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 includes 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 aquifer(s) within different geological units, 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 30 metres thick, except in areas of linear bedrock lows where the thickness of the surficial deposits can exceed 100 metres. The Buried Vermilion Valley is the main linear bedrock low in the County. The Buried Vermilion Valley is present in townships 050 and 051, ranges 06 and 07, W4M and trends northeast to township 055, range 03, W4M. Cross-section A-A' passes through parts of the Buried Vermilion Valley, and shows the thickness of the surficial deposits varying from less than ten to more than 100 metres.

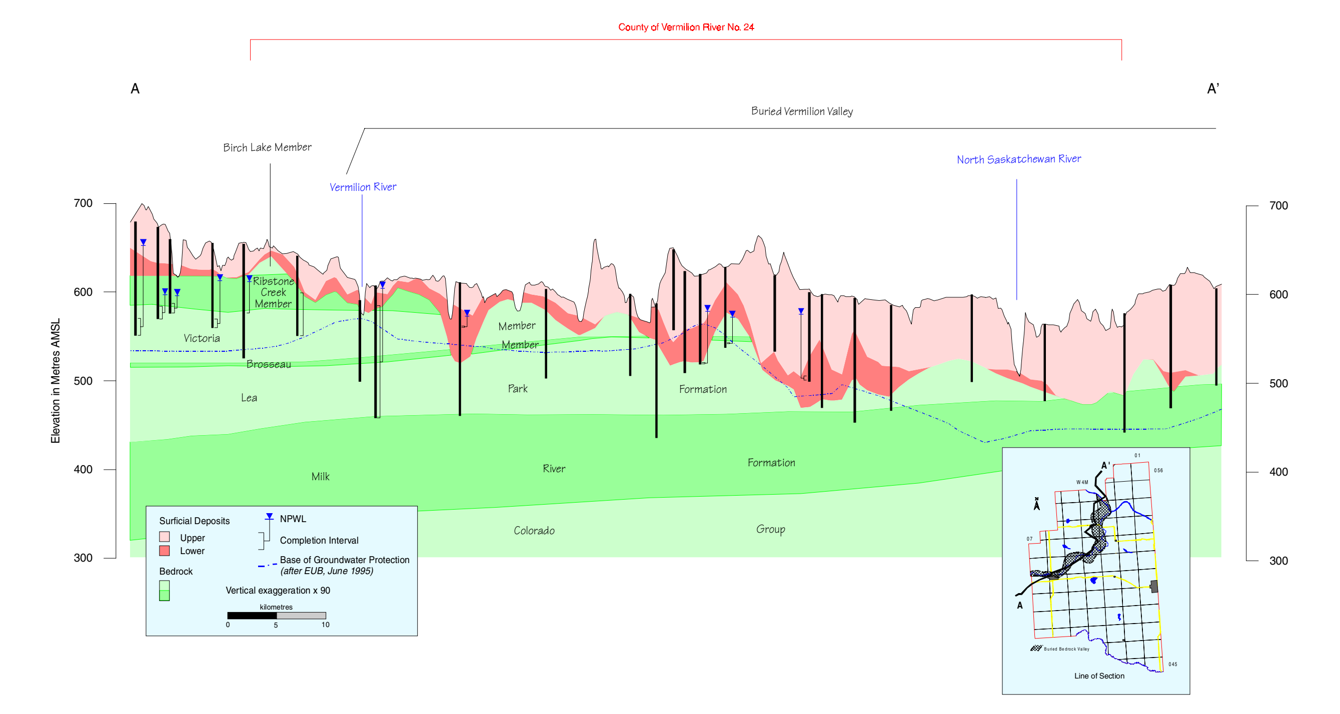

Figure 7. Cross-Section A - A'

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 that are 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 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, casing-diameter information is available for 1,241 of the 1,790 water wells completed in the surficial deposits; 243 of these have a casing diameter of more than 300 millimetres, and are assumed to be bored or dug water wells.

5.1.2 Bedrock Aquifers

The upper bedrock includes rocks that are less than 200 metres below the bedrock surface and above the Colorado Group. 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, although some of the sandstones are friable[7] and water well screens are a necessity. The groundwater from the bedrock aquifers is usually chemically soft.

