completion information available. Where an aquifer can be determined, the largest total licensed allocations are in the Upper Scollard Aquifer.

Aquifer **	No. of Diversions	Licensed Groundwater Users* (m³/day) Agricultural	Commerical	Municipal	Exploration	Irrigation	Recreation	Total	Percentage
Upper Sand and Gravel	9	129	0	10	0	0	0	139	2.4
Lower Sand and Gravel	14	150	0	277	0	0	3	430	7.3
Bedrock	22	538	0	51	0	0	24	613	10.4
Lower Lacombe	5	122	3	0	0	0	0	125	2.1
Haynes	24	759	120	4	0	0	0	883	15.0
Upper Scollard	29	900	63	3	0	0	0	966	16.4
Lower Scollard	15	728	0	0	0	0	0	728	12.4
Upper Horseshoe Canyon	17	184	0	84	0	0	0	268	4.6
Middle Horseshoe Canyon	15	73	0	74	0	0	0	147	2.5
Lower Horseshoe Canyon	8	139	0	37	0	0	0	176	3.0
Unknown	44	796	0	44	555	10	0	1,405	23.9
Total	202	4,518	186	584	555	10	27	5,880	100
Percentage		76.8	3.2	9.9	9.4	0.2	0.5	100	

* - data from AENV ** - Aquifer identified by HCL

Table 1. Licensed Groundwater Diversions

Based on the 2001 Agriculture Census (Statistics Canada), the calculated water requirement for 777,856 livestock for the County is in the order of 19,150 m³/day. This value includes intensive livestock use but not domestic animals. Of the 19,150 m³/day average calculated livestock use, AENV has licensed a groundwater diversion of 4,518 m³/day (24%) and licensed a surface-water diversion of 2,195 m³/day (11%). The remaining 65% of the calculated livestock use would have to be from unlicensed sources.

2.3.6 Groundwater Chemistry and Base of Groundwater Protection

Groundwaters from the surficial deposits can be expected to be chemically hard, with a high dissolved iron content. High nitrate + nitrite (as N) concentrations were evident in 5% of the available chemical data for the surficial aquifers and 2% of the available chemical data for the upper bedrock aquifer(s); a plot of nitrate + nitrite (as N) in surficial aquifers is on the accompanying CD-ROM. The TDS concentrations in the groundwaters from the upper bedrock in the County range from less than 500 to more than 2,000 mg/L (page A-30). Groundwaters from the bedrock aquifers frequently are chemically soft, with generally low concentrations of dissolved iron. The chemically soft groundwater is high in concentrations of sodium. More than 25% of the chemical analyses for bedrock water wells indicate a fluoride concentration above 1.5 mg/L, with most of the exceedances occurring in the western third of the County (see page A-31 and the CD-ROM).

The minimum, maximum and median[7] concentrations of TDS, sodium, sulfate, chloride and fluoride in the groundwaters from water wells completed in the upper bedrock in the County have been compared to the Summary of Guidelines for Canadian Drinking Water Quality (SGCDWQ) in Table 2. Of the five constituents compared to the SGCDWQ, median concentrations of TDS and sodium exceed the guidelines; maximum values of all five constituents exceed the guidelines.

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	1,528	14	7,419	1,069	500
Sodium	975	0	2,333	350	200
Sulfate	1,503	0	5,180	285	500
Chloride	1,385	0	1,403	13	250
Fluoride	1,322	0	9.5	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, 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 2. Concentrations of Constituents in Groundwaters from Upper Bedrock Aquifer(s)

