5.2 Aquifers in Surficial Deposits

The surficial deposits are the sediments above the bedrock surface. This includes pre-glacial materials, which were deposited before glaciation, and materials deposited directly or indirectly by glaciation. The lower surficial deposits include the pre-glacial fluvial[9] and lacustrine[10] deposits. The lacustrine deposits include clay, silt, fine-grained sand and coal. The upper surficial deposits include the more traditional glacial deposits of till and meltwater deposits.

5.2.1 Geological Characteristics of Surficial Deposits

While the surficial deposits are treated as one hydrogeological unit, they consist of three hydraulic parts. The first is the sand and gravel deposits of the lower surficial deposits, the second is the saturated sand and gravel deposits of the upper surficial deposits and third is the sand and gravel close to ground level, which is usually unsaturated. Sand and gravel deposits in the upper part of the surficial deposits can extend above the upper limit of the saturation zone and because they are not saturated, they are not an aquifer. However, these sand and gravel deposits are significant since they provide a pathway for liquid contaminants to move downward into the groundwater. Because of the significance of the shallow sand and gravel deposits, they have been mapped where they are present within one metre of the ground surface and are referred to as the “first sand and gravel”.

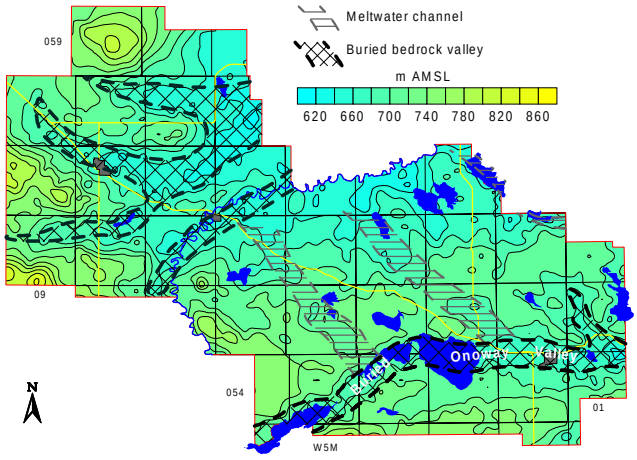

Figure 9. Bedrock Topography

Over the majority of the County, the surficial deposits are less than 40 metres thick. The exceptions are mainly in association with the linear lows in the bedrock surface, which occur throughout the County. Three of the buried valleys are noted on the adjacent map. The main linear bedrock low has been designated as the Buried Onoway Valley. This Valley, shown on the adjacent map, trends from west to east and underlies Isle Lake and Lac Ste. Anne in the southern part of the County. A second buried valley trends from west to east and underlies the Town of Mayerthorpe. The Town of Mayerthorpe developed the sand and gravel aquifer associated with the buried valley for its water supply in 1959. A third buried valley trends from west to east and is south of the Town of Mayerthorpe, and generally follows the present-day Pembina River.

In addition to the Buried Onoway Valley, there are minor linear bedrock lows that are believed to be associated with meltwater channels. Three of these channels are noted on the above map. These meltwater channels trend perpendicular to the Buried Onoway Valley. Their location and orientation is a direct influence of glaciation.

[9] See glossary
[10] See glossary

The lower surficial deposits are composed mostly of fluvial and lacustrine deposits. The total thickness of the lower surficial deposits is mainly less than 30 metres. 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 Onoway Valley. The lowest sand and gravel deposits are of fluvial origin and are usually no more than a few metres thick.

The upper surficial deposits are either directly or indirectly a result of glacial activity. The deposits include till, with minor sand and gravel deposits of meltwater origin, which occur as isolated pockets. The thickness of the upper surficial deposits can exceed 30 metres. The greatest thickness of upper surficial deposits occurs in the areas of the buried bedrock valleys.

Sand and gravel deposits can occur throughout the entire unconsolidated section. The total thickness of sand and gravel deposits is generally less than 10 metres throughout the County. The greatest thickness of sand and gravel deposits occurs in the areas of the buried bedrock lows and meltwater channels. The combined thickness of all sand and gravel deposits has been determined as a function of the total thickness of the surficial deposits.

