M.D. of Rocky View No. 44

Part of the South Saskatchewan River Basin
Tp 021 to 029, R 25 to 29, W4M & Tp 023 to 029, R 01 to 06, W5M
Regional Groundwater Assessment

Prepared for the M.D. of Rocky View No. 44

In conjunction with

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

Canada

Prepared by
hydrogeological consultants ltd.
1-800-661-7972
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Acknowledgements

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Mr. Frank Misura – M.D. of Rocky View

1. Project Overview

"Water is the lifeblood of the earth." - Anonymous

How a Municipal District (M.D.) takes care of one of its most precious resources - groundwater - reflects the future wealth and health of its people. Good environmental practices are not an accident. They must include genuine foresight with knowledgeable planning. Implementation of strong practices not only commits to a better quality of life for future generations, but also creates a solid base for increased economic activity. **Though this report's scope is regional, it is a first step for the M.D. of Rocky View 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 M.D. of Rocky View prepared by Hydrogeological Consultants Ltd. (HCL) with financial and technical assistance from the Prairie Farm Rehabilitation Administration arm of Agriculture and Agri-Food Canada (AAFC-PFRA). The regional groundwater assessment provides the information to assist in the management of the groundwater resource within the M.D. Groundwater resource management involves determining the suitability of various areas in the M.D. for particular activities. These activities can vary from the development of groundwater for agricultural or industrial purposes, to the siting of waste storage. **Proper management ensures protection and utilization of the groundwater resource for the maximum benefit of the people of the M.D.**

The regional groundwater assessment will:

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

Under the present program, the groundwater-related data for the M.D. have been assembled. Where practical, the data have been digitized. These data are then used in the regional groundwater assessment for the M.D. of Rocky View.

[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 M.D. of Rocky View, (b) the processes used for the present project, and (c) the groundwater characteristics in the M.D.

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

Appendix A features page-size copies of the figures within the report plus additional maps and cross-sections. An index of the page-size maps and figures is given at the beginning of Appendix A. A plastic M.D. 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 new Water Act
3) a flow chart showing the licensing of a groundwater diversion under the new Water Act
4) interpretation of chemical analysis of drinking water
5) additional information.

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

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

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

[3] See glossary

2. Introduction

2.1 Setting

The M.D. of Rocky View is situated in south-central Alberta. Most of this area is part of the western Alberta Plains region, with the western part of the M.D. being part of the Foothills Belt. The M.D. is within the South Saskatchewan River basin; a small part of the southern boundary is the Bow River. The City of Calgary forms the south-central boundaries. The other M.D. boundaries follow township or section lines. The area includes parts of the area bounded by township 023, range 05, W5M in the southwest and township 028, range 24, W4M in the northeast. There are two tribal lands in the area.

Regionally, the topographic surface varies between 850 and 1,450 metres above mean sea level (AMSL). The lowest elevations occur mainly in the northeastern part of the M.D. and the highest are in the western parts of the M.D. as shown on Figure 1 and page A-3. The area is well drained by numerous streams, the main ones being the Bow and Elbow rivers.

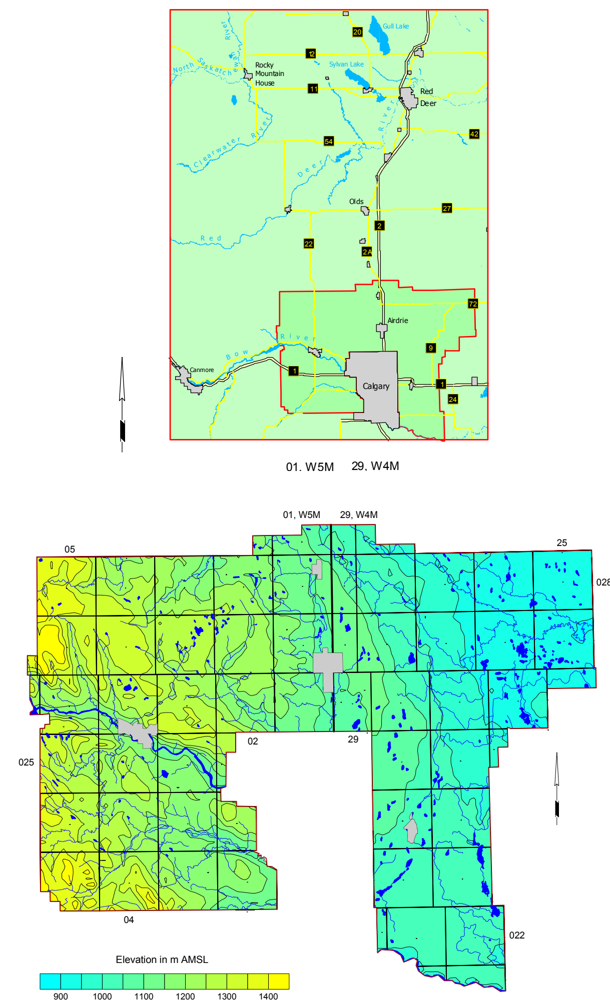

Figure 1. Index Map

2.2 Climate

The M.D. of Rocky View lies within the Dfb[4] climate boundary. This classification is based on potential evapotranspiration[5] values determined using the Thornthwaite method (Thornthwaite and Mather, 1957), combined with the distribution of natural ecoregions in the area. The ecoregions map (Strong and Leggatt, 1981) shows that the M.D. is located in both the Low Boreal Mixedwood region and the Aspen Parkland region. Increased precipitation and cooler temperatures, resulting in additional moisture availability, influence this vegetation change.

A Dfb climate consists of long, cool summers, 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.

