5.3.7 Oldman Aquifer

The Oldman Aquifer comprises the porous and permeable parts of the Oldman Formation. The Oldman Formation is present under the entire County, but subcrops only in a small area of township 040, range 10, W4M. The thickness of the Oldman Formation is mainly between 100 and 120 metres, but can be up to 130 metres in parts of township 035 and 036, W4M.

5.3.7.1 Depth to Top

The depth to the top of the Oldman Formation is mainly less than 20 metres in the eastern part of the County where the Formation subcrops. In the western part of the County where the Oldman is below the Bearpaw and the Horseshoe Canyon formations, the depth to the top of the Oldman Formation can be more than 180 metres. In the western part of the County, the Base of Groundwater Protection coincides with the base of the Oldman Formation. A map showing the depth to the Base of Groundwater Protection is given on page 6 of this report, in Appendix A, and on the CD-ROM.

5.3.7.2 Apparent Yield

The apparent yields for individual water wells completed through the Oldman Aquifer are mainly less than 50 m³/day. However, the large expanse of expected low yields may be a reflection of the limited amount of data rather than the hydraulic properties of the Aquifer. The adjacent map indicates that water wells with apparent yields of more than 100 m³/day are expected toward the eastern side of the County. There are little or no data for the Aquifer in the western parts of the County. In these areas, the Oldman Aquifer would be at a depth of more than 180 metres.

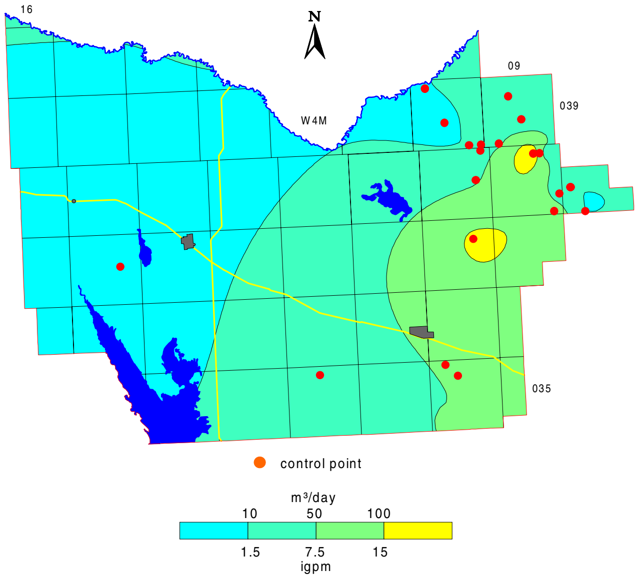

Figure 21. Apparent Yield for Water Wells Completed through Oldman Aquifer

5.3.7.3 Quality

Groundwaters from the Oldman Aquifer are mainly sodium-bicarbonate-type waters (see CD-ROM). TDS concentrations are expected to be in the order of less than 1,000 to more than 1,500 mg/L, although there is a paucity of data west of range 10, W4M. However, since the Base of Groundwater Protection coincides with the base of the Oldman Formation in the western part of the County, the TDS west of range 10 would still be expected to be below 4,000 mg/L.

Chloride concentrations in the groundwaters from the Oldman Aquifer are less than 10 mg/L where the Formation subcrops. The indications are that in the central and western parts of the County, the chloride concentrations are expected to be over 250 mg/L.

5.3.8 Foremost Aquifer

The Foremost Aquifer comprises the porous and permeable parts of the Foremost Formation and underlies the Oldman Formation. The thickness of the Foremost Aquifer generally ranges from 140 to 180 metres in the County. There are three records in the database for water wells completed in the Foremost Aquifer in the County; however, no chemistry and limited apparent yield data were available from the database for this Aquifer in the County.

5.3.8.1 Depth to Top

The Foremost Formation is present under the entire County. The depth to the top of the Formation is variable, ranging from less than 100 metres near the Battle River in the northeastern part of the County, to more than 360 metres in the western part of the County. In most of the area, the Base of Groundwater Protection coincides with the top of the Foremost Formation.