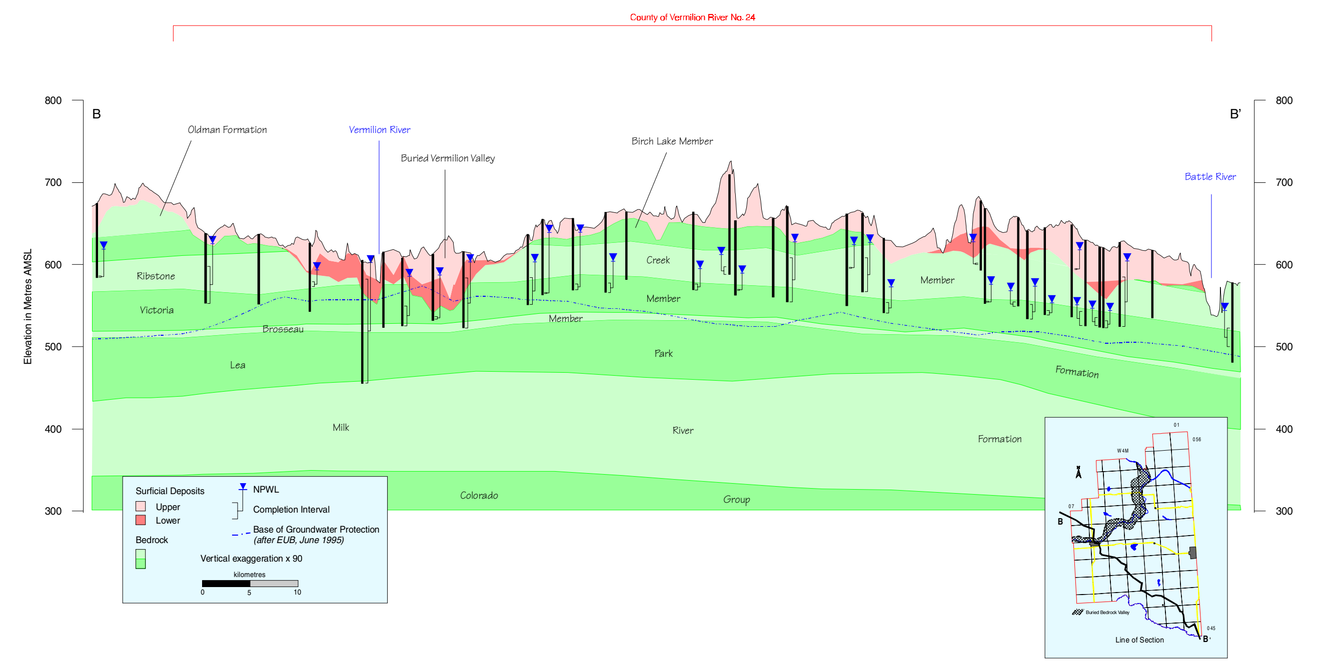

Figure 8. Cross-Section B - B'

The data for 1,941 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. Within the County, casing-diameter information is available for 1,830 of the 1,941 water wells completed in the bedrock aquifers. Of these 1,830 water wells, 98% have surface-casing diameters of less than 275 mm and these bedrock water wells have been mainly completed with either a screen or as open hole. There were 163 bedrock water wells that were completed with a slotted liner.

The upper bedrock includes a part of the Belly River Group, the Lea Park Formation and the Milk River Formation (Figure 8). The Lea Park Formation is a regional aquitard[8]. The Colorado Group underlies the Milk River Formation.

---

7 See glossary
8 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[9] and lacustrine[10] deposits. The lacustrine deposits include clay, silt and fine-grained sand. The *upper surficial deposits* include the more traditional glacial deposits of till[11] 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 units. The first unit is the sand and gravel deposits of the lower surficial deposits when present. These deposits are mainly saturated, where present. The second and third hydraulic units are associated with the sand and gravel deposits in the upper surficial deposits. The sand and gravel deposits in the upper surficial deposits occur mainly as pockets. The second hydraulic unit is the saturated part of these sand and gravel deposits; the third hydraulic unit is the unsaturated part of these deposits. See Figure 5 for a graphical depiction of the above description. While the unsaturated deposits are not technically an aquifer, they are significant as 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 the tops of these deposits are present within one metre of the ground surface; these shallow deposits are referred to as the “first sand and gravel”.

