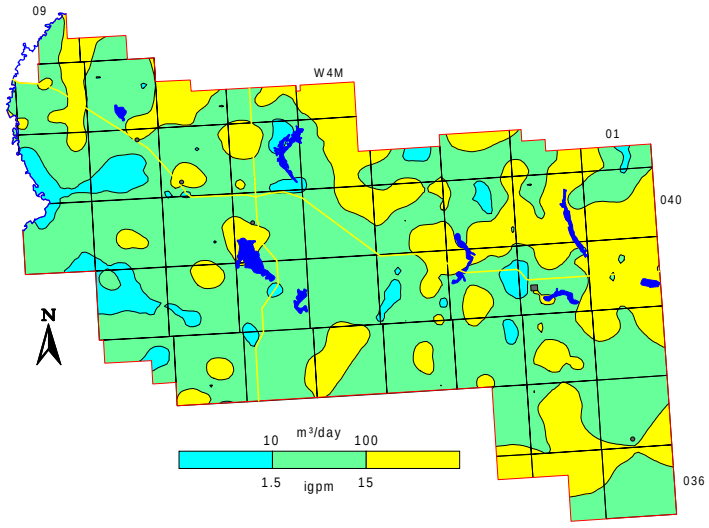

Figure 17. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

Aquifer	No. of Water Wells with Apparent Yields	Number of Water Wells with Apparent Yields <10 m³/day	10 to 100 m³/day	>100 m³/day
Bearpaw	7	2	5	0
Oldman	231	43	159	29
Continental Foremost	19	2	10	7
Milan	8	2	4	2
Marine Foremost	180	14	87	79
Birch Lake Member	22	5	13	4
Ribstone	19	1	10	8
Victoria	4	1	2	1
Totals	490	70	290	130

Table 4. Apparent Yields of Bedrock Aquifers

5.3.3 Chemical Quality of Groundwater

The TDS concentrations in the groundwaters from the upper bedrock aquifer(s) range from less than 500 to more than 2,000 mg/L. In more than 80% of the area, TDS values are less than 1,000 mg/L, with only a few areas having TDS concentrations of less than 500 mg/L. The higher values are expected in the central parts of the M.D.

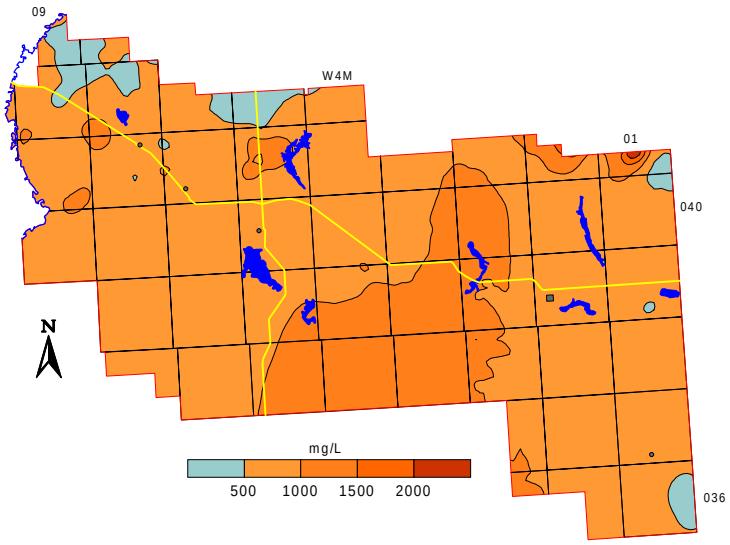

Figure 18. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

The majority of the sulfate concentrations were less than 250 mg/L. The chloride concentration in groundwater from the upper bedrock aquifer(s) is less than 100 mg/L in 90% of the M.D.

In 95% of the M.D., the fluoride ion concentration in the groundwater from the upper bedrock aquifer(s) is less than 1.0 mg/L.

The Piper tri-linear diagrams (see Appendix A) show that all chemical types of groundwater occur in the upper bedrock aquifer(s). However, the majority of the groundwaters are sodium-bicarbonate types.