5.3.8.2 Apparent Yield

With only one apparent yield control point in the County from the groundwater database, the summary results of DSTs from the EUB database were used. The DST summaries from temporary completions in the Foremost Aquifer were used to determine apparent yield values available from the Aquifer.

The results of 60 DST summaries were used to calculate apparent long-term yields at locations where no water well information is available. The apparent long-term yield values vary from less than one to more than 40 m³/day. The apparent yields for individual water wells completed in the Foremost Aquifer are mainly less than 10 m³/day, based on data from the EUB database. The adjacent map indicates that apparent yields of more than 30 m³/day are expected in the northeastern part of the County.

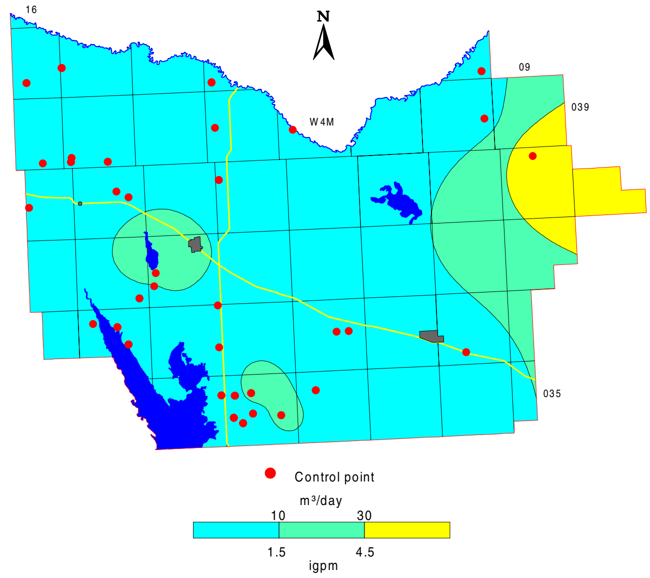

Figure 22. Apparent Yield for Water Wells Completed through Foremost Aquifer

5.3.8.3 Quality

There are no chemistry data for groundwaters from the Foremost Aquifer in the County of Painteearth; however, data from the adjacent municipality, Flagstaff County, indicate that the groundwaters from the Foremost Formation are mainly sodium-bicarbonate or sodium-sulfate-type waters. In Flagstaff County, TDS concentrations in the groundwaters from the Foremost Aquifer are expected to be in the order of 500 to 2,000 mg/L. Although no chemistry data are available for the County of Painteearth, chemistry maps for the County have been prepared based on the data from adjacent municipalities. Chemical data from the Energy Resources Conservation Board (ERCB) microfiche indicate that the TDS concentrations of groundwaters from the Foremost Formation, at depths below 220 metres, will be greater than 5,000 mg/L.

6 Groundwater Budget

6.1 Hydrograph

There are two locations in the County where water levels are being measured and recorded with time. These sites are observation water wells that are part of the AEP regional groundwater-monitoring network. Observation Water Well (Obs WW) No. 130 is in 09-18-035-09 W4M and Obs WW No. 231 is in 04-31-035-10 W4M; both are in the vicinity of the Town of Coronation. The hydrograph for AEP Obs WW No. 130 is shown on the adjacent graph and in Appendix A; the hydrograph for AEP Obs WW No. 231 is also shown in Appendix A, but is of limited use.

AEP Obs WW No. 130 is completed at a depth of 62.0 metres in the Bearpaw Aquifer. The water level in the AEP Obs WW declined 1.5 metres from 1958 to 1967 and declined an additional four metres between 1968 and 1971. There are eight water source wells within a four-kilometre radius of AEP Obs WW No. 130 that are completed in the Bearpaw Aquifer.

