4.4 Maps and Cross-Sections

Once grids for geological surfaces have been prepared, various grids need to be combined to establish the extent and thickness of individual geological units. For example, the relationship between an upper bedrock unit and the bedrock surface must be determined. This process provides both the aquifer outline and the aquifer thickness. The aquifer thickness is used to determine the aquifer transmissivity by multiplying the hydraulic conductivity by the thickness.

Grids must also be combined to allow the calculation of projected long-term yields for individual water wells. The grids related to the elevation of the non-pumping water level and the elevation of the top of the aquifer are combined to determine the available drawdown. The available drawdown data and the transmissivity values are used to calculate values for projected long-term yields for individual water wells, completed in a specific aquifer, wherever the aquifer is present.

Once the appropriate grids are available, the maps are prepared by contouring the grids. The areal extent of individual parameters is outlined by masks to delineate individual aquifers. Appendix A includes page-size maps from the text, plus additional page-size maps and figures that support the discussion in the text. A list of maps and figures that are included on the CD-ROM is given in Appendix B.

Cross-sections are prepared by first choosing control points from the database along preferred lines of section. Data from these control points are then obtained from the database and placed in an AutoCAD drawing with an appropriate vertical exaggeration. The data placed in the AutoCAD drawing include the geo-referenced lithology, completion intervals and non-pumping water levels. Data from individual geological units are then transferred to the cross-section from the digitally prepared surfaces.

Once the technical details of a cross-section are correct, the drawing file is moved to the software package CorelDRAW! for simplification and presentation in a hard-copy form. These cross-sections are presented in this report and in Appendix A, are included on the CD-ROM, and are in Appendix D in a page-size format.

4.5 Software

The files on the CD-ROM have been generated from the following software:

- Microsoft Professional Office 97
- Surfer 6.04
- ArcView 3.0a
- AutoCAD 14.01
- CorelDRAW! 8.0
- Acrobat 3.0

5 AQUIFERS

5.1 Background

An aquifer is a porous and permeable rock that is saturated. If the NPWL is above the top of the rock unit, this type of aquifer is an artesian aquifer. If the rock unit is not entirely saturated and the water level is below the top of the unit, this type of aquifer is a water-table aquifer. These types of aquifers occur in one of two general geological settings in the County. The first geological setting is the sediments that overlie the bedrock surface. In this report, these are referred to as the surficial deposits. The second geological setting includes aquifers in the upper bedrock. The geological settings, the nature of the deposits making up the aquifers within each setting, the expected yield of water wells completed in different aquifers, and the general chemical quality of the groundwater associated with each setting are reviewed separately.

5.1.1 Surficial Aquifers

Surficial deposits in the County are mainly less than 20 metres thick, except in areas of linear bedrock lows where the thickness of surficial deposits can exceed 60 metres. The Buried Buffalo Lake Valley is one of the main linear bedrock lows. This linear low is present in the northern part of the County. Cross-section A-A' passes south of Buffalo Lake and shows the thickness of the surficial deposits being approximately 90 metres.