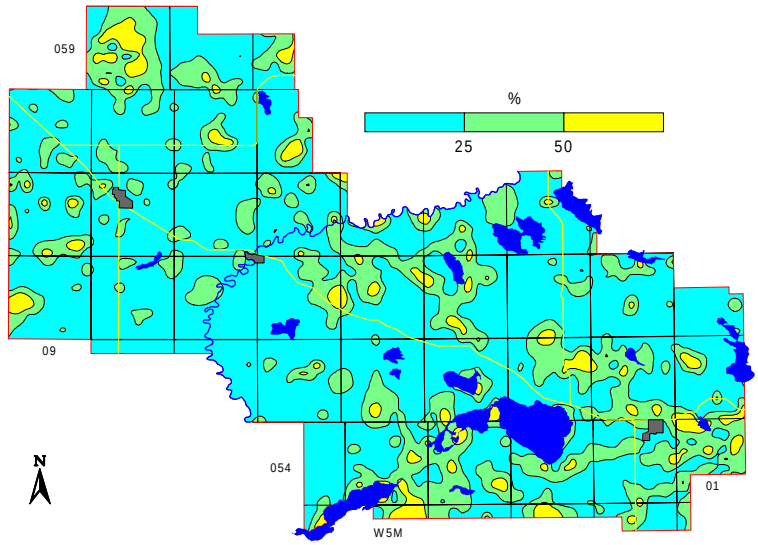

Figure 10. Amount of Sand and Gravel in Surficial Deposits

Over approximately 80% of the County, the sand and gravel deposits are less than 25% of the total thickness of the surficial deposits. The areas where the sand and gravel percentage is higher are associated with the buried bedrock lows and meltwater channels.

5.2.2 Sand and Gravel Aquifer(s)

One source of groundwater in the County includes aquifers in the surficial deposits. The actual aquifer that is developed is usually dictated by which aquifer is present. Some water wells are completed in aquifers in the lower surficial deposits and some are completed in aquifers in the upper surficial deposits.

The adjacent map shows water well yields that are expected in the County, based on the 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 only a few areas of the County. The most notable areas where higher yields are expected include the towns of Mayerthorpe and Onoway, south of the community of Cherhill, and in the vicinity of Lac Ste. Anne. Over approximately 25% of the County, the sand and gravel deposits are not present or if present, are not saturated.

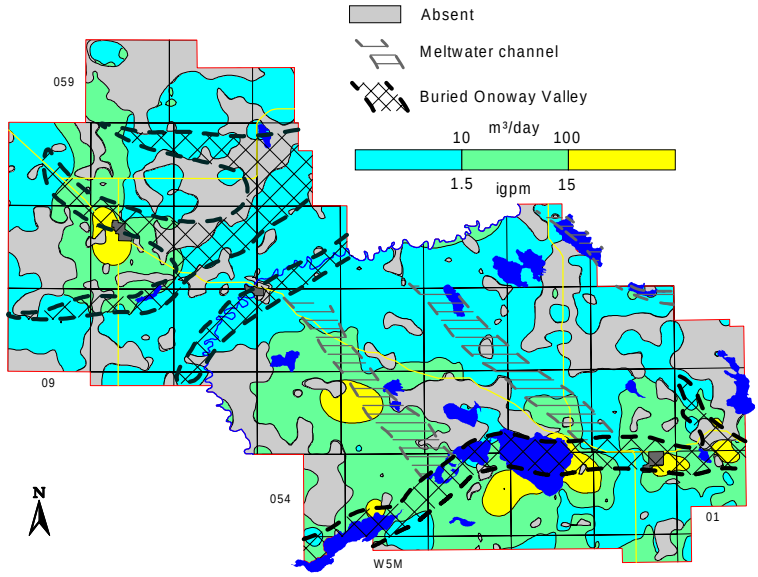

Figure 11. Apparent Yield for Water Wells Completed through Sand and Gravel Aquifer(s)

The main groundwater supply from surficial deposits that has been developed in the County is for the Town of Mayerthorpe. The Town uses a sand and gravel aquifer associated with a linear bedrock low. In 1997, the Town of Mayerthorpe used more than 800 m³/day of groundwater. However, the water level in this aquifer has declined more than 25 metres between 1962 and 1996 (Hydrogeological Consultants Ltd., 1998).

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 is that there appears to be no major chemical difference between groundwater from the upper and lower sand and gravel aquifers. The groundwaters from these aquifers are generally chemically hard and high in dissolved iron.

The Piper tri-linear diagrams show that the majority of the groundwaters are sodium-bicarbonate-type or calcium-magnesium-bicarbonate-type waters; however, some are groundwaters from the surficial deposits are sodium-sulfate-type waters.

Eighty percent of the groundwaters from the surficial aquifers have a chemical hardness of more than 50 mg/L. The total dissolved solids (TDS) concentrations in the groundwaters from the surficial deposits range from less than 500 to over 2,000 mg/L, with 70% of the 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 northern part of the County. Groundwaters with sulfate concentrations of greater than 400 mg/L occur in areas where TDS values exceed 1,100 mg/L.

