Mountain View County
Part of the Red Deer River Basin
Parts of Tp 029 to 034, R 26 to 29, W4M and R 01 to 07, W5M
Regional Groundwater Assessment

Prepared for

In conjunction with

Agriculture and Agri-Food Canada
Prairie Farm Rehabilitation Administration

Agriculture et Agroalimentaire Canada
Administration du rétablissement agricole des Prairies

Prepared by
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HYDROGEOLOGICAL CONSULTANTS LTD.

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Date ______________________________

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The Association of Professional Engineers, Geologists and Geophysicists of Alberta

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**Glossary**

Aquifer - a formation, group of formations, or part of a formation that contains saturated permeable rocks capable of transmitting groundwater to water wells or springs in economical quantities.

Aquitard - a confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer.

Available Drawdown - in a confined aquifer, the distance between the non-pumping water level and the top of the aquifer. In an unconfined aquifer (water table aquifer), two thirds of the saturated thickness of the aquifer.

Borehole - includes all “work types” except springs.

Dewatering - the removal of groundwater from an aquifer for purposes other than use.

Evapotranspiration - a combination of evaporation from open bodies of water, evaporation from soil surfaces, and transpiration from the soil by plants (Freeze and Cherry, 1979).

Fluvial - produced by the action of a stream or river.

Friable - poorly cemented.

Hydraulic Conductivity - the rate of flow of water through a unit cross-section under a unit hydraulic gradient; units are length/time.

km - kilometre.


Lacustrine - fine-grained sedimentary deposits associated with a lake environment and not including shore-line deposits.

Lithology - description of rock material.

Lsd - Legal Subdivision.

m - metres.

mm - millimetres.

m²/day - metres squared per day.

m³ - cubic metres.

m³/day - cubic metres per day.

mg/L - milligrams per litre.

Obs WW - Observation Water Well.
Piper tri-linear diagram is a method that permits the major cation and anion compositions of single or multiple samples to be represented on a single graph. This presentation allows groupings or trends in the data to be identified. From the Piper tri-linear diagram, it can be seen that the groundwater from this sample water well is a sodium-bicarbonate-type. The chemical type has been determined by graphically calculating the dominant cation and anion. For a more detailed explanation, please refer to Freeze and Cherry, 1979.

Rock earth material below the root zone

Surficial Deposits includes all sediments above the bedrock

Thalweg the line connecting the lowest points along a stream bed or valley; longitudinal profile

Till a sediment deposited directly by a glacier that is unsorted and consisting of any grain size ranging from clay to boulders

Transmissivity the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient: a measure of the ease with which groundwater can move through the aquifer

Apparent Transmissivity: the value determined from a summary of aquifer test data, usually involving only two water-level readings

Effective Transmissivity: the value determined from late pumping and/or late recovery water-level data from an aquifer test

Aquifer Transmissivity: the value determined by multiplying the hydraulic conductivity of an aquifer by the thickness of the aquifer

Water Well a hole in the ground for the purpose of obtaining groundwater; “work type” includes test hole, chemistry, deepened, well inventory, federal well survey, reconditioned, reconstructed, new, old well-test

Yield a regional analysis term referring to the rate a properly completed water well could be pumped, if fully penetrating the aquifer

Apparent Yield: based mainly on apparent transmissivity

Long-Term Yield: based on effective transmissivity

AENV Alberta Environment

AMSL above mean sea level

DEM Digital Elevation Model

DST drill stem test
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUB</td>
<td>Alberta Energy and Utilities Board</td>
</tr>
<tr>
<td>GCDWQ</td>
<td>Guidelines for Canadian Drinking Water Quality</td>
</tr>
<tr>
<td>NPWL</td>
<td>non-pumping water level</td>
</tr>
<tr>
<td>PFRA</td>
<td>Prairie Farm Rehabilitation Administration</td>
</tr>
<tr>
<td>TDS</td>
<td>Total Dissolved Solids</td>
</tr>
<tr>
<td>WSW</td>
<td>Water Source Well or Water Supply Well</td>
</tr>
</tbody>
</table>
I. PROJECT OVERVIEW

“Water is the lifeblood of the earth.” - Anonymous

How a County takes care of one of its most precious resources – groundwater - reflects the future wealth and health of its people. Good environmental practices are not an accident. They must include genuine foresight with knowledgeable planning. Implementation of strong practices not only commits to a better quality of life for future generations, but also creates a solid base for increased economic activity. **Though this report’s scope is regional, it is a first step for Mountain View County in managing their groundwater. It is also a guide for future groundwater-related projects.**

A. Purpose

This project is a regional groundwater assessment of Mountain View County prepared by Hydrogeological Consultants Ltd. (HCL) with financial assistance from Prairie Farm Rehabilitation Administration (PFRA). The regional groundwater assessment provides the information to assist in the management of the groundwater resource within the County. Groundwater resource management involves determining the suitability of various areas in the County for particular activities. These activities can vary from the development of groundwater for agricultural or industrial purposes, to the siting of waste storage. **Proper management ensures protection and utilization of the groundwater resource for the maximum benefit of the people of the County.**

The regional groundwater assessment will:

- identify the aquifers\(^1\) within the surficial deposits\(^2\) and the upper bedrock
- spatially identify the main aquifers
- describe the quantity and quality of the groundwater associated with each aquifer
- identify the hydraulic relationship between aquifers
- identify possible groundwater depletion areas associated with each upper bedrock aquifer.

Under the present program, the groundwater-related data for the County have been assembled. Where practical, the data have been digitized. These data are then being used in the regional groundwater assessment for Mountain View County.

\(^1\) See glossary
\(^2\) See glossary
B. The Project

This regional study should only be used as a guide. Detailed local studies are required to verify hydrogeological conditions at given locations.

The present project is made up of eight parts as follows:

- Task 1 - Data Collection and Review
- Task 2 - Hydrogeological Maps, Figures, Digital Data Files
- Task 3 – Hydrogeological Evaluation and Preparation of Report
- Task 4 - Groundwater Information Query Software
- Task 5 – Review of Draft Report and GIS Data Files
- Task 6 – Report Presentation and Training Session
- Task 7 – Provision of Report, Maps, Data Layers and Query
- Task 8 – Provision of Compact Disk for Sale to General Public.

This report and the accompanying maps represent Tasks 2 and 3.

C. About This Report

This report provides an overview of (a) the groundwater resources of Mountain View County, (b) the processes used for the present project, and (c) the groundwater characteristics in the County.

Additional technical details are available from files on the CD-ROM to be provided with the final version of this report. The files include the geo-referenced electronic groundwater database, maps showing distribution of various hydrogeological parameters, the groundwater query, and ArcView files. Likewise, all of the illustrations and maps from the present report, plus additional maps, figures and cross-sections, are available on the CD-ROM. For convenience, poster-size maps and cross-sections have been prepared as a visual summary of the results presented in this report. Copies of these poster-size drawings have been forwarded with this report, and are included as page-size drawings in Appendix D.

Appendix A features page-size copies of the figures within the report plus additional maps and cross-sections. An index of the page-size maps and figures is given at the beginning of Appendix A.

Appendix B provides a complete list of maps and figures included on the CD-ROM.

Appendix C includes the following:

1) a procedure for conducting aquifer tests with water wells\(^3\)
2) a table of contents for the Water (Ministerial) Regulation under the new Water Act
3) a flow chart showing the licensing of a groundwater diversion under the new Water Act
4) interpretation of chemical analysis of drinking water
5) additional information.

The Water (Ministerial) Regulation deals with the wellhead completion requirement (no more water-well pits), the proper procedure for abandoning unused water wells and the correct procedure for installing a pump in a water well. The new Water Act was proclaimed 10 Jan 1999.

Appendix D includes page-size copies of the poster-size figures provided with this report.

Appendix E provides a list of water wells recommended for field verification.

\(^3\) See glossary
II. INTRODUCTION

A. Setting

Mountain View County is situated in south-central Alberta. Most of this area is part of the Alberta Plains region, with the western part of the County being part of the Foothills Belt. The County is within the Red Deer River basin; a small part of the County’s northern boundary is the James River. The other County boundaries follow township or section lines. The area includes parts of the area bounded by township 029, range 06, W5M in the southwest and township 034, range 27, W4M in the northeast.

Regionally, the topographic surface varies between 900 and 1,350 metres above mean sea level (AMSL). The lowest elevations occur mainly in the eastern part of the County in townships 030 and 31, range 27, W4M and the highest are in the western parts of the County as shown on Figure 1 and page A-2. The area is well drained by numerous streams.

B. Climate

Mountain View County lies within the Dfb climate boundary. This classification is based on potential evapotranspiration\(^4\) values determined using the Thornthwaite method (Thornthwaite and Mather, 1957), combined with the distribution of natural ecoregions in the area. The ecoregions map (Strong and Leggatt, 1981) shows that the County is located in both Low and Mid Boreal Mixedwood regions and the Aspen Parkland region. Increased precipitation and cooler temperatures, resulting in additional moisture availability, influence this vegetation change.

A Dfb climate consists of long, cool summers and severe winters. The mean monthly temperature drops below -3\(^\circ\) C in the coolest month, and exceeds 10\(^\circ\) C in the warmest month.

The mean annual precipitation averaged from three meteorological stations within the County measured 483 millimetres (mm), based on data from 1962 to 1993. The mean annual temperature averaged 3.1\(^\circ\) C, with the mean monthly temperature reaching a high of 15.0\(^\circ\) C in July, and dropping to a low of -9.8\(^\circ\) C in January. The calculated annual potential evapotranspiration is 495 millimetres.

\(^4\) See glossary
C. Background Information

1) Number, Type and Depth of Water Wells

There are currently records for 7,827 water wells in the groundwater database for the County. Of the 7,827 water wells, 6,908 are for domestic/stock purposes. The remaining 919 water wells were completed for a variety of uses, including industrial, municipal, observation, injection, irrigation, investigation and dewatering. Based on a rural population of 11,277 (Phinney, 1999), there are 2.7 domestic/stock water wells per family of four. It is unknown how many of these water wells may still be active. The domestic or stock water wells vary in depth from 0.60 metres to 177 metres below ground level. Details for lithology are available for 4,882 water wells.

2) Number of Water Wells in Surficial and Bedrock Aquifers

There are 4,114 water well records with sufficient information to identify the aquifer in which the water wells are completed. The water wells that were not drilled deep enough to encounter the bedrock plus water wells that have the bottom of their completion interval above the top of the bedrock are water wells completed in surficial aquifers. Of the 4,114 water wells for which aquifers could be defined, 431 are completed in surficial aquifers, with 80% having a completion depth of less than 30 metres. The adjacent map shows that the water wells completed in the surficial deposits occur mainly in the vicinity of the Town of Sundre in the northwestern part of the County.

The 3,683 water wells that have the top of their completion interval deeper than the top of the bedrock are referred to as bedrock water wells. From Figure 2, it can be seen that water wells completed in bedrock aquifers occur throughout the County.

There are currently records for 63 springs in the groundwater database, located mainly in the vicinity of the Red Deer River and the Little Red Deer River valleys. Two-thirds of the 27 available chemical values for springs have total dissolved solids (TDS) concentrations of less than 500 milligram per litre (mg/L).

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5 See glossary
3) Casing Diameter and Type

Data for casing diameters are available for 4,777 water wells, with 4,768 (99%) indicated as having a diameter of less than 275 mm and nine having a diameter of more than 275 mm. The casing diameters of greater than 275 mm are mainly bored or dug water wells and those with a surface-casing diameter of less than 275 mm are drilled water wells. There are only nine large-diameter or bored water wells in the County and they are mainly in the areas where major meltwater channels are present in association with major river valleys as shown on Figure 2.

