By assigning 1.1 m³/day for domestic use, 6.3 m³/day for stock use and 7.4 m³/day for domestic/stock use, and using the total maximum authorized diversion associated with any licensed water well that can be linked to a record in the database, a map has been prepared that shows the estimated groundwater use in terms of volume (licensed plus unlicensed) per section per day for the County(not including springs).

There are 5,383 sections in the County. In 79% (4,245) of the sections in the County, there is no domestic or stock or licensed groundwater user. The range in groundwater use from the remaining 1,138 sections with groundwater use is from 1.1 to more than 4,000 m³/day, with an average use per section of 13.5 m³/day (2.1 igpm). Of the 78 licensed users, eight have an authorized diversion of 0 m³/day. The estimated water well use per section can be more than 30 m³/day in 43 of the 1,138 sections. The most notable areas where water well use of more than 30 m³/day is expected occur mainly in the vicinity of linear bedrock lows and near populated centres, as shown on Figure 32.

Groundwater Use within Cypress County (m³/day)		%
Domestic/Stock (licensed and unlicensed)	9,830	33
Municipal (licensed)	5,463	18
Commercial/Irrigation/Recreation et al (licensed)	14,361	48
Total	29,654	100

Table 7. Total Groundwater Diversions

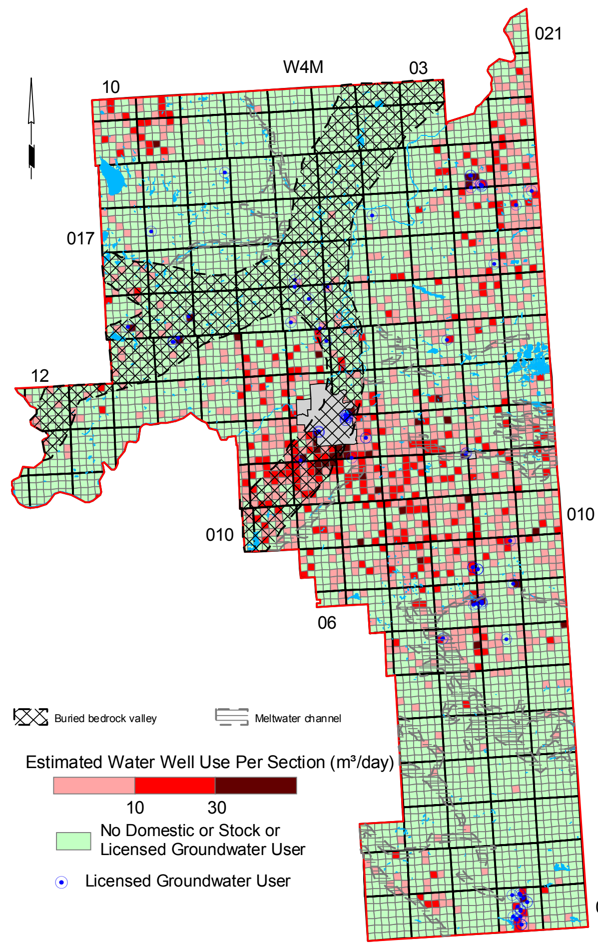

Figure 32. Estimated Water Well Use Per Section

In summary, the estimated total groundwater use within Cypress County is 29,654 m³/day, with the breakdown as shown in the table above. Approximately 862 m³/day is being withdrawn from unknown aquifer units. The remaining 24,337 m³/day has been assigned to specific aquifer units.

Approximately 69% of the total estimated groundwater use is from licensed water wells.

