Regional Groundwater Assessment

Part of the North Saskatchewan River Basin
Parts of Tp 044 to 048, R 22 to 28, W4M & Tp 045 to 047, R 01 to 07, W5M

Prepared for the County of Wetaskiwin

In conjunction with

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada
Prairie Farm Rehabilitation Administration | Administration du rétablisseme agricole des Prairies

Canada

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Our File No.: **07-771.03**

March 2008

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Acknowledgements

Hydrogeological Consultants Ltd. would like to thank the following people for their cooperation and helpful contributions on this project:

Mr. Jim Craig – AAFC-PFRA
Mr. Stephen Majek – County of Wetaskiwin

For additional copies of the report/CD-ROM, please contact the following:

- 1-800-GEO-WELL
- The Groundwater Centre/Regional Groundwater Assessment

http://www.groundwatercentre.com/m_info_rgwa.asp

1 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 can be used as a decision-support tool by the County of Wetaskiwin in managing their groundwater. It is also a guide for future groundwater-related projects.**

1.1 Purpose

This project is a regional groundwater assessment of the County of Wetaskiwin prepared by Hydrogeological Consultants Ltd. (HCL) with financial and technical assistance from the Prairie Farm Rehabilitation Administration branch of Agriculture and Agri-Food Canada (AAFC-PFRA) and the County of Wetaskiwin. The project study area includes the parts of the County of Wetaskiwin bounded by townships 044 to 048, ranges 22 to 28, W4M, and townships 045 to 047, ranges 01 to 07, W5M (herein referred to as the County). The regional groundwater assessment provides 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 country residential, 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 aquifer(s) in the surficial deposits and in the upper bedrock.

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 used in the regional groundwater assessment for the County of Wetaskiwin.

[1] See glossary
[2] See glossary

1.2 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 Familiarization 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.

1.3 About This Report

This report provides an overview of (a) the groundwater resources of the County of Wetaskiwin, (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 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, ArcView files and ArcExplorer files. Likewise, all of the illustrations and maps shown in this report, plus additional maps, figures and cross-sections, are available on the CD-ROM. In order to avoid map-edge effects, all maps are based on an analysis of hydrogeological data from those parts of townships 044 to 048, ranges 22 to 28, W4M, and townships 045 to 047, ranges 01 to 07, W5M, that make up the County, plus a buffer area of 5,000 metres. For convenience, some 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. A plastic County map outline is provided to overlay the maps, and contains information such as towns, main rivers, etc.

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 *Water Act*
3) interpretation of chemical analysis of drinking water
4) 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 *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 that are recommended for field-verification.

This report, and the accompanying support documents, has been prepared in SI Units (metric); for conversions, please refer to Conversion Table on page 68.

[3] See glossary

2 METHODOLOGY

2.1 Data Collection and Synthesis

The Alberta Environment (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) locations of some springs
4) locations for some water wells determined during water well surveys
5) chemical analyses for some groundwaters[4]
6) locations of some flowing shot holes
7) locations of some structure test holes
8) a variety of data related to the groundwater resource.

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

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

The present project uses the 10TM coordinate system based on the NAD83 datum. This means that a record for the SE ¼ of section 01, township 045, range 04, W5M would have a horizontal coordinate with an Easting of 37,507 metres and a Northing of 5,853,081 metres, the centre of the quarter section. If the water well has been repositioned by AAFC-PFRA using orthorectified aerial photographs, the location will be more accurate, possibly within several tens of metres of the actual location. Once the horizontal coordinates are determined for a record, a ground elevation for that record is obtained from the 1:20,000 Digital Elevation Model (DEM); AltaLIS Ltd. provides the DEM.

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

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

[4] Since 1986, Alberta Health and Wellness has restricted access to chemical analysis data; however, 30% of the total chemical analysis data used in the preparation of the hydrogeological maps are from projects involving HCL.

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

1) depth to bedrock
2) total thickness of sand and gravel below 15 metres
3) total thickness of saturated sand and gravel
4) depth to the top and bottom of completion intervals[5].

Also, where sufficient information is available, values for apparent transmissivity[6] and apparent yield[7] are calculated, based on the aquifer test summary data supplied on the water well drilling reports. Where valid detailed aquifer test results exist, the interpreted data provide values for aquifer transmissivity and effective transmissivity. Since the last regional hydrogeological maps covering the County were published in 1971 (LeBreton) and (Tokarsky), and in 1972 (Ozoray), more than 3,700 values for apparent transmissivity and more than 3,400 values for apparent yield have been added to the groundwater database. With the addition of the apparent yield values, including a 0.1-cubic metres per day (m³/day) value assigned to “dry” water wells and water test holes, a hydrogeological map has been prepared to help illustrate the general groundwater availability across the County (Figure 1 and page A-14). The map is based on groundwater being obtained from all aquifers and has been prepared to allow direct comparison with the results provided on the Alberta Geological Survey (AGS) hydrogeological maps (1971 and 1972). In general, the AGS maps show higher estimated long-term yields. The differences between the two map renderings may be a result of fewer apparent yield values, not applying a 0.1-m³/day for “dry” water wells, and the gridding method employed by the AGS.

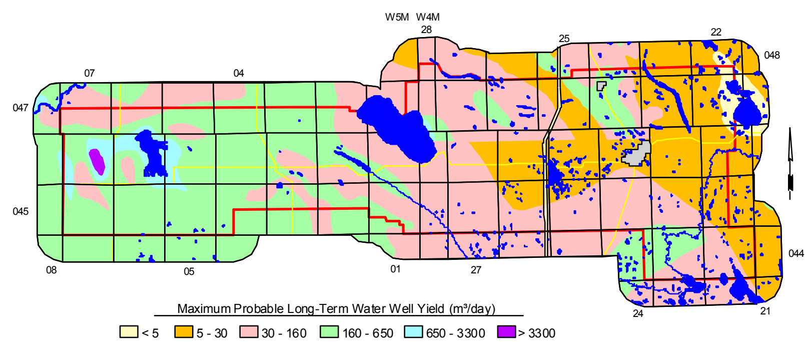

Figure 1. Hydrogeological Map (after LeBreton, Tokarsky, Ozoray)

The Alberta Energy and Utilities Board (EUB) well database includes records for wells drilled for the oil and gas industry. The information from this source includes:

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

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

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

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[5] See glossary
[6] For definitions of Transmissivity, see glossary
[7] For definitions of Yield, see glossary

2.2 Spatial Distribution of Geologic Units

Determination of the spatial distribution of the geologic units is based on:

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

The geologic units 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[8] 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.

2.3 Hydrogeological Parameters

Water well records that indicate the depths to the top and bottom of their completion interval are compared digitally to the spatial distribution of the various geological surfaces. This procedure allows for the determination of the aquifer in which individual water wells are completed. When the completion depth of a water well cannot be established, 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 geologic unit, the parameters from the water well records are assigned to the individual geologic units. The parameters include non-pumping (static) water level (NPWL), apparent transmissivity, and apparent water well yield. The parameters are provided and calculated from data included on the water well drilling reports. The NPWL given on the water well record is usually the water level recorded when the water well was drilled, measured prior to the initial aquifer test. In areas where groundwater levels have since declined, the NPWL may now be lower and, accordingly, the potential apparent yield would be reduced. The total dissolved solids (TDS), sulfate, chloride, Nitrate + Nitrite (as N), fluoride and total hardness concentrations from the chemical analyses of the groundwaters are also assigned to applicable geologic units. Nitrate + Nitrite (as N) concentrations can often be attributed to physical conditions at or near the water well, and may not indicate general aquifer conditions.

Constituent	Recommended Maximum Concentration SGCDWQ (mg/L)	Colour Blends Used on Maps to Indicate Areas that are Below SGCDWQ	Colour Blends Used on Maps to Indicate Areas that Exceed SGCDWQ
Total Dissolved Solids	500		
Nitrate + Nitrite (as N)	10		
Sulfate	500		
Chloride	250		
Fluoride	1.5		

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives (AOs) except for Fluoride and Nitrate + Nitrite (as N), which are for Maximum Acceptable Concentrations (MACs)
SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality
Federal-Provincial-Territorial Committee on Drinking Water, March 2006

Blue hues have been chosen to represent map areas where the chemical parameters are below the Summary of Guidelines for Canadian Drinking Water Quality (SGCDWQ) and orange hues have been chosen to represent map areas where the chemical parameters are above the SGCDWQ.

8 See glossary

After the values for the various parameters of the individual aquifers are established, the spatial distribution of these parameters must be determined. The distribution of individual parameters involves the same process as the distribution of geological surfaces. This means establishing a representative data set and then preparing a grid. The representative data set included using the available data from townships 044 to 048, ranges 22 to 28, W4M, and townships 045 to 047, ranges 01 to 07, W5M, plus a buffer area of at least 5,000 metres. Even when only limited data are available, grids are prepared. However, the grids prepared from the limited data must be used with extreme caution because the gridding process can be unreliable; for the maps, the areas with little or no data are identified.

On some maps, values are posted as a way of showing anomalies to the underlying grid or as a means of emphasizing either the lack of sufficient data or areas where there is concentrated hydrogeological data control.

2.4 Maps and Cross-Sections

After 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.

After the appropriate grids are available, the maps are prepared by contouring the grids. For the Upper Bedrock Aquifer(s) where areas of sufficient data are not available from the groundwater database, prepared maps have been masked with a solid faded pink colour to indicate these areas. These masks have been added to the hydrogeological maps for the Lacombe and Haynes members of the Paskapoo Formation, the Scollard, and the Horseshoe Canyon formations. 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.

Water well records to be used on cross-sections are chosen from the groundwater database, and where possible have the following criteria: geo-referenced lithology; completion interval; and NPWL. Data from these water well control points are then placed in the AutoCAD drawing with an appropriate vertical exaggeration. Tops from individual geologic units are then transferred to the cross-section from the digitally prepared surfaces.

After the technical details of a cross-section have been finalized, the drawing file is moved to the software package CorelDraw! for simplification and presentation in a hard-copy form. Seven cross-sections are presented in Appendix A of this report and as poster-size drawings forwarded with this report; two (A-A’ and B-B’) are included in the text of this report. The cross-sections are also included on the CD-ROM; page-size maps of the poster-size cross-sections are included in Appendix D of this report.

2.5 Software

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

- Acrobat 7.0
- AquaChem 3.7
- ArcView 3.2
- AutoCAD 2004
- CorelDraw! 12.0
- Grapher 3
- Microsoft Office 2003
- Surfer 8

3 INTRODUCTION

3.1 Setting

The County of Wetaskiwin is situated in central Alberta. The County boundaries follow township or section lines, which include parts of the area bounded by townships 044 to 048, ranges 22 to 28, W4M, and townships 045 to 047, ranges 01 to 07, W5M.

The western half of the County is dominated by northwest-trending ridges with elevations ranging from 700 to 1,040 metres above mean sea level (AMSL). The topography in the eastern half of the County is flat to gently rolling with elevations ranging from 700 to 900 metres AMSL, as shown on Figure 2 and page A-5.

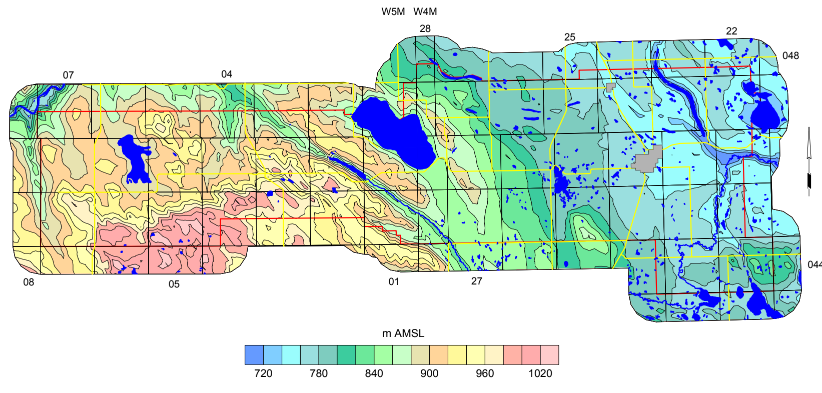

Figure 2. Surface Topography

The County is within the North Saskatchewan River and Battle River sub-basins of the North Saskatchewan River Basin, and the Red Deer sub-basin of the South Saskatchewan River basin (see page A-4). The area is well drained by the Battle River, and numerous smaller rivers, creeks, and lakes.

3.2 Climate

The County of Wetaskiwin lies mainly within the humid, continental Dfb[9] climate. This classification is based on potential evapotranspiration[10] 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 Leggat, 1981) shows that the County is located mainly in the Aspen Parkland region and the Low Boreal Mixedwood region; a small portion in the western part of the County is in the Lower Boreal Cordilleran region. Increased precipitation and cooler temperatures, resulting in additional moisture availability, influence these vegetation changes.

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

The mean annual precipitation averaged from two meteorological stations within the County measured 554 millimetres (mm), based on data from 1971 to 2000. The annual temperature averaged 2.9° C, with the mean monthly temperature reaching a high of 15.7° C in July, and dropping to a low of -11.8° C in January. The calculated annual potential evapotranspiration is 474.4 millimetres.

[9] See glossary
[10] See glossary

4 BACKGROUND INFORMATION

4.1 Number, Type and Depth of Water Wells

There are currently 11,282 records in the groundwater database for the County, of which 9,481 are water wells. Of the 9,481 water wells, there is a proposed use for 8,947 water wells, as shown in the adjacent table. Of the 8,947 water wells, there are records for domestic (6,342), domestic/stock (1,260) or stock (979) purposes. The remaining 366 water wells were completed for industrial (196), municipal (89), and other numerous categories (81); 534 water well designations are classified as "unknown".

Date Completed	Domestic	Domestic/Stock	Stock	Municipal	Industrial	Other	Unknown	Total
No Date	2057	162	48	25	19	24	335	2670
pre-1955	61	224	1	3	3	0	50	342
1955	116	13	11	8	15	0	12	175
1960	263	34	37	11	2	3	25	375
1965	203	69	47	3	9	4	22	357
1970	388	64	107	3	5	2	19	588
1975	589	153	200	4	9	7	27	989
1980	582	138	174	8	52	17	27	998
1985	513	221	169	8	32	9	9	961
1990	531	134	85	10	4	8	2	774
1995	677	26	36	3	38	2	3	785
2000	362	22	64	3	8	5	3	467
Total	6342	1260	979	89	196	81	534	9481

Table 1. Proposed Use for Water Wells

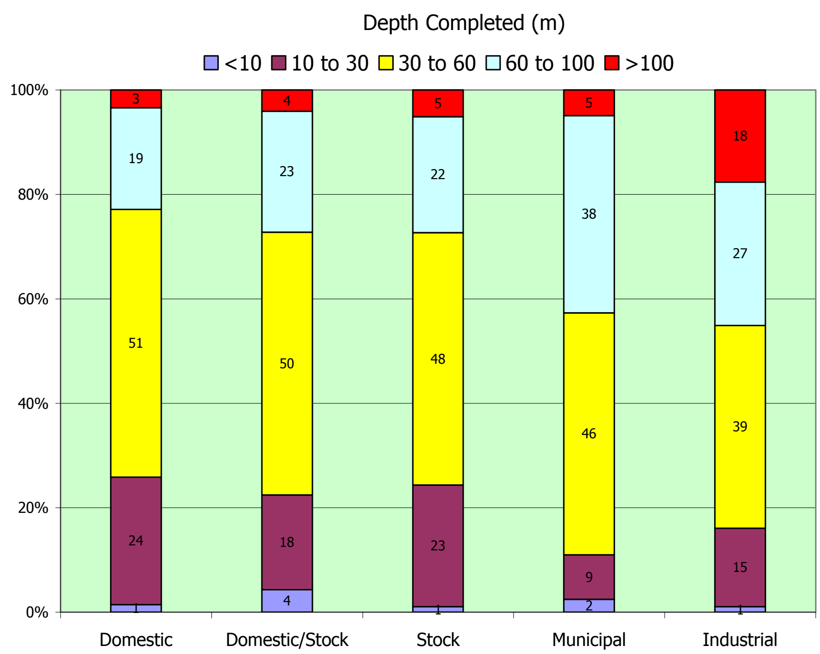

Figure 3. Proposed Use vs Completed Depth

The highest percentages of domestic (51%), domestic/stock (50%), stock (48%), municipal (38%), and industrial (39%) water wells are completed in the depth interval between 30 and 60 metres below ground surface, as shown in Figure 3.

Details for lithology[11] are available for 6,407 water wells.

[11] See glossary

4.2 Number of Water Wells in Surficial and Bedrock Aquifers

There are 5,747 water wells with completion interval and lithologic information, such that the aquifer in which the water wells are completed can be identified. 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**. The water wells that were drilled deep enough that the top of their completion interval is below the top of the bedrock are completed in at least one **bedrock aquifer.** Of the 5,747 water wells with completion interval and lithologic information, 202 are completed in surficial aquifers, and 5,545 are completed in at least one bedrock aquifer.

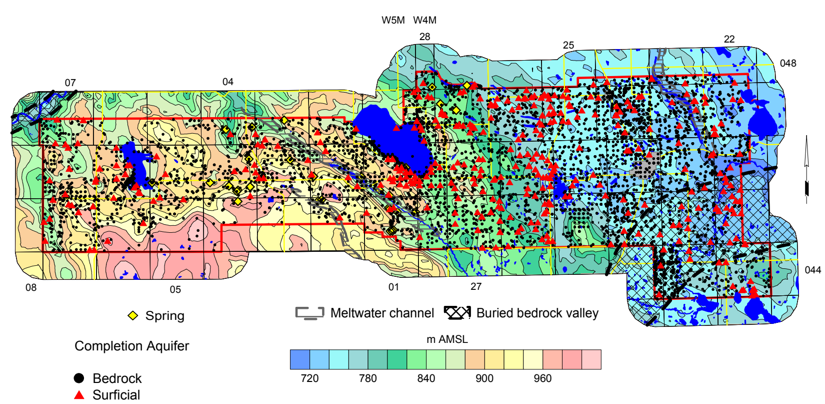

Figure 4. Locations of Water Wells and Springs Relative to Bedrock Topography

From the present hydrogeological analysis, 438 water wells are completed in aquifers in the surficial deposits. This number of water wells (438) is more than twice the number (202) determined to be completed in aquifers in the surficial deposits, based on lithologies given on the water well drilling reports. The larger number is obtained by comparing the elevation of the reported depth of a water well to the elevation of the bedrock surface at the same location. For example, if only the depth of a water well is known, the elevation of the completed depth can be calculated. If the elevation of the completed depth is above the elevation of the bedrock surface determined from the gridded bedrock topographic surface at the same location, then the water well is considered to be completed in an aquifer in the surficial deposits. If the elevation of the top of the completion interval is below the elevation of the bedrock surface, then the water well is considered to be completed in at least one bedrock aquifer. From the present hydrogeological analysis, 8,364 water wells are completed in at least one bedrock aquifer.

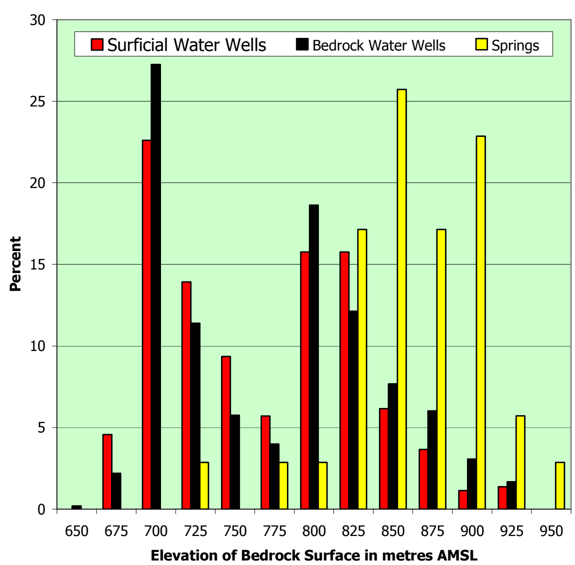

Figure 5. Water Wells and Springs Relative to Bedrock Topography

Water wells completed in surficial deposits and in bedrock aquifers are mainly completed in areas of bedrock elevations of less than 850 metres AMSL, as shown on Figure 4. When the bedrock surface is below 825 metres AMSL, there are generally more water wells completed in surficial deposits than water wells completed in bedrock aquifers. When the bedrock surface is above 825 metres AMSL, there are generally more water wells completed in surficial deposits than water wells completed in bedrock aquifers, as shown on the adjacent bar chart (Figure 5).

Within the County of Wetaskiwin, there are currently records for 35 springs in the groundwater database, The springs are mainly in areas where the bedrock elevation is above 825 metres AMSL. There are 21 springs having at least one TDS value, with five springs having a TDS of more than 500 milligrams per litre (mg/L). There are two springs in the groundwater database with flow rates; the flow rates were measured by the Alberta Research Council in 1969.

4.3 Casing Diameter and Type

Data for casing diameters are available for 6,556 water wells, with 6,496 (99%) indicated as having a diameter of less than 275 mm and 60 (1%) having a diameter of more than 275 mm. The casing diameters of greater than 275 mm are mainly bored, hand dug, or dug by backhoe water wells and those with a surface-casing diameter of less than 275 mm are mainly drilled water wells. The entire water well database for the County suggests that 160 of the water wells in the County were bored, hand dug or dug by backhoe and 7,820 are drilled water wells.

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. Within the County, casing-diameter information is available for 178 of the 438 water wells completed in the surficial deposits, of which 144 surficial water wells have a casing diameter of less than 275 mm and are assumed to be drilled water wells. Within the County, casing-diameter information is available for 5,760 of the 8,364 water wells completed below the top of bedrock, of which 5,749 have a surface-casing diameter of less than 275 mm and have been mainly completed with either a perforated liner or as open hole. Water wells completed in bedrock aquifers usually do not require water well screens, although some of the sandstones may be friable[12] and water well screens are a necessity. In the County, 37 bedrock water wells are completed with a water well screen.

Where the casing material is known, steel surface casing materials have been used in 59% of the drilled water wells over the last 50 years. For the remaining drilled water wells with known surface casing material, 22% were completed with galvanized steel, and the remaining 19% were completed with plastic casing. The main years where the type of surface casing was undocumented were prior to 1955 to the mid-1960s. Plastic casing was first used in May 1970, and is currently being used in 73% of the water wells drilled in the County.

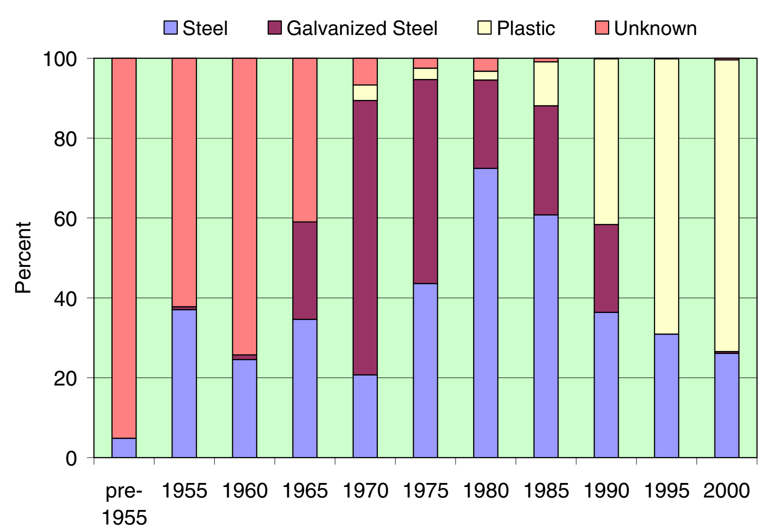

Figure 6. Surface Casing Types Used in Drilled Water Wells

4.4 Dry Water Test Holes

In the County, there are 11,282 records in the groundwater database. Of these 11,282 records, 68 (< 1%) are indicated as being "dry" or "abandoned" with "insufficient water"[13]. Of the 68 "dry" water test holes, five are completed in surficial deposits and 63 are completed in bedrock. Eleven percent of all water wells with apparent yield estimates were judged to yield less than 6.5 m³/day (1 igpm).

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

4.5 Requirements for Licensing

With some exemptions, a diversion of groundwater starting after 01 Jan 1999 must have a licence. Exemptions include (1) the diversion for household use of up to 3.4 cubic metres per day (1,250 m³/year [750 imperial gallons per day[14]]), (2) the diversion of groundwaters with total dissolved solids in excess of 4,000 mg/L, (3) the diversion from a manually pumped water well, or (4) a diversion of groundwater that was eligible for registration as "Traditional Agriculture Use" but was not registered can continue to be used for Traditional Agriculture Use but without the protection of the *Water Act*.

In the last update from the AENV groundwater database, 1,448 groundwater licences and/or registrations were shown to be within the County, with the most recent groundwater user being licensed in August 2007. Of the 1,448 licensed and/or registered groundwater users, 1,140 (79%) are registrations of Traditional Agriculture Use under the *Water Act*. These 1,140 registered users will continue to divert groundwater for stock watering and/or crop spraying. Typically, the groundwater diversion for crop spraying averages less than one m³/day so most registered groundwater diversion is for stock watering. Of the remaining 308 groundwater users, 269 are for agricultural purposes (mainly stock watering), 16 are for municipal purposes (mainly urban), ten are for industrial purposes, nine are for commercial purposes, two are for dewatering purposes, one is for recreation purposes, and the remaining one is listed as for other purposes. Of the 1,140 registrations, 827 (73%) could be linked to the AENV groundwater database. Of the 308 licensed groundwater diversions in the County, 258 (84%) could be linked to the AENV groundwater database. The maximum amount of groundwater that can be diverted each year from the water wells associated with these licences and/or registrations is 8,328 m³/day, although actual use could be less. Of the 8,328 m³/day, 3,113 m³/day (37%) is registered for Traditional Agriculture Use, 2,147 m³/day (26%) is licensed for agricultural purposes, 1,523 m³/day (18%) is licensed for municipal purposes, 1,058 m³/day (13%) is licensed for industrial purposes, and 185 m³/day (2.3%) is licensed for dewatering, other and recreation purposes, as shown below in Table 2. A figure showing the locations of the groundwater users with either a licence or a registration is in Appendix A (page A-10) and on the CD-ROM. Table 2 also shows a breakdown of the 1,448 groundwater licences and/or registrations by the aquifer in which the water well is completed. Sixty-six percent of the total quantity of licensed and registered groundwater use is from the Dalehurst (26%) and Upper Horseshoe Canyon (40%) aquifers. The water wells associated with the 319 licensed and/or registered use where a specific aquifer cannot be determined is because insufficient completion information is available.

Aquifer **	No. of Licences and/or Registrations	Registrations (m³/day)	Licensed Groundwater Users* (m³/day) Agricultural	Municipal	Commercial	Industrial	Dewatering	Recreation	Other	Total Groundwater Diversion (m³/day)	Percentage
Upper Sand and Gravel	58	111	22	0	162	0	122	0	0	416	5.0
Lower Sand and Gravel	21	46	17	0	0	0	0	0	0	63	0.8
Mulitple Bedrock Completion	84	173	170	30	0	74	0	0	0	447	5.4
Dalehurst	356	778	374	77	0	906	0	0	0	2,135	25.6
Upper Lacombe	94	124	88	44	5	0	0	0	56	316	3.8
Lower Lacombe	85	173	40	0	5	78	0	0	0	296	3.6
Haynes	61	173	20	0	0	0	0	0	0	194	2.3
Upper Scollard	62	120	134	0	0	0	0	0	0	255	3.1
Lower Scollard	66	136	185	0	0	0	0	0	0	321	3.9
Upper Horseshoe Canyon	405	946	987	1,372	10	0	0	7	0	3,321	39.9
Middle Horseshoe Canyon	71	133	85	0	0	0	0	0	0	217	2.6
Lower Horseshoe Canyon	11	10	17	0	0	0	0	0	0	27	0.3
Unknown	74	190	8	0	121	0	0	0	0	319	3.8
Total	1,448	3,113	2,147	1,523	302	1,058	122	7	56	8,328	100.0
Percentage		37.4	25.8	18.3	3.6	12.7	1.5	0.1	0.7	100	

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

Table 2. Licensed and/or Registered Groundwater Diversions

14 see conversion table on page 64

Based on the 2006 Agriculture Census (Statistics Canada, 2007), the calculated water requirement for 326,344 livestock within the County is in the order of 7,294 m³/day. This number includes intensive livestock use but not domestic animals and is based on an estimate of water use per livestock type. Of the 7,294 m³/day calculated livestock use, AENV has authorized a groundwater diversion of 5,260 m³/day (agricultural and registration) and licensed a surface-water diversion (stock and registration) based on consumptive use of 1,584 m³/day, for a total diversion of 6,844 m³/day. Agriculture purpose includes water diverted and used for stockwatering and feedlot use. This assumes the majority of the groundwater and surface water authorized for diversion for Traditional Agriculture Use is used for watering livestock. Using this assumption, 94% of the estimated total water requirements of 7,294 m³/day is accounted for.

Livestock Type	Number [1]	Estimated Water Requirement (m³/day)
Total hens and chickens [2]	91,230	19
Turkeys	69,063	47
Other poultry	3,333	1
Total cattle and calves	111,772	6,097
Total pigs	29,049	528
Total sheep and lambs	8,505	77
Horses and ponies	5,792	263
Goats	0	0
Mink	0	0
Fox	0	0
Bison	4,835	220
Deer and elk	2,453	39
Llamas and alpacas	312	3
Totals	326,344	7,294

(1) 2006 Census of Agriculture

(2) 2001 Census of Agriculture; 2006 data was suppressed to meet confidentiality of the *Statistics Act*

Table 3. Estimated Water Requirement for Livestock in the County of Wetaskiwin

The remaining 450 m³/day (6%) of the calculated water requirement for livestock use would have to be from other, including unlicensed, sources. The discrepancy may be partially accounted for in several ways. At the time of application for the licence, the applicant may have had more livestock than the current 2006 Agriculture Census numbers, or the applicant applied for the amount of water needed for a planned expansion that did not take place. Based on some monitoring and reporting situations, the estimated water requirements for livestock, used by AENV, tend to be somewhat high. Some livestock water requirements would be made up from free-standing water following precipitation events, thus reducing the expected quantity needed. Also, it should be noted that 'household use', as defined in the *Water Act*, can provide sufficient water for about 75 head of cattle, with no need for a licence. It is possible that some such use may have been registered as Traditional Agriculture Use and would therefore be included in the registration quantity. Also, diversions of groundwater and surface water that were eligible for registration as Traditional Agriculture Use can continue to be used for traditional agricultural purposes without the need for authorization.

4.6 Base of Groundwater Protection

In general, AENV defines the Base of Groundwater Protection (BGP) as the elevation below which the groundwater will have more than 4,000 mg/L of total dissolved solids. By using the ground elevation, formation elevations, and Alberta Energy and Utilities Board (EUB) information indicating the formations containing the deepest useable water for agricultural needs, a value for the depth to the BGP can be determined. These values are gridded using the Kriging method to prepare a depth to the BGP 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 a TDS concentration that exceeds 4,000 mg/L, the groundwater use does not require licensing by AENV. In the County, the depth to the Base of Groundwater Protection ranges from less than 200 metres to more than 700 metres, as shown below on Figure 7, on some cross-sections presented in Appendix A, and on the CD-ROM. In the western part of the County, the BGP trends from the west corresponding to near the top of the Lower Scollard Formation to the east to near the top of the Oldman Formation (see pages A-15, A-16, and A-21).

There are 8,783 water wells with completed depth data, of which two appear to be completed below the BGP. The two water wells that are completed below the BGP, were drilled for industrial purposes, and have completed depths of more than 300 metres BGL. Chemistry details are available for 2,115 of the 8,783 water wells; the TDS concentrations for the 2,115 water wells are less than 3,000 mg/L.

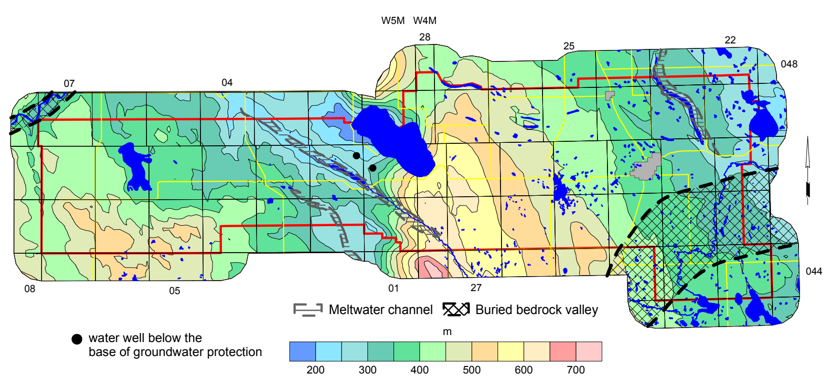

Figure 7. Depth to Base of Groundwater Protection (after EUB, 1995 and Tokarsky, 1986)

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 (see page A-68 for the observation water well locations). Of the two observation water wells, only one is currently being monitored (see section 7.1 of this report). In the past, the data for authorized diversions have been difficult to obtain from AENV, in part because of the failure of the applicant to provide the data. Even with the available sources of data, the number of water level data points relative to the size of the County is too few to provide a reliable groundwater budget (see section 7.3 of this report). The most cost-efficient method to collect additional groundwater monitoring data would be to have the water well owners measuring the water level in their own water well on a regular basis, as has been the case in the Wildrose Country Ground Water Monitoring Association and the M.D. of Flagstaff.

The County of Grande Prairie was involved in a Regional Groundwater Assessment in 2002 and, from the study, it was identified that there is a shortage of information related to changes in the water levels in the various aquifers in the region. In an attempt to supplement the existing data, a groundwater monitoring program has been set up to measure the water levels in 50 selected water wells each month over the next five years; in three selected water wells, water levels are being measured six times a day with a dedicated data logger. Also, groundwater samples are to be collected from the 50 monitored water wells in the County of Grande Prairie to determine if changes in the groundwater quality are taking place.

5 TERMS

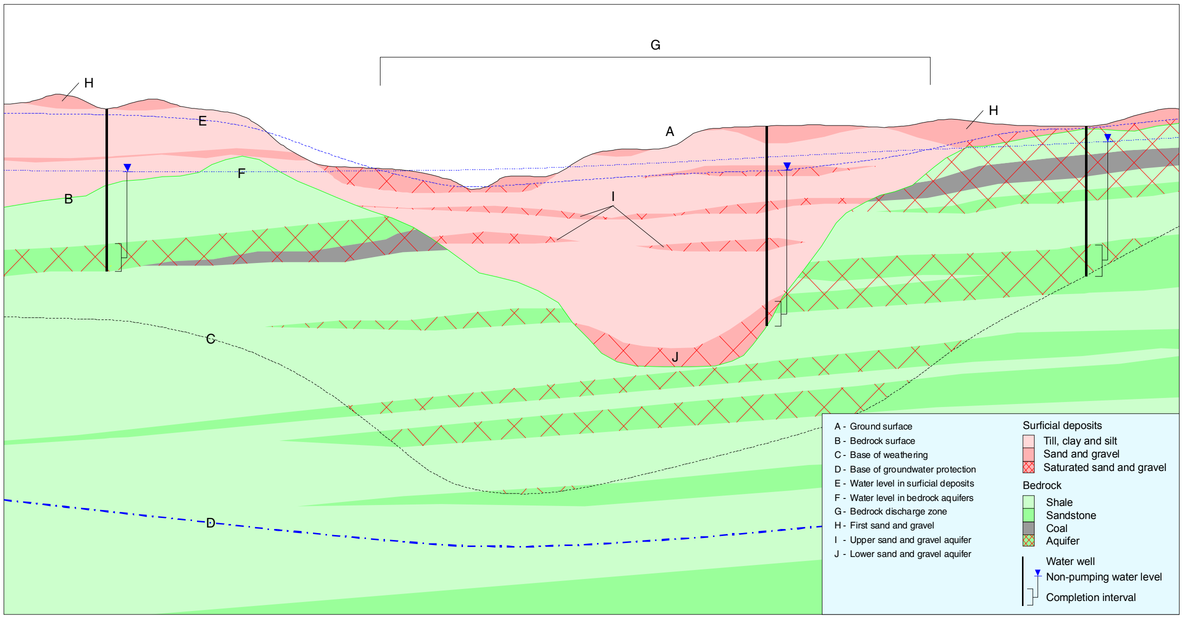

Figure 8. Generalized Cross-Section (for terminology only)

(for larger version, see page A-12)

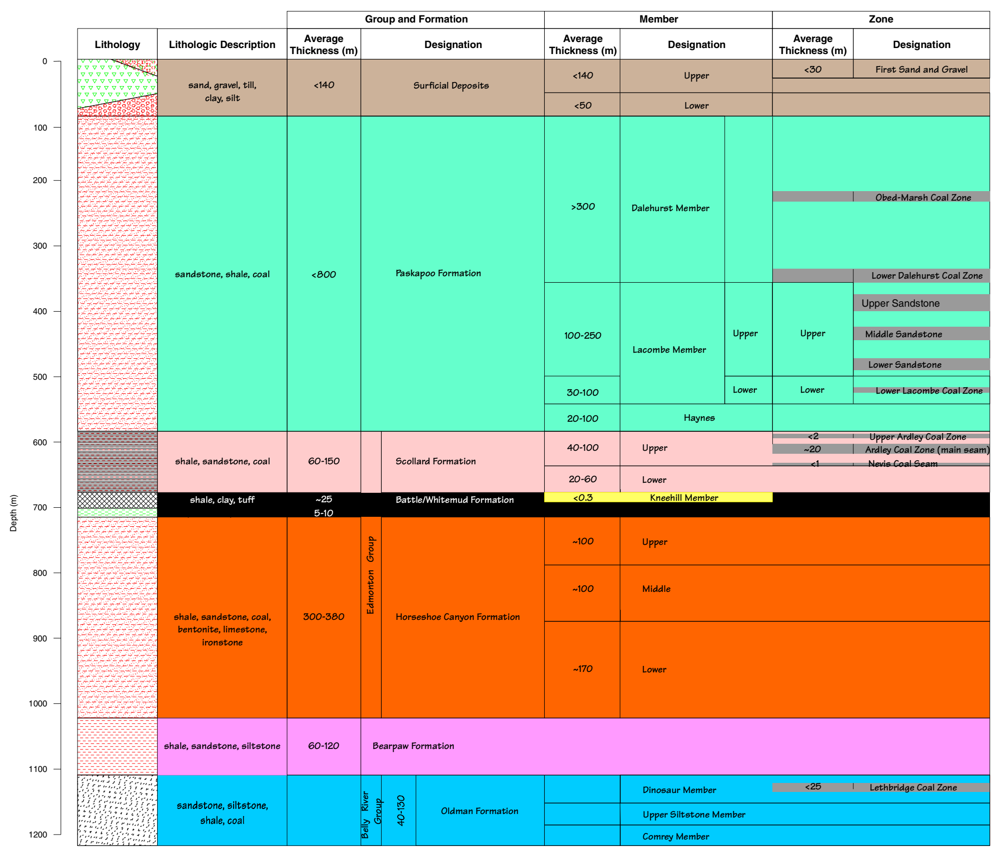

Figure 9. Geologic Column

(for larger version, see page A-13)

6 AQUIFERS

6.1 Background

An aquifer is a permeable geologic unit[15] that is saturated. In this context, “geologic unit” refers to subsurface materials, such as sand, gravel, sandstone and coal. 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 sediments are referred to as the surficial deposits. The second geological setting includes aquifers in the upper bedrock. If the NPWL is above the top of the geologic unit, this type of aquifer is a confined or artesian aquifer. If the rock unit is not entirely saturated and the water level is below the top of the geologic unit, this type of aquifer is a water-table aquifer. 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.

6.2 Surficial Deposits – Geological Characteristics

The surficial deposits are the sediments above the bedrock surface. These include pre-glacial materials, which were deposited before glaciation, and materials deposited directly or indirectly as a result of glaciation. For the present study, the surficial deposits have been assigned to two different groupings in the County: (a) Lower Surficial, (b) Upper Surficial. The Lower Surficial deposits include pre-glacial fluvial[16] deposits. The Upper Surficial deposits include the traditional glacial sediments of till[17] and ice-contact deposits. Pre-glacial materials are expected to be present in association with linear bedrock lows.

While the surficial deposits are treated as one hydrogeologic unit[18], they consist of three hydraulic units[19]. The first unit is the preglacial sand and gravel deposits of the Lower Surficial deposits that directly overlie the bedrock surface, when present. These deposits are mainly saturated. The second and third hydraulic units are associated with the sand and gravel deposits in the Upper Surficial deposits. The sand and gravel deposits in the Upper Surficial deposits occur mainly as pockets. The second hydraulic unit is the saturated part of these sand and gravel deposits; the third hydraulic unit is the unsaturated part of these deposits that occurs close to ground surface. For a graphical depiction of the above description, please refer to Figure 8, page 14 and to page A-12. While the unsaturated deposits are not technically an aquifer, they are significant as they provide a pathway for soluble 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 following page on Figure 10 and on page A-22. Regionally, the bedrock surface varies between 720 and 1,100 metres AMSL. The lowest elevations occur in the buried bedrock valleys.

Over the majority of the County, the surficial deposits are less than 30 metres thick (see CD-ROM). The exceptions are mainly in association with areas where bedrock lows are present, where the deposits can have a maximum thickness of 50 metres.

15 See glossary
16 See glossary
17 See glossary
18 See glossary
19 See glossary

6.2.1 Buried Valleys

The main linear bedrock low in the County is the Red Deer Buried Valley. The Red Deer Buried Valley is a southwest-northeast-trending linear bedrock low that is present in the southeastern part of the County. The Valley ranges from approximately nine to 15 kilometres wide, with local bedrock relief being less than 40 metres. Sand and gravel deposits can be expected in association with the bedrock low, but the thickness of the sand and gravel deposits in these areas is expected to be mainly less than ten metres (see page A-23).

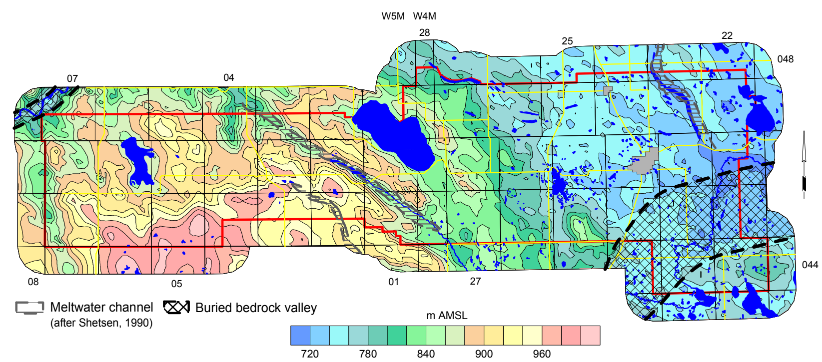

Figure 10. Bedrock Surface Topography

The Drayton Buried Valley (Carlson, 1970) is a southwest-northeast-trending linear bedrock low that it is occupied by the present-day North Saskatchewan River, which borders the extreme northwestern border of the County. In the County, the Drayton Buried Valley ranges from approximately four to eight kilometres wide, with local bedrock relief being less than 60 metres. Sand and gravel deposits can be expected in association with the bedrock low, but the thickness of the sand and gravel deposits is expected to be mainly less than five metres.

The combined thickness of all sand and gravel deposits has been determined as a function of the total thickness of the surficial deposits. Where sand and gravel deposits are present, the sand and gravel deposits are mainly less than five percent of the total thickness of the surficial deposits, as shown on the adjacent figure. The areas where sand and gravel deposits constitute more than ten percent of the total thickness of the surficial deposits are mainly in association with the Red Deer Buried Valley, as shown on the adjacent figure.

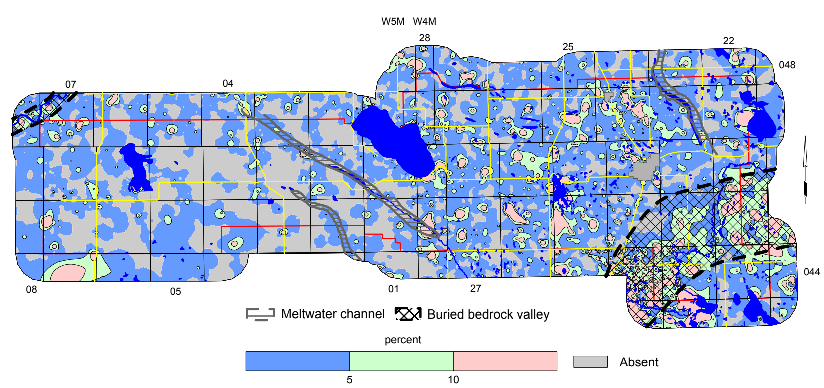

Figure 11. Percentage of Sand and Gravel in Surficial Deposits

The upper surficial deposits are either directly or indirectly a result of glacial activity. The deposits include till, with minor sand and gravel deposits of meltwater origin, which are expected to occur mainly as isolated pockets. In the County, there are linear bedrock lows that trend mainly northwest to southeast and are indicated as being of meltwater origin. The two major meltwater channels in the County have been outlined by Shetsen (1990). The thickness of the upper surficial deposits is mainly less than 30 metres. Upper surficial deposits are present throughout most of the County (see CD-ROM). The upper sand and gravel deposits are mainly less than two metres thick (see CD-ROM).

The lower surficial deposits are composed mostly of fluvial and lacustrine deposits. Lower surficial deposits occur over the County, but mainly in linear bedrock lows. The total thickness of the lower surficial deposits is mainly less than two metres, but can be more than five metres in the linear bedrock lows (see CD-ROM). The lowest part of the lower surficial deposits includes pre-glacial sand and gravel deposits. These deposits would generally overlie the bedrock surface in the Buried Red Deer Valley, as shown below on Cross-Section B-B’ and page A-16. The lowest sand and gravel deposits are of fluvial origin, are usually less than ten metres thick and may be discontinuous (see CD-ROM).

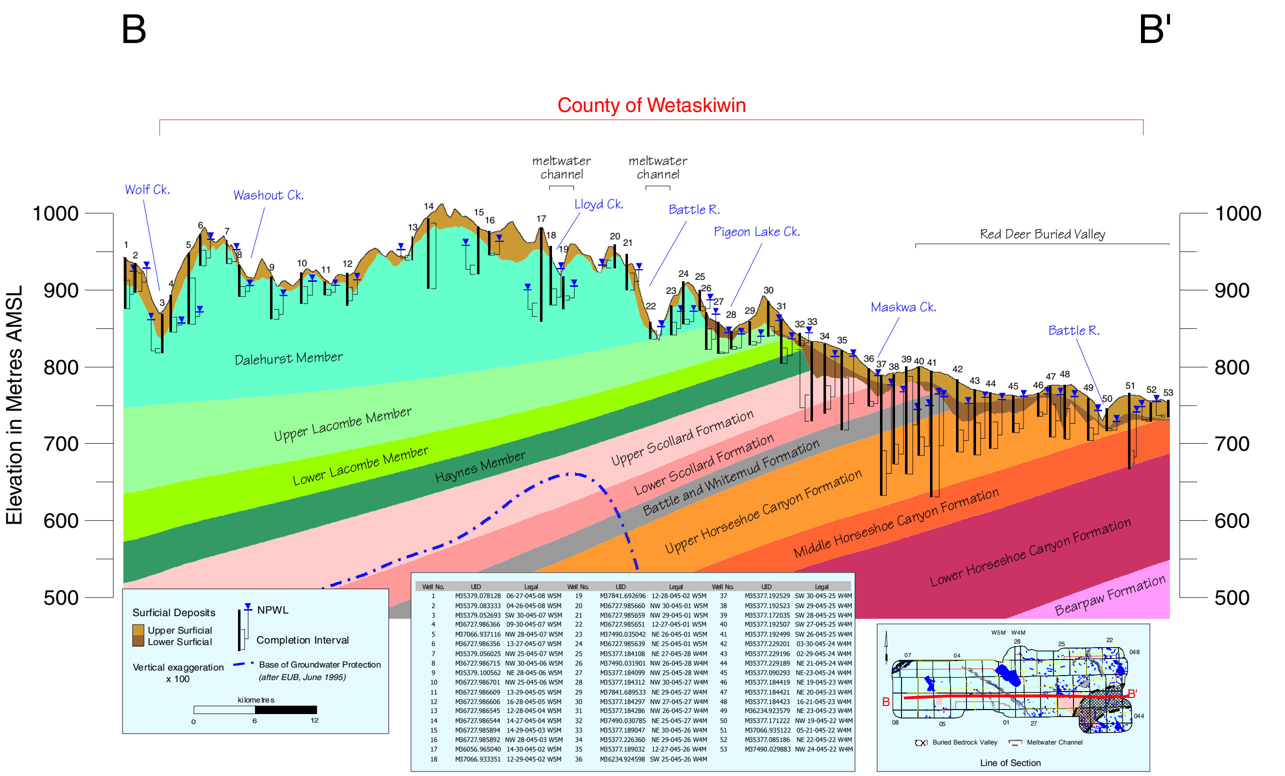

Figure 12. Cross-Section B - B'

6.2.2 Sand and Gravel Aquifer(s)

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 non-pumping water level in water wells that are less than 20 metres deep. The base of the surficial deposits is the bedrock surface.

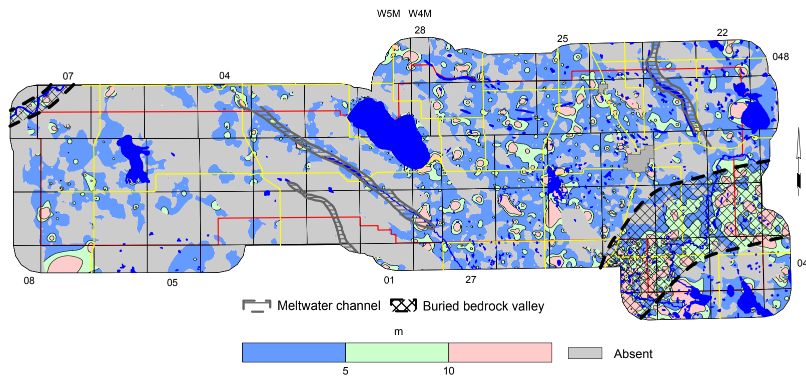

Figure 13. Thickness of Sand and Gravel Aquifer(s)

Since the Sand and Gravel Aquifer(s) are not present everywhere, the actual aquifer that is developed at a given location is usually dictated by the aquifer that is present. Over approximately 45% of the County, saturated sand and gravel deposits are not present; these areas are designated as grey on the adjacent map. In the County, the thickness of the Sand and Gravel Aquifer(s) is generally less than five metres, but can be more than ten metres, particularly in association with the Red Deer Buried Valley, as shown in Figure 13, in Appendix A and on the CD-ROM.

Of the 9,481 water wells in the database, 438 were defined as being completed in surficial aquifers (see page 9). Of the 438 water wells, 343 are completed in aquifers in the Upper Surficial deposits, 94 are completed in aquifers in the Lower Surficial deposits, and one water well is completed in multiple surficial aquifers. Water wells completed in the Lower Surficial deposits are in association with the Red Deer Buried Valley, and in areas where the bedrock elevation is below 850 metres AMSL. Water wells completed in the Upper Surficial deposits are frequently in bedrock lows but are also located at higher bedrock elevations, as shown on Figure 14.

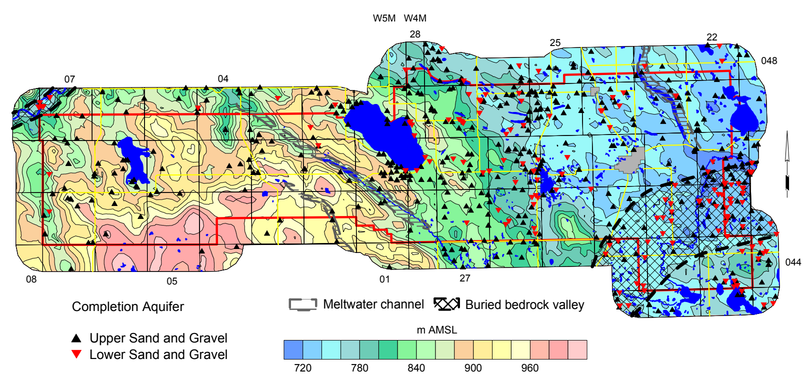

Figure 14. Location of Surficial Water Wells Relative to Bedrock Topography

In the County, there are 49 records for surficial water wells with apparent yield data, which is 11% of the 438 surficial water wells. Eleven (22%) of the 49 water wells completed in the Sand and Gravel Aquifer(s) have apparent yields that are less than ten m³/day, 25 (51%) have apparent yield values that range from 10 to 100 m³/day, and 13 (27%) have apparent yield values that are greater than 100 m³/day. In addition to the 49 records for surficial water wells with apparent yield data, there are five records that indicate that the water test hole is "dry". In order to depict a more accurate yield map, an apparent yield of 0.1 m³/day was assigned to each of the five "dry" water test holes prior to gridding.

Aquifer	No. of Water Wells with Values for Apparent Yield (*)	Number of Water Wells with Apparent Yields <10 m³/day	10 to 100 m³/day	>100 m³/day
Upper Surficial	34	11	16	7
Lower Surficial	15	0	9	6
Totals	49	11	25	13

Table 4. Apparent Yields of Sand and Gravel Aquifer(s)

The adjacent map shows expected yields for water wells completed in the Sand and Gravel Aquifer(s).

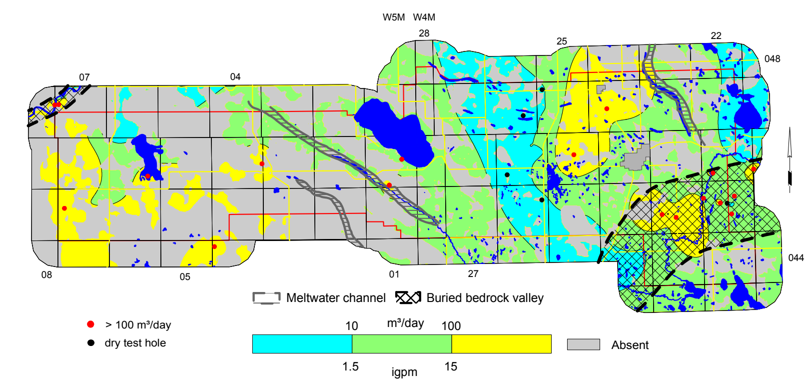

Figure 15. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

Based on the aquifers that have been developed by existing water wells, these data show that water wells with yields of more 100 m³/day (15 igpm) can be expected in several areas of the County. The most notable areas where yields of more than 100 m³/day from the Sand and Gravel Aquifer(s), where present, can be expected, and based on the most number of control points, are in association with the Red Deer Buried Valley. Between Nov 10 and 20, 1981, AENV drilled and tested numerous water test holes in townships 045 and 046, ranges 21 and 22, W4M to determine the continuity of sand and gravel deposits for a proposed dam on the Battle River near Gwynne (Lorberg, 1982).

Apparent yields for water wells completed in the Sand and Gravel Aquifer(s) vary significantly over the County both with location and with depth. As Figure 16 shows, most apparent yields are less than 100 m³/day, and the majority of the water wells completed in the Sand and Gravel Aquifer(s) are less than 30 metres deep.

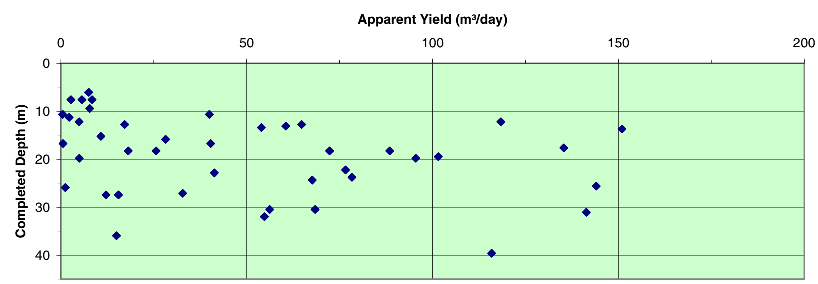

Figure 16. Sand and Gravel Water Well Yields vs Completed Depth

6.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

Groundwaters from aquifers in the surficial deposits can be expected to be chemically hard, with a total hardness of at least a few hundred mg/L (see CD-ROM), and a dissolved iron concentration such that the groundwater must be treated before being used for domestic needs. Forty percent of the groundwaters from the surficial deposits are reported to have dissolved iron concentrations of more than the aesthetic objective (AO) of 0.3 mg/L. However, many iron analyses results are questionable due to varying sampling and analytical methodologies.

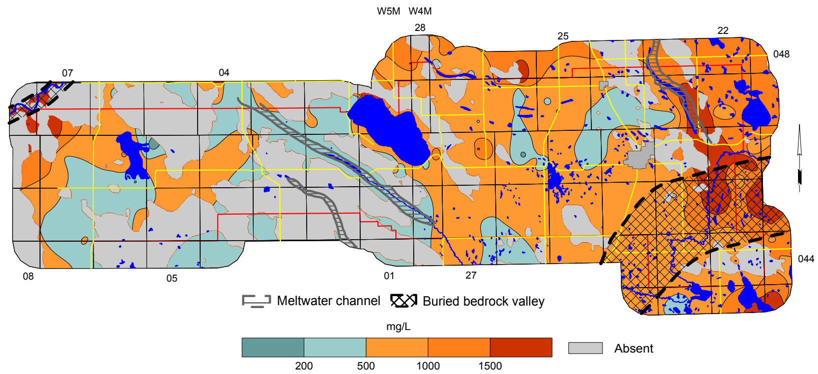

Figure 17. Total Dissolved Solids in Groundwater from Surficial Deposits

The Piper tri-linear diagram[20] for the surficial deposits (see page A-32) shows that the groundwaters from the surficial deposits are mainly a calcium-magnesium-bicarbonate-type waters. More than 65% of the groundwaters from the surficial deposits have a TDS concentration of more than 500 mg/L.

In some areas, the groundwater chemistry of the surficial deposits is such that sulfate is the major 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; in more than 85% of the samples analyzed for surficial deposits in the County, the chloride ion concentration is less than 50 mg/L (see CD-ROM). In the County, the Nitrate + Nitrite (as N) concentrations in the groundwaters from the surficial deposits exceed the maximum acceptable concentration (MAC) of ten mg/L in two of the 101 groundwater samples analyzed. A plot of Nitrate + Nitrite (as N) in surficial aquifers is on the accompanying CD-ROM.

The minimum, maximum and median[21] 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 Summary of Guidelines for Canadian Drinking Water Quality (SGCDWQ) in the adjacent table. The range of concentrations shown in Table 5 is from values in the groundwater database; however, the extreme minimum and maximum concentrations generally represent less than 0.2% of the total number of analyses and should have little effect on the median values. These extreme values are not used in the preparation of the figures.

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	144	70	2,794	621	500
Sodium	112	0	570	125	200
Sulfate	144	0	1,600	53	500
Chloride	144	0	851	4	250
Nitrate + Nitrite (as N)	101	0	25	0.0	10

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Nitrate + Nitrite (as N), which is for Maximum Acceptable Concentration (MAC)
SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality Federal-Provincial-Territorial Committee on Drinking Water, March 2006

Table 5. Concentrations of Constituents in Groundwaters from Surficial Deposits

Of the five constituents that have been compared to the SGCDWQ, median concentrations of TDS exceed the guidelines.

20 See glossary
21 See glossary

6.2.3 Upper Sand and Gravel Aquifer

The Upper Sand and Gravel Aquifer includes saturated sand and gravel deposits in the Upper Surficial deposits. Typically, these aquifers are present within the surficial deposits at no particular depth. Saturated sand and gravel deposits in the Upper Surficial deposits are not usually continuous over large areas but are expected over approximately 15% of the County.

6.2.3.1 Aquifer Thickness

The thickness of the Upper Sand and Gravel Aquifer is a function of two parameters: (1) the elevation of the non-pumping water-level surface associated with the surficial deposits; and (2) the depth to the bedrock surface or the depth to the top of the Lower Surficial deposits, when present. In the County, the thickness of the Upper Sand and Gravel Aquifer is mainly less than two metres but can be more than five metres in the buried bedrock valleys.

6.2.3.2 Apparent Yield

The permeability of the Upper Sand and Gravel Aquifer can be high. The high permeability combined with significant thickness leads to an extrapolation of high yields for water wells; however, because the sand and gravel deposits occur mainly as hydraulically discontinuous pockets, the long-term yields of the water wells are expected to be less than the apparent yields. The long-term yields for water wells completed through this Aquifer are expected to be mainly less than those shown on the adjacent figure.

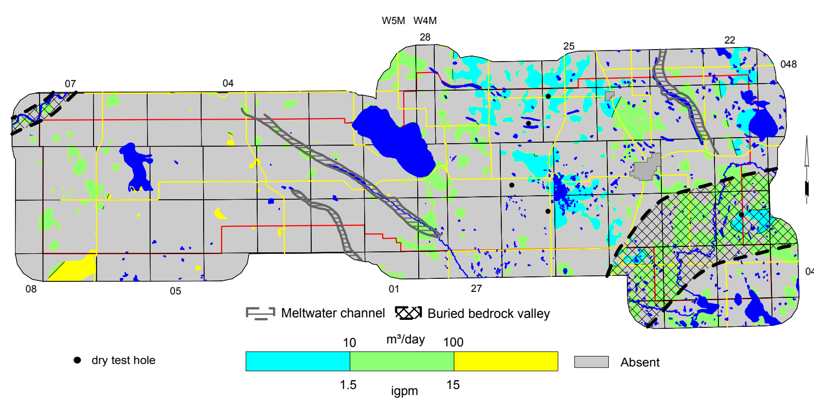

Figure 18. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

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

Figure 18 indicates that in 10% of the County, water wells completed through the Upper Sand and Gravel Aquifer where present are expected to have apparent yields that are less than 100 m³/day. In the County, there are 14 “dry” water test holes completed in the Upper Sand and Gravel Aquifer.

In the County, there are 58 licensed and registered water wells that are completed through the Upper Sand and Gravel Aquifer, for a total authorized diversion of 416 m³/day (Table 2, page 11), with a median authorized amount of 1.6 m³/day. Twenty-four of the 58 licences and registrations for water wells completed through the Upper Sand and Gravel Aquifer could be linked to a water well in the AENV groundwater database.

The highest authorized groundwater diversion of 162 m³/day is for a water well that is used by the gravel industry for aggregate washing. The County of Wetaskiwin is authorized to divert 122 m³/day for dewatering purposes from two water wells completed in the Upper Sand and Gravel Aquifer. The combined total of 284 m³/day represents 68% of the total authorized diversion of 416 m³/day. The highest authorized groundwater use for a registered water well completed in the Upper Sand and Gravel Aquifer is 9.3 m³/day in SE 31-046-26 W4M.

6.2.4 Lower Sand and Gravel Aquifer

The Lower Sand and Gravel Aquifer, the oldest of the surficial deposits, is a saturated sand and gravel deposit that occurs at or near the base of the surficial deposits in the deeper part of the buried bedrock valleys. The thickness of the Lower Sand and Gravel Aquifer is generally less than five metres but can be more than five metres mainly in association with the Red Deer Buried Valley.

6.2.4.1 Depth to Top

The depth to the top of the Lower Sand and Gravel Aquifer ranges from ground surface to more than 30 metres BGL (see CD-ROM).

6.2.4.2 Apparent Yield

The apparent yield values for individual water wells completed through the Lower Sand and Gravel Aquifer range from less than ten to greater than 300 m³/day, and have a median apparent yield of 57 m³/day. Water wells with yields of greater than 100 m³/day are expected to be mainly in association with the Red Deer Buried Valley, as shown on Figure 19.

In the County, there are no “dry” water test holes completed in the Lower Sand and Gravel Aquifer.

