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 40 metres thick, except in areas of linear bedrock lows where the thickness of the surficial deposits can exceed 80 metres. The Buried Vegreville and Vermilion valleys are two of the main linear bedrock lows. The Buried Vegreville Valley is present in the western part of the County and trends generally from south to north. The Buried Vermilion Valley is present in the eastern half of the County and trends generally from southwest to northeast. Cross-section A-A' passes across both the Buried Vegreville and Vermilion valleys, and shows the thickness of the surficial deposits varies from less than 10 to more than 60 metres.

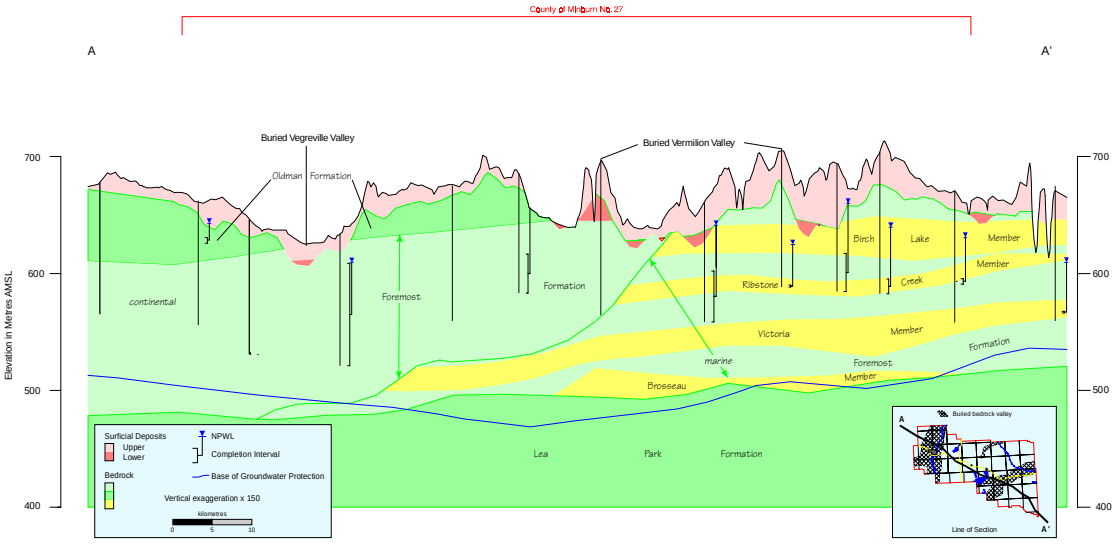

Figure 7. Cross-Section A - A'

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. 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 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 is usually treated before being used for domestic needs. Within the County, 59% of the water wells completed in the surficial deposits have a casing diameter of greater than 400 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 are permeable enough to transmit groundwater for a specific need. Water wells completed in bedrock aquifers usually do not require water well screens, though some of the sandstones are friable[8] and water well screens are a necessity. The groundwater from the bedrock aquifers is usually chemically soft. The data for 909 water wells show 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 909 water wells, more than 97% have surface casing diameters of less than 220 mm and 40% of these bedrock water wells have been completed with water well screens. Of the drilled water wells completed in bedrock aquifers without water well screens, 70% have completion intervals of 20 metres or less; the largest completion interval for a drilled water well completed in a bedrock aquifer within the County is 100 metres.

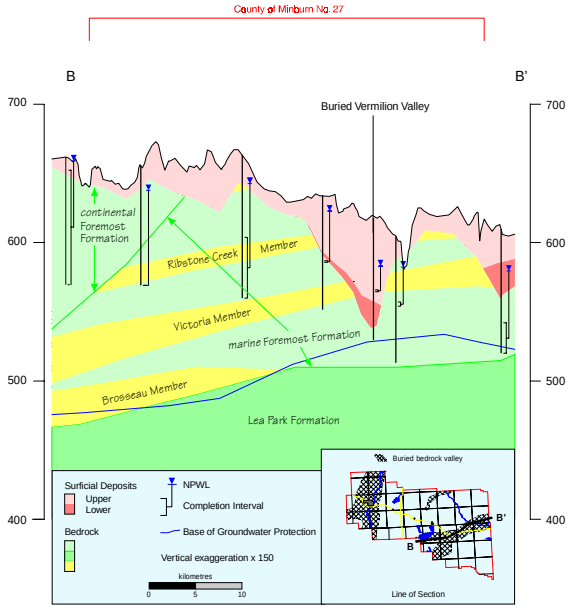

Figure 8. Cross-Section B - B'

The upper bedrock includes parts of the Belly River Group. The Belly River Group, which has a maximum thickness of 250 metres in the County, is underlain by the Lea Park Formation (Figure 8). The Belly River Group includes the Oldman Formation and both the *continental* and *marine* facies[9] of the Foremost Formation. The *marine* Foremost Formation is divided into shale and sandstone members. The sandstone units include the Birch Lake, Ribstone Creek, Victoria and Brosseau members. The lower 10 metres of the *continental* Foremost Formation and the upper part of the *marine* Foremost Formation is included in the Milan Aquifer. In the County, the Lea Park Formation is a regional aquitard[10].