6.3 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; flow through the aquifers takes into consideration hydrogeological conditions outside the County border. Based on these assumptions, the estimated lateral groundwater flow through the individual aquifers can be summarized below in Table 9:

Aquifer/Area	Trans (m²/day)	Gradient (m/m)	Width (m)	Flow (m³/day)	Aquifer Flow (m³/day)	Licensed Diversion (m³/day)	Unlicensed Diversion (m³/day)	Total (m³/day)
Upper Sand and Gravel					1,600	206	3,832	4,142
Lethbridge								
north	60	0.0013	20,000	1500				
Northeastern								
northeast	1	0.0050	25,000	125				
southwest	1	0.0050	25,000	125				
Lower Sand and Gravel					2,500	18,944	2,538	21,482
Medicine Hat								
north	500	0.0025	1,100	1375				
Lethbridge								
east	240	0.0006	1,100	158				
Dunmore								
west	125	0.0028	1,000	347				
East Boundary								
north	125	0.0010	1,000	125				
North slopes								
southwest	18	0.0083	3,000	450				
Horseshoe Canyon					4,300	328	16	344
Central								
northeast	25	0.004	16,000	1500				
northwest	25	0.011	10,000	2813				
Bearpaw					8,100	0	861	861
South								
North	6.6	0.012	50,000	3850				
South	6.6	0.005	40,000	1320				
Northeast								
southwest	7	0.010	30,000	2100				
north	7	0.006	20,000	840				
Oldman					9,900	152	1,225	1,377
Northwest								
East	5	0.025	50,000	6133				
Northeast								
northwest	3	0.001	60,000	167				
West central								
East	4	0.003	40,000	500				
East central								
north	7	0.006	22,000	963				
east and northeast	7	0.003	70,000	1531				
Southern								
east/south/west	7	0.003	29,000	634				
Foremost					4,320	74	609	683
Northwest								
Northeast	8	0.002	70,000	1120				
East								
North/northwest	8	0.005	75,000	3000				
South								
South	1	0.005	40,000	200				

Table 8. Groundwater Budget

Table 8 indicates that there is more groundwater flowing through the aquifers than has been authorized to be diverted from the individual aquifers, except for the Upper Sand and Gravel and Lower Sand and Gravel aquifers.

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.

6.3.1 Quantity of Groundwater

An estimate of the volume of groundwater stored in the sand and gravel aquifers in the surficial deposits is 2.5 to 15 cubic kilometres. This volume is based on an areal extent of 10,000 square kilometres and a saturated sand and gravel thickness of five 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. The water levels from these water wells were used for the calculation of the saturated thickness of the surficial deposits. In areas where the elevation of the water-level surface is below the bedrock surface, the surficial deposits are not saturated (indicated by grey areas on the map). The water-level map for the surficial deposits shows a general flow direction toward the buried bedrock valleys.

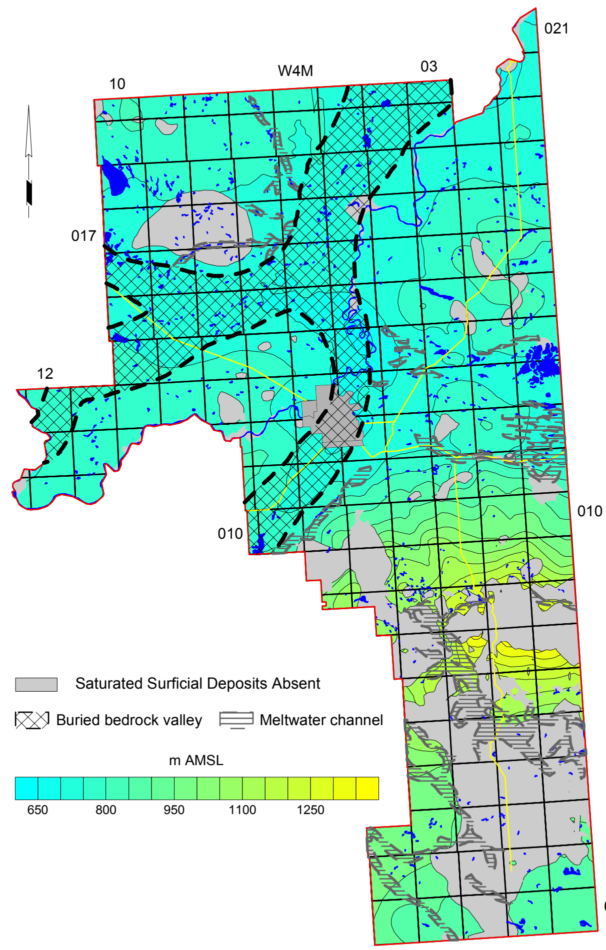

Figure 33. Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep

6.3.2 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.

