In the County, there are 136 records for surficial water wells with apparent yield data, which is 21% of the 645 surficial water wells. Of the 136 water well records with apparent yield values, 56 have been assigned to aquifers associated with specific geologic units. Fifteen percent (20) of the 136 water wells completed in the sand and gravel aquifer(s) have apparent yields that are less than ten m³/day, 52% (71) have apparent yield values that range from 10 to 100 m³/day, and 33% (45) have apparent yields that are greater than 100 m³/day, as shown in Table 3. In addition to the 136 records for surficial water wells, there are 14 records that indicate that the water well is dry[17], or abandoned with "insufficient water". In order to depict a more accurate yield map, an apparent yield of 0.1 m³/day was assigned to the 14 dry holes prior to gridding. The majority of the dry holes are in multiple surficial completions.

Aquifer	No. of Water Wells with Values for Apparent Yield (*)	Number of Water Wells with Apparent Yields <10 m³/day	10 to 100 m³/day	>100 m³/day
Upper Surficial	8	1	4	3
Lower Surficial	48	4	22	22
Multiple Completions	80	15	45	20
Totals	136	20	71	45

* - does not include dry test holes

Table 3. Apparent Yields of Sand and Gravel Aquifer(s)

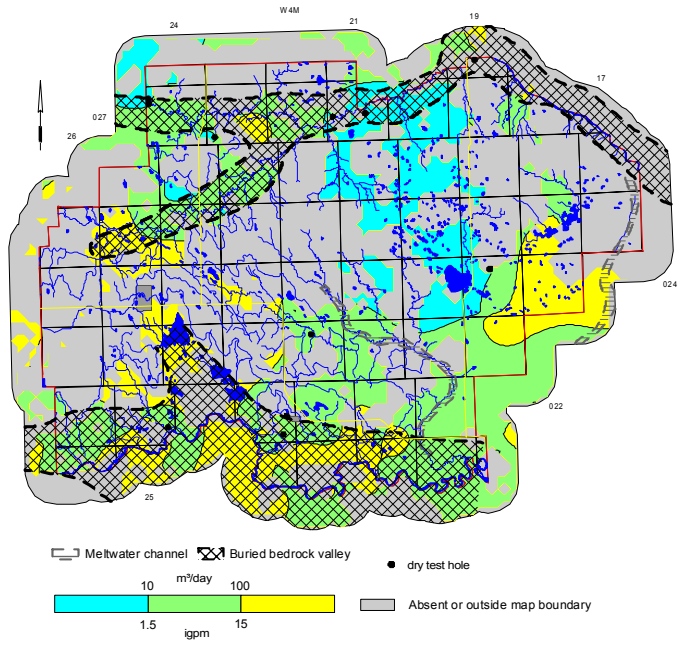

Figure 14. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

The adjacent map shows expected yields for water wells completed in sand and gravel aquifers(s).

Based on the aquifers that have been developed by existing water wells, these data show that water wells with yields of less than 100 m³/day from sand and gravel aquifer(s) can be expected in most of the County. The most notable areas where yields of more than 100 m³/day are expected are mainly in association with the buried bedrock valleys.

[17] "dry" can be due to a variety of reasons: skill of driller, type of drilling rig/method used, the geology

5.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

The chemical analysis results of groundwaters from the surficial deposits indicate the groundwaters are generally chemically hard and high in dissolved iron. In Wheatland County, groundwaters from the surficial aquifers mainly have a chemical hardness of greater than 200 mg/L (see CD-ROM).

The Piper tri-linear diagram[18] (page A-28) for surficial deposits shows the groundwaters have no dominant cation but are mainly bicarbonate-type waters. Nearly 90% of the groundwaters from the surficial deposits have a TDS concentration of more than 500 mg/L. Groundwaters having TDS concentrations of less than 500 mg/L occur mainly along the Bow River. Forty-five percent of the groundwaters from the surficial deposits are reported to have dissolved iron concentrations of less than or equal to the aesthetic objective (AO) of 0.3 mg/L. However, many iron analysis results are questionable due to varying sampling and analytical methodologies.