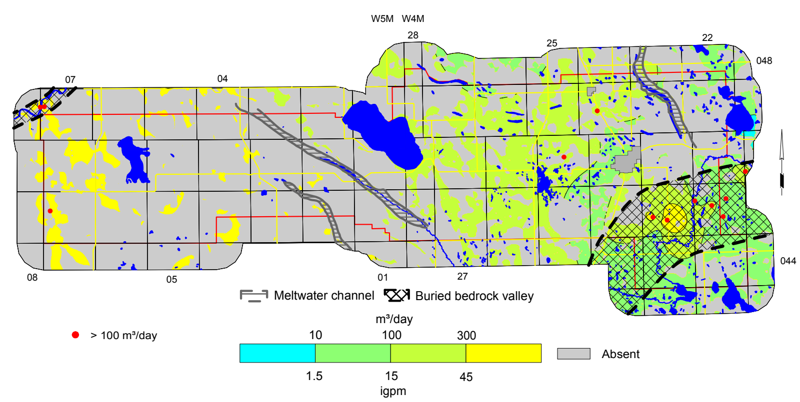

Figure 19. Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer

In the County, there are 21 licensed and/or registered water wells that are completed through the Lower Sand and Gravel Aquifer, for a total authorized diversion of 63 m³/day (Table 2, page 11), with a median authorized amount of 2.7 m³/day. The highest authorized groundwater use for a water well completed in the Lower Sand and Gravel Aquifer is registered to divert 9.2 m³/day in NE 25-045-26 W4M. Nine of the 21 licences and/or registrations could be linked to water wells in the AENV groundwater database.

6.3 Bedrock

6.3.1 Geological Characteristics

The upper bedrock in the County includes the Paskapoo Formation and the Edmonton Group. The adjacent bedrock geology map and cross-section on the following page, showing the subcrop of different geologic units, have been prepared in part from the interpretation of geophysical logs related to oil and gas activity. A generalized geologic column is illustrated in Figure 9, in Appendix A and on the CD-ROM.

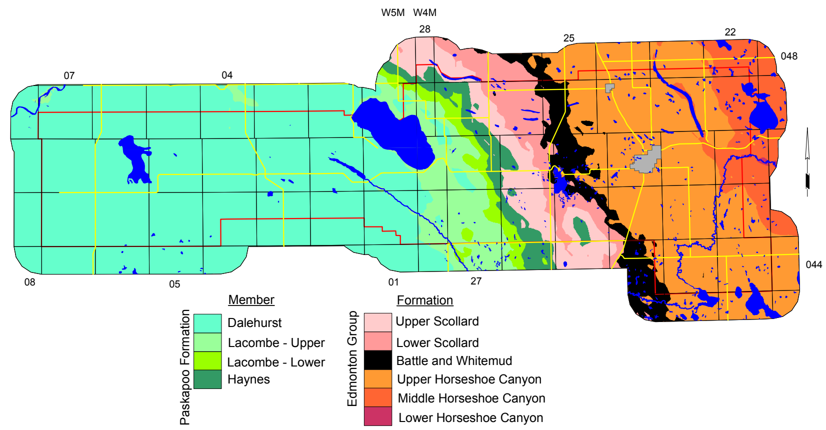

Figure 20. Bedrock Geology

The Paskapoo Formation in Alberta consists of the Dalehurst, Lacombe and Haynes members (Demchuk and Hills, 1991). The Paskapoo Formation consists of cycles of thick, tabular sandstone, siltstone and mudstone layers (Glass, 1990). The Edmonton Group underlies the Paskapoo Formation, and includes the Scollard, Battle and Whitemud, and Horseshoe Canyon formations. The Belly River Group underlies the Edmonton Group, and includes the Oldman and Foremost formations. Some of this bedrock contains saturated rocks that are permeable enough to transmit groundwater for a specific need.

The Dalehurst Member is the upper bedrock in the western half of the County. This Member has a maximum thickness of 200 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, has a maximum thickness of 100 metres, and has two separate designations: Upper and Lower. The Upper Lacombe Member is mostly composed of shale interbedded with sandstone and has a maximum thickness of 65 metres. The Lower Lacombe Member is composed of sandstone and coal layers. In the middle of the Lower Lacombe Member is a coal zone, which can be up to five metres thick. The Lower Lacombe Member has a maximum thickness of 35 metres.

The Haynes Member underlies the Lacombe Member and is composed mainly of sandstone with some siltstone, shale and coal. In the County, the Haynes Member has a maximum thickness of 45 metres.

The Scollard Formation underlies the Haynes Member, has a maximum thickness of 135 metres, and has two separate designations: Upper and Lower. The Upper Scollard consists mainly of sandstone, siltstone, shale and coal seams or zones. Two prominent coal zones within the Upper Scollard are the Ardley Coal (up to 20 metres thick) and the Nevis Coal (up to 3.5 metres thick). The bottom of the Nevis Coal Seam is the border between the Upper and Lower Scollard formations. In the County, the Upper Scollard has a maximum thickness of 85 metres; the Lower Scollard Formation has a maximum thickness of 50 metres, and is composed mainly of shale and sandstone.

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

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

The Horseshoe Canyon Formation is the lower part of the Edmonton Group and is the upper bedrock in the eastern portion of the County. The Horseshoe Canyon Formation consists of deltaic[22] and fluvial sandstone, siltstone and shale with interbedded coal seams, bentonite and thin nodular beds of limestone and ironstone. Because of the low-energy environment in which deposition occurred, the sandstones, when present, tend to be finer grained. The lower 60 to 70 metres and the upper 30 to 50 metres of the Horseshoe Canyon Formation can include coarser grained sandstone deposits. In the County, the Horseshoe Canyon Formation has a maximum thickness of 290 metres and has three separate designations: Upper, Middle and Lower. The Upper Horseshoe Canyon can be up to 95 metres thick, the Middle Horseshoe Canyon can be up to 50 metres thick, and the Lower Horseshoe Canyon can be up to 145 metres thick.

The Bearpaw Formation underlies the Horseshoe Canyon Formation and has a maximum thickness of 145 metres within the County. The Bearpaw Formation consists of marine shale, siltstone and minor sandstone layers, except in some areas where the thickness of the sandstone layers can be significant. The Bearpaw Formation "represents the final widespread marine unit in the Western Canada Foreland Basin" (Catuneanu et al, 1997).

The Oldman Formation underlies the Bearpaw Formation, and has a maximum thickness of 130 metres. The Oldman Formation is composed of continental deposits, sandstone, siltstone, shale and coal. The Formation is the upper part of the Belly River Group.

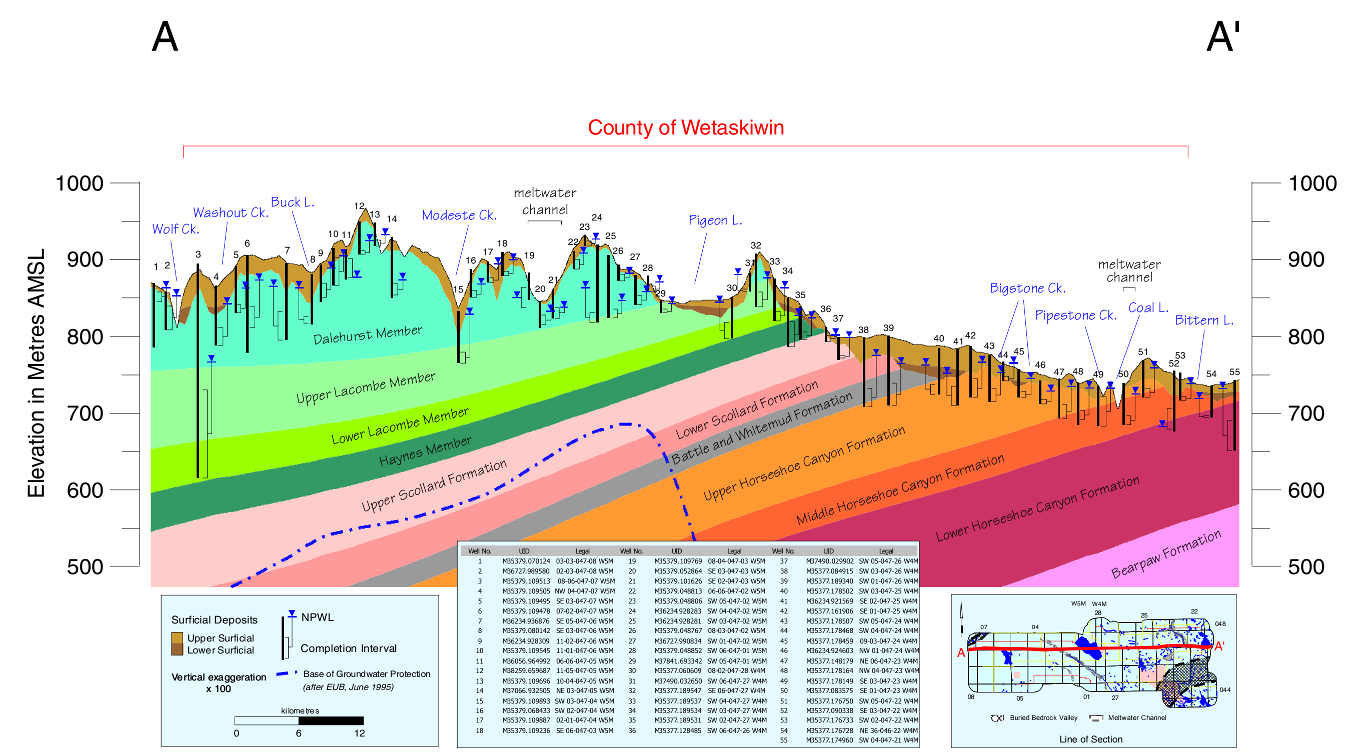

Figure 21. Cross-Section A - A'

22 See glossary

6.3.2 Upper Bedrock Completion Aquifer(s)

Of the 9,481 water wells in the database, 8,364 were defined as being completed below the top of bedrock (see page 9). Assigning a water well to a specific geologic unit is possible only if the completion interval is identified. In order to make use of additional information within the groundwater database, it was assumed that the completion interval was the bottom 20% of the total completed depth of a water well. With this assumption, it has been possible to designate the specific bedrock aquifer of completion to 7,808 bedrock water wells. The remaining 556 of the total 8,364 upper bedrock water wells are identified as being completed in more than one bedrock aquifer, as shown in Table 6. The bedrock water wells are mainly completed in the Dalehurst and Upper Horseshoe Canyon aquifers. Hydrogeological data associated with the water wells completed in saline aquifers were not used in the preparation of figures.

Geologic Unit	No. of Bedrock Water Wells
Dalehurst	2,103
Upper Lacombe	1,212
Lower Lacombe	443
Haynes	221
Upper Scollard	260
Lower Scollard	359
Battle/Whitemud	1
Upper Horseshoe Canyon	2,770
Middle Horseshoe Canyon	342
Lower Horseshoe Canyon	93
Saline	4
Multiple Bedrock Completions	556
Total	8,364

Table 6. Completion Aquifer for Upper Bedrock Water Wells

There are 3,672 records for bedrock water wells in the County that have apparent yield values, which is 44% of the 8,360 non-saline bedrock water wells.

Nearly 70% of the water wells completed in the Upper Bedrock Aquifer(s) have apparent yield values of less than 100 m³/day, with a median apparent yield of 44 m³/day. Many of the areas with yields of more than 100 m³/day are in the western part of the County. These higher yield areas may identify areas of increased permeability resulting from the weathering process.

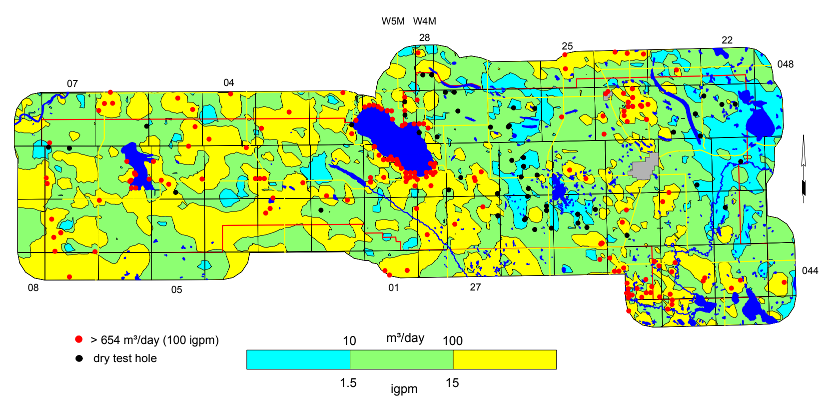

Figure 22. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

In addition to the 3,672 records for bedrock water wells in the County with apparent yield values, there are 63 records that indicate that the water well/water test hole is “dry”, or abandoned with “insufficient water”. In order to depict a more accurate yield map, an apparent yield of 0.1 m³/day was assigned to the 63 “dry” water test holes prior to gridding.

Of the 3,672 water wells completed in bedrock aquifers with apparent yield values, 620 (17%) have apparent yields that are less than ten m³/day, 1,900 (52%) have apparent yield values that range from 10 to 100 m³/day, and 1,152 (31%) have apparent yield values that are greater than 100 m³/day, as shown in Table 7.

Aquifer	Water Wells with Values for Apparent Yield (*)	with Apparent Yields <10 m³/day	10 to 100 m³/day	>100 m³/day
Dalehurst	840	83	449	308
Upper Lacombe	510	24	252	234
Lower Lacombe	211	15	105	91
Haynes	86	12	46	28
Upper Scollard	98	33	55	10
Lower Scollard	156	52	83	21
Battle/Whitemud	0	0	0	0
Upper Horseshoe Canyon	1,283	155	732	396
Middle Horseshoe Canyon	131	76	52	3
Lower Horseshoe Canyon	27	19	6	2
Multiple Bedrock Completions	330	151	120	59
Totals	3,672	620	1,900	1,152

* - does not include dry test holes

Table 7. Apparent Yields of Bedrock Aquifers

Apparent yields for water wells completed in the Upper Bedrock Aquifer(s) vary significantly over the County both with location and with depth. As Figure 23 shows, most apparent yields are less than 150 m³/day and the majority of the water wells are less than 100 metres deep. Most of the water wells with apparent yields of greater than 100 m³/day are less than 100 metres deep.

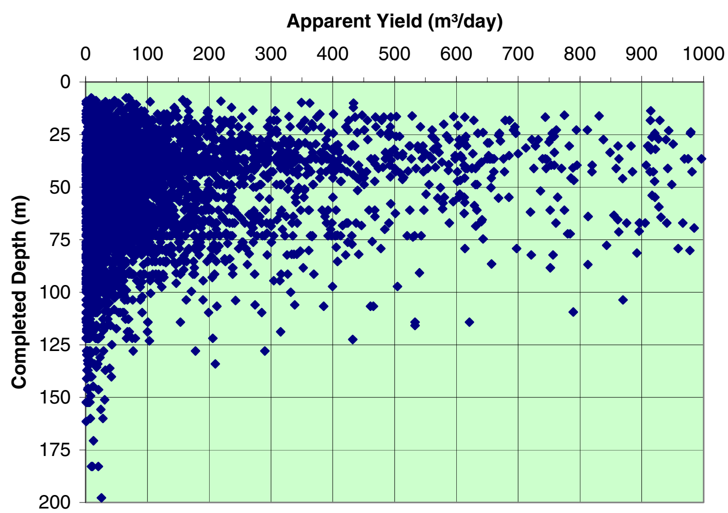

Figure 23. Bedrock Water Well Yields vs Completed Depth

6.3.3 Chemical Quality of Groundwater

The Piper tri-linear diagram for Upper Bedrock Aquifer(s) (page A-32) shows that groundwaters from bedrock aquifers are mainly sodium-bicarbonate or sodium-sulfate-type waters; the majority of these groundwaters have a sodium ion concentration that exceeds 200 mg/L. Because the sodium concentration can be elevated, the groundwater can pose a risk to people on low-sodium diets.

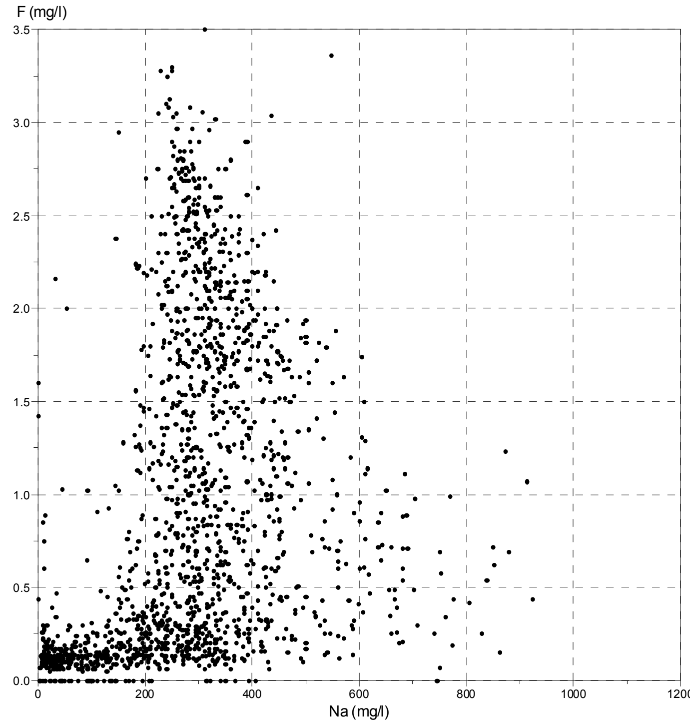

Figure 24. Fluoride vs Sodium Concentrations in Groundwater in Upper Bedrock Aquifer(s)

In the County, approximately 43% 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 27% of the groundwater samples from the entire County are between 0.5 and 1.5 mg/L and approximately 30% exceed the MAC for fluoride of 1.5 mg/L, with fluoride concentrations of greater than 1.5 mg/L occurring in the eastern part of the County (see CD-ROM).

The fluoride concentrations in the groundwaters appear to be a function of the sodium concentration. Below a sodium concentration of 175 mg/L, there is generally very little fluoride in the groundwater. When the sodium concentration reaches 200 mg/L, the maximum fluoride concentration can increase dramatically. As the sodium concentration increases, the maximum solubility of fluoride decreases and once the sodium concentration reaches 600 mg/L, the maximum solubility of fluoride is mainly below the MAC of 1.5 mg/L, as shown above in Figure 24 and on page A-36.

The TDS concentrations in the groundwaters from the Upper Bedrock Aquifer(s) range from less than 500 mg/L to 1,500 mg/L, with most of the groundwaters with higher TDS concentrations occurring in the northeastern part of the County (see page A-35). The lower TDS concentrations may be a result of more active flow systems and shorter flow paths due to the pronounced local relief. In the County, the relationship between TDS and sulfate concentrations shows that when TDS values in the groundwaters from the Upper Bedrock Aquifer(s) exceed 1,000 mg/L, the sulfate concentrations exceed 400 mg/L.

The sulfate concentrations in groundwaters from the Upper Bedrock Aquifer(s) were compared to the distance of completion depth from the top of the Lacombe Member. Groundwaters from bedrock water wells mainly completed within 200 metes below 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 25. Groundwaters from Dalehurst water wells mainly have sulfate concentrations of less than 200 mg/L.

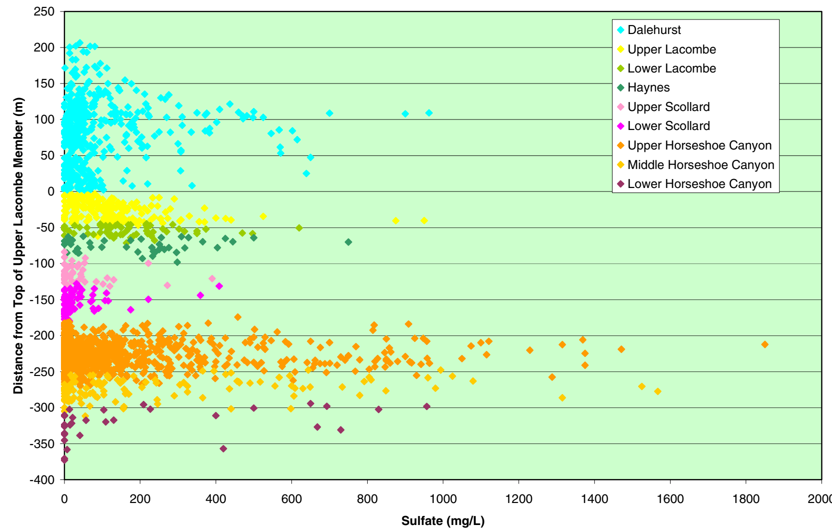

Figure 25. Distance from Top of Lacombe Member vs Sulfate Concentrations in Groundwaters from Upper Bedrock Aquifer(s)

In the County, 90% of the chloride concentrations in the groundwaters from the Upper Bedrock Aquifer(s) are less than 100 mg/L. In the County, there were four groundwater samples that had Nitrate + Nitrite (as N) concentrations that were greater than the SGCDWQ of 10 mg/L for the Upper Bedrock Aquifer(s). Approximately 75% of the total hardness values in the groundwaters from the Upper Bedrock Aquifer(s) are less than 100 mg/L.

The minimum, maximum and median 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 SGCDWQ in Table 8. Of the five constituents compared to the SGCDWQ, median concentrations of TDS and sodium exceed the guidelines.

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	2,468	10	3,216	770	500
Sodium	2,076	0	923	293	200
Sulfate	2,465	0	1,850	64	500
Chloride	2,297	0	953	4	250
Fluoride	2,219	0	388	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality Federal-Provincial-Territorial Committee on Drinking Water, March 2006

Table 8. Concentrations of Constituents in Groundwaters from Upper Bedrock Aquifer(s)

6.3.4 Dalehurst Aquifer

The Dalehurst Aquifer comprises the permeable parts of the Dalehurst Member, as defined for the present program. The Dalehurst Member subcrops under the surficial deposits in the western half of the County. The thickness of the Dalehurst Member varies from less than two metres at the eastern edge of the subcrop to 200 metres in the western part of the County. The regional groundwater flow direction in the Dalehurst Aquifer is downgradient, northwest toward the South Saskatchewan River and northeast toward Pigeon Lake (see CD-ROM).

6.3.4.1 Depth to Top

The depth to the top of the Dalehurst Member is mainly less than 15 metres and is a reflection of the thickness of the surficial deposits.

6.3.4.2 Apparent Yield

The apparent yields for individual water wells completed through the Dalehurst Aquifer are mainly greater than ten m³/day, and have a median apparent yield value of 60 m³/day.

There are four “dry” water test holes that are completed in the Dalehurst Aquifer.

In 1995, as part of a groundwater program for Paramount Resources Ltd., an extended aquifer test conducted with Shallow WSW No. 01-17 in 01-17-045-07 W5M determined the water source well was capable of supplying the required 240 m³/day for injection purposes (HCL, June 1995).

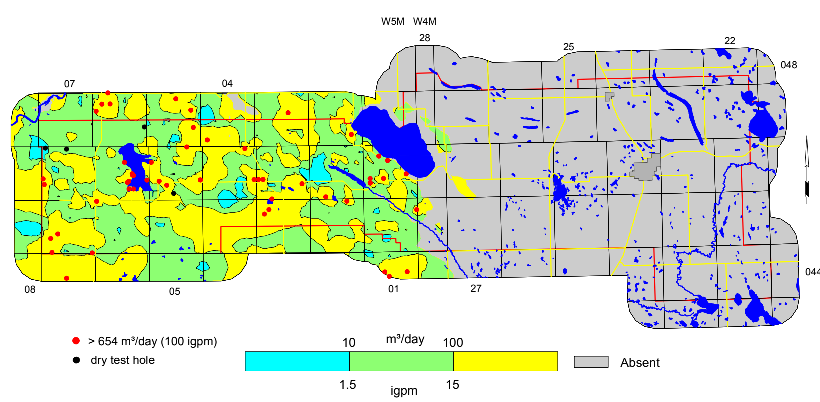

Figure 26. Apparent Yield for Water Wells Completed through Dalehurst Aquifer

Seven water source wells (WSWs) from the EUB database have been designated as being completed in the Dalehurst Aquifer. From 1961 to 2008, a total of nearly 6.2 million cubic metres of groundwater was pumped from these water source wells. The maximum combined production was in 1972, when the average daily production was 697 m³/day, an average of 174 m³/day from each of the four water source wells. Since 2001, all reported groundwater production has been from one water source well (WSW No. 04-25) in 04-25-046-02 W5M. In 2007, WSW No. 04-25 produced an average of 175 m³/day.

The water levels were measured by Mow-Tech Ltd. in the Shallow Observation Water Well (Obs WW) No. 01-17 from 1995 to early 2006, and in the Obs WW No. 04-25 since 1987. Because the water-level data do not indicate that groundwater production from the Shallow WSW No. 01-17 and WSW No. 04-25 has had an adverse effect on the Dalehurst Aquifer at the location of both observation water wells, it is expected that the decrease in production from the Dalehurst Aquifer was based on water need, and not on the ability of the Aquifer to provide the larger quantity of groundwater on a long-term basis.

There are 356 licensed and/or registered groundwater users that have water wells completed through the Dalehurst Aquifer, for a total groundwater diversion of 2,135 m³/day, of which 42% is used for industrial (injection) purposes. The highest authorized groundwater use is for a water source well completed to a depth of 85.3 metres below ground surface in the Dalehurst Aquifer that is licensed to divert 348 m³/day for industrial (injection) purposes in 08-22-046-07 W5M. According to the EUB database, there has been no groundwater production from this water source well since 2001.

Of the 356 licences and/or registrations, 313 could be linked to water wells in the AENV groundwater database.

6.3.4.3 Quality

The groundwaters from the Dalehurst Aquifer are mainly a sodium-bicarbonate-type (see Piper diagram on CD-ROM), with groundwater samples having TDS concentrations ranging from less than 500 to more than 1,000 mg/L (page A-40). Ninety percent of the TDS concentrations in groundwater from the Dalehurst Aquifer are less than 1,000 mg/L. The higher TDS values are expected in the western half where the Dalehurst Member is the upper bedrock in the County, and at the eastern edge of the Aquifer. Seventy-five percent of the sulfate concentrations in groundwaters from the Dalehurst Aquifer are less than 100 mg/L. More than 90% of the chloride concentrations from the Dalehurst Aquifer are less than ten mg/L, and 94% of the groundwater samples have fluoride concentrations of less than the MAC of 1.5 mg/L.

A chemical analysis of a groundwater sample collected in March 2005 from the Shallow WSW No. 01-17 in 01-17-045-07 W5M indicates the groundwater is a sodium-bicarbonate type, with a TDS concentration of 840 mg/L, a sulfate concentration of 219 mg/L, a chloride concentration of 7 mg/L, and a fluoride concentration of 0.29 mg/L.

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS exceed the guidelines. The median concentrations of constituents from water wells completed in the Dalehurst Aquifer are less than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	547	19	1,738	538	770	500
Sodium	464	0	570	163	293	200
Sulfate	551	0	963	44	64	500
Chloride	542	0	130	1	4	250
Fluoride	502	0	316	0.2	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality Federal-Provincial Subcommittee on Drinking Water, March 2006

Table 9. Apparent Concentrations of Constituents in Groundwater from Dalehurst Aquifer

6.3.5 Upper Lacombe Aquifer

The Upper Lacombe Aquifer comprises the permeable parts of the Upper Lacombe Member that underlie the Dalehurst Member. Structure contours have been prepared for the top of the Upper Lacombe Member. The structure contours show that the Upper Lacombe Member ranges in elevation from less than 740 to more than 880 metres AMSL and has a maximum thickness of 65 metres. The regional groundwater flow direction in the Upper Lacombe Aquifer is downgradient, northwest toward the North Saskatchewan River (see CD-ROM).

6.3.5.1 Depth to Top

The depth to the top of the Upper Lacombe Member ranges from less than 25 metres to more than 250 metres in the extreme southwestern part of the County (page A-41).

6.3.5.2 Apparent Yield

The apparent yields for individual water wells completed through the Upper Lacombe Aquifer are mainly greater than ten m³/day, and have a median apparent yield value of 65 m³day. The higher yielding water wells adjacent to Pigeon Lake, completed in the Upper Lacombe Aquifer, may be influenced by induced infiltration from the lake. There are little or no data for the Aquifer in the western parts of the County. In these areas, the depth to burial is more than 100 metres below ground surface.

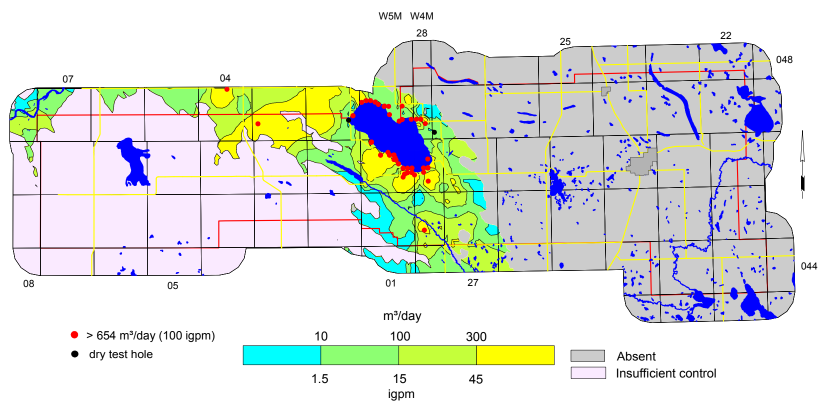

Figure 27. Apparent Yield for Water Wells Completed through Upper Lacombe Aquifer

Two Talisman Energy Inc. water source wells (WSW Nos. 1 and 2) in 16-34-047-02 W5M, northwest of Pigeon Lake just outside the County border, are authorized to divert a total of 130,800 m³ (HCL, 2008). The water source wells are completed in the Upper Lacombe Aquifer. Long-term monitoring of the two water source wells has indicated effective transmissivities ranging from 15 to 25 metres squared per day (m²/day) for WSW No. 1, and from 25 to 32 m²/day for WSW No. 2.

There are two “dry” water test holes completed in the Upper Lacombe Aquifer.

There are 94 licensed and/or registered groundwater users that have water wells completed through the Upper Lacombe Aquifer, for a total authorized groundwater diversion of 316 m³/day, with a median authorized amount of 1.7 m³/day. The highest authorized groundwater use is for a water supply well completed to a depth of 18.3 metres BGL in the Upper Lacombe Aquifer in SW 12-047-02 W5M that is licensed to divert 55.7 m³/day.

Seventy-six of the 94 licences and/or registrations could be linked to water wells in the AENV groundwater database.

6.3.5.3 Quality

The groundwaters from the Upper Lacombe Aquifer are mainly a sodium-bicarbonate to sodium-sulfate-type (see Piper diagram on CD-ROM), with groundwater samples having TDS concentrations ranging mainly from greater than 200 to mainly less 1,000 mg/L (page A-43). Nearly 70% of the TDS concentrations in groundwater from the Upper Lacombe Aquifer range between 500 and 1,000 mg/L. At the eastern edge of the Aquifer, TDS values are expected to be mainly greater than 500 mg/L. Sixty percent of the sulfate concentrations in groundwaters from the Upper Lacombe Aquifer are less than 100 mg/L. The sulfate concentrations of greater than 100 mg/L are expected mainly at the eastern edge of the Aquifer. Ninety-six percent of the chloride concentrations from the Upper Lacombe Aquifer are less than ten mg/L, and 85% of the groundwater samples have fluoride concentrations of less than the MAC of 1.5 mg/L.

Groundwaters from the two Talisman water source wells are a sodium-bicarbonate type. Chemical analyses of groundwater samples from WSW Nos. 1 and 2 indicate TDS concentrations of less than 1,000 mg/L, sulfate concentrations of less than ten mg/L, and chloride concentrations of less than 25 mg/L.

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS and sodium exceed the guidelines. The median concentrations of sulfate from water wells completed in the Upper Lacombe Aquifer are greater than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	253	192	1,940	655	770	500
Sodium	223	6	611	240	293	200
Sulfate	254	0	950	90	64	500
Chloride	253	0	140	2	4	250
Fluoride	225	0	388	0.4	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality Federal-Provincial Subcommittee on Drinking Water, March 2006

Table 10. Apparent Concentrations of Constituents in Groundwaters from Upper Lacombe Aquifer

6.3.6 Lower Lacombe Aquifer

The Lower Lacombe Aquifer comprises the permeable parts of the Lower Lacombe Member that underlie the Upper Lacombe Member. Structure contours have been prepared for the top of the Lower Lacombe Member. The structure contours show that the Lower Lacombe Member ranges in elevation from less than 620 to more than 840 metres AMSL and has a maximum thickness of 35 metres. The regional groundwater flow direction in the Lower Lacombe Aquifer is downgradient, northwest toward the North Saskatchewan River (see CD-ROM).

6.3.6.1 Depth to Top

The depth to the top of the Lower Lacombe Member ranges from less than 25 metres below ground surface at the eastern extent to more than 250 metres in the extreme western part of the County (page A-44).

6.3.6.2 Apparent Yield

The apparent yields for individual water wells completed through the Lower Lacombe Aquifer are mainly greater than ten m³/day, and have a median apparent yield value of 65 m³/day. The large expanse of expected high yields west of Pigeon Lake may be a reflection of the limited amount of data rather than the hydraulic properties. There are little or no data for the Aquifer in the western parts of the County. In these areas, the depth to burial is more than 150 metres below ground surface.

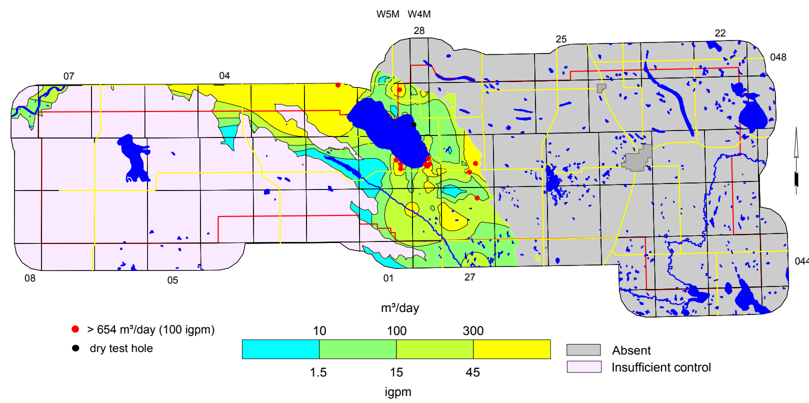

Figure 28. Apparent Yield for Water Wells Completed through Lower Lacombe Aquifer

Two water source wells from the EUB database have been designated as being completed in the Lower Lacombe Aquifer. From 1994 to 2002, a combined total of nearly 40,000 cubic metres of groundwater was pumped from WSW No. 1-91 and from the 1981 WSW No. 10-12. Groundwater production data from WSW No. 1-91 were reported to EUB from 1994 to 1997 and from the 1981 WSW No. 10-12 in 1998 and 2002.

WSW No. 1-91 is completed in the Lower Lacombe Aquifer in the depth interval from 143 to 180 metres below ground surface in 14-34-046-02 W5M. An extended aquifer test conducted with WSW No. 1-91 indicated an effective transmissivity of 3.4 m²/day, and a projected long-term yield ranging from 35 to 60 m³/day (HCL, 1991). Long-term monitoring of WSW No. 1-91, and Obs WW No. 2-91, has indicated that the aquifer has three aquifer boundaries within 1,000 metres of WSW No. 1-91, an effective transmissivity of 11 m²/day and a corresponding storativity of 0.00013 (HCL, Jan 2001a).

There is one “dry” water test hole completed in the Lower Lacombe Aquifer.

There are 85 licensed and/or registered groundwater users that have water wells completed through the Lower Lacombe Aquifer, for a total authorized groundwater diversion of 296 m³/day, with a median authorized amount of 1.6 m³/day. The highest authorized groundwater use is for WSW No. 1-91, which is licensed to divert 48.6 m³/day for industrial purposes in 14-34-046-02 W5M.

Fifty-three of the 85 licences and/or registrations could be linked to water wells in the AENV groundwater database.

6.3.6.3 Quality

The groundwaters from the Lower Lacombe Aquifer are a sodium-bicarbonate to sulfate-type (see Piper diagram on CD-ROM), with groundwater samples having TDS concentrations ranging mainly from greater than 200 to mainly less 1,000 mg/L (page A-46). More than 70% of the TDS concentrations in groundwater from the Lower Lacombe Aquifer range between 500 and 1,000 mg/L. More than 70% of the sulfate concentrations in groundwaters from the Lower Lacombe Aquifer are greater than 100 mg/L. More than 90% of the chloride concentrations from the Lower Lacombe Aquifer are less than ten mg/L, and 80% of the groundwater samples have fluoride concentrations of less than the MAC of 1.5 mg/L.

The groundwater from WSW No. 1-91 is a sodium-bicarbonate type. A chemical analysis of a groundwater sample collected from WSW No.1-91 in September 1991 indicates a TDS concentration of 577 mg/L, a sulfate concentration of 21 mg/L, a chloride concentration of 26 mg/L, and a fluoride concentration of 4 mg/L (HCL, 1991).

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS and sodium exceed the guidelines. The median concentrations of TDS, sulfate and fluoride from water wells completed in the Lower Lacombe Aquifer are greater than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	71	241	1,310	776	770	500
Sodium	62	7	919	291	293	200
Sulfate	71	0	620	155	64	500
Chloride	71	0	66.2	2	4	250
Fluoride	66	0	4	0.9	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)
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Table 11. Apparent Concentrations of Constituents in Groundwaters from Lower Lacombe Aquifer

6.3.7 Haynes Aquifer

The Haynes Aquifer comprises the permeable parts of the Haynes Member that underlie the Lower Lacombe Member. Structure contours have been prepared for the top of the Haynes Member. The structure contours show that the Haynes Member ranges in elevation from less than 560 to more than 840 metres AMSL and has a maximum thickness of 45 metres. The regional groundwater flow direction in the Haynes Aquifer is downgradient, northwest toward the North Saskatchewan River and southwest toward the Battle River (see CD-ROM).

6.3.7.1 Depth to Top

The depth to the top of the Haynes Member ranges from less than 25 metres below ground surface at the eastern extent to more than 400 metres in the extreme southwestern part of the County (page A-47).

6.3.7.2 Apparent Yield

The apparent yields for individual water wells completed through the Haynes Aquifer are mainly greater than ten m³/day, and have a median apparent yield value of 42 m³/day. Apparent yields of greater than 100 m³/day appear to be throughout the Aquifer, where sufficient control exists, as shown on Figure 29.

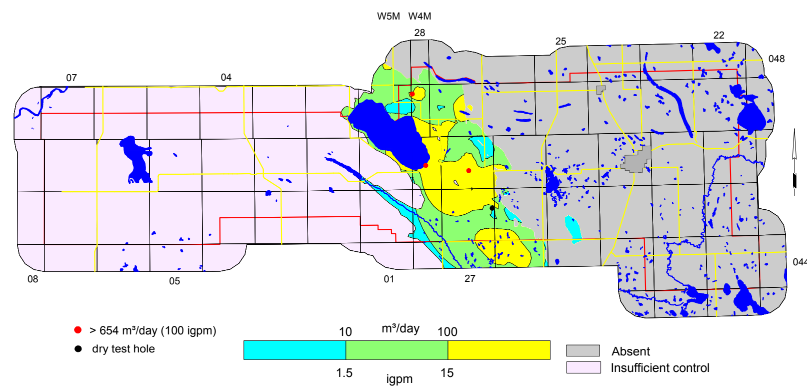

Figure 29. Apparent Yield for Water Wells Completed through Haynes Aquifer

There are little or no data for the Aquifer in the western parts of the County. In these areas, the depth to burial is more than 100 metres below ground surface.

There is one "dry" water test hole that is completed in the Haynes Aquifer.

There are 61 licensed and/or registered groundwater users that have water wells completed through the Haynes Aquifer, for a total authorized groundwater diversion of 194 m³/day, with a median authorized amount of 2.5 m³/day. The highest allocation is for a water well completed to a depth of 29.2 metres below ground surface in the Haynes Aquifer that is licensed to divert 13.5 m³/day for agricultural (stock) purposes in 06-01-048-28 W4M.

Forty-four of the 61 licences and/or registrations could be linked to water wells in the AENV groundwater database.

6.3.7.3 Quality

The groundwaters from the Haynes Aquifer are mainly a sodium-bicarbonate to sodium-sulfate-type (see Piper diagram on CD-ROM), with groundwater samples having TDS concentrations ranging from greater than 200 to less than 1,500 mg/L (page A-49). Fifty percent of the TDS concentrations in groundwater from the Haynes Aquifer range between 500 and 1,000 mg/L. Nearly 70% of the sulfate concentrations in groundwaters from the Haynes Aquifer are greater than 50 mg/L. More than 90% of the chloride concentrations from the Haynes Aquifer are less than ten mg/L, and 90% of the groundwater samples have fluoride concentrations of less than the MAC of 1.5 mg/L.

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS and sodium exceed the guidelines. The median concentrations of TDS and sulfate from water wells completed in the Haynes Aquifer are greater than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s)

Constituent	No. of Analyses	Range for County in mg/L			All Bedrock Median	Recommended Maximum Concentration SGCDWQ
		Minimum	Maximum	Median		
Total Dissolved Solids	50	270	1,462	845	770	500
Sodium	41	12	511	260	293	200
Sulfate	52	0	750	199	64	500
Chloride	51	0	38	2	4	250
Fluoride	45	0	3	0.4	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

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Table 12. Apparent Concentrations of Constituents in Groundwaters from Haynes Aquifer

6.3.8 Upper Scollard Aquifer

The Upper Scollard Aquifer comprises the permeable parts of the Upper Scollard Formation that underlie the Haynes Member. Structure contours have been prepared for the top of the Formation. The structure contours show that the Upper Scollard Formation ranges in elevation from less than 500 to more than 820 metres AMSL and has a maximum thickness that is in the order of 85 metres. The regional groundwater flow direction in the Upper Scollard Aquifer is downgradient, northeast toward the North Saskatchewan River, and east toward numerous creeks and rivers (see CD-ROM).

6.3.8.1 Depth to Top

The depth to the top of the Upper Scollard Formation ranges from less than 25 metres below ground surface at the eastern extent to more than 400 metres in the extreme southwestern part of the County (page A-50).

6.3.8.2 Apparent Yield

The apparent yields for individual water wells completed through the Upper Scollard Aquifer range between ten and 100 m³/day, and have a median apparent yield value of 23 m³/day.

There are little or no data for the Aquifer in the western parts of the County. In these areas, the depth to burial is more than 100 metres below ground surface.

There 11 “dry” water test holes that are completed in the Upper Scollard Aquifer.

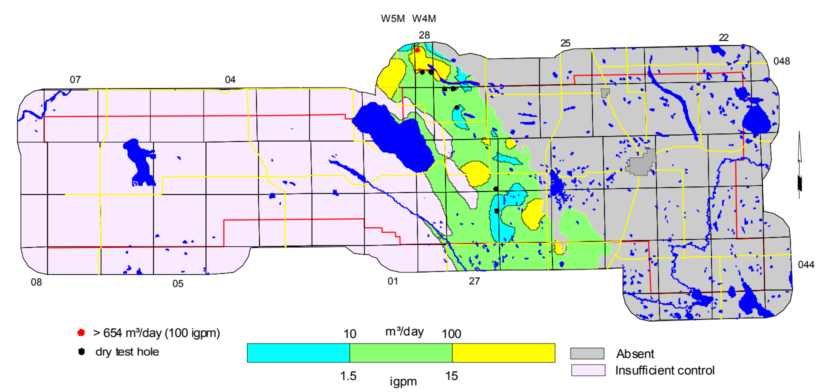

Figure 30. Apparent Yield for Water Wells Completed through Upper Scollard Aquifer

There are 62 licensed and/or registered groundwater users that have water wells completed through the Upper Scollard Aquifer, for a total authorized groundwater diversion of 255 m³/day, with a median authorized amount of 2.6 m³/day. The highest allocation is for a water well completed to a depth of 44.8 metres below ground surface in the Haynes Aquifer that is licensed to divert 39.0 m³/day for agricultural (stock) purposes in NW 20-045-26 W4M.

Forty-four of the 62 licences and/or registrations could be linked to water wells in the AENV groundwater database.

6.3.8.3 Quality

The groundwaters from the Upper Scollard Aquifer are mainly a sodium-bicarbonate-type (see Piper diagram on CD-ROM), with groundwater samples having TDS concentrations ranging from greater than 200 to more than 1,500 mg/L (page A-52). Nearly 90% of the TDS concentrations in groundwater from the Upper Scollard Aquifer are greater than 500 mg/L. The higher TDS values are expected at the eastern edge of the Aquifer. More than 65% of the sulfate concentrations in groundwaters from the Upper Scollard Aquifer are less than 50 mg/L. Nearly 60% of the chloride concentrations from the Upper Scollard Aquifer are less than ten mg/L, and 63% of the groundwater samples have fluoride concentrations of less than the MAC of 1.5 mg/L.

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS and sodium exceed the guidelines. The median concentrations for TDS, sodium, chloride, and fluoride from water wells completed in the Upper Scollard Aquifer are greater than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	63	347	1,568	860	770	500
Sodium	52	13	660	373	293	200
Sulfate	63	0	390	20	64	500
Chloride	62	0	226	7	4	250
Fluoride	56	0	3	1.2	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

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Table 13. Apparent Concentrations of Constituents in Groundwaters from Upper Scollard Aquifer

6.3.9 Lower Scollard Aquifer

The Lower Scollard Aquifer comprises the porous and permeable parts of the Lower Scollard Formation that underlie the Upper Scollard Formation. Structure contours have been prepared for the top of the Formation. The structure contours show that the Lower Scollard Formation ranges in elevation from less than 600 to more than 1,020 metres AMSL and has a maximum thickness of 50 metres. The regional groundwater flow direction in the Lower Scollard Aquifer is downgradient, northeast toward Buckinghorse Lake, and east toward Bearhills Lake (see CD-ROM).

6.3.9.1 Depth to Top

The depth to the top of the Lower Scollard Formation ranges from less than 25 metres below ground surface at the eastern extent to more than 400 metres in the extreme western part of the County (page A-53).

6.3.9.2 Apparent Yield

The apparent yields for individual water wells completed through the Lower Scollard Aquifer range mainly from 10 to 100 m³/day, and have a median apparent yield value of 16 m³/day. There are little or no data for the Aquifer in the western parts of the County. In these areas, the depth to burial is more than 120 metres below ground surface.

There are ten “dry” water test holes that are completed in the Lower Scollard Aquifer.

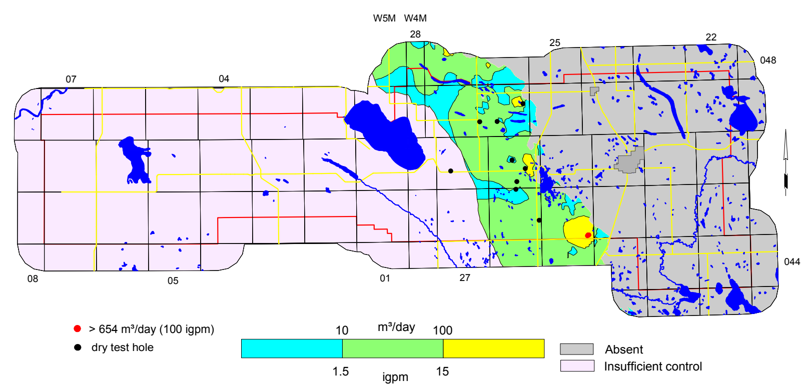

Figure 31. Apparent Yield for Water Wells Completed through Lower Scollard Aquifer

In the County, there are 66 licensed and/or registered groundwater users that have water wells that are completed in the Lower Scollard Aquifer, for a total authorized diversion of 321 m³/day, with a median authorized amount of 3.0 m³/day. The highest allocation is for two water wells completed in the Haynes Aquifer that are each licensed to divert 27.0 m³/day for agricultural (stock) purposes.

Fifty-three of the 66 licences and/or registrations could be linked to water wells in the AENV groundwater database.

6.3.9.3 Quality

The groundwaters from the Lower Scollard Aquifer are mainly a sodium-bicarbonate-type (see Piper diagram on CD-ROM), with groundwater samples having TDS concentrations ranging from less than 500 to more than 1,500 mg/L (page A-55). More than 65% of the TDS concentrations in groundwater from the Lower Scollard Aquifer are between 500 and 1,000 mg/L. The higher TDS values are expected at the eastern edge of the Aquifer. Seventy-six percent of the sulfate concentrations in groundwaters from the Lower Scollard Aquifer are less than 50 mg/L. The sulfate concentrations of greater than 100 mg/L are expected mainly at the eastern edge of the Aquifer. Nearly 85% of the chloride concentrations from the Lower Scollard Aquifer are less than 50 mg/L, and nearly 60% of the groundwater samples have fluoride concentrations of less than the MAC of 1.5 mg/L.

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS and sodium exceed the guidelines. The median concentrations of TDS, sodium, chloride and fluoride from water wells completed in the Lower Scollard Aquifer are greater than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	93	190	1,708	930	770	500
Sodium	74	80	548	382	293	200
Sulfate	92	0	409	15	64	500
Chloride	93	0	546	12	4	250
Fluoride	73	0	6	1.4	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)
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Federal-Provincial Subcommittee on Drinking Water, March 2006

Table 14. Apparent Concentrations of Constituents in Groundwaters from Lower Scollard Aquifer

6.3.10 Upper Horseshoe Canyon Aquifer

The Upper Horseshoe Canyon Aquifer comprises the permeable parts of the Upper Horseshoe Canyon Formation that underlie the Battle Formation. Structure contours have been prepared for the top of the Formation. The structure contours show that the Upper Horseshoe Canyon Formation ranges in elevation from less than 300 to more than 800 metres AMSL and has a maximum thickness of 95 metres. The regional groundwater flow direction in the Upper Horseshoe Canyon Aquifer is mainly downgradient toward the Battle River (see CD-ROM).

6.3.10.1 Depth to Top

The depth to the top of the Upper Horseshoe Canyon Formation is variable, ranging from less than 25 metres at the eastern extent to more than 600 metres in the extreme southwestern part of the County (page A-57).

6.3.10.2 Apparent Yield

The apparent yields for individual water wells completed through the Upper Horseshoe Canyon Aquifer range mainly from 10 to 100 m³/day, and have a median apparent yield value of 51 m³/day. There are little or no data for the Aquifer in the western parts of the County. In these areas, the depth to burial is more than 150 metres below ground surface.

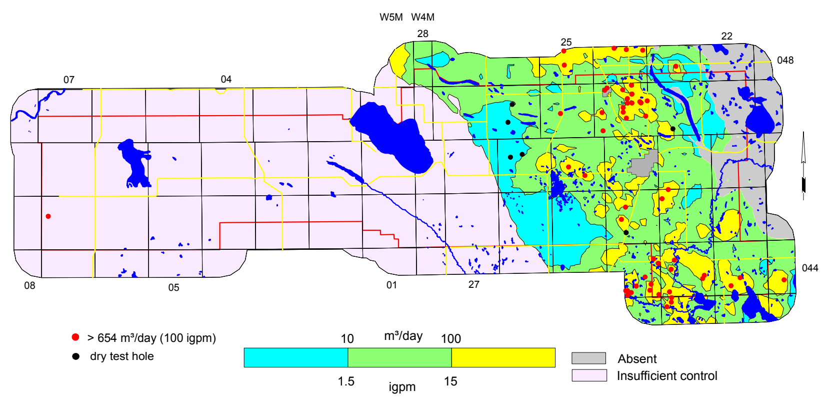

Figure 32. Apparent Yield for Water Wells Completed through Upper Horseshoe Canyon Aquifer

In 1994, the Town of Millet retained HCL to conduct a groundwater program in order to determine if additional water supplies for the Town of Millet could be developed (HCL, 1994). Two water test holes were drilled and completed as WSW No. 1-94 and WSW No. 2-94. WSW No. 1-94 is completed from 45.1 to 55.8 metres below ground surface, and WSW No. 2-94 is completed from 32.6 to 36.6 metres below ground surface. Extended aquifer testing indicated that the two water supply wells are completed within separate zones within the Upper Horseshoe Canyon Aquifer, but were hydraulically connected having an effective transmissivity of 55 m²/day, and a corresponding storativity of 0.0014. Using these aquifer parameters, WSW No. 1 has a long-term yield of 250 m³/day and WSW No. 2 has a long-term yield of 190 m³/day. Both water supply wells were licensed by AENV for these amounts.

There are 11 “dry” water test holes that are completed in the Upper Horseshoe Canyon Aquifer.

In the County, there are 405 licensed and/or registered groundwater users with water wells that are completed in the Upper Horseshoe Canyon Aquifer, for a total authorized diversion of 3,321 m³/day, with a median authorized amount of 3.4 m³/day. The highest groundwater use is for a licence that allows the City of Wetaskiwin to divert up to 446 m³/day from three water supply wells, and a licence that allows the Town of Millet to divert up to 862 m³/day from four water supply wells, for municipal purposes. According to the County, the City of Wetaskiwin has not diverted groundwater for municipal purposes since the early 1980s.

Three hundred and eleven of the 405 licensed and/or registered water wells could be linked to a water well in the AENV groundwater database.

6.3.10.3 Quality

The groundwaters from the Upper Horseshoe Canyon Aquifer are mainly a sodium-type with no dominant anion (see Piper diagram on CD-ROM), with groundwater samples having TDS concentrations ranging mainly from 500 to more than 1,500 mg/L (page A-59). Nearly 85% of the TDS concentrations in groundwater from the Upper Horseshoe Canyon Aquifer are between 500 and 1,500 mg/L. The higher TDS values are expected at the eastern edge of the Aquifer. Fifty-six percent of the sulfate concentrations in groundwaters from the Upper Horseshoe Canyon Aquifer are less than 100 mg/L. The sulfate concentrations of greater than 500 mg/L are expected mainly at the northeastern edge of the Aquifer. Seventy-five percent of the chloride concentrations from the Upper Horseshoe Canyon Aquifer are less than 50 mg/L, and 56% of the groundwater samples have fluoride concentrations of less than the MAC of 1.5 mg/L.

The groundwaters from the Town of Millet's WSW No. 1-94 and WSW No. 2-94 are a sodium-bicarbonate type. The chemical analysis for the groundwater sample collected from WSW No. 1-94 indicates a TDS concentration of 799 mg/L, a sulfate concentration of 61 mg/L, a chloride concentration of 6 mg/L, and a fluoride concentration of 2.38 mg/L. The chemical analysis for the groundwater sample collected from WSW No. 2-94 indicates a TDS concentration of 872 mg/L, a sulfate concentration of 117 mg/L, a chloride of concentration of 4 mg/L, and a fluoride concentration of 1.85 mg/L (HCL, 1994).

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS and sodium exceed the guidelines. The median concentrations from water wells completed in the Upper Horseshoe Canyon Aquifer are all greater than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	1072	10	2,949	835	770	500
Sodium	898	0	923	323	293	200
Sulfate	1068	0	1,850	75	64	500
Chloride	1071	0	602	12	4	250
Fluoride	968	0	6	1.2	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)
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Table 15. Apparent Concentrations of Constituents in Groundwaters from Upper Horseshoe Canyon Aquifer

A comparison was made of fluoride concentrations in the groundwaters from water wells in the County completed in Upper Bedrock Aquifer(s) with fluoride concentrations in the groundwaters from water wells in the adjacent counties of Leduc, Camrose and Ponoka. Groundwaters that report more than 1.5 mg/L of fluoride in water wells completed in the Lower Scollard and Horseshoe Canyon aquifers are shown by the coloured postings on the figure below. The comparison was made to show the extent of elevated fluoride concentrations in the groundwater in Upper Bedrock Aquifer(s). The data show that in the County of Wetaskiwin, fluoride concentrations of more than 1.5 mg/L are in water wells completed mainly in the Lower Scollard and Upper Horseshoe Canyon aquifers, as shown in Figure 33 and on page A-37.

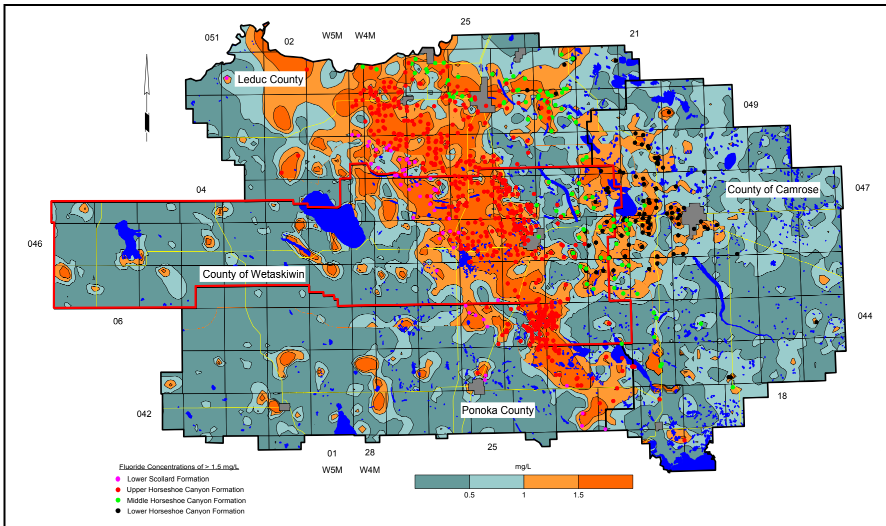

Figure 33. Fluoride in Groundwater in Upper Bedrock Aquifer(s) in County of Wetaskiwin and Surrounding Counties

6.3.11 Middle Horseshoe Canyon Aquifer

The Middle Horseshoe Canyon Aquifer comprises the permeable parts of the Middle Horseshoe Canyon Formation that underlie the Upper Horseshoe Canyon Formation. The structure contours show that the Middle Horseshoe Canyon Formation ranges in elevation from less than 200 to more than 750 metres AMSL and has a maximum thickness of 50 metres. The regional groundwater flow direction in the Middle Horseshoe Canyon Aquifer is downgradient toward Coal Lake, Bittern Lake, and the Battle River (see CD-ROM).

6.3.11.1 Depth to Top

The depth to the top of the Middle Horseshoe Canyon Formation is variable, ranging from less than 25 metres at the eastern extent to more than 700 metres in the extreme southwestern part of the County (page A-60).

6.3.11.2 Apparent Yield

The apparent yields for individual water wells completed through the Middle Horseshoe Canyon Aquifer are mainly less than ten m³/day, and have a median apparent yield value of 8.4 m³/day. There are little or no data for the Aquifer in the western parts of the County. In these areas, the depth to burial is more than 80 metres below ground surface.

There are six “dry” water test holes that are completed in the Middle Horseshoe Canyon Aquifer.

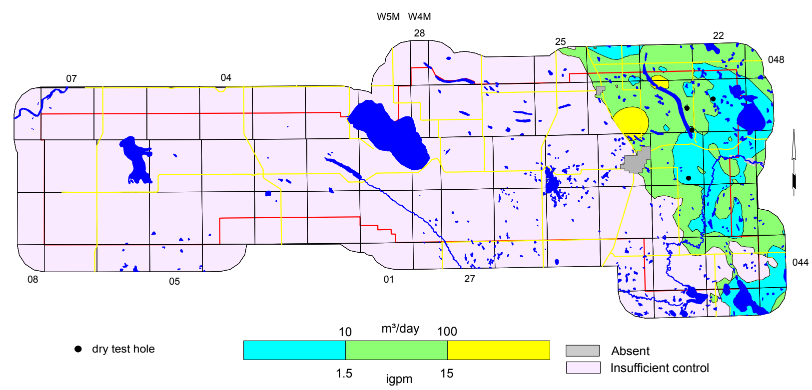

Figure 34. Apparent Yield for Water Wells Completed through Middle Horseshoe Canyon Aquifer

In the County, there are 71 licensed and/or registered groundwater users with water wells that are completed in the Middle Horseshoe Canyon Aquifer, for a total authorized diversion of 217 m³/day, with a median authorized amount of 2.2 m³/day. The highest allocation is for a water well completed to a depth of 67.1 metres below ground surface in the Middle Horseshoe Canyon Aquifer that is licensed to divert 27 m³/day in 14-13-046-023 W4M for agricultural (stock) purposes.

Forty-six of the 71 licensed and/or registered water wells could be linked to a water well in the AENV groundwater database.

6.3.11.3 Quality

The groundwaters from the Middle Horseshoe Canyon Aquifer are mainly a sodium-bicarbonate to sodium-sulfate-type (see Piper diagram on CD-ROM), with groundwater samples having TDS concentrations ranging mainly from more than 500 to more than 1,500 mg/L (page A-62). Nearly 75% of the TDS concentrations in groundwater from the Middle Horseshoe Canyon Aquifer are between 500 and 1,500 mg/L. The higher TDS values are expected in the northeastern part of the County. Nearly 70% of the sulfate concentrations in groundwaters from the Middle Horseshoe Canyon Aquifer are greater than 50 mg/L. The sulfate concentrations of greater than 500 mg/L are expected mainly in the northeastern part of the County. Nearly 80% percent of the chloride concentrations from the Middle Horseshoe Canyon Aquifer are less than 50 mg/L, and 70 % of the groundwater samples have fluoride concentrations have fluoride concentrations of less than the MAC of 1.5 mg/L.

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS and sodium exceed the guidelines. The median concentrations in the Middle Horseshoe Canyon Aquifer are all greater than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	145	336	2,992	1005	770	500
Sodium	117	91	872	371	293	200
Sulfate	140	0	1,567	143	64	500
Chloride	144	0	442	8	4	250
Fluoride	125	0	3	0.9	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)

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Table 16. Apparent Concentrations of Constituents in Groundwaters from Middle Horseshoe Canyon Aquifer

6.3.12 Lower Horseshoe Canyon Aquifer

The Lower Horseshoe Canyon Aquifer comprises the permeable parts of the Lower Horseshoe Canyon Formation that underlie the Middle Horseshoe Canyon Formation. The Lower Horseshoe Canyon Formation is present under the surficial deposits in all of the County. Structure contours have been prepared for the top of the Formation. The structure contours show that the Lower Horseshoe Canyon Formation ranges in elevation from less than 150 to more than 750 metres AMSL and has a maximum thickness of 145 metres. The regional groundwater flow direction in the Lower Horseshoe Canyon Aquifer is downgradient toward the Battle River (see CD-ROM).

6.3.12.1 Depth to Top

The depth to the top of the Lower Horseshoe Canyon Formation is variable, ranging from less than 50 metres at the eastern extent to more than 800 metres in the extreme southwestern part of the County (page A-63).

6.3.12.2 Apparent Yield

The apparent yields for individual water wells completed through the Lower Horseshoe Canyon Aquifer are mainly less than ten m³/day, and have a median apparent yield value of six m³/day. There are little or no data for the Aquifer in the western half of the County. In this area, the depth to burial is more than 100 metres below ground surface.

There are four “dry” water test holes that are completed in the Lower Horseshoe Canyon Aquifer.

