4.2 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 pre-glacial fluvial[10] and lacustrine[11] deposits. The lacustrine deposits include clay, silt and fine-grained sand. The upper surficial deposits include the more traditional glacial deposits of till[12] and meltwater deposits. In the County, no lower surficial deposits have been defined to date and the upper surficial deposits include mainly till.

4.2.1 Geological Characteristics of Surficial Deposits

While the surficial deposits are treated as one hydrogeological unit, they consist of two hydraulic parts. The first is the saturated sand and gravel deposits of the upper surficial deposits and the second is the sand and gravel close to ground level, which is usually unsaturated. The 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”.

Over the majority of the County, the surficial deposits are less than 30 metres thick. The exceptions are mainly in association with the linear bedrock lows where the deposits can have a thickness of more than 30 metres. There are two main linear bedrock lows in the County as shown on the adjacent bedrock topography map.

Sand and gravel deposits can occur throughout the surficial deposits. The total thickness of sand and gravel deposits is generally less than 5 metres but can be more than 10 metres in the areas of the linear bedrock lows.

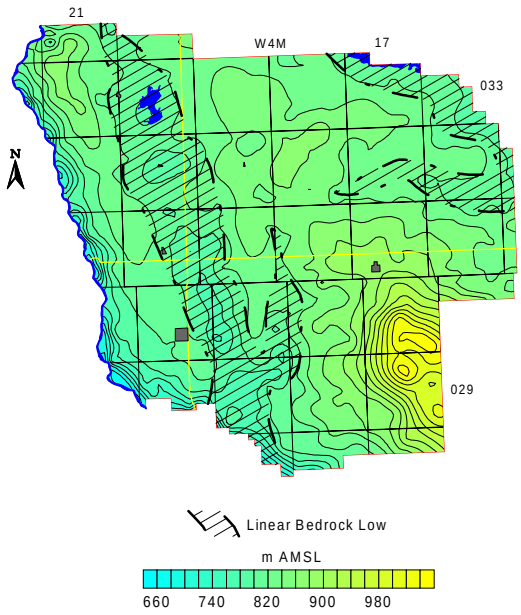

Figure 9. Bedrock Topography

[10] See glossary
[11] See glossary
[12] See glossary

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 20% of the County where sand and gravel deposits are present, the sand and gravel deposits are more than 50% of the total thickness of the surficial deposits. Some areas where the sand and gravel percentages are higher are areas where linear bedrock lows are present. Other areas where sand and gravel deposits constitute more than 50% of the surficial deposits may be areas where linear bedrock lows exist but have not been identified due to a shortage of accurate bedrock control points. The higher percentage of sand and gravel in townships 031, 032 and 033, ranges 18 and 19 is extensive, with no evidence of a linear bedrock low.

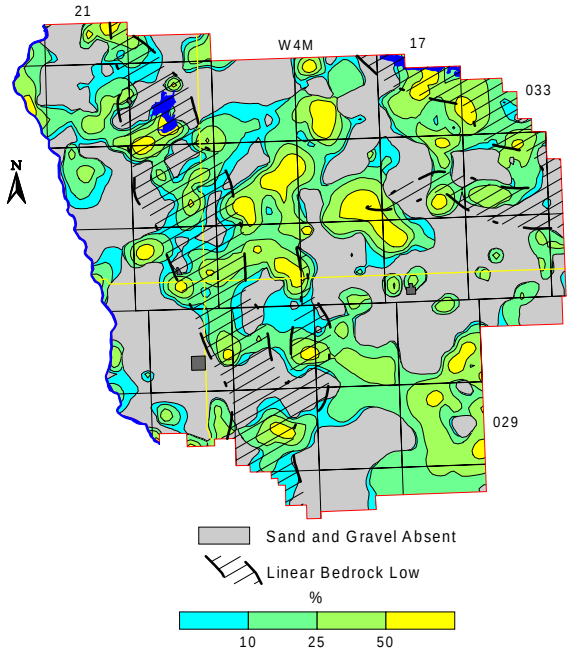

Figure 10. Amount of Sand and Gravel in Surficial Deposits

4.2.2 Sand and Gravel Aquifer(s)

One source of groundwater in the County 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, 408 water wells are completed in aquifers in the upper surficial deposits. This number of 408 water wells completed in aquifers in the surficial deposits is eight times the number of water wells determined to be completed in aquifers in the surficial deposits based on lithologies given on the water well drilling reports.