In the County, steel, galvanized steel and plastic represent 99% of the materials that have been used for surface casing in drilled water wells over the last 40 years. Until the 1960s, the type of surface casing used in drilled water wells was mainly undocumented. Steel casing was in use in the 1950s and is still used in 98% of the water wells being drilled in the County in the 1990s. Steel is the main casing type used since surface casing type has been documented.

Galvanized steel and plastic surface casing have been used in less than 2% of the new water wells; galvanized steel was last used in September 1983.

4) Requirements for Licensing

Water wells used for household needs in excess of 1,250 cubic metres per year and providing groundwater with TDS of less than 4,000 mg/L must be licensed. At the end of 1999, 288 groundwater allocations were licensed in the County. Of the 288 licensed groundwater users, 193 could be linked to the AENV groundwater database. Of the 288 licensed groundwater users, 249 are for agricultural purposes, and the remaining 39 are for municipal, industrial, commercial, recreation, exploration and dewatering purposes. The total maximum authorized diversion from the water wells associated with these licences is 6,519 cubic metres per day (m$^3$/day), although actual use could be less. Of the 6,519 m$^3$/day, 51% is allotted for agricultural use, and 40% is allotted for municipal use. The remaining 9% has been licensed for industrial, commercial, recreation and dewatering use as shown in Table 2 on the following page; a figure showing the locations of the licensed users can be found in Appendix A (page A-4) and on the CD-ROM.

The largest potable groundwater allocation within the County is for the Town of Sundre, having a diversion of 1,352 m$^3$/day. The water supply well, used for municipal purposes, is completed in the Sand and Gravel Aquifer.
The following table shows a breakdown of the 288 licensed groundwater allocations by the aquifer in which the water well is completed. The largest total licensed allocations are in the Dalehurst and Lacombe aquifers; the majority of the groundwater is used for agricultural and municipal purposes.

<table>
<thead>
<tr>
<th>Aquifer **</th>
<th>No. of Diversions</th>
<th>Licensed Groundwater Users* (m³/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agricultural</td>
<td>Commercial</td>
</tr>
<tr>
<td>Sand and Gravel</td>
<td>13</td>
<td>116</td>
</tr>
<tr>
<td>Disturbed Aquifer</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Dalehurst</td>
<td>137</td>
<td>1,207</td>
</tr>
<tr>
<td>Lacombe</td>
<td>99</td>
<td>1,744</td>
</tr>
<tr>
<td>Bedrock</td>
<td>7</td>
<td>66</td>
</tr>
<tr>
<td>Unknown</td>
<td>30</td>
<td>207</td>
</tr>
<tr>
<td>Total</td>
<td>288</td>
<td>3,350</td>
</tr>
</tbody>
</table>

* - data from AENV  ** - identification of Aquifer by HCL

Table 2. Licensed Groundwater Diversions

Based on the 1996 Agriculture Census, the calculated water requirement for livestock for the County is in the order of 22,095 m³/day. Of the 22,095 m³/day average calculated livestock use, AENV has licensed a groundwater diversion of 3,350 m³/day (15%) and a licensed surface-water diversion of 1,227 m³/day (6%). The remaining 79% of the calculated livestock use would have to be mainly from unlicensed sources.

5) **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 and nitrite (as N) were not evident in the available chemical data for the surficial or upper bedrock aquifer(s); a plot of nitrate and 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 are generally less than 1,500 mg/L. Groundwaters from the bedrock aquifers frequently are chemically soft with generally low concentrations of dissolved iron. The chemically soft groundwater is high in sodium concentration. More than 15% of the chemical analyses indicate a fluoride concentration above 1.5 mg/L, with most the exceedances occurring in the eastern part of the County (see CD-ROM).

The minimum, maximum and average 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 Guidelines for Canadian Drinking Water Quality (GCDWQ) in Table 3. Of the five constituents compared to the GCDWQ, average values of TDS and sodium concentrations exceed the guidelines.

Table 3. Concentrations of Constituents in Groundwaters from Upper Bedrock Aquifer(s)
Alberta Environment (AENV) defines the Base of Groundwater Protection as the elevation below which the groundwater is expected to have more than 4,000 mg/L of total dissolved solids. By using the ground elevation, and the elevation of the Base of Groundwater Protection provided by the Alberta Energy and Utilities Board (EUB), a depth to the Base of Groundwater Protection can be determined. These values are gridded using the Kriging 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 Base of Groundwater Protection ranges from less than 300 metres to more than 1,100 metres below ground level, as shown on Figure 3.

Of the 4,114 water wells with completed depth data, none are completed below the Base of Groundwater Protection and of the 2,418 values for TDS available, only two exceed 4,000 mg/L. 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 two 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.

However, 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.

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* See glossary
III. TERMS

Figure 4. Generalized Cross-Section (for terminology only)

Figure 5. Geologic Column
IV. METHODOLOGY

A. 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) water well locations determined during water well surveys
5) chemical analyses for some groundwaters
6) location of flowing shot holes
7) location of structure test holes
8) a variety of data related to the groundwater resource.

The main disadvantage to the database is the absence of quality control. 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. The present database for the County contains a possible 200 duplicate water well IDs.

The AENV groundwater database uses a 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. This means that a record for the SE ¼ of section 04, township 033, range 05, W5M, would have a horizontal coordinate with an Easting of 24,512 metres and a Northing of 5,736,178 metres, the centre of the quarter section. If the water well has been repositioned by 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); the Resource Data Division of AENV 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.
Where possible, determinations are made from individual records for the following:

1) depth to bedrock  
2) total thickness of sand and gravel  
3) thickness of first sand and gravel when present within one metre of ground surface  
4) total thickness of saturated sand and gravel  
5) depth to the top and bottom of completion intervals.

Also, where sufficient information is available, values for apparent transmissivity and apparent yield 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 hydrogeology map was published in 1978 (Ozoray and Barnes, 1978), 980 values for apparent transmissivity and 783 values for apparent yield have been added to the groundwater database. With the addition of the apparent yield values, a hydrogeological map has been prepared to help illustrate the general groundwater availability across the County.

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, apparent yield and hydraulic conductivity 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.
B. 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) 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.

C. 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 if neither aquifer nor effective volumes are available, and apparent water well yield. 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). 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.

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. Even when only limited data are available, grids are prepared. However, the data from these grids must be used with extreme caution because the gridding process can be unreliable.
D. Maps and Cross-Sections

Once grids for geological surfaces have been prepared, various grids need to be combined to establish the extent and thickness of individual geologic units. For example, the relationship between an upper bedrock unit and the bedrock surface must be determined. This process provides both the outline and the thickness of the geologic unit.

Once the appropriate grids are available, the maps are prepared by contouring the grids. The areal extent of individual parameters is outlined by “masks” to delineate individual aquifers. Appendix A includes page-size maps from the text, plus additional page-size maps and figures that support the discussion in the text. A list of maps and figures that are included on the CD-ROM is given in Appendix B.

Cross-sections are prepared by first choosing control points from the database along preferred lines of section. Data from these control points are then obtained from the database and placed in an AutoCAD drawing with an appropriate vertical exaggeration. The data placed in the AutoCAD drawing include the geo-referenced lithology, completion intervals and NPWLs. Data from individual geologic units are then transferred to the cross-section from the digitally prepared surfaces.

Once the technical details of a cross-section are correct, the drawing file is moved to the software package CorelDRAW! for simplification and presentation in a hard-copy form. These cross-sections are presented in this report and as poster-size drawings forwarded with this report. The cross-sections also are in Appendix A, and are included on the CD-ROM; page-size maps of the poster-size cross-sections are included in Appendix D of this report.

E. Software

The files on the CD-ROM have been generated from the following software:

- Acrobat 4.0
- ArcView 3.1
- AutoCAD 14.01
- CorelDRAW! 8.0
- Microsoft Professional Office 2000
- Surfer 6.04
V. AQUIFERS

A. Background

An aquifer is a porous and permeable rock that is saturated. If the NPWL is above the top of the rock unit, this type of aquifer is an artesian aquifer. If the rock unit is not entirely saturated and the water level is below the top of the unit, this type of aquifer is a water-table aquifer. These types of aquifers occur in one of two general geological settings in the County. The first geological setting includes the sediments that overlie the bedrock surface. In this report, these are referred to as the surficial deposits. The second geological setting includes aquifers in the upper bedrock. The geological settings, the nature of the deposits making up the aquifers within each setting, the expected yield of water wells completed in aquifer(s) within different geologic units, and the general chemical quality of the groundwater associated with each setting are reviewed separately.

1) Surficial Aquifers

Surficial deposits in the County are mainly less than 30 metres thick, except in areas of linear bedrock lows where the thickness of the surficial deposits can exceed 30 metres. There are no significant buried linear bedrock lows in the County; the linear bedrock lows are present in the form of meltwater channels. These meltwater channels are mainly located in the eastern third of the County and extend northwest to southeast. Cross-section A-A' passes through the towns of Sundre and Olds, and across parts of three meltwater channels, and shows a maximum thickness of surficial deposits of slightly less than 50 metres.

The main aquifers in the surficial materials are sand and gravel deposits. In order for a sand and gravel deposit to be an aquifer, it must be saturated; if not saturated, a sand and gravel deposit is not an aquifer. The top of the surficial aquifers has been determined from the NPWL in water wells that are less than 15 metres deep. The base of the surficial deposits is the bedrock surface.

For a water well with a small-diameter casing to be effective in surficial deposits and to provide sand-free groundwater, the water well must be completed with a water well screen. Some water wells completed in the surficial deposits are completed in low-permeability aquifers and have a large-diameter casing. The large-diameter water wells may have been hand dug or bored and because they are completed in very low permeability aquifers, most of these water wells would not benefit from water well screens. The groundwater from an aquifer in the surficial deposits usually has a chemical hardness of at least a few hundred mg/L and a dissolved iron concentration such that the groundwater must be treated before being used for domestic needs.
Within the County, casing-diameter information is available for 415 of the 431 water wells completed in the surficial deposits; two percent of these have a casing diameter of more than 275 millimetres, and are assumed to be bored or dug water wells.

2) Bedrock Aquifers

The upper bedrock includes the Disturbed Belt, and the Dalehurst and Lacombe members of the Paskapoo Formation. The Haynes Member and the upper part of the Scollard Formation underlie the Lacombe Member. The upper bedrock includes rocks that are less than 200 metres below the bedrock surface and above the Haynes Member. Some of this bedrock contains saturated rocks that are permeable enough to transmit groundwater for a specific need. Water wells completed in bedrock aquifers usually do not require water well screens, although some of the sandstones may be friable\(^9\) and water well screens are a necessity. The groundwater from the bedrock aquifers is usually chemically soft.

The data for 3,683 water wells show that the top of the water well completion interval is below the bedrock surface, indicating that the water wells are completed in at least one bedrock aquifer. Within the County, casing-diameter information is available for 3,584 of the 3,683 water wells completed below the top of bedrock. Of these 3,584 water wells, 99% have surface-casing diameters of less than 275 mm and these bedrock water wells have been mainly completed with either a perforated liner or as open hole; there are 39 bedrock water wells completed with a water well screen.

\(^9\) See glossary
B. Aquifers in Surficial Deposits

The surficial deposits are the sediments above the bedrock surface. This includes pre-glacial materials, which were deposited before glaciation, and materials deposited directly or indirectly as a result of glaciation. The *lower surficial deposits* include pre-glacial fluvial and lacustrine deposits. The lacustrine deposits include clay, silt and fine-grained sand. The *upper surficial deposits* include the more traditional glacial deposits of till and meltwater deposits. In the County, no lower surficial deposits have been defined to date and the upper surficial deposits include mainly till.