7 see glossary

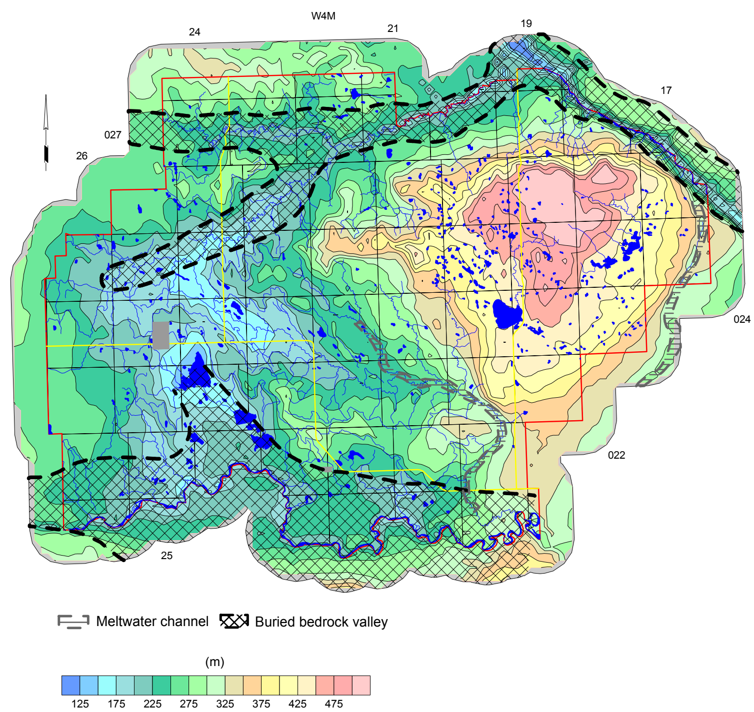

Figure 4. Depth to Base of Groundwater Protection (after EUB, 1995)

In general, Alberta Environment defines the Base of Groundwater Protection as the elevation below which the groundwater will have more than 4,000 mg/L of total dissolved solids. By using the ground elevation, formation elevations, and Alberta Energy and Utilities Board (EUB) information indicating the formations containing the deepest useable water for agricultural needs, a value for the depth to the Base of Groundwater Protection can be determined. These values are gridded using the Kriging[8] method to prepare a depth to the Base of Groundwater Protection surface. This depth, for the most part, would be the maximum drilling depth for a water well for agricultural purposes or for a potable water supply. If a water well has total dissolved solids exceeding 4,000 mg/L, the groundwater use does not require licensing by AENV. In the County, the depth to the Base of Groundwater Protection ranges from less than 125 metres at Eagle Lake southeast of Strathmore in the western part of the County, and in the Red Deer River Valley in the northeastern part of the County, to more than 500 metres below ground surface in the northeastern part of the County, as shown on Figure 4 and on some cross-sections presented in Appendix A and on the CD-ROM.

There are 3,918 water wells with completed depth data, of which none are completed below the Base of Groundwater Protection. In the County, the Base of Groundwater Protection is below the Upper Scollard Formation (see Figures A-11 to A-15).

Proper management of the groundwater resource requires water-level data. These data are often collected from observation water wells. At the present time, there are three AENV-operated observation water wells within the County. Additional data can be obtained from some of the licensed groundwater diversions. In the past, the data for licensed diversions have been difficult to obtain from AENV, in part because of the failure of the licensee to provide the data.

Even with the available sources of data, the number of water-level data points relative to the size of the County is too few to provide a reliable groundwater budget (see section 6.0 of this report). The most cost-efficient method to collect additional groundwater monitoring data would be to have the water well owners measuring the water level in their own water well on a regular basis, as has been the case in the Wildrose Country Ground Water Monitoring Association and Flagstaff County.