The water wells completed in the upper surficial deposits are located throughout the County, as shown in Figure 11.

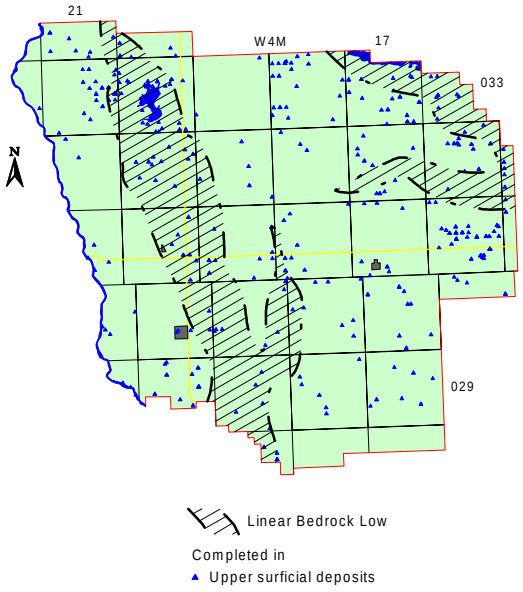

Figure 11. Water Wells Completed in Surficial Deposits

The adjacent map shows water well yields that are expected in the County, based on sand and gravel aquifer(s) 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 less than 10% of the County. The most notable areas where yields of more than 100 m³/day are present are mainly in the north-central parts of the County. Over the majority of the County where the sand and gravel aquifer(s) are present, water wells completed in the sand and gravel aquifer(s) would have apparent yields of less than 100 m³/day. In 60% of the County there are no sand and gravel aquifer(s) present.

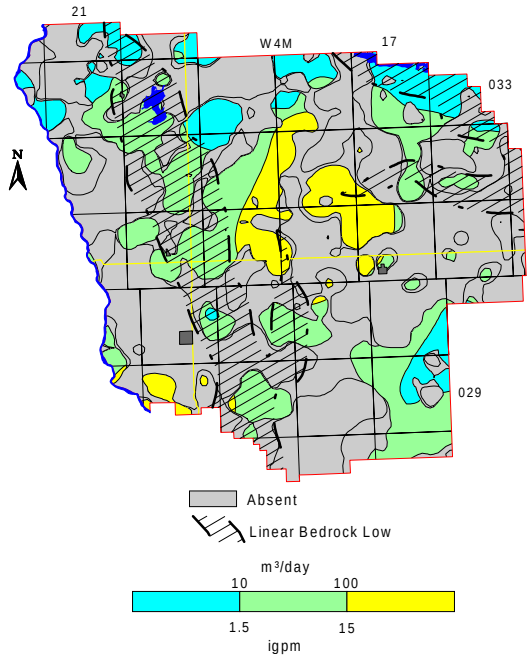

Figure 12. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

4.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

The Piper tri-linear diagram[13] shows that all chemical types of groundwater occur in the surficial deposits. However, the majority of the groundwaters have calcium or sodium as the main cation, and bicarbonate or sulfate as the main anion. The TDS concentrations in the groundwaters from the surficial deposits range from less than 500 to more than 2,000 mg/L. In more than 50% of the area, TDS values are less than 1,500 mg/L. The groundwaters with a TDS of more than 2,000 mg/L occur mainly in the northwestern part of the County.

The groundwaters with elevated levels of sulfate generally 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 County, the chloride ion concentration is less than 100 mg/L.

Groundwaters from the surficial deposits are expected to have dissolved iron concentrations of greater than 1 mg/L.

