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 NPWL and the elevation of the top of the aquifer are combined to determine the available drawdown[7]. 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 from the digitally prepared surfaces to the cross-section.

Once the technical details of the 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 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

[7] See glossary

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 Region. 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 nature of the water wells, and the general chemical quality of the groundwater associated with each setting are reviewed separately.

5.1.1 Surficial Aquifers

Surficial deposits in the Region are mainly less than 60 metres thick, except in areas of linear bedrock lows where the thickness of surficial deposits can exceed 100 metres. The Buried Beverly Valley is one of the main linear lows. This linear low is present in the southern third of the Region and trends west to east. Cross-section A-A' passes through the Buried Beverly Valley and shows the surficial deposits being more than 100 metres thick within the Valley. The present-day North Saskatchewan River has eroded down into the *marine* Foremost Formation in the southern part of the Region.

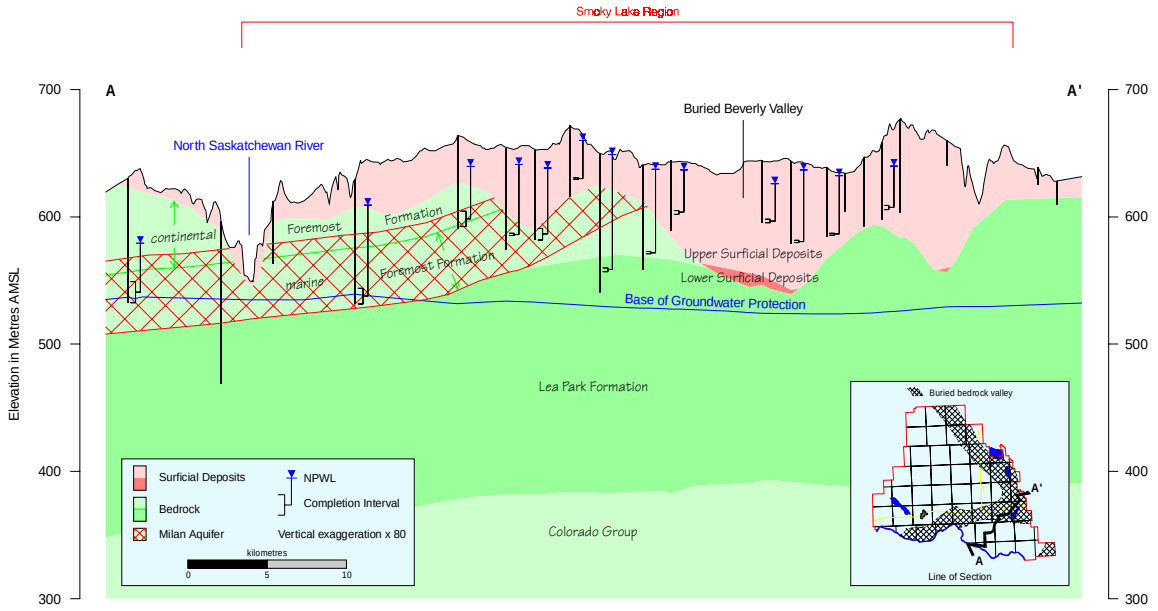

Figure 7. Cross-Section A - A'

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 deposits 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. Some 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 can be completed in low-permeability aquifers, these water wells would not generally 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 Region, 27% of the water wells completed in the surficial deposits have a casing diameter of greater than 350 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 311 water wells indicate that the top of the water well completion interval is below the top of the bedrock surface, indicating that the water wells are completed in at least one bedrock aquifer. Of these 311 water wells in the database, 246 have values for surface casing diameter. Of the 246 water wells, 95% have casing diameters of less than 350 millimetres and 52% of these water wells have been completed with water well screens.

The upper bedrock includes parts of the Belly River Group and the Lea Park Formation (Figure 8). The Belly River Group has a maximum thickness of 250 metres and includes the lowest part of the Oldman Formation and both the *continental* and *marine* facies[8] of the Foremost Formation. In the Smoky Lake Region, the Lea Park Formation is a regional aquitard[9]. The upper part of the *marine* Foremost Formation is included in the Milan Aquifer.