8 See glossary

3. Terms

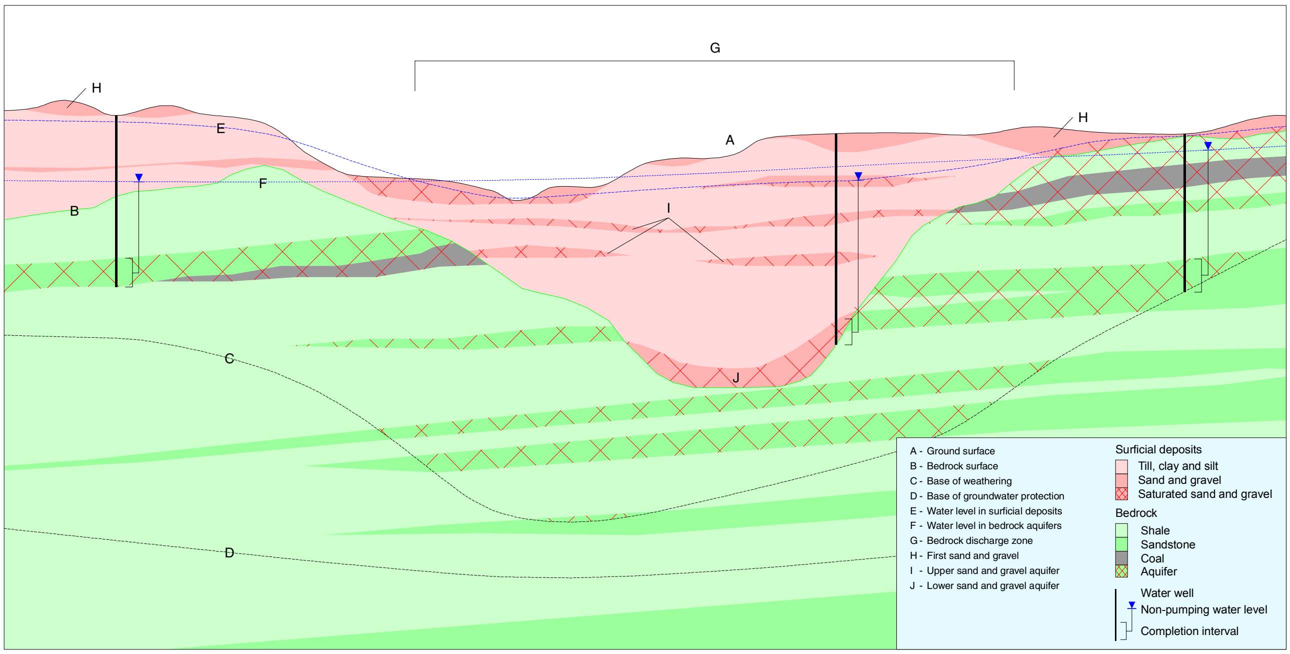

Figure 5. Generalized Cross-Section (for terminology only)

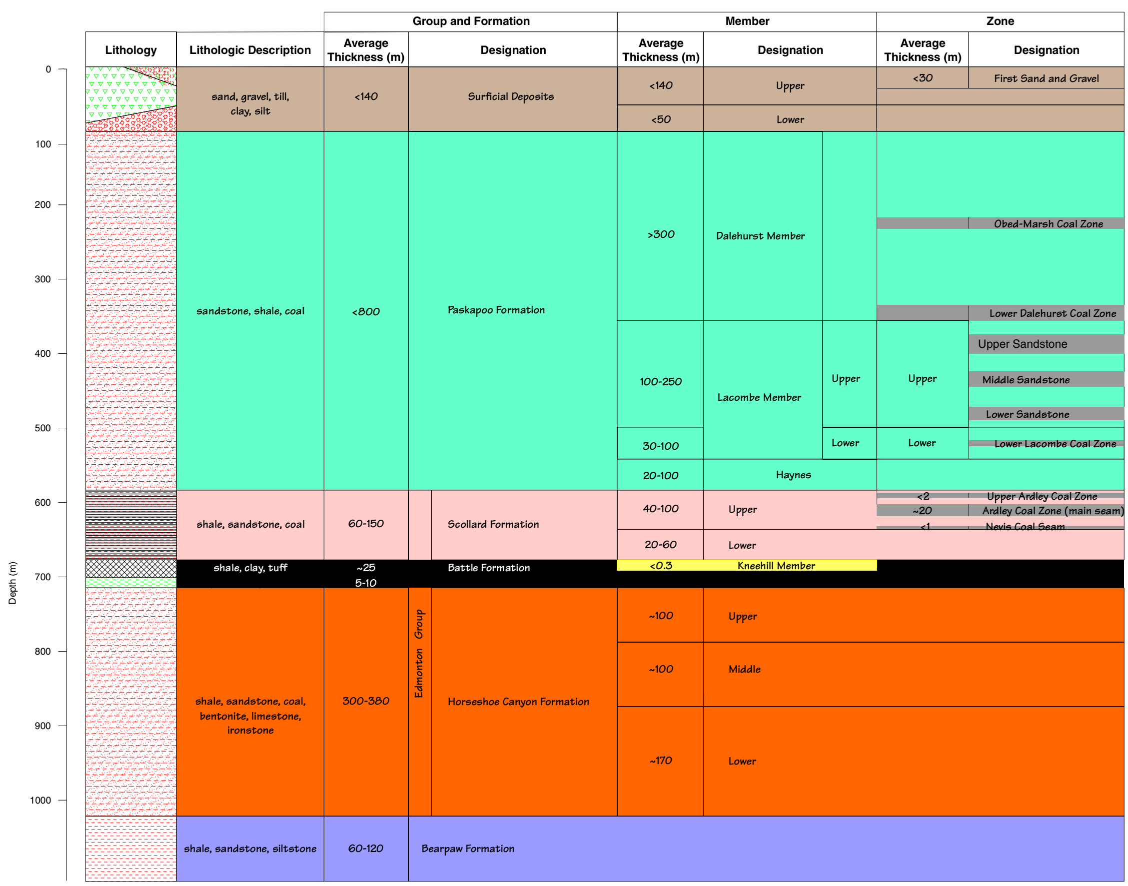

Figure 6. Geologic Column

4. Methodology

4.1 Data Collection and Synthesis

The AENV groundwater database is the main source of groundwater data. The database includes the following:

1) water well drilling reports
2) aquifer test results from some water wells
3) location of some springs
4) locations for some water wells determined during water well surveys
5) chemical analyses for some groundwaters[9]
6) location of some flowing shot holes
7) location of some structure test holes
8) a variety of data related to the groundwater resource.

The main disadvantage to the database is the reliability of the information entered into the database. Very little can be done to overcome this lack of quality control in the data collection, other than to assess the usefulness of control points relative to other data during the interpretation. Another disadvantage to the database is the lack of adequate spatial information. Any duplicate water wells that have been identified within the County have been removed from the database used in this regional groundwater assessment.

The AENV groundwater database uses an area-land-based system with only a limited number of records having a value for ground elevation. The locations for records usually include a quarter section description; a few records also have a land description that includes a Legal Subdivision (Lsd). For digital processing, a record location requires a horizontal coordinate system. In the absence of an actual location for a record, the record is given the coordinates for the centre of the land description.

The present project uses the 10TM coordinate system based on the NAD27 datum. This means that a record for the SE ¼ of section 10, township 025, range 24, W4M, would have a horizontal coordinate with an Easting of 121,342 metres and a Northing of 5,661,466 metres, the centre of the quarter section. If the water well has been repositioned by AAFC-PFRA using orthorectified aerial photos, the location will be more accurate, possibly within several tens of metres of the actual location. Once the horizontal coordinates are determined for a record, a ground elevation for that record is obtained from the 1:20,000 Digital Elevation Model (DEM); AltaLIS Ltd. provides the DEM.

At many locations within the County, more than one water well is completed at one legal location. Digitally processing this information is difficult. To obtain a better understanding of the completed depths of water wells, a digital surface was prepared representing the minimum depth for water wells and a second digital surface was prepared for the maximum depth. Both of these surfaces are used in the groundwater query on the CD-ROM. When the maximum and minimum water well depths are similar, there is only one aquifer that is being used at a given location.

After assigning spatial control for the ground location for the records in the groundwater database, the data are processed to determine values for hydrogeological parameters**.** As part of the processing, obvious keying errors in the database are corrected.

[9] Since 1986, Alberta Health and Wellness has restricted access to chemical analysis data, and hence the database includes only limited amounts of chemical data since 1986.

Where possible, determinations are made from individual records in order to assign water wells to aquifers and to obtain values for the following:

1) depth to bedrock
2) total thickness of sand and gravel below 15 metres
3) total thickness of saturated sand and gravel
4) depth to the top and bottom of completion intervals[10].

Also, where sufficient information is available, values for apparent transmissivity[11] and apparent yield[12] are calculated, based on the aquifer test summary data supplied on the water well drilling reports. Where valid detailed aquifer test results exist, the interpreted data provide values for aquifer transmissivity and effective transmissivity. Since the last regional hydrogeological map covering at least a part of the County was published in 1974 (Ozoray and Lytviak, 1974), 1,535 values for apparent transmissivity and apparent yield have been added to the groundwater database. With the addition of the apparent yield values, including a 0.1-m³/day value assigned to "dry" water wells and water test holes, a hydrogeological map has been prepared to help illustrate the general groundwater availability across the County (Figure 7). The map is based on groundwater being obtained from all aquifers and has been prepared to allow direct comparison with the results provided on the Alberta Research Council hydrogeological maps.