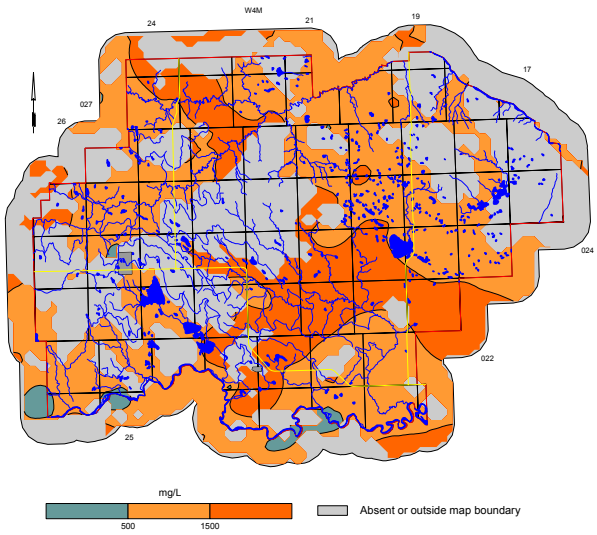

Figure 15. Total Dissolved Solids in Groundwater from Surficial Deposits

There are groundwaters with sulfate as the main anion. The groundwaters with elevated levels of sulfate generally occur in areas where there are elevated levels of total dissolved solids. There are very few groundwaters from the surficial deposits with appreciable concentrations of the chloride ion and in nearly 90% of the samples analyzed for surficial deposits in the County, the chloride ion concentration is less than 50 mg/L (see CD-ROM).

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	391	199	7,048	921	500
Sodium	289	0	1,722	175	200
Sulfate	390	0	4,514	254	500
Chloride	390	0	2,099	12	250
Nitrate + Nitrite (as N)	268	0	56	0.0	10

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Nitrate + Nitrite (as N), which is for Maximum Acceptable Concentration (MAC)
SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality Federal-Provincial Subcommittee on Drinking Water, March 2001

Table 4. Concentrations of Constituents in Groundwaters from Surficial Deposits

In the County, the nitrate + nitrite (as N) concentrations in the groundwaters from the surficial deposits exceed the maximum acceptable concentrations (MAC) of ten mg/L in 14 of the 288 groundwater samples analyzed (up to about 1986).

The minimum, maximum and median concentrations of TDS, sodium, sulfate, chloride and nitrate + nitrite (as N) in the groundwaters from water wells completed in the surficial deposits in the County have been compared to the SGCDWQ in the adjacent table. Of the five constituents that have been compared to the SGCDWQ, the median value of TDS concentrations exceeds the guidelines.

[18] See glossary

5.2.3 Upper Sand and Gravel Aquifer

The Upper Sand and Gravel Aquifer includes saturated sand and gravel deposits in the upper surficial deposits. Typically, these aquifers are present within the surficial deposits at no particular depth. Saturated sand and gravel deposits in the upper surficial deposits are not usually continuous over large areas but are expected over approximately 20% of the County.

5.2.3.1 Aquifer Thickness

The thickness of the Upper Sand and Gravel Aquifer is a function of two parameters: (1) the elevation of the non-pumping water-level surface associated with the surficial deposits; and (2) the depth to the bedrock surface or the depth to the top of the lower surficial deposits when present. In the County, the thickness of the Upper Sand and Gravel Aquifer is generally less than 25 metres, but can be more than 50 metres in association with the linear bedrock lows present in the southeastern part of the County (see CD-ROM).

5.2.3.2 Apparent Yield

The permeability of the Upper Sand and Gravel Aquifer can be high. The high permeability combined with significant thickness leads to an extrapolation of high yields for water wells; however, because the sand and gravel deposits occur mainly as hydraulically discontinuous pockets, the long-term yields of the water wells are expected to be less than the apparent yields. The long-term yields for water wells completed through this Aquifer are expected to be mainly less than those shown on the adjacent figure. The apparent yields of greater than 100 m³/day shown in the western part of the County are the result of gridding one control point in township 026, range 23, W4M.

