5.3.6 *Continental* Foremost Aquifer

The *continental* Foremost Aquifer comprises the porous and permeable parts of the *continental* Foremost Formation and subcrops under the northeastern third of the County. The thickness of the *continental* Foremost Aquifer can be up to 175 metres in the west-central part of the County.

5.3.6.1 Depth to Top

The depth to the top of the *continental* Foremost Formation is variable, ranging from less than 20 to more than 60 metres. The largest area where the top of the *continental* Foremost Formation is more than 60 metres below ground level is in the vicinity of the Towns of Bruderheim, Lamont, Chipman and Mundare.

5.3.6.2 Apparent Yield

The projected long-term yields for individual water wells completed through the *continental* Foremost Aquifer are mainly less than 1 m³/day but can be more than 60 m³/day. The higher yields are mainly in the northern part of the County along the North Saskatchewan River, and in the central part of the County. The higher yield areas appear to be related to channels and not to weathering or fracturing.

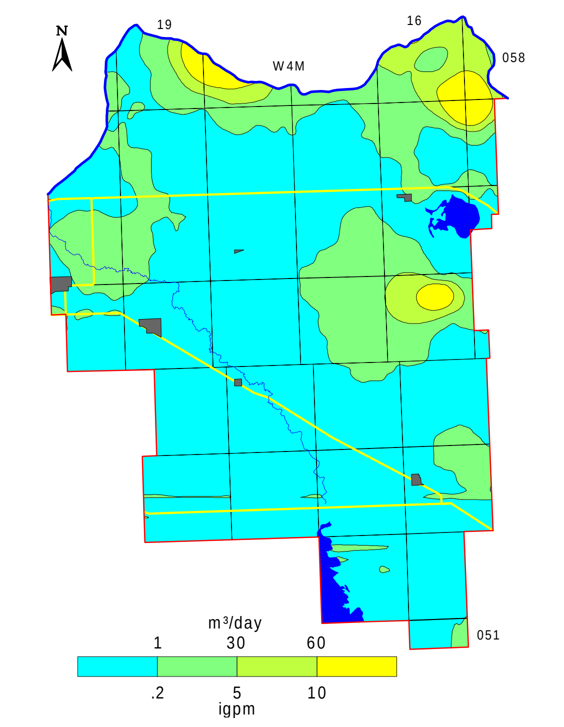

Figure 16. Apparent Yield for Water Wells Completed through continental Foremost Aquifer

5.3.6.3 Quality

The Piper tri-linear diagrams show that all chemical types of groundwater occur in the *continental* Foremost Aquifer. However, the majority of the groundwaters are sodium-bicarbonate or sodium-chloride types.

The TDS concentrations in the groundwaters from the *continental* Foremost Aquifer range from less than 1,000 to over 2,000 mg/L in the *continental* Foremost Aquifer. When TDS values exceed 1,200 mg/L, the sulfate concentrations exceed 600 mg/L. Because the groundwater quality is so variable, establishing meaningful trends based on the data is not practical.

Chloride concentrations of more than 250 mg/L can be expected in the groundwaters from the *continental* Foremost Aquifer.

Very few chemical analysis results indicate a fluoride concentration above 1.0 mg/L.

5.3.7 Milan Aquifer

The upper 40 metres of the *marine* Foremost Formation and the lower 10 metres of the *continental* Foremost Formation are classified as a separate aquifer referred to as the Milan Aquifer. The Milan Aquifer is present underlying the Bearpaw and Oldman formations in two-thirds of the County but subcrops only in a few areas along the North Saskatchewan River. However, there are approximately a dozen water wells in the County of Lamont completed in the Milan Aquifer, of which eight are located above Tp 057, W4M.

5.3.7.1 Depth to Top

The top of the Milan Aquifer underlies the northeastern two-thirds of the County, reaching depths of as much as 300 metres below ground to less than 50 metres along the North Saskatchewan River.

5.3.7.2 Apparent Yield

The projected long-term yields for individual water wells completed in the Milan Aquifer can be expected to be more than 100 m³/day.

The projected long-term yield for the Deep Water Supply Well (WSW) owned by the Town of Mundare (Hydrogeological Consultants Ltd., 1977) and completed in the Milan Aquifer was 111 m³/day (17 gpm).