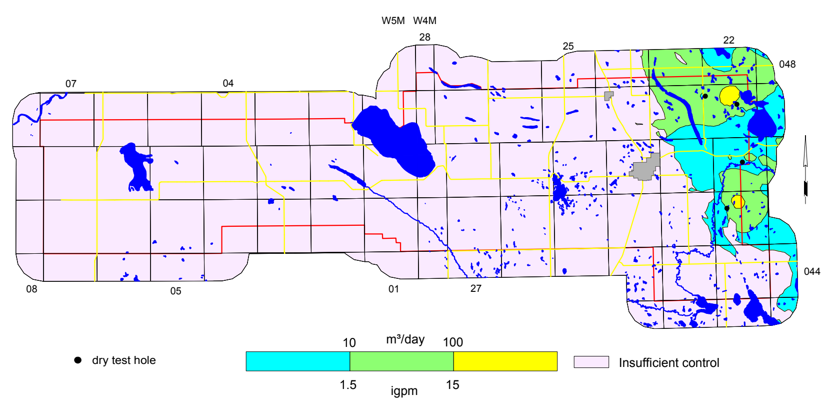

Figure 35. Apparent Yield for Water Wells Completed through Lower Horseshoe Canyon Aquifer

In the County, there are 11 licensed and/or registered groundwater users with water wells that are completed in the Lower Horseshoe Canyon Aquifer, for a total authorized diversion of 27 m³/day, with a median authorized amount of 1.1 m³/day. The highest allocation is for a water well completed to a depth of 57 metres below ground surface in the Lower Horseshoe Canyon Aquifer that is licensed to divert 7.1 m³/day in 07-21-046-022 W4M for agricultural (stock) purposes.

All 11 licensed and/or registered water wells could be linked to a water well in the AENV groundwater database.

6.3.12.3 Quality

The groundwaters from the Lower Horseshoe Canyon Aquifer are mainly a sodium-bicarbonate-type with no dominant anion (see Piper diagram on CD-ROM), with groundwater samples having TDS concentrations ranging from 500 to more than 1,500 mg/L (page A-65). Nearly 70% of the groundwater samples analyzed from the Lower Horseshoe Canyon Aquifer have TDS concentrations of greater than 1,000 mg/L. More than 50% of the sulfate concentrations in groundwaters from the Lower Horseshoe Canyon Aquifer are greater than 50 mg/L. More than 50% of the chloride concentrations from the Lower Horseshoe Canyon Aquifer are greater than 50 mg/L, and 55% of the groundwater samples have fluoride concentrations of less than the MAC of 1.5 mg/L.

Of the five constituents that have been compared to the SGCDWQ, the median values of TDS and sodium exceed the guidelines. The median concentrations from water wells completed in the Lower Horseshoe Canyon Aquifer are all greater than the median concentrations from water wells completed in all Upper Bedrock Aquifer(s).

Constituent	No. of Analyses	Range for County in mg/L Minimum	Maximum	Median	All Bedrock Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	37	617	2,408	1,150	770	500
Sodium	29	177	800	434	293	200
Sulfate	36	0	1,200	78	64	500
Chloride	37	0	650	50	4	250
Fluoride	33	0	2	1.3	0.7	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives except for Fluoride, which is for Maximum Acceptable Concentration (MAC)
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Table 17. Apparent Concentrations of Constituents in Groundwaters from Lower Horseshoe Canyon Aquifer

7 GROUNDWATER BUDGET

7.1 Hydrographs

In the County, there is one observation water well that is part of the AENV regional groundwater monitoring network where water levels are currently being measured and recorded as a function of time. This observation water well, AENV Observation Water Well Wetaskiwin #26 (AENV Obs WW No. 150), is located in 12-01-046-26 W4M, and is completed from 18.3 to 64.3 metres below ground surface in the Upper Horseshoe Canyon Formation. Water levels in a second AENV observation water well, Wetaskiwin 1962-2 (AENV Obs WW No. 151), were monitored from 1963 to 1989. AENV Obs WW No. 151 is located in 14-19-046-23 W4M, and is completed at a depth of 54.9 metres below ground surface in the Upper Horseshoe Canyon Formation. Detailed completion data for AENV Obs WW No. 151 are not available.

In order to show a closer comparison between the water-level trends in AENV Obs WW No. 150 and AENV Obs WW No. 151, the water levels in AENV Obs WW No. 151 were shifted down eight metres. This comparison is shown on the adjacent graph.

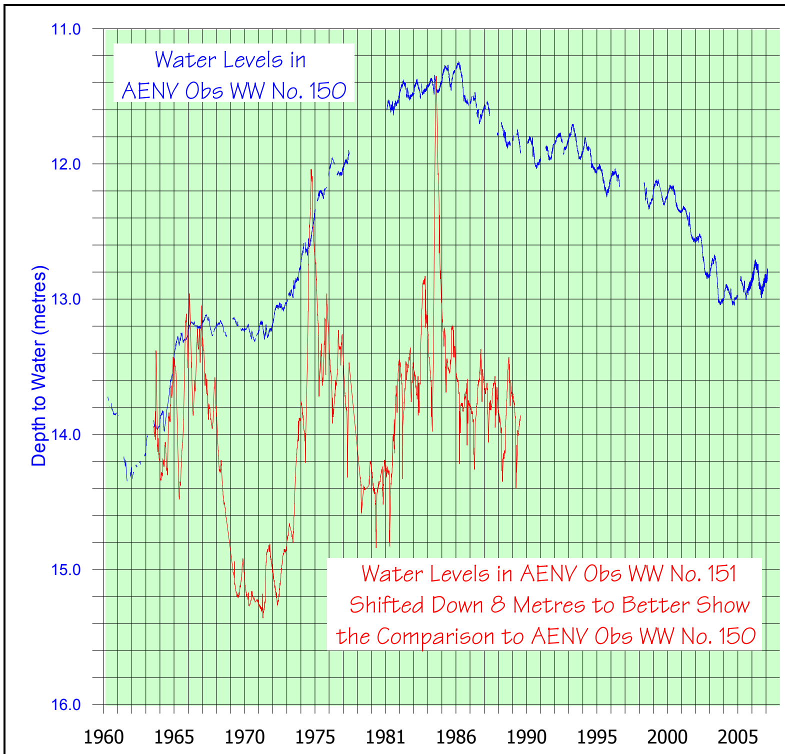

Figure 36. Hydrograph – AENV Obs WW No. 150 and AENV Obs WW No. 151

These hydrographs show annual water-level fluctuations and longer-term fluctuations. Both hydrographs show similar occurrences of water-level rise and decline, but the magnitude of water-level decline in AENV Obs WW No. 151 is greater than in AENV Obs WW No. 150. For example, from 1966 to 1971, the water level in AENV Obs WW No. 151 declined close to 2.2 metres, but the water level in AENV Obs WW No. 150 declined only 0.2 metres. The sharper cycles of water-level decline in AENV Obs WW No. 151 may be a result of high seasonal groundwater use in the area. Since 1986, the water level in AENV Obs WW No. 150 has declined 1.8 metres.

In an area where there are no pronounced seasonal uses of groundwater, the highest yearly water level will mostly occur in late spring/early summer and the lowest yearly water level will be in late winter/early spring. The rise in water level in late spring/early summer could be associated with recharge when the frost leaves the ground. The rise in water level late in the year would be associated with excess precipitation after most vegetation has been killed by frost and before the ground has frozen. In Figure 36, it is apparent that the lowest water levels in AENV Obs WW No. 150 are mainly during the summer/fall months, and the highest water levels occur mainly during the late winter/early spring months. The highest water levels measured in AENV Obs WW No. 151 occur mainly in late fall/early winter and the lowest water levels occur mainly in late spring/early summer. This situation is a result of increased groundwater use prior to and during the summer months. From the early 1960s to the early 1980s, the City of Wetaskiwin diverted groundwater for municipal use from water supply wells completed in the Upper Horseshoe Canyon Aquifer. In an attempt to correlate groundwater production from the City of Wetaskiwin water supply wells to the water levels measured in AENV Obs WW Nos. 150 and 151, HCL personnel approached the County to obtain the groundwater-production data. Unfortunately, the data are not available. In an attempt to confirm a correlation between groundwater use and measured water levels in the observation water wells, a mathematical model was used to calculate water levels at the location of AENV Obs WW No. 150. The model, developed by Mow-Tech Ltd., is called the *Infinite Artesian Aquifer Model* (IAAM) and is used to calculate water levels at specific locations in the aquifer; the model can be used to simulate boundary conditions and interference from nearby pumping water wells. The model aquifer is homogeneous and isotropic, and behaves as an aquifer of infinite areal extent; the model does not account for recharge to the aquifer. In the absence of groundwater-production data, the following procedure was used for assigning a discharge to each water well completed in the Upper Horseshoe Canyon Aquifer that is located within a 5,000-metre radius of the AENV Obs WW No. 150. For licensed water wells completed in the Upper Horseshoe Canyon Aquifer, the protected amount was used. The start date for production is the effective date of the approval. In the case of the City of Wetaskiwin water supply wells, a stop date of 1981 for groundwater diversion was used. For unlicensed and unregistered domestic, and domestic and stock water wells, diversion was set to 3.4 m³/day, and the water well completion date was used as the start date of groundwater diversion. It was assumed that water wells used for stock only purposes have been registered. The results did not show a reasonable comparison between the calculated and measured water levels, and have not been included in this report.

The water-level fluctuations in AENV Obs WW No. 150 from 1996 to 2006 have been compared to the annual precipitation measured at the Wetaskiwin South weather station. The smaller interval was chosen in order to make an easier visual comparison. In the adjacent figure, it appears that from 1996 to 2002, that there is a reasonable correlation between annual precipitation and the net water-level change. However, from 2003 to 2005, the increase in precipitation did not provide sufficient groundwater recharge to counteract an apparent increase in groundwater usage in the Upper Horseshoe Canyon Aquifer.

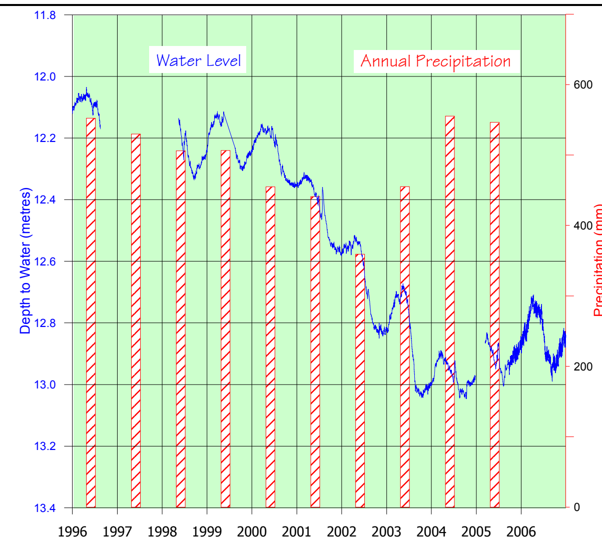

Figure 37. Comparison of Water-Level Measurements in AENV Obs WW No. 150 to Annual Precipitation Measured at the Wetaskiwin South Weather Station

NCE Resources Group Inc. (NCE) diverted groundwater from Shallow WSW No. 01-17 from Jun 1996 to Feb 2000 for their Alder Flats area enhanced-oil-recovery unit. Shallow WSW No. 01-17 is completed from 35.1 to 79.9 metres below ground surface in the Dalehurst Aquifer in 01-17-045-07 W5M. NCE also maintained an observation water well, Shallow Obs WW No. 01-17. Shallow Obs WW No. 01-17 is completed from 38.5 to 79.8 metres below ground surface in the Dalehurst Aquifer in 01-17-045-07 W5M. The water levels in Shallow WSW No. 01-17 and Shallow Obs WW No. 01-17 were measured four times a day using a data logger. In July 2003, the water level in Shallow Obs WW No. 01-17 was manually measured until June 2006, which concluded Mow-Tech's Ltd. involvement at the site. The water level in Shallow Obs WW No. 01-17 fluctuated between 15.4 to 16.8 metres below ground surface when Shallow WSW No. 01-17 was diverting groundwater. After groundwater production ceased in Feb 2000, the water level fluctuated between 14.85 to 16.0 metres below ground surface, as shown on Figure 38 on the following page.

The *IAAM* was used to calculate the water level at the site of Shallow Obs WW No. 01-17. The model used the groundwater production recorded for Shallow WSW No. 01-17. The model aquifer has an effective transmissivity of 57 m²/day, and a corresponding storativity of 0.00048, is homogeneous and isotropic, and behaves as an aquifer of infinite areal extent; the model does not account for recharge to the aquifer. The results of the simulation show there is an acceptable comparison between the calculated and lowest measured water levels in Shallow Obs WW No. 01-17, as shown in the adjacent figure.

The water level in Shallow Obs WW No. 01-17 has been compared to the monthly precipitation measured at the Gwynne meteorological station from March 2000 to March 2005. Figure 38 shows that the highest water levels in Shallow Obs WW No. 01-17 tend to correspond to the highest monthly precipitation, and the lowest water-level measurements correspond to the lowest monthly precipitation.

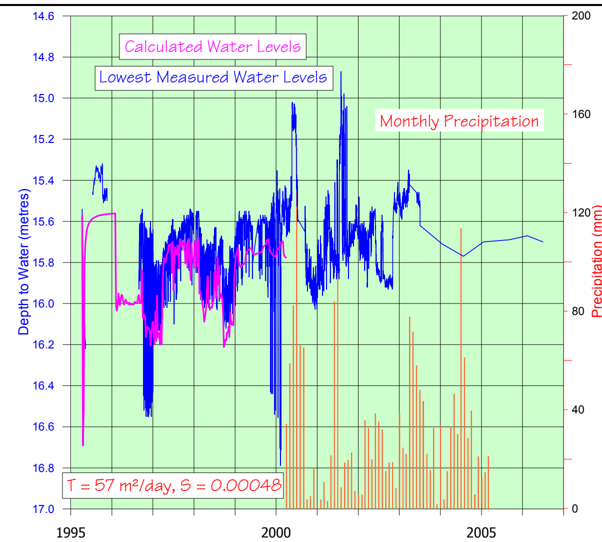

Figure 38. Water-Level Comparison – Shallow Obs WW No. 01-17

7.2 Estimated Groundwater Use in the County of Wetaskiwin

An estimate of the quantity of groundwater removed from each geologic unit in the County of Wetaskiwin must include both the groundwater diversions with licences and/or registrations and the groundwater diversions without licences and/or registrations. As stated previously on page 12 of this report, the daily water requirement for livestock for the County based on the 2006 census is 7,294 cubic metres. AENV has licensed the use of 6,844 m³/day for livestock, which includes both surface water (based on consumptive use) and groundwater in the County. To obtain an estimate of the quantity of groundwater being diverted from the individual geologic units, it has been assumed that the remaining 450 m³/day of water required for livestock watering is obtained from other approved sources of surface water. Under the *Water Act*, Section 51(6), "a licensee of water for irrigation purposes is entitled to divert, as part of the acquired water,

i. up to a maximum of 1,250 cubic metres of water per year for household purposes,

and

ii. up to a maximum of 6,250 cubic metres of water per year for the purposes of raising animals",

As a result, an additional 168 m³/day could be diverted for stock watering use based on the ten licensed users in the County authorized to divert surface water for irrigation purposes.

Ranchers do not need to license the water source for free-ranging cattle that have access to surface water, as long as the water is not pumped to a dugout or cattle waterer. It is also suspected that there are many unlicensed dugouts used for stock.

Because of the limitations of the data, it has, therefore, been assumed that all livestock use has been accounted for.

In the County, there are a total of 8,581 water wells being used for domestic (6,342), domestic/stock (1,260) or stock (979) purposes. It has been assumed that these 8,581 water wells are active; however, many are very old and may not be in use or may have been abandoned.

Groundwater for household use requires authorization if the use is more than 1,250 m³/year. Under the *Water Act*, a residence is protected for up to 3.4 m³/day. However, the standard groundwater use for household purposes (a family of four) is 1.1 m³/day. Since there are 7,602 domestic (6,342) or domestic/stock (1,260) water wells in the County of Wetaskiwin serving a population of 10,695, the domestic use per water well is 0.4 m³/day. Because it does not appear that there is any stock use without a licence and/or registration, 0.4 m³/day was also assigned for domestic/stock water wells, and no value was assigned for stock water wells. Because of the limitations of the data, no attempt has been made to compensate for dugouts, springs or inactive water wells.

	Domestic and Domestic/Stock Diversions					***Licensed and/or Registered Groundwater Diversions***	***Total Groundwater Diversions***
Aquifer Designation	Number of Domestic	Daily Use (0.4 m³/day)	Number of Domestic and Stock	Daily Use (0.4 m³/day)	Totals m³/day	Totals (m³/day)	Totals m³/day
Multiple Surficial Completions	1	0	0	0	0	0	0
Upper Sand and Gravel	199	80	77	31	110	416	527
Lower Sand and Gravel	51	20	15	6	26	63	89
Multiple Surficial/Multiple Bedrock Completions	4	2	1	0	2	0	2
Multiple Bedrock Completions	347	139	61	24	163	447	610
Dalehurst	1,253	501	361	144	646	2,135	2781
Upper Lacombe	1030	412	53	21	433	316	750
Lower Lacombe	330	132	26	10	142	296	438
Haynes	140	56	23	9	65	194	259
Upper Scollard	168	67	34	14	81	255	335
Lower Scollard	232	93	57	23	116	321	437
Upper Horseshoe Canyon	1,886	754	437	175	929	3,321	4250
Middle Horseshoe Canyon	188	75	72	29	104	217	321
Lower Horseshoe Canyon	55	22	21	8	30	27	58
Unknown	458	183	22	9	192	319	511
Totals [(1)]	6,342	2,537	1,260	504	3,041	8,328	11,369

[(1)] The values given in the table have been rounded and, therefore, the columns and rows may not add up equally

Table 18. Total Domestic and Stock Groundwater Diversions by Aquifer

Based on using 0.4 m³/day for all available domestic or domestic/stock water wells, and the protected amount for licensed and/or registered water wells, an estimate of the groundwater use from each geologic unit was prepared, as shown on the previous page in Table 18. The data provided in Table 18 indicate that 11,369 m³/day of groundwater is being diverted in the County, of which 4,250 m³/day (37%) is from the Upper Horseshoe Canyon Aquifer, and 2,781 m³/day (24%) is from the Dalehurst Aquifer.

By assigning 0.4 m³/day for all available domestic or domestic/stock water wells, and using the total maximum authorized diversion associated with any licensed and/or registered water well, a map has been prepared that shows the estimated groundwater use in terms of volume per section per day for the County (not including springs).

There are 1,512 sections in the County. In 21% (316) of the sections in the County, there is no domestic, stock or licensed and/or registered groundwater user. The groundwater use for the remaining 1,196 sections varies from 0.4 m³/day to 890 m³/day, with an average use per section of 9.4 m³/day. Daily groundwater use of more than 30 m³/day can be expected in the vicinity of Pigeon Lake. The estimated water well use per section can be more than ten m³/day in 261 of the 1,196 sections. Two hundred and sixty-three of the total 1,448 licensed and/or registered groundwater users are in areas where the groundwater use is greater than ten m³/day.

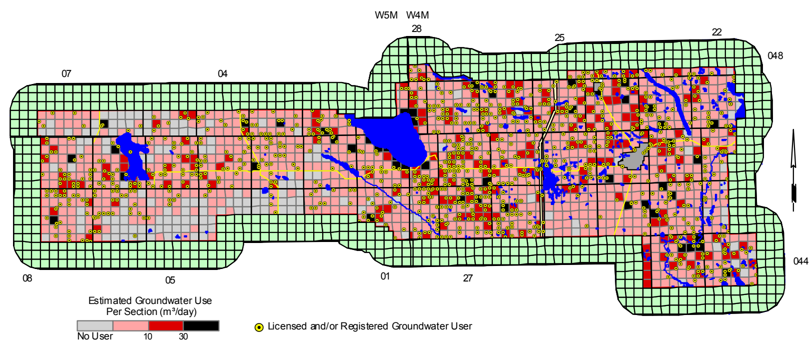

Figure 39. Estimated Water Well Use Per Section

In summary, the estimated total groundwater use within the County of Wetaskiwin is 11,369 m³/day, with the breakdown as shown in Table 19. An estimated 10,248 m³/day is being withdrawn from a specific aquifer. Of the remaining 1,123 m³/day (9.9%), 610 m³/day is being withdrawn from multiple bedrock aquifers, and 511 m³/day is being withdrawn from unknown aquifer units. Approximately 73% of the total estimated groundwater use is from licensed and/or registered water wells.

Groundwater Use within the County of Wetaskiwin (m³/day)		%
Domestic/Stock (including agriculture and/or registrations)	8,301	*73*
Municipal (licensed)	1,523	*13*
Commercial/industrial/Dewatering/Recreation/Other (licensed)	1,545	*14*
Total	11,369	*100*

Table 19. Total Groundwater Diversions

7.3 Groundwater Flow

A direct measurement of groundwater recharge or discharge is not possible from the data that are available for the County. One indirect method of measuring recharge is to determine the quantity of groundwater flowing laterally through each individual aquifer. This method assumes that there is sufficient recharge to the aquifer to maintain the flow through the aquifer and the discharge is equal to the recharge. However, even the data that can be used to calculate the quantity of flow through an aquifer must be averaged and estimated. To determine the flow requires a value for the average transmissivity of the aquifer, an average hydraulic gradient and an estimate for the width of the aquifer. For the present program, the flow has been estimated for various parts of individual aquifers within the County.

Aquifer/Area	Trans (m^2/day)	Gradient (m/m)	Width (km)	Flow (m^3/day)	Aquifer Flow (m^3/day)	Licensed and/or Registered Diversion (m^3/day)
Upper Surficial					0	416
Insufficient Data						
Lower Surficial					858	63
Red Deer Buried Valley						
Flow to east	26	0.003	11	858		
Dalehurst					50,653	2,135
West						
Flow to west (north part)	15.3	0.007	13	1,326		
Flow to north	15.3	0.009	7	918		
Flow to west (south part)	15.3	0.012	16	2,938		
Buck Lake						
Flow to west	15.3	0.010	16	2,448		
Flow to northwest	15.3	0.010	10	1,530		
Flow to east	15.3	0.008	20	2,448		
Battle River						
Flow to northeast	15.3	0.020	30	9,180		
Flow to west	15.3	0.012	6	1,102		
Flow to northwest	15.3	0.013	10	2,040		
Flow to east	15.3	0.017	16	4,080		
Flow to southwest	15.3	0.030	30	13,770		
Pigeon Lake						
Flow to northeast	15.3	0.017	30	7,650		
Flow to southeast	15.3	0.008	10	1,224		
Upper Lacombe					13,823	316
Battle River						
Flow to southwest	14.3	0.008	30	3,218		
Pigeon Lake						
Flow to west (north part)	14.3	0.007	25	2,383		
Flow to north	14.3	0.008	10	1,073		
Flow to west (south part)	14.3	0.013	40	7,150		
Lower Lacombe					970	296
North Saskatchewan River (NSR)						
Flow to northwest	13.3	0.002	35	970		
Pigeon Lake						
Flow to southwest	13.3	0.013	27	4,489		
Flow to northeast	13.3	0.009	16	1,995		
Haynes					1,348	194
NSR						
Flow to west	9.5	0.001	36	194		
East of Pigeon Lake						
Flow to northeast	9.5	0.004	34	1,153		
Upper Scollard					2,272	255
Bearhills Lake Basin						
Flow to east	5.8	0.005	30	906		
Flow to west	5.8	0.008	10	483		
Wizard Lake						
Flow to northeast	5.8	0.010	8	483		
NSR						
Flow to north	5.8	0.001	55	399		
Lower Scollard					1,135	321
South Pigeon Lake High						
Flow to northwest	3	0.008	5	120		
Flow to northeast	3	0.017	7	350		
Flow to southeast	3	0.003	19	166		
Bearhills High						
Flow to northeast	3	0.006	19	324		
Flow to northwest	3	0.002	24	175		
Upper Horseshoe Canyon					9,479	3,321
Coal Lake						
Flow to west	7.5	0.009	30	2,109		
Flow to east	7.5	0.009	24	1,688		
Pipestone Creek						
Flow to west	7.5	0.006	14	656		
Flow to east	7.5	0.006	30	1,406		
Battle River						
Flow to north	7.5	0.008	16	1,000		
Flow to east	7.5	0.005	10	391		
Bearhills High						
Flow to northeast	7.5	0.013	8	750		
Flow to west	7.5	0.009	6	422		
West Highland						
Flow to northeast	7.5	0.005	19	693		
Flow to southeast	7.5	0.003	14	365		
Middle Horseshoe Canyon					2,348	217
Coal Lake						
Flow to west	2.8	0.006	24	420		
Flow to east	2.8	0.004	14	163		
Bittern Lake						
Flow to east	2.8	0.003	14	123		
Battle River						
Flow to west	2.8	0.008	24	560		
Flow to east	2.8	0.013	26	910		
Bearhills High						
Flow to northwest	2.8	0.002	16	93		
Flow to southeast	2.8	0.002	18	79		
Lower Horseshoe Canyon					615	27
Coal Lake						
Flow to west	1.8	0.0125	14	315		
Bittern Lake						
Flow to east	1.8	0.002	5	19		
Battle River						
Flow to west	1.8	0.012	13	281		

Table 20. Groundwater Budget

The flow through each aquifer assumes that by taking a large enough area, an aquifer can be considered as homogeneous, the average gradient can be estimated from the non-pumping water-level surface, and flow takes place through the entire width of the aquifer; flow through the aquifers also takes into consideration hydrogeological conditions outside the County border. Based on these assumptions, the estimated lateral groundwater flow through the individual aquifers has been summarized in Table 20.

Table 20 indicates that there is more groundwater flowing through the aquifers than has been authorized to be diverted from the individual aquifers. However, even where use is less than the calculated aquifer flow, there can still be local impacts on water levels. The calculations of flow through individual aquifers as presented in the adjacent table are very approximate and are intended only as a guide for future investigations.

7.3.1 Quantity of Groundwater

An estimate of the volume of groundwater stored in the surficial deposits is 0.5 to 3.0 cubic kilometres. This volume is based on an areal extent of 1,950 square kilometres and a saturated thickness of five metres. The variation in the total volume is based on the value of porosity that is used for the surficial deposits. 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).

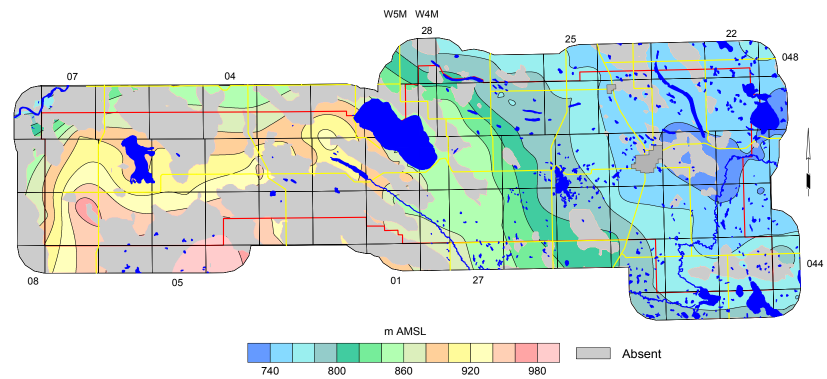

Figure 40. Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep

The adjacent non-pumping water-level map has been prepared from water levels associated with water wells completed to depths of less than 20 metres in aquifers in the surficial deposits. The water levels from these water wells were used for the calculation of the saturated thickness of the surficial deposits and for calculations of recharge/discharge areas. In areas where the elevation of the water-level surface is below the bedrock surface, the surficial deposits are not saturated (indicated by grey areas on the map). The water-level map for the surficial deposits shows the main flow direction in the western part of the County, west of Pigeon Lake, is toward the North Saskatchewan River Valley, and in the eastern part of the County is toward the Battle River and Bittern Lake, south and east of Coal Lake.

7.3.2 Recharge/Discharge

The hydraulic relationship between the groundwater in the surficial deposits and the groundwater in the bedrock aquifers is given by the non-pumping water-level surface associated with each hydraulic unit. 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.

7.3.2.1 Bedrock Aquifers

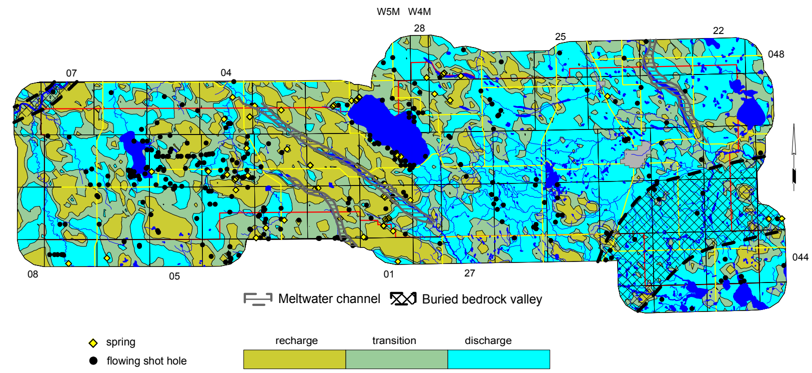

Figure 41. Bedrock Recharge/Discharge Areas

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, an alternative approach has been used to establish approximate recharge and discharge areas. The first objective was to determine the location of springs, 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 bedrock surface. This resulting depth to water level grid was contoured to reflect the positioning of springs, 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 five metres below bedrock surface. The discharge areas are where the water level in the upper bedrock aquifer(s) is more than five metres above the bedrock surface. When the depth to water level in the upper bedrock aquifer(s) is between five metres below and five metres above the bedrock surface, the area is classified as a transition, that is, no recharge and no discharge.

Figure 41 shows that, in nearly 20% of the County, there is a downward hydraulic gradient from the bedrock surface toward the upper bedrock aquifer(s) (i. e. recharge). Areas where there is an upward hydraulic gradient from the bedrock to the bedrock surface (i. e. discharge) are mainly in the vicinity of creeks and river valleys and the Red Deer Buried Valley. 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.

With nearly 20% of the County land area being one of recharge to the bedrock, and the average precipitation being 554 mm per year, seven percent of the annual precipitation is sufficient to provide the total calculated quantity of groundwater flowing through the upper bedrock aquifer(s).

7.4 Areas of Groundwater Decline

The method of calculating changes in water levels is at best an estimate. In order to determine the areas of possible water-level decline in the Sand and Gravel Aquifer(s) and in the Upper Bedrock Aquifer(s), the following approach was used. The areas of groundwater decline in the Sand and Gravel Aquifer(s) and in the Upper Bedrock Aquifer(s) have been calculated by determining the frequency of non-pumping water level control points per five-year period. Additional data would be needed to verify water-level change.

7.4.1 Sand and Gravel Aquifer(s)

In the County and buffer area, there are 203 surficial water wells with a non-pumping water level and date; 101 are from water wells completed before 1975 and 103 are from water wells after 1975.

Where the earliest water level (before 1975) is at a higher elevation than the latest water level (after 1975), there is the possibility that some groundwater decline has occurred. The interpretation of the adjacent map should be limited to areas where both earliest and latest water level control points are present.

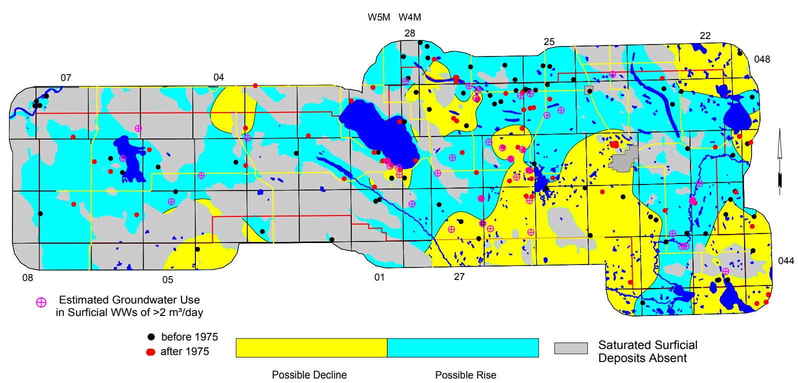

Figure 42. Changes in Water Levels in Surficial Deposits

Where the earliest water level is at a lower elevation than the latest water level, there is the possibility that the groundwater has risen at that location. The water level may have risen as a result of recharge in wetter years or may be a result of the water well being completed in a different surficial aquifer.

Figure 42 indicates that in 30% of the County where surficial deposits are present, it is possible that the non-pumping water level has declined. Of the 41 surficial water wells having an estimated groundwater use of more than two m³/day, 11 are within one kilometre of where it is possible that there has been a water-level decline in the surficial deposits.

In areas where a water-level decline is indicated, 5% of the area has no estimated water well use; 75% of the use is less than ten m³/day; 18% of the use is between ten and 30 m³/day per section; and the remaining 2% of the declines occurred where the estimated groundwater use per section is greater than 30 m³/day, as shown in Table 21.

The areas of groundwater decline in the Sand and Gravel Aquifer(s) where there is no estimated water well use suggest that groundwater diversion is not having an impact and that the decline may be due to variations in recharge to the aquifer or because the water wells are not on file with AENV.

Estimated Water Well Use Per Section (m³/day)	*% of Area with a Decline*
<10	*75*
10 to 30	*18*
>30	*2*
no use	*5*

Table 20. Water-Level Decline in Sand and Gravel Aquifer(s)

7.4.2 Upper Bedrock Aquifer(s)

In the County and buffer area, there are 9,537 bedrock water wells with a non-pumping water level and date; 5,213 are from water wells completed before 1985 and 4,324 are from water wells completed after 1985.

Where the earliest water level (before 1985) is at a higher elevation than the latest water level (after 1985), there is the possibility that some groundwater decline has occurred.

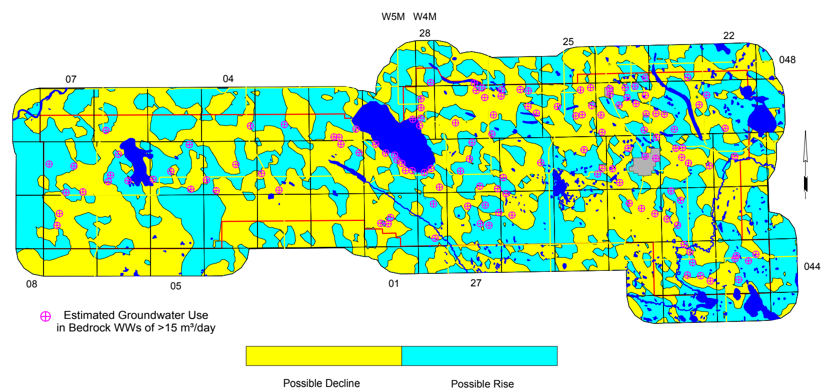

Figure 43. Areas of Potential Groundwater Decline – Upper Bedrock Aquifer(s)

The adjacent map indicates that in 55% of the County, it is possible that the NPWL has declined. Of the 62 bedrock water wells having an estimated use of more than 15 m³/day, 34 are within one kilometre of where it is possible that there has been a water-level decline in the Upper Bedrock Aquifer(s).

In areas where a water-level decline is indicated, 14% of the area has no estimated water well use; 67% is less than ten m³/day; 15% is between ten and 30 m³/day per section; and the remaining 4% of the declines occurred where the estimated groundwater use per section is greater than 30 m³/day, as shown below in Table 22.

Estimated Water Well Use Per Section (m³/day)	*% of Area with a Decline*
<10	*67*
10 to 30	*15*
>30	*4*
no use	*14*

Table 21. Water-Level Decline in Upper Bedrock Aquifer(s)

The areas of groundwater decline in the Upper Bedrock Aquifer(s) where there is no estimated water well use suggest that groundwater production is not having an impact and that the decline may be due to variations in recharge to the aquifer or because the water wells are not on file with AENV

8 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 213 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. There are 15 water wells for which the County has responsibility; the County-operated water wells are included in Appendix E. It is recommended that the County-operated water wells plus the 213 water wells be field-verified, water levels be measured, a water sample be collected for analysis, and a short aquifer test be conducted. An attempt to update the quality of the entire database is not recommended.

Before an attempt is made to provide a major upgrade to the level of interpretation provided in this report, the accompanying maps and the groundwater query, it is recommended that the 213 water wells listed in Appendix E for which water well drilling reports are available, plus the County–operated water wells, 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 83 or some other system that will allow conversion to 10TM NAD 83 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.

This additional information would provide a baseline to be used for comparison to either existing chemical analyses or aquifer tests, or to determine if future monitoring would be necessary if significant changes in the aquifer parameters had occurred.

A list of the 228 water wells that could be considered for the above program is given in Appendix E and on the CD-ROM.

An attempt to link the AENV groundwater and licensing databases was 75% successful in this study (see CD-ROM); 25% of the licensed and/or registered water wells do not appear to have corresponding records in the AENV groundwater database. There is a need to improve the quality of the AENV licensing database. It is recommended that attempts be made in a future study to find and add missing drilling records to the AENV groundwater database and to determine the aquifer in which the authorized non-exempt water wells are completed.

While there are a few areas where water-level data are available at different times, 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 County of Rocky View and in the M.D. of Flagstaff, water well owners were being provided with a tax credit if they accurately measured 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 (Buchanan, Bob [(editor)]. Alberta Agriculture, Food and Rural Development, 1996).

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.

The County of Grande Prairie recognizes that economic growth must be balanced with environmental objectives to ensure the preservation and enhancement of its prosperity, and the quality of life for its residents and, has therefore, taken special interest in ensuring long-term water supplies by proposing further groundwater investigation within the area to try to quantify the availability of groundwater through further studies.

In 2006, the County of Grande Prairie committed to and requested funding for a five-year program to sample and monitor 50 water wells. Funding for the first two years from the existing Canada-Alberta Water Supply Expansion Program (CAWSEP) was requested to initiate and cover costs to the maximum allowable for a project of this nature. For years three, four, and five, the County of Grande Prairie will then work together with any future programming that may be available to continue this project.

Communities that are concerned about apparent water-level declines in the aquifers in which their water supply wells are completed should implement a conscientious groundwater-monitoring program.

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 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.

In summary, for the next level of study, the database needs updating. The updating of information for existing water wells requires more details for the water wells listed in Appendix E; the additional information for new water wells is mainly better spatial control.

Groundwater is a renewable resource and it must be managed.

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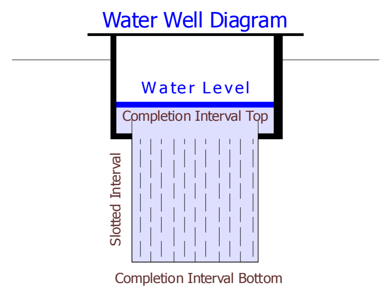
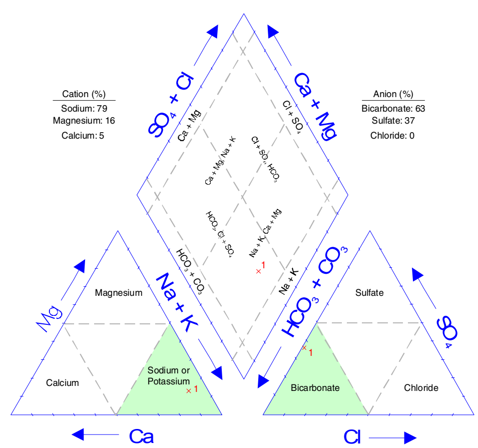
10 GLOSSARY

AAFC-PFRA	Prairie Farm Rehabilitation Administration Branch of Agriculture and Agri-Food Canada
AENV	Alberta Environment
AMSL	above mean sea level
Anion	negatively charged ion
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
BGP	Base of Groundwater Protection
Borehole	includes all “work types” except springs
Cation	positively charged ion
Completion Interval	see diagram
Deltaic	a depositional environment in standing water near the mouth of a river
DEM	Digital Elevation Model
Dfb	one of the Köppen climate classifications; a Dfb climate consists of warm to cool summers, severe winters, and no dry season. The mean monthly temperature drops below -3° C in the coolest month, and exceeds 10° C in the warmest month.
DST	drill stem test
EUB	Alberta Energy and Utilities Board
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)
Facies	the aspect or character of the sediment within beds of one and the same age (Pettijohn, 1957)
Fluvial	produced by the action of a stream or river
Friable	poorly cemented
Geologic Unit	a distinguishable rock unit based on rock type and/or rock age



Completion Interval

Hydraulic Conductivity	the rate of flow of water through a unit cross-section under a unit hydraulic gradient; units are length/time
Hydraulic Unit	a rock type where changes in hydraulic head at one location directly impact hydraulic-head conditions at all locations measurable in less than a year
Hydrogeologic Unit	a hydrogeologic setting comprised of one or more saturated rock types where groundwater characteristics are closely related
Kriging	a geo-statistical method for gridding irregularly-spaced data (Cressie, 1990)
Lacustrine	fine-grained sedimentary deposits associated with a lake environment and not including shore-line deposits
Lithology	description of rock material
Lsd	Legal Subdivision
m²/day	metres squared per day
m³	cubic metres
m³/day	cubic metres per day
mg/L	milligrams per litre
Median	the value at the centre of an ordered range of numbers
NPWL	non-pumping water level
Piper tri-linear diagram	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



Piper Tri-Linear Diagram

Rock	earth material below the root zone
SGCDWQ	Summary of Guidelines for Canadian Drinking Water Quality
Surficial Deposits	includes all sediments above the bedrock
Thalweg	the lowest elevation of a linear bedrock low

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, discharge rate and time of discharge

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” as defined by AENV 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 and 70% of available drawdown

Long-Term Yield: the method used for determining the theoretical long-term yield in the Alberta Environment Groundwater Evaluation Guidelines, and based on effective transmissivity

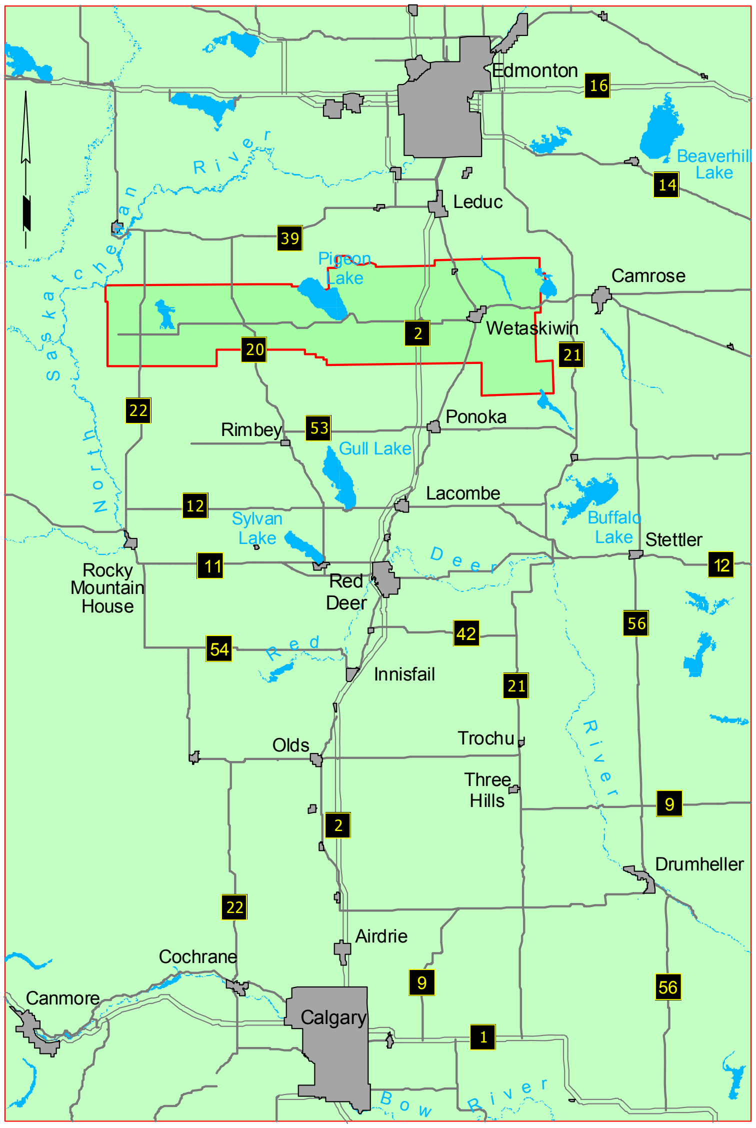
11 CONVERSIONS

Multiply	by	To Obtain
Length/Area		
feet (ft)	0.3 048	metres
metres (m)	3.2 810	feet
hectares (ha)	2.4 711	acres
centimetre (cm)	0.0 328	feet
centimetre	0.3 937	inches
acres (ac)	0.4 047	hectares
inches (in)	25.4 000	millimetres
miles (mi)	1.6 093	kilometres
kilometre (km)	0.6 214	miles (statute)
square feet (ft^2)	0.0 929	square metres (m^2)
square metres (m^2)	10.7 639	square feet (ft^2)
square metres (m^2)	0.0 000	square kilometres (km^2)
Concentration		
grains/gallon (UK)	14.2 700	parts per million (ppm)
ppm	0.9 989	mg/L
mg/L	1.0 011	ppm
Volume (capacity)		
acre feet	1233.4 818	cubic metres
cubic feet	0.0 283	cubic metres
cubic metres	35.3 147	cubic feet
cubic metres	219.9 692	gallons (UK)
cubic metres	264.1 721	gallons (US liquid)
cubic metres	1000.0 000	litres
gallons (UK)	0.0 045	cubic metres
imperial gallons	4.5 460	litres
Rate		
litres per minute (lpm)	0.2 200	UK gallons per minute (igpm)
litres per minute	1.4 400	cubic metres/day (m^3/day)
igpm	6.5 463	cubic metres/day (m^3/day)
cubic metres/day	0.1 528	igpm

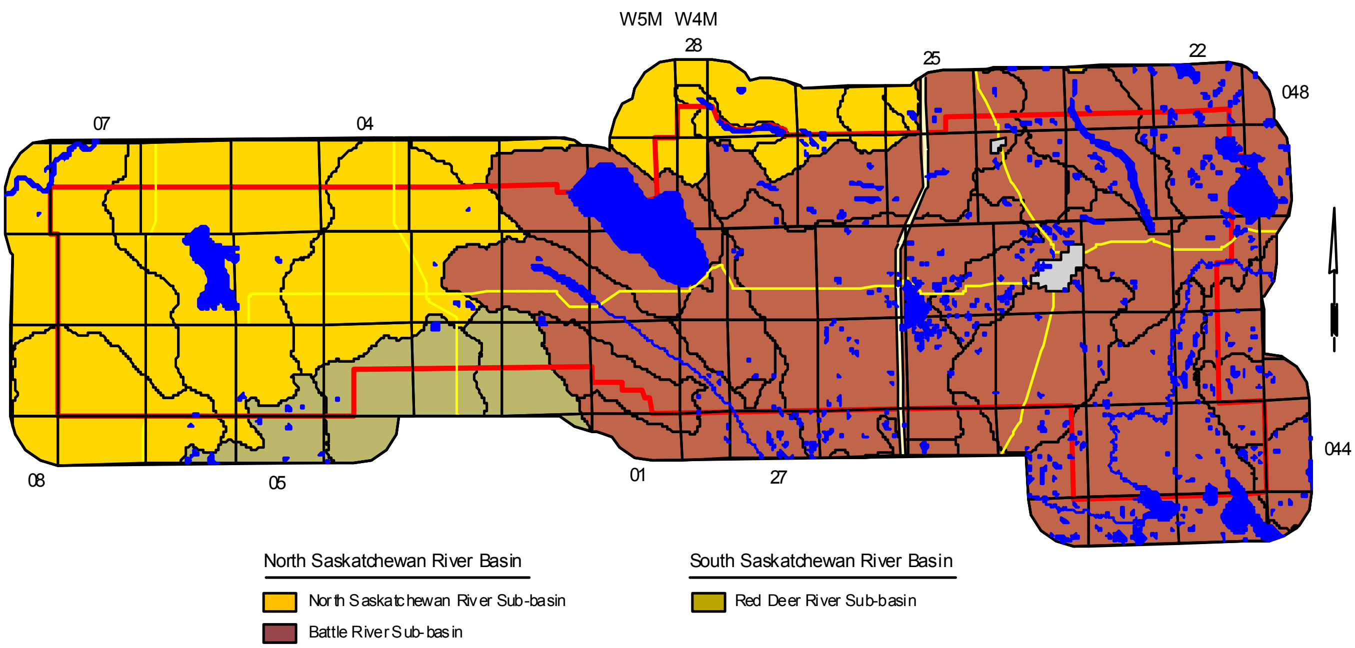
COUNTY OF WETASKIWIN
Appendix A

Hydrogeological Maps and Figures

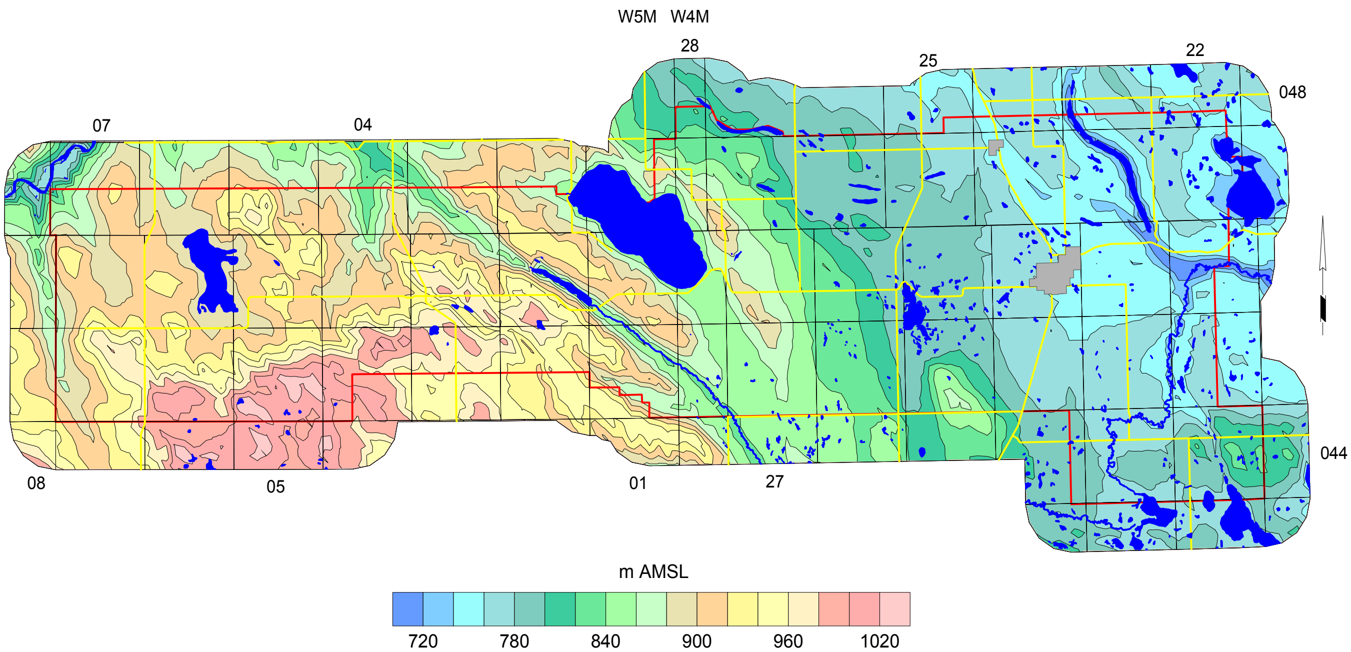
Index Map


Edmonton
16
Beaverhill Lake
14
Leduc
39
North Saskatchewan River
Pigeon Lake
Camrose
2
Wetaskiwin
20
21
22
Ponoka
Rimbey
53
Gull Lake
Lacombe
12
Sylvan Lake
Buffalo Lake
Stettler
12
11
Rocky Mountain House
Red Deer
Red Deer River
56
54
42
Innisfail
21
Trochu
Olds
Three Hills
9
2
Drumheller
22
Airdrie
Cochrane
9
56
Canmore
Calgary
1
Bow River

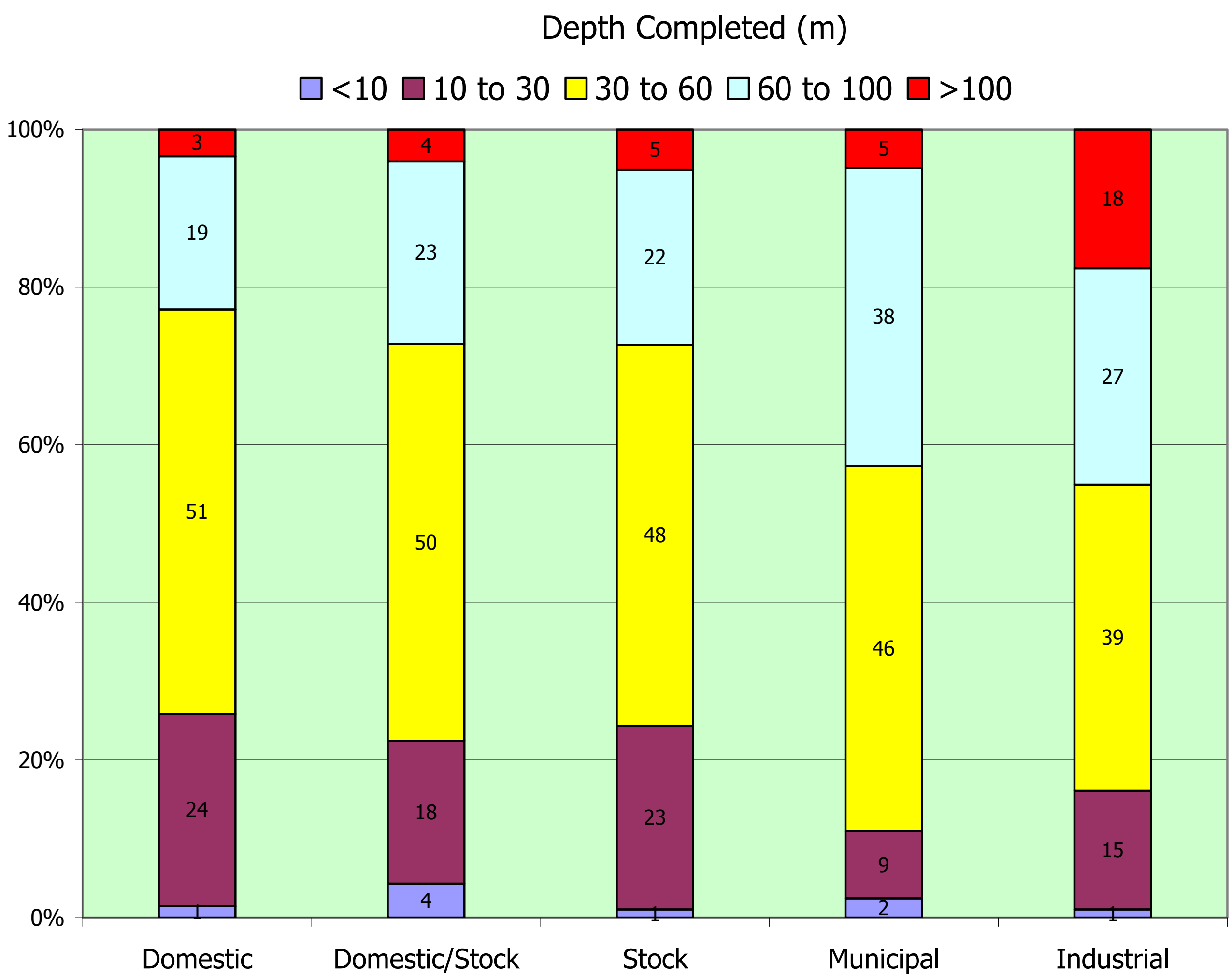
River Sub-Basins



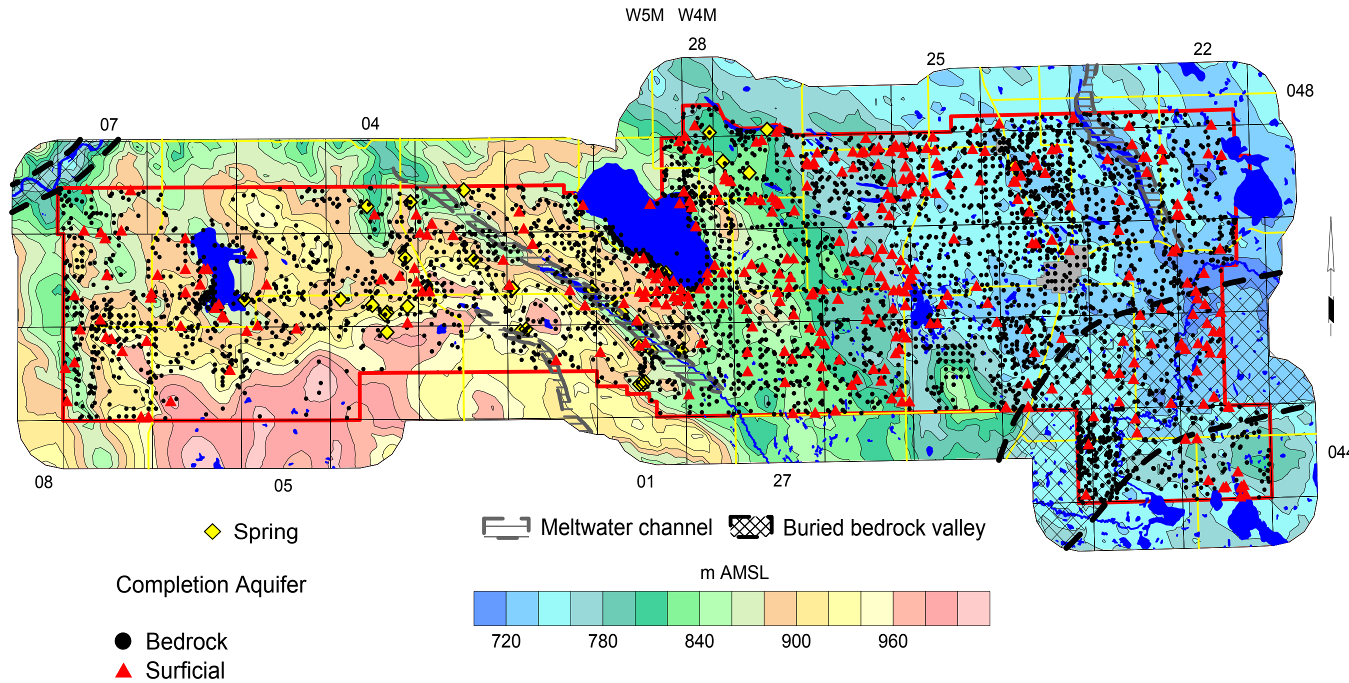
Surface Topography

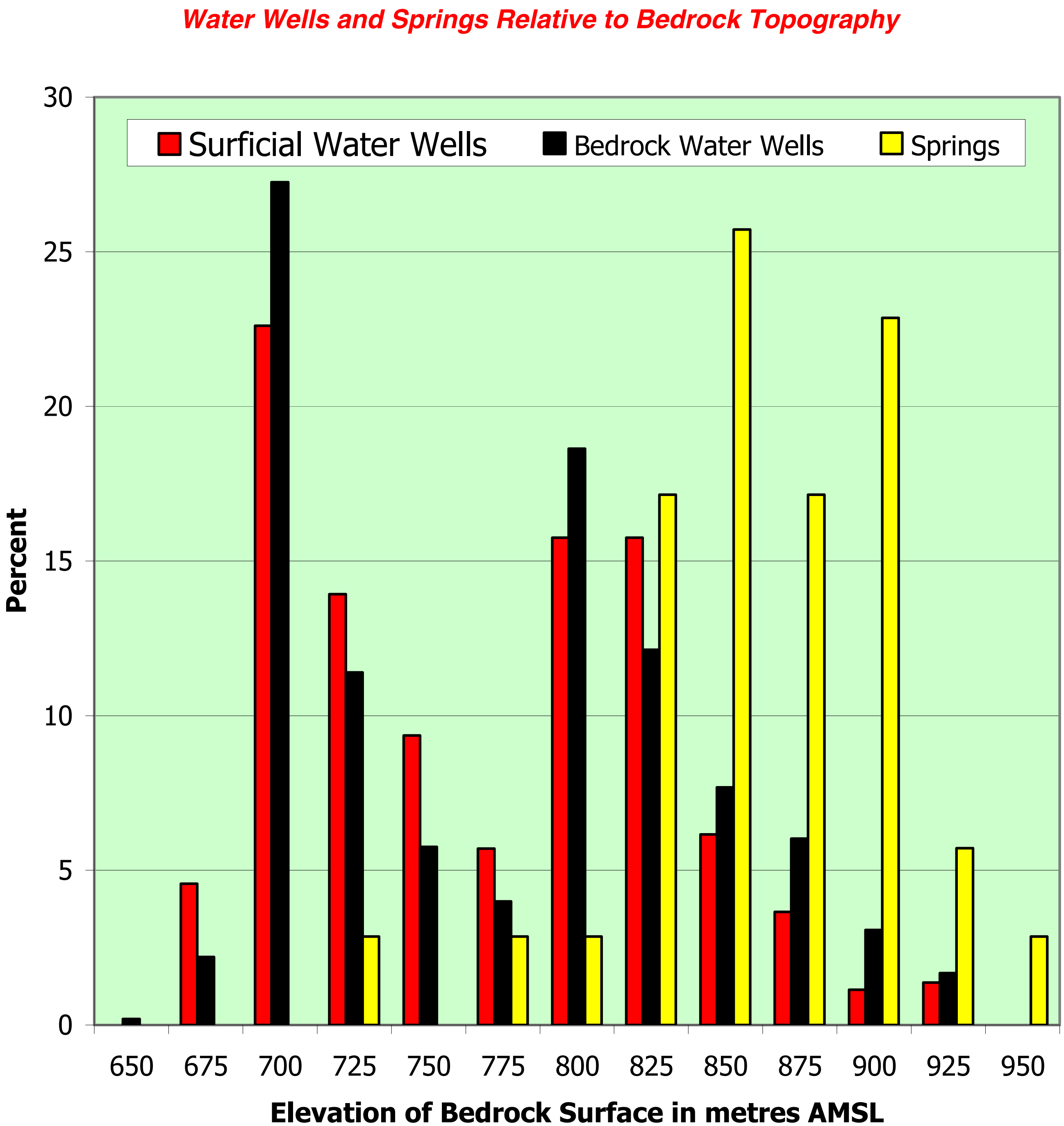


Proposed Use vs Completed Depth

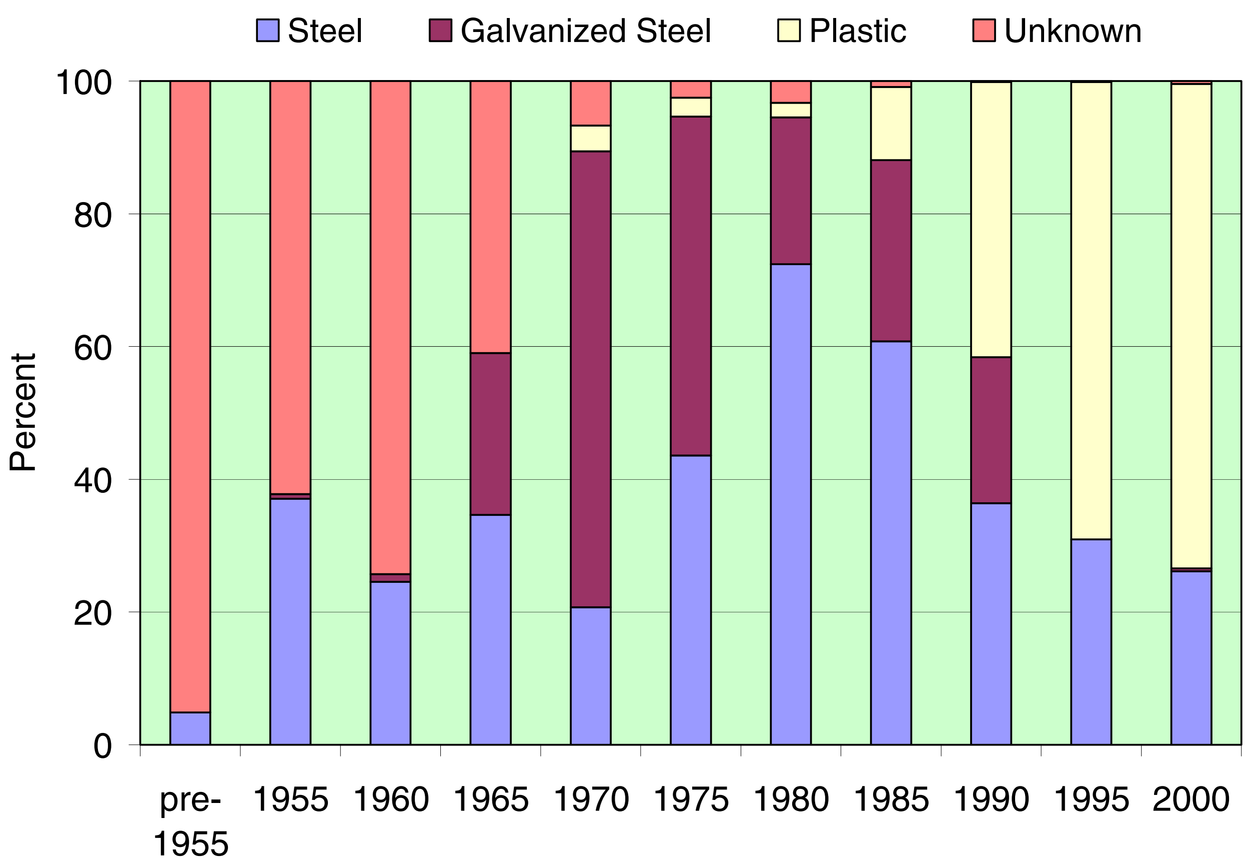


Location of Water Wells and Springs Relative to Bedrock Topography

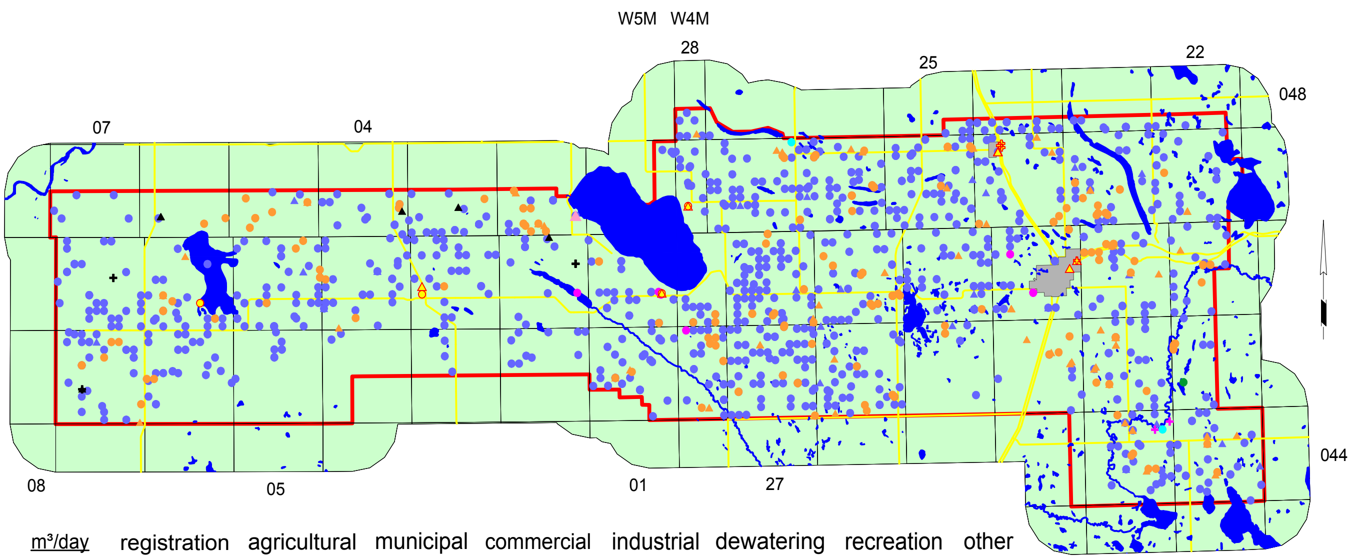



Water Wells and Springs Relative to Bedrock Topography
Surficial Water Wells
Bedrock Water Wells
Springs
Percent
0
5
10
15
20
25
30
650
675
700
725
750
775
800
825
850
875
900
925
950
Elevation of Bedrock Surface in metres AMSL