[8] See glossary
[9] See glossary
[10] 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 materials deposited directly or indirectly by glaciation. The lower surficial deposits include pre-glacial fluvial[11] and lacustrine[12] deposits. The lacustrine deposits include clay, silt and fine-grained sand. The upper surficial deposits include the more traditional glacial deposits of till and meltwater deposits. In the County, pre-glacial materials are expected to be present in association with the Buried Vegreville and Vermilion valleys.

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 40 metres thick. The exceptions are mainly in association with the linear bedrock lows where the deposits can have a thickness of more than 80 metres. The two most significant linear bedrock lows in the County have been designated as the Buried Vegreville and Vermilion valleys. The Buried Vegreville Valley is in the western part of the County as shown on the adjacent map. The Buried Vegreville Valley trends mainly from south to north, is approximately 5 to 15 kilometres wide within the County, with local bedrock relief being less than 60 metres. Sand and gravel deposits can be present in association with this bedrock low, but the thickness of the sand and gravel deposits is expected to be mainly less than 20 metres.

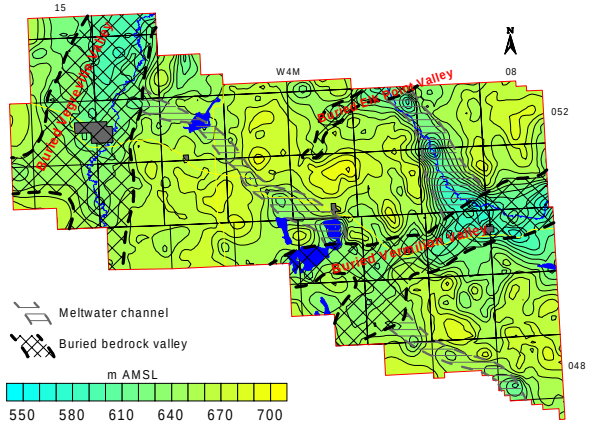

Figure 9. Bedrock Topography

The second linear bedrock low, the Buried Vermilion Valley, trends from southwest to northeast in the eastern half of the County. The Buried Vermilion Valley is approximately 5 to 10 kilometres wide, with local bedrock relief being less than 60 metres. Sand and gravel deposits can be expected to be present in association with this bedrock low, with the thickness of the deposits expected to be mainly less than 20 metres.

[11] See glossary
[12] See glossary

In addition to the Buried Vegreville and Vermilion valleys, there is a linear bedrock low in the northeastern part of the County that has been designated as the Buried Elk Point Valley. The Buried Elk Point Valley, trending from southwest to northeast, is approximately three kilometres wide, with local bedrock relief being less than 60 metres.

There are other linear bedrock lows shown on the bedrock topography map. The majority of these lows trend northwest to southeast in the County 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 Vegreville and Vermilion Valley drainage systems.

The lower surficial deposits are composed mainly of fluvial and lacustrine deposits. Lower surficial deposits occur over approximately 15% of the County, in association with linear bedrock lows. The total thickness of the lower surficial deposits is mainly less than 10 metres, but can be up to 20 metres in the areas of linear bedrock lows. 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 Vegreville and Vermilion valleys. The lowest sand and gravel deposits are of fluvial origin, are usually less than 4 metres thick and may be discontinuous.

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 20 metres. The greatest thickness of upper surficial deposits occurs mainly in association with the Buried Vermilion 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 50 metres in the areas of the buried bedrock lows and meltwater channels.