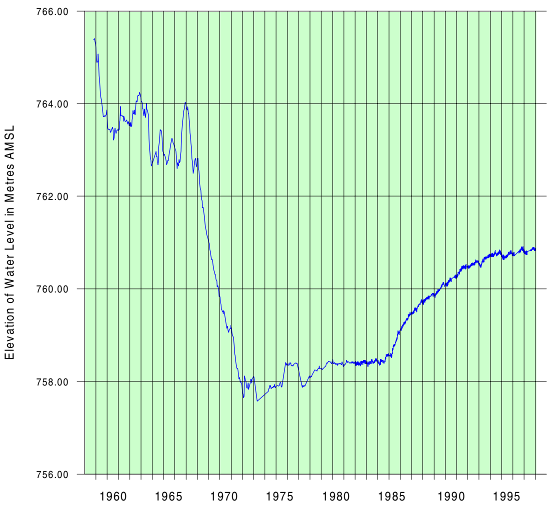

Figure 23. Hydrograph - AEP Observation Water Well No. 130

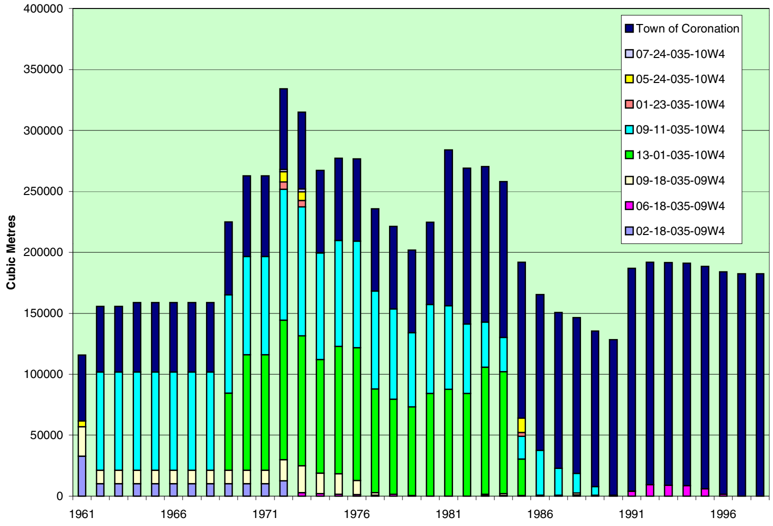

Figure 24. Annual Groundwater Production - WSWs

Groundwater production is available from these eight water source wells from the EUB database. Groundwater production has been recorded since 1961, with the data estimated until 1968; after 1968, the groundwater production was measured. The adjacent graph shows that the maximum production from the eight water source wells occurred in 1972 when the maximum groundwater diversion was over 250,000 cubic metres. The adjacent graph also shows the groundwater use by the Town of Coronation from the Bearpaw Aquifer. When the Town's groundwater use is added to the production from the water source wells, the maximum diversion in 1972 is close to 350,000 cubic metres. In recent years, the production from the water source wells has decreased and use by the Town has increased. In 1998, the Town used just under 200,000 cubic metres and there is no reported use by the water source wells.

In order to determine if these water source wells have had an impact on the Bearpaw Aquifer in which AEP Obs WW No. 130 is completed, a mathematical model was used to calculate water levels at the location corresponding to the Obs WW.

The model aquifer has an effective transmissivity of 30 m²/day and a corresponding storativity of 0.0004. The model assumes a homogeneous, isotropic aquifer of infinite areal extent and does not account for aquifer recharge. Two simulations were completed. The first is based on the annual groundwater production from the eight water source wells, without the Town of Coronation production. The second simulation includes the combined production from the water source wells and the Town of Coronation water supply wells. The simulations are used to calculate the water level at the site of AEP Obs WW No. 130. The results of the two simulations are shown on the adjacent graph.