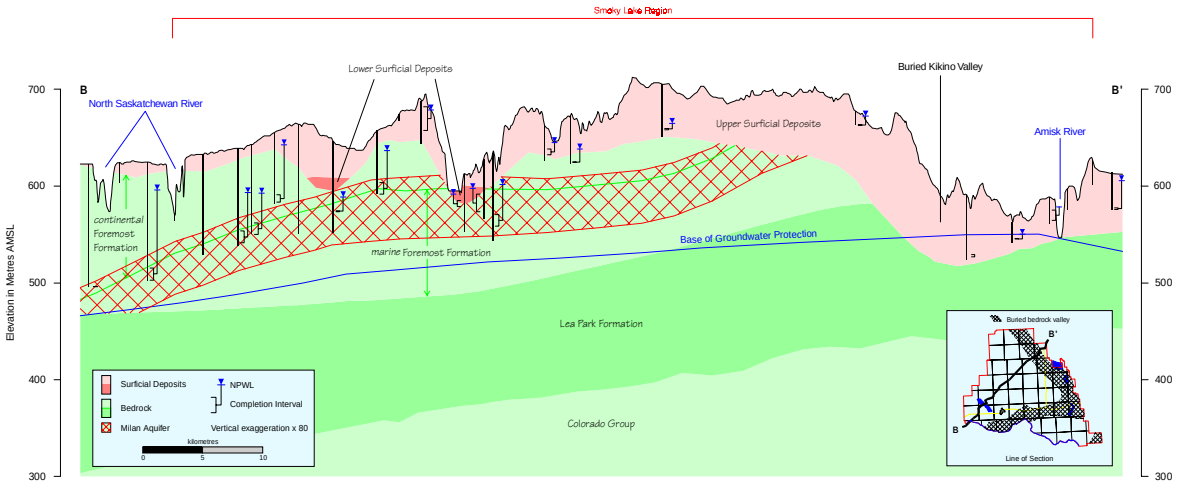

Figure 8. Cross-Section B - B'

[8] See glossary
[9] See glossary

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 sediment deposited as the glaciers advanced. 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 two hydraulic parts. One hydraulic part includes sand and gravel aquifers associated with major linear lows in the bedrock surface and are part of the lower surficial deposits. The second hydraulic unit includes sand and gravel deposits that are not necessarily associated with major linear lows in the bedrock surface and are in the upper part of the surficial deposits. 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 mechanism 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 Region, the surficial deposits are less than 60 metres thick. The exceptions are mainly in association with the linear bedrock lows where the deposits can have a thickness of more than 100 metres. The two most significant linear bedrock lows have been designated as the Buried Beverly Valley and the Buried Kikino Valley. The Buried Beverly Valley is in the southern part of the Region as shown on the adjacent map. The Valley trends from southwest to east, extending from the valley of the present-day North Saskatchewan River to the east side of the Region, where it joins the Buried Kikino Valley. The Buried Beverly Valley is approximately 6 to 9 kilometres wide, with local bedrock relief being less than 60 metres. Sand and gravel deposits can be expected in association with this bedrock low, with the thickness of the sand and gravel deposits expected to be mainly less than 30 metres.

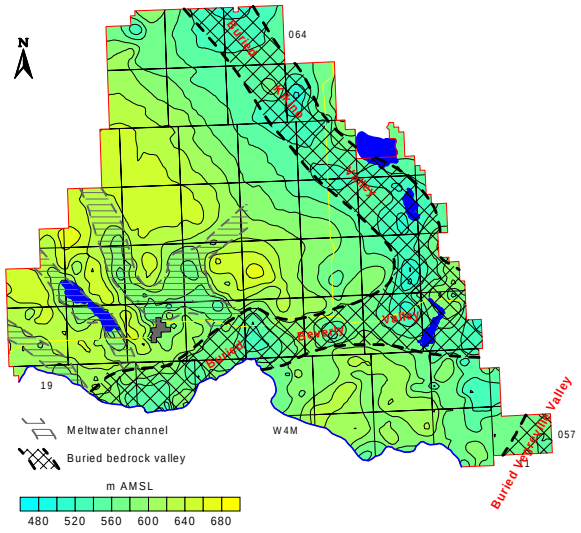

Figure 9. Bedrock Topography

The second linear bedrock low, the Buried Kikino Valley, trends from northwest to southeast along the eastern edge of the Region, joining the Buried Beverly Valley in the southeastern part of the Region. The Buried Kikino Valley is approximately 9 kilometres wide, with local relief being less than 60 metres. Sand and gravel deposits associated with this linear bedrock low can be expected to be less than 30 metres thick.