5.3.7.3 Quality

The Piper tri-linear diagrams show that all chemical types of groundwater occur in the Milan Aquifer. However, the majority of the groundwaters are sodium-bicarbonate or sodium-chloride types.

The TDS concentrations in the groundwaters from the Milan Aquifer are mainly more than 2,000 mg/L. Chloride concentrations of more than 250 mg/L can be expected in the groundwaters from the Milan Aquifer. A groundwater sample was collected from the Town of Mundare Deep WSW on April 11, 1977 (Hydrogeological Consultants Ltd., 1977). The TDS concentration was 13,720 mg/L and the chloride concentration was 8,120 mg/L. Additional groundwater samples were collected from this water well during April 1977 and there was little variation in the TDS and chloride results.

There are significant quantities of groundwater available from the Milan Aquifer, but because of the poor quality, the groundwater has limited applications.

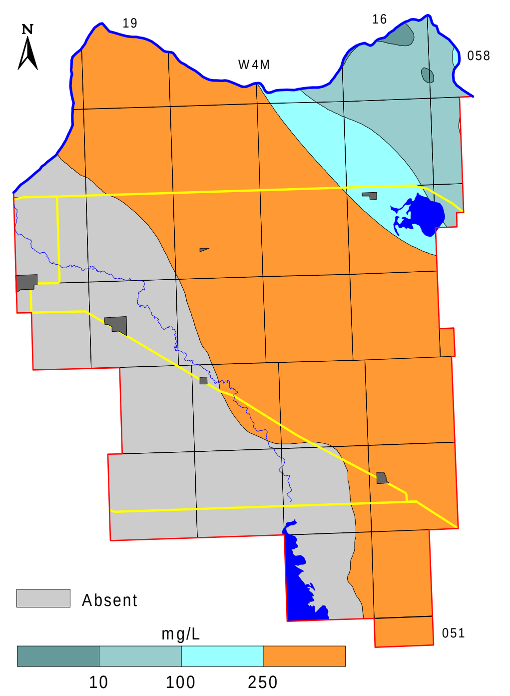

Figure 17. Chloride in Groundwater from Milan Aquifer

6 GROUNDWATER BUDGET

Estimation of the groundwater budget for the sand and gravel aquifers and the bedrock aquifers requires different methods. This is because recharge to and discharge from the bedrock aquifers is mainly through the surficial deposits while most of the recharge to and discharge from the surficial deposits is from the land surface.

6.1 Aquifers in Surficial Deposits

The groundwater in the surficial deposits is the net result of recharge to and discharge from these deposits. The recharge is mainly from precipitation, although some groundwater enters the surficial deposits from the underlying bedrock. The discharge includes losses to bedrock aquifers, discharge from springs, evapotranspiration, and discharge from water wells. The change in the quantity of groundwater in the surficial deposits is apparent from the change in the water level associated with individual aquifers within the surficial deposits.

6.1.1 Quantity of Groundwater

An estimate of the volume of groundwater stored in the sand and gravel aquifers in the surficial deposits is 0.4 to 2.5 cubic kilometres. This volume is based on an areal extent of 2,600 square kilometres and a saturated sand and gravel thickness of four 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).

Because the sand and gravel deposits are mainly confined aquifers, the change in water level in the aquifer remains a function of the storativity of the aquifer rather than the porosity. The storativity values for the sand and gravel range from 8.9 x 10^{-4} to 2.2 x 10^{-4}. Based on a storativity value of 5 x 10^{-4}, and an available drawdown of 20 metres, a total volume of available groundwater from the confined aquifer is 0.03 cubic kilometres.

The groundwater in the Sand and Gravel Aquifer(s) in the Buried Beverly Valley flows in general from the southwest to the northeast toward the North Saskatchewan River Valley. Based on an average transmissivity of 50 m²/day, a gradient of 0.004, and an average valley width of ten kilometres, total estimated flow for the Buried Beverly Valley is 2,000 m³/day.