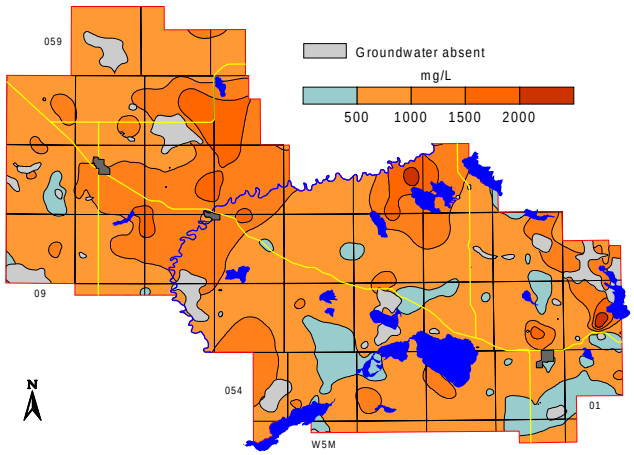

Figure 12. Total Dissolved Solids in Groundwater from Surficial Deposits

There are very few groundwaters with appreciable concentrations of the chloride ion and in most of the County the chloride ion concentration is less than 100 mg/L.

There are very few water wells completed in sand and gravel aquifers within the surficial deposits. This is mainly because the groundwaters from these aquifers tend to be chemically hard and high in dissolved iron. The most significant water wells completed in sand and gravel aquifers are those used by the Town of Mayerthorpe (Hydrogeological Consultants Ltd., 1996).

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 660 metres AMSL. The saturated sand and gravel deposits are not continuous and are expected to be present over approximately 50% of the County.

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 associated with the upper surficial deposits and in part a result of the depth to the bedrock surface. Since the non-pumping water level 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 ten metres thick in some areas, but over the majority of the County, is less than five metres thick or 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 yield of the water wells is 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.

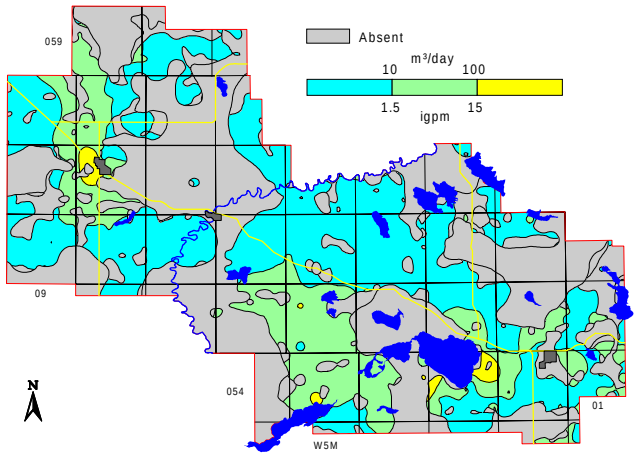

Figure 13. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

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. Coal fragments are frequently associated with the Lower Sand and Gravel Aquifer in the southern part of the County. During well development, the presence of the coal deposits can create a problem by plugging the water well screen. The Lower Sand and Gravel Aquifer may be a continuous aquifer in the Buried Onoway Valley, where the thickness of the sand and gravel deposits may reach five metres. In all, the Lower Sand and Gravel Aquifer is present in less than 50% of the County.

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 Onoway Valley east of Lac Ste. Anne. In this area, the projected long-term yields from individual water wells could be more than 150 m³/day. The yields for water wells completed in the Lower Sand and Gravel Aquifer are expected to be less than 10 m³/day in the majority of the County.