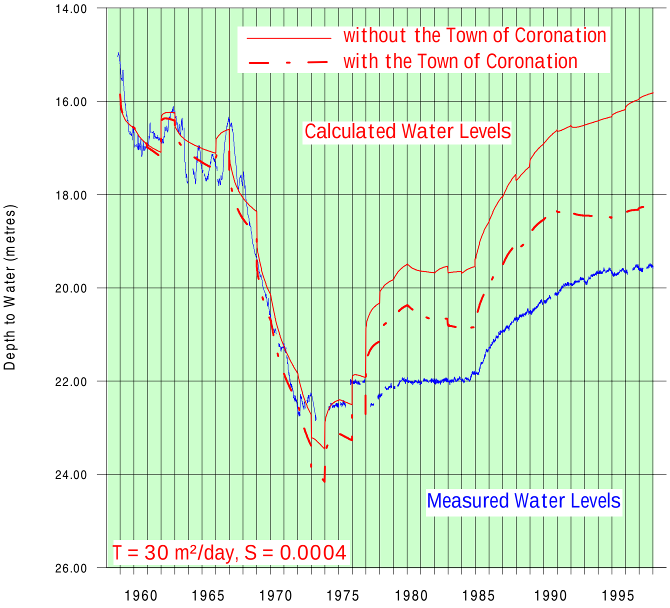

Figure 25. AEP Observation Water Well No. 130 - Water-Level Simulations

There is a reasonable match between the three water-level-data sets from 1959 to 1972. For the simulation that includes only the production from the water source wells, there is a reasonable match between the measured and calculated from 1972 to 1976 but from 1976 to 1998, the calculated water level is up to four metres higher than the measured water level. In the simulation that includes the Town of Coronation's production, the calculated water level is lower than the measured water level from 1972 to 1976 and higher than the measured from 1976 to 1998. However, in the 1976 to 1998 data set, the calculated water level from the simulation that includes the Town's production is closer to the measured water level than the simulation that does not include the production.

The present simulations do not provide a definitive answer. However, they do show that production from the Town of Coronation water supply wells could have an impact on the water level in the Bearpaw Aquifer at the site of AEP Obs WW. No. 130, 15 kilometres from the Town.

An attempt was made to determine if there has been any other change in water levels in the Bearpaw Aquifer within the County. Since there are only two observation water well sites, the attempt included documenting the difference in water levels when new water well(s) were drilled at sites of an existing water well(s). There are 258 sites where there is more than one water well, each with a water level recorded at the time the water well was drilled. There are 71 sites when the water wells at the given site have depths that differ by less than five metres and the dates between the two water levels are more than 200 days. The water-level changes at these sites vary between a rise of 33.5 metres and a decline of 68.9 metres. An analysis of 67 water-level changes between a rise of nine metres and a decline of 40 metres shows that 30% of the water levels rose and 70% declined; the average decline was ten metres. The main area of water-level decline is in the vicinity of the Town of Coronation and ten kilometres southeast of the Town. In the remainder of the County where the Bearpaw Aquifer is used as a source of potable water, the water-level change with time shows there are very few areas with a water-level rise.

6.2 Groundwater Flow

A direct measurement of groundwater recharge or discharge is not possible from the data that are available for the County. One indirect method of measuring recharge is to determine the quantity of groundwater flowing laterally through each individual aquifer. This method assumes that there is sufficient recharge to the aquifer to maintain the flow through the aquifer and the discharge is equal to the recharge. However, even the data that can be used to calculate the quantity of flow through an aquifer must be averaged and estimated. To determine the flow requires a value for the average transmissivity of the aquifer, an average hydraulic gradient and an estimate for the width of the aquifer. For the present program, the flow has been estimated for those parts of the various aquifers within the County.

The flow through each aquifer assumes that by taking a large enough area, an aquifer can be considered as homogeneous, the average gradient can be estimated from the non-pumping water-level surface, and flow takes place through the entire width of the aquifer. Based on these assumptions, the estimated lateral groundwater flow through the individual bedrock aquifers can be summarized as follows:

Aquifer Designation	Transmissivity (m^2/day)	Gradient (m/m)	Width (km)	Main Direction of Flow	Quantity (m^3/day)	Authorized Diversion (m^3/day)
Surficial Deposits (northwestern part)	9	0.008	30	Northeast	2,160	**61**
Middle Horseshoe Canyon	5	0.002	5	North	50	**0**
Lower Horseshoe Canyon	5	0.004	70	Northeast	1,000	**869**
Bearpaw	3	0.004	40	Northeast	480	**683**
Oldman	2	0.0001	48	Northwest	10	**433**

The data provided in the above table indicate there is more groundwater flowing through the individual bedrock aquifers than has been authorized to be diverted from each aquifer, except for the Bearpaw and Oldman aquifers. The calculations of flow through individual aquifers as presented in the above table are very approximate and are intended as a guide for future investigations.

