B. Groundwater Flow

A direct measurement of groundwater recharge or discharge is not possible from the data that are available for the project area. 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 project area.

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/Area	Transmissivity (m^2/day)	Hydraulic Gradient	Width (km)	General Direction of Flow	Volume (m^3/day)	Aquifer Volume (m^3/day)	Authorized Diversion (m^3/day)
Upper Surficial						31,000(1)	1,873
Buried Calgary Valley						600	265
	57	0.001	14.4	east	570		
Lower Horseshoe Canyon						3500	4,991
Western area	3.5	0.003	48	west	420		
	3.5	0.009	48	east	1575		
Eastern part	3.5	0.004	52.8	west	770		
	3.5	0.004	52.8	east	770		
Bearpaw						3300	723
Western area	2	0.003	57.6	west-south-west	288		
	2	0.004	57.6	East-northeast	480		
Central area	5	0.001	153.6	west	800		
	5	0.001	153.6	east	800		
Eastern area - Northern part	6	0.002	19.2	west	180		
	6	0.003	19.2	east	309		
Eastern area - Southern part	2	0.002	38.4	west	160		
	2	0.004	38.4	east	274		
Oldman						1500	1,582
West flow	2.5	0.002	67.2	southwest	280		
	2.5	0.002	67.2	northwest	350		
East flow	2.5	0.003	38.4	northeast	240		
	2.5	0.002	38.4	southeast	200		
	2.5	0.004	38.4	north	400		
Birch Lake						900	64
	2.8	0.002	96	westerly	448		
	2.8	0.002	96	easterly	448		
Ribstone Creek						1400	9
	8	0.002	56	easterly	933		
	8	0.001	56	westerly	467		

(1) HCL, May 1996

The data provided in the above table indicate there is more groundwater flowing through two of the seven individual bedrock aquifers than has been authorized to be diverted from the individual aquifer. For the Oldman Aquifer, the authorized diversion slightly exceeds the calculated flow through the aquifer. In the case of the Lower Horseshoe Canyon Aquifer, the authorized diversion is approximately 50% more than the calculated flow through the Aquifer. The calculations of flow through individual aquifers as presented in the above table are very approximate and are intended only as a guide for future investigations.

1) Quantity of Groundwater

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 Red Deer River and Sounding Creek, with the lowest water-level elevations occurring along the Red Deer River.

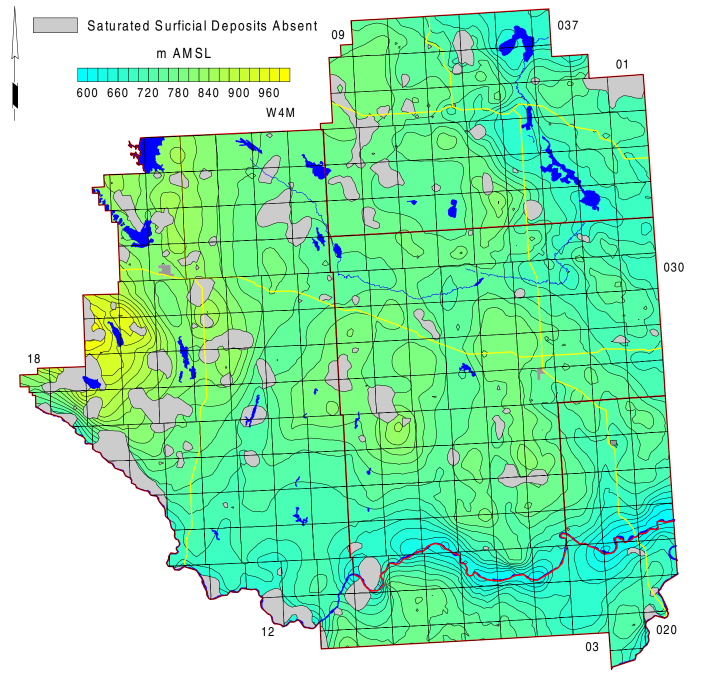

Figure 29. Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep

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.

a) 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.