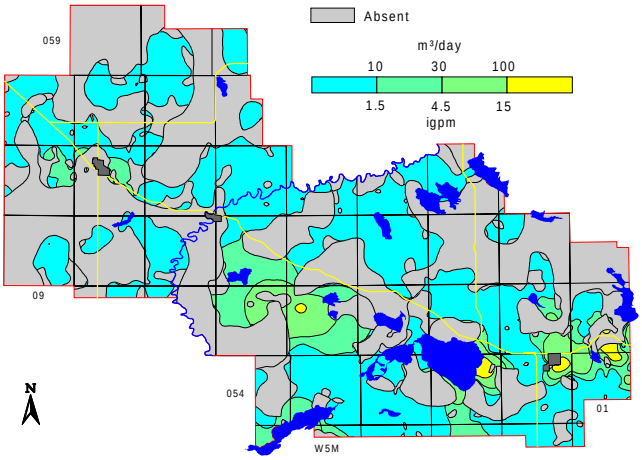

Figure 14. Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer

5.3 Bedrock

5.3.1 Geological Characteristics

The upper bedrock in the County is the Paskapoo Formation and the Edmonton Group. The Paskapoo Formation consists of cycles of thick, tablular sandstones, siltstone and mudstone layers (Glass, D. J.[editor], 1990). The Edmonton Group consists of fresh and brackish-water deposits of fine-grained sandstone and silty shale, thick coal seams, and numerous bentonite beds (Carrigy, 1971). The thickness of the Paskapoo Formation can be up to 800 metres. The thickness of the Edmonton Group varies from 300 to 500 metres, and is underlain by the Bearpaw Formation. The Edmonton Group in the County includes the Scollard, Battle, Whitemud and Horseshoe Canyon formations.

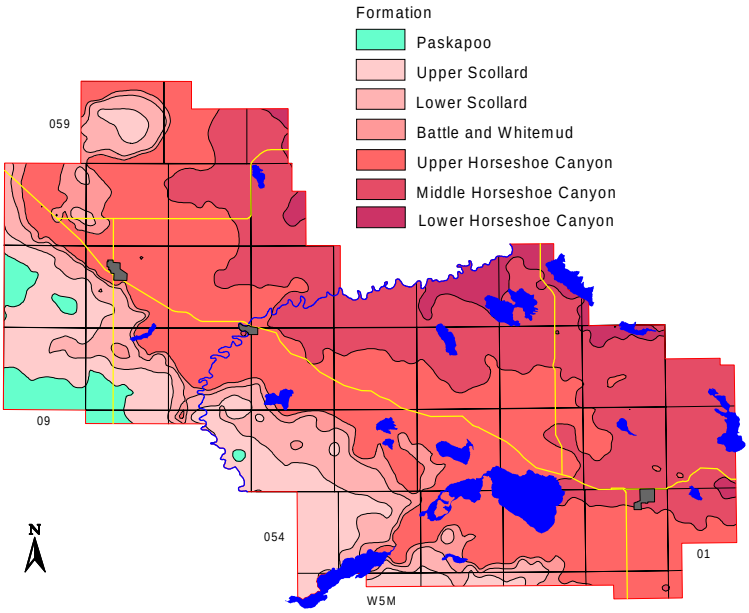

Figure 15. Bedrock Geology

The Paskapoo Formation is the upper bedrock and subcrops in the southwestern part of the County. The total thickness of the Paskapoo Formation within the County is mainly less than 100 metres.

The Scollard Formation underlies the Paskapoo Formation and also subcrops in the southwestern part of the County. The Scollard Formation has a maximum thickness of 120 metres within the County and includes the Upper and Lower Scollard formations. The Upper Scollard consists mainly of sandstone, siltstone, shale and coal seams or zones. Two prominent coal zones within the Upper Scollard are the Ardley Coal (up to 20 metres thick) and the Nevis Coal (up to 3.5 metres thick). The bottom of the Nevis Coal Seam is the border between the Upper and Lower Scollard formations. The Lower Scollard Formation has a maximum thickness of 40 metres and is composed mainly of shale and sandstone.

Beneath the Scollard Formation are two formations having a maximum thickness of 30 metres: the two are the Battle and Whitemud formations. The Battle and Whitemud formations are also present only in the southwestern part of the County. The Battle Formation is composed mainly of claystone, tuff, shale and bentonite, and includes the Kneehills Member, a 2.5- to 30-cm thick tuff bed. The Whitemud Formation is composed mainly of shale, siltstone, sandstone and bentonite. The Battle and Whitemud formations are considered to be significant geologic markers, and were used to prepare the structural maps and hydrostratigraphy classifications. Because of the ubiquitous nature of the bentonite in the Battle and Whitemud formations, there is very little significant permeability within these two formations.

The Horseshoe Canyon Formation is the lower part of the Edmonton Group and is the upper bedrock in the remainder of the County. The Horseshoe Canyon Formation has a maximum thickness of 350 metres and within the County includes the Upper, Middle and Lower Horseshoe Canyon formations. The Upper Horseshoe Canyon, which can be up to 100 metres thick, is the upper bedrock in the central third of the County where the Scollard Formation is absent. The Middle Horseshoe Canyon, which is up to 70 metres thick, is the upper bedrock in the northeastern part of the County. The Lower Horseshoe Canyon, which is up to 180 metres thick, is the upper bedrock in a few areas of the northeastern part of the County.