1) Geological Characteristics of Surficial Deposits

While the surficial deposits are treated as one hydrogeological unit, they are not usually one continuous unit. Sand or gravel deposits in the upper surficial deposits typically occur as pockets, except in linear bedrock lows where a sand or gravel deposit may be several hundred metres wide and continuous over a distance of several tens of kilometres. The sand and gravel deposits associated with linear bedrock lows are usually saturated, where present. The sand and gravel deposits that occur higher in the stratigraphic section, and tend to occur as pockets, may or may not be saturated. For a graphical depiction of the above description, please refer to Figure 4, Page 8. While the unsaturated deposits are not technically an aquifer, they are significant as they provide a pathway for liquid contaminants to move downward into the groundwater.

The base of the surficial deposits is the bedrock surface, represented by the bedrock topography as shown on the adjacent map. Over the majority of the County, the surficial deposits are less than 30 metres thick (page A-14). The exceptions are mainly in association with areas where major meltwater channels are present, where the deposits can have a maximum thickness of close to 50 metres.

There are no defined buried bedrock valleys in the County, but the major meltwater channels in the County have been outlined as per Shetsen (1987). These lows trend mainly northwest to southeast in the County and mainly occur along creek and river valleys.

Sand and gravel deposits can occur throughout the surficial deposits. The total thickness of sand and gravel deposits is generally less than two metres but can be more than five metres in the areas of major meltwater channels.
The combined thickness of all sand and gravel deposits has been determined as a function of the total thickness of the surficial deposits. Over approximately 25% of the County, the sand and gravel deposits, where present, are more than 30% of the total thickness of the surficial deposits (page A-16). The areas where sand and gravel deposits constitute more than 30% of the total thickness of the surficial deposits are mainly in the western part of the County and in the areas of the major meltwater channels in the eastern part of the County.

One source of groundwater in the County includes aquifers in the surficial deposits. Since the sand and gravel aquifer(s) are not everywhere, the actual aquifer that is developed at a given location is usually dictated by the aquifer that is present.

From the present hydrogeological analysis, 424 water wells are completed in aquifers in the surficial deposits. This number of 424 water wells is slightly less than the number (431), based on lithologies given on the water well drilling reports. This situation is unlike other areas in the Province. The main reasons for the difference are (1) there are very few water wells completed in surficial deposits; and (2) the lithologies have been re-interpreted on some drilling reports based on the data from other bedrock control.

Water wells completed in the surficial deposits are sporadic throughout the project area, but are mainly concentrated in the vicinity of the Town of Sundre as shown on the figures completed for the surficial deposits (see Appendix A and the CD-ROM).
a) Chemical Quality of Groundwater from Surficial Deposits

The chemical analysis results of groundwaters from the sand and gravel aquifers in the surficial deposits indicate the groundwaters are generally chemically hard and high in dissolved iron. In Mountain View County, groundwaters from the surficial aquifers mainly have a chemical hardness of less than 400 mg/L.

The Piper tri-linear diagrams (see Appendix A) show the groundwaters from the surficial deposits are mainly calcium-magnesium-bicarbonate or sodium-bicarbonate-type waters. The records with the sodium-bicarbonate waters were individually checked in the database to confirm the completion aquifer. Sixty percent of the groundwaters have a TDS concentration of less than 500 mg/L. The groundwaters with a TDS concentration of less than 500 mg/L occur mainly near the Town of Sundre, where there are the greatest number of control points, as shown on Figure 10. The large expanse showing TDS concentrations ranging between 500 and 1,500 mg/L is a result of gridding a limited amount of data available for that area. Seventy-two percent of the groundwaters from the surficial deposits have dissolved iron concentrations of less than 1 mg/L.

Although the majority of the groundwaters are bicarbonate-type waters, there are groundwaters from the surficial deposits 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 most of the County, the chloride ion concentration is mainly less than 50 mg/L.

In the County, the nitrate + nitrite (as N) concentrations in the groundwaters from the surficial deposits do not exceed the maximum acceptable concentrations (MAC) of 10 mg/L (see CD-ROM).

The minimum, maximum and average 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 Guidelines for Canadian Drinking Water Quality (GCDWQ) in the adjacent table. Of the five constituents that have been compared to the GCDWQ, only the average values of TDS concentrations exceed the guidelines.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Range for County in mg/L</th>
<th>Recommended Maximum Concentration GCDWQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Dissolved Solids</td>
<td>204 1671 650</td>
<td>500</td>
</tr>
<tr>
<td>Sodium</td>
<td>1 476 102</td>
<td>200</td>
</tr>
<tr>
<td>Sulfate</td>
<td>6 643 163</td>
<td>500</td>
</tr>
<tr>
<td>Chloride</td>
<td>&lt;1 87 10</td>
<td>250</td>
</tr>
<tr>
<td>Nitrate + Nitrite (as N)</td>
<td>&lt;0.05 5.7 0.5</td>
<td>10</td>
</tr>
</tbody>
</table>

Concentration in milligrams per litre unless otherwise stated

Note: indicated concentrations are for Aesthetic Objectives

GCDWQ - Guidelines for Canadian Drinking Water Quality, Sixth Edition
Minister of Supply and Services Canada, 1996

Table 4. Concentrations of Constituents in Groundwaters from Surficial Aquifers
2) Sand and Gravel Aquifer(s)

   a) Aquifer Thickness

These aquifers can directly overlie or be close to the bedrock surface. Saturated sand and gravel deposits are not continuous but are expected over approximately 20% of the County. The thickness of the 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. Since the non-pumping water-level surface in the surficial deposits tends to be a subdued replica of the bedrock surface, the thickness of the Sand and Gravel Aquifer tends to be directly proportional to the thickness of the surficial deposits. In the County, the thickness of the sand and gravel aquifer(s) is generally less than two metres, but can be more than five metres in areas of major meltwater channels (page A-17).

   b) Apparent Yield

The permeability of the 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 apparent yields of the water wells are limited. The apparent yields for water wells completed in this Aquifer are expected to be mainly less than 500 m³/day, except adjacent to parts of the Red Deer River in the northwestern part of the County as shown on Figure 12. Higher yields present in the eastern part of the County could be a result of the gridding procedure used to process a very limited number of data points. Licensed water wells completed in the Sand and Gravel Aquifer are also shown on the figure. Where the 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 yields and quality of groundwater from the bedrock aquifers are suitable.

A Town of Sundre water supply well completed in the Sand and Gravel Aquifer in 03-10-033-05 WSM is authorized to divert a total of 1,352 m³/day. Although the Town is located adjacent to the Red Deer River, there are no data available to indicate that there is direct hydraulic continuity between the Sand and Gravel Aquifer and the Red Deer River.

A preliminary recovery-only aquifer test was conducted by Alken Basin Drilling with the new Village of Cremona Water Supply Well (WSW) No. 12 on 05 Apr 2000. The new water supply well is completed in the Sand and Gravel Aquifer in NW 08-030-04 WSM and was drilled in an attempt by the Village to find a suitable water source to meet the Village’s needs. The results of the aquifer test conducted with WSW No. 12 indicated an apparent yield of more than 2,700 m³/day based on an apparent transmissivity of 465 m²/day. An extended aquifer test with WSW No. 12 will be completed by the end of October 2000.

Groundwater from the Cremona WSW No. 12 is a bicarbonate-type with no dominant cation, has a TDS concentration of 367 mg/L, a total hardness concentration of 211 mg/L, a sulfate concentration of 13 mg/L, and a chloride concentration of 1.3 mg/L.
C. Bedrock

1) Geological Characteristics

The upper bedrock in the County is the Paskapoo Formation. The Paskapoo Formation consists of cycles of thick, tabular sandstones, siltstone and mudstone layers (Glass, 1990). The maximum thickness of the Paskapoo Formation can be 800 metres, but in the County, the thickness is from 0 to 550 metres. A generalized geologic column is illustrated on Figure 5, Appendix A and on the CD-ROM.

The Paskapoo Formation is the upper bedrock and subcrops in all the County, with the exception of the area in the foothills region that is referred to as the Disturbed Belt.

The Disturbed Belt is the upper bedrock in the extreme western part of the County. The outline of the Disturbed Belt has been defined based on the Geological Map of Alberta (Hamilton et al, 1999 and Green, 1972). The Rocky Mountains and Foothills together form the Disturbed Belt, an area that has been deformed by folding and thrust faulting (Tokarsky, 1971). Water wells that were located within the Disturbed Belt boundary were defined as being completed in surficial deposits or in the Disturbed Belt Aquifer.

The Paskapoo Formation in central Alberta consists of the Dalehurst, Lacombe and Haynes members (Demchuk and Hills, 1991). In the County, only the Dalehurst and Lacombe members of the Paskapoo Formation are the upper bedrock. The Edmonton Group underlies the Paskapoo Formation. The Edmonton Group includes the Scollard, Battle, Whitemud and Horseshoe Canyon formations.

The Dalehurst Member is the upper bedrock and subcrops mainly west of the 5th Meridian. This Member has a maximum thickness of 300 metres within the County and is mostly composed of shale and siltstone with sandstone, bentonite and coal seams or zones. Two prominent coal zones within the Dalehurst are the Obed-Marsh Coal (up to 30 metres thick) and the Lower Dalehurst Coal (up to 50 metres thick). The bottom of the Lower Dalehurst Coal is the border between the Dalehurst and Lacombe members (Demchuk and Hills, 1991).

The Lacombe Member underlies the Dalehurst Member and subcrops east of the 5th Meridian, within the County border. The Lacombe Member has a maximum thickness of 350 metres. The upper part of the Lacombe Member is mostly composed of shale interbedded with sandstone and has a maximum thickness of 250 metres. 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 lower part of the Lacombe Member has a maximum thickness of 100 metres. The Lacombe Member has a maximum thickness of 250 metres within the County.

The Haynes Member underlies the Lacombe Member, has a maximum thickness of 100 metres and is composed mainly of sandstone with some siltstone, shale and coal.

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. The Lower Scollard Formation has an average thickness of 40 metres in the County, and is composed mainly of shale and sandstone.

There will be no direct review of either the Haynes Member or the Scollard Formation in the text of this report because there are no water wells that extend into either the Haynes Member or the Scollard Formation; the only maps associated with the Haynes Member or the Scollard Formation to be included on the CD-ROM will be structure-contour maps.

In the County, the Base of Groundwater Protection extends below the Haynes Member. 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.

2) Aquifers

Of the 7,827 water wells in the database, 3,683 were defined as being completed below the top of bedrock. However, at least a reported completion depth is available for the majority of water wells and assigning the water well to specific geologic units 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 if the total drilled depth of a water well was more than ten metres below the top of a particular geologic unit, the water well was assigned to the particular geologic unit. With this assumption, it has been possible to designate the aquifer of completion for 3,254 additional water wells. There are 78 water wells that have been identified as being completed in more than one bedrock aquifer.

The bedrock water wells are mainly completed in the Dalehurst and Lacombe aquifers, as shown in the above table.

<table>
<thead>
<tr>
<th>Geologic Unit</th>
<th>No. of Water Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disturbed Belt</td>
<td>520</td>
</tr>
<tr>
<td>Dalehurst</td>
<td>4,851</td>
</tr>
<tr>
<td>Lacombe</td>
<td>1,488</td>
</tr>
<tr>
<td>Multiple Completions</td>
<td>78</td>
</tr>
<tr>
<td>Total</td>
<td>6,937</td>
</tr>
</tbody>
</table>

Table 5. Completion Aquifer

There are 866 records for bedrock water wells that have apparent yield values, or 12% of all bedrock water wells. In the County, yields for water wells completed in the upper bedrock aquifer(s) are mainly between ten and 100 m³/day. Some of the areas with yields of more than 100 m³/day indicated on the adjacent figure are in the vicinity of major meltwater channels. These higher yield areas may identify areas of increased permeability resulting from the weathering process. In addition to the 866 water wells, there are records for 150 dry or abandoned water wells due to insufficient water in many of these areas. In order to depict a more accurate yield map, an apparent yield of 0.1 m³/day was assigned to the 150 dry holes prior to gridding. Also included in these postings is any record that includes water well comments that state the well goes dry in dry years.
Of the 866 water well records with apparent yield values, 852 have been assigned to aquifers associated with specific geologic units that are being discussed. Forty-four percent (386) of the water wells completed in the bedrock aquifers have apparent yields that range from ten to 100 m$^3$/day, 27% (237) have apparent yields that are less than ten m$^3$/day, and 19% (163) have apparent yield values that range from 100 to 500 m$^3$/day, as shown in the adjacent table.