6.2.1 Quantity of Groundwater

An estimate of the volume of groundwater stored in the sand and gravel aquifers in the surficial deposits is 0.1 to 0.7 cubic kilometres. This volume is based on an areal extent of 800 square kilometres and a saturated sand and gravel thickness of three metres. The variation in the total volume is based on the value of porosity that is used for the sand and gravel. One estimate of porosity is 5%, which gives the low value of the total volume. The high estimate is based on a porosity of 30% (Ozoray, Dubord and Cowen, 1990).

The adjacent water-level map has been prepared from water levels associated with water wells completed in aquifers in the surficial deposits. These water levels were used for the calculation of the saturated thickness of surficial deposits. In areas where the elevation of the water-level surface is below the bedrock surface, the surficial deposits are not saturated. The water-level map for the surficial deposits shows a general flow direction toward the Battle River, with the lowest water-level elevations occurring in township 040, range 10, W4M.

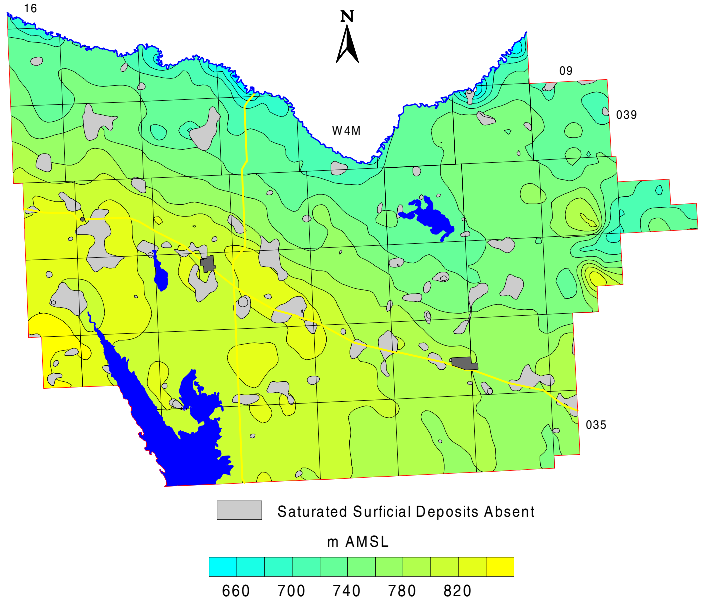

Figure 26. Non-Pumping Water-Level Surface in Surficial Deposits

6.2.2 Recharge/Discharge

The hydraulic relationship between the groundwater in the surficial deposits and the groundwater in the bedrock aquifers is given by the non-pumping water-level surface associated with each of the hydraulic units. Where the water level in the surficial deposits is at a higher elevation than the water level in the bedrock aquifers, there is the opportunity for groundwater to move from the surficial deposits into the bedrock aquifers. This condition would be considered as an area of recharge to the bedrock aquifers and an area of discharge from the surficial deposits. The amount of groundwater that would move from the surficial deposits to the bedrock aquifers is directly related to the vertical permeability of the sediments separating the two aquifers. In areas where the surficial deposits are unsaturated, the extrapolated water level for the surficial deposits is used.

When the hydraulic gradient is from the bedrock aquifers to the surficial deposits, the condition is a discharge area from the bedrock aquifers, and a recharge area to the surficial deposits.

6.2.2.1 Surficial Deposits/Bedrock Aquifers

The hydraulic gradient between the surficial deposits and the upper bedrock aquifer(s) has been determined by subtracting the non-pumping water-level surface associated with all water wells completed in the upper bedrock aquifer(s) from the non-pumping water-level surface determined for all water wells in the surficial deposits. The recharge classification on the map below includes those areas where the water level in the surficial deposits is more than five metres above the water level in the upper bedrock aquifer(s). The discharge areas are where the water level in the surficial deposits is more than five metres lower than the water level in the bedrock. When the water level in the surficial deposits is between five metres above and five metres below the water level in the bedrock, the area is classified as a transition.