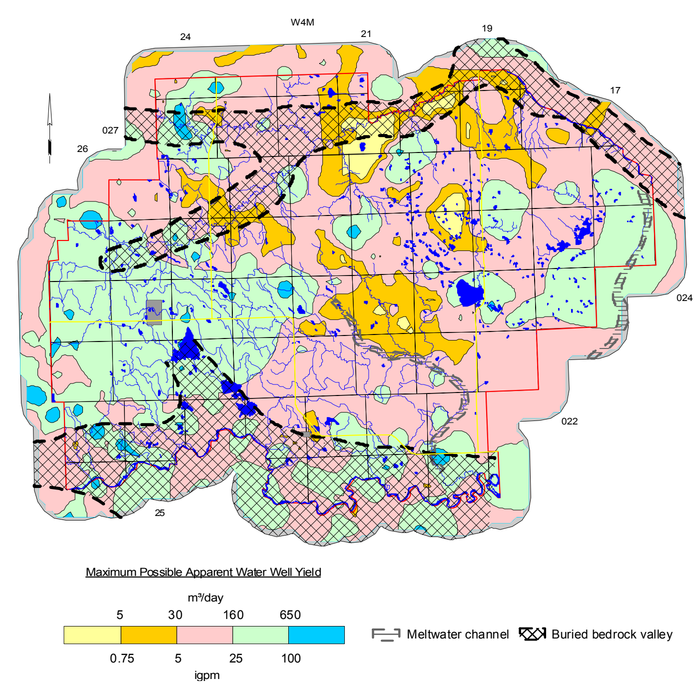

Figure 7. Hydrogeological Map

The EUB well database includes records for all of the wells drilled by the oil and gas industry. The information from this source includes:

1) spatial control for each well site
2) depth to the top of various geologic units
3) type and intervals for various down-hole geophysical logs
4) drill stem test (DST) summaries.

Values for apparent transmissivity and apparent yield are calculated from the DST summaries.

Published and unpublished reports and maps provide the final source of information to be included in the new groundwater database. The reference section of this report lists the available reports. The only digital data from publications are from the Geological Atlas of the Western Canada Sedimentary Basin (Mossop and Shetsen, 1994). These data are used to support the geological interpretation of geophysical logs but cannot be distributed because of a licensing agreement.

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10 See glossary
11 For definitions of Transmissivity, see glossary
12 For definitions of Yield, see glossary

4.2 Spatial Distribution of Aquifers

Determination of the spatial distribution of the aquifers is based on:

1) lithologs provided by the water well drillers
2) geophysical logs from structure test holes
3) geophysical logs for wells drilled by the oil and gas industry
4) data from existing cross-sections.

The aquifers are defined by mapping the tops and bottoms of individual geologic units. The values for the elevation of the top and bottom of individual geologic units at specific locations help to determine the spatial distribution of the individual surfaces. Establishment of a surface distribution digitally requires preparation of a grid. The inconsistent quality of the data necessitates creating a representative sample set obtained from the entire data set. If the data set is large enough, it can be treated as a normal population and the removal of extreme values can be done statistically. When data sets are small, the process of data reduction involves a more direct assessment of the quality of individual points. Because of the uneven distribution of the data, all data sets are gridded using the Kriging method.

The final definition of the individual surfaces becomes an iterative process involving the plotting of the surfaces on cross-sections and the adjusting of control points to fit with the surrounding data.

4.3 Hydrogeological Parameters

Water well records that indicate the depths to the top and bottom of their completion interval are compared digitally to the spatial distribution of the various geological surfaces. This procedure allows for the determination of the aquifer in which individual water wells are completed. When the completion interval of a water well cannot be established unequivocally, the data from that water well are not used in determining the distribution of hydraulic parameters.

After the water wells are assigned to a specific aquifer, the parameters from the water well records are assigned to the individual aquifers. The parameters include non-pumping (static) water level (NPWL), apparent transmissivity, and apparent water well yield. The NPWL given on the water well record is usually the water level recorded when the water well was drilled, measured prior to the initial aquifer test. In areas where groundwater levels have since fallen, the NPWL may now be lower and accordingly, potential apparent yield would be reduced. The total dissolved solids, sulfate and chloride concentrations from the chemical analysis of the groundwater are also assigned to applicable aquifers. In addition, chemical parameters of nitrate + nitrite (as N) are assigned to surficial aquifers and fluoride is assigned to upper bedrock aquifer(s).

Once the values for the various parameters of the individual aquifers are established, the spatial distribution of these parameters must be determined. The distribution of individual parameters involves the same process as the distribution of geological surfaces. This means establishing a representative data set and then preparing a grid. The representative data set included using the available data from townships 021 to 028, ranges 17 to 26, W4M, plus a buffer area of at least 5,000 metres. Even when only limited data are available, grids are prepared. However, the grids prepared from the limited data must be used with extreme caution because the gridding process can be unreliable; for the maps, the areas with little or no data are identified.