### Table 6. Apparent Yields of Bedrock Aquifers

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>No. of Water Wells with Values for Apparent Yield</th>
<th>Number of Water Wells with Apparent Yields</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;10 m$^3$/day</td>
<td>10 to 100 m$^3$/day</td>
</tr>
<tr>
<td>Disturbed Belt</td>
<td>45</td>
<td>10</td>
</tr>
<tr>
<td>Dalehurst</td>
<td>497</td>
<td>133</td>
</tr>
<tr>
<td>Lacombe</td>
<td>310</td>
<td>83</td>
</tr>
<tr>
<td>Multiple Completions</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Totals</td>
<td>866</td>
<td>237</td>
</tr>
</tbody>
</table>

3) Chemical Quality of Groundwater

The TDS concentrations in the groundwaters from the upper bedrock aquifer(s) range from less than 500 to more than 1,500 mg/L, with most of the groundwaters with lower TDS concentrations occurring in the western third of the County.

The relationship between TDS and sulfate concentrations shows that when TDS values in the groundwaters from the upper bedrock aquifer(s) exceed 1,200 mg/L, the sulfate concentrations exceed 400 mg/L. The sulfate concentrations in groundwaters from upper bedrock aquifer(s) were compared to the distance of completion depth from the top of the Lacombe Member. Groundwaters from bedrock water wells completed within 100 metres of the top of the Lacombe Member tend to have higher sulfate concentrations than groundwaters from water wells completed outside that range, as shown in Figure 15.

The chloride concentrations in the groundwaters from the upper bedrock aquifer(s) are less than 100 mg/L in more than 98% of the County. Groundwaters with chloride concentrations of less than ten mg/L can be expected in 90% of the western third of the County, where the Disturbed Belt and Dalehurst aquifers subcrop.

In the County, particularly in the western third, approximately 60% of the groundwater samples from upper bedrock aquifer(s) have fluoride concentrations that are too low (less than 0.5 mg/L) to meet the recommended daily needs of people. Approximately 25% of the groundwater samples from the entire County are between 0.5 and 1.5 mg/L and approximately 15% exceed the maximum acceptable concentration for fluoride of 1.5 mg/L, particularly in the eastern half.

The Piper tri-linear diagrams (see Appendix A) show that all chemical types of groundwater occur in the bedrock aquifers. However, the majority of the groundwaters are sodium-bicarbonate or calcium-magnesium-bicarbonate-sulfate types.
4) Disturbed Belt Aquifer

The Disturbed Belt Aquifer comprises the permeable parts of the Disturbed Belt, as defined for the present program. Structure contours have not been prepared for the top and bottom of the Disturbed Belt, which underlies the extreme western part of the County.

a) Apparent Yield

The apparent yields for individual water wells completed through the Disturbed Belt Aquifer are mainly in the range of ten to 100 m³/day. The areas where water wells with higher yields are expected are mainly in townships 032 and 033, range 07, W5M.

There are two licensed water wells for stock purposes completed in the Disturbed Belt Aquifer in SW 30-033-06 W5M that are licensed for a total of 10.2 m³/day.

b) Quality

The groundwaters from the Disturbed Belt Aquifer are mainly a bicarbonate type with no dominant cation (see CD-ROM), with TDS concentrations ranging from less than 200 to more than 500 mg/L. The higher values of TDS concentrations occur mainly in townships 032 and 033, ranges 06 and 07, W5M.

The chloride concentrations of the groundwaters from the Disturbed Belt Aquifer can be expected to be mainly less than ten mg/L.
5) Dalehurst Aquifer

The Dalehurst Aquifer comprises the permeable parts of the Dalehurst Member, as defined for the present program. The top of the Dalehurst Member is the bedrock surface where the Dalehurst Member is present under the western two-thirds of the County. The Dalehurst Member has a thickness that is less than 300 metres.

a) Depth to Top

The depth to the top of the Dalehurst Member is a function of the thickness of the surficial deposits, which ranges from less than five to more than 30 metres.

b) Apparent Yield

The apparent yields for individual water wells completed through the Dalehurst Aquifer are mainly in the range of ten to 100 m³/day, with 28% of the values being more than 100 m³/day. Also shown on the adjacent map are the locations of dry test holes. An apparent yield of 0.1 m³/day was assigned to the dry holes prior to gridding. Water wells with yields of less than ten m³/day also occur throughout the area where the Dalehurst Aquifer is present. The low yields may be variations in the permeability of the aquifer or the techniques used to complete the water wells.

c) Quality

The groundwaters from the Dalehurst Aquifer are mainly sodium-bicarbonate or calcium-magnesium-bicarbonate-sulfate types (see Piper diagram on CD-ROM). The TDS concentrations range from less than 500 to more than 1,500 mg/L. The TDS concentrations increase from west to east across the County, with higher TDS concentrations being associated with the edge of the Aquifer. The sulfate concentrations are mainly less than 500 mg/L, and also increase eastward. The sulfate concentrations in groundwaters from the Dalehurst Aquifer were compared to the distance of completion depth from the top of the Lacombe Member. Groundwaters from the Dalehurst Aquifer completed within 100 metres of the top of the Lacombe Member tend to have higher sulfate concentrations than groundwaters from water wells completed outside that range, as shown in Figure 19.

Chloride concentrations in the groundwaters from the Dalehurst Aquifer are mainly less than ten mg/L.
6) Lacombe Aquifer

The Lacombe Aquifer comprises the porous and permeable parts of the Lacombe Member that underlies the Dalehurst Member, and subcrops under the surficial deposits in the eastern one-third of the County. Structure contours have been prepared for the top of the Member, which underlies most of the County. The structure contours show the Lacombe Member having a maximum thickness of in the order of 350 metres.

i) Depth to Top

The depth to the top of the Lacombe Member ranges from less than ten metres below ground level where the Member subcrops in the eastern part of the County to more than 350 metres in the western part of the County. The greatest depth is in areas where the Dalehurst Member is also present.

ii) Apparent Yield

The apparent yields for individual water wells completed through the Lacombe Aquifer range mainly from ten to 500 m³/day. The adjacent map indicates that water wells with apparent yields of more than 500 m³/day are expected mainly in association with areas where major meltwater channels are present. In these areas, weathering processes may be increasing the local permeability. There are no data from the groundwater database for the Aquifer west of the Town of Olds, and the maps prepared for the Lacombe Aquifer have been hatched to indicate this area.

A groundwater monitoring report conducted by HCL for the Town of Olds indicated that two of their water supply wells in 24-032-29 W4M completed in the Lacombe Aquifer could be diverting a total of more than 1,200 m³/day (HCL, 1974).

A water supply well completed in the Lacombe Aquifer in 08-08-031-27 W4M is authorized to divert nearly 100 m³/day for agricultural purposes. A groundwater review conducted by HCL in 1996 indicated that a projected long-term yield for this water test hole was 80 m³/day (HCL, January 1997).

iii) Quality

The groundwaters from the Lacombe Aquifer are mainly sodium-bicarbonate or sodium-sulfate types (see Piper diagram on CD-ROM). Total dissolved solids concentrations are expected to range mainly from 500 to 1,500 mg/L.

When TDS values in the groundwaters from the Lacombe Aquifer exceed 1,200 mg/L, the sulfate concentrations exceed 400 mg/L. The indications are that chloride concentrations are expected to be less than ten mg/L, with the exception in the vicinity of the towns of Olds and Didsbury, where the chloride concentrations are expected to be greater than 100 mg/L.
VI. GROUNDWATER BUDGET

A. Hydrographs

There are three locations in the County where water levels are being measured and recorded with time. Two of these sites are observation water wells that are part of the AENV regional groundwater-monitoring network and the third site is a water supply well for the Village of Cremona. The two AENV observation water wells (Obs WW Nos. 126 and 227) are located in 04-30-032-28 W4M. The water-level record for Obs No. 126 is from 1961 to 1995 and the water-level record for AENV Obs WW No. 227 is from 1986 to 1999.

AENV Obs WW No. 126, formerly Olds Well No. 147, (Toth, 1966) was drilled to 212 metres in 1961, and is completed open hole from 46.0 to 212 metres below ground level in the Lacombe Aquifer. The adjacent hydrograph shows a water-level decline of in the order of six metres from 1966 to 1977 as a result of groundwater production from the Town of Olds water supply wells. In mid-1977, the Town of Olds developed an alternate water source and the water supply wells were taken out of service. Once the water supply wells were no longer used, the water level began to rise, and by 1995, the water level had risen more than nine metres above the 1977 level and more than three metres above the 1965 level. Toth first compared the water-level fluctuations in AENV Obs WW No. 126 in 04-30-032-28 W4M to the 1961 to 1964 summer precipitation. For the comparison, summer precipitation included the months of May, June, July and August. Toth noted that the correlation between precipitation data and groundwater levels in the Olds Well No. 147 indicated a direct recharge of the groundwater regime by precipitation. With the addition of 31 years of water-level data, HCL has compared the summer precipitation measured at the Olds weather station to the water-level fluctuations in AENV Obs WW No. 126. The comparison shows that the water-level fluctuation reflects the changes in summer precipitation. The impact of summer precipitation is most easily observed after Olds went to an alternate water supply in 1977. For example, from 1979 to 1981, the water level rose three metres as a result of three consecutive years with summer precipitation that was greater than 290 mm. In 1982 and 1983, summer precipitation was less than 200 mm, and the water level remained at a relatively constant elevation. The water-level fluctuations show two peaks for most years. The first peak would be associated with recharge when the frost leaves the ground and the second coincides with the end of the growing season. The low water level at the start of each year is a result of no recharge to the groundwater flow system during the time of ground frost.

AENV Obs WW No. 227, drilled in 1985 but reconstructed in 1986, is screened from 45.1 to 48.2 metres below ground level and completed in the Lacombe Member. The hydrograph (see Appendix A) shows that the water levels in AENV Obs WW No. 227 appear to replicate the water levels measured in AENV No. 126 from 1986 to 1995, both showing a water-level rise of approximately 3.5 metres.
The Village of Cremona is licensed to operate six water supply wells, for a total groundwater diversion of 267 m$^3$/day. Based on a current population of 380 (Phinney, 1999), the minimum quantity of groundwater required would be 418 m$^3$/day. The six water supply wells are all completed in the Dalehurst Aquifer. Water Supply Well No. 9 is 18.3 metres deep and is the only location where the Village has collected continuous water-level data. Hydrogeological Consultants Ltd. obtained the water-level charts for WSW No. 9 from the Village. The charts include water-level and groundwater-production data between 1986 and 1997.

The charts from 1986 to 1988 have been processed. The processing included obtaining the highest and lowest weekly water level and the weekly production. From November 1986 to May 1987, there was no groundwater pumped from WSW No. 9 and no charts were used. Prior to the water well being taken out of service, the highest weekly water level was close to a metre below the measuring point, presumably the top of the casing. Between June 1987 and the middle of October 1988, the total quantity of groundwater pumped was 12,686 cubic metres. Over the same time interval, the highest weekly water level declined from 1.20 to 4.35 metres. The water-level decline as a result of groundwater production indicates an effective transmissivity of 20 m$^2$/day. Based on an effective transmissivity of 20 m$^2$/day, WSW No. 9 would have a long-term yield of 75 m$^3$/day.