In addition to the Buried Beverly and Kikino valleys, the Buried Vegreville Valley passes below the eastern part of the Saddle Lake I.R. 125 in parts of township 057, range 11, W4M.

Four other linear bedrock lows are shown on the bedrock topography map. All of these lows are in the southwestern part of the Region 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 Beverly Valley drainage system.

The lower surficial deposits are composed mainly of fluvial[10] and lacustrine[11] 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 20 to more than 60 metres in parts of the Buried Beverly and Kikino 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 Beverly and Kikino 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 Kikino 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.

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 50% of the Region, the sand and gravel deposits are more than 25% of the total thickness of the surficial deposits. The areas where the greatest percentage of sand and gravel tend to occur are in the southwestern part of the Region where linear bedrock lows are present.

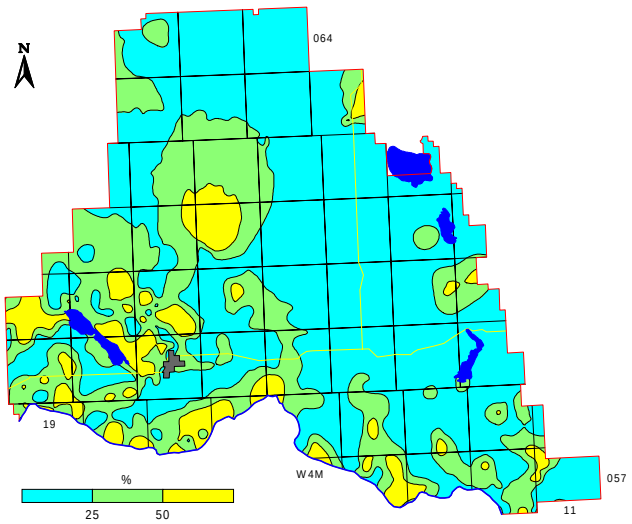

Figure 10. Amount of Sand and Gravel in Surficial Deposits

[10] See glossary
[11] See glossary

5.2.2 Sand and Gravel Aquifer(s)

One significant source of groundwater in the Region 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, 166 water wells are completed in aquifers in the lower surficial deposits and 2,388 are completed in aquifers in the upper surficial deposits. This number of 2,554 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.

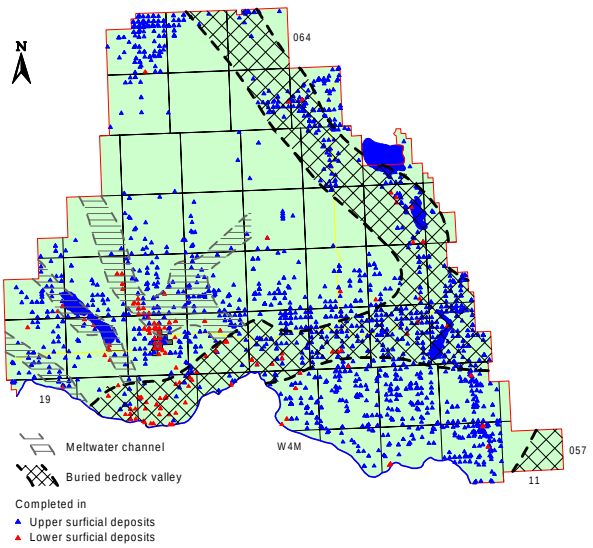

Figure 11. Water Wells Completed in Surficial Deposits

The majority of the water wells completed in the upper surficial deposits are located in the southern half of the Region, as shown on Figure 11. The majority of the water wells completed in the lower surficial deposits are located along the Buried Beverly Valley or in the meltwater channel north of the Town of Smoky Lake.