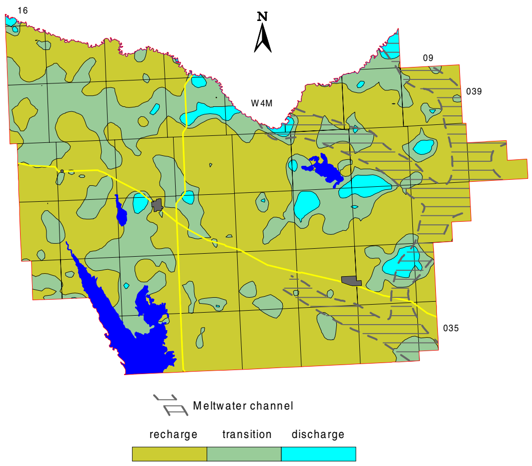

Figure 27. Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)

The adjacent map shows that, in more than 65% of the County, there is a downward hydraulic gradient from the surficial deposits toward the upper bedrock aquifer(s). Areas where there is an upward hydraulic gradient from the bedrock to the surficial deposits are mainly in the vicinity of the meltwater channels. The remaining parts of the County are areas where there is a transition condition.

Because of the paucity of data, a calculation of the volumes of groundwater entering and leaving the surficial deposits has not been attempted.

6.2.2.2 Bedrock Aquifers

Recharge to the bedrock aquifers within the County takes place from the overlying surficial deposits and from flow in the aquifer from outside the County. The recharge/discharge maps show that generally for most of the County, there is a downward hydraulic gradient from the surficial deposits to the bedrock, i.e. recharge to the bedrock aquifers. On a regional basis, calculating the quantity of water involved is not possible because of the complexity of the geological setting and the limited amount of data. However, because of the generally low permeability of the upper bedrock materials, the volume of water is expected to be small.

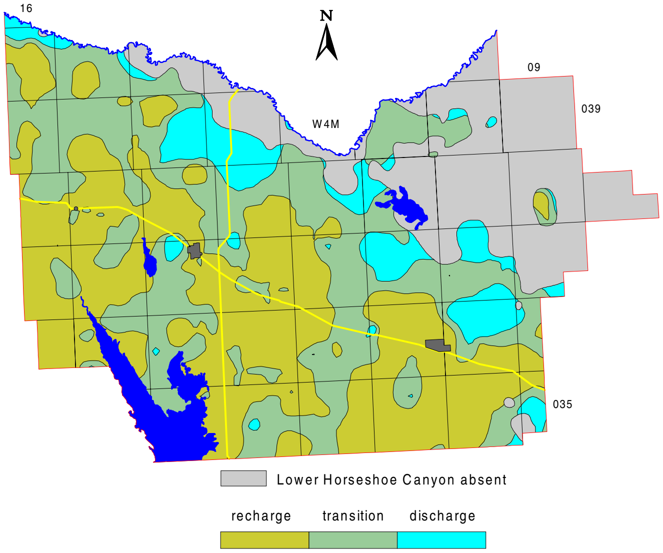

Figure 28. Recharge/Discharge Areas between Surficial Deposits and Lower Horseshoe Canyon Aquifer

The hydraulic relationship between the surficial deposits and the Lower Horseshoe Canyon Aquifer indicates that in more than 50% of the County where the Lower Horseshoe Canyon Aquifer is present, there is a downward hydraulic gradient. Discharge areas for the Lower Horseshoe Canyon Aquifer are associated with the northeast edge of the Aquifer. The hydraulic relationship between the surficial deposits and the remainder of the bedrock aquifers indicates there is mainly a downward hydraulic gradient.

7 Potential for Groundwater Contamination

The most common sources of contaminants that can impact groundwater originate on or near the ground surface. The contaminant sources can include leachate from landfills, effluent from leaking lagoons or from septic fields, and petroleum products from storage tanks or pipeline breaks. The agricultural activities that generate contaminants include the spreading of fertilizers, pesticides, herbicides and manure. The spreading of highway salt can also degrade groundwater quality.