As a result of increased population and reportedly declining water levels in the Village of Cremona’s water supply wells, a new water supply well, WSW No. 12, was drilled in April 2000. The new water supply well is completed in the Sand and Gravel Aquifer close to the Little Red Deer River. A recovery-only aquifer test was conducted at the time of the completion of WSW No. 12. The results of the test indicate the water supply well has an apparent yield of more than 2,700 m$^3$/day. Additional aquifer tests are required to establish a more accurate long-term yield for WSW No. 12. Long-term monitoring of the water level in the Sand and Gravel Aquifer at the site of WSW No. 12 is recommended.
B. Estimated Water Use from Unlicensed Groundwater Users

An estimate of the quantity of groundwater removed from each geologic unit in Mountain View County must include both the licensed diversions and the unlicensed use. As stated previously on page 6 of this report, the daily water requirement for livestock for the County is estimated to be 22,095 cubic metres. Of the 22,095 m³/day required for livestock, 4,577 m³/day has been licensed by Alberta Environment. To obtain an estimate of the quantity of groundwater being diverted from the individual geologic units, it has been assumed that the remaining 17,518 m³/day of water required for livestock watering is obtained from unlicensed groundwater use. In the groundwater database for the County, there are records for 6,908 water wells that are used for domestic/stock purposes. These 6,908 water wells include both licensed and unlicensed water wells. Of the 6,908 water wells, 968 water wells are used for stock, 1,572 are used for domestic/stock purposes, and 4,368 are for domestic purposes only.

There are 2,540 water wells that are used for stock or domestic/stock purposes. There are 249 licensed groundwater users for agricultural (stock) purposes, giving 2,291 unlicensed stock water wells. (Please refer to Table 2 on page 6 for the breakdown by aquifer of the 249 licensed stock groundwater users). By dividing the number of unlicensed stock and domestic/stock water wells (2,291) into the quantity of groundwater required for stock purposes that is not licensed (17,518 m³/day), the average unlicensed water well diverts 7.6 m³/day.

These calculations do not take into consideration the approximately 700 dugouts and more than 60 springs in the area nor do they take into account inactive water wells. However, in order to determine whether inactive water wells would have a significant effect on the calculations used, it was assumed that water wells older than 30 years would be inactive. Of the 6,908 water wells, 60% were completed after 1970, 9% were completed before 1970, and 31% have no completion date. A check was then made to see if the percentage of domestic to stock water wells, and domestic to domestic/stock water wells for water wells completed after 1970 is consistent to the water wells completed before 1970. The analysis indicated that in both scenarios, approximately 50% of the water wells were used for domestic purposes, 30% were used for domestic/stock purposes, and 20% were used for stock purposes only.

However, because of the limitations of the data no attempt has been made to compensate for dugouts, springs or inactive water wells and the average stock use of 7.6 m³/day per stock water well is a reasonable estimate.

Groundwater for household use does not require licensing. Under the Water Act, a residence is protected for up to 3.4 m³/day. However, the standard groundwater use for household purposes is 1.1 m³/day.

To obtain an estimate of the groundwater from each geologic unit, there are three possibilities for a water well. A summary of the possibilities and the quantity of water for each use is as follows:

- Domestic  1.1 m³/day
- Stock  7.6 m³/day
- Domestic/stock  8.7 m³/day
Based on using all available domestic, domestic/stock, and stock water wells and corresponding calculations, the following table was prepared. The table shows a breakdown of the 6,908 unlicensed and licensed water wells used for domestic, stock, or domestic/stock purposes by the geologic unit in which each water well is completed. The final column in the table equals the total amount of unlicensed groundwater that is being used for both domestic and stock purposes.

<table>
<thead>
<tr>
<th>Aquifer Designation</th>
<th>Unlicensed and Licensed Groundwater Diversions</th>
<th>Licensed Groundwater Diversions</th>
<th>Unlicensed Groundwater Diversions</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Number of Daily Use</td>
<td>Number of Daily Use</td>
<td>Number of Daily Use</td>
</tr>
<tr>
<td></td>
<td>Domestic (1.1 m³/day)</td>
<td>Stock (7.6 m³/day)</td>
<td>Domestic and Stock (8.7 m³/day)</td>
</tr>
<tr>
<td>Sand/Gravel</td>
<td>248</td>
<td>273</td>
<td>58</td>
</tr>
<tr>
<td>Bedrock</td>
<td>23</td>
<td>25</td>
<td>18</td>
</tr>
<tr>
<td>Disturbed Belt</td>
<td>314</td>
<td>345</td>
<td>55</td>
</tr>
<tr>
<td>Dalehurst</td>
<td>2,754</td>
<td>3,029</td>
<td>675</td>
</tr>
<tr>
<td>Lacombe</td>
<td>653</td>
<td>718</td>
<td>154</td>
</tr>
<tr>
<td>Unknown</td>
<td>376</td>
<td>414</td>
<td>8</td>
</tr>
<tr>
<td>Totals</td>
<td>4,368</td>
<td>4,805</td>
<td>968</td>
</tr>
</tbody>
</table>

The data provided in the above table indicate that most of the 24,052 m³/day, estimated to be diverted from unlicensed domestic, stock, or domestic/stock water wells, is from the Dalehurst Aquifer.

By assigning 1.1 m³/day for domestic use, 7.6 m³/day for stock use and 8.7 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 figure has been prepared that shows the estimated groundwater use in terms of volume (licensed plus unlicensed) per section per day for the County.

In the vicinity of Sundre, Olds, Didsbury, Carstairs and Cremona, the estimated water well use per section can be more than 30 m³/day as shown on the adjacent figure. The only AENV-operated observation water wells in the County are in close proximity to the Town of Olds. Since the Town’s water supply wells were taken out of service in the 1970s, there has been a general rise in water levels in these observation water wells.
C. 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. Based on these assumptions, the estimated lateral groundwater flow through the individual bedrock aquifers can be summarized as follows:

<table>
<thead>
<tr>
<th>Aquifer/Area</th>
<th>Trans (m²/day)</th>
<th>Gradient (m/m)</th>
<th>Width (m)</th>
<th>Flow (m³/day)</th>
<th>Total (m³/day)</th>
<th>Aquifer/Area</th>
<th>Trans (m²/day)</th>
<th>Gradient (m/m)</th>
<th>Width (m)</th>
<th>Volume (m³/day)</th>
<th>Total (m³/day)</th>
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<tr>
<td>Sand and Gravel</td>
<td>942</td>
<td>1,532</td>
<td>1,190</td>
<td>2,724</td>
<td></td>
<td>Northwest Area</td>
<td></td>
<td>84,670</td>
<td></td>
<td>2,750</td>
<td>15,523</td>
</tr>
<tr>
<td>Red Deer River north</td>
<td>90</td>
<td>0.008</td>
<td>1,000</td>
<td>675</td>
<td></td>
<td>south</td>
<td></td>
<td>20</td>
<td>0.012</td>
<td>9,000</td>
<td>2,160</td>
</tr>
<tr>
<td>Little Red Deer River north</td>
<td>55</td>
<td>0.008</td>
<td>400</td>
<td>165</td>
<td></td>
<td>west</td>
<td></td>
<td>20</td>
<td>0.010</td>
<td>40,000</td>
<td>8,000</td>
</tr>
<tr>
<td>East of Carstairs south</td>
<td>20</td>
<td>0.003</td>
<td>800</td>
<td>42</td>
<td></td>
<td>east</td>
<td></td>
<td>20</td>
<td>0.010</td>
<td>40,000</td>
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</tr>
<tr>
<td>East of Olds southeast</td>
<td>20</td>
<td>0.003</td>
<td>1,200</td>
<td>60</td>
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<td></td>
<td>20</td>
<td>0.010</td>
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<tr>
<td>Castor</td>
<td>11,573</td>
<td>1,832</td>
<td>4,939</td>
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<td></td>
<td></td>
<td>castor</td>
<td></td>
<td>20</td>
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<td>50,000</td>
</tr>
<tr>
<td>west</td>
<td>8</td>
<td>0.003</td>
<td>45,000</td>
<td>960</td>
<td></td>
<td>east</td>
<td></td>
<td>20</td>
<td>0.017</td>
<td>50,000</td>
<td>17,000</td>
</tr>
<tr>
<td>east</td>
<td>8</td>
<td>0.004</td>
<td>45,000</td>
<td>1,440</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Area west</td>
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<td>25,000</td>
<td>2,867</td>
<td></td>
<td>east</td>
<td></td>
<td>10</td>
<td>0.006</td>
<td>45,000</td>
<td>2,700</td>
</tr>
<tr>
<td>east</td>
<td>8</td>
<td>0.013</td>
<td>25,000</td>
<td>2,867</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Carstairs northeast</td>
<td>8</td>
<td>0.008</td>
<td>15,000</td>
<td>960</td>
<td></td>
<td>east</td>
<td></td>
<td>15</td>
<td>0.003</td>
<td>45,000</td>
<td>2,025</td>
</tr>
<tr>
<td>east</td>
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<td>0.003</td>
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<td>960</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>northeast</td>
<td>8</td>
<td>0.008</td>
<td>30,000</td>
<td>1,020</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8. Groundwater Budget

The above table indicates that there is significantly more groundwater flowing through the aquifers than the total of the licensed and unlicensed diversions from the individual aquifers, except for the Sand and Gravel Aquifer. The calculations of flow through individual aquifers as presented in the above table are very approximate and are intended as a guide for future investigations. Because a significant aquifer cannot be delineated in the Disturbed Belt, no attempt has been made to calculate the flow through the Disturbed Belt Aquifer.
1) Quantity of Groundwater

An estimate of the volume of groundwater stored in the sand and gravel aquifers in the surficial deposits is 0.3 to two cubic kilometres. This volume is based on an areal extent of 1,200 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 wells that post in the absent area are a reflection of the spatial control. 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. The water-level map for the surficial deposits shows a general flow direction toward the eastern part of the County, and in the vicinity of Sundre, the flow is toward the Red Deer River.

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) 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. 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.

In the absence of sufficient water-level data in the surficial deposits, a reasonable hydraulic gradient between the surficial deposits and the upper bedrock aquifer(s) could not be determined. Therefore, the first objective was to determine the location of flowing shot holes and any water wells that had a water level measurement depth of
less than 0.1 metres. These locations would reflect where there is an upward hydraulic gradient from the bedrock to the surficial deposits (i.e. discharge). The depth to water level for water wells completed in 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 topographic surface. This resulting depth to water level grid was contoured to reflect the positioning of the flowing shot holes and flowing water wells (i.e. discharge). The recharge classification is used where the water level in the upper bedrock aquifer(s) is more than 15 metres below ground surface. The discharge areas are where the water level in the upper bedrock aquifer(s) is less than ten metres below ground surface. When the depth to water level in the upper bedrock aquifer(s) is between ten and 15 metres below ground surface, the area is classified as a transition, that is, no recharge and no discharge.

The adjacent map shows that, in more than 60% of the County, there is a downward hydraulic gradient from the surficial deposits toward the upper bedrock aquifer(s) (i.e. recharge). Areas where there is an upward hydraulic gradient from the bedrock to the surficial deposits (i.e. discharge) are mainly in the vicinity of creeks and river valleys and major meltwater channels. The remaining parts of the County are areas where there is a transition condition.

Because of the paucity of data, recharge/discharge maps for the individual bedrock aquifers have not been attempted.

D. 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. The available non-pumping water-level elevation for each water well completed in the sand and gravel aquifer(s)/bedrock aquifer was first sorted by location, and then by date of water-level measurement. The dates of measurements were required to differ by at least 365 days. Only the earliest and latest control points at a given location were used.