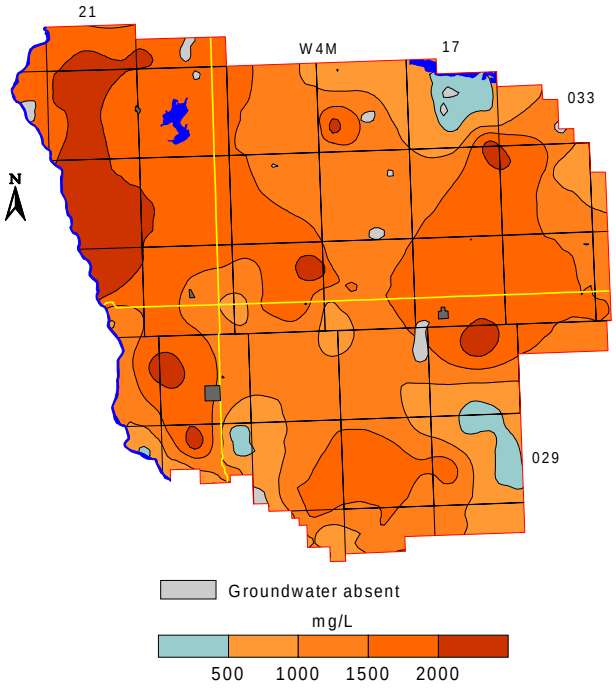

Figure 13. Total Dissolved Solids in Groundwater from Surficial Deposits

[13] See glossary

4.3 Bedrock

4.3.1 Geological Characteristics

The upper bedrock in the County is the Edmonton Group. 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 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.

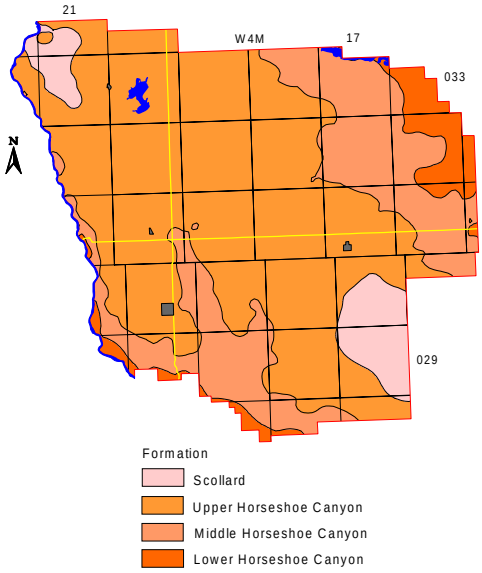

Figure 14. Bedrock Geology

The Scollard Formation is the upper bedrock and subcrops mainly in the northwestern and southeastern parts 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 northwestern and southeastern parts 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; they are, therefore, included with the Upper Horseshoe Canyon Formation on Figure 14 and in the Groundwater Query.

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 majority of the County immediately adjacent to the area where the Scollard Formation subcrops. The Middle Horseshoe Canyon, which is up to 80 metres thick, is the upper bedrock in the southwestern and northeastern parts of the County. The Lower Horseshoe Canyon, which is up to 180 metres thick, is the upper bedrock along the southwestern and northeastern edges of the County.

The Horseshoe Canyon Formation consists of deltaic[14] 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[15], shallow marine (shoreface[16]) and open marine facies[17] deposits. In the County, the Bearpaw Formation is composed mainly of shale and as such is a regional aquitard. 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. Because the Bearpaw Formation is an aquitard, there will be no direct review of the Bearpaw Aquitard in the text of this report. However, maps associated with the Bearpaw Aquitard are included on the CD-ROM.

The Belly River Group includes the Oldman and Foremost formations. The main areas of higher permeability occur near the base of the Belly River Group at a depth of approximately 600 plus metres below ground level. The porous and permeable zones may be developed for hydrocarbons and limited quantities of groundwater, with total dissolved solids of up to 20,000 mg/L. However, parts of the Oldman Formation are also porous and permeable and attempts have been made to develop some groundwater supplies from the Oldman Formation. A limited discussion of the Oldman Formation is included in the present report.