Surface Casing Types used in Drilled Water Wells



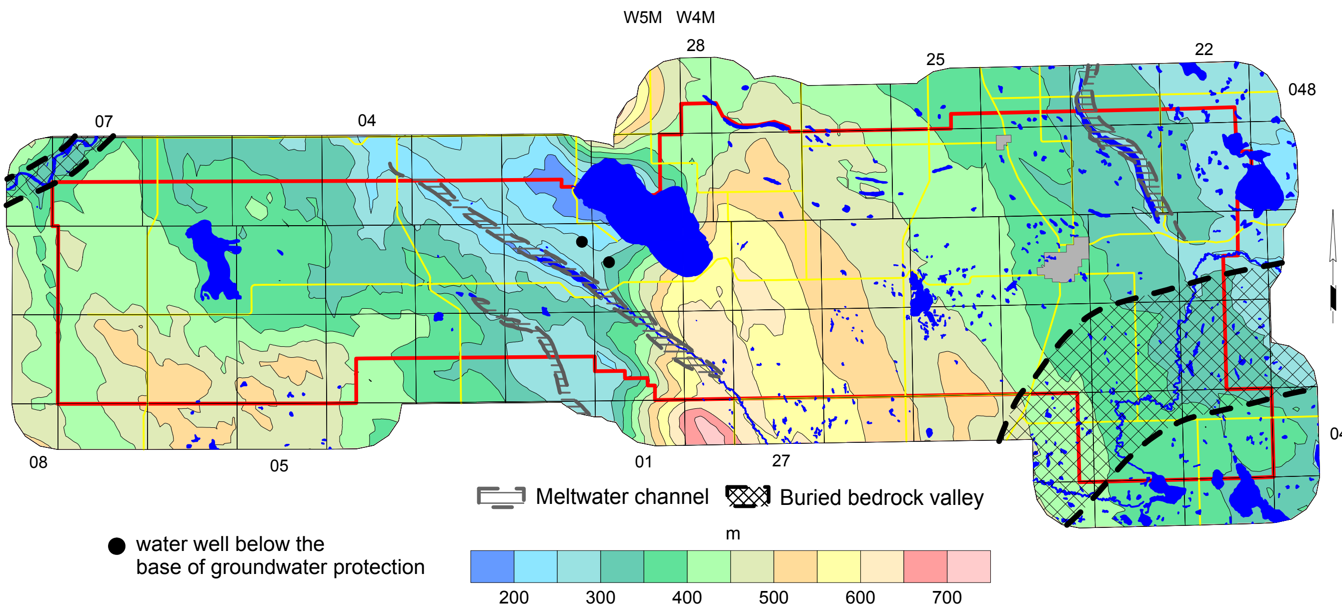
Licensed and Registered Groundwater Water Wells



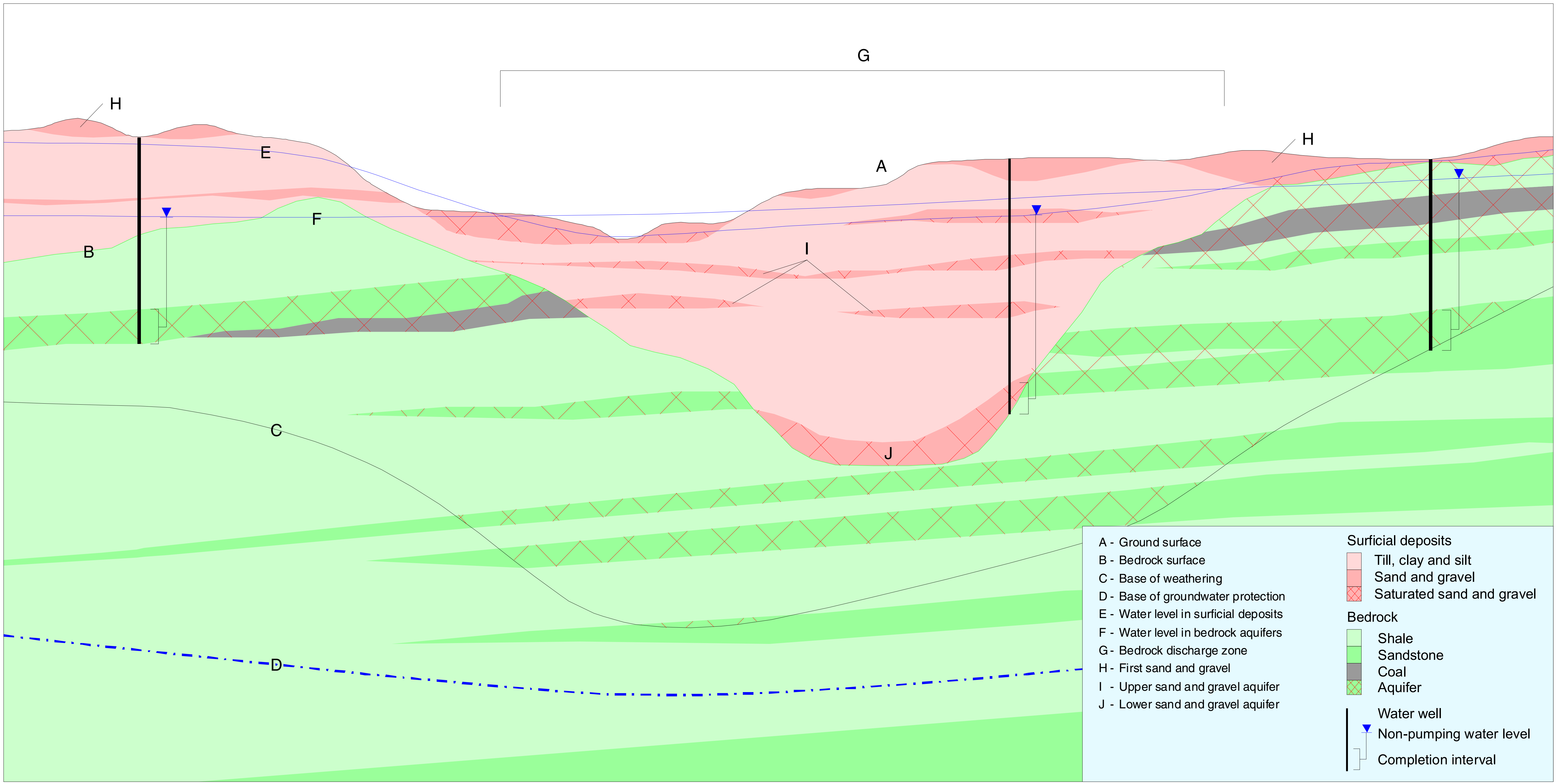
m³/day	registration	agricultural	municipal	commercial	industrial	dewatering	recreation	other
< 10	(1,114)	(191)	(4)	(7)	(0)	(1)	(1)	(0)
10 to 100	(26)	(78)	(7)	(0)	(6)	(0)	(0)	(1)
> 100	(0)	(0)	(5)	(2)	(4)	(0)	(0)	(0)

Depth to Base of Groundwater Protection

(modified after EUB, 1995)



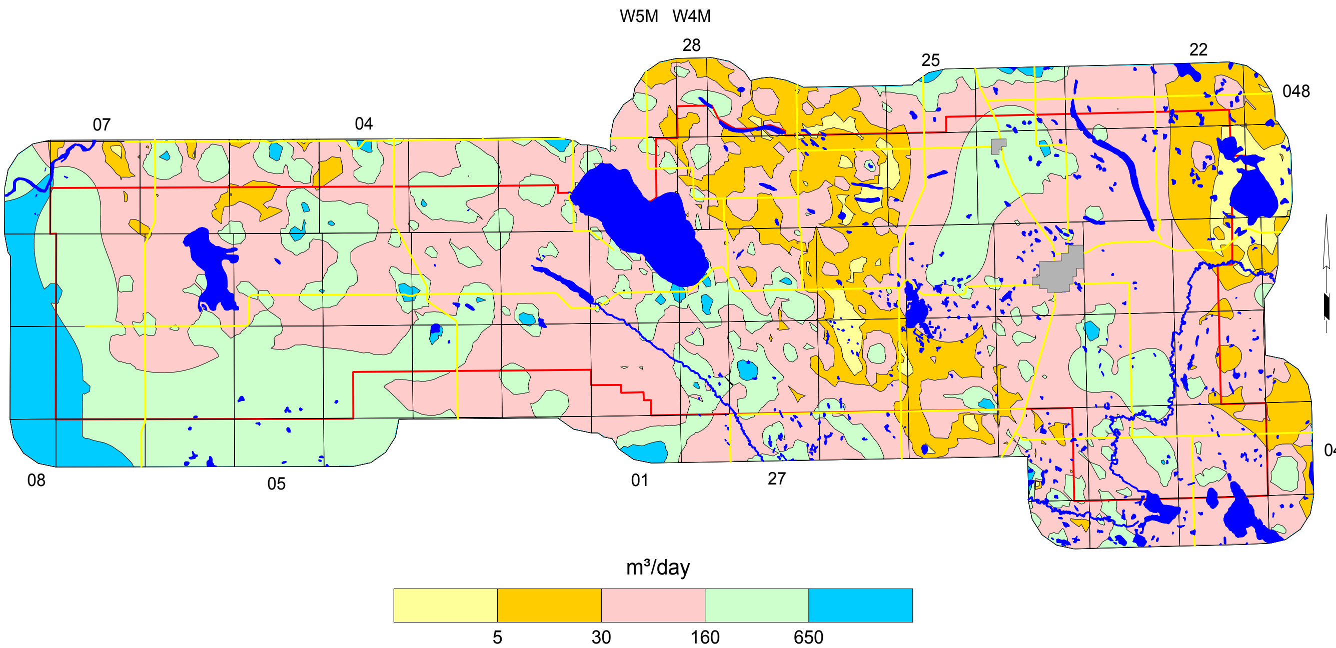
Generalized Cross-Section
(for terminology only)



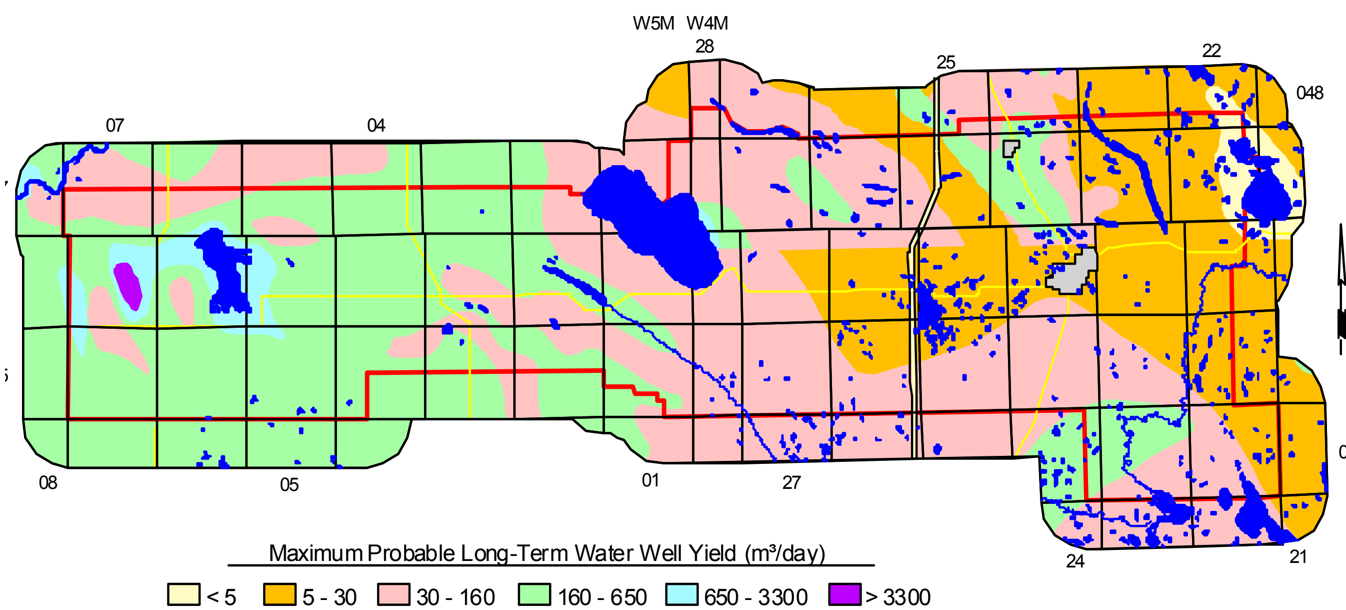
Geologic Column

	Group and Formation		Member		Zone	
Lithologic Description	Average Thickness (m)	Designation	Average Thickness (m)	Designation	Average Thickness (m)	Designation
sand, gravel, till, clay, silt	<140	Surficial Deposits	<100	Upper	<30	First Sand and Gravel
			<20	Lower		
sandstone, shale, coal	<800	Paskapoo Formation	>300	Dalehurst Member		Obed-Marsh Coal Zone
						Lower Dalehurst Coal Zone
			100-250	Lacombe Member Upper	Upper	Upper Sandstone
						Middle Sandstone
						Lower Sandstone
			30-100	Lacombe Member Lower	Lower	Lower Lacombe Coal Zone
			20-100	Haynes		
shale, sandstone, coal	60-150	Scollard Formation	40-100	Upper	<2	Upper Ardley Coal Zone
					~20	Ardley Coal Zone (main seam)
					<1	Nevis Coal Seam
			20-60	Lower		
shale, clay, tuff	~25 5-10	Battle/Whitemud Formation	<0.3	Kneehill Member		
shale, sandstone, coal, bentonite, limestone, ironstone	300-380	Edmonton Group: Horseshoe Canyon Formation	~100	Upper		
			~100	Middle		
			~170	Lower		
shale, sandstone, siltstone	60-120	Bearpaw Formation				
sandstone, siltstone, shale, coal		Belly River Group: 40-130 Oldman Formation		Dinosaur Member	<25	Lethbridge Coal Zone
				Upper Siltstone Member		
				Comrey Member		

Hydrogeological Maps

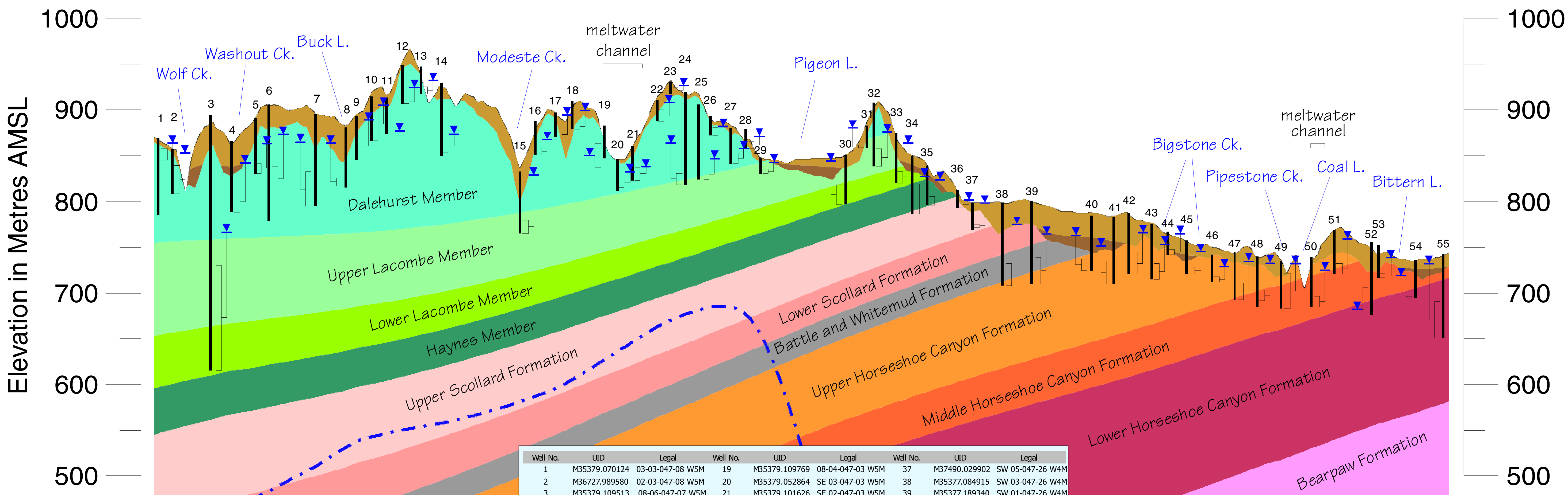


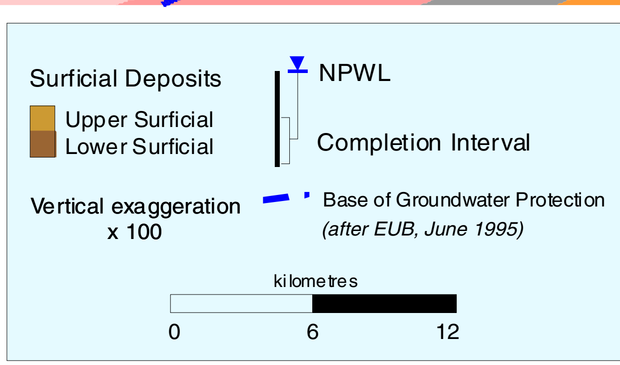
2007 Hydrogeological Consultants Ltd. (HCL)



Alberta Geological Survey (1971, 1979, 1982)

Cross-Section A - A'





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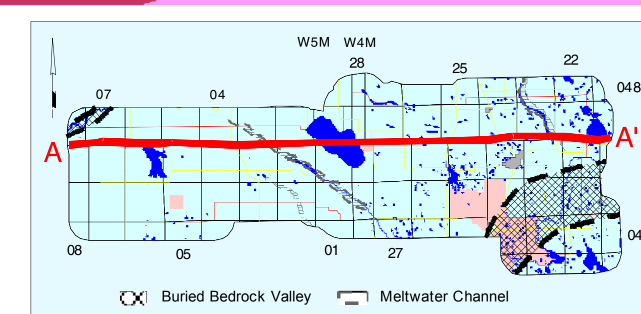
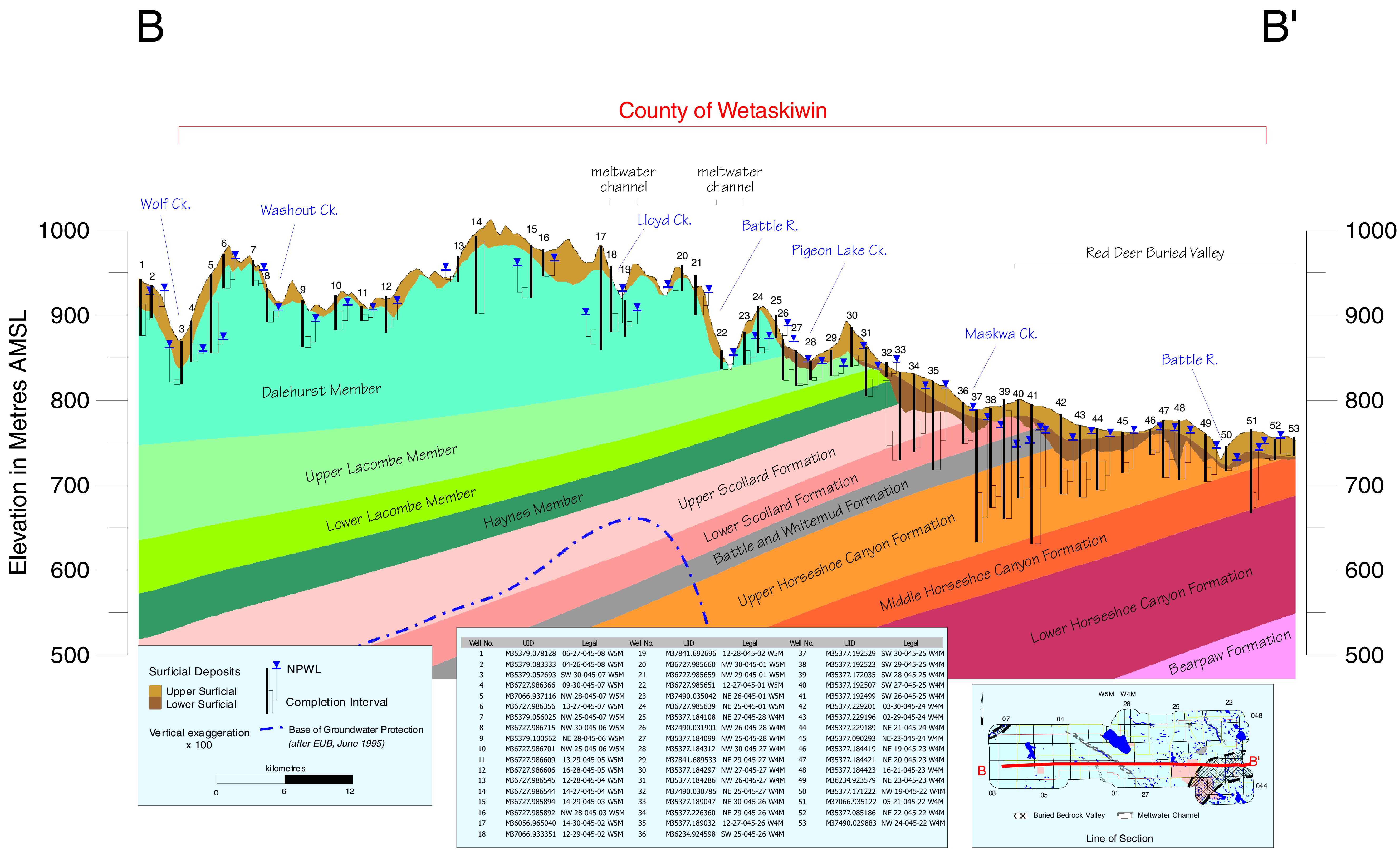
1	M35379.070124	03-03-047-08 W5M	19	M35379.109769	08-04-047-03 W5M	37	M37490.029902	SW 05-047-26 W4M
2	M36727.989580	02-03-047-08 W5M	20	M35379.052864	SE 03-047-03 W5M	38	M35377.084915	SW 03-047-26 W4M
3	M35379.109513	08-06-047-07 W5M	21	M35379.101626	SE 02-047-03 W5M	39	M35377.189340	SW 01-047-26 W4M
4	M35379.109505	NW 04-047-07 W5M	22	M35379.048813	06-06-047-02 W5M	40	M35377.178502	SW 03-047-25 W4M
5	M35379.109495	SE 03-047-07 W5M	23	M35379.048806	SW 05-047-02 W5M	41	M36234.921569	SE 02-047-25 W4M
6	M35379.109478	07-02-047-07 W5M	24	M36234.928283	SW 04-047-02 W5M	42	M35377.161906	SE 01-047-25 W4M
7	M36234.936876	SE 05-047-06 W5M	25	M36234.928281	SW 03-047-02 W5M	43	M35377.178507	SW 05-047-24 W4M
8	M35379.080142	SE 03-047-06 W5M	26	M35379.048767	08-03-047-02 W5M	44	M35377.178468	SW 04-047-24 W4M
9	M36234.928309	11-02-047-06 W5M	27	M36727.990834	SW 01-047-02 W5M	45	M35377.178459	09-03-047-24 W4M
10	M35379.109545	11-01-047-06 W5M	28	M35379.048852	SW 06-047-01 W5M	46	M36234.924603	NW 01-047-24 W4M
11	M36056.964992	06-06-047-05 W5M	29	M37841.693342	SW 05-047-01 W5M	47	M35377.148179	NE 06-047-23 W4M
12	M38259.659687	11-05-047-05 W5M	30	M35377.060609	08-02-047-28 W4M	48	M35377.178164	NW 04-047-23 W4M
13	M35379.109696	10-04-047-05 W5M	31	M37490.032650	SW 06-047-27 W4M	49	M35377.178149	SE 03-047-23 W4M
14	M37066.932505	NE 03-047-05 W5M	32	M35377.189547	SE 06-047-27 W4M	50	M35377.083575	SE 01-047-23 W4M
15	M35379.109893	SW 03-047-04 W5M	33	M35377.189537	SW 04-047-27 W4M	51	M35377.176750	SW 05-047-22 W4M
16	M35379.068433	SW 02-047-04 W5M	34	M35377.189534	SW 03-047-27 W4M	52	M35377.090338	SE 03-047-22 W4M
17	M35379.109887	02-01-047-04 W5M	35	M35377.189531	SW 02-047-27 W4M	53	M35377.176733	SW 02-047-22 W4M
18	M35379.109236	SE 06-047-03 W5M	36	M35377.128485	SW 06-047-26 W4M	54	M35377.176728	NE 36-046-22 W4M
						55	M35377.174960	SW 04-047-21 W4M



Line of Section

Cross-Section B - B'



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3	M35379.052693	SW 30-045-07 W5M	21	M36727.985659	NW 29-045-01 W5M	39	M35377.172035	SW 28-045-25 W4M
4	M36727.986366	09-30-045-07 W5M	22	M36727.985651	12-27-045-01 W5M	40	M35377.192507	SW 27-045-25 W4M
5	M37066.937116	NW 28-045-07 W5M	23	M37490.035042	NE 26-045-01 W5M	41	M35377.192499	SW 26-045-25 W4M
6	M36727.986356	13-27-045-07 W5M	24	M36727.985639	NE 25-045-01 W5M	42	M35377.229201	03-30-045-24 W4M
7	M35379.056025	NW 25-045-07 W5M	25	M35377.184108	NE 27-045-28 W4M	43	M35377.229196	02-29-045-24 W4M
8	M36727.986715	NW 30-045-06 W5M	26	M37490.031901	NW 26-045-28 W4M	44	M35377.229189	NE 21-045-24 W4M
9	M35379.100562	NE 28-045-06 W5M	27	M35377.184099	NW 25-045-28 W4M	45	M35377.090293	NE-23-045-24 W4M
10	M36727.986701	NW 25-045-06 W5M	28	M35377.184312	NW 30-045-27 W4M	46	M35377.184419	NE 19-045-23 W4M
11	M36727.986609	13-29-045-05 W5M	29	M37841.689533	NE 29-045-27 W4M	47	M35377.184421	NE 20-045-23 W4M
12	M36727.986606	16-28-045-05 W5M	30	M35377.184297	NW 27-045-27 W4M	48	M35377.184423	16-21-045-23 W4M
13	M36727.986545	12-28-045-04 W5M	31	M35377.184286	NW 26-045-27 W4M	49	M36234.923579	NE 23-045-23 W4M
14	M36727.986544	14-27-045-04 W5M	32	M37490.030785	NE 25-045-27 W4M	50	M35377.171222	NW 19-045-22 W4M
15	M36727.985894	14-29-045-03 W5M	33	M35377.189047	NE 30-045-26 W4M	51	M37066.935122	05-21-045-22 W4M
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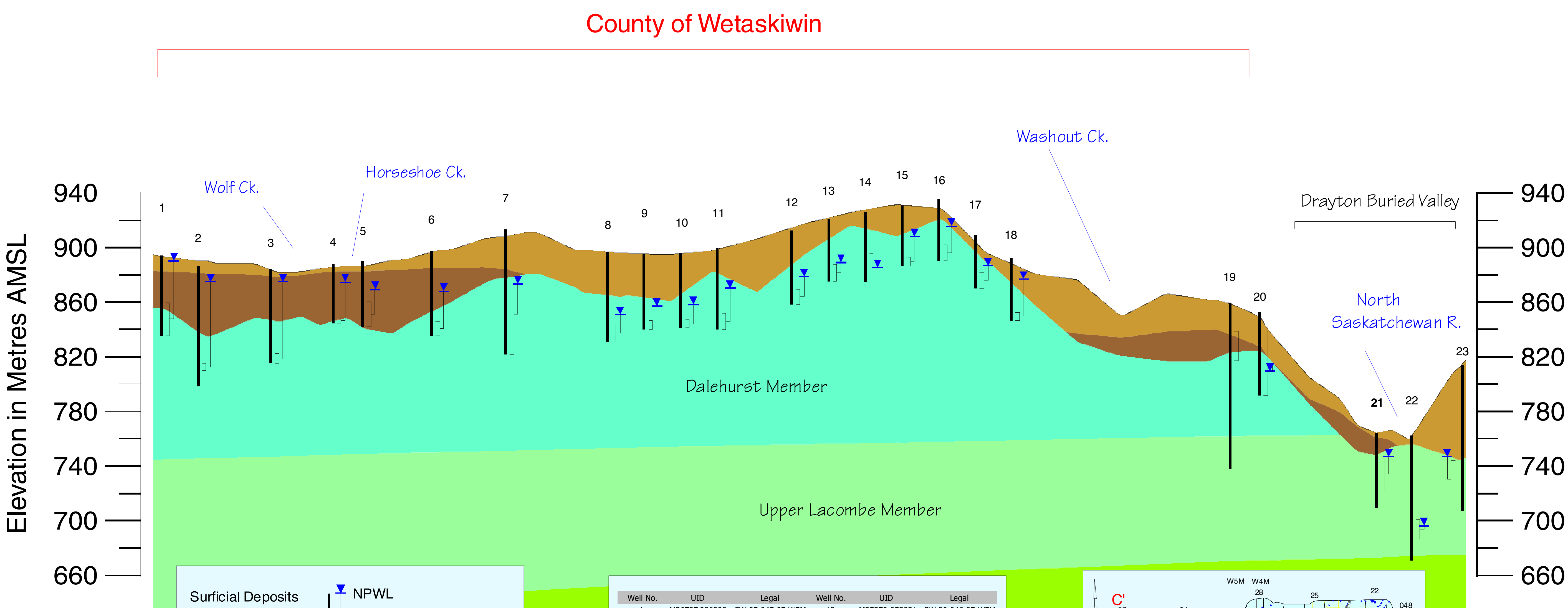
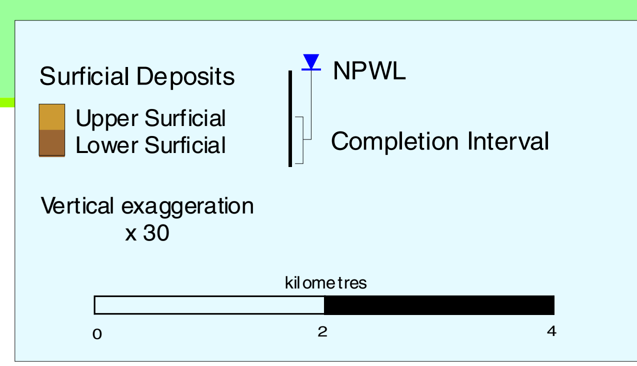
Cross-Section C - C'





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3	M36727.986309	NE 07-045-07 W5M	15	M36727.987690	SW 29-046-07 W5M
4	M35379.106304	NW 17-045-07 W5M	16	M36727.987692	NW 29-046-07 W5M
5	M37066.933071	13-17-045-07 W5M	17	M35379.102366	SW 32-046-07 W5M
6	M36727.986336	13-20-045-07 W5M	18	M36727.987705	NW 32-046-07 W5M
7	M36727.986362	13-29-045-07 W5M	19	M35379.110352	NE 17-047-07 W5M
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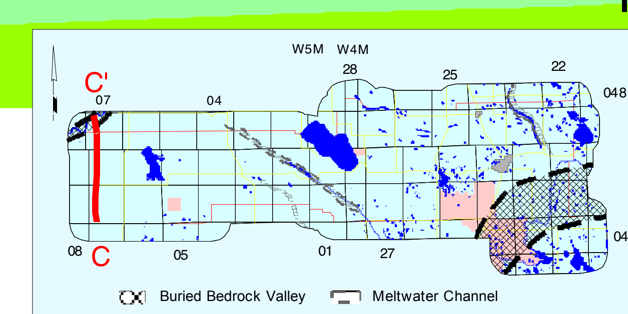
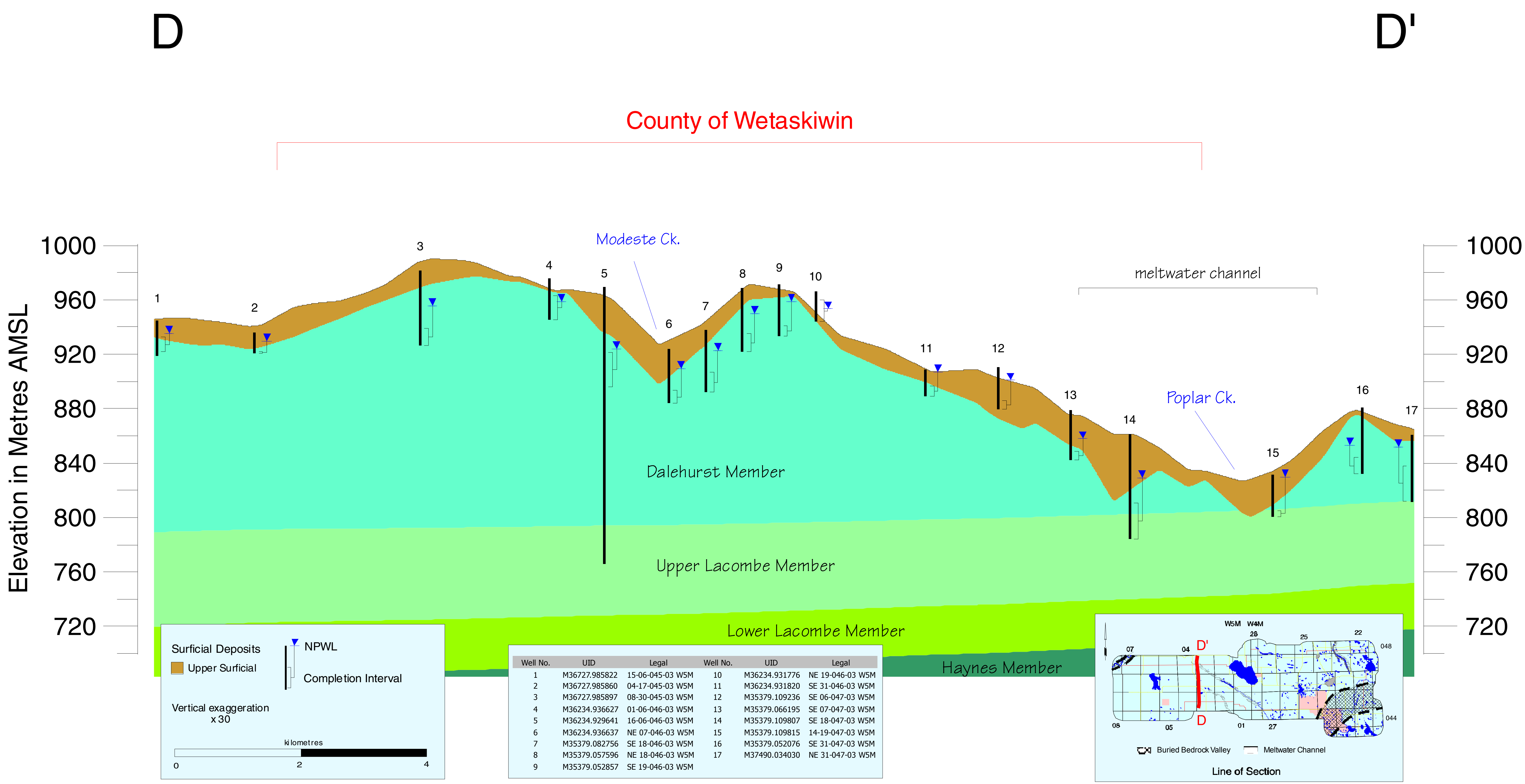


Line of Section

Cross-Section D - D'



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3	M36727.985897	08-30-045-03 W5M	12	M35379.109236	SE 06-047-03 W5M
4	M36234.936627	01-06-046-03 W5M	13	M35379.066195	SE 07-047-03 W5M
5	M36234.929641	16-06-046-03 W5M	14	M35379.109807	SE 18-047-03 W5M
6	M36234.936637	NE 07-046-03 W5M	15	M35379.109815	14-19-047-03 W5M
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8	M35379.057596	NE 18-046-03 W5M	17	M37490.034030	NE 31-047-03 W5M
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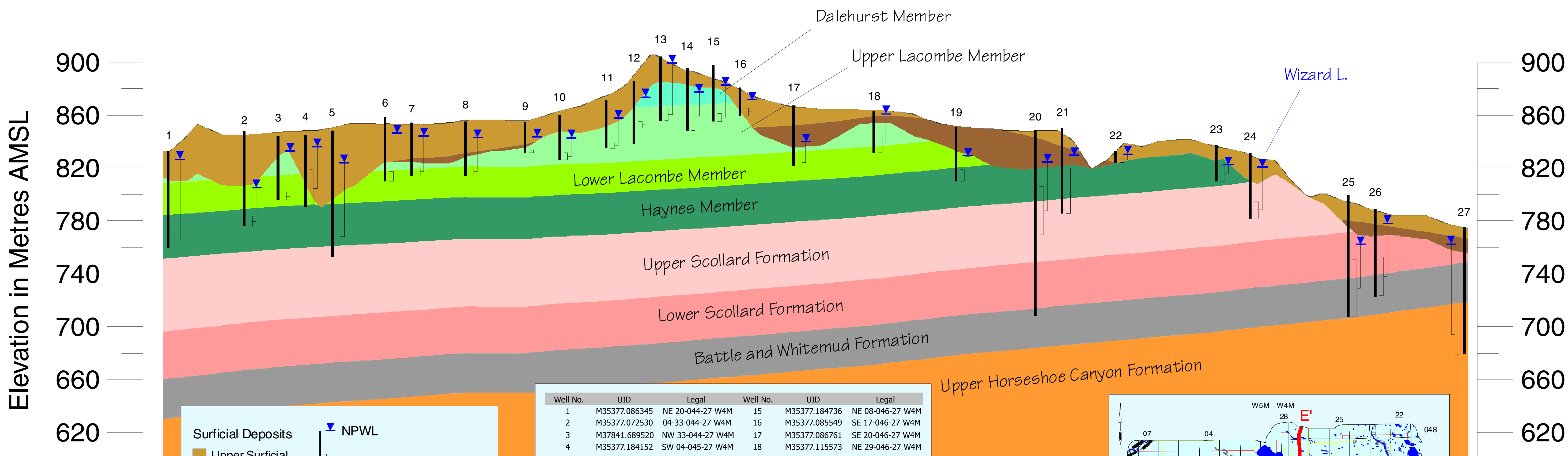
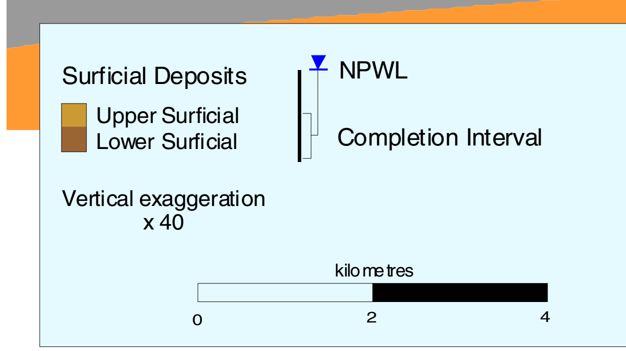
Cross-Section E - E'





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4	M35377.184152	SW 04-045-27 W4M	18	M35377.115573	NE 29-046-27 W4M
5	M35377.184155	NW 04-045-27 W4M	19	M35377.189533	SW 03-047-27 W4M
6	M35377.184176	NW 09-045-27 W4M	20	M36727.983243	NW 10-047-27 W4M
7	M35377.184216	SW 16-045-27 W4M	21	M35377.189582	SW 15-047-27 W4M
8	M35377.184246	SW 21-045-27 W4M	22	M35377.189664	SW 22-047-27 W4M
9	M35377.184305	SE 29-045-27 W4M	23	M35377.189707	04-34-047-27 W4M
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12	M37841.691477	SE 05-046-27 W4M	26	M35377.084009	SW 15-048-27 W4M
13	M35377.050174	NE 05-046-27 W4M	27	M35377.081887	09-22-048-27 W4M
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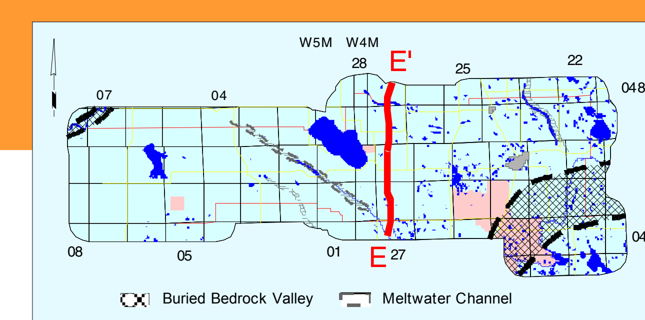
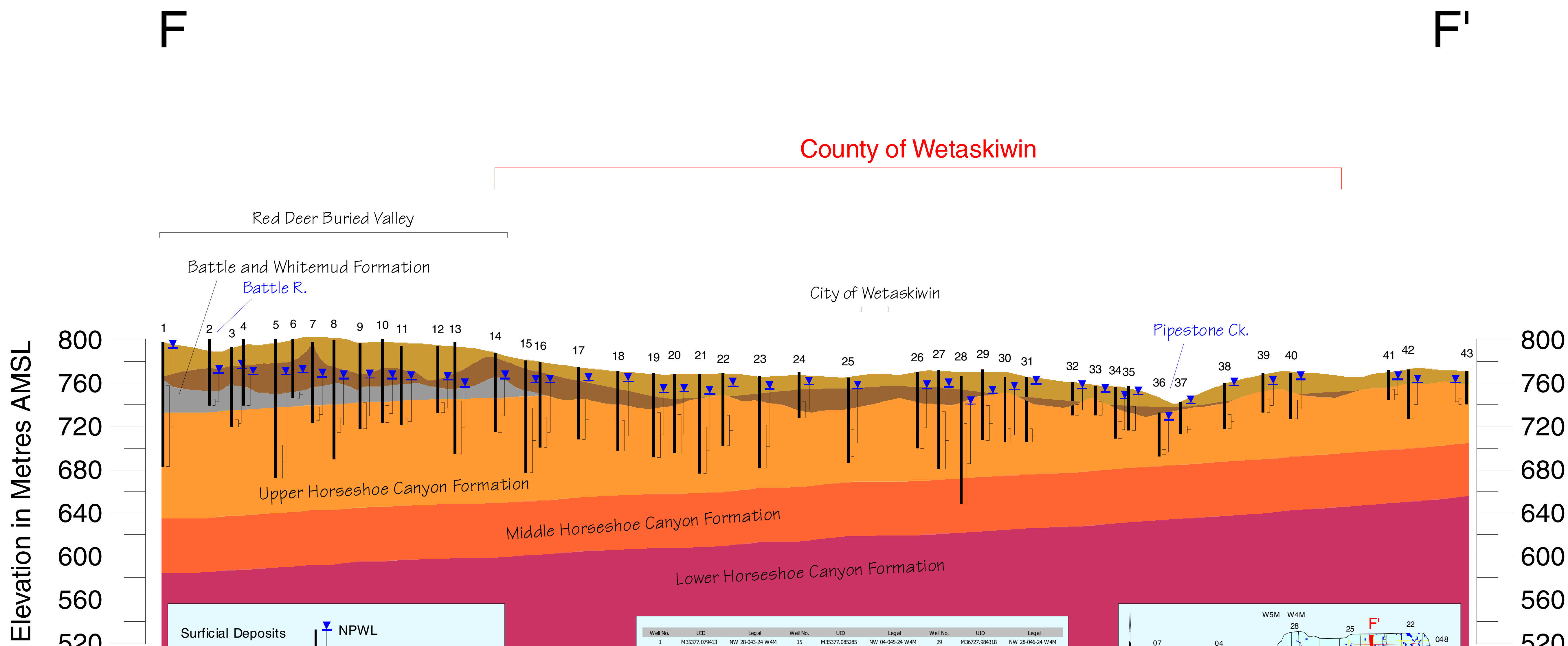
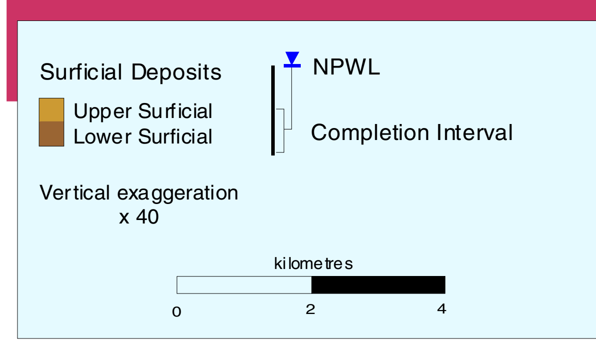


Line of Section

Cross-Section F - F'





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4	M35377.172359	NW 04-044-24 W4M	18	M35377.229181	14-16-045-24 W4M	32	M35377.178457	NW 03-047-24 W4M
5	M35377.085606	SW 09-044-24 W4M	19	M35377.186714	11-21-045-24 W4M	33	M35377.178554	SW 10-047-24 W4M
6	M35377.085607	NW 09-044-24 W4M	20	M35377.186729	04-28-045-24 W4M	34	M37841.690100	NW 10-047-24 W4M
7	M35377.070513	SW 16-044-24 W4M	21	M35377.229146	12-28-045-24 W4M	35	M35377.178968	04-15-047-24 W4M
8	M36234.923556	NW 16-044-24 W4M	22	M35377.071357	04-33-045-24 W4M	36	M36727.983233	NW 15-047-24 W4M
9	M35377.070803	SE 21-044-24 W4M	23	M35377.229258	14-33-045-24 W4M	37	M37490.029898	SW 22-047-24 W4M
10	M35377.092117	NW 21-044-24 W4M	24	M35377.177479	NW 04-046-24 W4M	38	M37490.029899	SW 27-047-24 W4M
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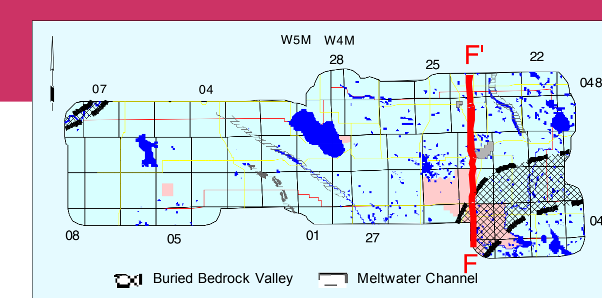
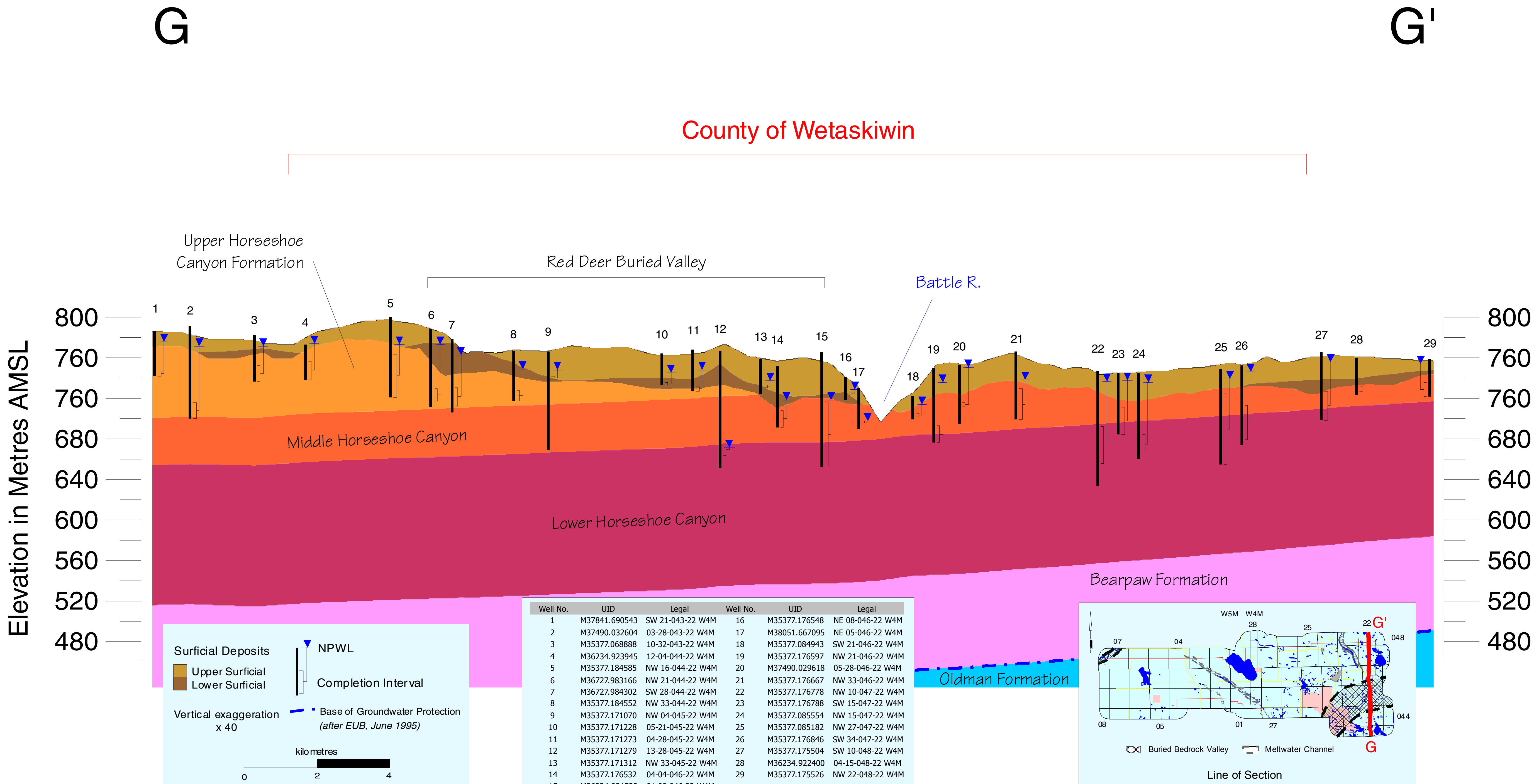
12	M35377.071121	03-28-044-24 W4M	26	M35377.177668	SW 21-046-24 W4M	40	M35377.063305	NW 34-047-24 W4M
13	M35377.071359	SW 33-044-24 W4M	27	M35377.177671	NW 21-046-24 W4M	41	M35377.179734	NW 10-048-24 W4M
14	M35377.091217	04-04-045-24 W4M	28	M35377.178066	SW 28-046-24 W4M	42	M35377.179764	SW 15-048-24 W4M
						43	M37066.934706	NW 22-048-24 W4M



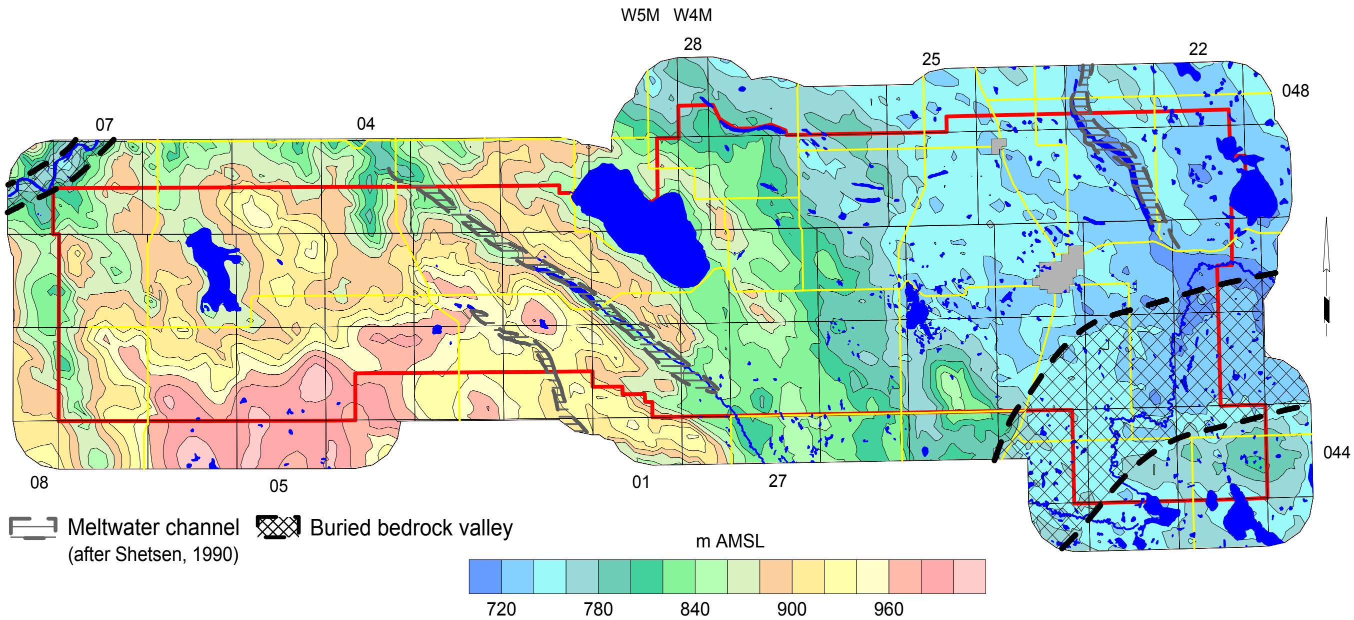
Line of Section

Cross-Section G - G'

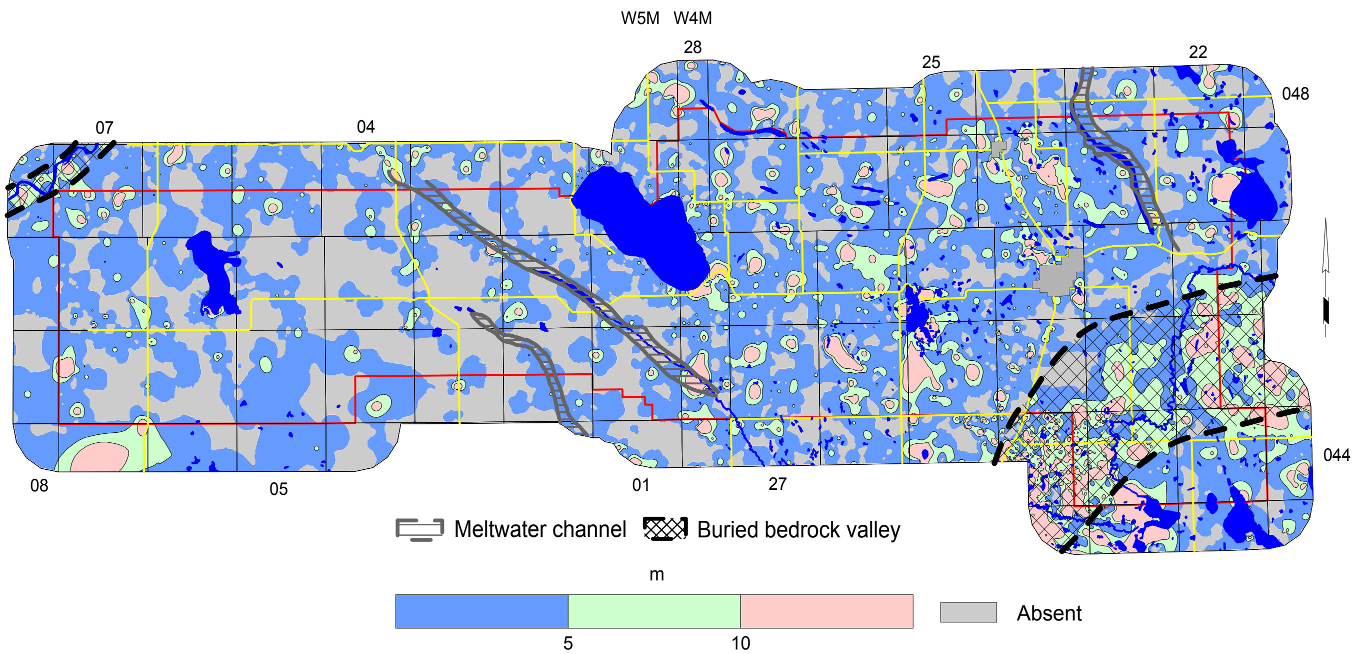


Well No.	UID	Legal	Well No.	UID	Legal
1	M37841.690543	SW 21-043-22 W4M	16	M35377.176548	NE 08-046-22 W4M
2	M37490.032604	03-28-043-22 W4M	17	M38051.667095	NE 05-046-22 W4M
3	M35377.068888	10-32-043-22 W4M	18	M35377.084943	SW 21-046-22 W4M
4	M36234.923945	12-04-044-22 W4M	19	M35377.176597	NW 21-046-22 W4M
5	M35377.184585	NW 16-044-22 W4M	20	M37490.029618	05-28-046-22 W4M
6	M36727.983166	NW 21-044-22 W4M	21	M35377.176667	NW 33-046-22 W4M
7	M36727.984302	SW 28-044-22 W4M	22	M35377.176778	NW 10-047-22 W4M
8	M35377.184552	NW 33-044-22 W4M	23	M35377.176788	SW 15-047-22 W4M
9	M35377.171070	NW 04-045-22 W4M	24	M35377.085554	NW 15-047-22 W4M
10	M35377.171228	05-21-045-22 W4M	25	M35377.085182	NW 27-047-22 W4M
11	M35377.171273	04-28-045-22 W4M	26	M35377.176846	SW 34-047-22 W4M
12	M35377.171279	13-28-045-22 W4M	27	M35377.175504	SW 10-048-22 W4M
13	M35377.171312	NW 33-045-22 W4M	28	M36234.922400	04-15-048-22 W4M
14	M35377.176532	04-04-046-22 W4M	29	M35377.175526	NW 22-048-22 W4M
15	M36234.921523	01-08-046-22 W4M			