Of the 254 water wells completed in the sand and gravel aquifer(s) with a NPWL and test date, there were only 19 control points. Due to limited control points, the data were not contoured, only posted as shown on the adjacent map. The map shows that, in the vicinity of Sundre, there were approximately the same number of locations where the water level rose, as declined.
Of the 6,571 bedrock water wells with a NPWL and test date, there were 809 control points. Where the earliest water level in bedrock water wells is at a higher elevation than the latest water level in the bedrock water wells, there is the possibility that some groundwater decline has occurred. Where the earliest water level in bedrock water wells is at a lower elevation than the latest water level in the bedrock aquifers, 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.

The adjacent map indicates that in 60% of the County, it is possible that the NPWL has declined. However, the areas that indicate a decline of more than five metres are based on only one or two control points. In order to determine if the water-level decline is a result of groundwater use by licensed users, the licensed users that are authorized to divert more than 50 m$^3$/day were posted on the above map. Of the 20 groundwater users authorized to divert more than 50 m$^3$/day, 16 occur in areas where a water-level decline exists.

Nearly 50% of the areas where there has been a water-level decline of more than five metres corresponds to where the estimated water well use is between ten and 30 m$^3$/day shown on Figure 24; only 21% of the decline occurred where the estimated water well use is more than 30 m$^3$/day.
VII. RECOMMENDATIONS

The present study has been based on information available from the groundwater database. The database has three problems:

1) the quality of the data
2) the coordinate system used for the horizontal control
3) the distribution of the data.

The quality of the data in the groundwater database is affected by two factors: a) the technical training of the persons collecting the data, and b) the quality control of the data. The possible options to upgrade the database include the creation of a “super” database, which includes only verified data. The first step would be to field-verify the more than 200 existing water wells listed in Appendix E. These water well records indicate that a complete water well drilling report is available along with at least a partial chemical analysis. The level of verification would have to include identifying the water well in the field, obtaining meaningful horizontal coordinates for the water well and the verification of certain parameters such as water level and completed depth. Even though the water wells for which the County has responsibility do not satisfy the above criteria, it is recommended that they be field-verified, water levels be measured, a water sample be collected for analysis, and a short aquifer test be conducted. There is one County-operated water well that is also included in Appendix E. An attempt to update the quality of the entire database is not recommended.

There is a need to establish a relationship between the AENV groundwater database and the AENV licensing database.

The present analysis shows the volume of water flowing through the Sand or Gravel Aquifer associated with the Little Red Deer River is less than 200 m³/day. Therefore, additional information is needed for the Village of Cremona to establish a sustainable yield for WSW No. 12.

While there are a few areas where water-level data are available, on the overall, there are an insufficient number of water levels to set up a groundwater budget. One method to obtain additional water-level data is to solicit the assistance of the water well owners who are stakeholders in the groundwater resource. In the M.D. of Rocky View and in Flagstaff County, water well owners are being provided with a tax credit if they accurately measure the water level in their water well once per week for a year. A pilot project indicated that approximately five years of records are required to obtain a reasonable data set. The cost of a five-year project involving 50 water wells would be less than the cost of one drilling program that may provide two or three observation water wells. Monitoring of water levels in domestic and stock water wells is a practice that is recommended by PFRA in the “Water Wells That Last for Generations” manual and accompanying videos (Alberta Agriculture, Food And Rural Development, 1996)(Appendix E).

A second approach to obtain water-level data would be to conduct a field survey to identify water wells not in use that could be used as part of an observation water well network. County personnel and/or local residents could measure the water levels in the water wells regularly.

In general, for the next level of study, the database needs updating. It requires more information from existing water wells, and additional information from new ones.
Before an attempt is made to provide a major upgrade to the level of interpretation provided in this report and the accompanying maps and groundwater query, it is recommended that all water wells for which water well drilling reports are available be subjected to the following actions (see pages C-2 to C-3):

1) The horizontal location of the water well should be determined within ten metres. The coordinates must be in 10TM NAD 27 or some other system that will allow conversion to 10TM NAD 27 coordinates.
2) A four-hour aquifer test (two hours of pumping and two hours of recovery) should be performed with the water well to obtain a realistic estimate for the transmissivity of the aquifer in which the water well is completed.
3) Water samples should be collected for chemical analysis after five and 115 minutes of pumping, and analyzed for major and minor ions.

A list of the more than 200 water wells that could be considered for the above program is given in Appendix E.

In addition to the data collection associated with the existing water wells, all available geophysical logs should be interpreted to establish a more accurate spatial definition of individual aquifers.

There is also a need to provide the water well drillers with feedback on the reports they are submitting to the regulatory agencies. The feedback is necessary to allow for a greater degree of uniformity in the reporting process. This is particularly true when trying to identify the bedrock surface. One method of obtaining uniformity would be to have the water well drilling reports submitted to the AENV Resource Data Division in an electronic form. The money presently being spent by AENV and PFRA to transpose the paper form to the electronic form should be used to allow for a technical review of the data and follow-up discussions with the drillers.

An effort should be made to form a partnership with the petroleum industry. The industry spends millions of dollars each year collecting information relative to water wells. Proper coordination of this effort could provide significantly better information from which future regional interpretations could be made. This could be accomplished by the County taking an active role in the activities associated with the construction of lease sites for the drilling of hydrocarbon wells and conducting of seismic programs.

**Groundwater is a renewable resource and it must be managed.**
VIII. REFERENCES


Alberta.


### IX. CONVERSIONS

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<th>by</th>
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</thead>
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<tr>
<td>square metres (m²)</td>
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<td>square kilometres (km²)</td>
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| **Concentration** | | |
| grains/gallon (UK) | 14.270 050 | parts per million (ppm) |
| ppm | 0.998 859 | mg/L |
| mg/L | 1.001 142 | ppm |

| **Volume (capacity)** | | |
| acre feet | 1233.481 838 | cubic metres |
| cubic feet | 0.028 317 | cubic metres |
| cubic metres | 35.314 667 | cubic feet |
| cubic metres | 219.969 248 | gallons (UK) |
| cubic metres | 264.172 050 | gallons (US liquid) |
| cubic metres | 1000.000 000 | litres |
| gallons (UK) | 0.004 546 | cubic metres |
| imperial gallons | 4.546 000 | litres |

<p>| <strong>Rate</strong> | | |
| litres per minute (lpm) | 0.219 974 | UK gallons per minute (igpm) |
| litres per minute | 1.440 000 | cubic metres/day (m³/day) |
| igpm | 6.546 300 | cubic metres/day (m³/day) |
| cubic metres/day | 0.152 759 | igpm |</p>
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<tr>
<td>Amount of Sand and Gravel in Surficial Deposits</td>
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<td>Thickness of Sand and Gravel Aquifer(s)</td>
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<td>Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)</td>
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<td>Fluoride in Groundwater from Upper Bedrock Aquifer(s)</td>
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<td>28</td>
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<td>29</td>
</tr>
<tr>
<td>Chloride in Groundwater from Dalehurst Aquifer</td>
<td>30</td>
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<td>Apparent Yield for Water Wells Completed through Lacombe Aquifer</td>
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<tr>
<td>Changes in Water Levels - Upper Bedrock Aquifer(s)</td>
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Surface Casing Types used in Drilled Water Wells

Steel  Galvanized Steel  Plastic  Unknown

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<tr>
<th>Year</th>
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<th>Plastic</th>
<th>Unknown</th>
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<td>10</td>
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Licensed Water Wells

Licensed Groundwater Users (m³/day)

- < 10
- 10 to 100
- > 100

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<tr>
<th>Category</th>
<th>Agricultural</th>
<th>Municipal</th>
<th>Industrial</th>
<th>Other</th>
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<td>(m³/day)</td>
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<td>(0)</td>
<td>(4)</td>
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<td>(m³/day)</td>
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<td>(15)</td>
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<td>(4)</td>
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<td>(m³/day)</td>
<td>(3)</td>
<td>(2)</td>
<td>(0)</td>
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Depth to Base of Groundwater Protection
(modified after EUB, 1995)
Generalized Cross-Section
(for terminology only)

- A - Ground surface
- B - Bedrock surface
- C - Base of weathering
- D - Base of groundwater protection
- E - Water level in surficial deposits
- F - Water level in bedrock aquifers
- G - Bedrock discharge zone
- H - First sand and gravel
- I - Upper sand and gravel aquifer
- J - Lower sand and gravel aquifer

**Surficial deposits**
- Till, clay and silt
- Sand and gravel

**Bedrock**
- Shale
- Sandstone
- Coal
- Aquifer

**Water well**
- Non-pumping water level
- Completion interval
Geologic Column

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Lithologic Description</th>
<th>Average Thickness (m)</th>
<th>Designation</th>
<th>Average Thickness (m)</th>
<th>Designation</th>
<th>Average Thickness (m)</th>
<th>Designation</th>
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<tbody>
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<td>&lt;30</td>
<td>Upper</td>
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<td>Passapoo</td>
<td>&lt;300</td>
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<td>Member</td>
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<td></td>
<td>Lower</td>
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<td>Sandstone</td>
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<td>Upper</td>
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<td></td>
<td></td>
<td>Upper</td>
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<td>Ardley</td>
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<td>Lower</td>
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<td>Coal Zone</td>
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<td>Zone</td>
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</tbody>
</table>
Cross-Section B - B'

Mountain View County

Disturbed Belt

Surficial Deposits

Bedrock

Vertical exaggeration x 50

NPWIL Completion Interval

Turnbull Creek
Silver Creek
Lonepine Creek
Dogpound Creek
Rosebud River

Carstairs
Disturbed Belt

Upper Scotland Formation
Haynes Member

Line of Section

Major Meltwater Channel (after Shetsen, 1987)
Cross-Section C - C’

Mountain View County

Lacombe

Upper Member

Little Red Deer River Valley

Dalehurst

Haynes

Red Deer River

Dogpound Creek

Cremora Slough

Disturbed Belt

Major Meltwater Channel (after Shetsen, 1987)

Upper Member

Lacombe Member

Haynes Member

Surficial Deposits

Bedrock

Vertical exaggeration x 50

NGWIC Completion Interval
Cross-Section D - D'

Mountain View County, Part of the Red Deer River Basin
Regional Groundwater Assessment, Parts of Tp 029 to 034, R 26 to 29, W4M and R 01 to 07, W5M

- Carstairs
- Dalehurst
- Haynes Member
- Upper Scollard Formation
- Lacombe Member
- Haynes Member
- Upper Scollard Formation
- Lacombe

Minor Meltwater Channel (after Shetsen, 1987)

Dalehurst Creek
Rosebud River

Major Meltwater Channel (after Shetsen, 1987)

Carstairs Creek

Cross-Section D - D'

Scale: 1:25,000

Legend:
- Surficial Deposits
- Bedrock
- Completion Interval
- NPLW

Vertical exaggeration: x 50

Line of Section
Bedrock Topography

Major Meltwater Channel (after Shetsen, 1987)

m AMSL

875 950 1025 1100 1175 1250 1325
**Thickness of Surficial Deposits**

[Map of thickness of surficial deposits with color coding for major meltwater channel.]
Thickness of Sand and Gravel Deposits

Absence of Sand and Gravel Deposits

Major Meltwater Channel
Amount of Sand and Gravel in Surficial Deposits

- Sand and Gravel Absent
- Major Meltwater Channel

Legend:
- %
  - 10
  - 30
Thickness of Sand and Gravel Aquifer(s)

Saturated Surficial Deposits Absent

Major Meltwater Channel

m

[Map showing thickness of sand and gravel aquifer(s) with color coding and legend]
Total Dissolved Solids in Groundwater from Surficial Deposits

Saturated Surficial Deposits Absent

Control point

mg/L

500
1500
Apparent Yield for Water Wells Completed through Sand and Gravel Aquifer(s)

- Saturation Surficial Deposits Absent
- Major Meltwater Channel
- Licensed User
- Control Point

Legend:
- 10 m³/day
- 100 m³/day
- 500 m³/day
- 1.5 gpm
- 15 gpm
- 75 gpm
Bedrock Geology