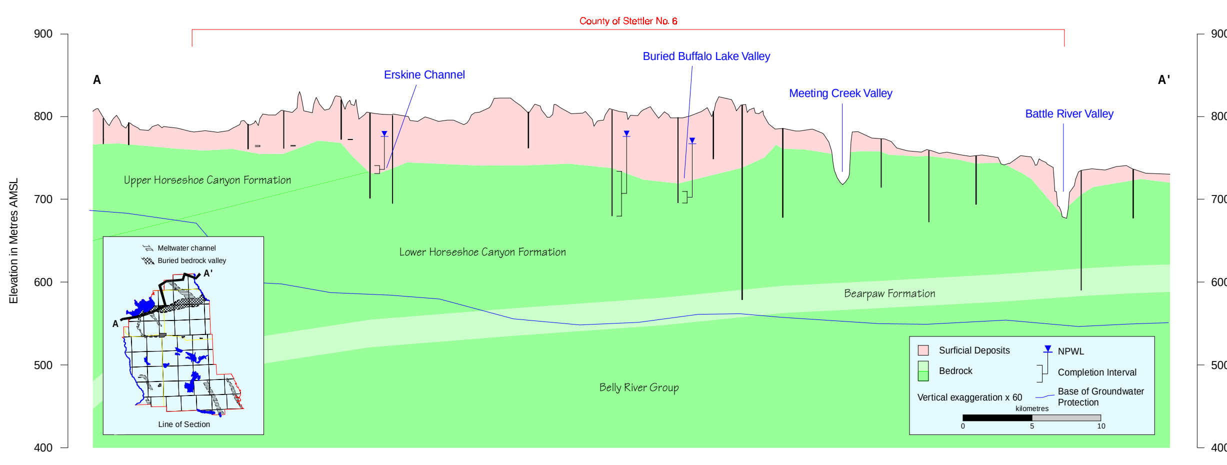

Figure 7. Cross-Section A - A'

The main aquifers in the surficial materials are sand and gravel deposits. In order for a sand and gravel deposit to be an aquifer, it must be saturated; if not saturated, a sand and gravel deposit is not an aquifer. The top of the surficial aquifers has been determined from the NPWL in water wells less than 15 metres deep. The base of the surficial aquifers is the bedrock surface.

For a water well with a small-diameter casing to be effective in surficial deposits and to provide sand-free groundwater, the water well must be completed with a water well screen. Many of the water wells completed in the surficial deposits are completed in low-permeability aquifers and have a large-diameter casing. The large-diameter water wells may have been hand dug or bored and because they are completed in very low permeability aquifers, most of these water wells would not benefit from water well screens. The groundwater from an aquifer in the surficial deposits usually has a chemical hardness of at least a few hundred mg/L and a dissolved iron concentration such that the groundwater must be treated before being used for domestic needs. Within the County, 27% of the water wells completed in the surficial deposits have a casing diameter of greater than 300 millimetres or no reported diameter for the surface casing, and are assumed to be dug or bored water wells.

5.1.2 Bedrock Aquifers

The upper bedrock includes rocks that are less than 200 metres below the bedrock surface. Some of this bedrock contains porous, permeable and saturated rocks that have a structure that is permeable enough for the rock to be an aquifer. Water wells completed in bedrock aquifers usually do not require water well screens and the groundwater is usually chemically soft. The data for 1,892 water wells indicate that the top of the water well completion interval is below the bedrock surface, indicating that the water wells are completed in at least one bedrock aquifer. Of these 1,892 water wells in the database, 1,781 have values for surface casing diameter. Of the 1,781 water wells, 98% have casing diameters of less than 300 millimetres.

The upper bedrock includes parts of the Scollard, Horseshoe Canyon and Bearpaw formations. The Belly River Group is not considered part of the upper bedrock in the Stettler area, even though in some areas it is less than 200 metres below the bedrock surface. The present-day Red Deer River has eroded down almost to the base of the Upper Horseshoe Canyon Formation along the southwestern part of the County.