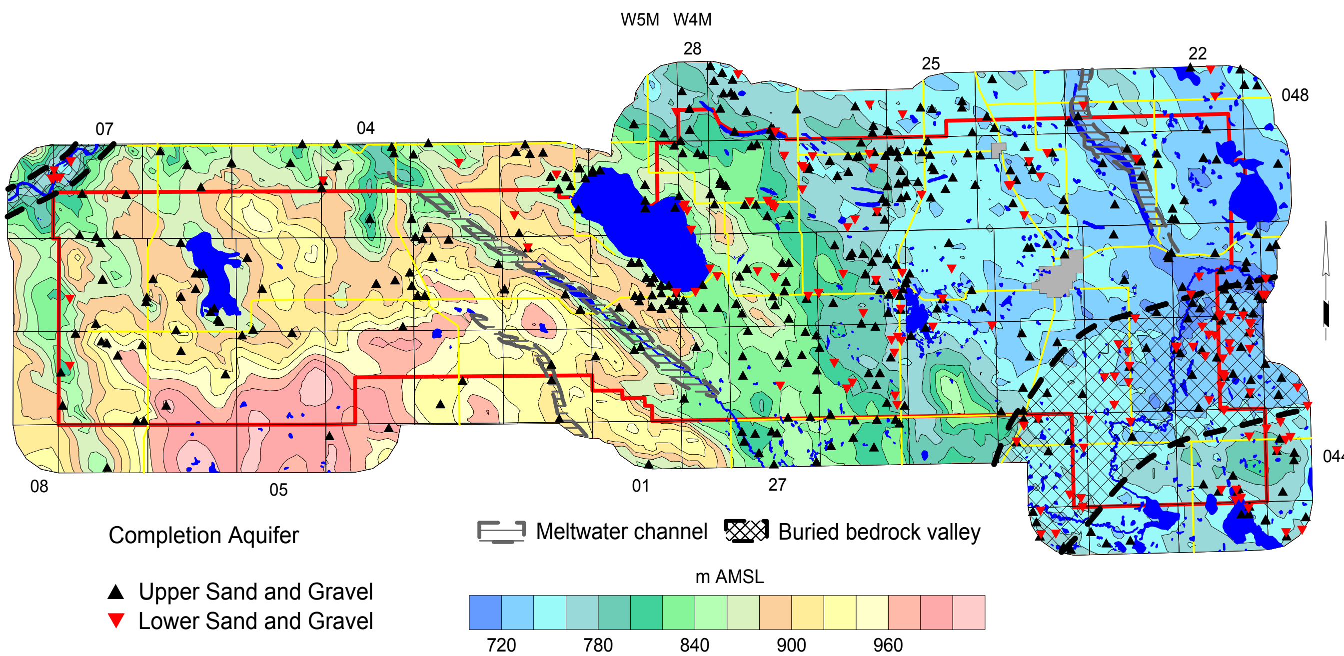
Bedrock Topography



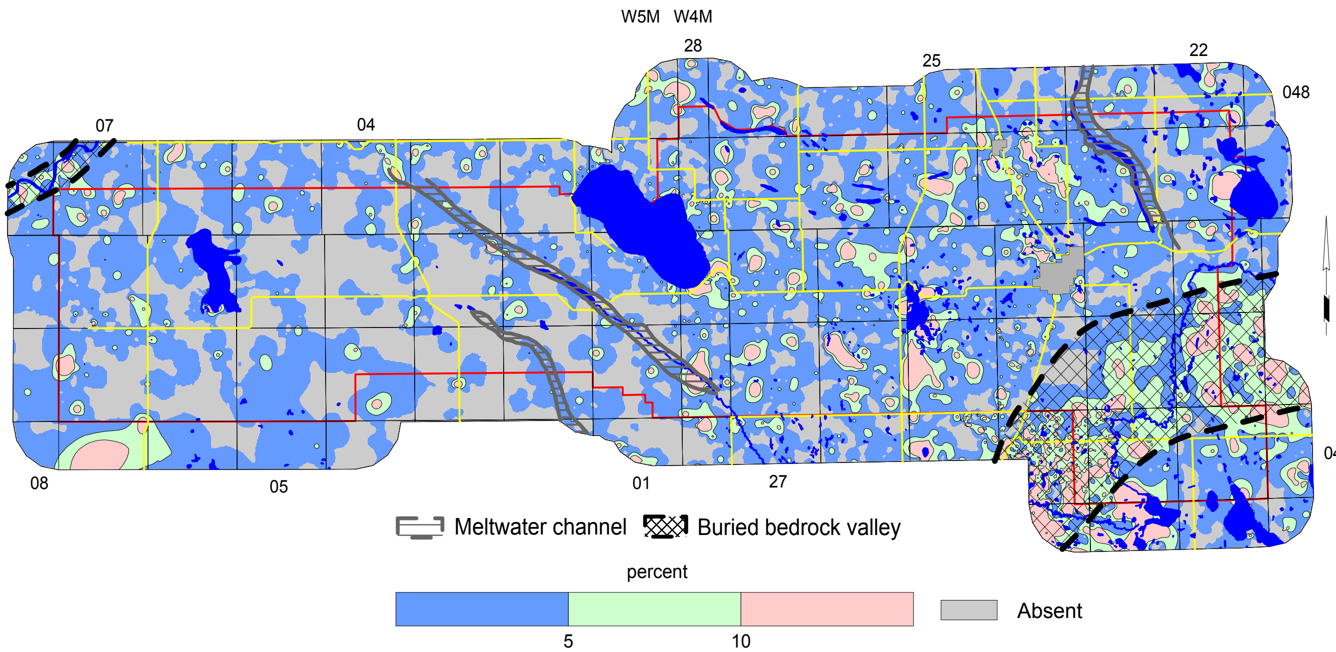
Thickness of Sand and Gravel Deposits



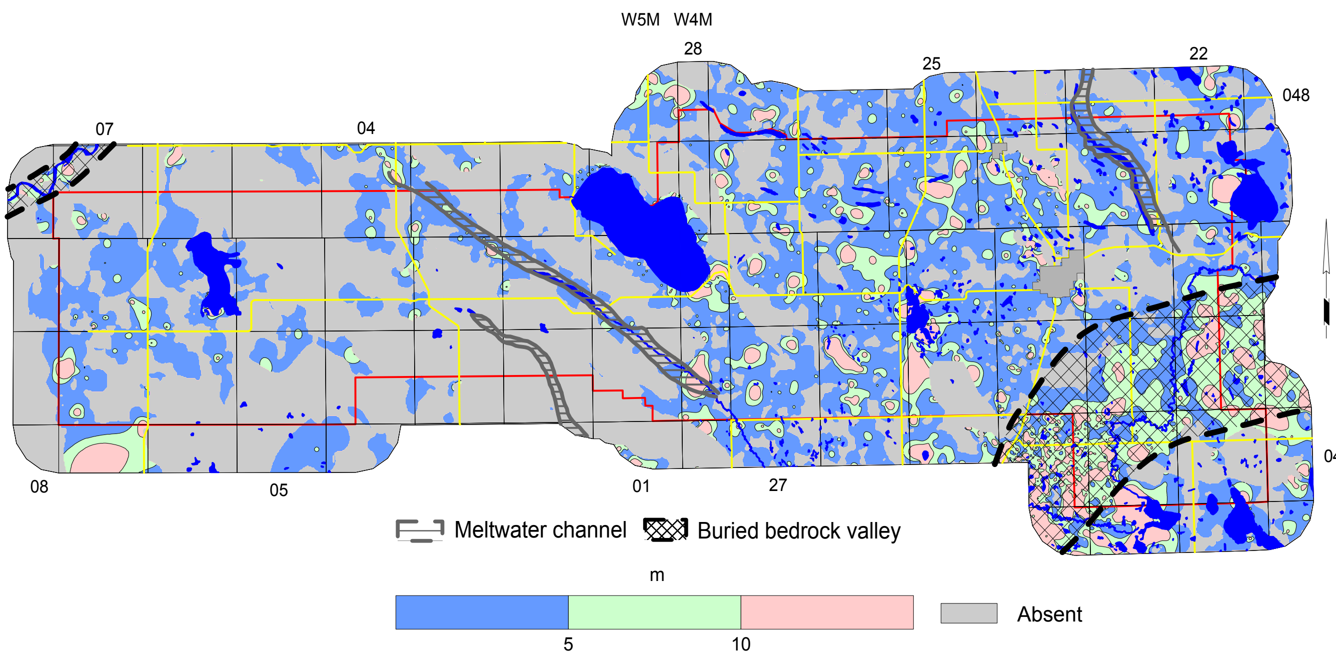
Location of Surficial Water Wells Relative to Bedrock Topography



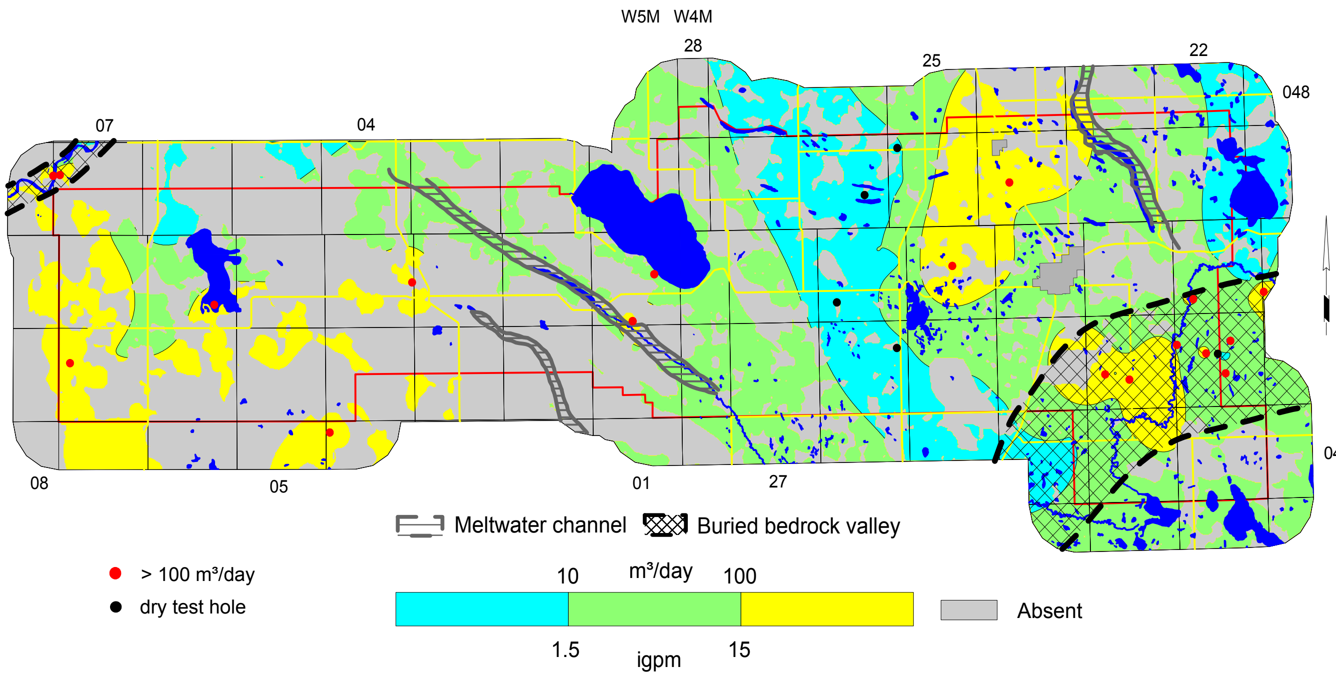
Percentage of Sand and Gravel in Surficial Deposits



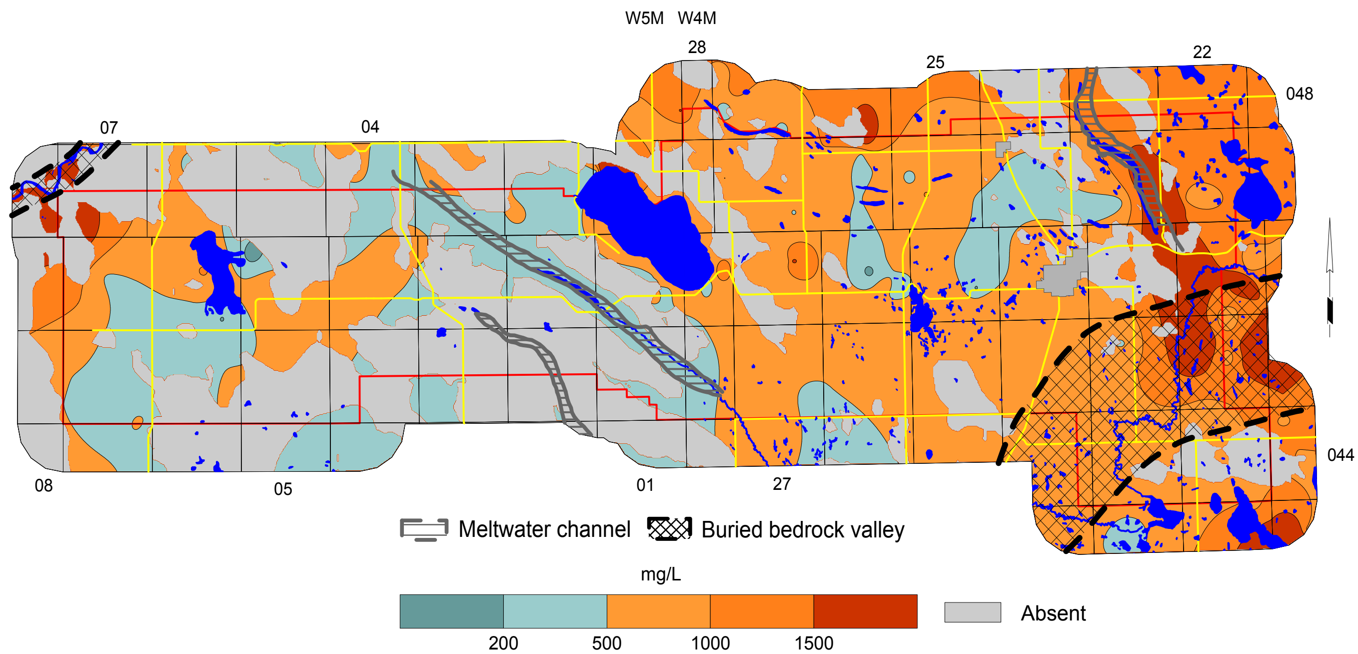
Thickness of Sand and Gravel Aquifer(s)



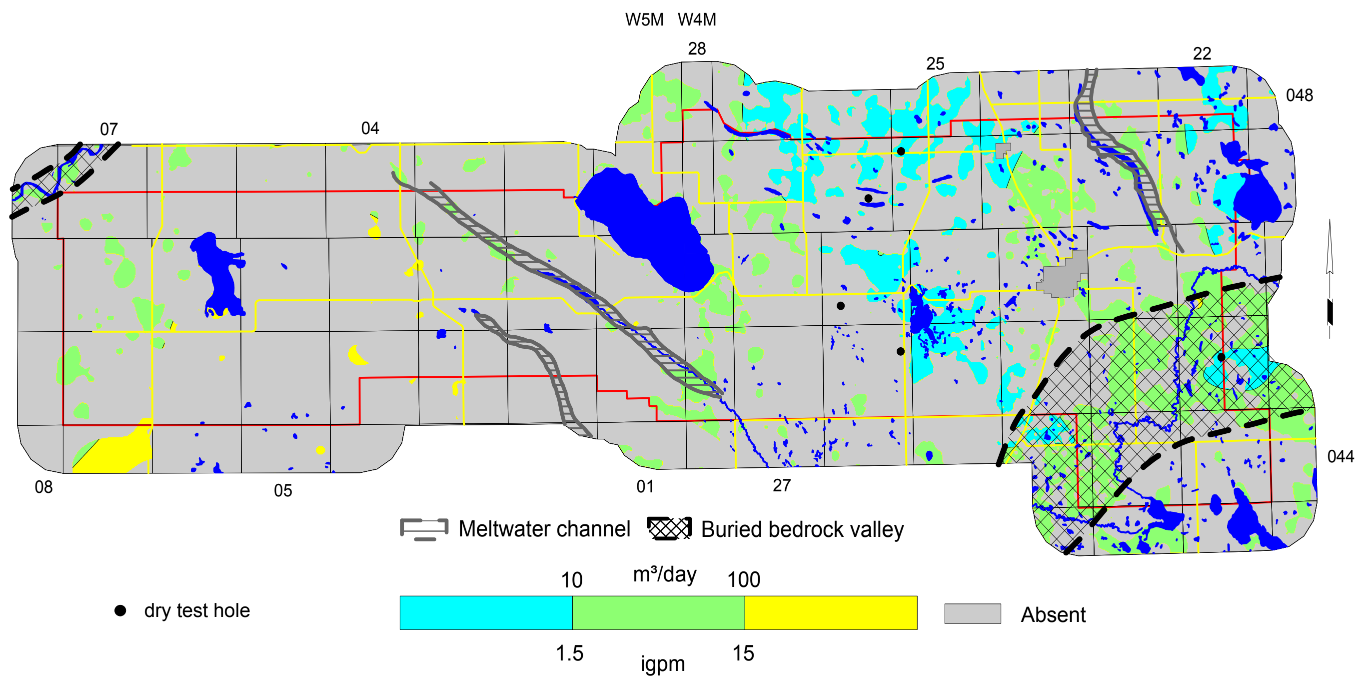
Apparent Yield of Water Wells Completed in Sand and Gravel Aquifer(s)



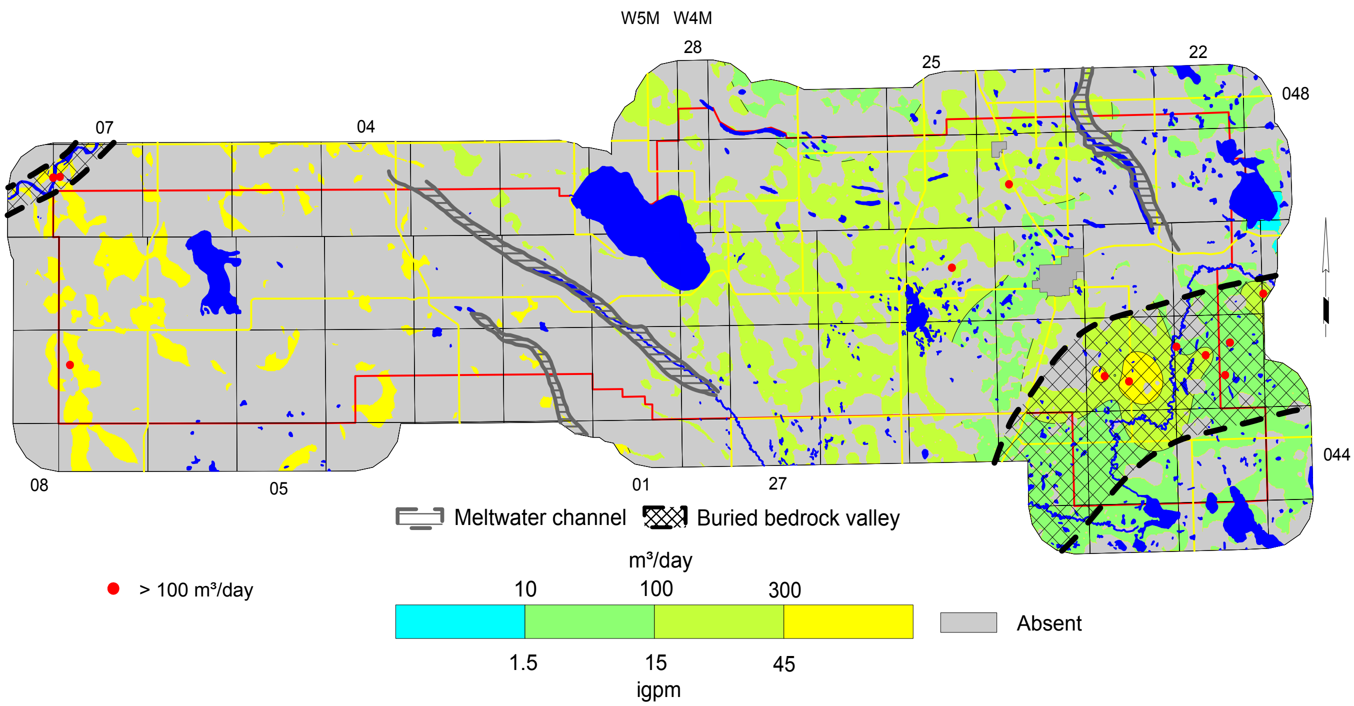
Total Dissolved Solids in Groundwater from Surficial Deposits



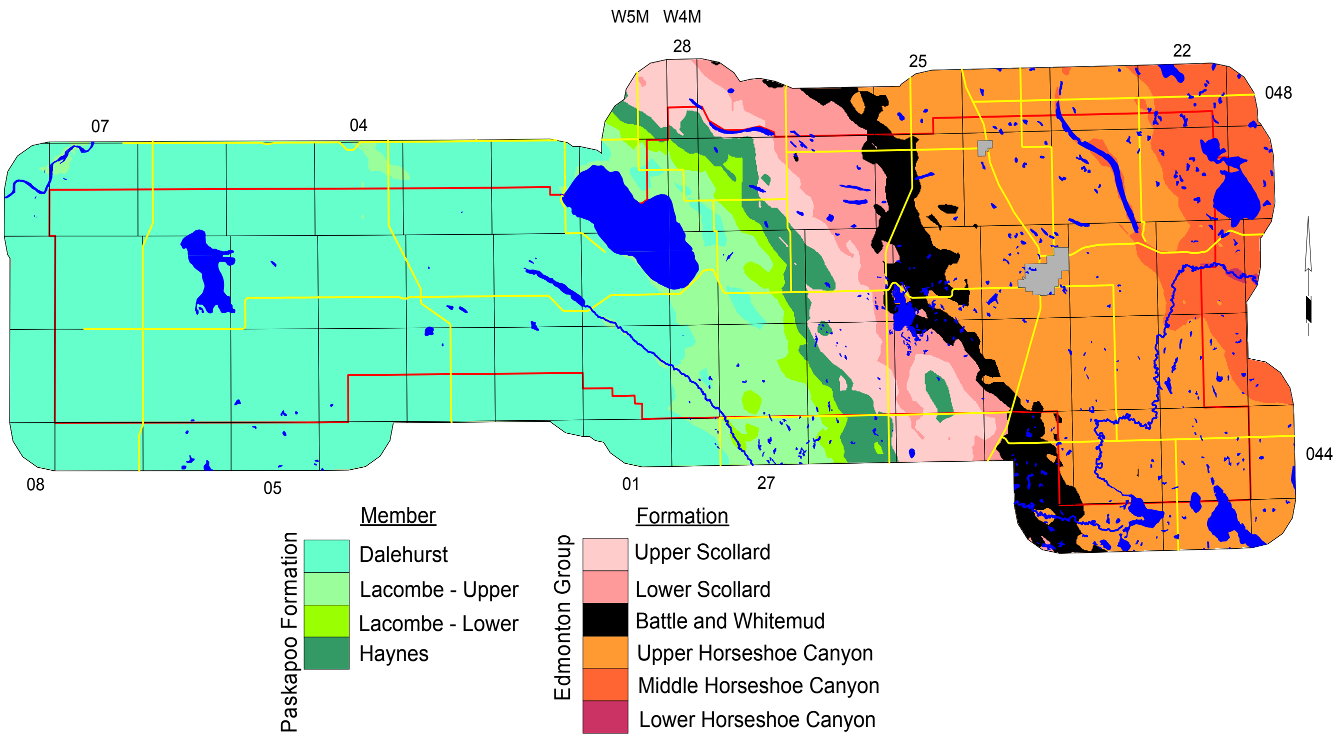
Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer



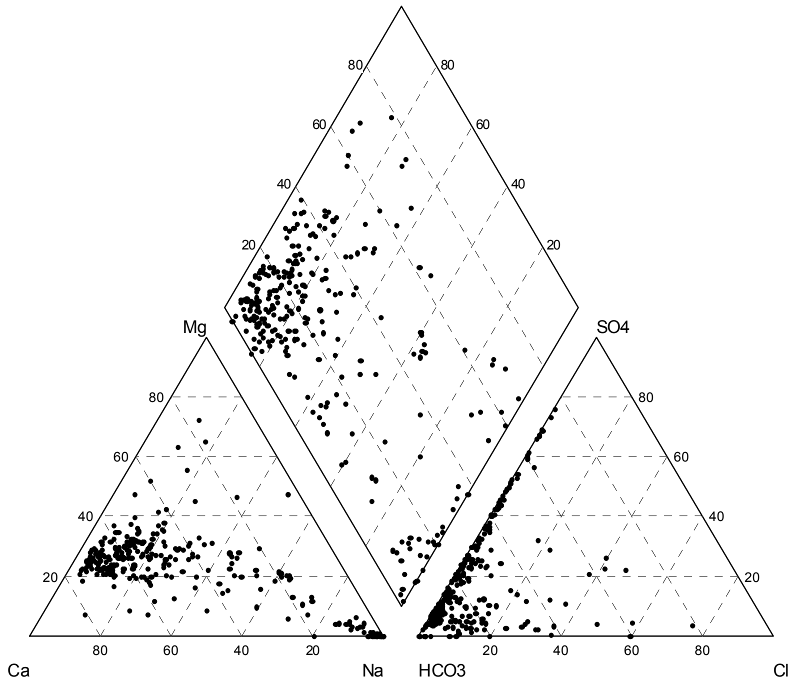
Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer



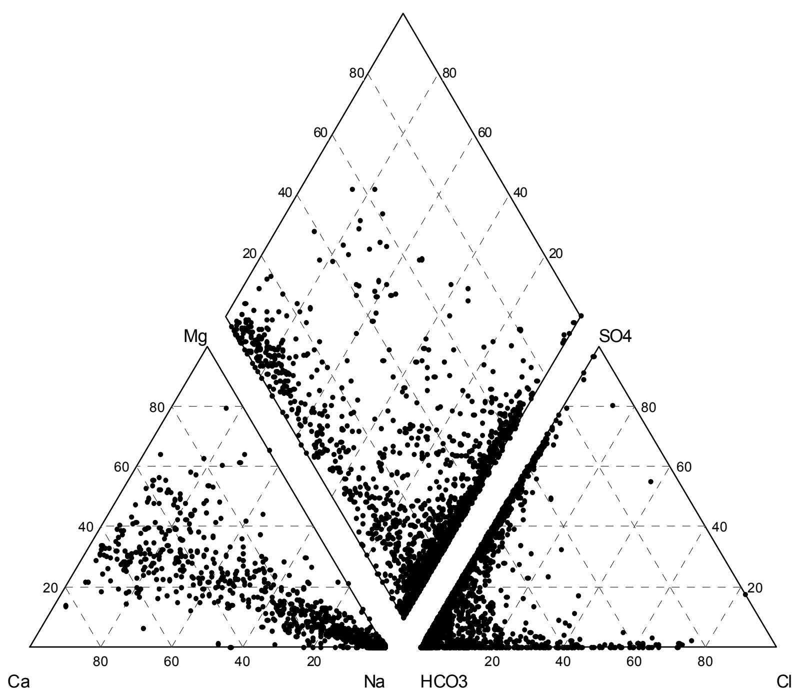
Bedrock Geology



Piper Diagrams

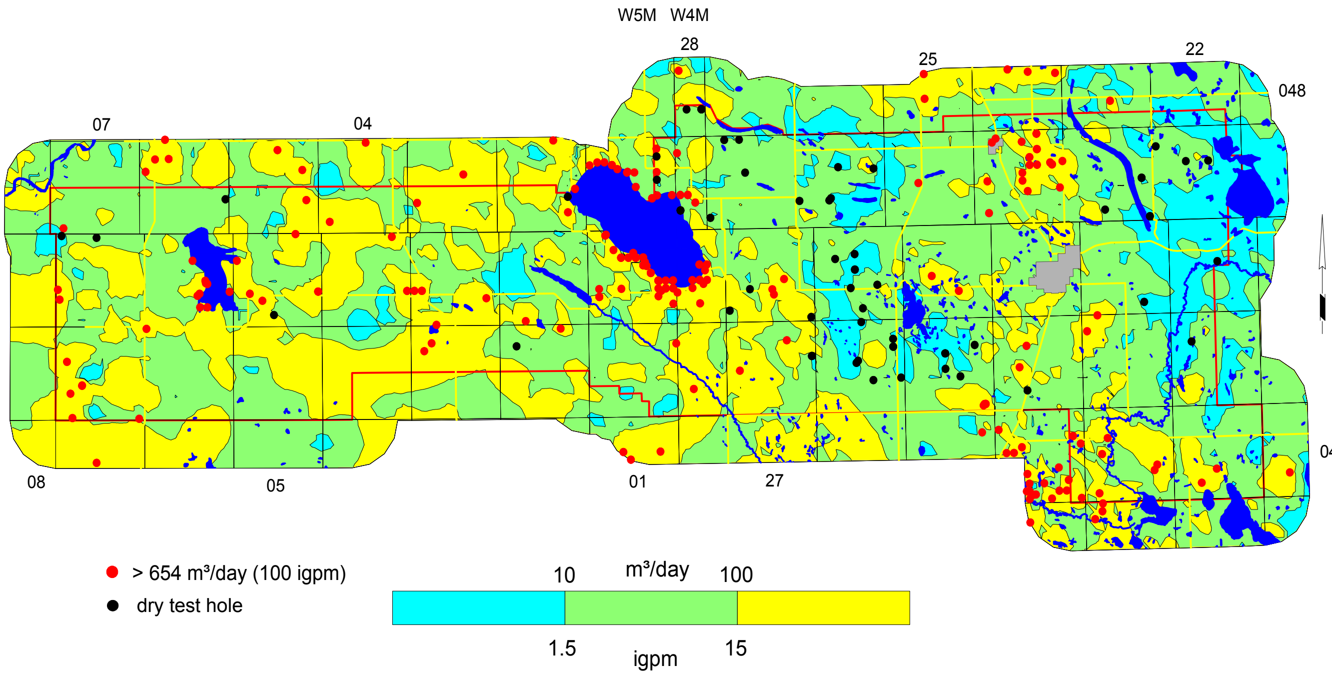


Surficial Deposits

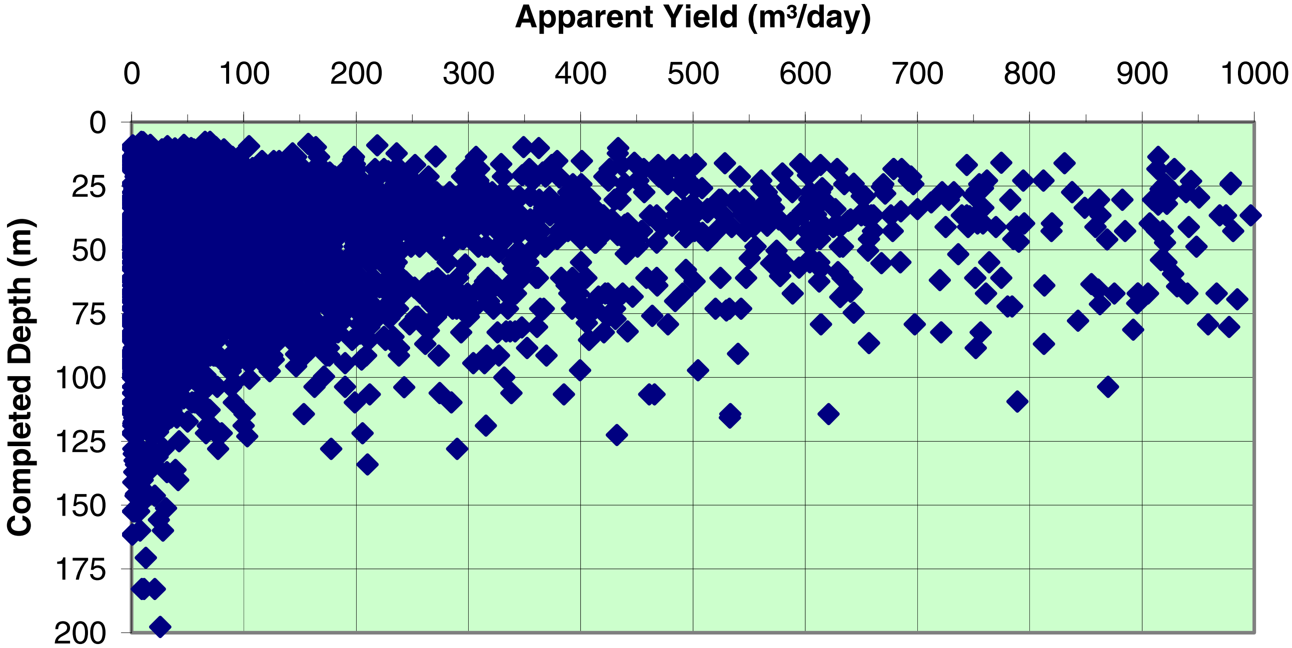


Bedrock Aquifers

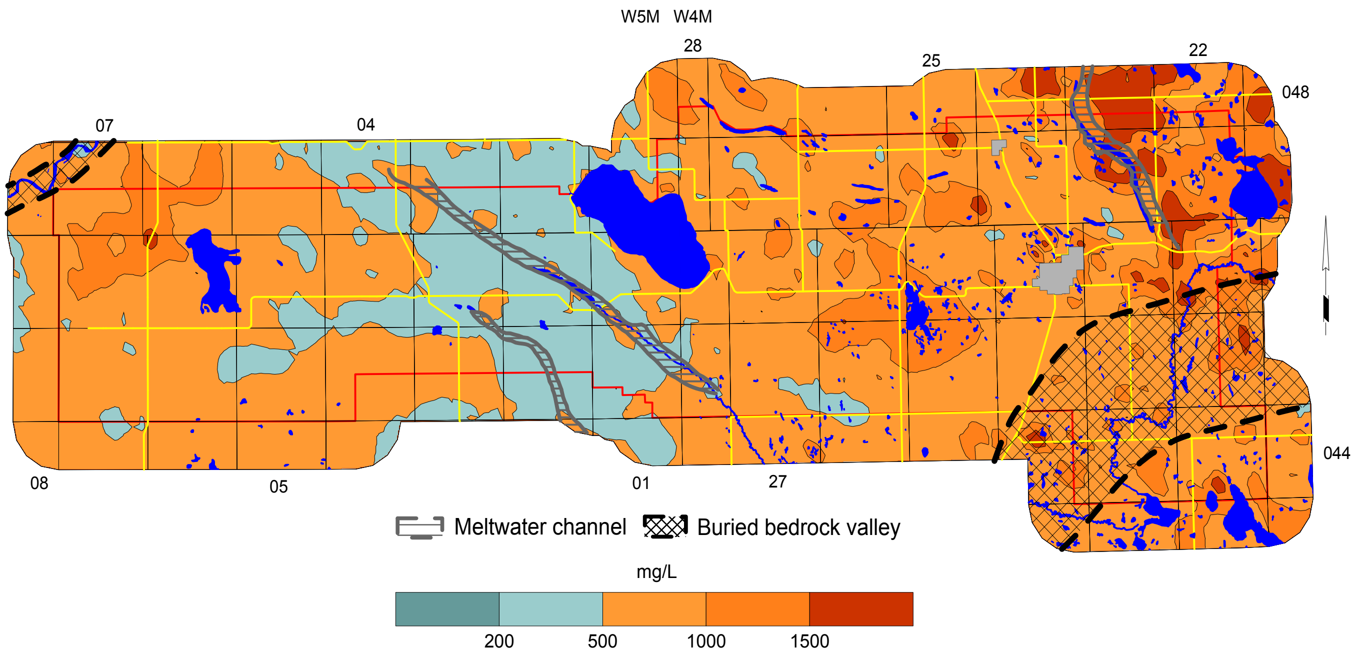
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)



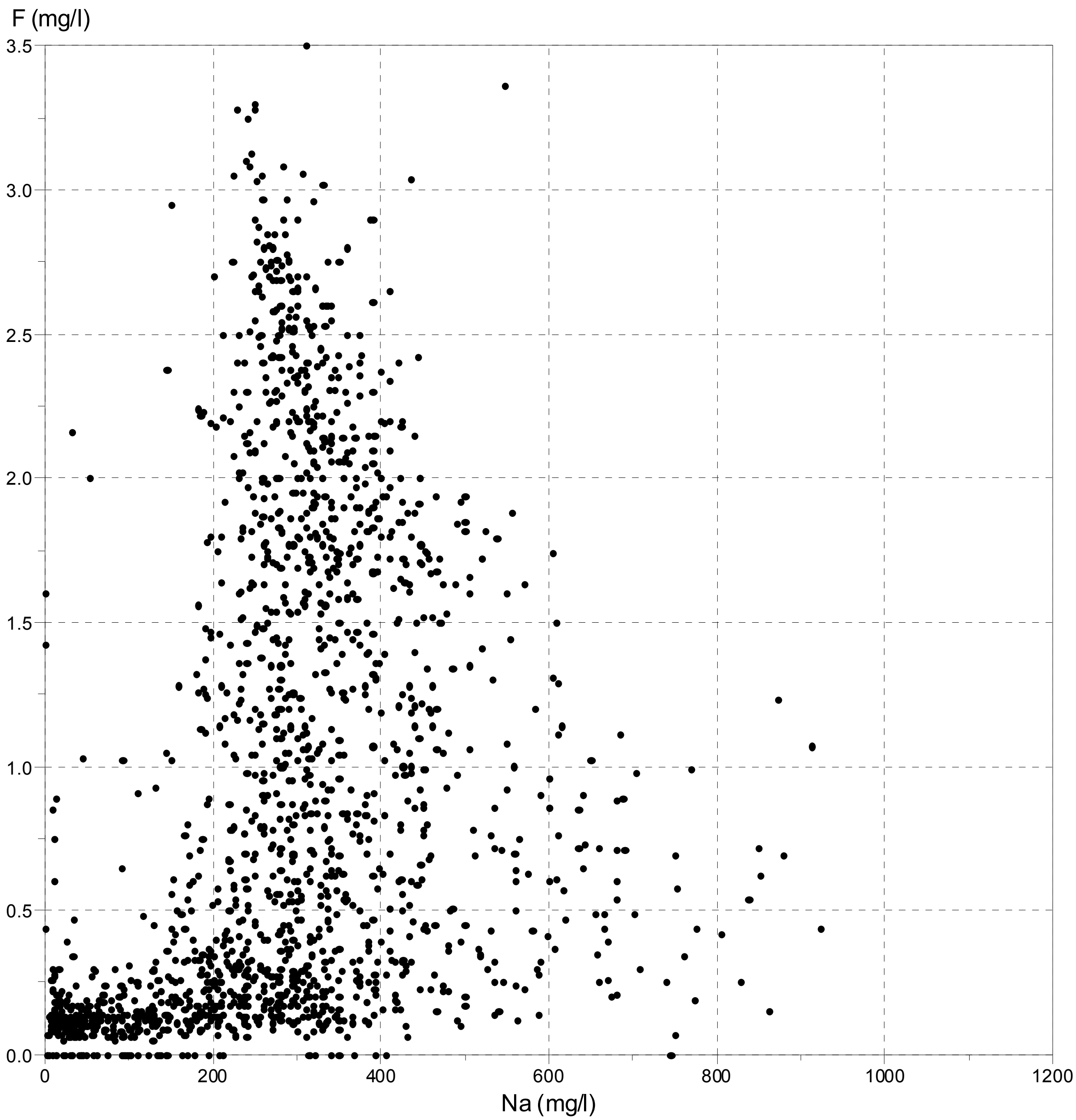
Bedrock Water Well Yields vs Completed Depth



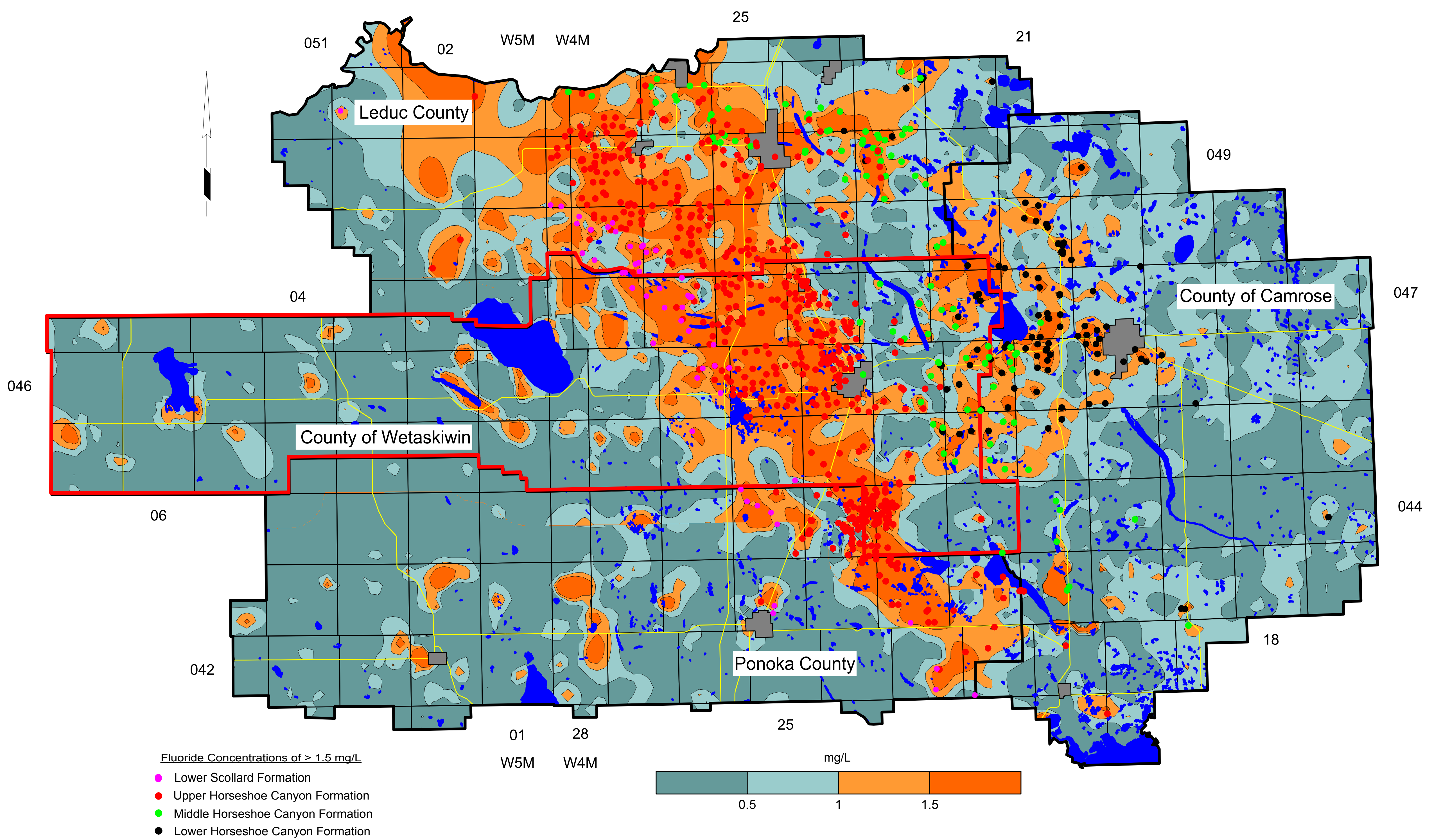
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)



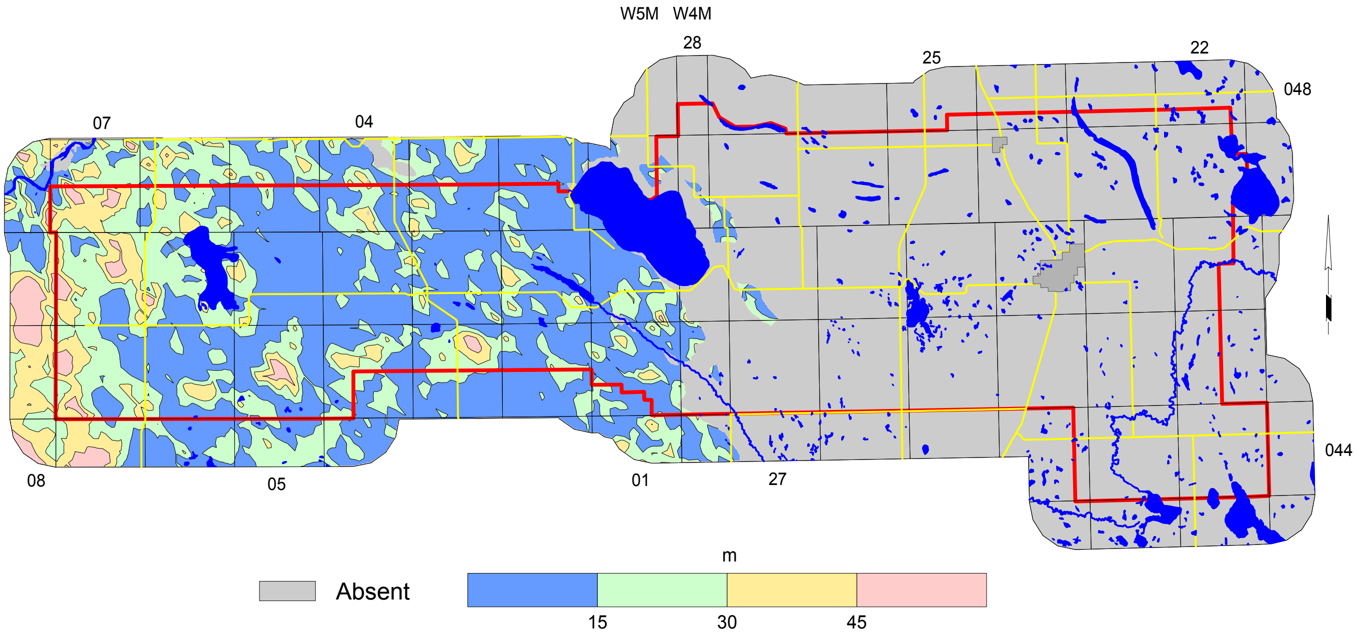
Fluoride vs Sodium Concentrations in Groundwater from Upper Bedrock Aquifer(s)



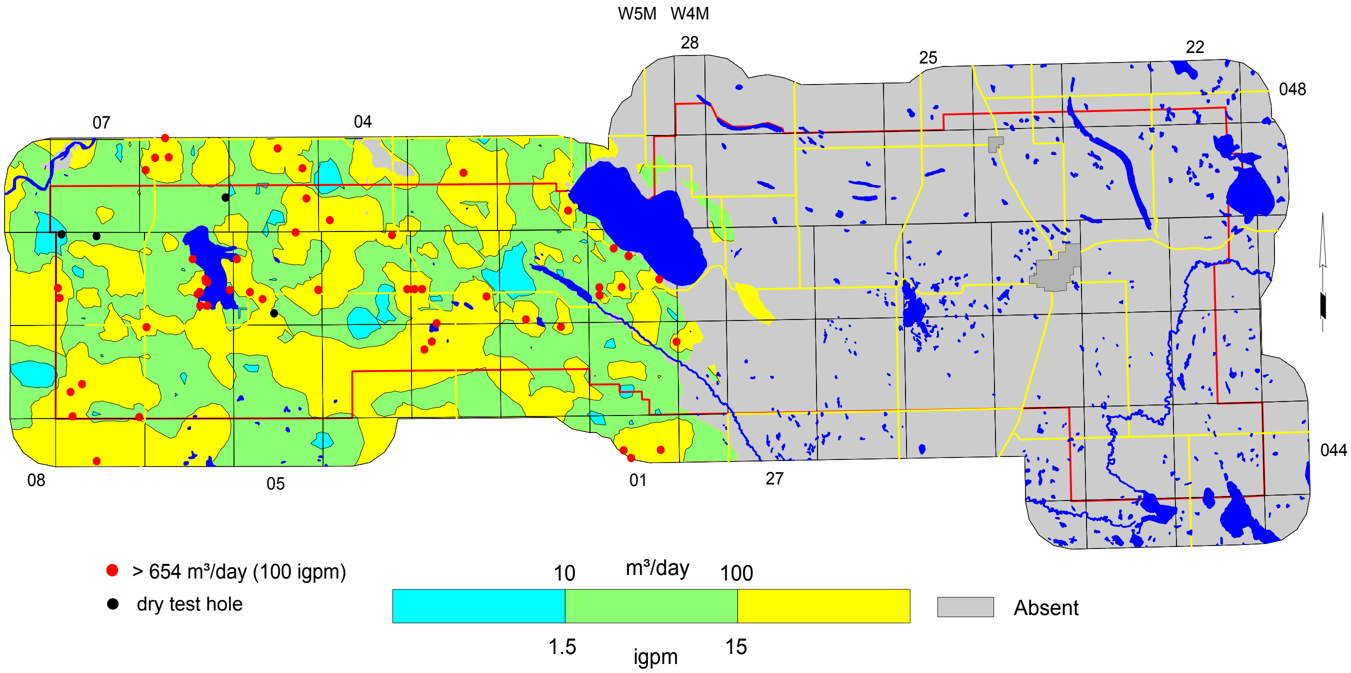
Fluoride vs Sodium Concentrations in Groundwater from Upper Bedrock Aquifer(s) in the County of Wetaskiwin and Surrounding Counties



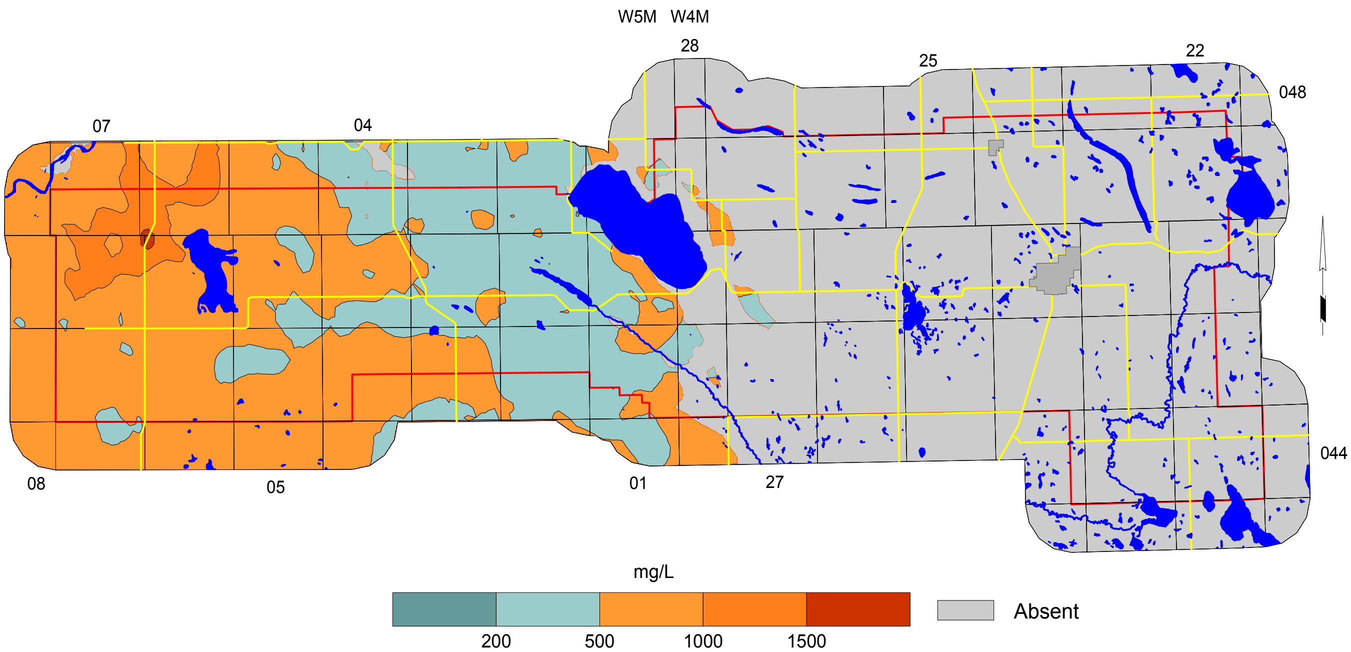
Depth to Top of Dalehurst Member



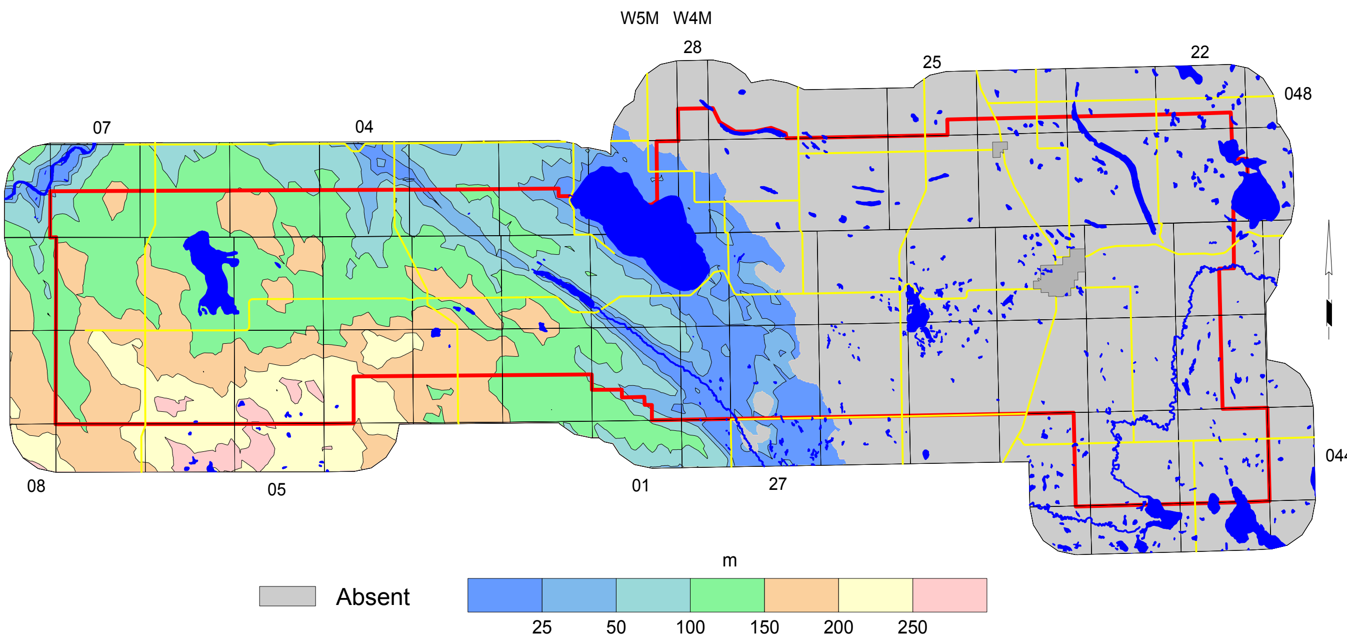
Apparent Yield for Water Wells Completed through Dalehurst Aquifer



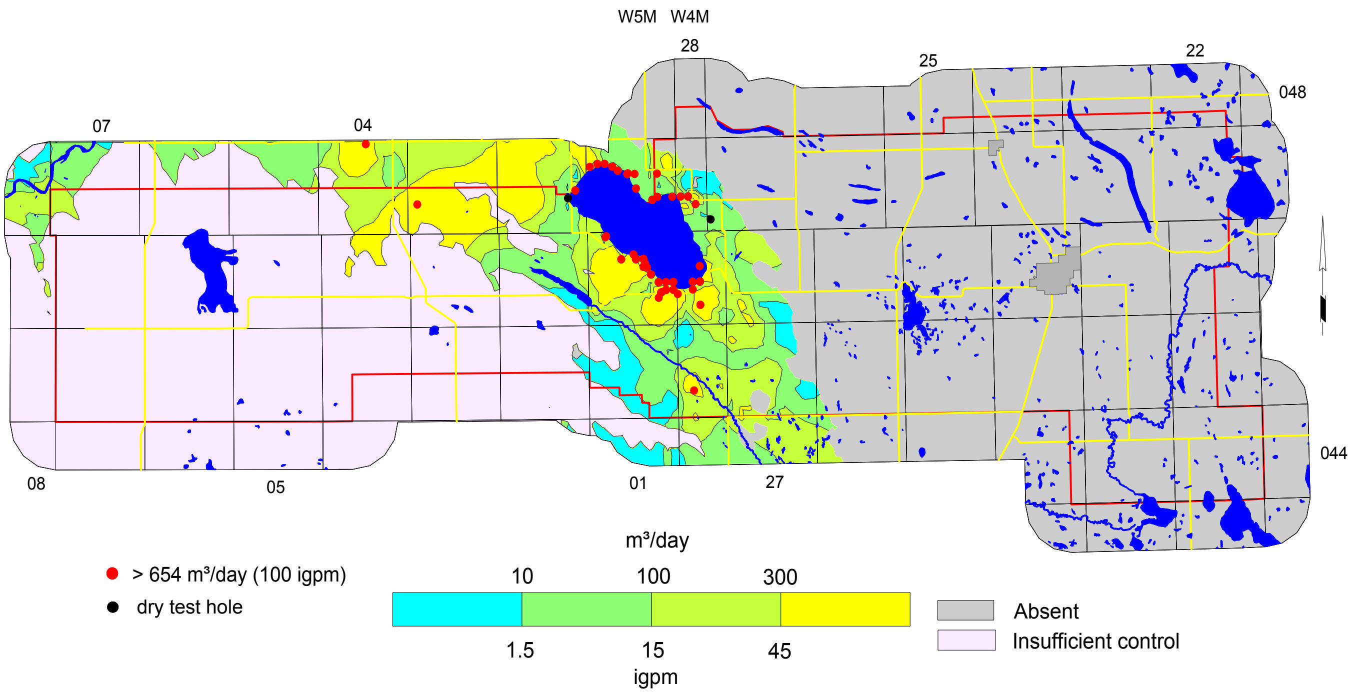
Total Dissolved Solids in Groundwater from Dalehurst Aquifer



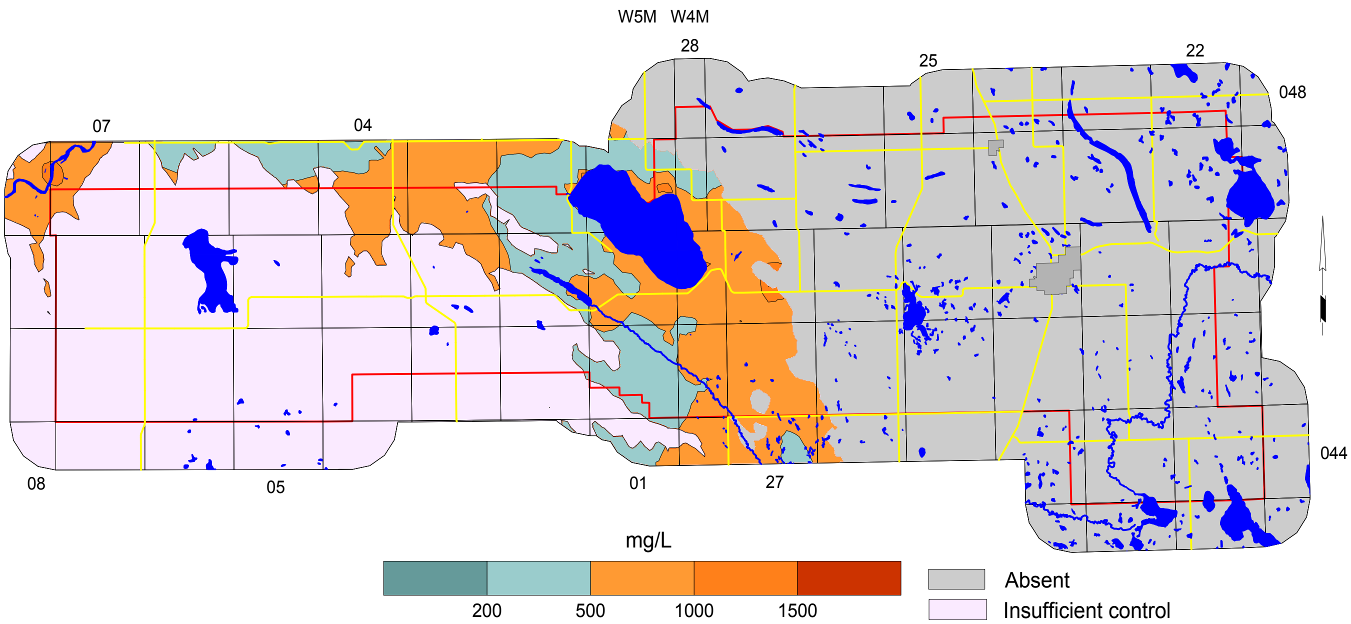
Depth to Top of Upper Lacombe Member



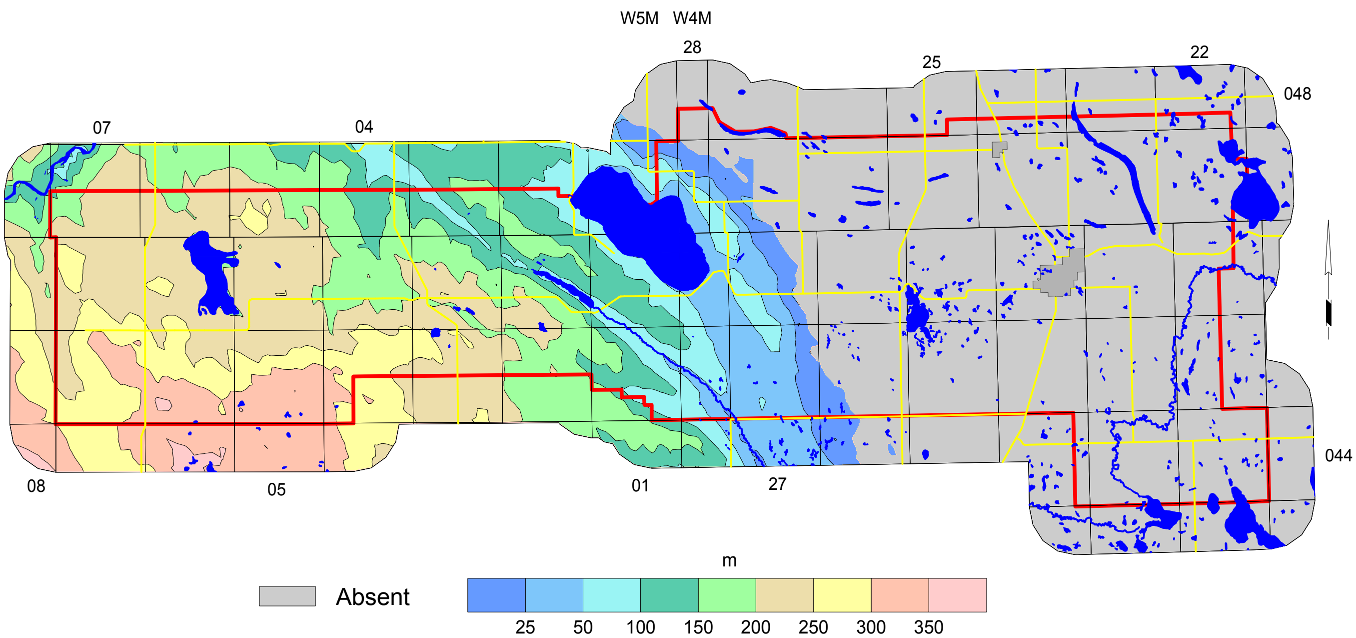
Apparent Yield for Water Wells Completed through Upper Lacombe Aquifer



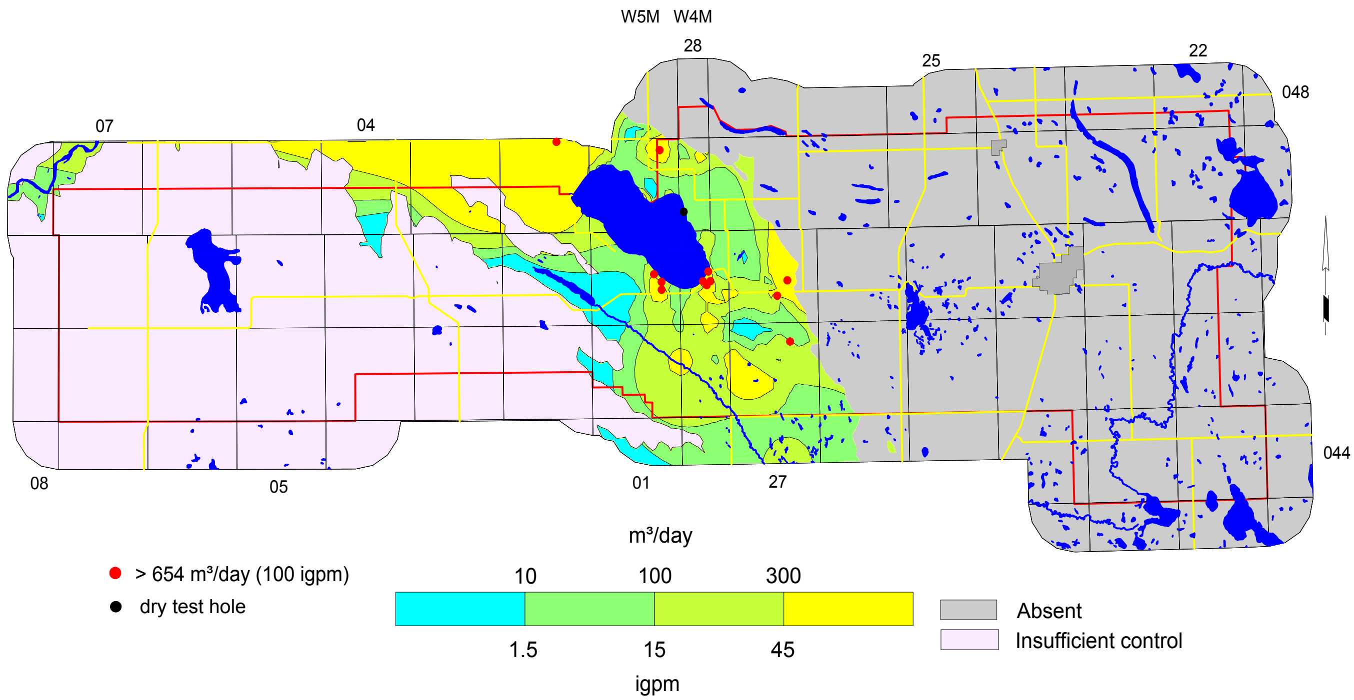
Total Dissolved Solids in Groundwater from Upper Lacombe Aquifer