The adjacent map shows water well yields that are expected in the Region, 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 in the sand and gravel aquifer(s) can be expected mainly in the Buried Beverly Valley and in 40% of the southeastern portion of the Region. Over the majority of the Region, 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.

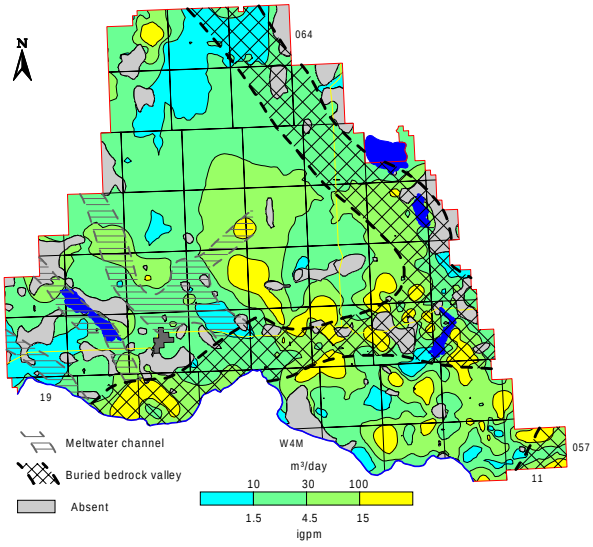

Figure 12. Apparent Yield for Water Wells Completed through Sand and Gravel Aquifer(s)

5.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

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.

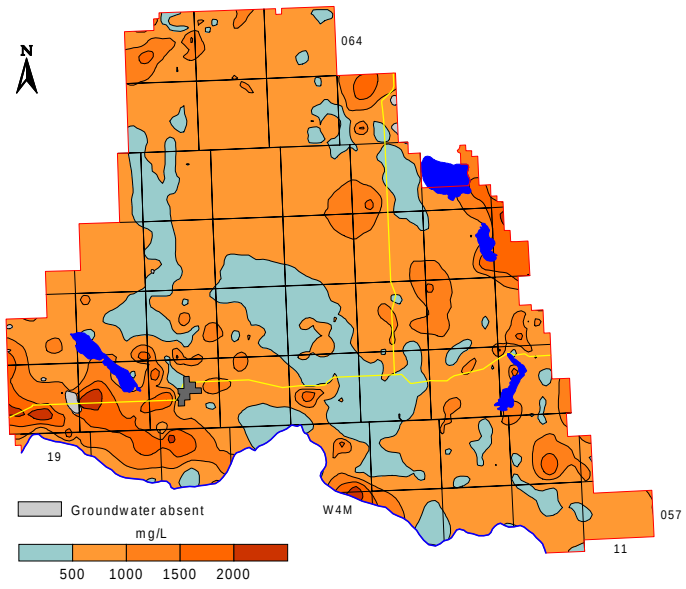

Figure 13. Total Dissolved Solids in Groundwater from Surficial Deposits

The groundwaters from the surficial deposits are mainly calcium-magnesium-bicarbonate-type waters, with 70% of groundwaters having total dissolved solids (TDS) of less than 1,000 mg/L. The groundwaters with a TDS of more than 1,500 mg/L occur mainly in the southwestern and eastern parts of the Region. All of the groundwaters from the surficial deposits are expected to have concentrations of dissolved iron of greater than 1 mg/L. The chemical analyses results for groundwater samples collected from water test holes completed near the Hamlet of Spedden (PFRA, 1990) in the Upper Sand and Gravel Aquifer, indicated TDS concentrations of more than 1,000 mg/L and a hardness of in the order of 600 mg/L.

Groundwater from the Town of Smoky Lake Recreation Complex Water Well completed in the Upper Sand and Gravel Aquifer has a TDS of 425 mg/L and a chemical hardness of 248 mg/L. The groundwater from WSW No. 1 in NW 28-059-17 W4M, which is completed in the Upper Sand and Gravel Aquifer, has a TDS of 300 and a chemical hardness of 255 mg/L.

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 Region the chloride ion concentration is less than 100 mg/L.