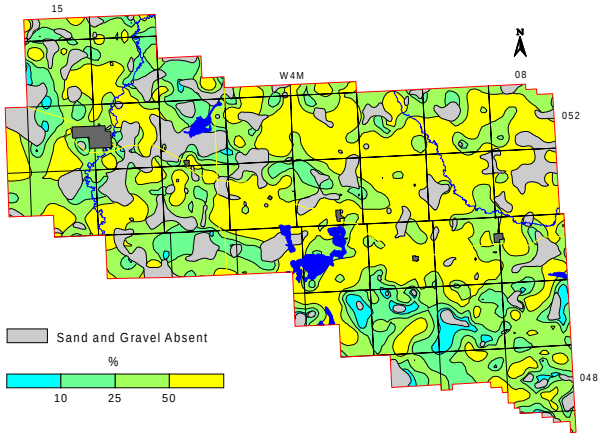

Figure 10. Amount of Sand and Gravel in Surficial Deposits

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 70% 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. The main areas where the sand and gravel percentages are higher are areas where linear bedrock lows are present. The other areas where sand and gravel deposits constitute more than 50% of the surficial deposits can 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 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, 54 water wells are completed in aquifers in the lower surficial deposits and 1,079 are completed in aquifers in the upper surficial deposits. This number of 1,133 water wells completed in aquifers in the surficial deposits is more than twice 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.

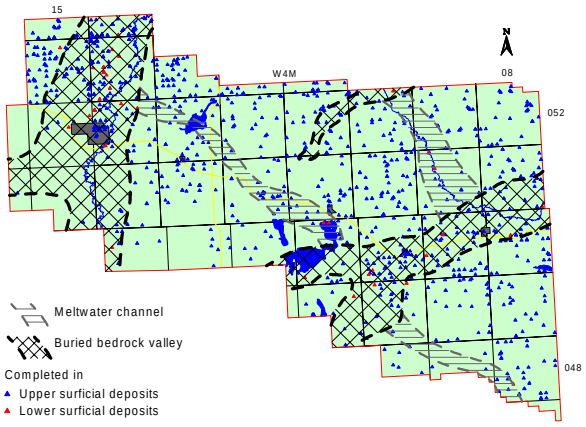

Figure 11. Water Wells Completed in Surficial Deposits

The water wells completed in the upper surficial deposits are located throughout the County, as shown in Figure 11. The majority of the water wells completed in the lower surficial deposits are located along the Buried Vegreville and Vermilion valleys.

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 300 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 300 m³/day are expected are mainly in or adjacent to the areas of linear bedrock lows. Over the majority of the County, water wells completed in the sand and gravel aquifer(s) would have apparent yields of less than 100 m³/day.

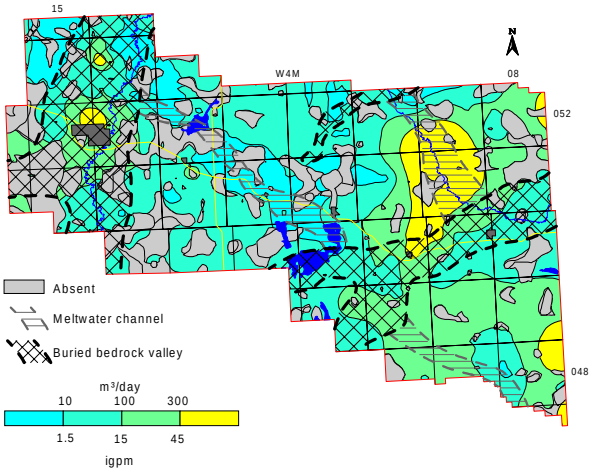

Figure 12. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

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 and 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 or sodium-sulfate-type waters, with 75% of the groundwaters having a TDS of less than 1,000 mg/L. The groundwaters with a TDS of less than 1,000 mg/L occur mainly east of range 12, W4M. Groundwaters from the surficial deposits are expected to have dissolved iron concentrations of greater than 1 mg/L. Groundwater from a water supply well drilled for the AEP Laboratory near the Town of Vegreville completed in the Lower Sand and Gravel Aquifer has a TDS of 1,120 mg/L, a hardness of 408 mg/L, a chloride concentration of 16 mg/L and an iron concentration of 4.62 mg/L (EBA Engineering Consultants Ltd., 1975).

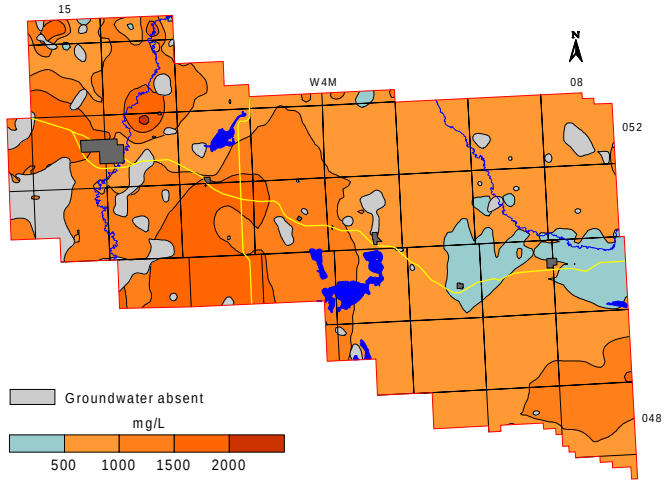

Figure 13. Total Dissolved Solids in Groundwater from Surficial Deposits

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 generally occur in areas where there are elevated levels of total dissolved solids. One exception is in the northeastern part of the County, which may be a result of lack of control. 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.