Paskapoo Formation

Dalehurst Member
Lacombe Member

Disturbed Belt
Piper Diagrams

Surficial Deposits

Bedrock Aquifers
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)
Fluoride in Groundwater from Upper Bedrock Aquifer(s)

mg/L

0.5 1 1.5
Apparent Yield for Water Wells Completed through Disturbed Belt Aquifer

- Absent
- > 100 m³/day
- dry

Legend:
- 10 m³/day
- 100 m³/day
- 1.5 igpm
- 15 igpm
Chloride in Groundwater from Disturbed Belt Aquifer

- **Absent**
- **Control Point**

Legend:
- Scale: **10** to **30** mg/L
Depth to Top of Dalehurst Member

Absent

Disturbed Belt

m

5 10 20 30
Apparent Yield for Water Wells Completed through Dalehurst Aquifer

Legend:
- Absent
- Disturbed Belt
- Major Meltwater Channel
- > 500 m³/day
- dry

Color Scale:
- 10 m³/day
- 100 m³/day
- 500 m³/day
- 1.5 igpm
- 15 igpm
- 75 igpm
Chloride in Groundwater from Dalehurst Aquifer

Absence: 10 mg/L
Disturbed Belt: 100 mg/L
Depth to Top of Lacombe Member

Disturbed Belt

m

10 25 50 100 150 200 250 300 350
Apparent Yield for Water Wells Completed through Lacombe Aquifer

- Disturbed Belt
- No data for Lacombe Member
- Major Meltwater Channel

Legend:
- > 500 m³/day
- > 75 15 m³/day
- Dry

Color Scale:
- 0 - 1.5 m³/day
- 15 - 100 m³/day
- 75 - 500 m³/day
- > 500 m³/day

Legend units:
- m³/day
- gpm
Chloride in Groundwater from Lacombe Aquifer

- Disturbed Belt
- No data for Lacombe Member

mg/L

10 100
Depth to Top of Haynes Member

Disturbed Belt

m

100 250 400 550
Depth to Top of Upper Scollard Formation
Estimated Water Well Use Per Section

Estimated Water Well Use Per Section (m³/day)

- < 10
- 10 - 30
- > 30

No Domestic or Stock User
Hydrographs - AENV Observation Water Wells and Cremona WSW No. 9

---

[Image of hydrographs showing water levels over time for different observation wells, with data points marked for specific years and depths.]

---

Legend:
- Non-Pumping Water Level
- Surficial Deposits
- Lacombe Member
- Dalehurst Member

[Map with geographic markers for different geological layers and observation wells, indicating locations based on meridians and sections.]
Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep
Recharge/Discharge Areas in Upper Bedrock Aquifer(s)

- Major Meltwater Channel
- flowing shot hole or flowing water well

Legend:
- Recharge
- Transition
- Discharge
Changes in Water Levels - Sand and Gravel Aquifer(s)

- Saturated Surficial Deposits Absent
- rise
- decline
Changes in Water Levels - Upper Bedrock Aquifer(s)

- licensed user of > 50 m³/day
- control point

rise 0 decline 5 decline

m
1) General

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- Surface Casing Types used in Drilled Water Wells
- Location of Water Wells
- Depth of Existing Water Wells
- Depth to Base of Groundwater Protection
- Generalized Cross-Section (for terminology only)
- Geologic Column
- Hydrogeology Map
- Cross-Section A - A'
- Cross-Section B - B'
- Cross-Section C - C'
- Cross-Section D - D'
- Bedrock Topography
- Bedrock Geology
- Relative Permeability
- Licensed Water Wells
- Estimated Water Well Use Per Section
- Water Wells Recommended for Field Verification

2) Surficial Aquifers

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- Total Dissolved Solids in Groundwater from Surficial Deposits
- Sulfate in Groundwater from Surficial Deposits
- Fluoride in Groundwater from Surficial Deposits
- Nitrate + Nitrite (as N) in Groundwater from Surficial Deposits
- Chloride in Groundwater from Surficial Deposits
- Total Hardness in Groundwater from Surficial Deposits
- Piper Diagram - Surficial Deposits
- Thickness of Sand and Gravel Deposits
- Amount of Sand and Gravel in Surficial Deposits
- Thickness of Sand and Gravel Aquifer(s)
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- Changes in Water Levels - Sand and Gravel Aquifer(s)
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      Sulfate in Groundwater from Upper Bedrock Aquifer(s)
      Distance from Top of Lacombe Member vs Sulfate in Groundwater from Upper Bedrock Aquifer(s)
      Chloride in Groundwater from Upper Bedrock Aquifer(s)
      Fluoride in Groundwater from Upper Bedrock Aquifer(s)
      Total Hardness of Groundwater from Upper Bedrock Aquifer(s)
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      Recharge/Discharge Areas in Upper Bedrock Aquifer(s)
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      Total Dissolved Solids in Groundwater from Disturbed Belt Aquifer
      Sulfate in Groundwater from Disturbed Belt Aquifer
      Chloride in Groundwater from Disturbed Belt Aquifer
      Piper Diagram - Disturbed Belt Aquifer
      Changes in Water Levels - Disturbed Belt Aquifer
   c) Dalehurst Member
      Depth to Top of Dalehurst Member
      Structure-Contour Map - Dalehurst Member
      Non-Pumping Water-Level Surface - Dalehurst Aquifer
      Apparent Yield for Water Wells Completed through Dalehurst Aquifer
      Total Dissolved Solids in Groundwater from Dalehurst Aquifer
      Sulfate in Groundwater from Dalehurst Aquifer
      Distance from Top of Lacombe Member vs Sulfate in Groundwater from Dalehurst Aquifer
      Chloride in Groundwater from Dalehurst Aquifer
      Piper Diagram - Dalehurst Aquifer
      Changes in Water Levels - Dalehurst Aquifer
   d) Lacombe Member
      Depth to Top of Lacombe Member
      Structure-Contour Map - Lacombe Member
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      Total Dissolved Solids in Groundwater from Lacombe Aquifer
      Sulfate in Groundwater from Lacombe Aquifer
      Distance from Top of Lacombe Member vs Sulfate in Groundwater from Lacombe Aquifer
      Chloride in Groundwater from Lacombe Aquifer
      Piper Diagram - Lacombe Aquifer
      Changes in Water Levels - Lacombe Aquifer
   e) Haynes Member
      Depth to Top of Haynes Member
      Structure-Contour Map - Haynes Member
   f) Upper Scollard Formation
      Depth to Top of Upper Scollard Formation
      Structure-Contour Map - Upper Scollard Formation
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General Water Well Information

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Domestic Water Well Testing

Purpose and Requirements

The purpose of the testing of domestic water wells is to obtain background data related to:

1) the non-pumping water level for the aquifer - Has there been any lowering of the level since the last measurement?
2) the specific capacity of the water well, which indicates the type of contact the water well has with the aquifer;
3) the transmissivity of the aquifer and hence an estimate of the projected long-term yield for the water well;
4) the chemical, bacteriological and physical quality of the groundwater from the water well.

The testing procedure involves conducting an aquifer test and collecting of groundwater samples for analysis by an accredited laboratory. The date and time of the testing are to be recorded on all data collection sheets. A sketch showing the location of the water well relative to surrounding features is required. The sketch should answer the question, "If this water well is tested in the future, how will the person doing the testing know this is the water well I tested?"

The water well should be taken out of service as long as possible before the start of the aquifer test, preferably not less than 30 minutes before the start of pumping. The non-pumping water level is to be measured 30, 10, and 5 minutes before the start of pumping and immediately before the start of pumping which is to be designated as time 0 for the test. All water levels must be from the same designated reference, usually the top of the casing. Water levels are to be measured during the pumping interval and during the recovery interval after the pump has been turned off; all water measurements are to be with an accuracy of ± 0.01 metres.

During the pumping and recovery intervals, the water level is to be measured at the appropriate times. An example of the time schedule for a four-hour test is as follows, measured in minutes after the pump is turned on and again after the pump is turned off:

1, 2, 3, 4, 6, 8, 10, 13, 16, 20, 25, 32, 40, 50, 64, 80, 100, 120.

For a four-hour test, the reading after 120 minutes of pumping will be the same as the 0 minutes of recovery. Under no circumstance will the recovery interval be less than the pumping interval.

Flow rate during the aquifer test should be measured and recorded with the maximum accuracy possible. Ideally, a water meter with an accuracy of better than ±1% displaying instantaneous and total flow should be used. If a water meter is not available, then the time required to completely fill a container of known volume should be recorded, noting the time to the nearest 0.5 seconds or better. Flow rate should be determined and recorded often to ensure a constant pumping rate.

Groundwater samples should be collected as soon as possible after the start of pumping and within 10 minutes of the end of pumping. Initially only the groundwater samples collected near the end of the pumping interval need to be submitted to the accredited laboratory for analysis. All samples must be properly stored for transportation to the laboratory and, in the case of the bacteriological analysis, there is a maximum time allowed between the time the sample is collected and the time the sample is delivered to the laboratory. The first samples collected are only analyzed if there is a problem or a concern with the first samples submitted to the laboratory.
Procedure

Site Diagrams

These diagrams are a map showing the distance to nearby significant features. This would include things like a corner of a building (house, barn, garage etc.) or the distance to the half-mile or mile fence. The description should allow anyone not familiar with the site to be able to unequivocally identify the water well that was tested. In lieu of a map, UTM coordinates accurate to within five metres would be acceptable. If a hand-held GPS is used, the post-processing correction details must be provided.

Surface Details

The type of surface completion must be noted. This will include such things as a pitless adapter, well pit, pump house, in basement, etc. Also, the reference point used for measuring water levels needs to be noted. This would include top of casing (TOC) XX metres above ground level; well pit lid, XX metres above TOC; TOC in well pit XX metres below ground level.

Groundwater Discharge Point

Where was the flow of groundwater discharge regulated? For example was the discharge through a hydrant downstream from the pressure tank; discharged directly to ground either by connecting directly above the well seal or by pulling the pump up out of the pitless adapter; from a tap on the house downstream from the pressure tank? Also note must be made if any action was taken to ensure the pump would operate continuously during the pumping interval and whether the groundwater was passing through any water-treatment equipment before the discharge point.

Water-Level Measurements

How were the water-level measurements obtained? If obtained using a contact gauge, what type of cable was on the tape, graduated tape or a tape with tags? If a tape with tags, when was the last time the tags were calibrated? If a graduated tape, what is the serial number of the tape and is the tape shorter than its original length (i.e. is any tape missing)?

If water levels are obtained using a transducer and data logger, the serial numbers of both transducer and data logger are needed and a copy of the calibration sheet. The additional information required is the depth the transducer was set and the length of time between when the transducer was installed and when the calibration water level was measured, plus the length of time between the installation of the transducer and the start of the aquifer test. All water levels must be measured at least to the nearest 0.01 metres.

Discharge Measurements

Type of water meter used. This could include such things as a turbine or positive displacement meter. How were the readings obtained from the meter? Were the readings visually noted and recorded or were they recorded using a data logger?

Water Samples

A water sample must be collected between the 4- and 6-minute water-level measurements, whenever there is an observed physical change in the groundwater being pumped, and 10 minutes before the end of the planned pumping interval. Additional water samples must be collected if it is expected that pumping will be terminated before the planned pumping interval.
Water Act - Water (Ministerial) Regulation

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        - Fees
        - Extension of time

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**ALBERTA REGULATION 205/98**

**WATER ACT**

**WATER (MINISTERIAL) REGULATION**

Alberta Regulation 205/98

**EXTRACT FROM THE ALBERTA GAZETTE**

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Water Act – Flowchart

Application to Alberta Environment (AENV) to undertake a diversion of water

If the proposed diversion is for groundwater, is application for oilfield injection in the "White Area" of Alberta?