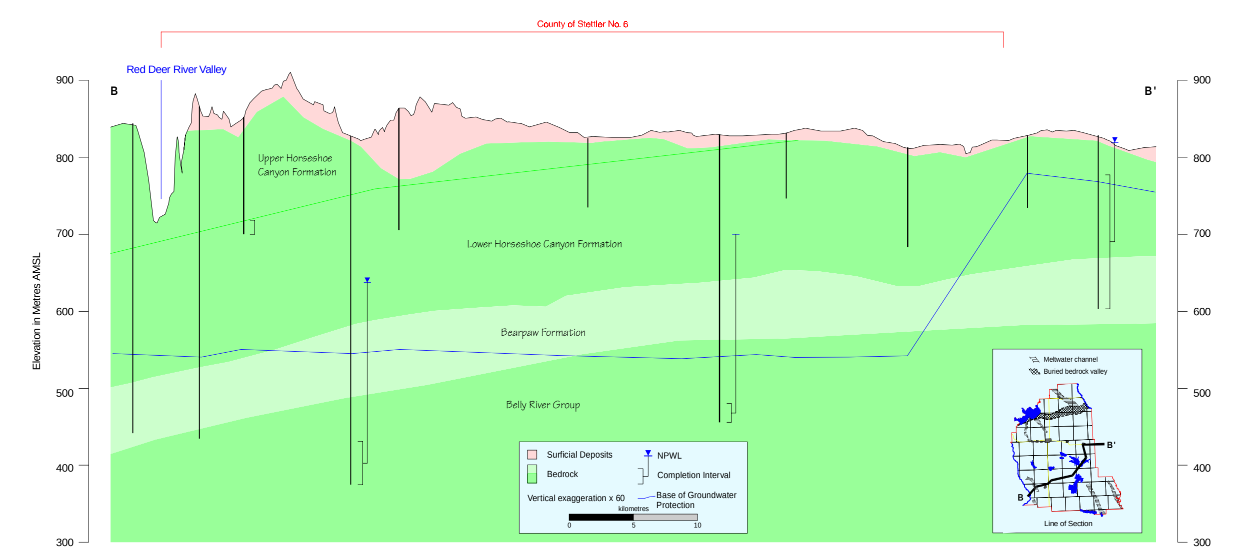

Figure 8. Cross-Section B - B'

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 drift, materials deposited directly by or indirectly during glaciation. The lower surficial deposits include the pre-glacial and some transitional sediments deposited as the glaciers advanced. The upper surficial deposits include the more traditional glacial deposits of till and meltwater deposits. In the County of Stettler, pre-glacial materials may be present in association with the Buried Buffalo Lake Valley, but none have been designated for the present study.

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 the third 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 20 metres thick. The exceptions are mainly in association with the main linear low in the bedrock surface, which occurs in the northern part of the County. This linear bedrock low has been designated as the Buried Buffalo Lake Valley, and is approximately 15 kilometres north of the Town of Stettler and is shown on the adjacent map. The Buried Buffalo Lake Valley trends from the southwest to the northeast and is a tributary valley to the Buried Wainwright Valley located in the County of Flagstaff.

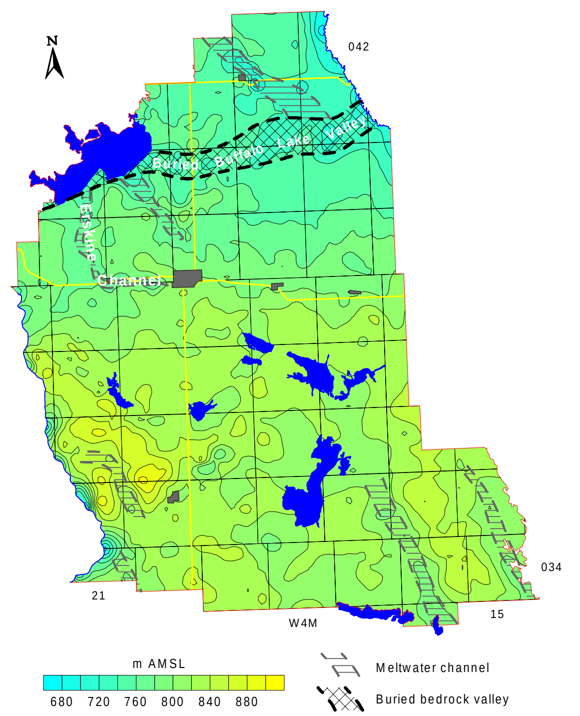

Figure 9. Bedrock Topography

The Buried Buffalo Lake Valley is approximately three to five kilometres wide with local relief being less than 40 metres. Sand and gravel deposits can be expected to be present in association with this bedrock low, but the thickness of the deposits is expected to be less than 10 metres.

Minor linear bedrock lows that are believed to be associated with meltwater channels also occur in the County. Seven are noted on the adjacent map. The linear bedrock low west of Stettler may be of meltwater origin or a tributary to the Buried Buffalo Lake Valley. This channel has been designated as the Erskine Channel (AEP Observation Well Network). The Town of Stettler developed the sand and gravel aquifer associated with the linear bedrock low for its water supply up until 1985. The four channels in the southern part of the County are of meltwater origin; the two channels north of Stettler may be tributaries to the Buried Buffalo Lake Valley.