When activities occur that can or do produce a liquid which could contaminate groundwater, it is prudent (from a hydrogeological point of view) to locate the activities where the risk of groundwater contamination is minimal. Alternatively, if the activities must be located in an area where groundwater can be more easily contaminated, the necessary action must be taken to minimize the risk of groundwater contamination.

The potential for groundwater contamination is based on the concept that the easier it is for a liquid contaminant to move downward, the easier it is for the groundwater to become contaminated. In areas where there is groundwater discharge, liquid contaminants cannot enter the groundwater flow systems to be distributed throughout the area. In groundwater recharge areas, low-permeability materials impede the movement of liquid contaminants downward. Therefore, if the soils develop on a low-permeability parent material of till or clay, the downward migration of a contaminant is slower relative to a high-permeability parent material such as sand and gravel of fluvial origin. Once a liquid contaminant enters the subsurface, the possibility for groundwater contamination increases if it coincides with a higher permeability material within one metre of the land surface.

To determine the nature of the materials on the land surface, the surficial geology map prepared by the Alberta Research Council (Shetsen, 1990) has been reclassified based on the relative permeability. The classification of materials is as follows:

1. high permeability - sand and gravel;
2. moderate permeability - silt, sand with clay, gravel with clay, and bedrock; and
3. low permeability - clay and till.

To identify the areas where sand and gravel can be expected within one metre of the ground surface, all groundwater database records with lithologies were reviewed. From a total of 1,180 records in the area of the County with lithological descriptions, 135 have the tops of a sand and gravel deposit present within one metre of ground level. In the remaining 1,045 records, the first sand and gravel is deeper or not present. This information was gridded to prepare a distribution of where the first sand and gravel deposit could be expected within one metre of ground level.

7.1.1 Risk of Groundwater Contamination Map

The information from the reclassification of the surficial geology map is the basis for preparing the initial risk map. The depth to the first sand and gravel is then used to modify the initial map and to prepare the final map. The criteria used for preparing the final Risk of Groundwater Contamination map are outlined in the adjacent table.

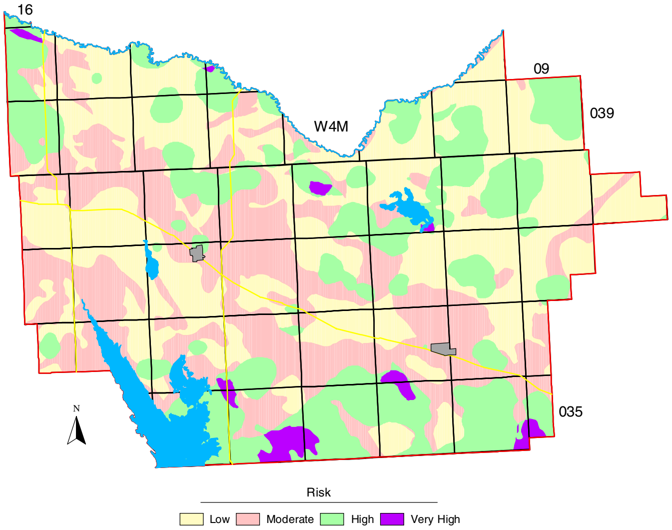

Figure 29. Risk of Groundwater Contamination

Surface Permeability	Sand or Gravel Present - Top Within One Metre Of Ground Surface	Groundwater Contamination Risk
Low	No	Low
Moderate	No	Moderate
High	No	High
Low	Yes	High
Moderate	Yes	High
High	Yes	Very High

Table 7. Risk of Groundwater Contamination Criteria

The Risk of Groundwater Contamination map shows that, in more than 25% of the County, there is a high or very high risk for the groundwater to be contaminated. These areas would be considered the least desirable ones for a development that has a product or by-product that could cause groundwater contamination. However, because the map has been prepared as part of a regional study, the designations are a guide only; detailed hydrogeological studies must be completed at any proposed development site to ensure the groundwater is protected from possible contamination. At all locations, good environmental practices should be exercised in order to ensure that contaminants will not affect groundwater quality.