4.3.2 Aquifers

Of the 1,616 water wells in the database, 578 were defined as being completed in bedrock aquifers based on the top of the completion interval being below the bedrock surface. However, less than half of the water well records in the database have values for the top of their completion intervals. The information that is available for the majority of water wells is their completion depth. 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 1,233 from 578. 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 1,233 bedrock water wells, 1,142 could be assigned a specific aquifer. The bedrock water wells are mainly completed in the Horseshoe Canyon aquifers as shown in the adjacent table.

Bedrock Aquifer	No. of Water Wells
Scollard	56
Upper Horseshoe Canyon	626
Middle Horseshoe Canyon	308
Lower Horseshoe Canyon	149
Oldman	3
Other	91
Total	1233

Table 3. Completion Aquifer

[14] See glossary
[15] See glossary
[16] See glossary
[17] See glossary

In general, water wells in the bedrock aquifers in the County can be expected to provide only limited quantities of groundwater.

There are 255 records for bedrock water wells that have apparent yield values, 20% of all bedrock water wells. In the County, water well yields in the upper bedrock aquifer(s) are mainly less than 100 m³/day. The areas of higher yields that are indicated on the adjacent figure are mainly in the northwestern and eastern parts of the County and the lower yields mainly trend from the southwest to the northeast through the centre of the County. The higher yields in the northwestern part of the County may be a result of increased permeability resulting from the weathering process in association with the linear bedrock lows.

There are 251 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.

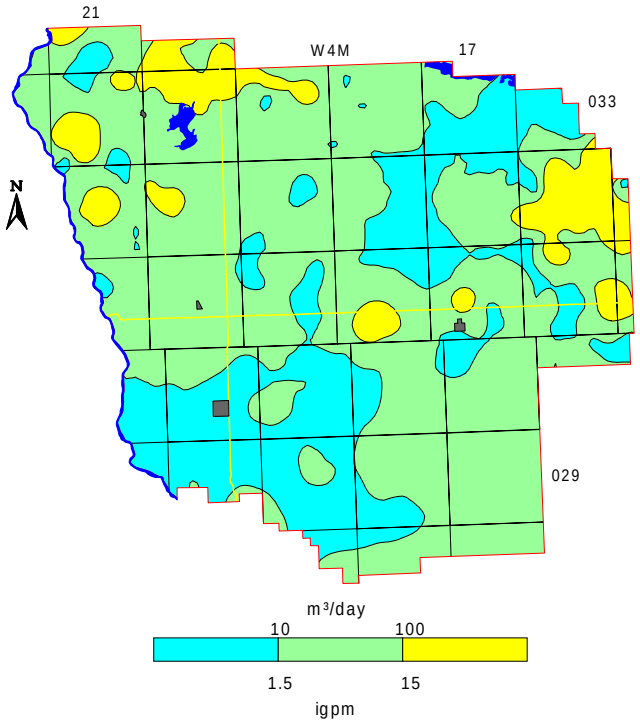

Figure 15. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

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
Scollard	13	6	6	1
Upper Horseshoe Canyon	149	39	85	25
Middle Horseshoe Canyon	54	26	22	6
Lower Horseshoe Canyon	35	5	16	14
Totals	251	76	129	46

Table 4. Apparent Yields of Bedrock Aquifers

4.3.3 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 1,500 mg/L, with only a few areas having TDS concentrations of less than 500 mg/L. The higher values are expected mainly in the western and eastern parts of the County.

The relationship between TDS and sulfate concentrations shows that when TDS values in the upper bedrock aquifer(s) exceed 1,200 mg/L, the sulfate concentrations exceed 400 mg/L. The chloride concentrations in the groundwaters from the upper bedrock aquifer(s) are less than 100 mg/L in more than 90% of the County.

In more than 95% of the County, the fluoride ion concentration in the groundwaters from the upper bedrock aquifer(s) is less than 1.5 mg/L.