Sand and gravel deposits can occur throughout the entire unconsolidated section. 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 5% of the County, the sand and gravel deposits are more than 50% of the total thickness of the surficial deposits. These areas tend to highlight the location of the minor linear bedrock lows where the surficial deposits are thinner. In the case of the Buried Buffalo Lake Valley, the surficial deposits include thick accumulations of till, and therefore, the percentage of sand and gravel deposits is less, when given as a function of the total thickness of surficial deposits.

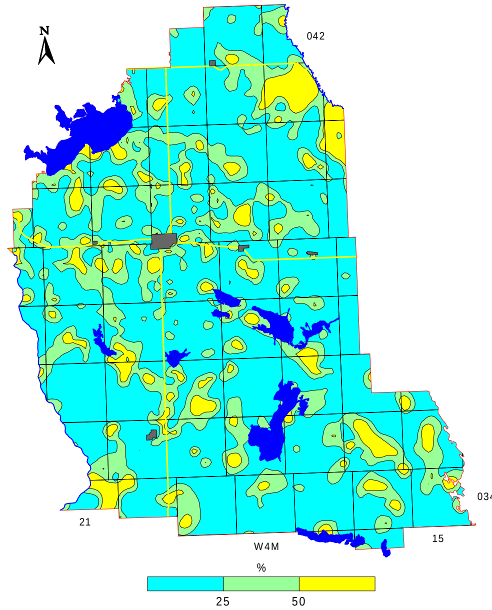

Figure 10. Amount of Sand and Gravel in Surficial Deposits

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.

The adjacent map shows water well yields that are expected in the County, based on the aquifers that have been developed by existing water wells. Based on these data, 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. Over approximately 25% of the County, the sand and gravel deposits are not present or if present, are not saturated.

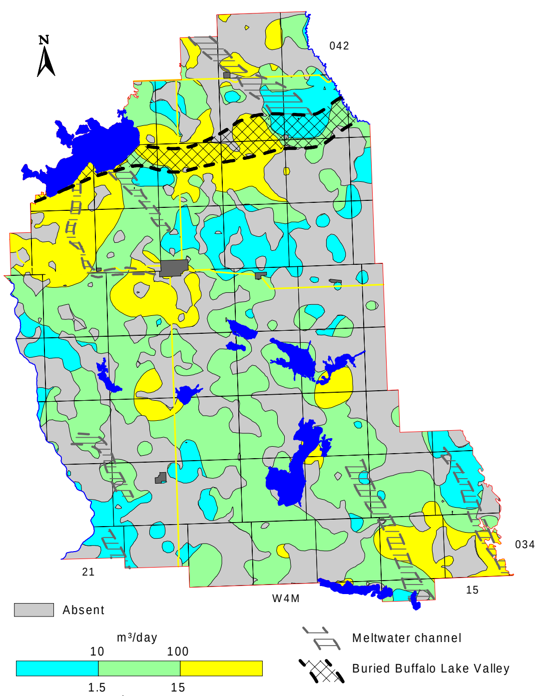

Figure 11. Apparent Yield for Water Wells Completed through Sand and Gravel Aquifer(s)

The main groundwater supply from surficial deposits that has been developed in the County was for the Town of Stettler. The Town used a sand and gravel aquifer associated with the Erskine Channel. Extensive studies of this aquifer indicate that a long-term supply of 3,000 m³/day of groundwater is available from this aquifer (AEP, 1980).

5.2.3 Chemical Quality of Groundwater from Surficial Deposits

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

Two-thirds of the groundwaters from the surficial aquifers have a chemical hardness of more than 50 mg/L. The TDS concentrations in the groundwaters from the surficial deposits range from less than 500 to over 2,000 mg/L, with 60% of the groundwaters having a TDS of less than 1,000 mg/L. The groundwaters with a TDS of more than 2,000 mg/L occur mainly in the eastern part of the County. The groundwaters with elevated levels of sulfate occur in areas where there are elevated levels of total dissolved solids. When TDS values exceed 1,100 mg/L, sulfate concentrations exceed 400 mg/L.