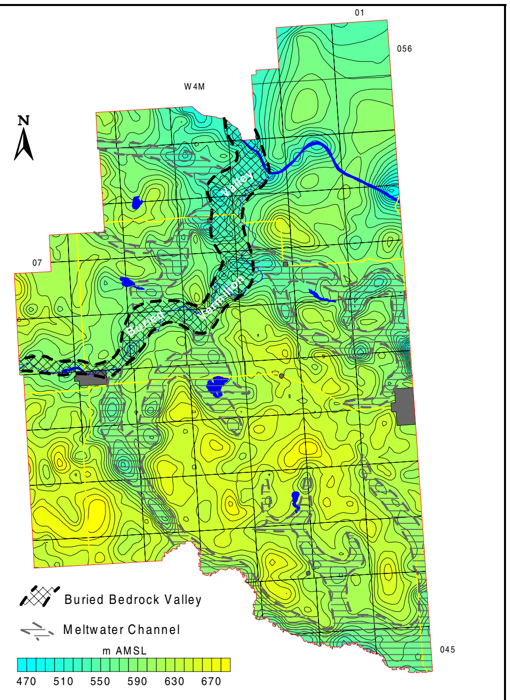

Figure 9. Bedrock Topography

The base of the surficial deposits is the bedrock surface, represented by the bedrock topography as shown on the adjacent map. There are numerous linear bedrock lows shown on the bedrock topography map. These lows trend mainly 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 Vermilion Valley drainage system present in the County.

Over the majority of the County, the upper 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 50 metres. The main linear bedrock low in the County has been designated as the Buried Vermilion Valley, as shown on Figure 9. This Valley trends east while occupying the present-day Vermilion River Valley, then turns northeast toward the North Saskatchewan River. The Buried Vermilion Valley is approximately eight to 15 kilometres wide, with local relief being up to 100 metres.

Sand and gravel deposits can occur throughout the surficial deposits. The total thickness of sand and gravel deposits is generally less than ten metres but can be more than 15 metres in the areas of the linear bedrock lows.

9 See glossary
10 See glossary
11 See glossary

Cross-section C – C' passes three kilometres north of Lloydminster. At the east end of the cross-section, the surficial deposits are indicated as being close to 200 metres thick in an area where significant linear bedrock lows are not present. The thickness of the surficial deposits is believed to reflect the existence of a collapse structure that was at least partially formed during glaciation. The structure which is close to circular forms as a result of the removal of salt in the Prairie Evaporites at a depth of approximately 700 metres. Other examples of collapse structures formed as a result of the removal of salt have been documented in southern Saskatchewan (Christiansen, 1971).

The bedrock topography map suggests the existence of other collapse structures in the County. However, the one north of Lloydminster is the only one that can be delineated with the available data. The data show the presence of sand or gravel below a depth of 100 metres and apparent water well yields can be several hundred cubic metres per day.

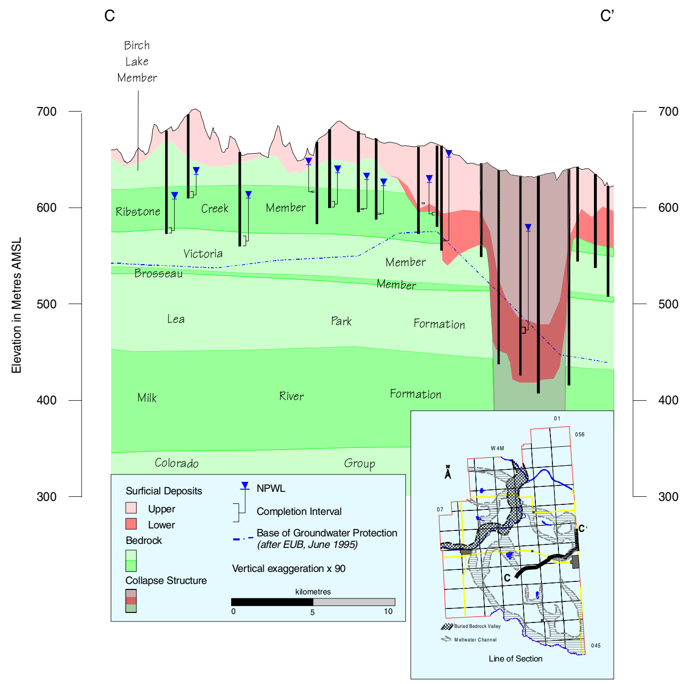

Figure 10. Cross-Section C – C'

The lower surficial deposits are composed mostly of fluvial and lacustrine deposits. Lower surficial deposits occur over more than 30% of the County, in association with linear bedrock lows. The total thickness of the lower surficial deposits is mainly less than 50 metres, but can be up to 100 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 Vermilion Valley. The lower sand and gravel deposits are of fluvial origin, are usually less than five metres thick and may be discontinuous.