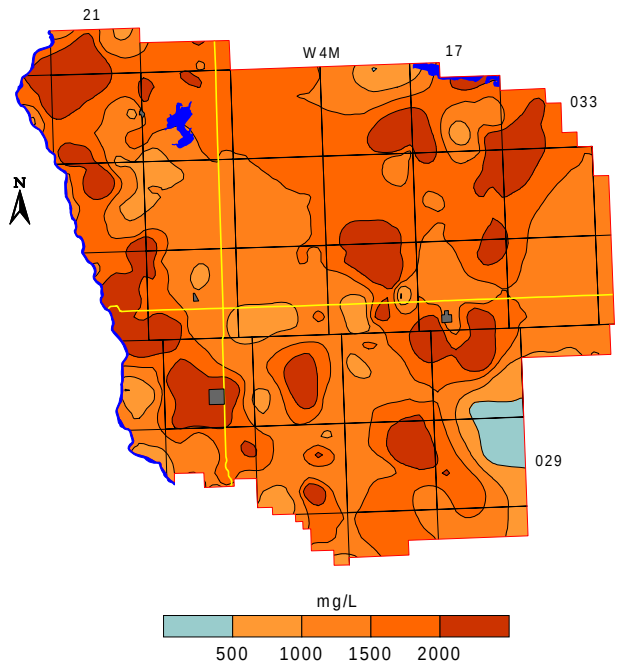

Figure 16. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

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

4.3.4 Scollard Aquifer

The Scollard Aquifer comprises the porous and permeable parts of the Scollard Formation that underlies the surficial deposits in approximately 170 square kilometres in the northwestern and southeastern parts of the County. The Scollard Formation is mainly less than 20 metres thick in the northwestern area but is mainly more than 50 metres thick in the southeastern area; in most of the County, the Scollard Formation has been eroded.

4.3.4.1 Depth to Top

The depth to the top of the Scollard Formation is mainly between 10 and 30 metres. The greatest depth is predominantly in the southeastern part of the County where the Formation is present.

4.3.4.2 Apparent Yield

The apparent yields for individual water wells completed through the Scollard Aquifer in the northwestern part of the County are mainly less than 10 m³/day and are predominantly between 10 and 100 m³/day in the southeastern part of the County. Adjacent to the Red Deer River Valley in township 034, range 22, W4M, the Scollard Formation is expected to be drained.

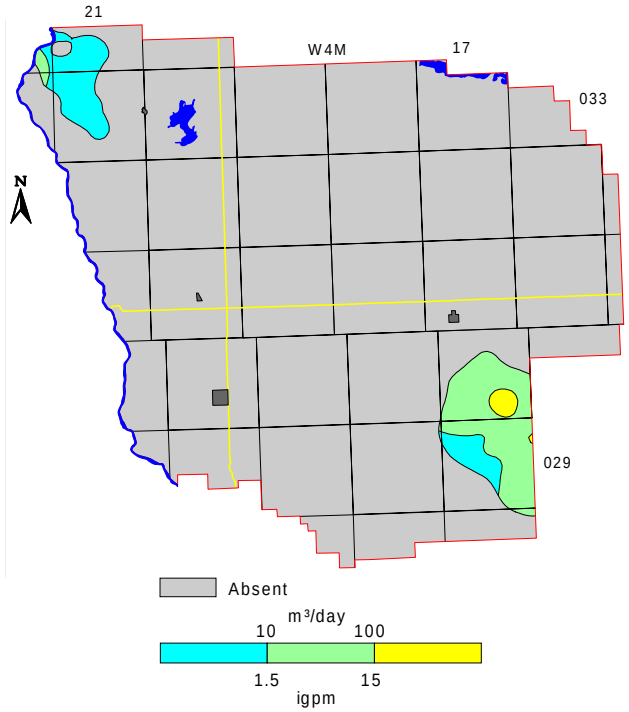

Figure 17. Apparent Yield for Water Wells Completed through Scollard Aquifer

4.3.4.3 Quality

The groundwaters from the Scollard Aquifer are mainly sodium-bicarbonate or sodium-sulfate types (see CD-ROM). The TDS concentrations range from less than 500 to more than 2,000 mg/L. The higher values are in the northwestern part of the County and the lower values are in the southeastern part of the County. The sulfate concentrations are more than 500 mg/L in the northwestern part of the County and mainly less than 100 mg/L in the southeastern part of the County. Chloride concentrations in the groundwaters from the Scollard Aquifer range from less than 5 to more than 10 mg/L, with the lower values in the southeastern part of the County.