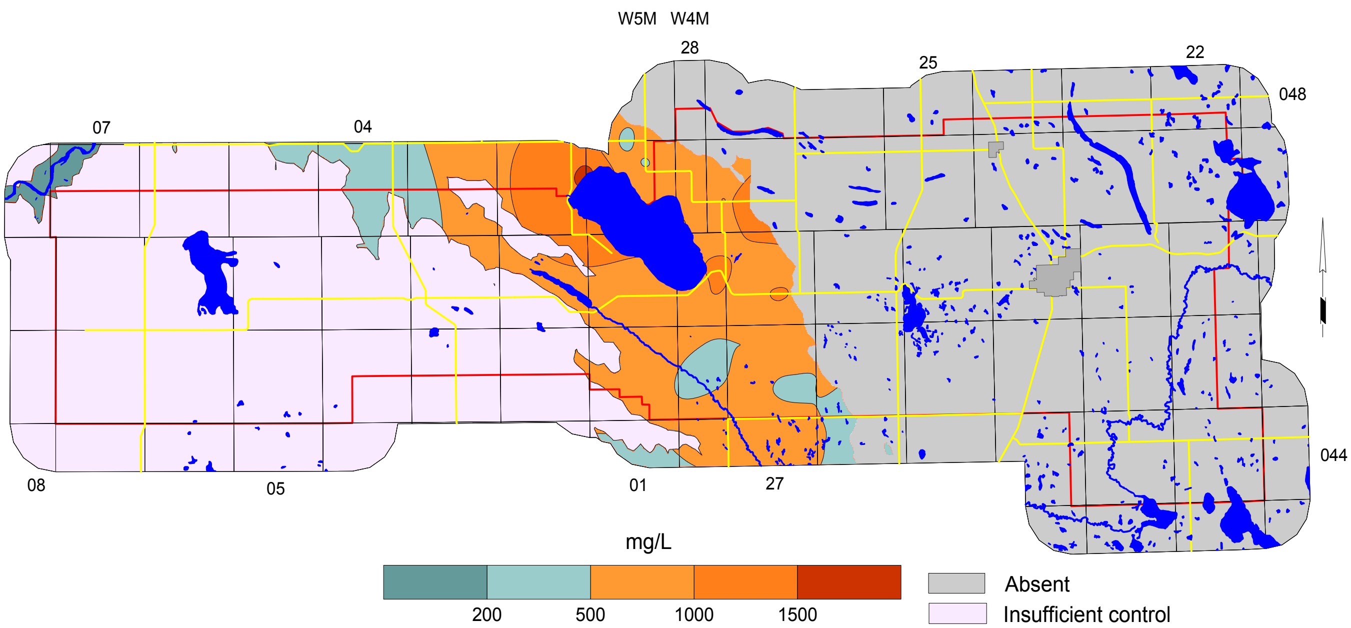
Depth to Top of Lower Lacombe Member



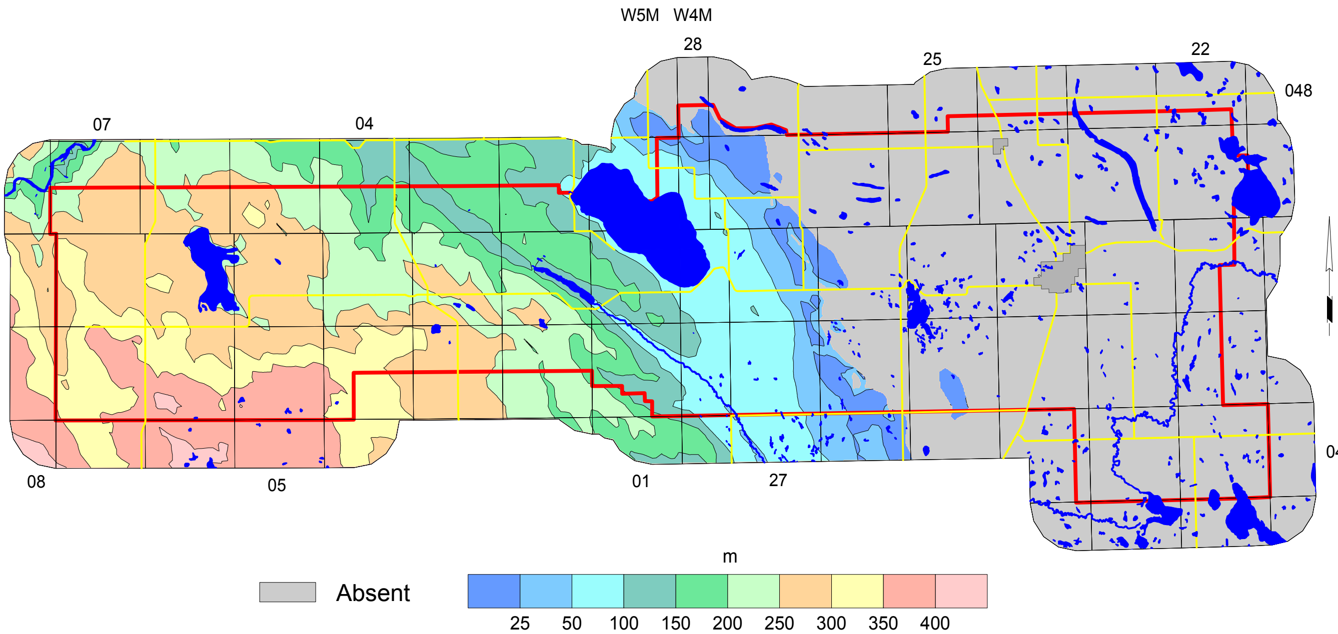
Apparent Yield for Water Wells Completed through Lower Lacombe Aquifer



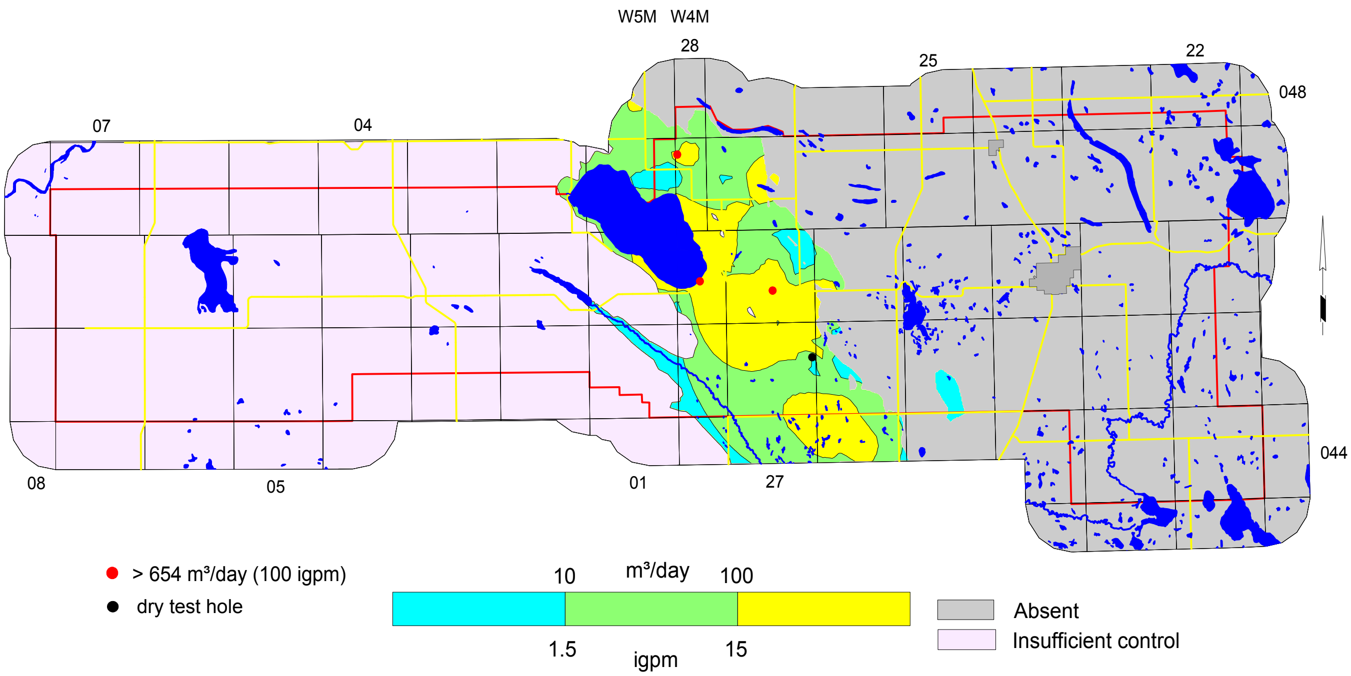
Total Dissolved Solids in Groundwater from Lower Lacombe Aquifer



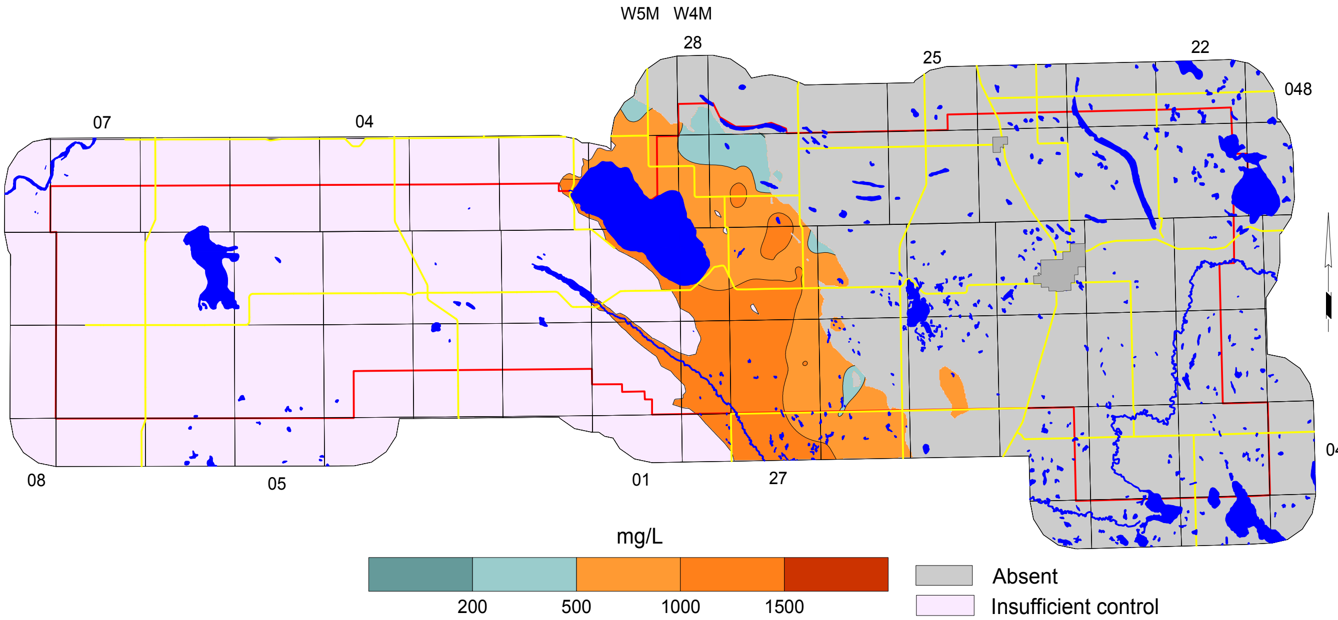
Depth to Top of Haynes Member



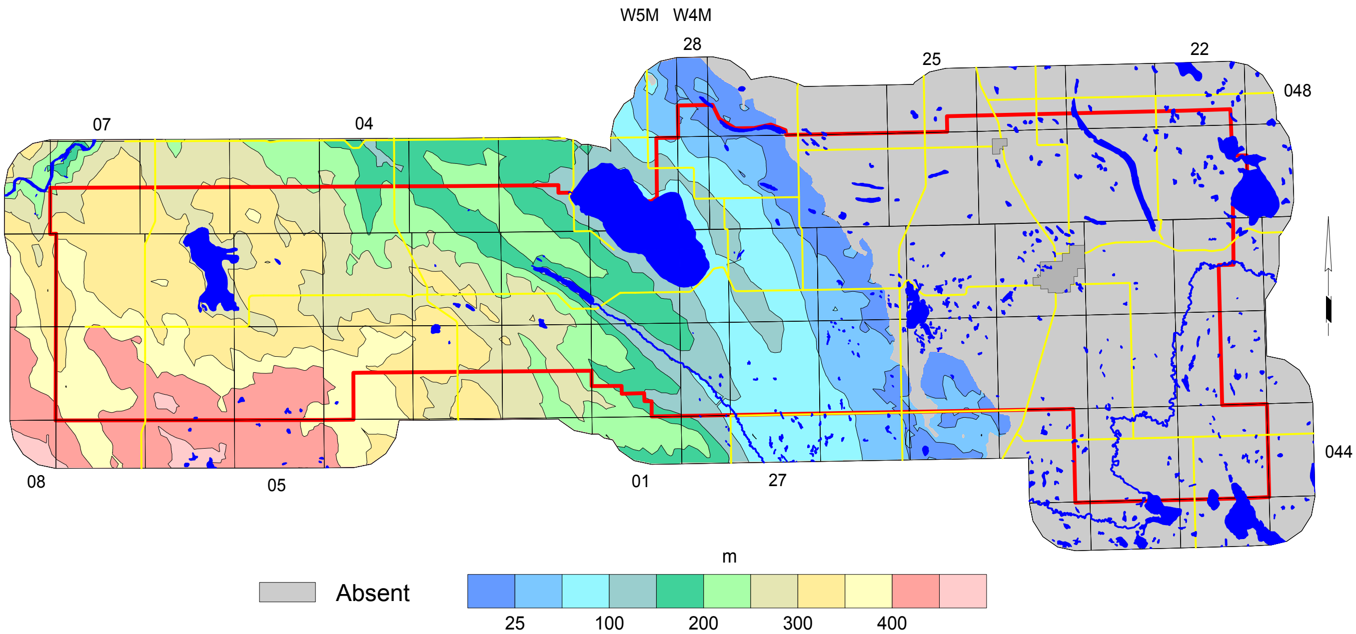
Apparent Yield for Water Wells Completed through Haynes Aquifer



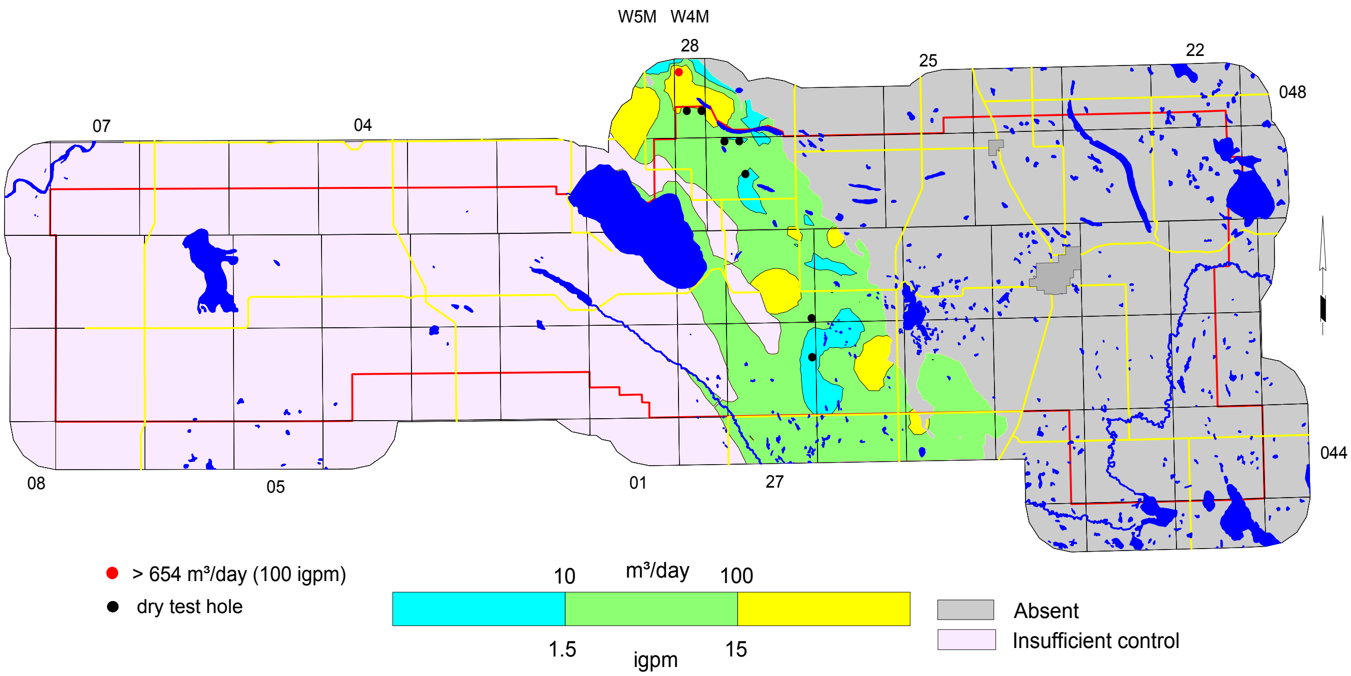
Total Dissolved Solids in Groundwater from Haynes Aquifer



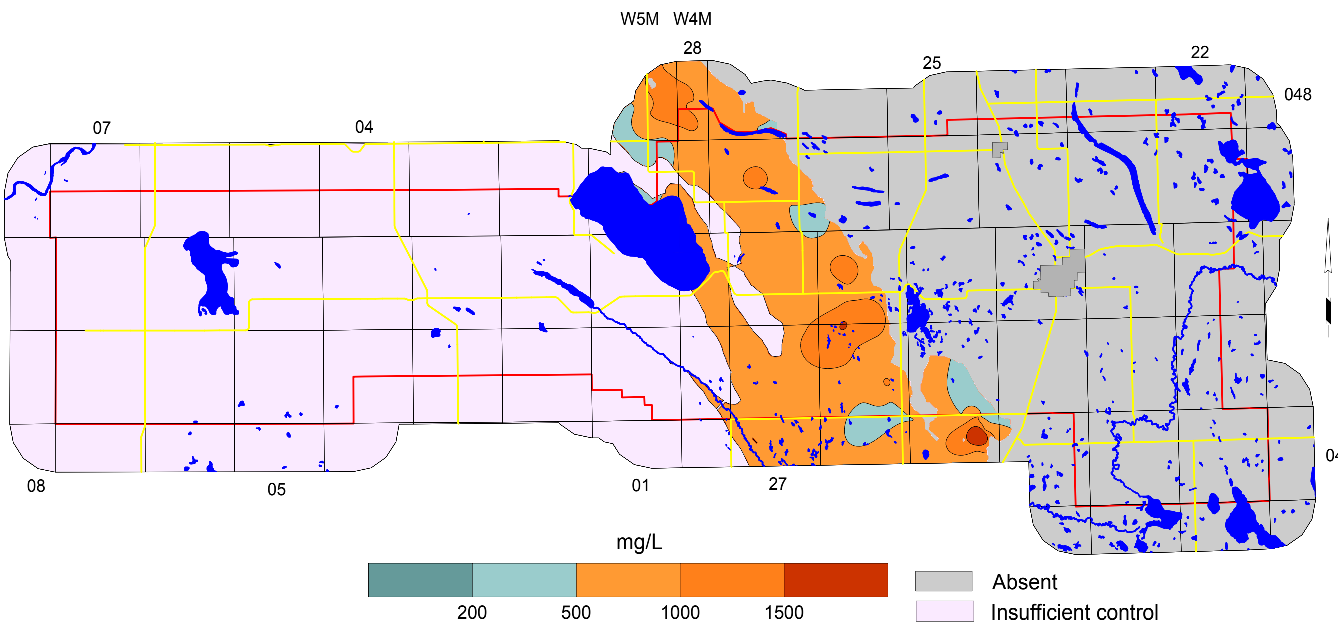
Depth to Top of Upper Scollard Formation



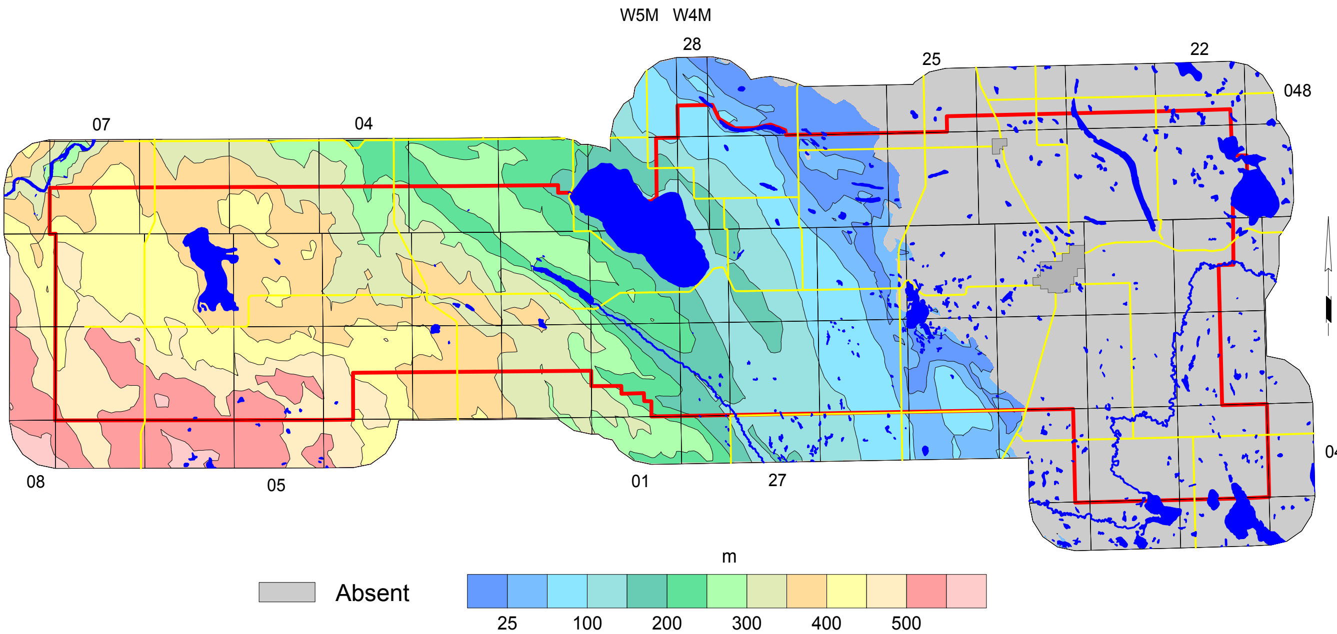
Apparent Yield for Water Wells Completed through Upper Scollard Aquifer



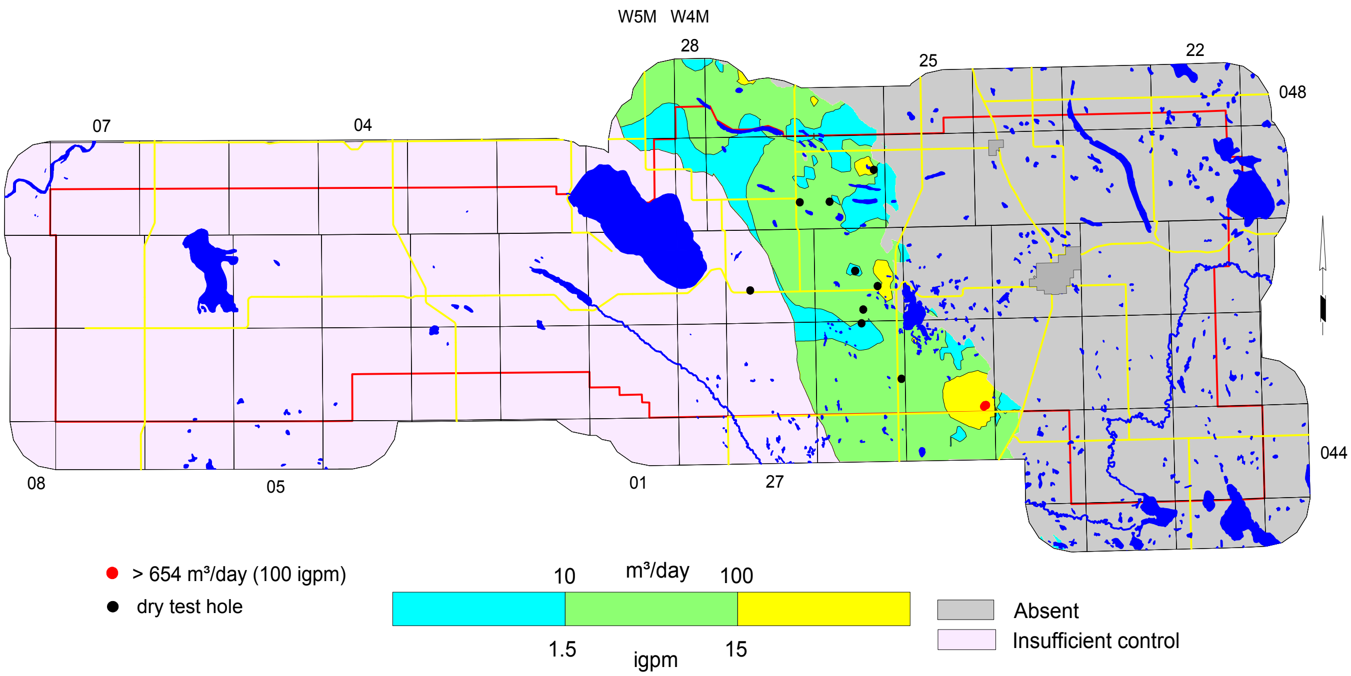
Total Dissolved Solids in Groundwater from Upper Scollard Aquifer



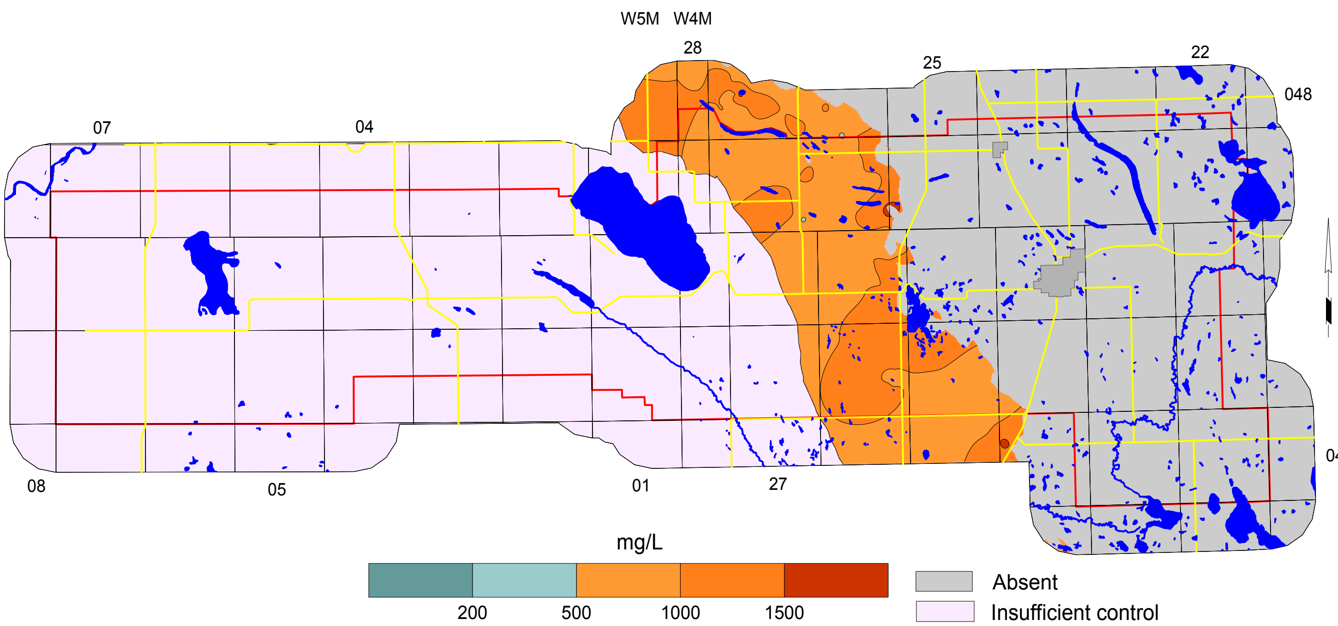
Depth to Top of Lower Scollard Formation



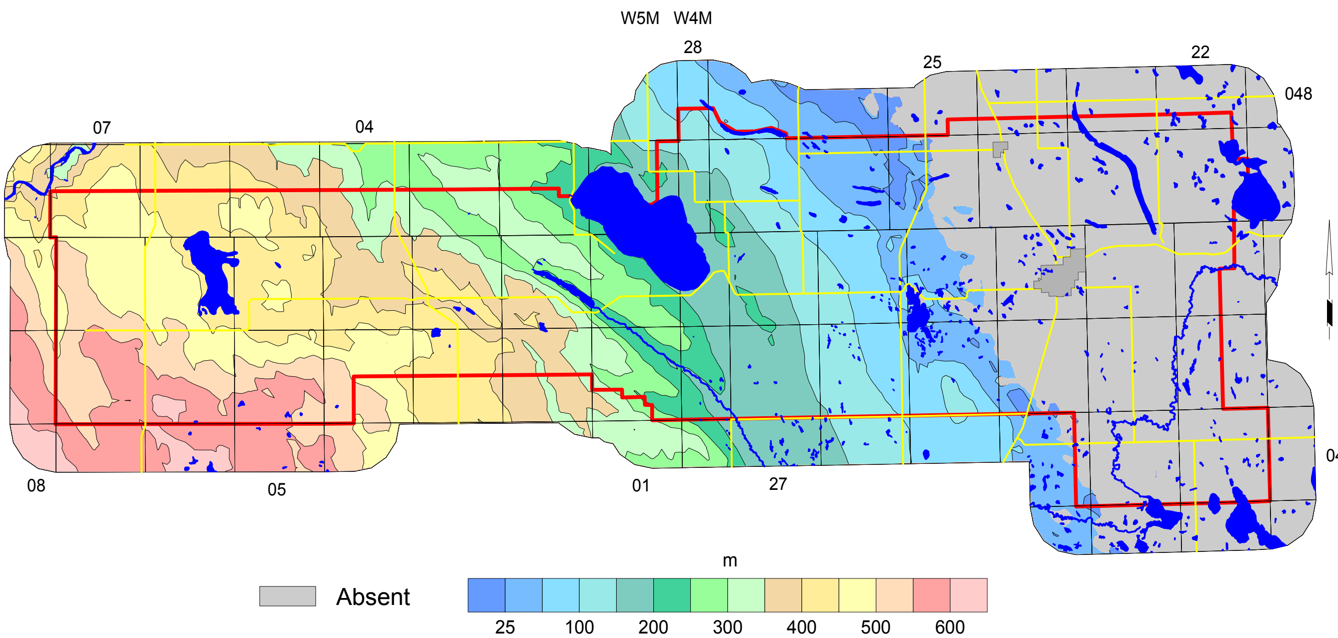
Apparent Yield for Water Wells Completed through Lower Scollard Aquifer



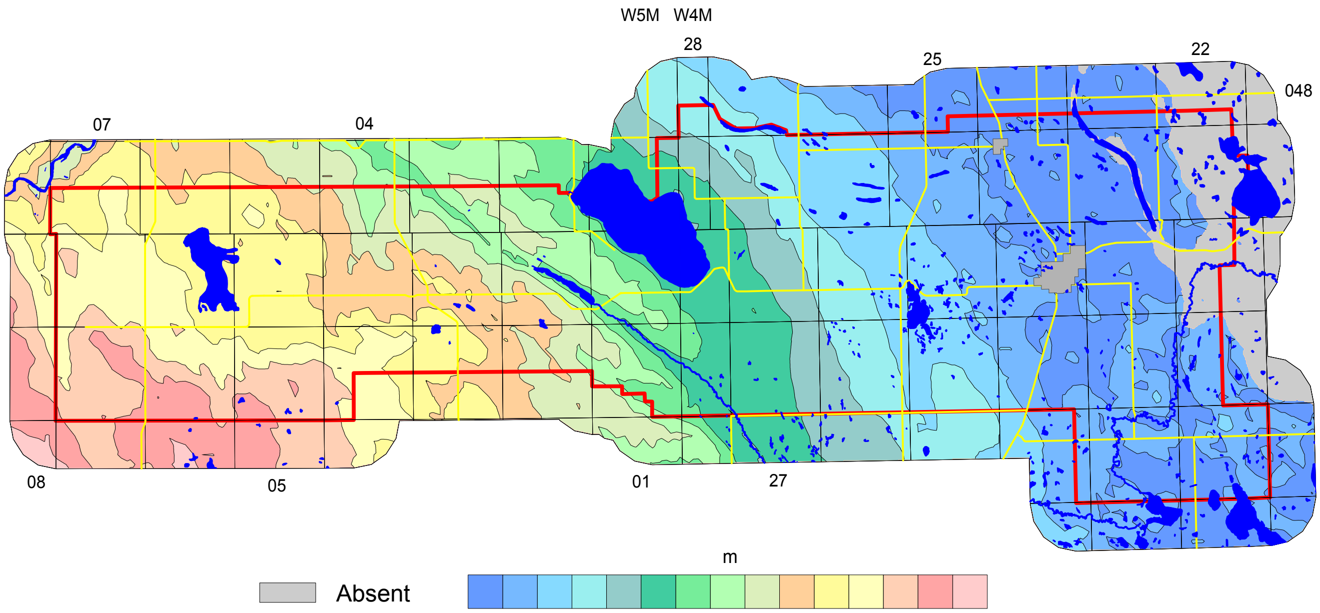
Total Dissolved Solids in Groundwater from Lower Scollard Aquifer



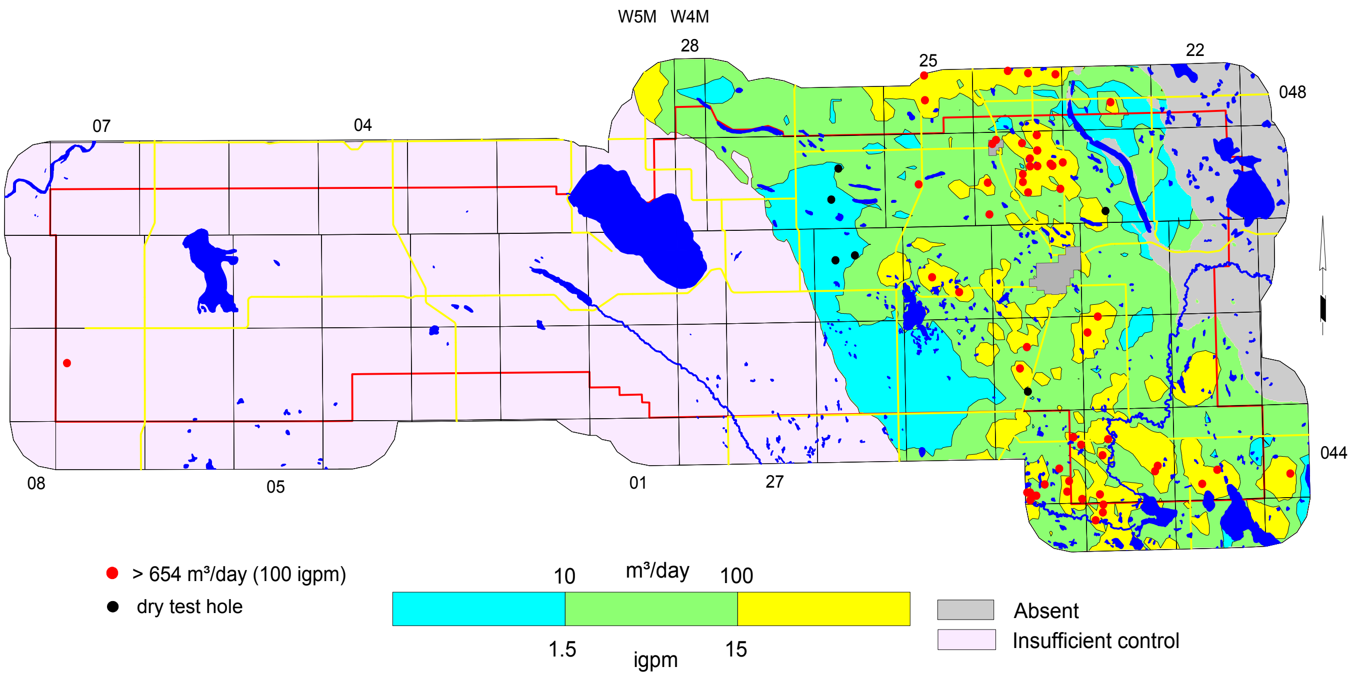
Depth to Top of Battle/Whitemud Formation



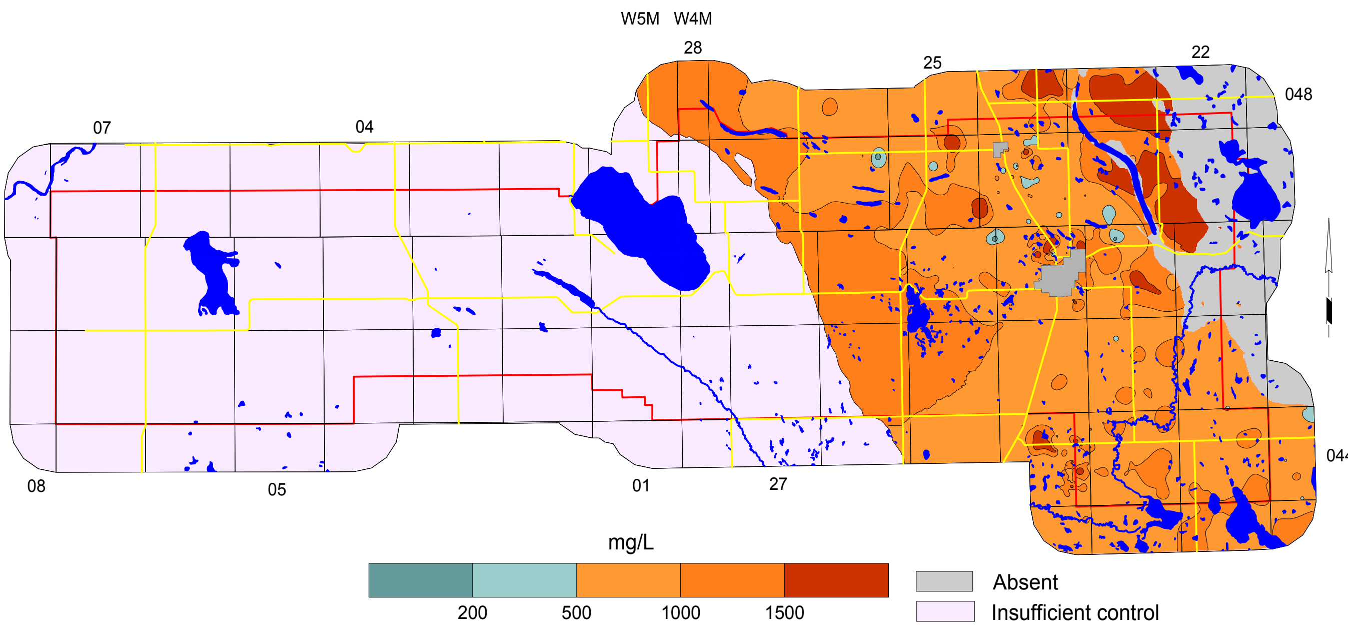
Depth to Top of Upper Horseshoe Canyon Formation



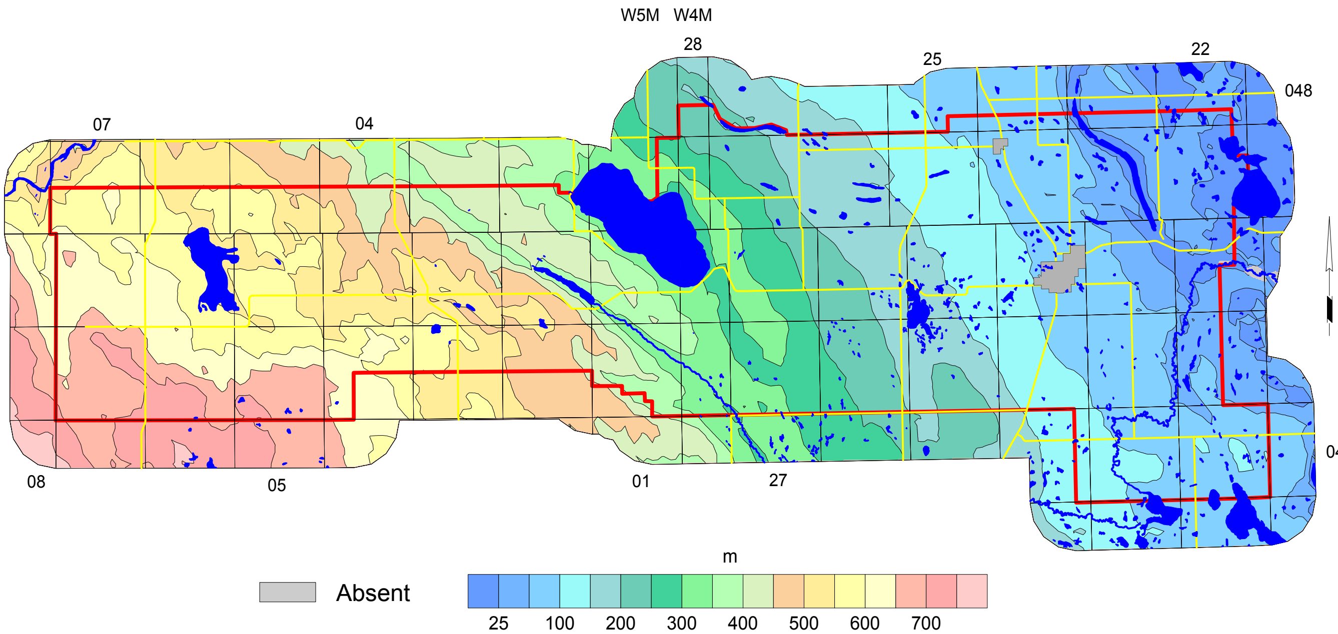
Apparent Yield for Water Wells Completed through Upper Horseshoe Canyon Aquifer



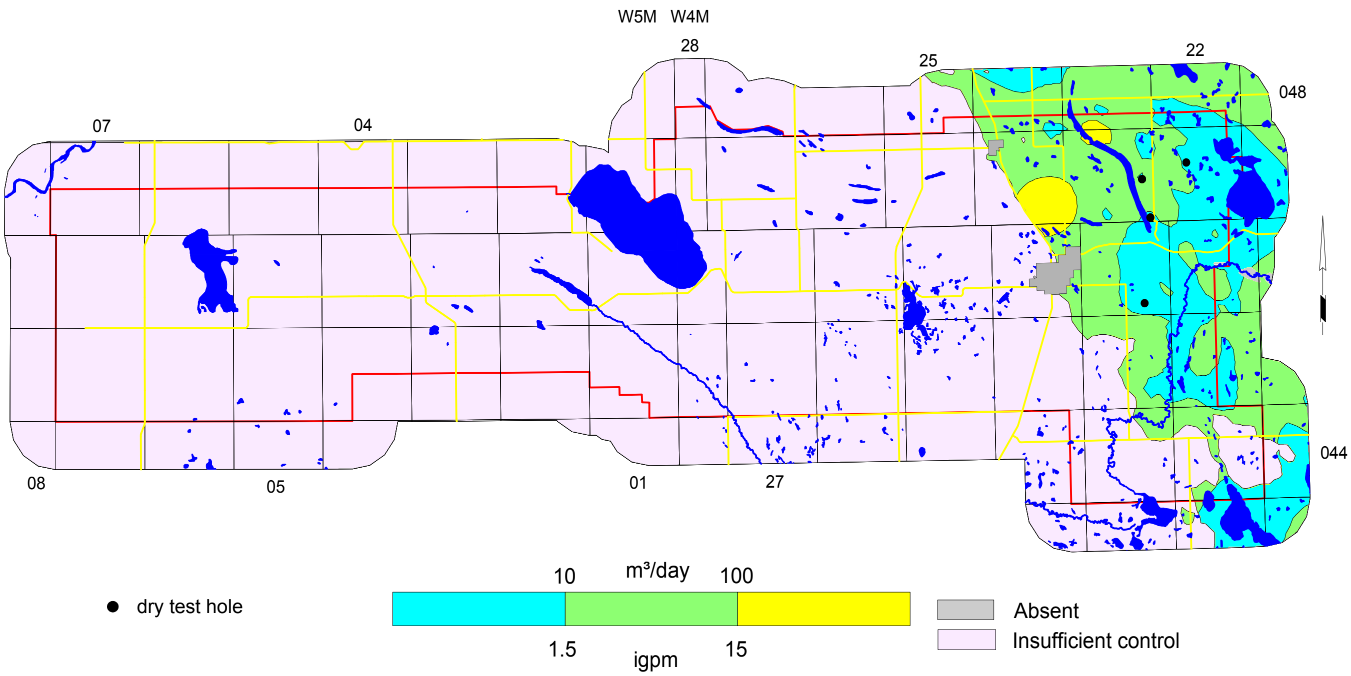
Total Dissolved Solids in Groundwater from Upper Horseshoe Canyon Aquifer



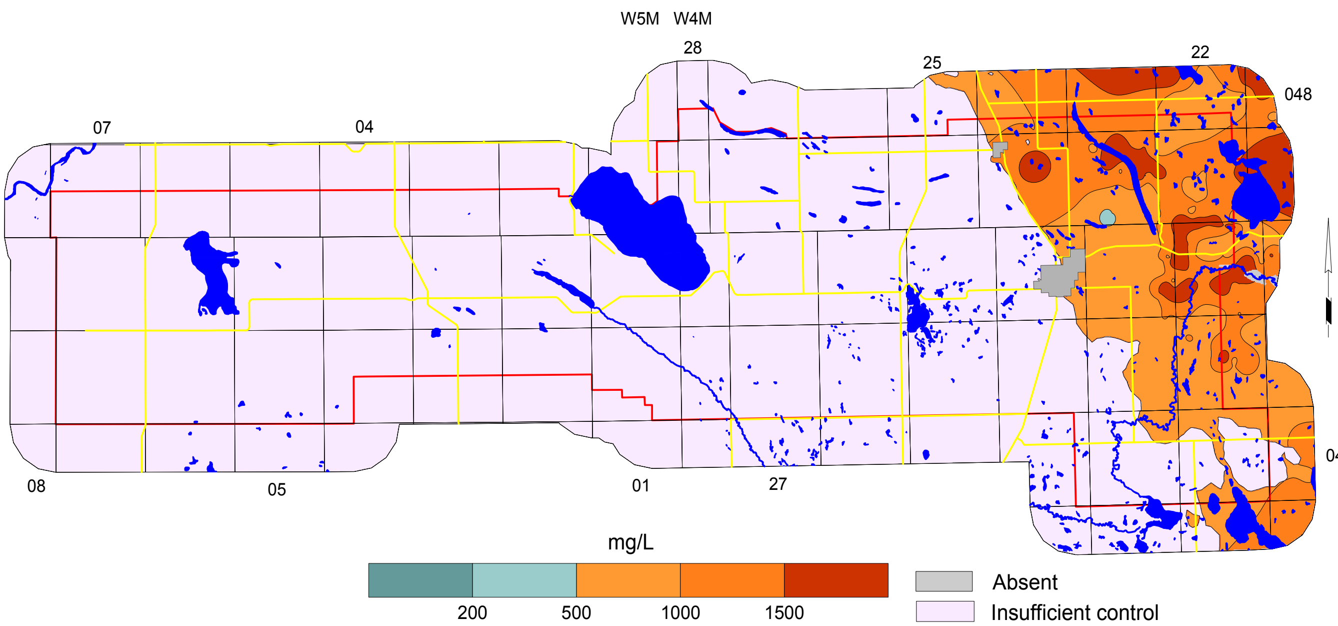
Depth to Top of Middle Horseshoe Canyon Formation



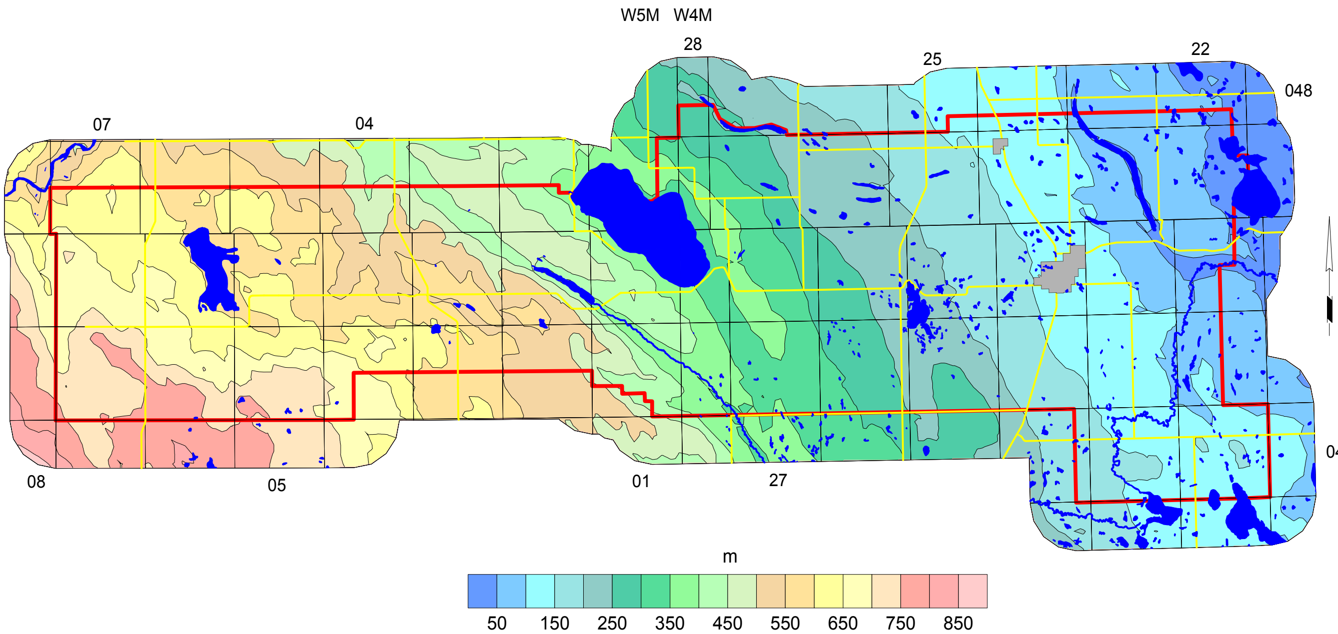
Apparent Yield for Water Wells Completed through Middle Horseshoe Canyon Aquifer



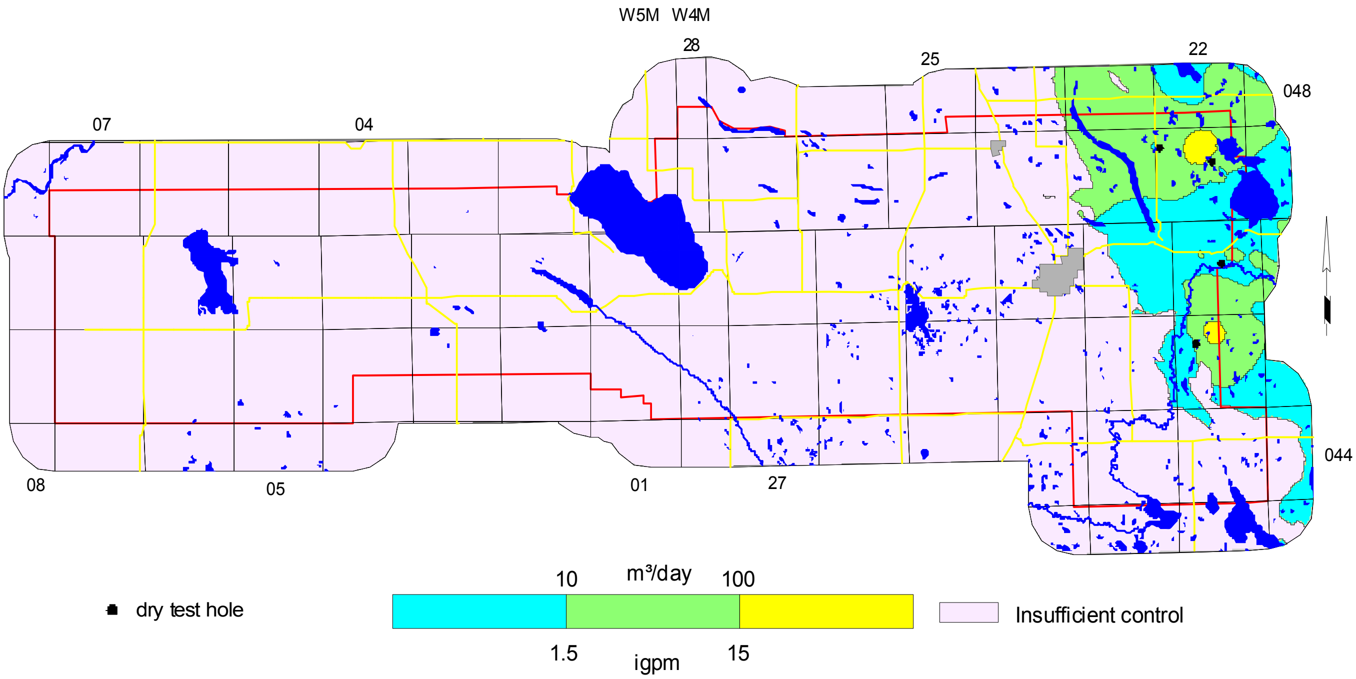
Total Dissolved Solids in Groundwater from Middle Horseshoe Canyon Aquifer



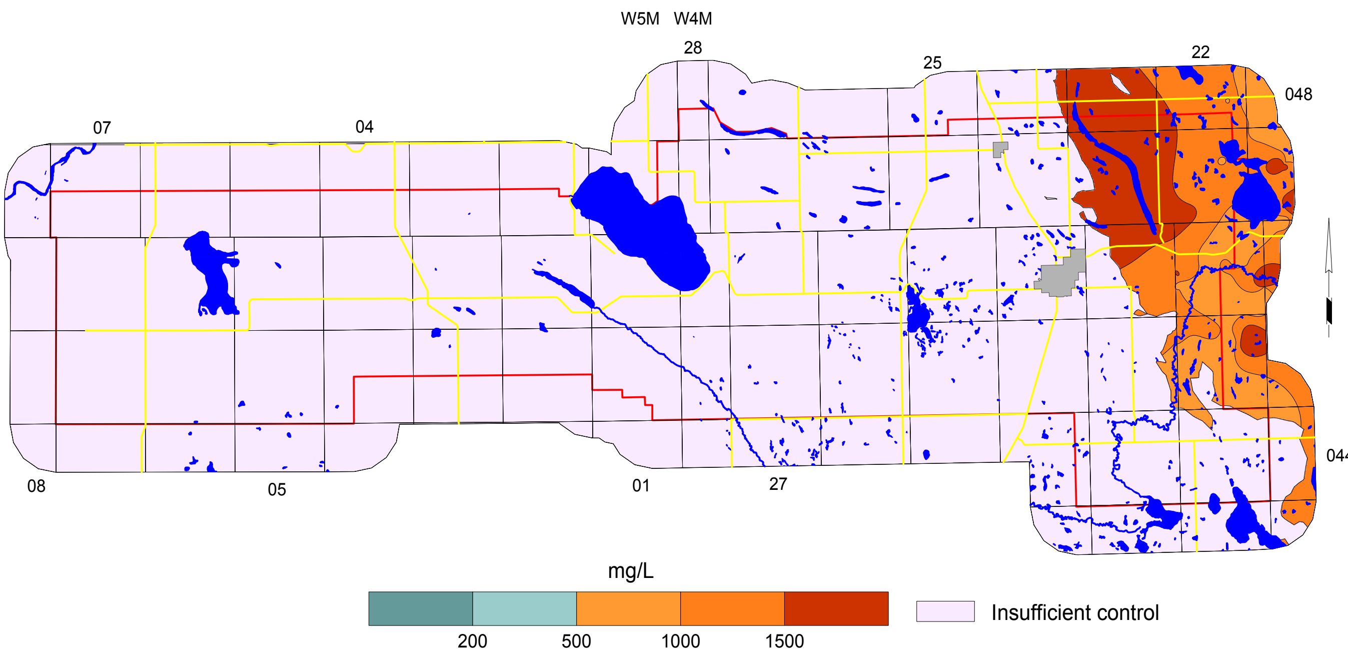
Depth to Top of Lower Horseshoe Canyon Formation



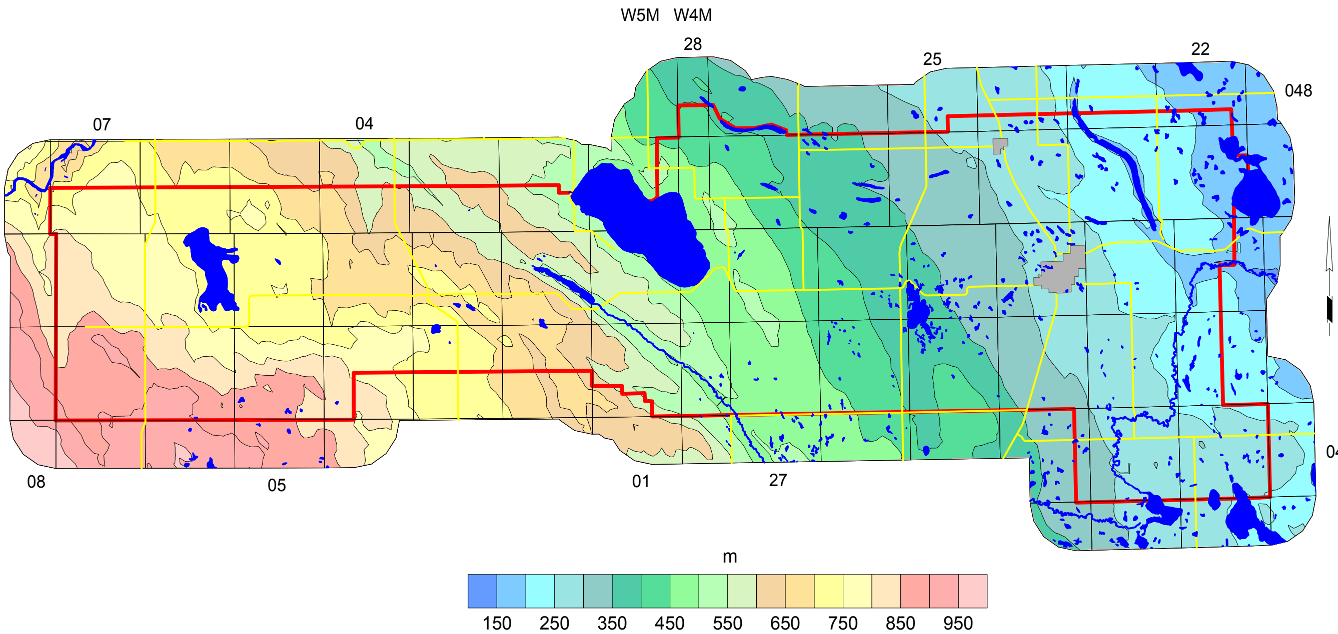
Apparent Yield for Water Wells Completed through Lower Horseshoe Canyon Aquifer



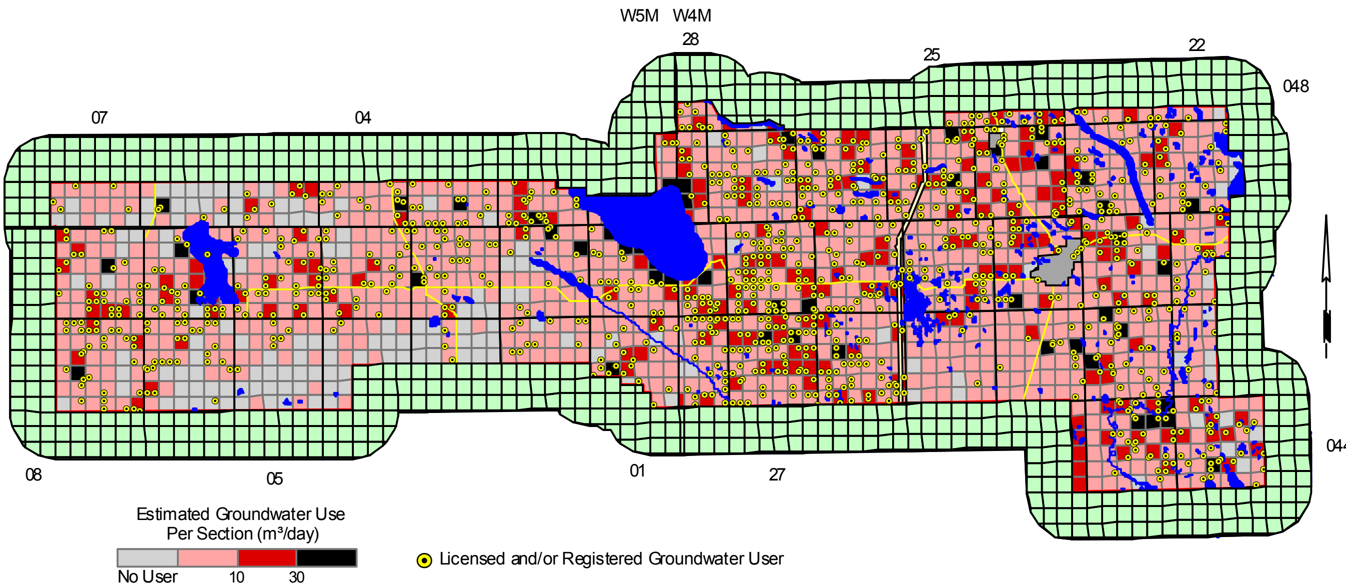
Total Dissolved Solids in Groundwater from Lower Horseshoe Canyon Aquifer