6.3.2.1 *Surficial Deposits/Bedrock Aquifers*

The hydraulic gradient between the surficial deposits and the upper bedrock aquifer(s) has been determined by subtracting the elevation of the non-pumping water-level surface associated with all water wells completed in the upper bedrock aquifer(s) from the elevation of the non-pumping water-level surface determined for all water wells in the surficial deposits. The recharge classification shown on Figure 34 includes those areas where the water-level surface in the surficial deposits is more than five metres above the water-level surface 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 County, there is a downward hydraulic gradient (recharge) from the surficial deposits toward the upper bedrock aquifer(s).

The few areas where there is an upward hydraulic gradient (i.e. discharge), from the bedrock to the surficial deposits, are mainly in the vicinity of linear bedrock lows. 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.

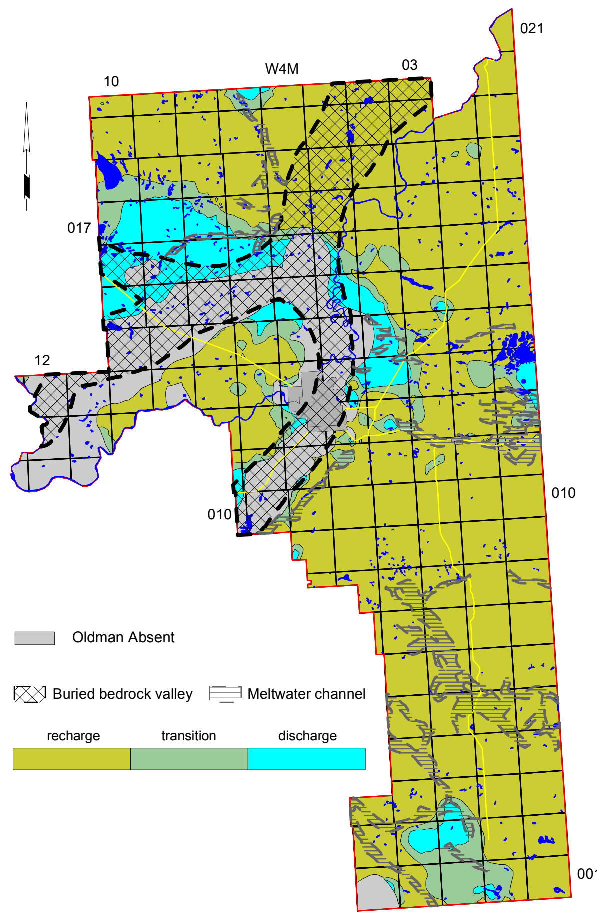

Figure 34. Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)

6.3.2.2 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.

The hydraulic relationship between the surficial deposits and the Oldman Aquifer indicates that in more than 80% of the County where the Oldman Aquifer is present and where there is data control, there is a downward hydraulic gradient (i.e. recharge). Discharge areas for the Oldman Aquifer are mainly associated with the edge of the Aquifer or in areas of linear bedrock lows.

The hydraulic relationship between the surficial deposits and the remainder of the bedrock aquifers indicates there is mainly a downward hydraulic gradient (see CD ROM).