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 are expected to occur mainly as isolated pockets. The thickness of the upper surficial deposits is mainly in association with the linear bedrock lows; there are several areas in the County where these deposits are not present.

Sand and gravel deposits can occur throughout the surficial deposits. The total thickness of sand and gravel deposits is generally less than five metres but can be more than 15 metres in the areas of the linear 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 5% of the County, the sand and gravel deposits are more than 50% of the total thickness of the surficial deposits. One area where the sand and gravel percentages are higher is in association with the Buried Vermilion Valley. The other areas where sand and gravel deposits constitute more than 50% of the total thickness of the surficial deposits may be in 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.

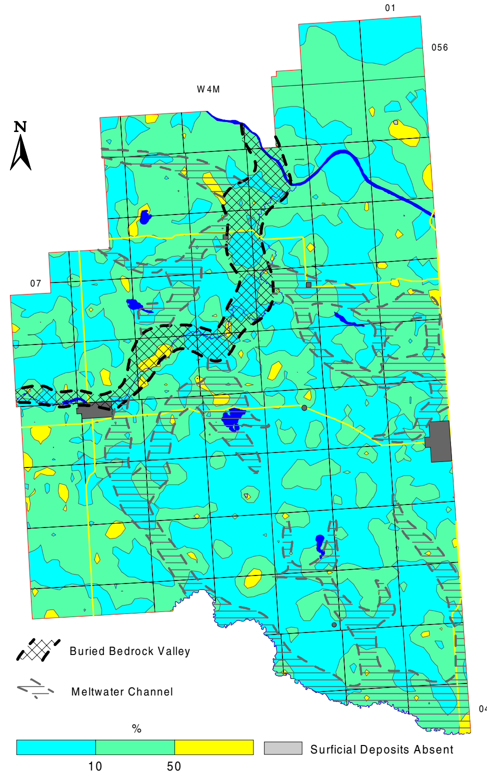

Figure 11. Amount of Sand and Gravel in Surficial Deposits

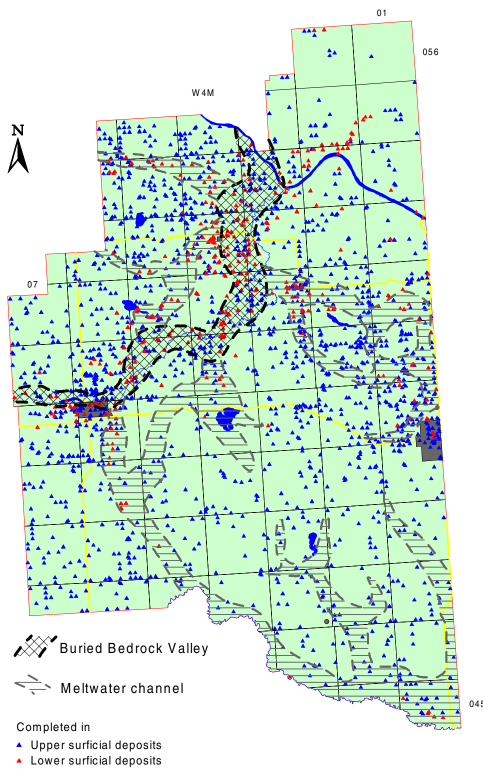

Figure 12. Water Wells Completed in Surficial Deposits

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, 430 water wells are completed in aquifers in the lower surficial deposits and 2,403 are completed in the upper surficial deposits. This number of water wells is more than 1.5 times the number determined to be completed in aquifers in the surficial deposits, based on lithologies given on the water well drilling reports. The larger number is obtained by comparing the elevation of the reported depth of a water well to the elevation of the bedrock surface at the same location. For example, if only the depth of a water well is known, the elevation of the completed depth can be calculated. If the elevation of the completed depth is above the expected elevation of the bedrock surface at the same location, then the water well is determined to be completed in an aquifer in the surficial deposits.

The water wells completed in the upper surficial deposits occur throughout the County, but are mainly concentrated in the northern half of the County, as shown in Figure 12. The majority of the water wells completed in the lower surficial deposits are located along the Buried Vermilion Valley and the meltwater channels north of the City of Lloydminster.