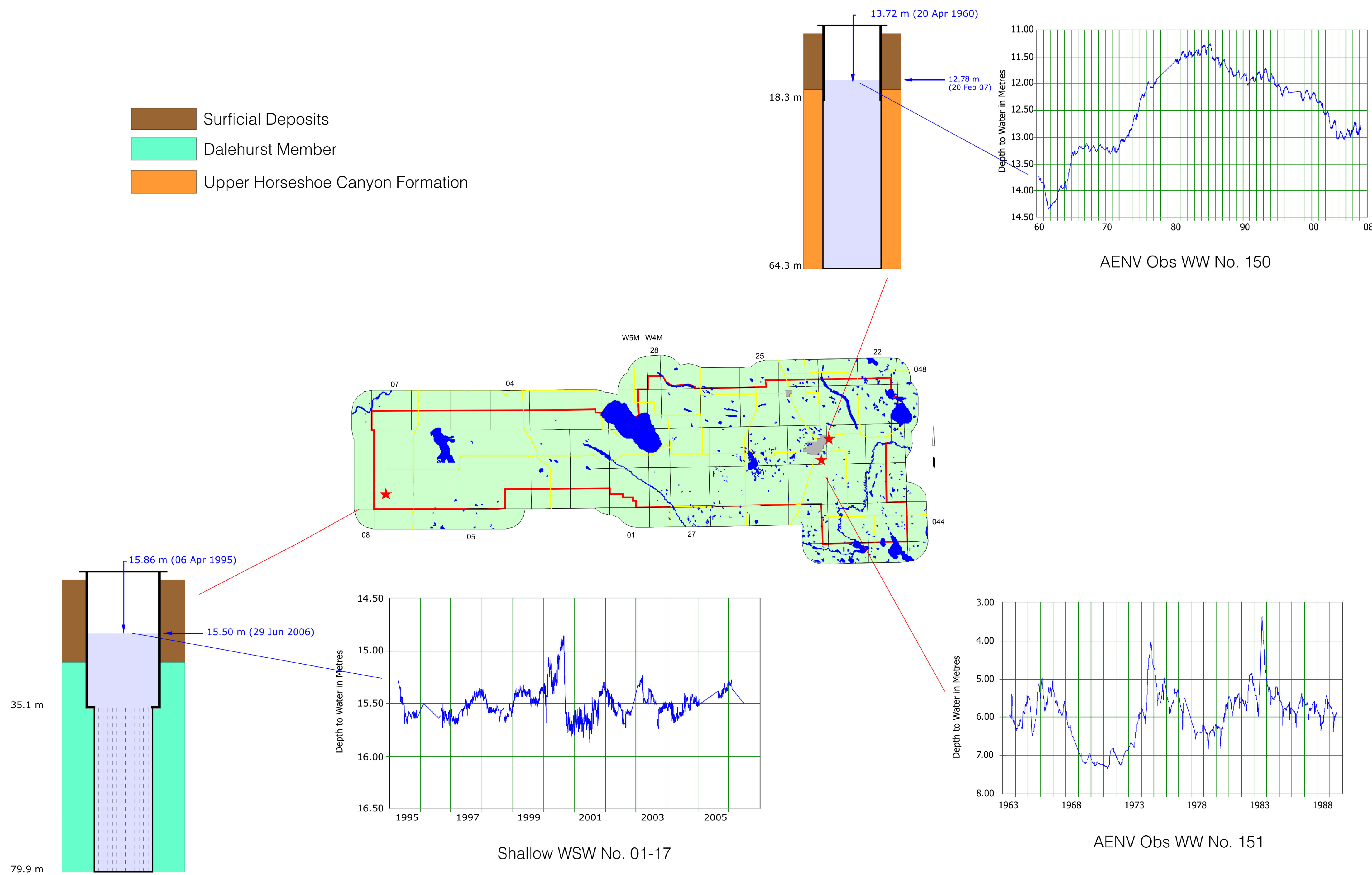
Depth to Top of Bearpaw Formation



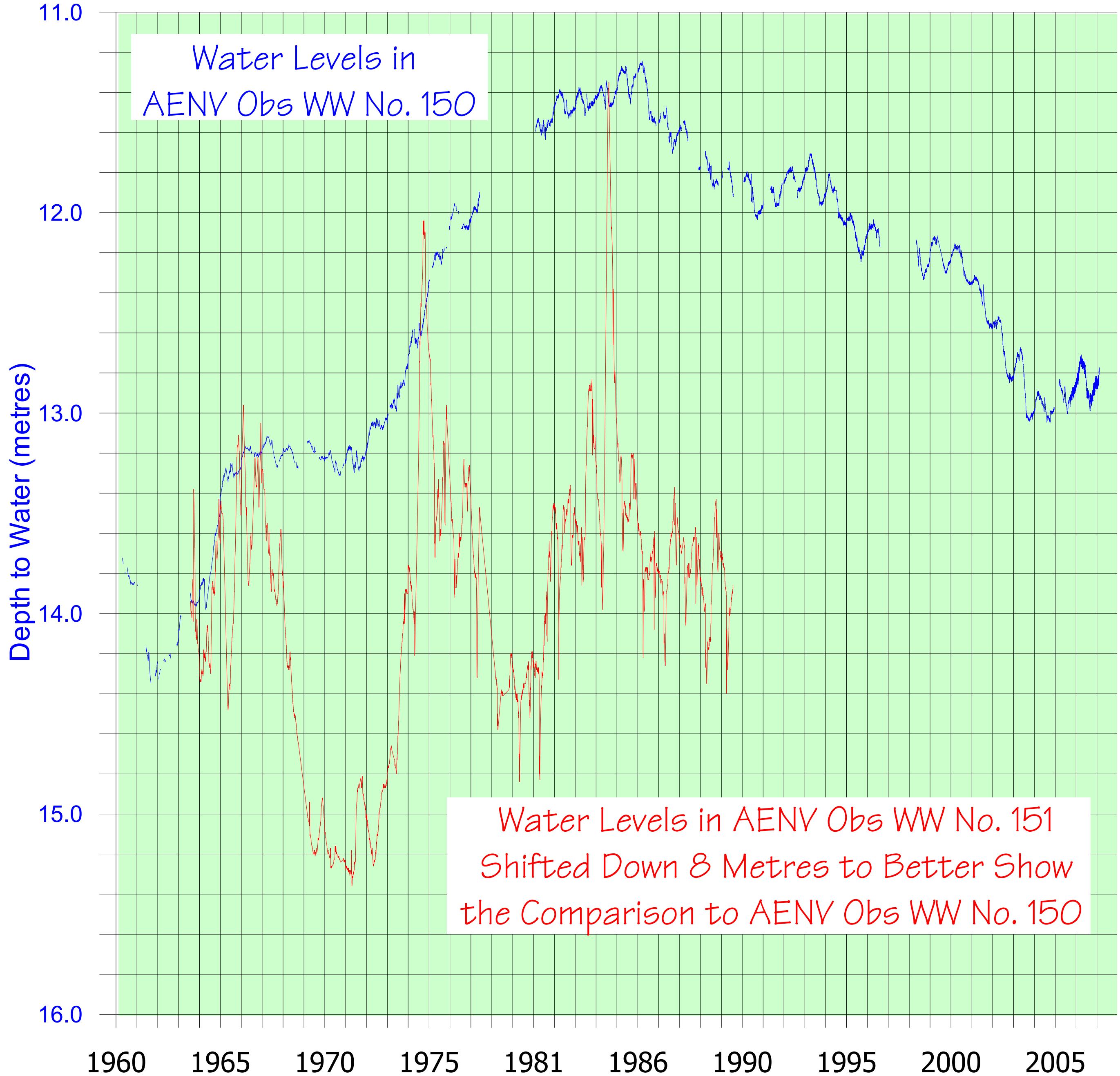
Estimated Water Well Use Per Section



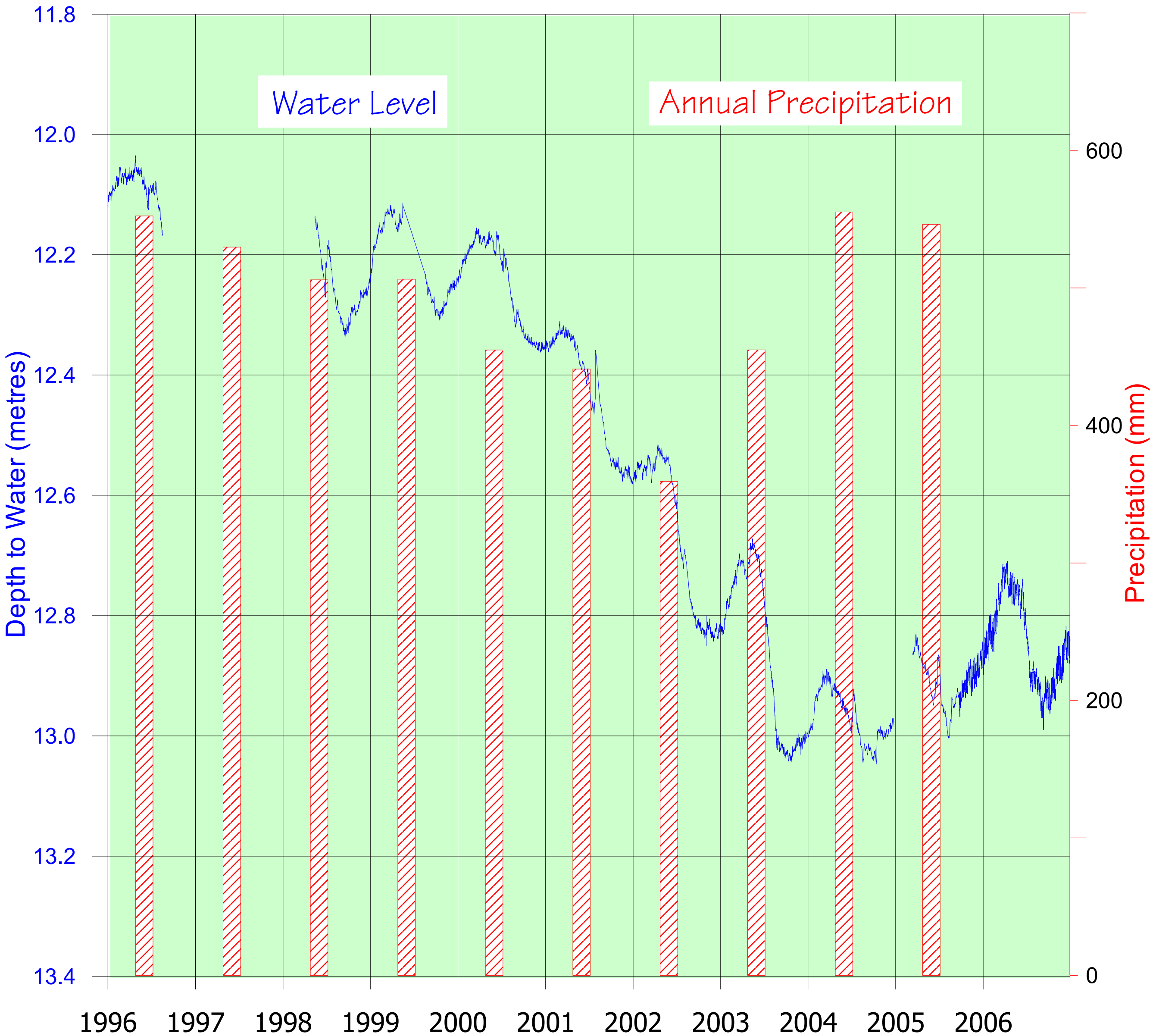
Hydrographs



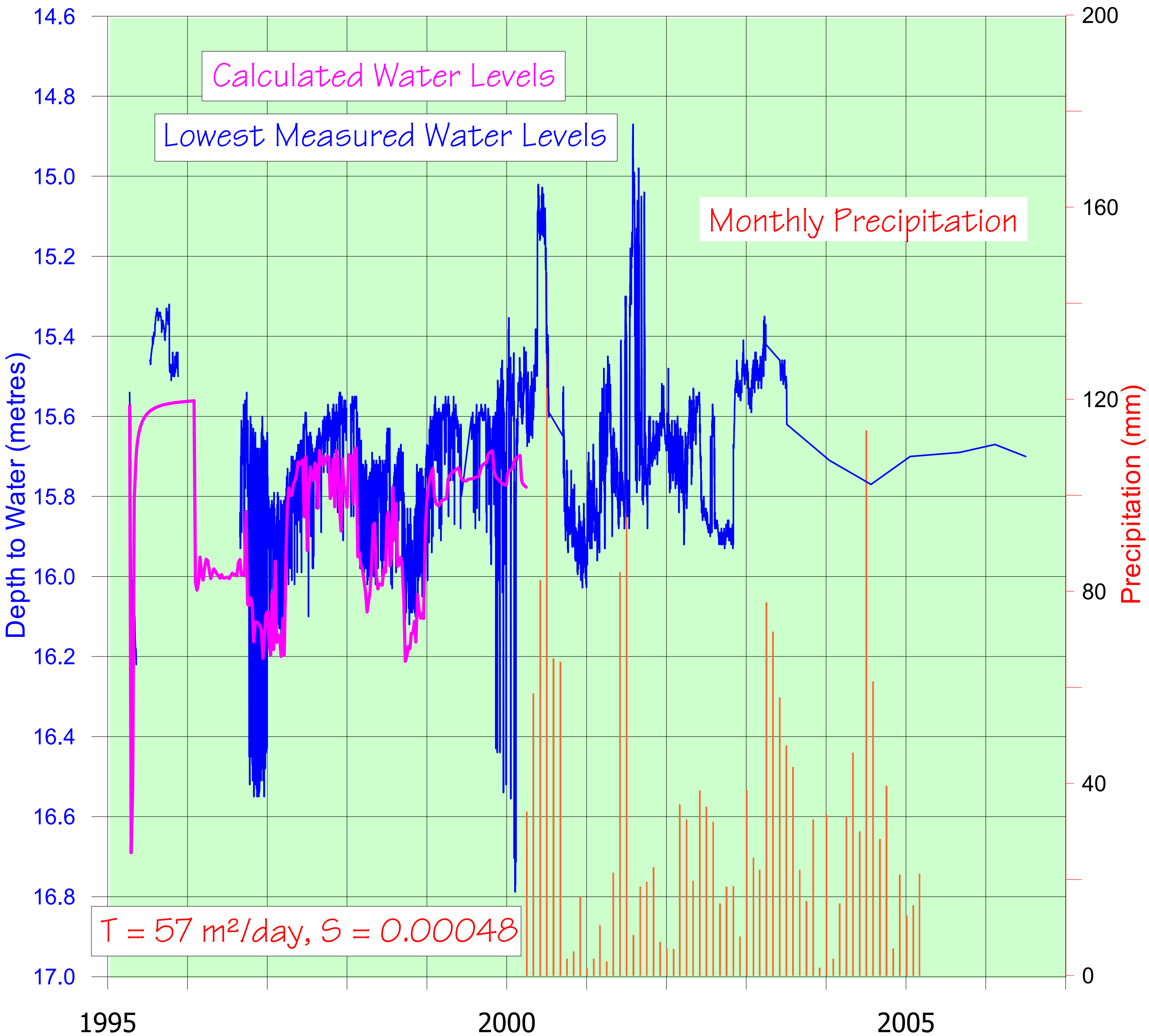
Water-Level Measurements in AENV Obs WW No. 150 and AENV Obs WW No. 151



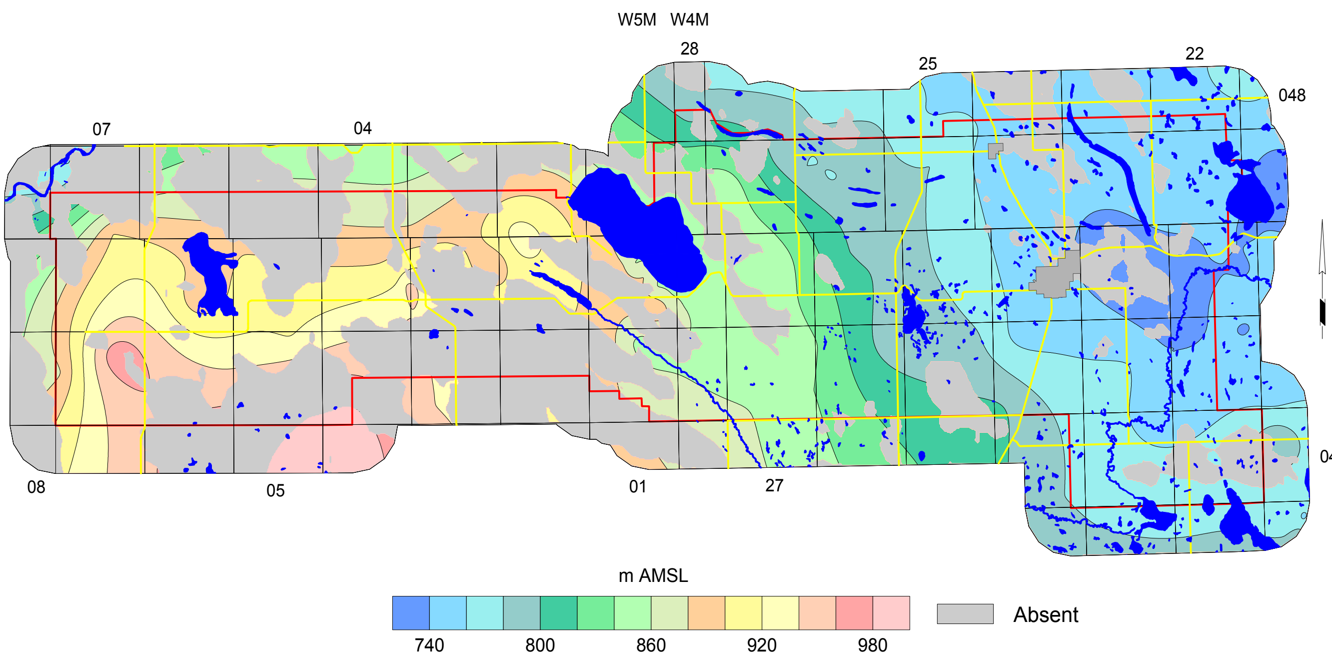
Annual Precipitation vs Water Level in AENV Obs WW No. 150



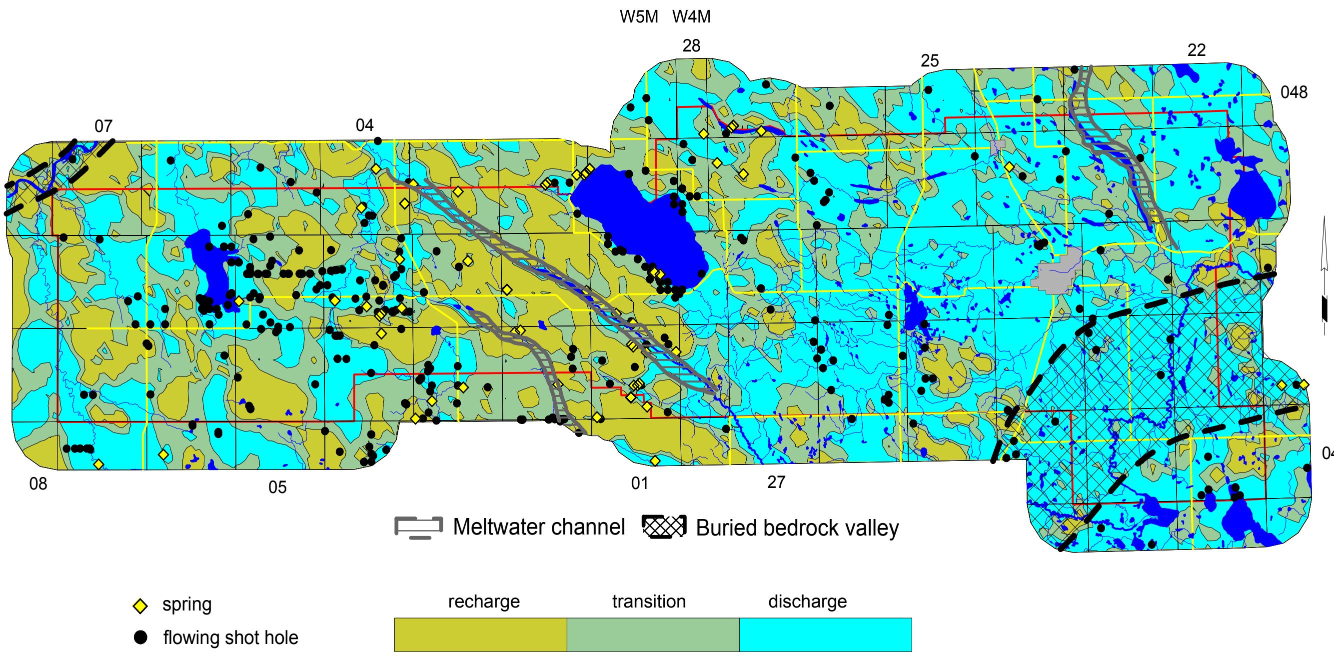
Water-Level Comparison in Shallow Obs WW No. 01-17 to Monthly Precipitation Measured at the Gwynne Meteorological Station



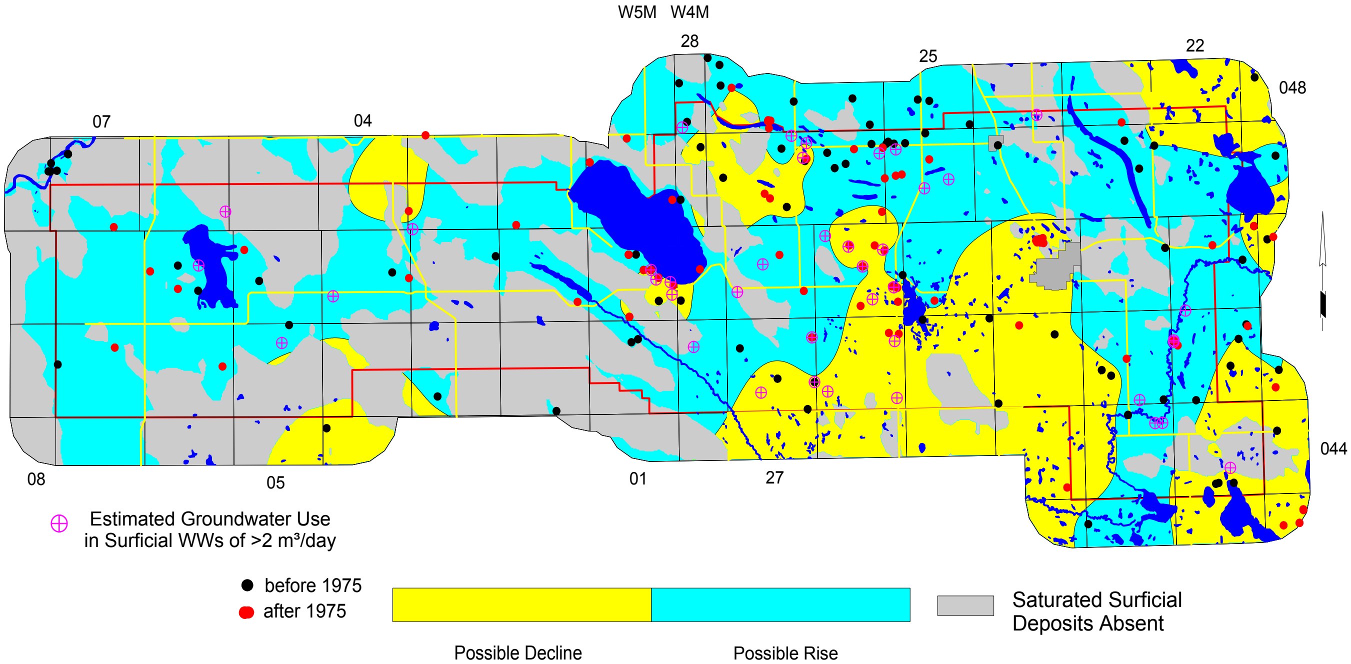
Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep



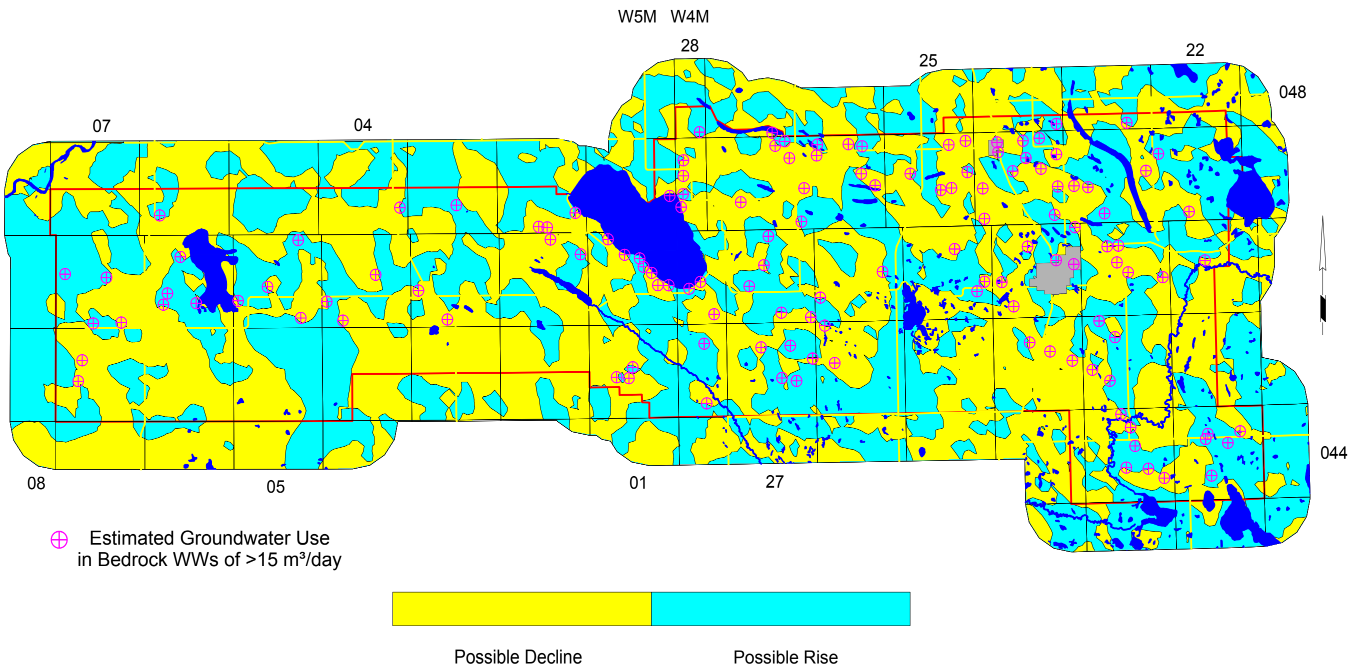
Bedrock Recharge/Discharge Areas



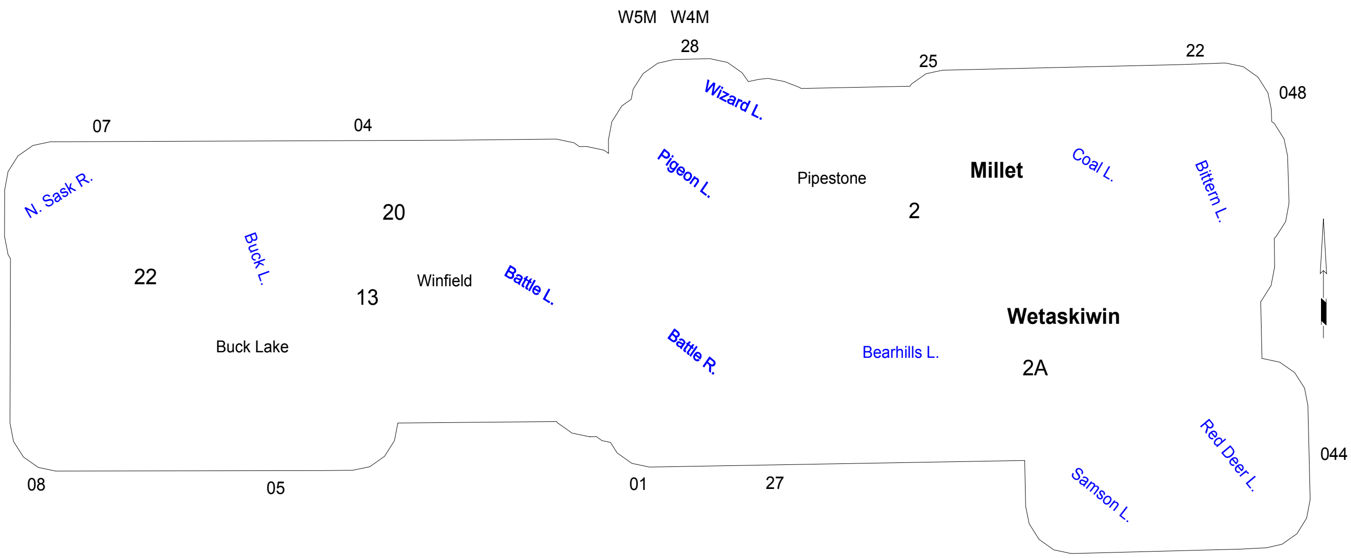
Changes in Water Levels in Surficial Deposits



Areas of Potential Groundwater Decline in Upper Bedrock Aquifer(s)



Overlay


W5M
W4M
28
25
22
048
07
04
Wizard L.
Pigeon L.
Pipestone
Millet
Coal L.
Bittern L.
N. Sask R.
20
2
Buck L.
22
13
Winfield
Battle L.
Wetaskiwin
Buck Lake
Battle R.
Bearhills L.
2A
Red Deer L.
044
Samson L.
08
05
01
27

COUNTY OF WETASKIWIN
Appendix B

Maps and Figures on CD-ROM

MAPS AND FIGURES ON CD-ROM

3) Bedrock Aquifers

D 4) Hydrographs and Observation Water Wells

COUNTY OF WETASKIWIN
Appendix C

General Water Well Information

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

PROVINCE OF ALBERTA

WATER ACT

WATER (MINISTERIAL) REGULATION

Alberta Regulation 205/98

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ALBERTA REGULATION 205/98

Water Act

WATER (MINISTERIAL) REGULATION

Table of Contents

1

Chemical Analysis of Farm Water Supplies

Adapted from Agdex 716 (D04) Published April 1991

A routine chemical analysis tests the water for 15 chemical parameters. It will reveal the hardness and iron concentration as well as the presence of other chemicals such as chlorides, sulphates, nitrates and nitrites. Chemicals, other than those listed below, can be tested but arrangements should be made with the lab before the sample is submitted. These special requests' must be clearly specified on the request form. Your farm water supply should be analyzed whenever a new water source is constructed, or when a change in water quality is noticed.

Your local health unit can provide you with the necessary water sample containers. Water samples specifically for human consumption must be submitted to the health unit.

The water sample you take should be representative. Choose an outlet as close to the source as possible. For most domestic samples, allow the water to run through the faucet for about five minutes and then fill the sample container.

Once you have obtained a good water sample, take it to your local health unit for forwarding to the appropriate laboratory. After the laboratory analysis is completed, the health inspector or technologist will receive a copy of the analysis and will be able to help you interpret the results.

Water Quality Criteria
It is not essential for private supplies to meet these guidelines. People have different reactions and tolerances to different minerals. If any chemical in your water exceeds drinking water limits consult you family doctor or local health unit.

All levels listed below (except pH) are listed in parts per million (ppm). Many labs report results in milligrams/Litre (mg/L), which is equivalent to ppm.

Sodium
Sodium is not considered a toxic metal, and 5,000 to 10,000 milligrams per day are consumed by normal adults without adverse effects. The average intake of sodium from water is only a small fraction of that consumed in a normal diet.

Persons suffering from certain medical conditions such as hypertension may require a sodium restricted diet, in which case the intake of sodium from drinking water could become significant. Sodium levels as low as 20 ppm are sometimes a concern to them. A maximum level of 300 (200*) ppm sodium has traditionally been used as a guideline but the "Guidelines for Canadian Drinking Water Quality" list no maximum acceptable concentration.

Sodium is a significant factor in assessing water for irrigation and plant watering. High sodium levels affect soil structure and a plant's ability to take up water.

Potassium
Potassium is usually only found in quantities of a few ppm in water. There is no recommended limit for potassium but levels over 2,000 ppm may be harmful to human nervous systems. Alberta water supplies rarely contain more than 20 ppm.

Calcium
Calcium is one cause of "hardness" in water. Calcium is not a hazard to health but is undesirable because it may be detrimental for domestic uses such as washing, bathing and laundering. It also tends to cause encrustations in kettles, coffee makers and water heaters. 200 ppm is often considered an acceptable limit.

Magnesium
Magnesium is another constituent causing "hardness" in water. A suggested limit of 150 ppm is used because of taste considerations.

Iron
Iron levels as low as 0.2 to 0.3 ppm will usually cause the staining of laundry and plumbing fixtures. The presence of iron bacteria in water supplies will often cause these symptoms at even lower levels. Iron gives water a metallic taste that may be objectionable to some persons at one to two ppm. Most water contains less that five ppm iron but occasionally levels over 30 ppm are found. Iron and iron bacteria are not considered a health concern.

Sulphate (SO4)
Sulphate concentrations over 500 ppm can be laxative to some humans and livestock. Sulphate levels over 500 ppm may be a concern for livestock on marginal intakes of certain trace minerals. Very high levels of sulphates have been associated with some brain disorders in cattle and pigs.

Chloride
Due to taste considerations the suggested maximum level for chloride is 250 ppm. Most water in Alberta contains less than 20 ppm chloride, although chloride in the 2,000 ppm range can be found.

NO2 Nitrogen (Nitrite)
Due to its toxicity, the maximum acceptable concentration of nitrite in drinking water is one ppm. Nitrite is usually an indicator of very direct contamination by sewage or manure because nitrites are unstable and quickly become nitrates.

The concentration in livestock water should not exceed 10 ppm.

NO3 Nitrogen (Nitrate)
Nitrates are also an indicator of contamination by human or livestock wastes, excessive fertilization or seepage from dump sites. The maximum acceptable concentration in drinking water is 10 ppm. The figure is based on the potential for the nitrate poisoning of infants. Adults can tolerate higher levels but high nitrate levels may cause irritation of the stomach and bladder. The suggested maximum for livestock use is 1,000 ppm.

Fluoride
Fluorides occur naturally in most well waters and are desirable since they help prevent dental cavities. Between one and 1.5 ppm is desirable. As fluoride levels increase above this amount there is an increase in the tendency to cause tooth mottling.

Fluoride levels less than four ppm are not considered a problem for livestock.

TDS Inorganic (Total Dissolved Solids)
This is a measure of the inorganic minerals dissolved in the water. As a general rule less than 1,000 (500*) ppm TDS is considered satisfactory. Levels higher than this are not necessarily a problem; it depends on the specific minerals present.

The suitability for livestock deteriorates as TDS exceeds the 2,000 to 3,000 ppm range.

Conductivity

Conductivity is measured in micro Siemens per centimetre. It can be used to estimate the total dissolved solids in the water. Multiplying the conductivity by 0.65 will give a good approximation of the total dissolved solids. Conductivity tests are often used to assess water suitability for irrigation.

pH

pH is a measure of how acidic or basic the water is. The pH scale goes from zero (acidic) to 14 (basic) with seven being neutral. The generally accepted range for pH is 6.5 to 8.5 with an upper limit of 9.5.

Hardness

The harder the water is the greater its ability to neutralize soap suds. Hardness is caused primarily by calcium and magnesium, but is expressed as ppm equivalent of calcium carbonate. Hard water causes soap curd which makes bathroom fixtures difficult to keep clean and causes greying of laundry.

Hard water will also tend to form scale in hot water tanks, kettles, piping systems, etc.

Type of Water	**Amount of Hardness**	
	ppm	**grains per gallon**
Soft	0- 50	0-3
Moderately Soft	50 - 100	3-6
Moderately Hard	100 - 200	6-12
Hard	200 - 400	12- 23
Very Hard	400 - 600	23 - 35
Extremely Hard	Over 600	Over 35

Alkalinity

Alkalinity is not a specific substance but rather a combined effect of several substances. It is a measure of the resistance of a water to a change in pH. The alkalinity of most Alberta waters is in the range of 100 - 500 ppm, which is considered acceptable. Water with higher levels is often used. Alkalinity is a factor in corrosion or scale deposition and may affect some livestock when over 1,000 ppm.

Water Treatment

Water treatment equipment can often improve water quality significantly. Each type of water treatment equipment has its limitations and thus should be selected carefully. For more information on water treatment please refer to the Agdex 71 6 D series of fact sheets.

Helpful Conversions

1 ppm (part per million) = 1 mg/L (milligram per litre)
1 gpg (grain per gallon) = 17.1 ppm (parts per million)

References

Guidelines for Canadian Drinking Water Quality (1987) Health and Welfare Canada

*Federal-Provincial Subcommittee on Drinking Water of the Federal-Provincial-Territorial Committee on Environment and Occupational Health. March 2001. Summary of Guidelines for Canadian Drinking Water Quality.

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);
http://www.agric.gov.ab.ca/water/wells/index.html
Quality Farm Dugouts - http://www.agric.gov.ab.ca/esb/dugout.html

ALBERTA ENVIRONMENT

WATER - http://www3.gov.ab.ca/env/water/

GROUNDWATER INFORMATION SYSTEM - http://www.telusgeomatics.com/tgpub/ag_water/

WATER WELL INSPECTORS
Jennifer MacPherson (Edmonton: 780-427-9517)

WATER WELL LICENSING
Glenn Winner (Edmonton: 780-427-6429)

GEOPHYSICAL INSPECTION SERVICE
Edmonton: 780-427-3932 or 310-000 - e-mail LFS.Seismic@gov.ab.ca

COMPLAINT INVESTIGATIONS
Jerry Riddell (Edmonton: 780-422-4851)

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)

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Jim Kiss (Edmonton: 780-427-2433)

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Jim Craig (Wetaskiwin: 780-349-3916) - bcraigj@agr.gc.ca
Tony Cowen (Edmonton: 780-495-4911) - cowent@agr.gc.ca
Terry Dash (Calgary: 403-292-5719) - dasht@agr.gc.ca

WILDROSE COUNTRY GROUND WATER MONITORING ASSOCIATION
Dave Andrews (Irricana:403-935-4478)

COUNTY OF GRANDE PRAIRIE
Jill Henry - *Rural Extension Officer - Alberta Environmentally Sustainable Agriculture Program*
(780) 513-3955 ext. 103

LOCAL HEALTH DEPARTMENTS

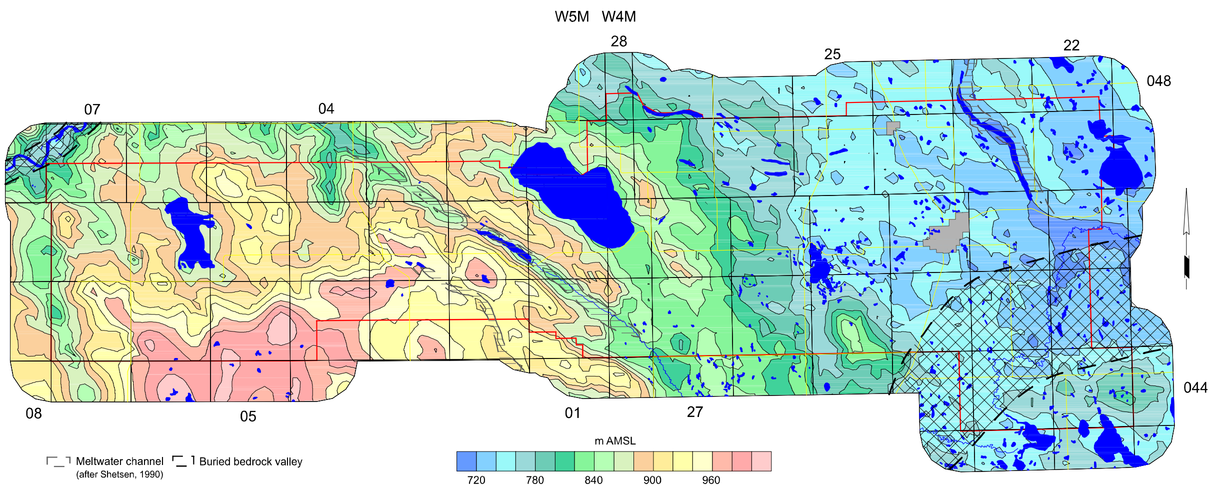
COUNTY OF WETASKIWIN

Appendix D

Maps and Figures Included as Large Plots

Bedrock Topography

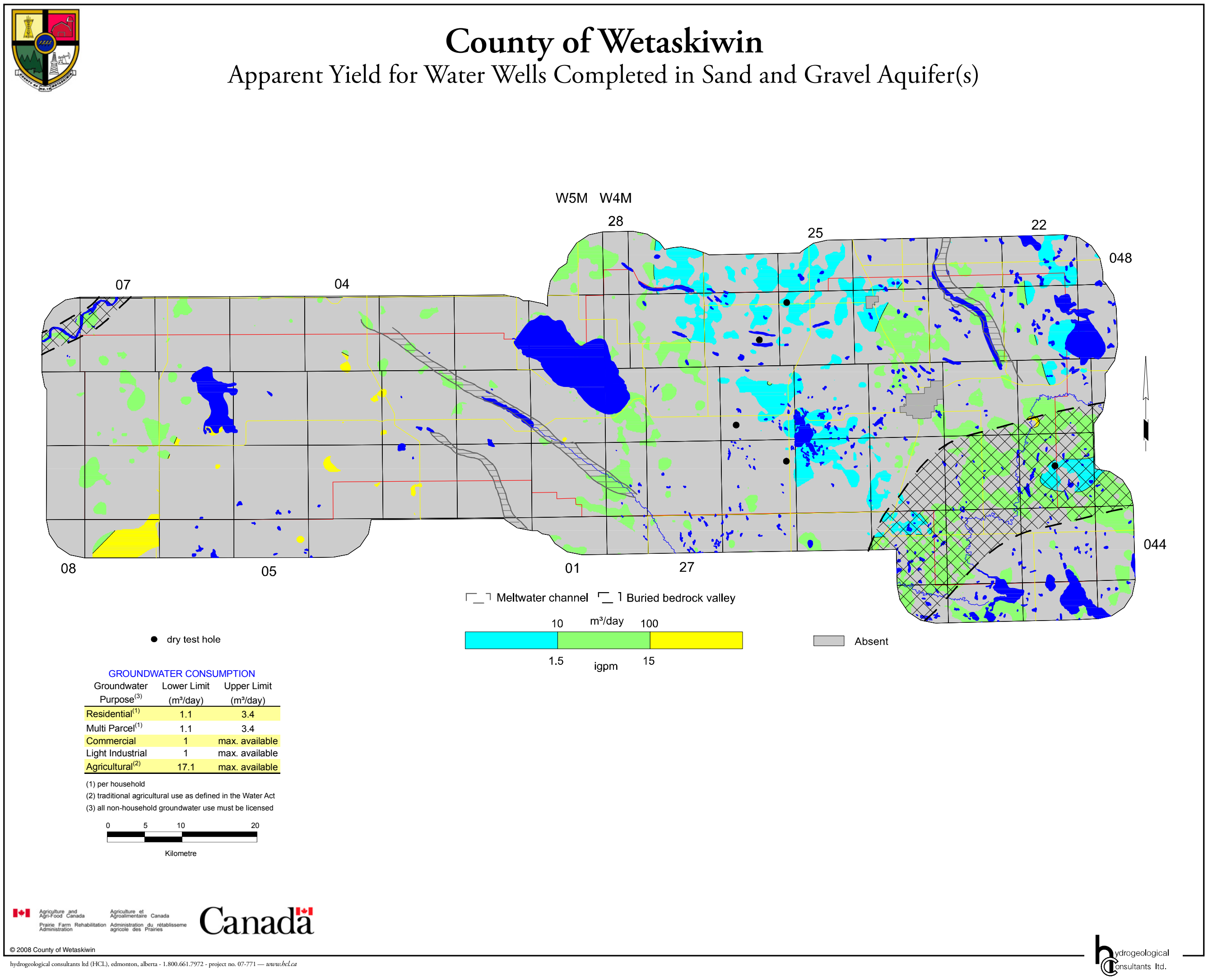
County of Wetaskiwin
Bedrock Surface Topography



Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada
Prairie Farm Rehabilitation Administration / Administration du rétablissement agricole des Prairies
Canada

hydrogeological consultants ltd (HCL), edmonton, alberta - 1.800.661.7972 - project no. 07-771 — www.hcl.ca

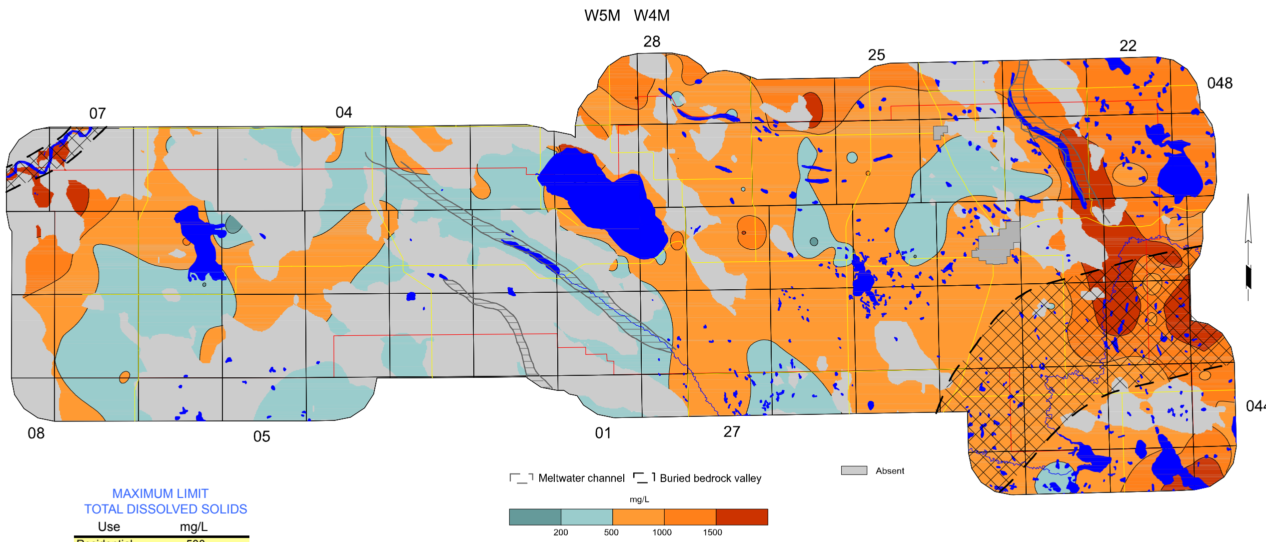
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)



Total Dissolved Solids in Groundwater from Surficial Deposits

County of Wetaskiwin

Total Dissolved Solids in Groundwater from Surficial Deposits



MAXIMUM LIMIT
TOTAL DISSOLVED SOLIDS

Use	mg/L
Residential	500
Livestock	3,000
Irrigation	500 - 3,500
Commercial	Depends on Purpose
Industrial	Depends on Purpose

from: Canadian Water Quality Guidelines, 1992

0 5 10 20
Kilometre

Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada
Prairie Farm Rehabilitation Administration / Administration du rétablissement agricole des Prairies
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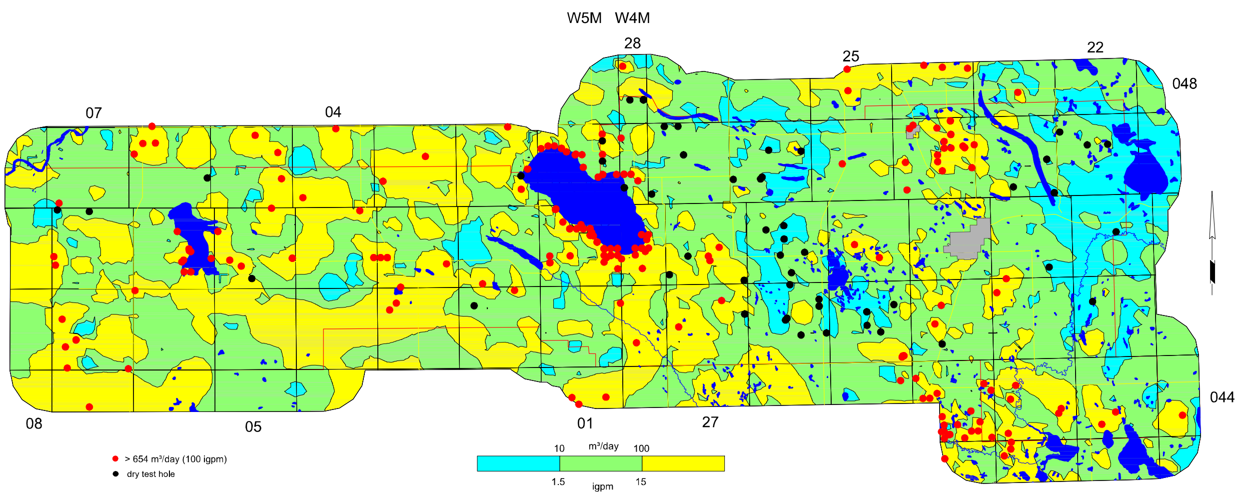
hydrogeological consultants ltd.

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

County of Wetaskiwin

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



GROUNDWATER CONSUMPTION

Groundwater Purpose[3]	Lower Limit (m^3/day)	Upper Limit (m^3/day)
Residential[1]	1.1	3.4
Multi Parcel[1]	1.1	3.4
Commercial	1	max. available
Light Industrial	1	max. available
Agricultural[2]	17.1	max. available

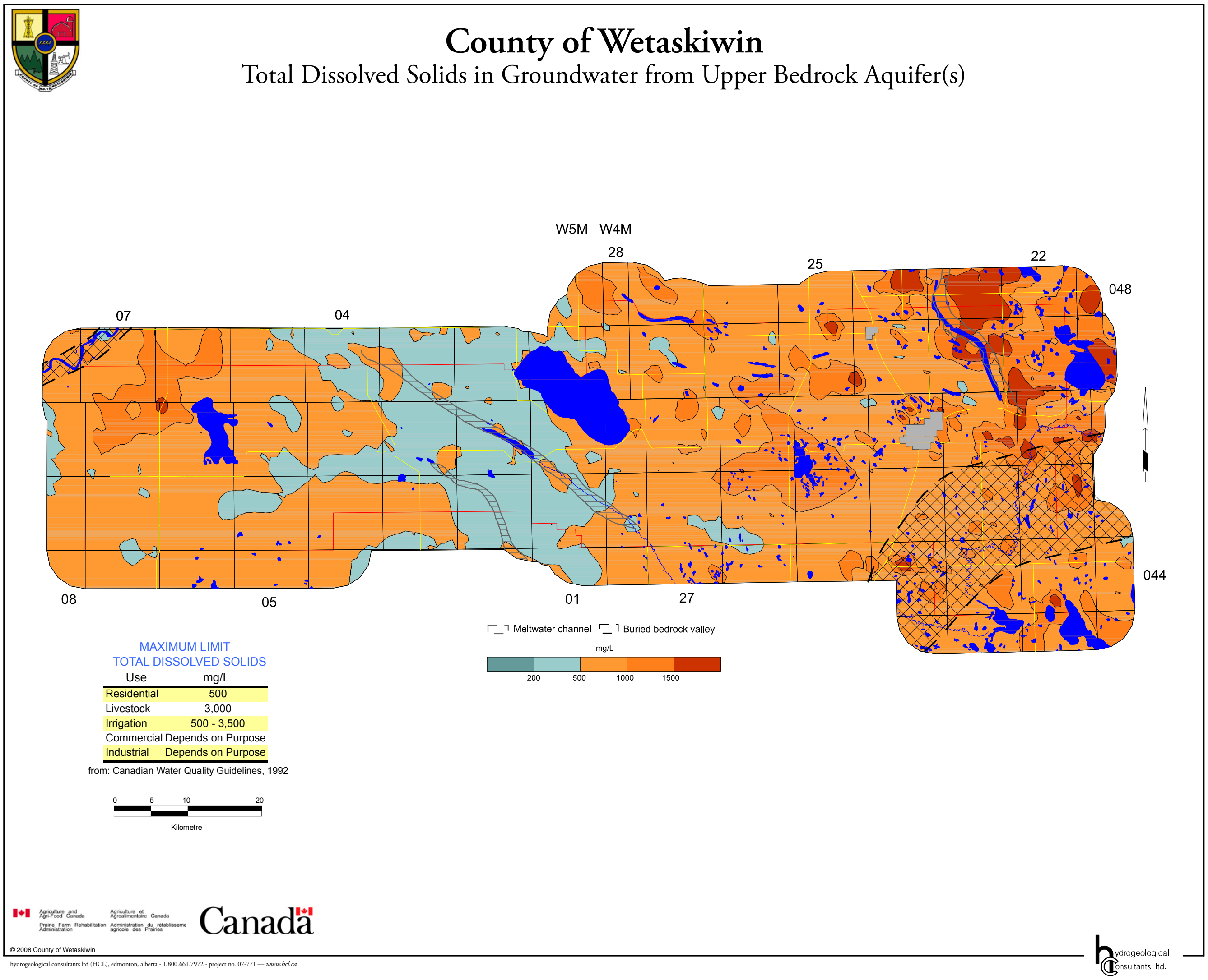
(1) per household
(2) traditional agricultural use as defined in the Water Act
(3) all non-household groundwater use must be licensed

0 5 10 20
Kilometre

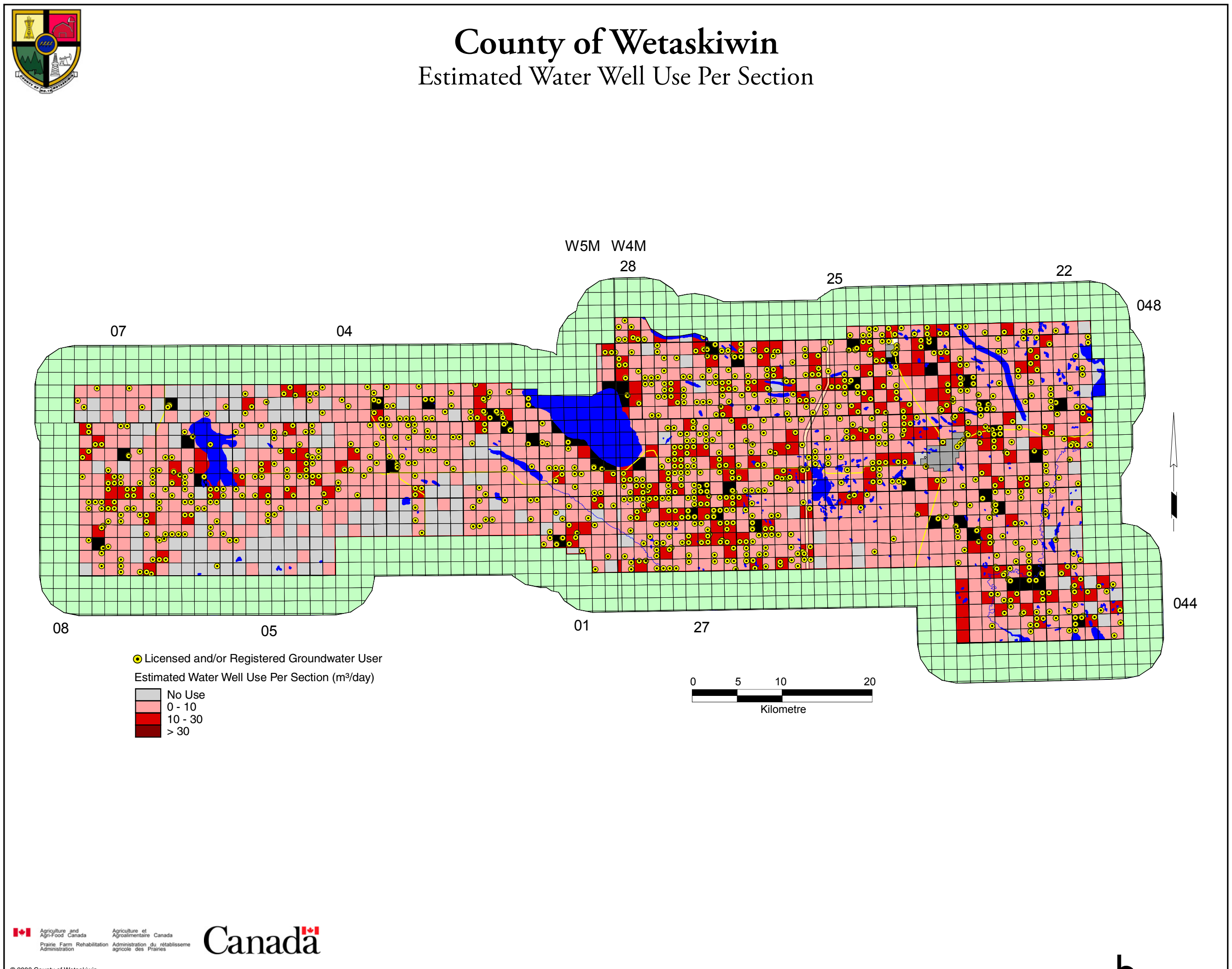
Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada
Prairie Farm Rehabilitation Administration / Administration du rétablisseme agricole des Prairies
Canada

hydrogeological consultants ltd (HCL), edmonton, alberta - 1.800.661.7972 - project no. 07-771 — *www.hcl.ca*

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



Estimated Water Well Use Per Section



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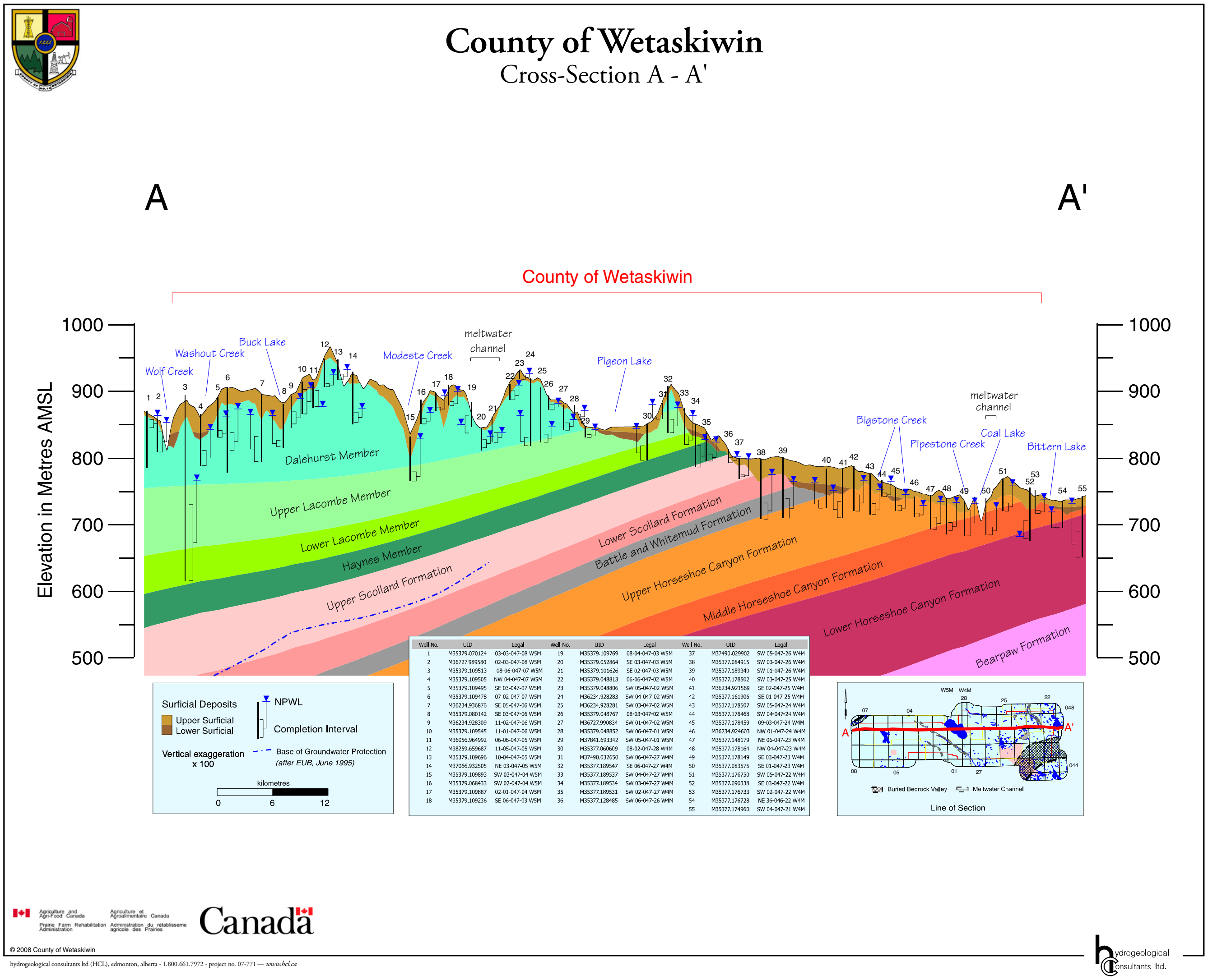
Cross-Section A - A'



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3	M35379.109513	08-06-047-07 W5M	21	M35379.101626	SE 02-047-03 W5M	39	M35377.189340	SW 01-047-26 W4M
4	M35379.109505	NW 04-047-07 W5M	22	M35379.048813	06-06-047-02 W5M	40	M35377.178502	SW 03-047-25 W4M
5	M35379.109495	SE 03-047-07 W5M	23	M35379.048806	SW 05-047-02 W5M	41	M36234.921569	SE 02-047-25 W4M
6	M35379.109478	07-02-047-07 W5M	24	M36234.928283	SW 04-047-02 W5M	42	M35377.161906	SE 01-047-25 W4M
7	M36234.936876	SE 05-047-06 W5M	25	M36234.928281	SW 03-047-02 W5M	43	M35377.178507	SW 05-047-24 W4M
8	M35379.080142	SE 03-047-06 W5M	26	M35379.048767	08-03-047-02 W5M	44	M35377.178468	SW 04-047-24 W4M
9	M36234.928309	11-02-047-06 W5M	27	M36727.990834	SW 01-047-02 W5M	45	M35377.178459	09-03-047-24 W4M
10	M35379.109545	11-01-047-06 W5M	28	M35379.048852	SW 06-047-01 W5M	46	M36234.924603	NW 01-047-24 W4M
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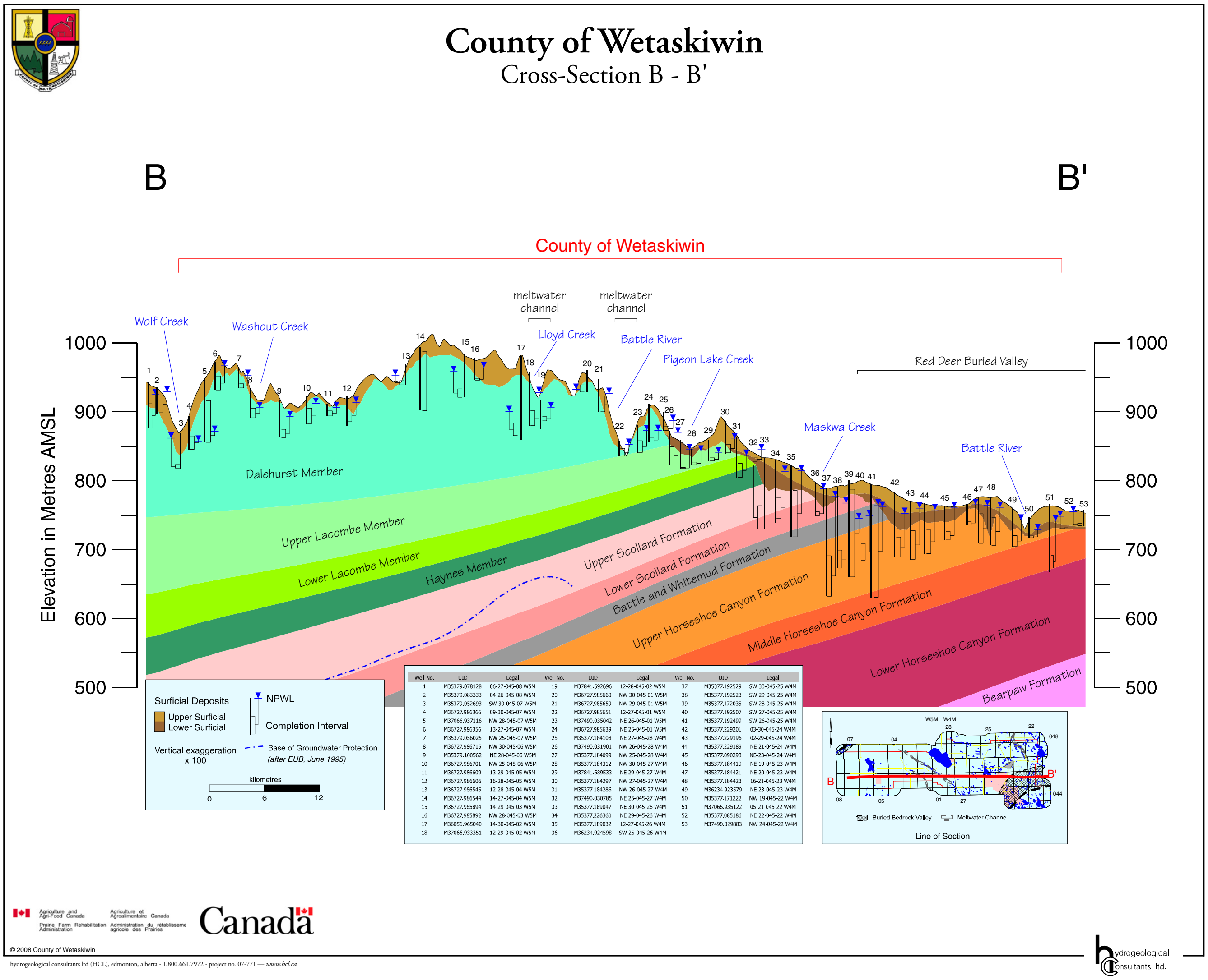
Cross-Section B - B’