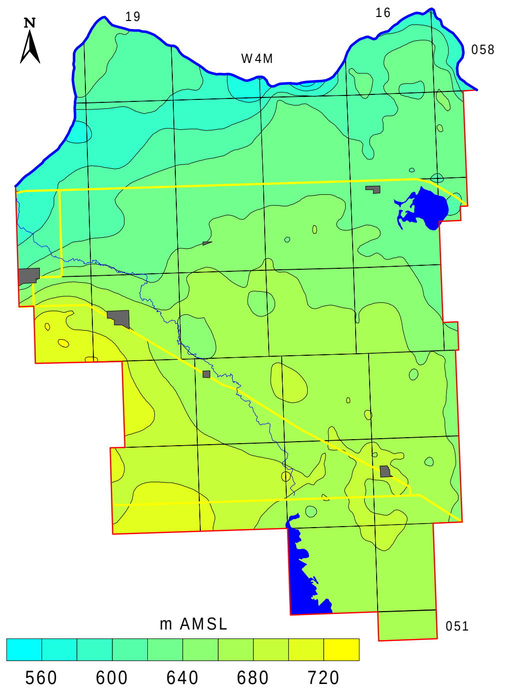

Figure 18. Non-Pumping Water-Level Surface in Surficial Deposits

Based on a gradient of 0.002, an average transmissivity for the surficial deposits of 1 m^2/day and an average aquifer width of 20 kilometres, the groundwater flow from the central part of the County toward the Buried Beverly Valley through the surficial deposits would be 400 m^3/day.

6.1.2 Recharge/Discharge

The hydraulic relationship between the groundwater in the sand and gravel aquifer and the groundwater in the bedrock aquifer is given by the non-pumping water levels 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.

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

The hydraulic gradient between the surficial deposits and the bedrock aquifers has been determined by subtracting the non-pumping water levels in the surficial deposits from the non-pumping water levels in the bedrock. The bedrock recharge classification includes those areas where the water level in the surficial deposits is more than five metres above the water level in the uppermost bedrock aquifer. The area classified as a bedrock discharge area is one 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 area.

The adjacent map shows that in more than 60% of the County there is a downward hydraulic gradient between the surficial deposits and the upper bedrock aquifer(s). The main area where there is an upward hydraulic gradient is associated with buried valleys or meltwater channels that have been incised into the bedrock. The largest areas of upward hydraulic gradient are in the Buried Beverly Valley north of the Village of Bruderheim and in the meltwater channels near the Town of Mundare. The Buried Beverly Valley area is approximately the size of four townships and in this area, groundwater from the bedrock could recharge the sand and gravel aquifers in the surficial deposits.

Because of the paucity of data, a meaningful calculation of the volumes of groundwater entering and leaving the surficial deposits is not possible.

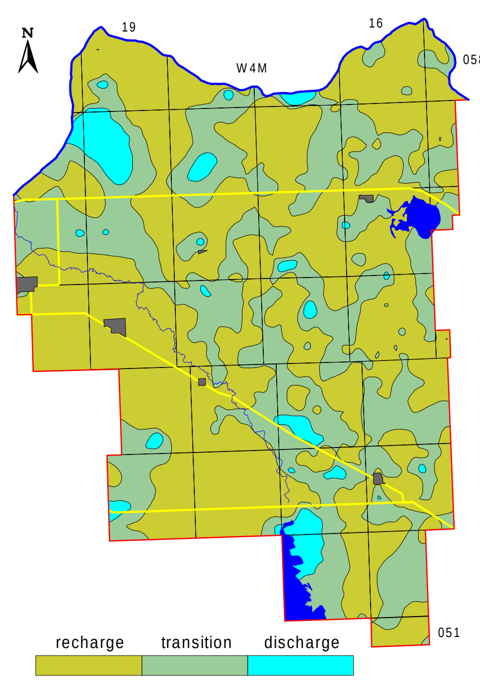

Figure 19. Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)

6.2 Bedrock Aquifers

Recharge to the bedrock aquifers within the County takes place from the overlying surficial deposits. The recharge/discharge maps show that in most of the County, there is a downward hydraulic gradient from the surficial deposits to the bedrock. 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.

The calculation of groundwater recharge has been attempted in the four main bedrock aquifers in the County: the Bearpaw, Oldman, *continental* Foremost and the Milan Aquifers.