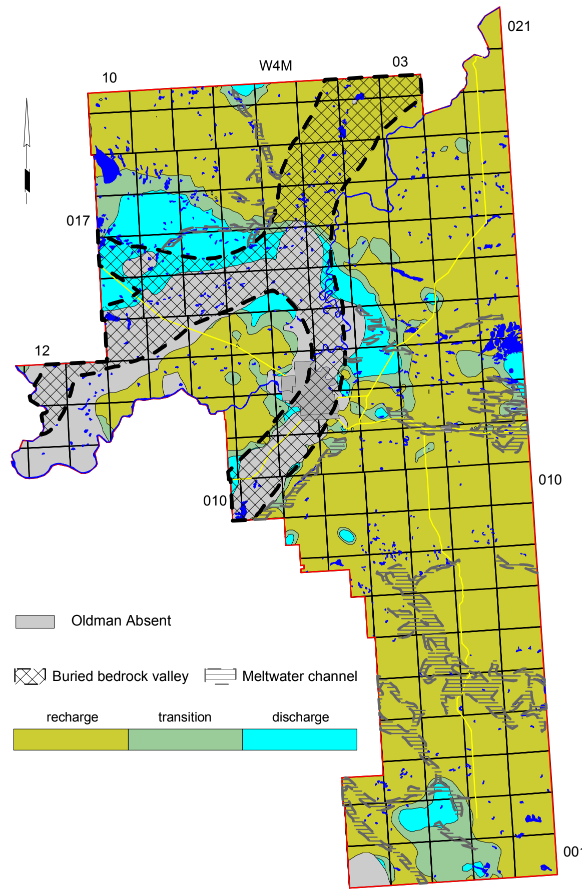

Figure 35. Recharge/Discharge Areas between Surficial Deposits and Oldman Aquifer

6.4 Areas of Groundwater Decline

The areas of groundwater decline in both the sand and gravel aquifer(s) and in the bedrock aquifers have been determined by using a similar procedure in both situations. Because major development began occurring in the 1970s, the changes in water-level maps are based on the differences between water-level elevations available before 1970 and after 1984. Where the earliest water level is at a higher elevation than the latest water level, there is the possibility that some groundwater decline has occurred. Where the earliest water level is at a lower elevation than the latest water level, there is the possibility that the groundwater has risen at that location. The water level may have risen as a result of recharge in wetter years or may be a result of the water well being completed in a different bedrock aquifer. In order to determine if the water-level decline is a result of groundwater use by licensed users, the licensed groundwater users were posted on the maps.

Of the 920 water wells completed in the sand and gravel aquifer(s) with a non-pumping water level and date, 383 are from water wells completed before 1970 and 216 are from water wells completed after 1984. Of the 383 water-level measurements, 175 were measured as part of the Federal Well Survey, with 152 being measured from 1935 to 1937. As a result of the disproportionate location of control points prior to and after major development, the adjacent map has been masked with a solid brown color to indicate areas of no control.

The adjacent map indicates that in 80% of the County where there is control, it is possible that the non-pumping water level has declined. The large area indicating that a water-level rise may have occurred in the northern part of the County, may be a result of the gridding process. Of the 78 licensed groundwater users, most occur in areas where a water-level decline may exist or there is no control.

Nine percent of the areas where there has been a water-level decline of more than five metres in the sand and gravel aquifer(s) corresponds to where the estimated water well use is between 10 and 30 m³/day per section; 1% of the declines occurred where the estimated water well use is more than 30 m³/day per section; 22% of the declines occurred where the estimated water well use is less than 10 m³/day per section; the remaining 68% occurred where there is no groundwater use per section, as shown on Figure 32.