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. Typically, these aquifers directly overlie or are close to the bedrock surface. Saturated sand and gravel deposits are not continuous but are expected over approximately 80% of the County.

5.2.3.1 Aquifer Thickness

The thickness of the Upper Sand and Gravel Aquifer is a function of two parameters: (1) the elevation of the non-pumping water-level surface associated with the upper surficial deposits; and (2) 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 20 metres thick in a few areas, but over the majority of the County, is less than ten metres thick; over 20% of the County, 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 apparent yields of the water wells are limited. The apparent yields for water wells completed in this Aquifer are expected to be mainly less than 30 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.

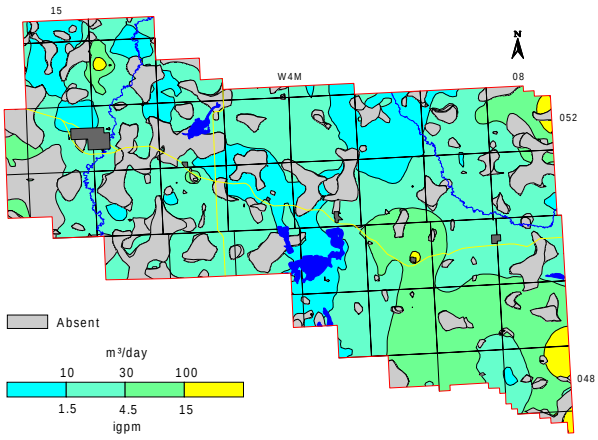

Figure 14. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

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 thickness of the sand and gravel deposits is mainly less than 10 metres. The Lower Sand and Gravel Aquifer is mostly restricted to the Buried Vegreville and Vermilion valleys and meltwater channels in the County.

5.2.4.1 Apparent Yield

Water wells completed in the Lower Sand and Gravel Aquifer range from less than 10 m³/day to more than 100 m³/day. The highest yields are expected in the Buried Vermilion Valley, in the meltwater channel north of the Buried Vermilion Valley, and in the Buried Vegreville Valley near the Town of Vegreville in township 052, ranges 14 and 15, W4M.

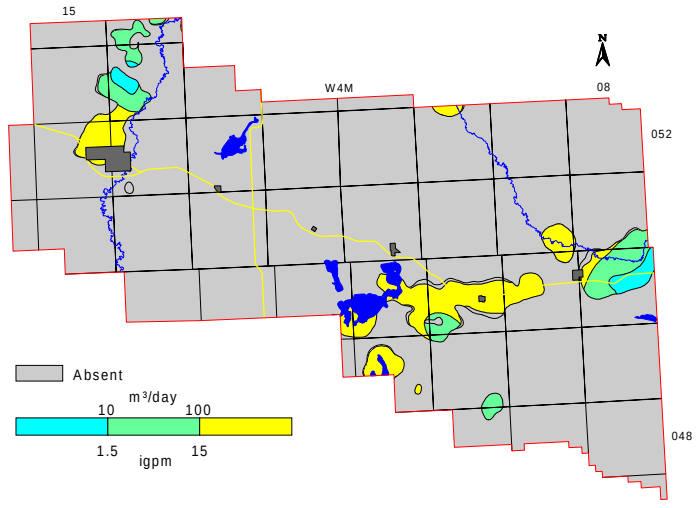

Figure 15. Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer

AEP has completed at least some of its water test holes in the Lower Sand and Gravel Aquifer associated with the Buried Vegreville Valley in 10-23-052-15 W4M. One water test hole was completed as a water supply well and two were completed as observation water wells for the AEP Laboratory. The projected long-term yield from the water supply well is in excess of 1,250 m³/day based on a transmissivity of 151 m²/day and a corresponding storativity of 1.38 x 10^{-4} (EBA Engineering Consultants Ltd., 1975). Based on the groundwater requirements for the lab, the water supply well was licensed for 3.4 m³/day for irrigation purposes.