6.2.1 Bearpaw Aquifer Recharge

An estimate of groundwater recharge to the bedrock has been calculated in the Bearpaw Aquifer, the upper bedrock in the southwestern one-third of the County. The non-pumping water level indicates that most of the groundwater flows from the southwest to the northeast. The water-level map for the Bearpaw Aquifer shows that the hydraulic gradient is in the order of two metres per kilometre. With an average transmissivity for the Aquifer of 1 m²/day and an Aquifer width of 40 kilometres, the flow through the Aquifer would be 80 m³/day.

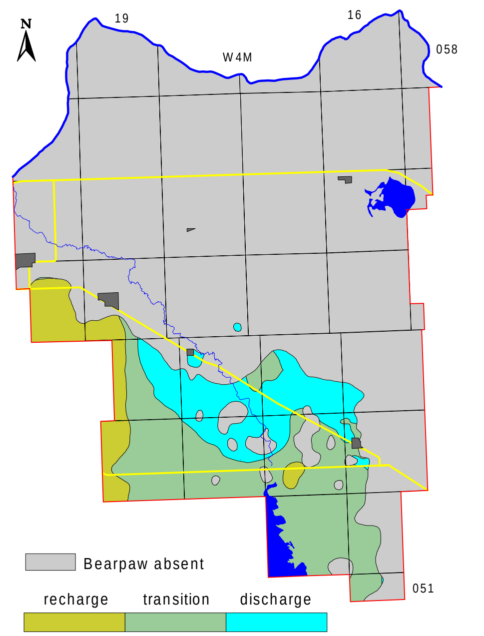

Figure 20. Recharge/Discharge Areas between Surficial Deposits and Bearpaw Aquifer

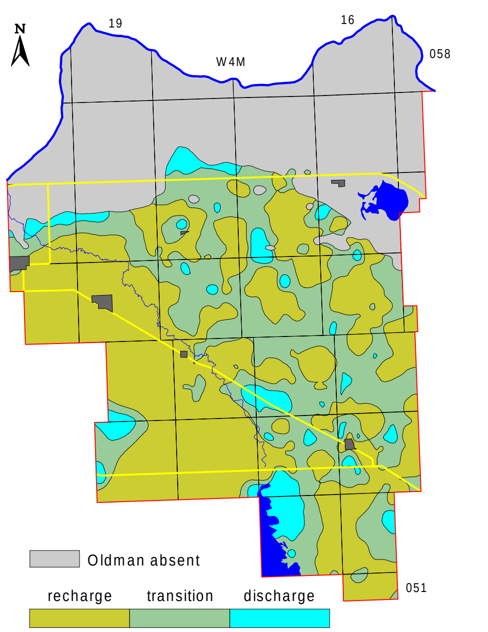

Figure 21. Recharge/Discharge Areas between Surficial Deposits and Oldman Aquifer

6.2.2 Oldman Aquifer Recharge

An estimate of groundwater recharge to the bedrock has been calculated in the Oldman Aquifer, the upper bedrock in the central part of the County. The non-pumping water level indicates that most of the groundwater flows from the south to the north and northeast. It appears that recharge is occurring within the meltwater channels of the surficial deposits. The water-level map for the Oldman Aquifer shows that the hydraulic gradient is in the order of four metres per kilometre. With an average transmissivity for the Aquifer of 5 m²/day and an Aquifer width of 40 kilometres, the flow through the Aquifer would be 800 m³/day.

6.2.3 *Continental* Foremost Aquifer Recharge

An estimate of groundwater recharge to the bedrock has been calculated in the *continental* Foremost Aquifer, the upper bedrock in the northeastern one-third of the County. The non-pumping water level indicates that most of the groundwater flows from the south to the north toward the Buried Beverly Valley and the North Saskatchewan River. The water-level map for the *continental* Foremost Aquifer shows that the hydraulic gradient is in the order of four metres per kilometre. With an average transmissivity for the Aquifer of 2 m²/day and an Aquifer width of 40 kilometres, the flow through the Aquifer would be 320 m³/day.