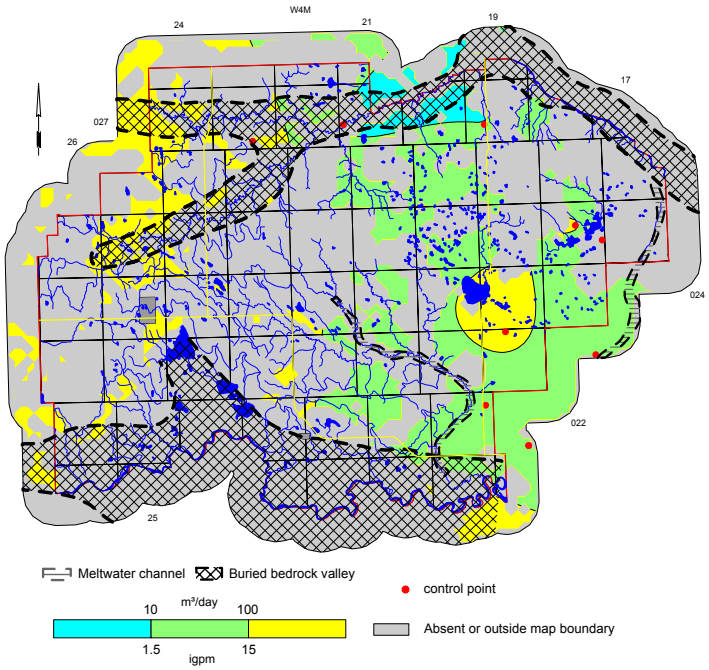

Figure 16. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

Where the Upper Sand and Gravel Aquifer is absent and where the yields are low, the development of water wells for the domestic needs of single families may not be possible from this Aquifer, and construction of a water supply well into the underlying bedrock may be the only alternative, provided that yields and quality of groundwater from the bedrock aquifer(s) are suitable.

In the County, there are nine licensed water wells that are completed through the Upper Sand and Gravel Aquifer, for a total authorized diversion of 139 m^3/day, of which 93% is used for agricultural purposes. Three of the nine licensed water wells completed through the Upper Sand and Gravel Aquifer could be linked to a water well in the AENV groundwater database.

5.2.4 Lower Sand and Gravel Aquifer

The Lower Sand and Gravel Aquifer is a saturated sand and gravel deposit that occurs at or near the base of the surficial deposits in the deeper part of the linear bedrock lows. The top of the lower surficial deposits is based on more than 1,000 control points across Alberta, including 13 in the County that are provided by Moran (1986) and Shetsen (1991).

5.2.4.1 Aquifer Thickness

The thickness of the Lower Sand and Gravel Aquifer is mainly less than five metres, but can be more than 15 metres in the buried bedrock valleys (see CD-ROM).

5.2.4.2 Apparent Yield

Apparent yields for water wells completed in the Lower Sand and Gravel Aquifer range from less than 10 m³/day to more than 100 m³/day. The most notable areas where yields of more than 100 m³/day are expected are mainly in association with the Buried Calgary Valley.

In the County, there are 14 licensed water wells that are completed through the Lower Sand and Gravel Aquifer, for a total authorized diversion of 430 m^3/day, of which 64% is used for municipal purposes.

Thirteen of the 14 licensed water wells completed through the Lower Sand and Gravel Aquifer could be linked to a water well in the AENV groundwater database.