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9	M35379.100562	NE 28-045-06 W5M	27	M35377.184099	NW 25-045-28 W4M	45	M35377.090293	NE-23-045-24 W4M
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16	M36727.985892	NW 28-045-03 W5M	34	M35377.226360	NE 29-045-26 W4M	52	M35377.085186	NE 22-045-22 W4M
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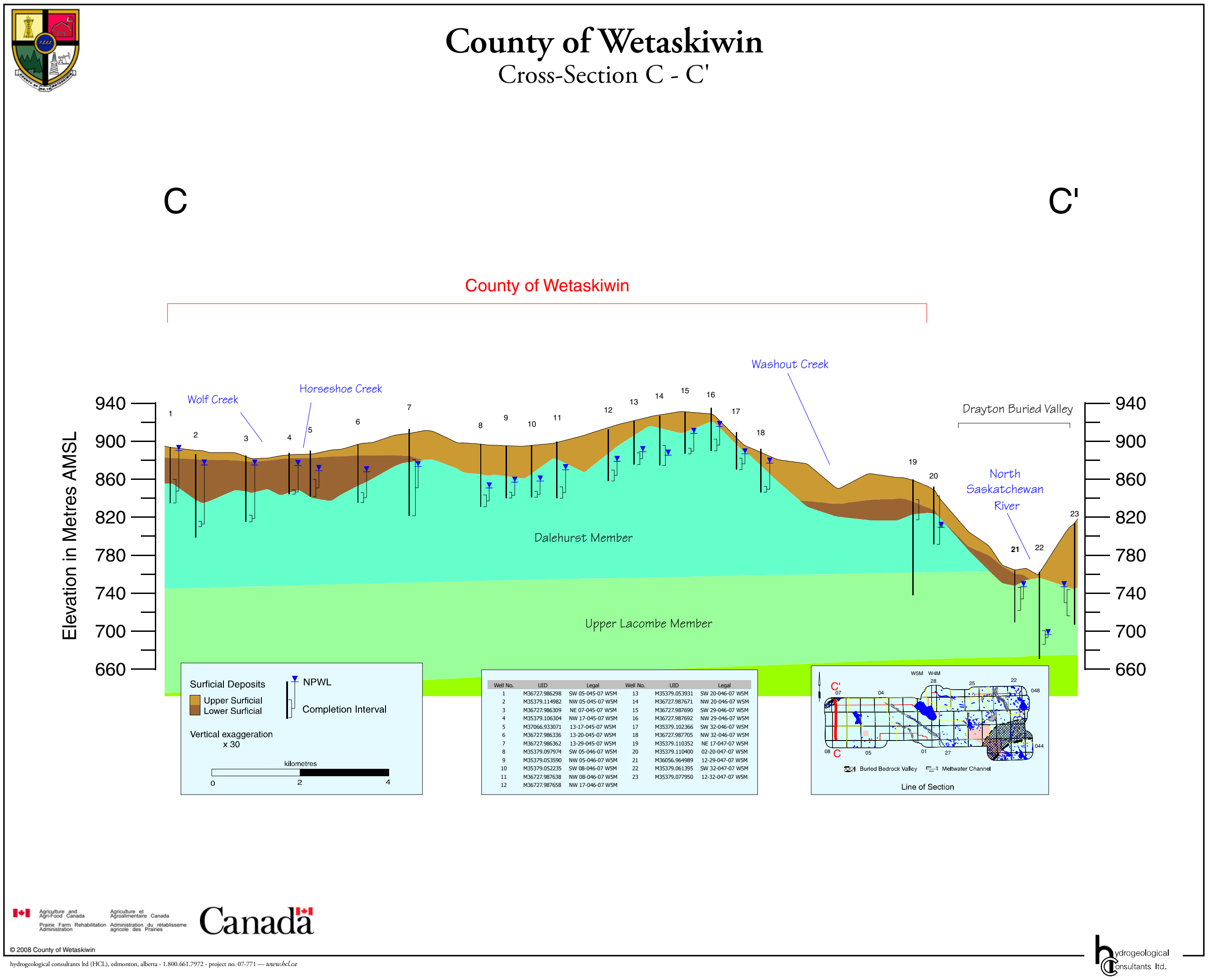
Cross-Section C - C'



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5	M37066.933071	13-17-045-07 W5M	17	M35379.102366	SW 32-046-07 W5M
6	M36727.986336	13-20-045-07 W5M	18	M36727.987705	NW 32-046-07 W5M
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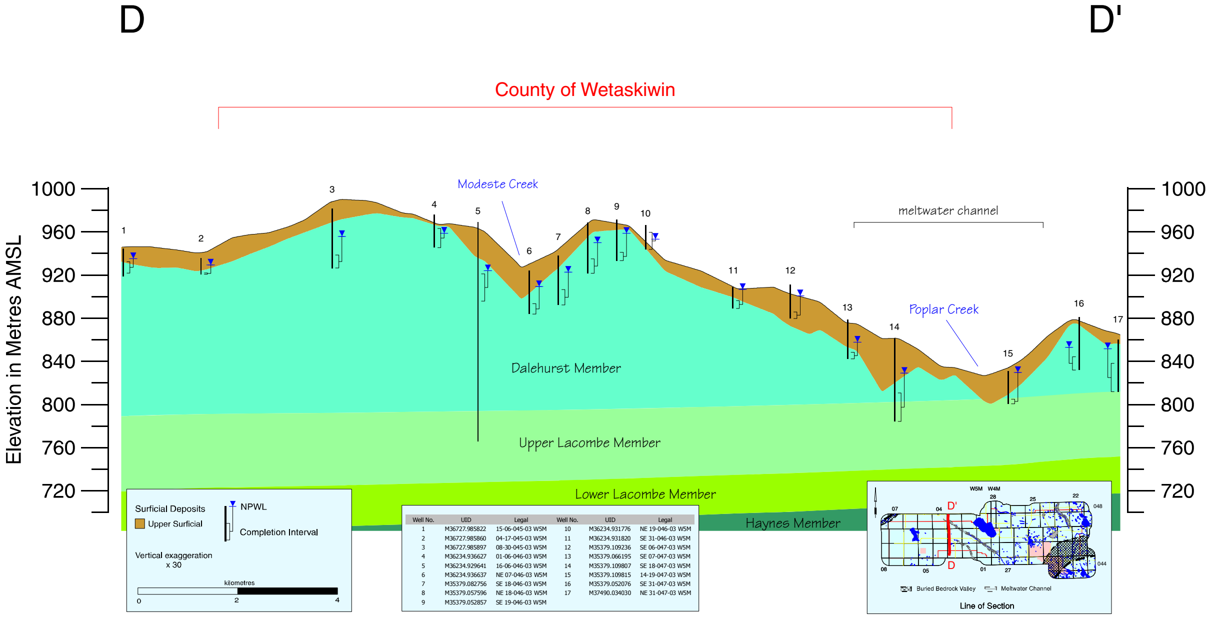
11	M36727.987638	NW 08-046-07 W5M	23	M35379.077950	12-32-047-07 W5M
12	M36727.987658	NW 17-046-07 W5M			

Cross-Section D - D'

County of Wetaskiwin
Cross-Section D - D'



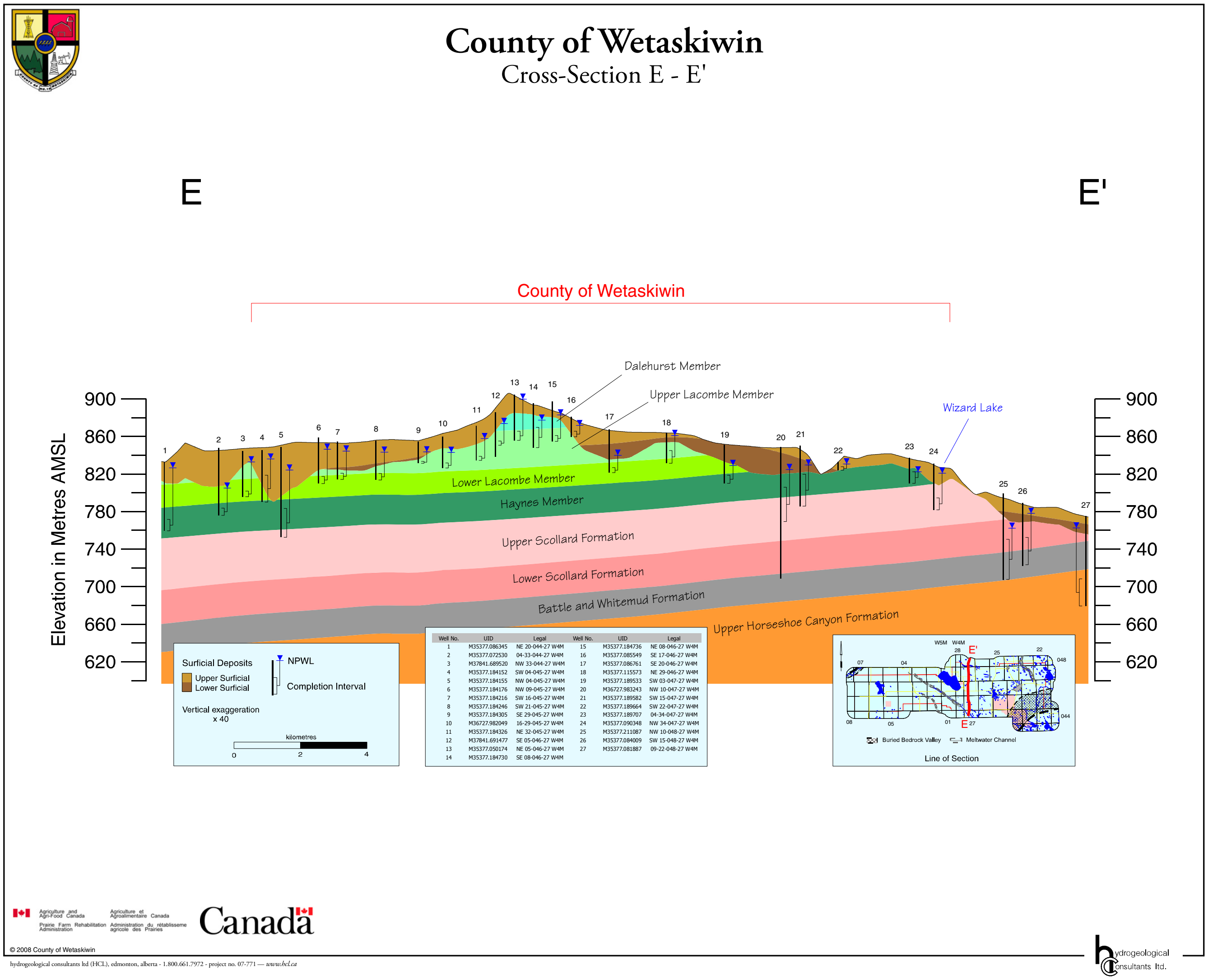
Well No.	UID	Legal	Well No.	UID	Legal
1	M36727.985822	15-06-045-03 W5M	10	M36234.931776	NE 19-046-03 W5M
2	M36727.985860	04-17-045-03 W5M	11	M36234.931820	SE 31-046-03 W5M
3	M36727.985897	08-30-045-03 W5M	12	M35379.109236	SE 06-047-03 W5M
4	M36234.936627	01-06-046-03 W5M	13	M35379.066195	SE 07-047-03 W5M
5	M36234.929641	16-06-046-03 W5M	14	M35379.109807	SE 18-047-03 W5M
6	M36234.936637	NE 07-046-03 W5M	15	M35379.109815	14-19-047-03 W5M
7	M35379.082756	SE 18-046-03 W5M	16	M35379.052076	SE 31-047-03 W5M
8	M35379.057596	NE 18-046-03 W5M	17	M37490.034030	NE 31-047-03 W5M
9	M35379.052857	SE 19-046-03 W5M			

Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada
Prairie Farm Rehabilitation Administration / Administration du rétablissement agricole des Prairies
Canada

hydrogeological consultants ltd (HCL), edmonton, alberta - 1.800.661.7972 - project no. 07-771 — www.hcl.ca

hydrogeological consultants ltd.

Cross-Section E - E'



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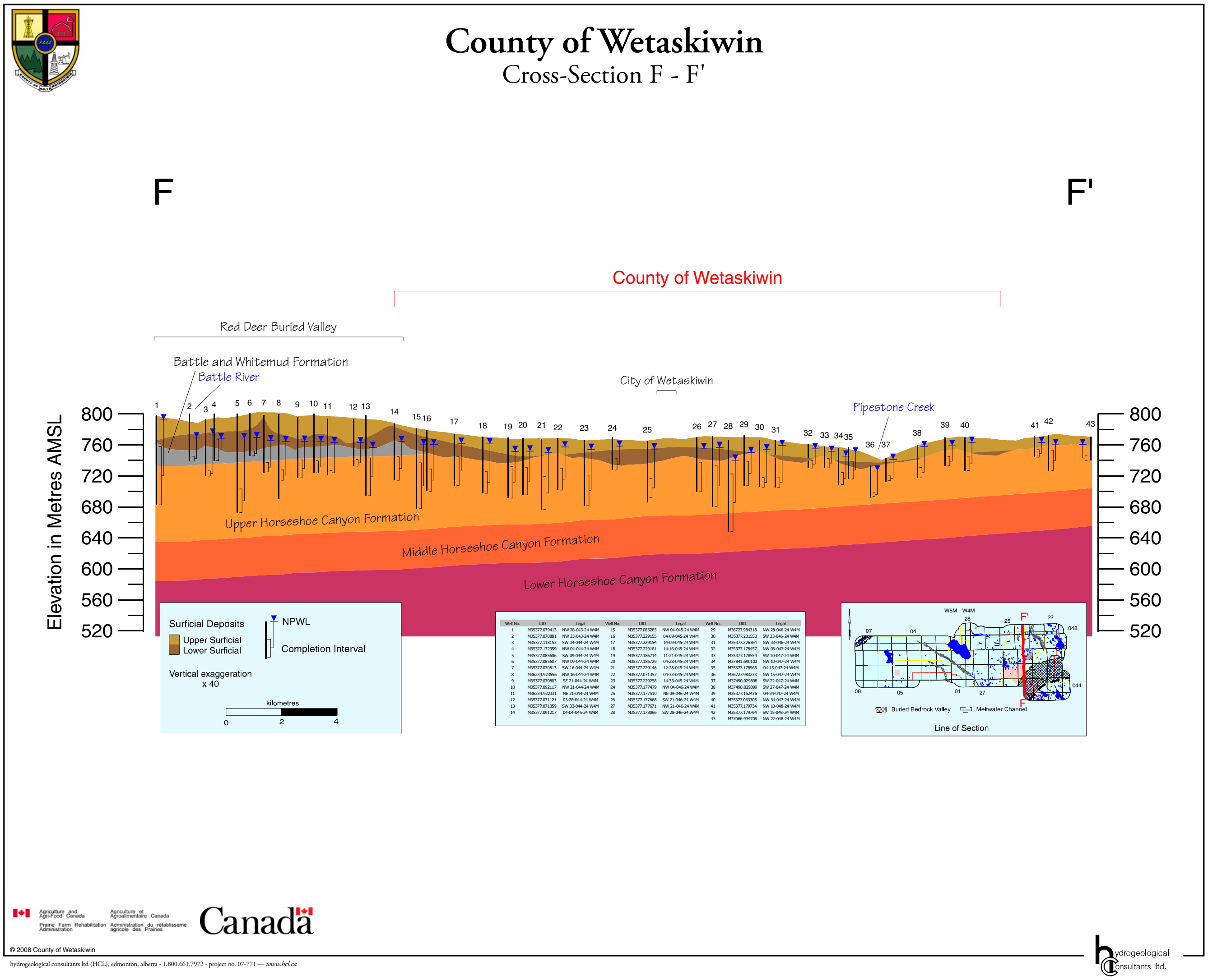
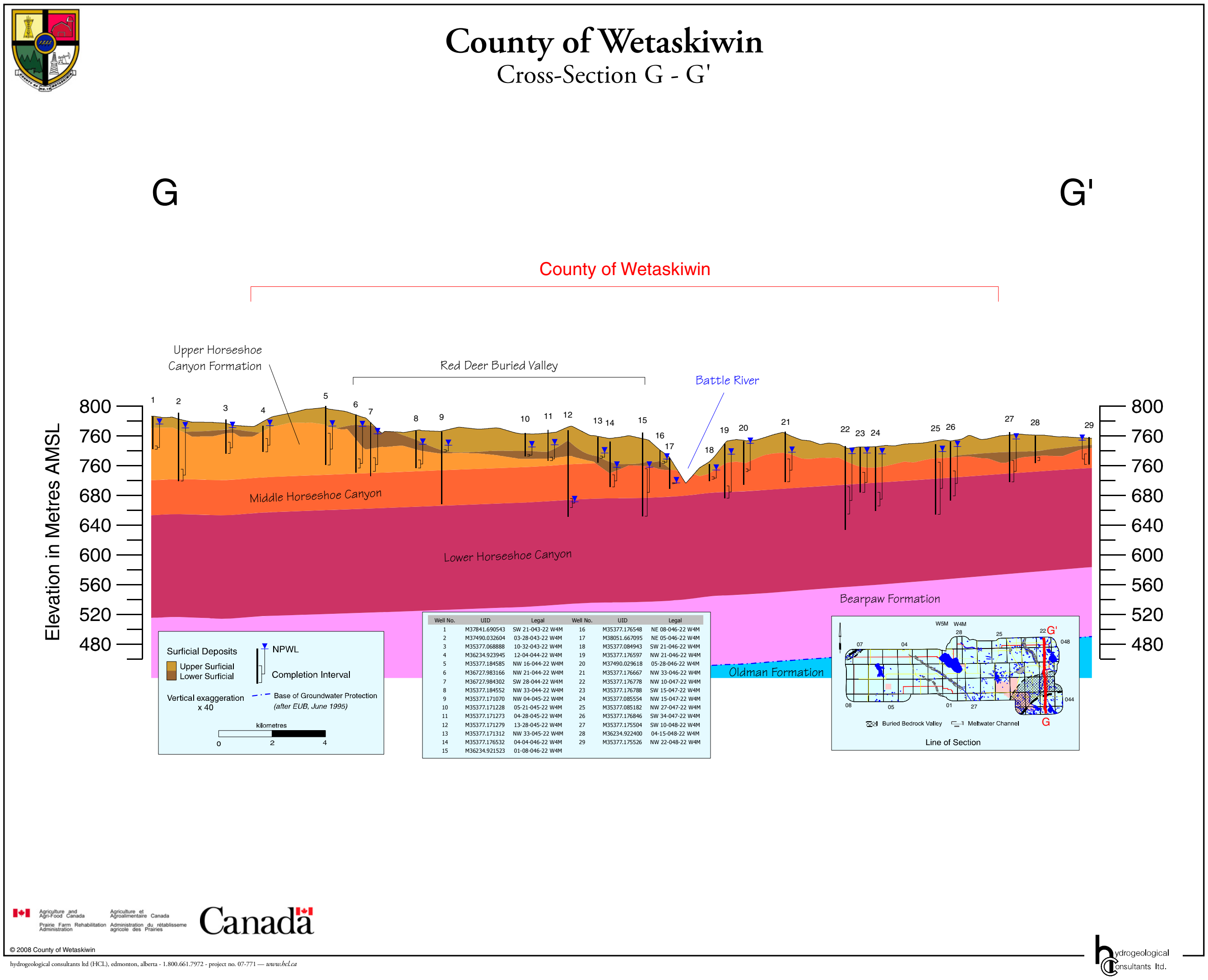
1	M35377.086345	NE 20-044-27 W4M	15	M35377.184736	NE 08-046-27 W4M
2	M35377.072530	04-33-044-27 W4M	16	M35377.085549	SE 17-046-27 W4M
3	M37841.689520	NW 33-044-27 W4M	17	M35377.086761	SE 20-046-27 W4M
4	M35377.184152	SW 04-045-27 W4M	18	M35377.115573	NE 29-046-27 W4M
5	M35377.184155	NW 04-045-27 W4M	19	M35377.189533	SW 03-047-27 W4M
6	M35377.184176	NW 09-045-27 W4M	20	M36727.983243	NW 10-047-27 W4M
7	M35377.184216	SW 16-045-27 W4M	21	M35377.189582	SW 15-047-27 W4M
8	M35377.184246	SW 21-045-27 W4M	22	M35377.189664	SW 22-047-27 W4M
9	M35377.184305	SE 29-045-27 W4M	23	M35377.189707	04-34-047-27 W4M
10	M36727.982049	16-29-045-27 W4M	24	M35377.090348	NW 34-047-27 W4M
11	M35377.184326	NE 32-045-27 W4M	25	M35377.211087	NW 10-048-27 W4M
12	M37841.691477	SE 05-046-27 W4M	26	M35377.084009	SW 15-048-27 W4M
13	M35377.050174	NE 05-046-27 W4M	27	M35377.081887	09-22-048-27 W4M
14	M35377.184730	SE 08-046-27 W4M			

Cross-Section F - F'



Cross-Section G - G'



COUNTY OF WETASKIWIN

Appendix E

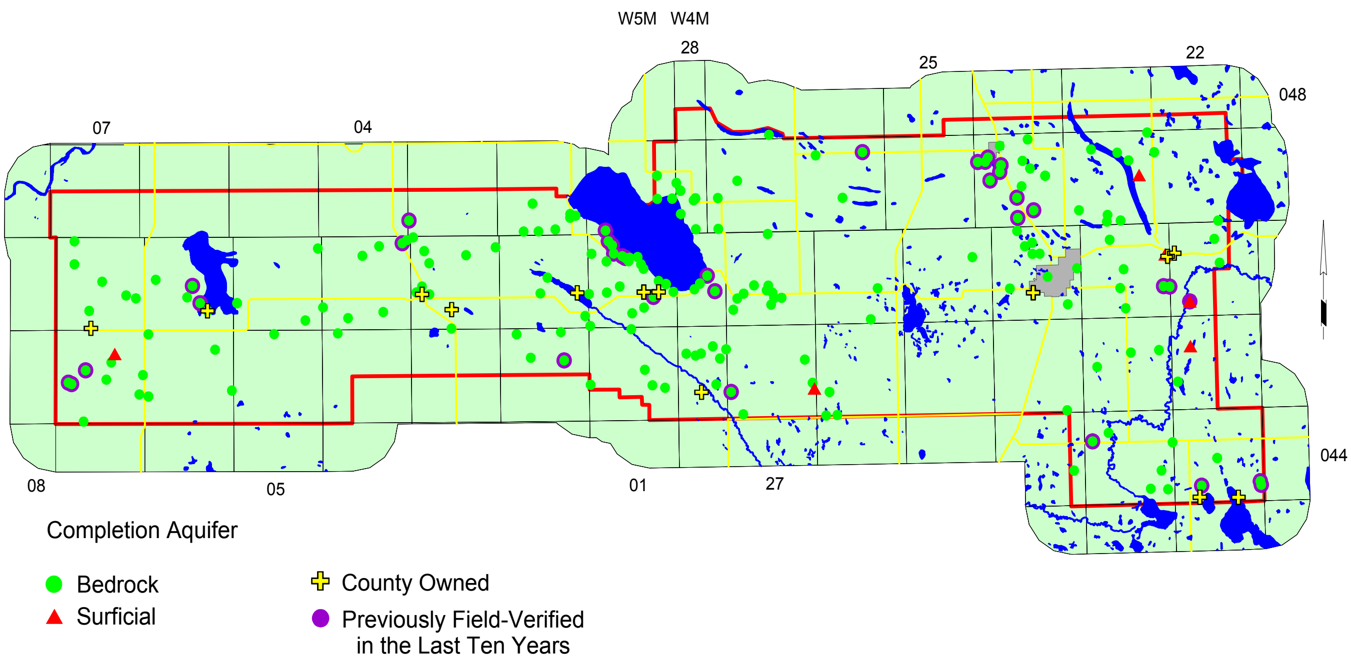
Water Wells That Are Recommended for Field-Verification

including

County-Operated Water Wells

Water Wells That Are Recommended For Field-Verification

(details on following pages)



WATER WELLS RECOMMENDED FOR FIELD-VERIFICATION THAT MEET CRITERIA

Owner	Location	Aquifer Name	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet	UID
Abstreiter, Myra	SW 10-046-27 W4M	Lower Lacombe Member	17-Aug-83	44.19	145.0	27.43	90.0	M35377.184741
Airth, Alex	NE 16-044-22 W4M	Upper Horseshoe Canyon	10-Aug-83	27.43	90.0	7.62	25.0	M35377.184589
Airth, Sandy	NE 16-044-22 W4M	Upper Horseshoe Canyon	26-Jul-79	60.96	200.0	13.72	45.0	M35377.184588
Alberta Fish & Wildlife	SW 11-046-06 W5M	Dalehurst Member	25-Feb-76	41.15	135.0	0	0.0	M36727.987454
Alberta Transportation	SW 17-046-03 W5M	Dalehurst Member	16-Nov-79	38.71	127.0	12.8	42.0	M36234.936678
Aldridge, C. C.	06-22-046-22 W4M	Lower Horseshoe Canyon	27-Oct-78	42.67	140.0	26.82	88.0	M35377.176600
Allan, David	SW 27-046-24 W4M	Upper Horseshoe Canyon	17-Dec-83	42.67	140.0	14.93	49.0	M35377.177899
Anderson, G.	SE 13-047-01 W5M	Upper Lacombe Member	22-Feb-86	28.95	95.0	19.2	63.0	M35379.092063
Anderson, Harvey	NW 35-045-02 W5M	Dalehurst Member	10-Dec-73	29.26	96.0	25.91	85.0	M36727.985780
Anderson, Norm	04-13-045-01 W5M	Dalehurst Member	01-Jan-68	74.67	245.0	45.72	150.0	M36727.985558
Archer, Darrel	15-12-046-23 W4M	Middle Horseshoe Canyon	28-Apr-88	57.91	190.0	16.76	55.0	M35377.189133
Axline, E.	SE 36-046-05 W5M	Dalehurst Member	12-Nov-79	38.1	125.0	23.77	78.0	M36727.987387
Baehl, J.	SE 25-045-28 W4M	Upper Lacombe Member	14-May-82	22.86	75.0	6.1	20.0	M35377.184094
Bailey, D	SW 29-046-01 W5M	Dalehurst Member	29-Mar-77	24.38	80.0	17.68	58.0	M36234.927430
Bailey, Eric	01-05-045-07 W5M	Dalehurst Member	05-May-84	92.96	305.0	30.48	100.0	M36727.986296
Ball, John	01-32-046-23 W4M	Upper Horseshoe Canyon	23-Apr-80	30.48	100.0	2.44	8.0	M35377.189268
Balstad, Nel	15-01-044-23 W4M	Upper Horseshoe Canyon	01-Mar-84	44.19	145.0	4.24	13.9	M35377.072494
Banack, Louie	01-16-046-06 W5M	Dalehurst Member	03-Jan-78	33.53	110.0	20.73	68.0	M36727.987504
Bauman, Rick	SE 04-047-02 W5M	Dalehurst Member	29-Jun-81	16.76	55.0	5.49	18.0	M35379.048777
Berghes, Rene	SW 15-046-27 W4M	Lower Lacombe Member	14-Jun-74	45.41	149.0	25.3	83.0	M35377.184781
Black, Bob	SW 21-045-07 W5M	Dalehurst Member	08-Apr-86	56.99	187.0	39.62	130.0	M35379.068822
Borzel, Max	06-18-046-03 W5M	Dalehurst Member	31-Jul-84	22.55	74.0	1.52	5.0	M36234.931758
Bossert, Edmund F.	09-18-045-07 W5M	Dalehurst Member	29-May-87	56.08	184.0	10.36	34.0	M36727.986330
Bray, George	SW 05-047-01 W5M	Upper Lacombe Member	01-Sep-71	12.5	41.0	3.66	12.0	M35379.047893
Breum	SW 14-045-01 W5M	Dalehurst Member	01-Apr-74	21.94	72.0	14.02	46.0	M36727.985562
Brittain, K.	NE 07-046-27 W4M	Upper Lacombe Member	10-Mar-83	25.91	85.0	10.67	35.0	M35377.184726
Burnett, D.	SE 32-046-01 W5M	Upper Lacombe Member	08-Aug-83	36.57	120.0	6.46	21.2	M36234.927463
Burnett, Ken	NE 26-045-06 W5M	Dalehurst Member	21-Oct-76	27.43	90.0	10.67	35.0	M36727.986705
Burrows, Bob	NW 14-046-28 W4M	Upper Lacombe Member	16-May-80	32	105.0	5.49	18.0	M35377.183975
Bushnell, Garry	16-12-046-23 W4M	Upper Horseshoe Canyon	23-Jun-76	30.48	100.0	13.72	45.0	M35377.190995
Buskas, Reg	14-02-044-23 W4M	Upper Horseshoe Canyon	17-Mar-83	53.34	175.0	5.18	17.0	M35377.072497
Chambers, Larry	NW 22-045-23 W4M	Upper Horseshoe Canyon	12-Jun-79	36.57	120.0	13.72	45.0	M35377.184426
Chapchuck, Ben	14-15-045-07 W5M	Dalehurst Member	18-Jul-79	24.38	80.0	10.97	36.0	M36727.986325
Chapchuk, B.	NW 31-045-06 W5M	Dalehurst Member	31-Oct-78	39.62	130.0	15.24	50.0	M36727.986720
Chapman, Randy	NE 28-046-24 W4M	Upper Horseshoe Canyon	13-Jul-79	36.57	120.0	12.19	40.0	M35377.178171
Clothier, R.	SE 23-047-24 W4M	Upper Horseshoe Canyon	01-Sep-80	36.57	120.0	13.72	45.0	M35377.179277
Cook, Ben	NE 33-045-05 W5M	Dalehurst Member	18-Aug-82	9.45	31.0	0.91	3.0	M36727.986630
Cook, Ralph	04-15-047-26 W4M	Lower Scollard	08-Jul-82	36.57	120.0	7.31	24.0	M35377.189409
Cornish, Don & Laurie	09-30-047-24 W4M	Upper Horseshoe Canyon	27-Feb-81	29.56	97.0	11.58	38.0	M35377.179873
Cranston, C.	SE 32-047-24 W4M	Upper Horseshoe Canyon	21-Aug-69	18.29	60.0	3.35	11.0	M35377.179948
Cymbaliuk, D E	NW 13-046-01 W5M	Upper Lacombe Member	24-Jun-83	38.1	125.0	9.75	32.0	M36234.927107
Czarnecki, Chester	SW 11-046-06 W5M	Dalehurst Member	24-May-84	39.62	130.0	0	0.0	M36727.987463
Davits, Charles A.	SE 23-047-24 W4M	Upper Horseshoe Canyon	22-May-81	48.77	160.0	10.67	35.0	M35377.179237
Devries, M.	09-04-047-23 W4M	Upper Horseshoe Canyon	30-Oct-81	18.29	60.0	10.67	35.0	M35377.177715
Didriksen, Ross	SE 25-046-23 W4M	Upper Surficial	04-Oct-74	10.36	34.0	7.01	23.0	M35377.189204
Dille, Leo	NE 28-046-04 W5M	Dalehurst Member	28-Jan-81	36.57	120.0	24.38	80.0	M36727.987149
Dornan, Fred	NW 28-046-24 W4M	Upper Horseshoe Canyon	16-Oct-81	48.77	160.0	14.63	48.0	M35377.178101
Doyle, Brian	01-30-047-24 W4M	Upper Horseshoe Canyon	09-Jul-96	45.72	150.0	10.637	34.9	M36234.921567
Duggan, Neil	14-05-046-22 W4M	Upper Surficial	23-Sep-94	39.62	130.0	30.48	100.0	M35377.209062
Duhamel, W.S.	NW 07-046-05 W5M	Dalehurst Member	05-Jun-84	19.81	65.0	3.05	10.0	M36727.987222
Dyberg, Mortin	16-24-044-23 W4M	Upper Horseshoe Canyon	02-May-80	64	210.0	16.46	54.0	M35377.072940
Dyers, Ronald	SE 22-047-28 W4M	Upper Lacombe Member	26-Apr-76	27.43	90.0	3.96	13.0	M35377.185205
Eisenbarth, Bruce	SW 29-046-03 W5M	Dalehurst Member	01-Sep-83	21.33	70.0	8.84	29.0	M36234.931815
Elgert, Richard & Karen	NW 21-047-24 W4M	Upper Horseshoe Canyon	13-Aug-02	54.86	180.0	15.696	51.5	M37841.690557
Elliot, R.H.J.	SW 11-047-28 W4M	Upper Lacombe Member	30-Jul-65	21.94	72.0	-2.13	-7.0	M35377.184899

WATER WELLS RECOMMENDED FOR FIELD-VERIFICATION THAT MEET CRITERIA

Owner	Location	Aquifer Name	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet	UID
Estland Dev Ltd c/o Polednik F	SE 03-046-26 W4M	Upper Scollard	02-Dec-85	38.1	125.0	4.57	15.0	M35377.178811
Ewing, J	NW 13-046-01 W5M	Upper Lacombe Member	28-May-76	33.53	110.0	6.71	22.0	M36234.927083
Falby, M E	NW 13-046-01 W5M	Upper Lacombe Member	26-Sep-80	35.05	115.0	11.58	38.0	M36234.927098
Falun Foods	SW 07-046-27 W4M	Upper Lacombe Member	01-Sep-78	39.62	130.0	18.29	60.0	M35377.184716
Falun School	NE 10-046-27 W4M	Lower Lacombe Member	14-Jul-67	39.62	130.0	19.51	64.0	M35377.171982
Falun School	NW 10-046-27 W4M	Lower Lacombe Member	08-Feb-64	45.72	150.0	24.69	81.0	M35377.172229
Falun School Teacherage	NW 10-046-27 W4M	Lower Lacombe Member	31-Oct-72	36.57	120.0	17.68	58.0	M35377.171980
Fechko, Arnold	SE 18-047-27 W4M	Lower Lacombe Member	29-Aug-81	36.57	120.0	31.09	102.0	M35377.089998
Ferguson, W	NE 14-046-01 W5M	Upper Lacombe Member	01-Jun-78	19.51	64.0	1.83	6.0	M36234.927154
Firingstone	SW 13-044-24 W4M	Upper Horseshoe Canyon	05-Mar-68	49.68	163.0	12.19	40.0	M35377.070384
Fisk, Larry	SE 27-045-07 W5M	Upper Surficial	17-Jun-85	18.29	60.0	6.4	21.0	M36727.986354
Fontain, L	SW 17-046-01 W5M	Dalehurst Member	19-Oct-57	24.38	80.0	13.72	45.0	M36234.927182
Fontaine, M	NW 16-046-01 W5M	Dalehurst Member	17-Jun-76	32.31	106.0	22.55	74.0	M36234.927174
Forester, Don	SE 21-046-23 W4M	Upper Horseshoe Canyon	02-Jul-84	22.86	75.0	12.19	40.0	M35377.189176
Foster, Bob	14-11-046-01 W5M	Dalehurst Member	10-Aug-00	34.44	113.0	3.83	12.6	M37490.033262
Foster, H. R.	SW 13-046-07 W5M	Dalehurst Member	22-Nov-71	36.57	120.0	0	0.0	M37066.937192
Fraser, G	SE 10-046-01 W5M	Dalehurst Member	10-Apr-78	47.24	155.0	16.76	55.0	M36234.926974
Fredrickson, Fred	SE 24-046-24 W4M	Upper Horseshoe Canyon	16-May-70	18.29	60.0	9.14	30.0	M35377.171984
Gander, T.A.	NE 23-047-01 W5M	Dalehurst Member	03-Jul-59	18.29	60.0	10.67	35.0	M35379.048511
Ganske, Herb	NE 32-046-24 W4M	Upper Horseshoe Canyon	28-Aug-82	33.53	110.0	15.24	50.0	M35377.178248
Garbouski, Clayton	08-03-047-02 W5M	Dalehurst Member	18-Apr-64	21.33	70.0	11.28	37.0	M35379.048767
Gardiner, John M.	SW 02-048-27 W4M	Lower Scollard	28-May-81	34.14	112.0	2.44	8.0	M35377.210989
Glacer, Art & Mable	10-27-047-23 W4M	Upper Horseshoe Canyon	18-Sep-82	7.01	23.0	2.44	8.0	M35377.178093
Goddkey, Dean	NW 32-045-04 W5M	Dalehurst Member	30-Jul-84	19.81	65.0	4.57	15.0	M36727.986558
Hagstrom, Jim	SW 02-047-22 W4M	Middle Horseshoe Canyon	01-Jun-75	35.36	116.0	13.72	45.0	M35377.176733
Hamblin, O.	SE 27-046-01 W5M	Upper Lacombe Member	17-Jun-81	32	105.0	12.19	40.0	M36234.927330
Hammar, Eckart	04-22-046-07 W5M	Dalehurst Member	30-Dec-83	30.48	100.0	19.81	65.0	M36727.987678
Hanna, Orton	NE 18-046-03 W5M	Dalehurst Member	12-Jul-84	27.43	90.0	16.76	55.0	M36234.931770
Harrowing, Colin	12-32-045-02 W5M	Dalehurst Member	17-Aug-81	24.99	82.0	13.72	45.0	M36727.985773
Hay, Ray	16-06-047-23 W4M	Upper Horseshoe Canyon	08-Jun-78	12.19	40.0	3.66	12.0	M35377.177769
Hegan, Tom	08-34-046-04 W5M	Dalehurst Member	22-Sep-77	47.55	156.0	39.62	130.0	M36727.987157
Heistad, David	NE 16-046-27 W4M	Lower Lacombe Member	21-Feb-79	39.62	130.0	23.77	78.0	M35377.184791
Hendrickson, Dennis	NW 01-046-24 W4M	Upper Horseshoe Canyon	20-Sep-77	32	105.0	7.92	26.0	M35377.177432
Hesp, D.	SW 18-045-01 W5M	Dalehurst Member	16-Jul-74	28.95	95.0	18.29	60.0	M36727.985589
Heukeroth, Reiner	04-07-047-03 W5M	Dalehurst Member	25-Feb-66	45.72	150.0	30.48	100.0	M35379.109780
Hledik, Norman	SE 03-047-23 W4M	Upper Horseshoe Canyon	09-Apr-81	13.72	45.0	4.57	15.0	M35377.178148
Hoflin, Duayne & Brenda	11-36-046-04 W5M	Dalehurst Member	06-Sep-95	42.67	140.0	9.14	30.0	M35379.110236
Hyam, A	SW 18-046-01 W5M	Dalehurst Member	17-Aug-79	16.46	54.0	9.45	31.0	M36234.927192
Hyer, Charles	SE 36-046-03 W5M	Dalehurst Member	09-Jun-75	30.48	100.0	23.16	76.0	M36234.931849
Jackson, Ken	NW 14-046-28 W4M	Upper Lacombe Member	01-Sep-74	36.57	120.0	7.92	26.0	M36234.941220
Jacobe, Don H.	SE 10-047-24 W4M	Upper Horseshoe Canyon	03-Apr-82	36.57	120.0	9.75	32.0	M35377.178550
Jeffcott, Clarence	NW 17-045-07 W5M	Dalehurst Member	15-Jun-82	36.57	120.0	21.03	69.0	M36727.986327
Jensen, Ulf	10-20-047-24 W4M	Upper Horseshoe Canyon	10-Jul-02	36.574	120.0	10.302	33.8	M38255.546245
Johnson, Tully	03-29-045-22 W4M	Lower Surficial	07-Sep-82	22.25	73.0	9.75	32.0	M35377.171288
Kasur, Randy	09-07-045-26 W4M	Haynes Member	19-Apr-78	24.38	80.0	0.49	1.6	M35377.188779
Kersey, G.	NW 27-046-22 W4M	Middle Horseshoe Canyon	15-Sep-82	28.95	95.0	5.67	18.6	M35377.176641
Kicku, Robert	NE 10-046-06 W5M	Dalehurst Member	04-Oct-82	35.66	117.0	0	0.0	M36727.987445
Kijewski, H	NE 04-046-01 W5M	Dalehurst Member	30-Mar-78	41.15	135.0	35.96	118.0	M36234.926939
Killaby, Evelyn	03-21-047-27 W4M	Haynes Member	07-Oct-83	36.57	120.0	24.38	80.0	M35377.189656
Krause, Roger	SW 17-046-24 W4M	Upper Horseshoe Canyon	17-Nov-75	51.81	170.0	14.63	48.0	M35377.177644
Laka, N	NE 29-046-01 W5M	Dalehurst Member	14-Jun-77	18.9	62.0	0.3	1.0	M36234.927439
Lange, Gus	14-29-047-26 W4M	Lower Scollard	22-Mar-78	67.05	220.0	8.23	27.0	M35377.189496
Lefebre, F J	SW 27-046-01 W5M	Upper Lacombe Member	16-Jun-75	22.86	75.0	5.94	19.5	M36234.927361
Leonhardt, Victor	SW 12-047-02 W5M	Dalehurst Member	21-Apr-67	18.29	60.0	0.3	1.0	M35379.049022
Leonhardtt, Don	08-11-047-02 W5M	Upper Lacombe Member	11-Aug-82	32.61	107.0	15.85	52.0	M35379.048996
Leonhargt, Don	01-11-047-02 W5M	Dalehurst Member	20-Aug-79	29.87	98.0	17.22	56.5	M35379.048991
Lerohl, Bert	16-29-047-23 W4M	Middle Horseshoe Canyon	27-Apr-83	30.48	100.0	3.05	10.0	M35377.178120
Lewis, G	SE 04-046-03 W5M	Dalehurst Member	30-May-83	22.25	73.0	17.07	56.0	M35379.063255
Lewis, Roy Samson Band	10-29-044-23 W4M	Upper Horseshoe Canyon	06-Jun-69	50.9	167.0	9.45	31.0	M35377.072988
Linden, Lenin	SW 26-047-23 W4M	Upper Horseshoe Canyon	10-Jun-80	15.24	50.0	12.19	40.0	M35377.178054

WATER WELLS RECOMMENDED FOR FIELD-VERIFICATION THAT MEET CRITERIA

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
Locke, D.	NW 14-047-28 W4M	Upper Lacombe Member	01-Oct-81	25.91	85.0	15.85	52.0	M35377.185284
Louis, Marlow / Samson Band	16-19-044-23 W4M	Upper Horseshoe Canyon	07-Sep-82	64	210.0	23.77	78.0	M35377.072884
Lueck, Robert	NE 36-047-23 W4M	Upper Horseshoe Canyon	09-May-70	21.33	70.0	7.62	25.0	M35377.178263
Lutheran Bible Camp	SW 01-047-28 W4M	Upper Lacombe Member	24-Apr-75	27.43	90.0	3.66	12.0	M35377.184875
Maciborsky, Alex	SW 09-046-07 W5M	Dalehurst Member	02-Oct-84	77.42	254.0	55.17	181.0	M36727.987643
MA-ME-O-BEACH Park	08-15-046-28 W4M	Upper Lacombe Member	01-Jun-54	34.14	112.0	4.88	16.0	M36234.941268
Manwaring, Clive	SW 13-047-28 W4M	Upper Lacombe Member	05-Nov-80	24.38	80.0	13.11	43.0	M35377.184971
Mason, Randy	01-24-045-07 W5M	Dalehurst Member	17-Oct-78	24.38	80.0	9.14	30.0	M36727.986350
Matthews, Harold	SE 31-046-03 W5M	Dalehurst Member	10-Nov-81	19.81	65.0	2.13	7.0	M36234.931820
Mayer, R.	NE 27-046-03 W5M	Dalehurst Member	18-Oct-85	28.95	95.0	10.06	33.0	M36234.931809
Mayer, Rudy	NE 36-046-04 W5M	Dalehurst Member	17-Nov-72	24.38	80.0	5.18	17.0	M36727.987169
Maygard, B.	16-18-045-23 W4M	Upper Horseshoe Canyon	17-Jun-83	38.1	125.0	6.1	20.0	M35377.184417
Mccalley, Ian	SW 13-047-28 W4M	Upper Lacombe Member	19-Jun-79	26.52	87.0	12.5	41.0	M35377.184968
McDonald, David & Mary	NW 28-046-01 W5M	Dalehurst Member	20-Jul-79	10.06	33.0	3.66	12.0	M36234.927413
Mclean, Joe	01-13-045-06 W5M	Dalehurst Member	26-Nov-68	25.91	85.0	16.77	55.0	M37066.937248
Mcnaughton, Joe	04-11-046-04 W5M	Dalehurst Member	01-Aug-84	32	105.0	0	0.0	M36727.987044
Melnychuk, William	10-34-047-24 W4M	Upper Horseshoe Canyon	18-Apr-85	36.57	120.0	10.36	34.0	M35377.063185
Micku, L.	SE 19-046-06 W5M	Dalehurst Member	21-Feb-77	34.44	113.0	14.63	48.0	M36727.987510
Midtdal, A.	NE 01-046-02 W5M	Dalehurst Member	10-Oct-67	11.58	38.0	7.62	25.0	M36234.927523
Midtdal, Ronald & Leona	14-23-045-02 W5M	Dalehurst Member	23-Apr-02	22.86	75.0	15.544	51.0	M37841.692695
Midtdol, R.	SW 06-046-01 W5M	Dalehurst Member	01-Oct-79	22.25	73.0	14.63	48.0	M36234.926946
Miller, Joe	NW 15-046-06 W5M	Dalehurst Member		27.43	90.0	12.5	41.0	M36727.987500
Millis, D.	SE 14-046-07 W5M	Dalehurst Member	25-Jul-86	33.53	110.0	11.28	37.0	M36727.987655
Minchau, Edward	01-02-045-24 W4M	Upper Horseshoe Canyon	02-Sep-82	60.96	200.0	18.9	62.0	M35377.186643
Mittelsteadt, Rita	NW 07-046-05 W5M	Dalehurst Member	09-May-86	39.62	130.0	4.57	15.0	M36727.987228
Moore, Bill	SE 28-046-24 W4M	Upper Horseshoe Canyon	28-Apr-76	39.62	130.0	14.63	48.0	M35377.178042
Mosa, Karl	NW 30-047-22 W4M	Middle Horseshoe Canyon	21-Aug-74	60.96	200.0	8.84	29.0	M35377.176835
Moure, W	NW 30-046-01 W5M	Dalehurst Member	12-Sep-81	36.57	120.0	23.16	76.0	M36234.927452
Neldner, H	SE 28-046-01 W5M	Dalehurst Member	03-Jun-86	18.29	60.0	2.74	9.0	M36234.927392
Nelson, A S	SE 13-046-01 W5M	Upper Lacombe Member	12-Aug-64	35.66	117.0	3.96	13.0	M36234.927054
Norstrom, Les	16-33-045-01 W5M	Dalehurst Member	27-May-68	15.24	50.0	7.02	23.0	M37066.939449
Oliver, Ralph	NW 14-047-28 W4M	Upper Lacombe Member	06-Jun-83	18.29	60.0	6.1	20.0	M35377.185286
Olsen, Ralph	SE 12-044-22 W4M	Upper Horseshoe Canyon	28-May-68	65.53	215.0	22.86	75.0	M35377.184615
Olsen, Ralph & Colleen & Jeff	01-12-044-22 W4M	Upper Horseshoe Canyon	04-Oct-02	54.861	180.0	20.939	68.7	M38255.546172
Olson, A.W.	04-13-044-23 W4M	Upper Horseshoe Canyon	02-Jul-65	51.81	170.0	16.46	54.0	M35377.072726
Papeneau, K.	SE 16-046-02 W5M	Dalehurst Member	01-Sep-71	19.81	65.0	13.72	45.0	M36234.927564
Parker, Roger	SW 16-047-02 W5M	Dalehurst Member	09-Oct-61	55.47	182.0	39.62	130.0	M35379.049058
Peterson, Sam	09-02-046-05 W5M	Dalehurst Member	26-Sep-71	19.81	65.0	10.97	36.0	M36727.987177
Pletz, Erhard	NE 04-047-24 W4M	Upper Horseshoe Canyon	25-Feb-84	48.77	160.0	8.84	29.0	M35377.178491
Pocatillo, W.G.	NE 22-047-24 W4M	Upper Horseshoe Canyon	12-Apr-77	39.62	130.0	16.15	53.0	M35377.179181
Podinsky, E	NW 13-046-01 W5M	Upper Lacombe Member	26-Apr-78	33.53	110.0	7.31	24.0	M36234.927094
Prout, Ted	NE 09-047-24 W4M	Upper Horseshoe Canyon	01-Sep-73	25.6	84.0	5.49	18.0	M35377.178537
Quast, Clarence	SW 13-045-28 W4M	Upper Lacombe Member	11-Apr-78	31.39	103.0	17.68	58.0	M35377.184067
Quast, Gordon	SW 26-045-28 W4M	Upper Lacombe Member	01-Nov-70	51.81	170.0	27.74	91.0	M35377.184101
Quast, Gordon	01-27-045-28 W4M	Upper Lacombe Member	22-Mar-79	48.77	160.0	28.04	92.0	M35377.184104
Rasmuson, Earl & Ralph	SW 24-047-23 W4M	Upper Surficial	01-Jul-73	11.89	39.0	5.18	17.0	M35377.177976
Reid, David M.	SE 28-046-01 W5M	Upper Lacombe Member	07-Jul-86	18.29	60.0	1.39	4.6	M37490.032932
Reid, E.	SW 27-045-28 W4M	Dalehurst Member	23-Apr-84	32	105.0	15.24	50.0	M35377.184106
Reimchen, Paul	NE 09-046-23 W4M	Upper Horseshoe Canyon	20-Apr-77	30.48	100.0	9.14	30.0	M35377.189120
Reist, Denis	SE 04-047-23 W4M	Upper Horseshoe Canyon	20-Jun-73	19.81	65.0	8.53	28.0	M35377.178153
Renner, Jerry	NE 24-046-23 W4M	Middle Horseshoe Canyon	12-Jun-80	9.14	30.0	1.83	6.0	M35377.189197
Ried, D	NW 28-046-01 W5M	Upper Lacombe Member	07-Jul-86	18.29	60.0	4.57	15.0	M36234.927417
Roan, Harry	SW 13-046-28 W4M	Lower Lacombe Member	14-Sep-90	48.77	160.0	21.33	70.0	M35377.085618
Robins, Cliff	SW 05-045-27 W4M	Upper Lacombe Member	27-Mar-81	28.95	95.0	14.32	47.0	M35377.184158
Robinson, John	SW 27-047-24 W4M	Upper Horseshoe Canyon	23-Oct-86	49.38	162.0	14.63	48.0	M35377.179604
Rooyakkers, William	13-31-046-03 W5M	Dalehurst Member	04-Oct-83	56.39	185.0	48.16	158.0	M36234.931821
Ruskowsky, Vern	SE 13-045-27 W4M	Lower Lacombe Member	20-Mar-76	18.29	60.0	2.44	8.0	M35377.184188
Rylance, Grant	05-07-046-04 W5M	Dalehurst Member	20-May-82	37.49	123.0	11.89	39.0	M36727.987017
Salo, Vic	NW 07-045-06 W5M	Dalehurst Member	20-Dec-74	21.33	70.0	0	0.0	M36727.986657
Schamber, Rick	04-20-047-24 W4M	Upper Horseshoe Canyon	22-Nov-01	30.48	100.0	3.96	13.0	M37490.031919

WATER WELLS RECOMMENDED FOR FIELD-VERIFICATION THAT MEET CRITERIA

Owner	Location	Aquifer Name	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet	UID
Schmidt, G.	SE 06-047-27 W4M	Dalehurst Member	09-May-56	30.48	100.0	14.93	49.0	M35377.189544
Schmuland, Ken	12-15-047-24 W4M	Upper Horseshoe Canyon	14-Aug-79	22.25	73.0	11.58	38.0	M35377.178970
Schnell, E W	NE 22-046-01 W5M	Upper Lacombe Member	12-Jul-65	18.59	61.0	1.83	6.0	M36234.927214
Schnell, G.	02-06-045-26 W4M	Lower Lacombe Member	02-Aug-79	29.87	98.0	10.06	33.0	M35377.188762
Schwengler, Paul	SW 29-046-07 W5M	Dalehurst Member	12-Mar-79	33.83	111.0	22.86	75.0	M35379.092276
Seidl, Art	SW 17-046-27 W4M	Upper Lacombe Member	07-May-79	32	105.0	23.77	78.0	M35377.184797
Sejdl, Joe	03-05-045-26 W4M	Lower Lacombe Member	13-Nov-61	20.73	68.0	7.62	25.0	M35377.188756
Shantz, Sid	NW 24-045-23 W4M	Upper Horseshoe Canyon	27-Oct-75	32.31	106.0	10.97	36.0	M35377.184438
Shaw, H	SE 23-046-28 W4M	Upper Lacombe Member	18-Jul-78	35.05	115.0	8.84	29.0	M35377.077312
Shaw, Ron	SE 22-045-01 W5M	Dalehurst Member	11-Aug-84	15.85	52.0	14.02	46.0	M35379.041664
Simon, Albert & Erika	SE 32-046-01 W5M	Upper Lacombe Member	20-Sep-00	33.53	110.0	1.01	3.3	M37490.033246
Simon, Paul	15-22-045-07 W5M	Dalehurst Member	09-Jun-65	42.67	140.0	31.09	102.0	M36727.986348
Sjolin, Oscar T.	SE 16-046-27 W4M	Upper Lacombe Member	24-Nov-76	33.83	111.0	17.68	58.0	M35377.184784
Smeltzer, Joe	03-30-047-24 W4M	Upper Horseshoe Canyon	24-Jul-86	51.81	170.0	17.98	59.0	M35377.179853
Smithson, R.	04-28-045-02 W5M	Dalehurst Member	27-Apr-68	14.02	46.0	7.31	24.0	M36727.985767
Sonnenberg, G.	NE 15-046-24 W4M	Upper Horseshoe Canyon	16-May-79	54.86	180.0	16.46	54.0	M35377.177636
Spiess, George	04-13-047-28 W4M	Upper Lacombe Member	14-Jun-72	21.33	70.0	6.71	22.0	M35377.184980
Stange, Lloyd	16-33-046-27 W4M	Haynes Member	25-May-68	33.22	109.0	21.33	70.0	M35377.184864
Stankey, Wallace	15-12-045-07 W5M	Dalehurst Member	18-Sep-78	44.19	145.0	15.85	52.0	M36727.986321
Steinke, G.	NE 04-046-23 W4M	Upper Horseshoe Canyon	15-May-76	30.48	100.0	12.19	40.0	M35377.189103
Stephan, Gus	16-12-045-27 W4M	Upper Surficial	12-Aug-69	13.72	45.0	3.66	12.0	M35377.184186
Stone, F.	NW 25-045-28 W4M	Upper Lacombe Member	01-Sep-73	41.15	135.0	14.02	46.0	M35377.184099
Stout, Monte	SW 22-046-02 W5M	Lacombe Member	19-Aug-86	14.63	48.0	4.88	16.0	M35379.061239
Strohschein, Ken	SE 26-046-25 W4M	Upper Horseshoe Canyon	06-Aug-79	74.67	245.0	28.04	92.0	M35377.178699
Tabler, Leonard	NW 24-045-27 W4M	Haynes Member	14-Jun-77	35.36	116.0	6.4	21.0	M35377.184269
Thomas, J.	SE 05-047-02 W5M	Dalehurst Member	23-Jul-82	22.86	75.0	13.41	44.0	M35379.048804
Tinis, Dale & Dorothy	01-08-044-22 W4M	Upper Horseshoe Canyon	02-Aug-85	42.67	140.0	6.1	20.0	M35377.184596
Unger, Ray	SE 35-047-26 W4M	Lower Scollard	11-Apr-00	27.43	90.0	15.24	50.0	M35377.189519
Unland, Bill	NE 24-045-28 W4M	Upper Lacombe Member	06-Jul-72	36.88	121.0	9.45	31.0	M35377.091842
Unland, Manley	NW 07-045-27 W4M	Upper Lacombe Member	14-Sep-60	22.86	75.0	7.62	25.0	M35377.184169
Van Immerzeel, Peter	09-17-046-27 W4M	Lower Lacombe Member	06-Apr-77	53.95	177.0	29.26	96.0	M35377.172231
Waterman, S.J.	SW 14-046-26 W4M	Scollard	26-Mar-59	24.38	80.0	5.49	18.0	M35377.178993
Weaver, Delwyn	14-07-045-22 W4M	Middle Horseshoe Canyon	20-Aug-82	50.29	165.0	10.67	35.0	M35377.171102
Webb, Geoffrey	SE 14-047-01 W5M	Upper Lacombe Member	23-Jun-61	30.48	100.0	2.74	9.0	M35379.048055
Wyley, Tom	SE 13-047-01 W5M	Upper Lacombe Member	17-Jul-74	24.38	80.0	2.44	8.0	M35379.047944
Yellowbird, Jim	SE 23-046-28 W4M	Upper Lacombe Member	03-Apr-62	42.67	140.0	7.92	26.0	M36234.941087
Zimmerman, Jerry	NE 05-046-04 W5M	Dalehurst Member	18-Sep-81	24.38	80.0	12.5	41.0	M36727.987009
Zukowski, Michael	NW 32-046-07 W5M	Dalehurst Member	18-Oct-78	45.72	150.0	15.24	50.0	M36727.987705

WATER WELLS THAT MEET CRITERIA AND WERE PREVIOUSLY VERIFIED IN THE LAST TEN YEARS

Owner	Location	Aquifer Name	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet	UID
County of Wetaskawin	03-04-046-07 W5M	Dalehurst Member	02-Aug-78	91.44	300.0	8.84	29.0	M36727.987608
County of Wetaskawin	SW 11-046-06 W5M	Dalehurst Member	11-Jun-98	41.15	135.0	2.32	7.6	M36727.989492
County of Wetaskiwin	SE 14-046-01 W5M	Bedrock	25-Aug-76	88.39	290.0	39.01	128.0	M36234.927128
County of Wetaskiwin	SE 15-046-01 W5M	Bedrock	15-Jul-75	84.73	278.0	27.43	90.0	M36234.927160
County of Wetaskiwin	16-24-046-23 W4M	Bedrock	09-Aug-61	70.1	230.0	9.14	30.0	M35377.189190
County of Wetaskiwin	SE 18-046-03 W5M	Dalehurst Member	03-Feb-66	37.79	124.0	11.58	38.0	M36056.964526
County of Wetaskiwin	SE 09-046-03 W5M	Dalehurst Member	25-Jun-70	49.68	163.0	1.83	6.0	M36234.936643
County of Wetaskiwin	NE 09-046-24 W4M	Upper Horseshoe Canyon	23-Jan-87	73.15	240.0	10.67	35.0	M35377.177510
County of Wetaskiwin	NE 09-046-24 W4M	Upper Horseshoe Canyon	14-May-86	91.44	300.0	15.24	50.0	M35377.177512
County of Wetaskiwin	SE 05-044-22 W4M	Upper Horseshoe Canyon		30.48	100.0	-0.03	-0.1	M35377.184630
County of Wetaskiwin	SW 13-046-02 W5M	Upper Lacombe Member	16-Jun-92	54.86	180.0	4.27	14.0	M35379.067087
County of Wetaskiwin	NW 11-045-28 W4M	Upper Lacombe Member	12-Jul-94	36.57	120.0	18.77	61.6	M35377.209238
County of Wetaskiwin (Lakedell School)	SE 15-046-01 W5M	Upper Lacombe Member	20-Nov-83	88.39	290.0	18.29	60.0	M36234.936879
County of Wetaskiwin No 10	SW 30-046-22 W4M	Bedrock	19-Aug-91	60.96	200.0	3.66	12.0	M35377.091306
County Park	SW 02-044-22 W4M	Lower Surficial		24.38	80.0	-0.03	-0.1	M35377.184622

COUNTY OF WETASKIWIN-OPERATED WATER WELLS

Owner	Location	Aquifer Name	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet	UID
County of Wetaskawin	03-04-046-07 W5M	Dalehurst Member	02-Aug-78	91.44	300.0	8.84	29.0	M36727.987608
County of Wetaskawin	SW 11-046-06 W5M	Dalehurst Member	11-Jun-98	41.15	135.0	2.32	7.6	M36727.989492
County of Wetaskiwin	SE 14-046-01 W5M	Bedrock	25-Aug-76	88.39	290.0	39.01	128.0	M36234.927128
County of Wetaskiwin	SE 15-046-01 W5M	Bedrock	15-Jul-75	84.73	278.0	27.43	90.0	M36234.927160
County of Wetaskiwin	16-24-046-23 W4M	Bedrock	09-Aug-61	70.1	230.0	9.14	30.0	M35377.189190
County of Wetaskiwin	SE 18-046-03 W5M	Dalehurst Member	03-Feb-66	37.79	124.0	11.58	38.0	M36056.964526
County of Wetaskiwin	SE 09-046-03 W5M	Dalehurst Member	25-Jun-70	49.68	163.0	1.83	6.0	M36234.936643
County of Wetaskiwin	NE 09-046-24 W4M	Upper Horseshoe Canyon	23-Jan-87	73.15	240.0	10.67	35.0	M35377.177510
County of Wetaskiwin	NE 09-046-24 W4M	Upper Horseshoe Canyon	14-May-86	91.44	300.0	15.24	50.0	M35377.177512
County of Wetaskiwin	SE 05-044-22 W4M	Upper Horseshoe Canyon		30.48	100.0	-0.03	-0.1	M35377.184630
County of Wetaskiwin	SW 13-046-02 W5M	Upper Lacombe Member	16-Jun-92	54.86	180.0	4.27	14.0	M35379.067087
County of Wetaskiwin	NW 11-045-28 W4M	Upper Lacombe Member	12-Jul-94	36.57	120.0	18.77	61.6	M35377.209238
County of Wetaskiwin (Lakedell School)	SE 15-046-01 W5M	Upper Lacombe Member	20-Nov-83	88.39	290.0	18.29	60.0	M36234.936879
County of Wetaskiwin No 10	SW 30-046-22 W4M	Bedrock	19-Aug-91	60.96	200.0	3.66	12.0	M35377.091306
County Park	SW 02-044-22 W4M	Lower Surficial		24.38	80.0	-0.03	-0.1	M35377.184622