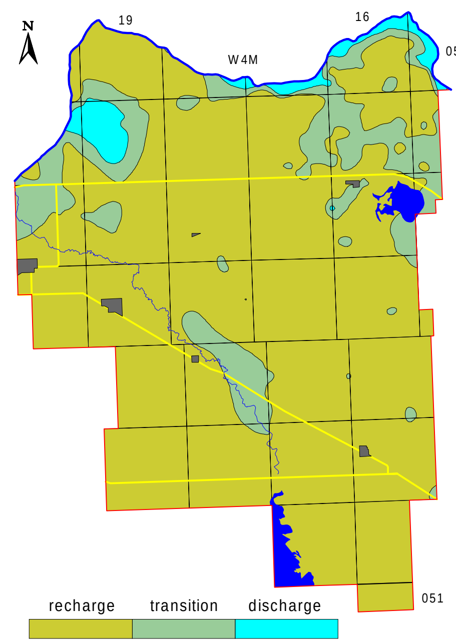

Figure 22. Recharge/Discharge Areas between Surficial Deposits and continental Foremost Aquifer

6.2.4 Milan Aquifer Recharge

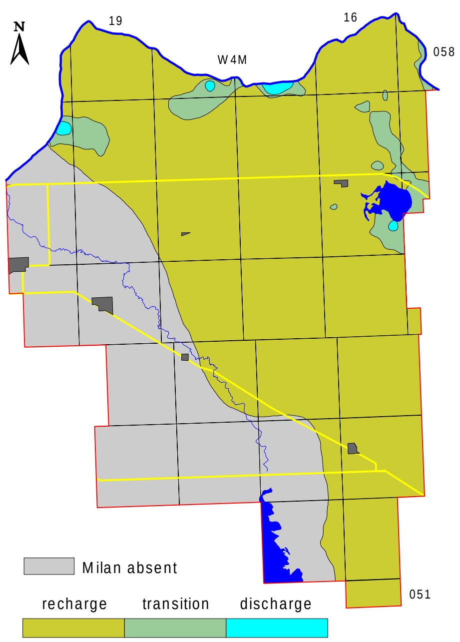

Figure 23. Recharge/Discharge Areas between Surficial Deposits and Milan Aquifer

An estimate of groundwater recharge to the bedrock has been calculated in the Milan Aquifer, the upper bedrock in a few places in the northern part of the County. The non-pumping water level indicates that most of the groundwater flows from the southeast to the northwest, in general, toward the Buried Beverly Valley. The water-level map for the Milan Aquifer shows that the hydraulic gradient is in the order of four metres per kilometre. With an average transmissivity for the Aquifer of 10 m²/day and an Aquifer width of 30 kilometres, the flow through the Aquifer would be 1,200 m³/day.

No attempt has been made to estimate the flow through any of the other bedrock aquifers.

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 spreading of fertilizers, pesticides, herbicides and manure. The spreading of highway salt can also degrade groundwater quality.

When activities occur that do or can 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. When there are 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 1,872 records in the area of the County with lithology descriptions, 255 have sand and gravel within one metre of ground level. In the remaining 1,617 records, the first sand and gravel is deeper or not present. This information was then 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 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.

Surface Permeability	Sand or Gravel Present To 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 2. Risk of Groundwater Contamination Criteria

The Risk of Groundwater Contamination map shows that, in 35% of the County, there is a high or very high risk of the groundwater being 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 groundwater contamination would not affect groundwater quality.

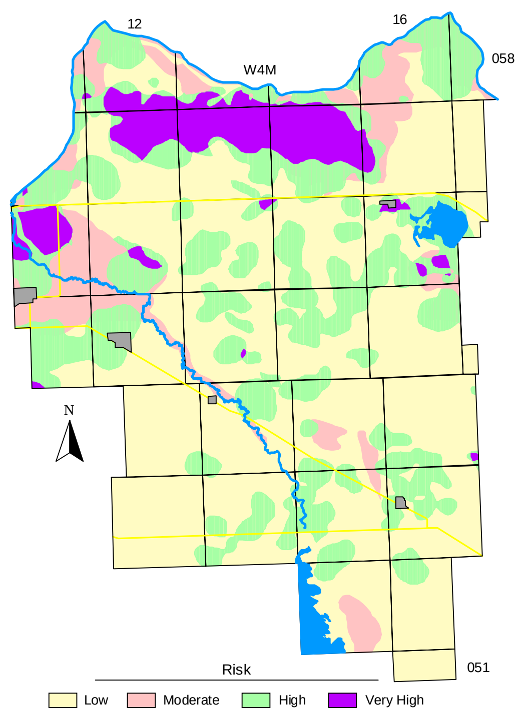

Figure 24. Risk of Groundwater Contamination