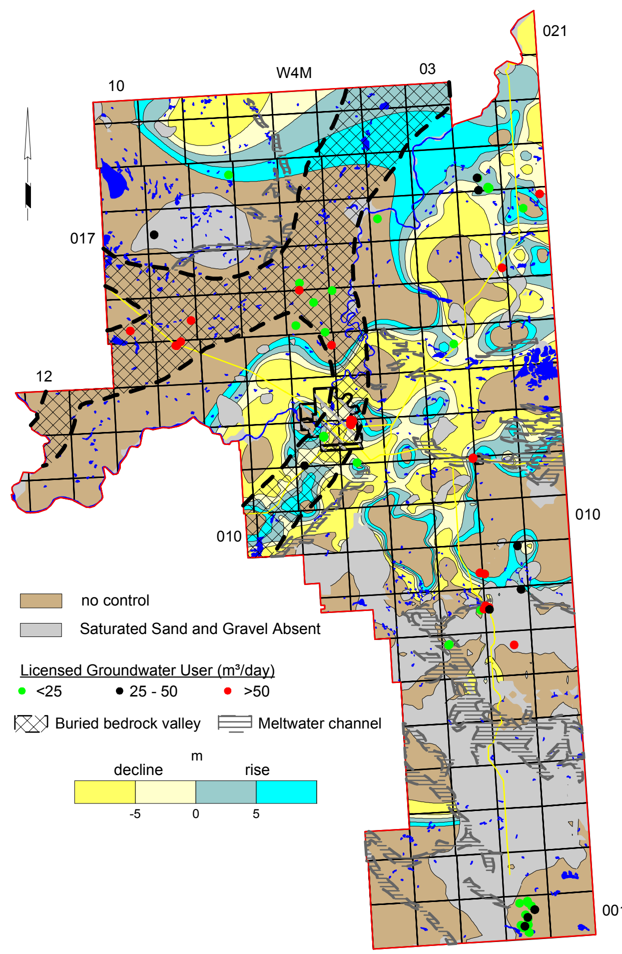

Figure 36. Changes in Water Levels in Sand and Gravel Aquifer(s) Based on Water Wells Less than 20 Metres Deep

Of the 806 bedrock water wells with a non-pumping water level and date, 201 are from water wells completed before 1970 and 269 are from water wells completed after 1984. Of the 201 water-level measurements, 55 were measured as part of the Federal Well Survey, with 43 being measured from 1935 to 1937. As a result of the disproportionate location of control points prior to and after major development, the adjacent map has been masked with a solid brown color to indicate these areas of no control and figures for the individual bedrock aquifers have not been created.

The adjacent map indicates that in 60% of the County, it is possible that the non-pumping water level has declined. Of the 78 licensed groundwater users, most occur in areas where a water-level decline may exist or there is no control.

Seven percent of the areas where there has been a water-level decline of more than five metres in upper bedrock aquifer(s) corresponds to where the estimated water well use is between 10 and 30 m³/day per section; 1% of the declines occurred where the estimated water well use is more than 30 m³/day per section; 16% of the declines occurred where the estimated water well use is less than 10 m³/day per section; the remaining 76% occurred where there is no groundwater use per section, as shown on Figure 32.

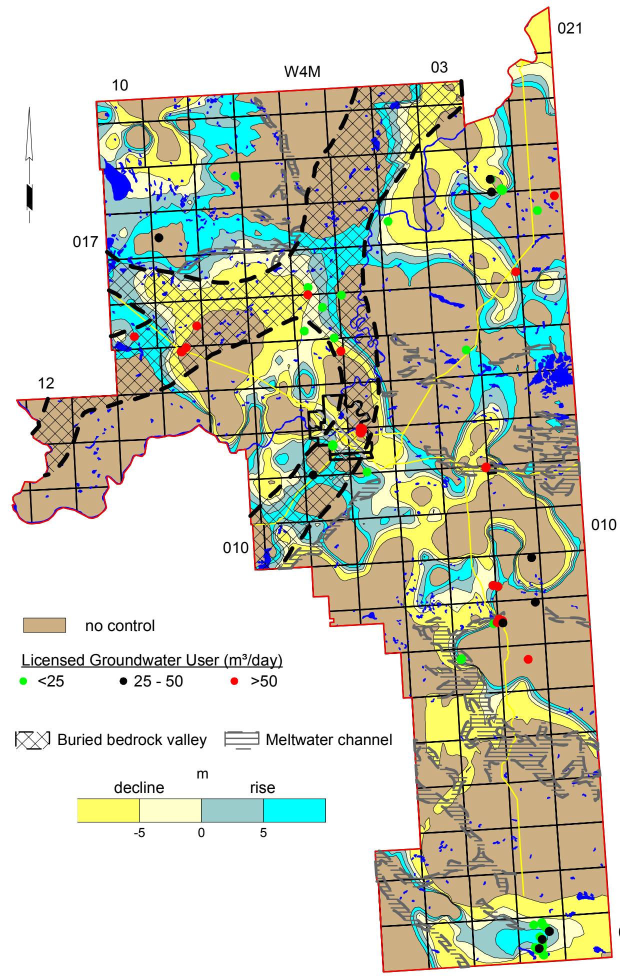

Figure 37. Changes in Water Levels in Upper Bedrock Aquifer(s)