The adjacent map shows that, in more than 70% of the project area, there is a downward hydraulic gradient (i. e. recharge) 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 Buried Calgary Valley, with local discharge along some segments of Berry Creek and the lower reaches of Sounding Creek, including around Sounding Lake. The remaining parts of the project area are areas where there is a transition condition.

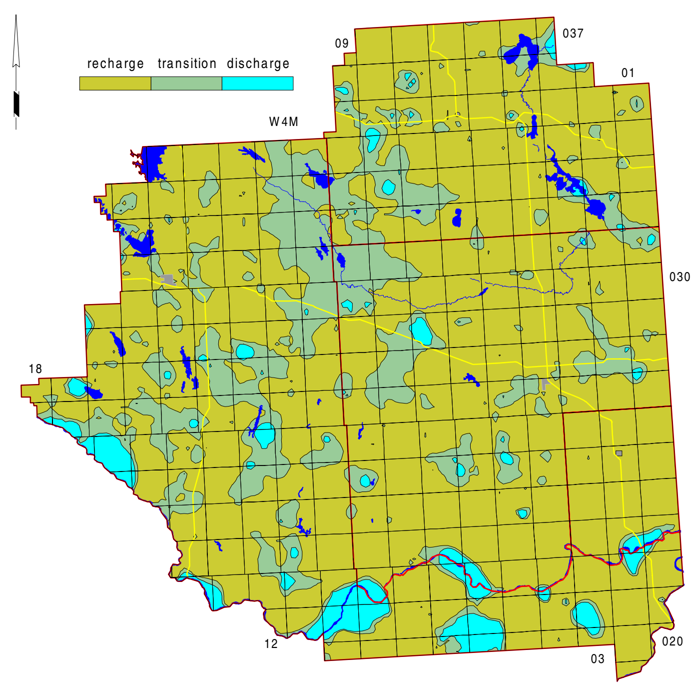

Figure 30. Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)

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

b) Bedrock Aquifers

Recharge to the bedrock aquifers within the project area takes place from the overlying surficial deposits and from flow in the aquifer from outside the project area. The recharge/discharge maps show that generally for most of the project area, 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.

The hydraulic relationship between the surficial deposits and the Bearpaw Aquifer indicates that in more than 75% of the project area where the Bearpaw Aquifer is present, there is a downward hydraulic gradient (i. e. recharge). Discharge areas for the Bearpaw Aquifer are mainly associated with the edge of the Aquifer. The hydraulic relationship between the surficial deposits and the remainder of the bedrock aquifers indicates there is also mainly a downward hydraulic gradient.

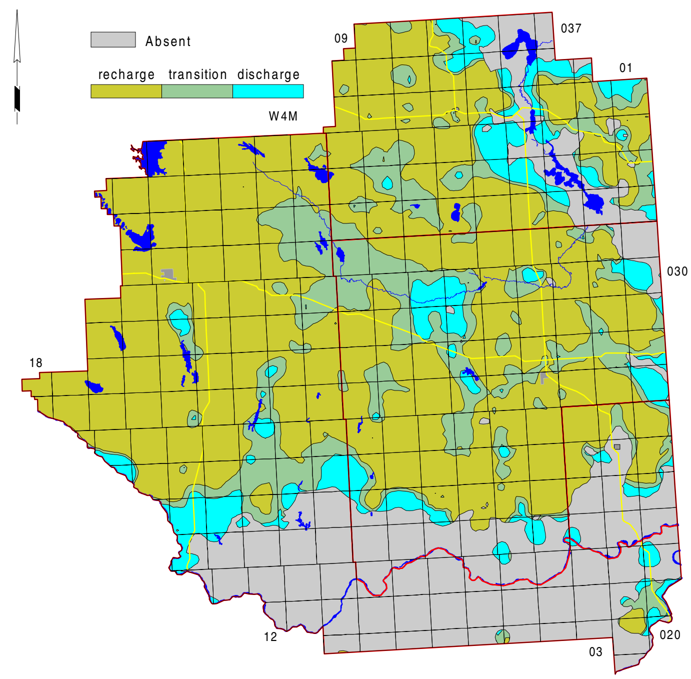

Figure 31. Recharge/Discharge Areas between Surficial Deposits and Bearpaw Aquifer