Yes

Undertake groundwater prognosis

Application rejected for environmental reasons (e.g. resource fully allocated). Appealable by applicant

No

AENV responds to applicant and provides public notice to be advertised

Advertise public notice

"Statement(s) of Concern" received within a specified (often 7-day) waiting period from "Directly Affected Person"

Yes

AENV issues approval to undertake an activity or confirms OK to proceed

Concerns addressed to AENV's satisfaction

Yes

No

Favorable

Abandon Project (or apply for source other than potable groundwater)

Yes

No

Surface Water Source

Obtain surface water source information as specified by AENV

Groundwater Source

Conduct groundwater exploration; comply with Terms & Conditions of Approval

Submit "Licensing Package" to AENV

"Statement(s) of Concern" received during a specified (often 30-day) waiting period

No

Yes

AENV issues approval to undertake an activity or confirms OK to proceed

Concerns addressed to AENV's satisfaction

Yes

Deficiencies addressed by Applicant / Consultant and submitted to AENV

Yes

No

Submission complete (no deficiencies)

Concerns addressed to AENV's satisfaction

AENV issues "term" licence with Terms & Conditions ** - appealable only by "Directly Affected Person" or licensee

On-going monitoring and reporting

Annual Report

Yes

No

MOW-TECH LTD.
Your Groundwater Source
1 800 661 6061
© 1999 Mow-Tech Ltd.

This flow chart was developed by Mow-Tech Ltd. and is provided as a guide only to Alberta's new Water Act. Mow-Tech Ltd. accepts no responsibility for the information provided.
INTERPRETATION OF CHEMICAL ANALYSIS OF DRINKING WATER

1. **TOTAL DISSOLVED SOLIDS (TDS)** - The recommended limit is 1000 mg/L for untreated and 500 mg/L for treated waters. TDS indicates the approximate concentration of organic and inorganic substances in the water. It will be high if other constituents of the analysis are high.

2. **IRON** - Amounts over 0.3 mg/L, usually stain laundry and plumbing fixtures and cause undesirable tastes. Iron filtration can be utilized. Iron bacteria may also be the cause of increased iron content.

3. **CALCIUM** - This is a constituent of hardness. Excessive calcium in drinking water may be a factor in disorders of the kidneys, bladder and urinary system.

4. **MAGNESIUM** - This is a constituent of hardness.

5. **HARDNESS** - A maximum acceptable concentration has not been established. Hardness is caused mainly by calcium and magnesium. Levels between 80 and 100 mg/L are satisfactory; 100 to 200 mg/L are less acceptable; more than 200 mg/L are considered to be poor and in excess of 500 mg/L are unacceptable for most domestic purposes. Softening can be helpful in given circumstances.

6. **SODIUM** - Ideally, there should be no more than 200 mg/L. The average intake of sodium from water is only a small fraction of that consumed in a normal diet. Persons suffering from hypertension or congestive heart failure may require a sodium-restricted diet, in which case the intake of sodium from drinking water could become significant. Your physician should be informed of the sodium content.

7. **NITRITE-NITROGEN & NITRATE-NITROGEN (NO₂ + NO₃)** - The maximum acceptable concentration is 10 mg/L. Any amount over that may be harmful to children up to 12 months of age, causing a condition known as methaemoglobinemia. Presence may indicate a contaminating source although other instances, e.g. fertilizer and decomposing vegetation can cause an elevated figure.

8. **NITRITE-NITROGEN** - The maximum acceptable concentration is 1.0 mg/L. Nitrite is unstable in water and converts to nitrate. An elevated figure may indicate a pollution problem.

9. **FLUORIDE** - Approximately 1 mg/L of fluoride is recommended in drinking water in order to give developing teeth some protection against decay. If the fluoride is higher than 1.5 mg/L you should talk to the dental staff of the Health Unit about the possibility of mottled enamel; if the fluoride is lower than 0.7 mg/L please ask about fluoride supplements for your children.

10. **SULPHATES** - The maximum acceptable concentration is 500 mg/L. Taste becomes noticeable between 250 and 600 mg/L and a laxative effect may be noticed by new users when sulphate combines with sodium or magnesium.
11. **CHLORIDE** - The recommended limit is 250 mg/L. Chloride content is usually low and an increase may indicate a nearby source of pollution (particularly if NO2 and NO3 and nitrite are high). Some wells contain naturally occurring chlorides. A salty taste may be evident.

12. **ALKALINITY T (Total)** - Alkalinity below 500 mg/L is generally accepted. Excessive alkalinity may result in incrustations on utensils, service pipes and water heaters.

13. **BICARBONATE** - Upper limit not established. Relates to alkalinity as bicarbonate of sodium, calcium and magnesium.

**NOTE:** mg/L = milligrams per litre.

The preceding notes and standards are for your guidance only based on an intake of 2 litres of water per day. The figures may be interpreted in a variety of ways and the public health inspector for your area can be contacted for further advice. Telephone: Stony Plain - 963-2206; Spruce Grove - 962-4072; Whitecourt - 778-5555.

For stock water and other agricultural uses the requirements are not necessarily the same as for domestic use. Please consult your District Agriculturalist for that kind of advice.
Additional Information

VIDEOS
Will the Well Go Dry Tomorrow? (Mow-Tech Ltd.: 1-800 GEO WELL)
Water Wells that Last (PFRA – Edmonton Office: 780-495-3307)
Ground Water and the Rural Community (Ontario Ground Water Association)

BOOKLET
Water Wells that Last (PFRA – Edmonton Office: 780-495-3307)

ALBERTA ENVIRONMENTAL PROTECTION
WATER WELL INSPECTORS
Jennifer McPherson (Edmonton: 780-427-6429)

GEOPHYSICAL INSPECTION SERVICE
Edmonton: 780-427-3932

COMPLAINT INVESTIGATIONS
Blair Stone (Red Deer: 403-340-5310)

UNIVERSITY OF ALBERTA – Department of Earth and Atmospheric Sciences - Hydrogeology
Carl Mendoza (Edmonton: 780-492-2664)

UNIVERSITY OF CALGARY – Department of Geology and Geophysics - Hydrogeology
Larry Bentley (Calgary: 403-220-4512)

FARMERS ADVOCATE
Paul Vasseur (Edmonton: 780-427-2433)

PRAIRIE FARM REHABILITATION ADMINISTRATION
Bill Franz (Red Deer: 403-340-4290)
Terry Dash (Calgary: 403-292-5719)

LOCAL HEALTH DEPARTMENTS
MOUNTAIN VIEW COUNTY
Appendix D

Maps and Figures Included as Large Plots

Bedrock Topography............................................................................................................................................2
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Bedrock Topography

Mountain View County
Bedrock Topography

Major Meltwater Channel (after Shetsen, 1987)

m AMSL

875 900 1025 1100 1175 1250 1325

0 km 10 km 20 km
Apparent Yield for Water Wells Completed through Sand and Gravel Aquifer(s)

Mountain View County
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
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<tbody>
<tr>
<td>Residential</td>
<td>1.1</td>
<td>3.4</td>
</tr>
<tr>
<td>Multi Parcel</td>
<td>1.1</td>
<td>3.4</td>
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<tr>
<td>Commercial</td>
<td>1 max. available</td>
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</tr>
<tr>
<td>Light Industrial</td>
<td>1 max. available</td>
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</tr>
<tr>
<td>Agricultural</td>
<td>17.1 max. available</td>
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</tbody>
</table>

(1) per household
(2) traditional agriculture use as defined in the Water Act

\[ \text{m}^3/\text{day} \]

10 100
1.5 15 75
500

Control point
Licensed User

Saturated Surficial Deposits Absent
Major Meltwater Channel

Canada
Total Dissolved Solids in Groundwater from Surficial Deposits

Mountain View County
Total Dissolved Solids in Groundwater from Surficial Aquifer(s)

<table>
<thead>
<tr>
<th>Use</th>
<th>MAXIMUM LIMIT TOTAL DISSOLVED SOLIDS</th>
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<tbody>
<tr>
<td>Residential</td>
<td>500 mg/L</td>
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<tr>
<td>Livestock</td>
<td>3,000 mg/L</td>
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<tr>
<td>Irrigation</td>
<td>500 - 3,500 mg/L</td>
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<tr>
<td>Commercial</td>
<td>Depends on Purpose</td>
</tr>
<tr>
<td>Industrial</td>
<td>Depends on Purpose</td>
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</table>

From: Canadian Water Quality Guidelines, 1992
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

Mountain View County
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Lower Limit (m³/day)</th>
<th>Upper Limit (m³/day)</th>
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</thead>
<tbody>
<tr>
<td>Residential</td>
<td>0.1</td>
<td>3.4</td>
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<tr>
<td>MultiParcel</td>
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<tr>
<td>Commercial</td>
<td>1 max. available</td>
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<tr>
<td>Light Industrial</td>
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</tr>
<tr>
<td>Agricultural</td>
<td>17.1 max. available</td>
<td></td>
</tr>
</tbody>
</table>

(1) per household
(2) traditional agriculture use as defined in the Water Act

> 500 m³/day
Dry

Major Meltwater Channel

0 km 10 km 20 km
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

Mountain View County
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

<table>
<thead>
<tr>
<th>Use</th>
<th>Maximum Limit (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>500</td>
</tr>
<tr>
<td>Livestock</td>
<td>3,000</td>
</tr>
<tr>
<td>Irrigation</td>
<td>500 - 3,500</td>
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<td>Commercial</td>
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<tr>
<td>Industrial</td>
<td>Depends on purpose</td>
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</table>

From: Canadian Water Quality Guidelines, 1992
Changes in Water Levels – Upper Bedrock Aquifer(s)

Mountain View County
Changes in Water Levels in Upper Bedrock Aquifer(s)

Mountain Views County, Part of the Red Deer River Basin
Regional Groundwater Assessment, Parts of Tp 029 to 034, R 26 to 29, W4M and R 01 to 07, W5M

hydrogeological consultants ltd, edmonton, alberta - 1.800.661.7972 - project no. 00-164

 licensed user of > 50 m³/day
control point

rise 0 decline 5 decline

0 km 10 km 20 km

5th Meridian
Cross-Section C - C'

Mountain View County

Cross-Section C - C'

Elevation in Meters AML

0 100 200 300

Surficial Deposits
MPLC Completion Interval
Hodrock

Vertical exaggeration x 50

Upper
Lacombe
Hugosson

Gulliver Creek
Dogpound Creek
Cremona Slough
Dalehurst
Haynes

Disturbed Belt
Major Meltwater Channel (after Shetsen, 1987)

Cross-Section C - C'

Mountain View County

Red Deer River
Cross-Section D - D'

Mountain View County
Cross-Section D - D'

- Lacombe
- Carstairs Creek
- Carstairs Member

- Rosebud River
- Olds
- Upper Scollard Formation
- Disturbed Belt
- Major Meltwater Channel (after Shetsen, 1987)
- Haynes Member
- Dalehurst Member
- Cross-Section D - D'
- Surface Deposits
- Groundwater Level
- Member
- Vertical exaggeration: x 50

Canada

Hydrogeological consultants Ltd., Edmonton, Alberta - 1.800.661.7972 - project no. 00-164
Appendix E

Water Wells Recommended for Field Verification

and

County-Operated Water Wells
Water Wells Recommended for Field Verification
(details on following pages)
<table>
<thead>
<tr>
<th>Owner</th>
<th>Location</th>
<th>Aquifer Name</th>
<th>Date Water Well Drilled</th>
<th>Completed Depth Metres</th>
<th>NPWL Metres</th>
<th>UID</th>
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<td>Dalehurst</td>
<td>May-54</td>
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<td>Alberta Environment</td>
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<td>Allison, Grace</td>
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<td>Archer, Gerald</td>
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<td>-</td>
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<td>Atkinson, Ernest</td>
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<td>Bell, Stan</td>
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## MOUNTAIN VIEW COUNTY-OPERATED WATER WELLS

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