The Horseshoe Canyon Formation consists of deltaic[11] and fluvial sandstone, siltstone and shale with interbedded coal seams, bentonite and thin nodular beds of ironstone. Because of the low-energy environment in which deposition occurred, the sandstones, when present, tend to be finer grained. The lower 60 to 70 metres and the upper 30 to 50 metres of the Horseshoe Canyon Formation can include coarser grained sandstone deposits.

The Bearpaw Formation underlies the Horseshoe Canyon Formation and is in the order of 80 metres thick within the County. The Bearpaw Formation includes transgressive, shallow marine (shoreface) and open marine facies[12] deposits. In Lac Ste. Anne County, the Bearpaw Formation is composed mainly of shale and as such is a regional aquitard.

5.3.2 Aquifers

In general, water wells in the bedrock aquifer(s) in Lac Ste. Anne County can be expected to provide only limited quantities of groundwater. The adjacent map shows water well yields that are based on the upper bedrock aquifer(s) that have been developed. Over approximately 50% of the County, water wells completed in the upper bedrock aquifer(s) have apparent yields of less than 10 m³/day. The higher yields are mainly in the western and southern part of the County.

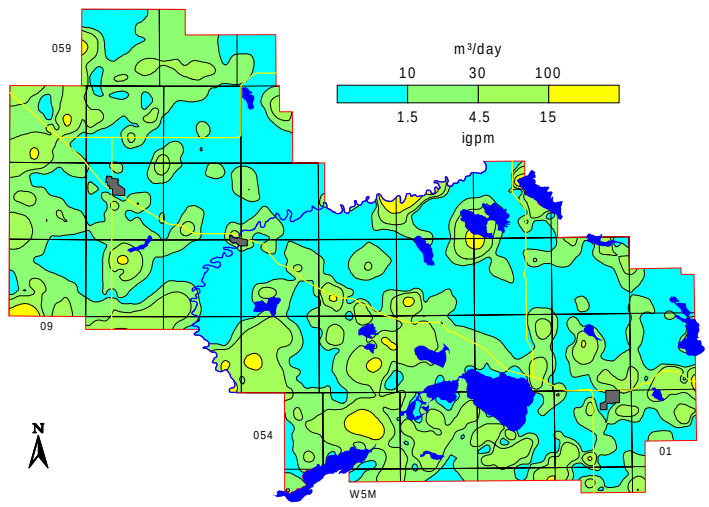

Figure 16. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

The water wells completed in the Upper Scollard and Upper Horseshoe Canyon Aquifers generally have higher yields than in the Middle Horseshoe Canyon Aquifer.

[11] See glossary
[12] See glossary

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 60% of the area, TDS values are less than 1,000 mg/L.

A relationship between TDS and sulfate concentrations shows that when TDS values in the upper bedrock aquifer(s) exceed 1,200 mg/L, the sulfate concentration exceeds 400 mg/L.

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

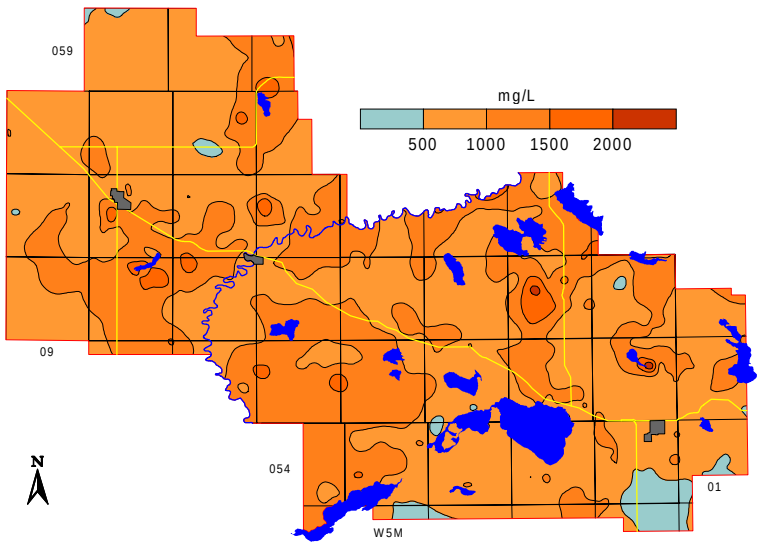

Figure 17. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

In 60% of the County, the fluoride ion concentration in the groundwater from the upper bedrock aquifer(s) is less than 1.0 mg/L.