There are very few groundwaters with appreciable concentrations of the chloride ion. All of the groundwaters from the surficial deposits are expected to have concentrations of dissolved iron of greater than 1 mg/L.

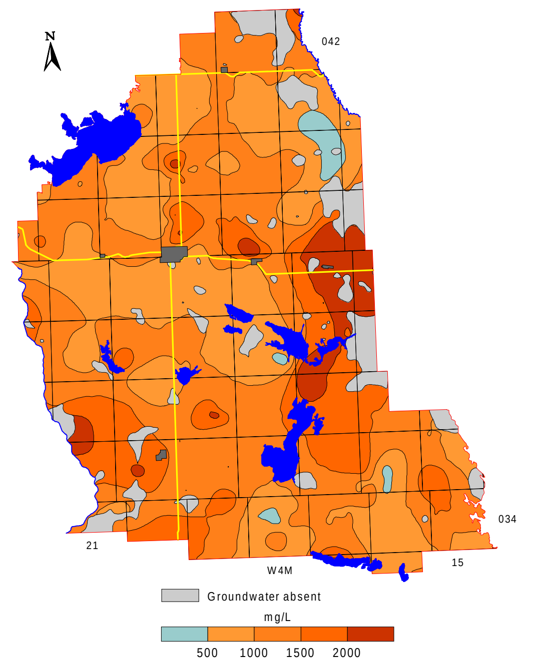

Figure 12. Total Dissolved Solids in Groundwater from Surficial Deposits

5.3 Bedrock

5.3.1 Geological Characteristics

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

The Scollard Formation is the upper bedrock and subcrops in the southwestern part of the County, mainly in townships 036 and 037, ranges 20 and 21, W4M. The Scollard Formation has a maximum thickness of 70 metres within the County and consists mainly of sandstone, siltstone, shale and coal seams or zones.

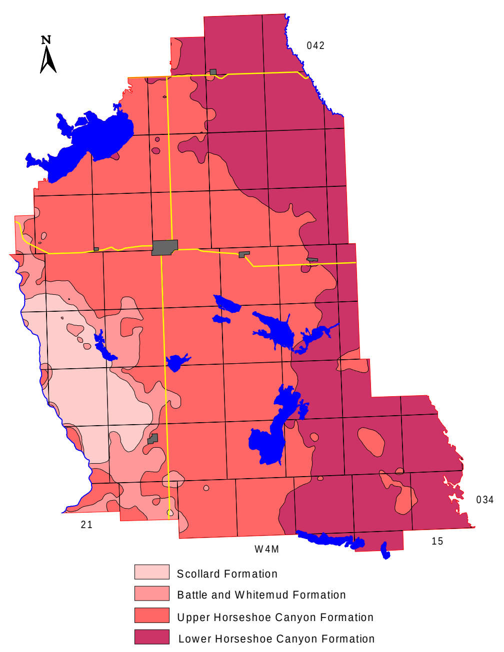

Figure 13. Bedrock Geology

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 ubiquitousness 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 380 metres and within the County includes the Upper and Lower Horseshoe Canyon Formation. The Middle Horseshoe Canyon Formation is absent within the County. The Upper Horseshoe Canyon, which can be up to 170 metres thick, is the upper bedrock in the western three-quarters of the County where the Scollard Formation is absent. The Lower Horseshoe Canyon, which is up to 200 metres thick, is the upper bedrock in the eastern one-quarter of the County. There are subcrops of the Upper Horseshoe Canyon that occur as outliers within the area of the Lower Horseshoe Canyon in the eastern part of the County.

The Horseshoe Canyon Formation consists of deltaic[7] and fluvial[8] 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 of the Horseshoe Canyon 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[9] deposits. In the County of Stettler, the Bearpaw Formation is composed mainly of shale and as such is a regional aquitard[10]. 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.

The Belly River Group includes the Foremost and Oldman 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 in the order of 20,000 mg/L.

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7 See glossary
8 See glossary
9 See glossary
10 See glossary