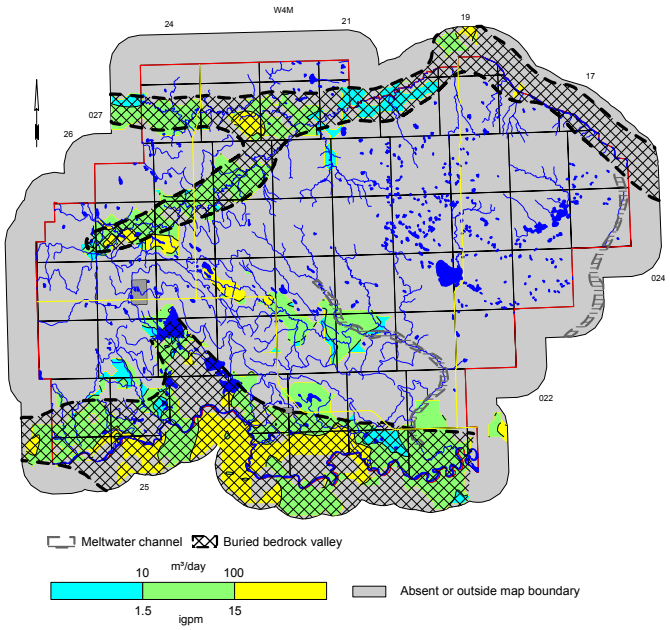

Figure 17. Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer

A preliminary groundwater study conducted for the Hamlet of Carseland in 1980 indicated that the existing 1975 Water Supply Well (WSW) in 06-12-022-26 W4M, and completed from 61.9 to 66.4 metres below ground surface in the Lower Sand and Gravel Aquifer, had an apparent yield of 137 m³/day (HCL, July 1980). In 1980, the Hamlet was pumping the 1975 WSW at a rate of 124 m³/day and required an additional water well to supply groundwater to a new subdivision. As a result of this preliminary study, HCL recommended that three water test holes be drilled. It was expected that although sand and gravel deposits associated with the Buried Calgary Valley might be thicker south of the Hamlet, the hydraulic data suggested that a higher yield might be encountered north of the existing water supply well. Carseland is currently licensed to divert groundwater from four water supply wells. Two water supply wells south of the 1975 water supply well in 01 and 02-12-022-26 W4M are licensed to divert a total of 64.2 m³/day, a third water supply well east of the 1975 WSW in 05-06-022-25 W4M is licensed to divert 37.2 m³/day, and a fourth water supply well north of the 1975 WSW is licensed to divert 162.2 m³/day. All four water supply wells are completed in the Lower Sand and Gravel Aquifer.

The groundwater from the 1975 WSW in 06-12-022-26 W4M has a TDS concentration of 775 mg/L, a sulfate concentration of 190 mg/L and a chloride concentration of 18.5 mg/L (HCL, July 1980).

5.3 Bedrock

5.3.1 Geological Characteristics

The upper bedrock in the County includes parts of the Paskapoo Formation, and the Scollard, Whitemud, Battle, Horseshoe Canyon and Bearpaw formations. The Paskapoo Formation in central Alberta consists of the Dalehurst, Lacombe and Haynes members (Demchuk and Hills, 1991). The Edmonton Group underlies the Paskapoo Formation. The Edmonton Group includes the Scollard, Battle, Whitemud and Horseshoe Canyon formations. A generalized geologic column is illustrated in Figure 6, Appendix A and on the CD-ROM.

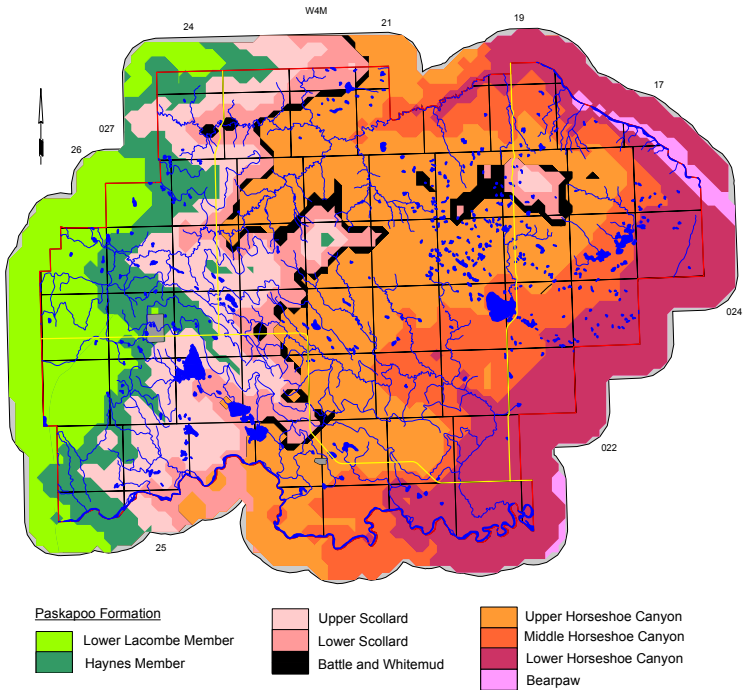

Figure 18. Bedrock Geology

The Paskapoo Formation consists of cycles of thick, tabular sandstone, siltstone and mudstone layers (Glass, 1990). The maximum thickness of the Paskapoo Formation is generally less than 800 metres. In the County, only the Lower Lacombe and the Haynes members of the Paskapoo Formation are present.

The Lower Lacombe Member subcrops in the extreme western part of the County. The lower part of the Lacombe Member is composed of sandstone and coal layers. In the middle of the lower part of the Lacombe Member there is a coal zone, which can be up to five metres thick. The maximum thickness of the Lower Lacombe Member in other parts of Alberta is generally less than 100 metres; however, within the County, the Lower Lacombe Member has a maximum thickness of 135 metres.

The Haynes Member underlies the Lacombe Member and is composed mainly of sandstone with some siltstone, shale and coal. In other parts of Alberta, the Haynes Member has a maximum thickness of 100 metres; in the County, the Haynes Member has a maximum thickness of 50 metres.

The Scollard Formation underlies the Haynes Member, has a maximum thickness of 160 metres and has two separate designations: Upper and Lower. The Upper Scollard consists mainly of sandstone, siltstone, shale and coal seams or zones. Two prominent coal zones within the Upper Scollard are the Ardley Coal (up to 20 metres thick) and the Nevis Coal (up to 3.5 metres thick). The bottom of the Nevis Coal Seam is the border between the Upper and Lower Scollard formations. In the County, the Upper Scollard has a maximum thickness of 80 metres; the Lower Scollard Formation has an average thickness of 30 metres, and is composed mainly of shale and sandstone.

Beneath the Scollard Formation are two formations having a maximum thickness of 30 metres; the two are the Battle and Whitemud formations. The Battle Formation is composed mainly of claystone, tuff, shale and bentonite, and includes the Kneehills Member, a 2.5- to 30-cm thick tuff bed. The Whitemud Formation is composed mainly of shale, siltstone, sandstone and bentonite. The Battle and Whitemud formations are significant geologic markers, and were used in the preparation of various geological surfaces within the bedrock.

Because of the ubiquitous nature of the bentonite in the Battle and Whitemud formations, there is very little significant permeability within these two formations.

The Horseshoe Canyon Formation is the lower part of the Edmonton Group and is the upper bedrock in the eastern two-thirds of the County. The Horseshoe Canyon Formation has a maximum thickness of 350 metres and has three separate designations: Upper, Middle and Lower. The Upper Horseshoe Canyon, which can be up to 100 metres thick, is the uppermost bedrock in the east-central part of the County immediately east of the area where the Battle and Whitemud formations and the Lower Scollard Formation subcrop. The Middle Horseshoe Canyon, which is up to 70 metres thick, subcrops in the eastern part of the County. The Lower Horseshoe Canyon, which is up to 170 metres thick, subcrops in the extreme eastern part of the County with the exception of a small area where the Bearpaw Formation subcrops.

The Horseshoe Canyon Formation consists of deltaic[19] and fluvial sandstone, siltstone and shale with interbedded coal seams, bentonite and thin nodular beds of limestone and ironstone. Because of the low-energy environment in which deposition occurred, the sandstones, when present, tend to be finer grained. The lower 60 to 70 metres and the upper 30 to 50 metres of the Horseshoe Canyon Formation can include coarser grained sandstone deposits.

The Bearpaw Formation underlies the Horseshoe Canyon Formation and is in the order of 130 metres thick within the County. The Bearpaw Formation consists of marine shale, siltstone and minor sandstone layers except in some areas where the thickness of the sandstone layers can be significant. The Bearpaw Formation "represents the final widespread marine unit in the Western Canada Foreland Basin" (Catuneanu et al, 1997).

There will be no direct review of the Bearpaw Formation in the text of this report because there are not sufficient data to create a meaningful contour map; the only maps associated with the Bearpaw Formation to be included on the CD-ROM will be structure-contour maps.

In the County, the Base of Groundwater Protection extends below the Upper Scollard Formation. A map showing the depth to the Base of Groundwater Protection is given on page 7 of this report, in Appendix A, and on the CD-ROM.

5.3.2 Aquifers

Of the 4,188 water wells in the database, 1,766 were defined as being completed below the top of bedrock and 241 completed in surficial aquifers, based on lithologic information and water well completion details. However, at least a reported completion depth is available for 3,919 water wells completed below the bedrock surface. Assigning a water well to a specific geologic unit is possible only if the completion interval is identified. In order to make use of additional information within the groundwater database, it was assumed that the top of the completion interval was 80% of the total completed depth of a water well. With this assumption, it has been possible to designate the specific bedrock aquifer of completion for 2,357 water wells. The remaining 694 of the total 3,051 bedrock water wells are identified as being completed in more than one bedrock aquifer as shown in Table 4. The bedrock water wells are mainly completed in the Haynes, Upper Scollard and Upper Horseshoe Canyon aquifers.

Geologic Unit	No. of Bedrock Water Wells
Lower Lacombe	228
Haynes	380
Upper Scollard	419
Lower Scollard	242
Battle Formation	46
Upper Horseshoe Canyon	593
Middle Horseshoe Canyon	278
Lower Horseshoe Canyon	163
Bearpaw	8
Multiple Completions	694
Total	3,051

Table 5. Completion Aquifer

[19] See glossary