The mean annual precipitation averaged from four meteorological stations within the M.D. measured 441 millimetres (mm), based on data from 1961 to 1993. The mean annual temperature averaged 4.0° C, with the mean monthly temperature reaching a high of 16.0° C in July, and dropping to a low of -8.6° C in January. The calculated annual potential evapotranspiration is 494 millimetres.

4 See glossary
5 See glossary

2.3 Background Information

2.3.1 Number, Type and Depth of Water Wells

There are currently records for 11,578 water wells in the groundwater database for the M.D. Of the 11,578 water wells, 10,856 are for domestic/stock purposes. The remaining 722 water wells were completed for a variety of uses, including municipal, industrial, observation, irrigation, investigation and monitoring. Based on a rural population of 23,326 (Phinney, 2001), there are 1.9 domestic/stock water wells per family of four. [It should be noted that the Alberta List population figure for the M.D. (Phinney, 2001) differs from the April 2000 census conducted by the M.D. by approximately 5,000 people.] It is unknown how many of these water wells may still be active (especially in areas where rural pipelines have been constructed in recent years). Of the 10,335 domestic or stock water wells with a completed depth, 8,003 are completed at depths of less than 60 metres below ground level. Details for lithology[6] are available for 8,449 water wells.

2.3.2 Number of Water Wells in Surficial and Bedrock Aquifers

There are 7,263 water well records 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. Of the 7,263 water wells for which aquifers could be defined, 222 are completed in surficial aquifers, with 183 (82%) having a completion depth of less than 40 metres below ground level. Only one of the 222 water wells completed in surficial aquifers with casing size is a bored or dug water well. The adjacent map shows that the water wells completed in the surficial deposits occur mainly along the Elbow River, especially near Bragg Creek, and in linear bedrock lows.

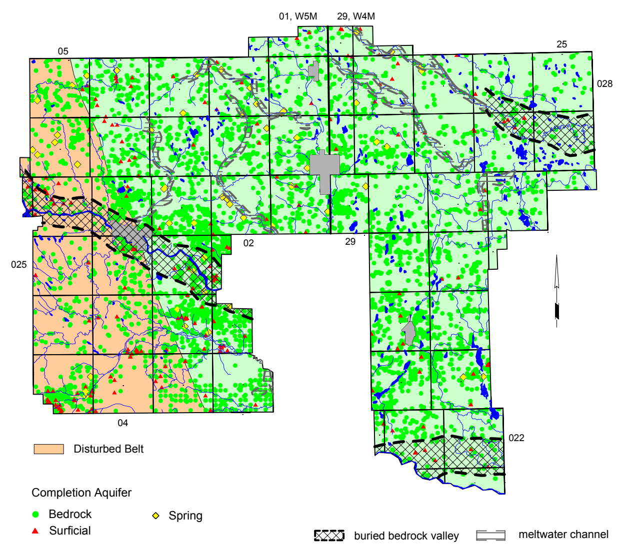

Figure 2. Location of Water Wells and Springs

The data for 7,041 water wells show that the top of the water well completion interval is below the bedrock surface, indicating that the water wells are completed in at least one bedrock aquifer. From Figure 2, it can be seen that water wells completed in bedrock aquifers occur throughout the M.D. Within the M.D., casing-diameter information is available for 6,885 of the 7,041 water wells completed below the top of bedrock. Of these 6,885 water wells, 99% have surface-casing diameters of less than 275 mm and these bedrock water wells have been mainly completed with either a perforated liner or as open hole; there are 19 bedrock water wells completed with a water well screen.

There are currently records for 64 springs in the groundwater database, including three springs that were documented by Borneuf (1983). Of the 30 springs having total dissolved solids (TDS) values, 20 have TDS concentrations of less than 500 milligrams per litre (mg/L). The spring groundwaters with TDS concentrations of more than 500 mg/L are in townships 027 to 029, range 28, W4M (see CD-ROM). Of the 30 available total hardness values, 87% have total hardness concentrations of less than 500 mg/L. The four available flow rates for springs within the M.D. range from less than 20 to 1,600 litres per minute (lpm), with the highest flow rates at three springs in Big Hill Springs Park in 14-29-026-03 W5M.

[6] See glossary

2.3.3 Casing Diameter and Type

Data for casing diameters are available for 8,070 water wells, with 8,049 (99%) indicated as having a diameter of less than 275 mm and 21 water wells having a surface-casing diameter of more than 275 mm. The casing diameters of greater than 275 mm are mainly bored or dug water wells and those with a surface-casing diameter of less than 275 mm are drilled water wells. In addition to the 8,070 water wells that have been designated as either bored or drilled water wells based on casing diameter, another 1,289 water wells have been designated as bored or drilled water wells based on the drilling method only, with no casing size indicated on the water well record. Of the 1,289 water wells having no casing size, 1,233 are drilled water wells and 56 are bored water wells. Forty percent of the bored water well locations are mainly along the Elbow River, especially near Bragg Creek. Most of the bored water wells are located in areas of generally lower groundwater development potential.

In the M.D., steel, galvanized steel and plastic surface casing materials have been used in 99% of the drilled water wells over the last 40 years. Until the mid-1960s, the type of surface casing used in drilled water wells was mainly undocumented. Steel casing was in use in the 1950s and is still used in 93% of the water wells being drilled in the M.D. in the late 1990s. Similar to Mountain View County, galvanized steel and plastic surface casing have been used in less than 3% of the new water wells; galvanized steel was last used in April 1996 for the completion of a dug water well.

Steel casing has been dominant in the M.D. probably because it has resisted corrosion and also because water well drillers may be reluctant to use PVC if there have been no documented problems with steel casing in the area.

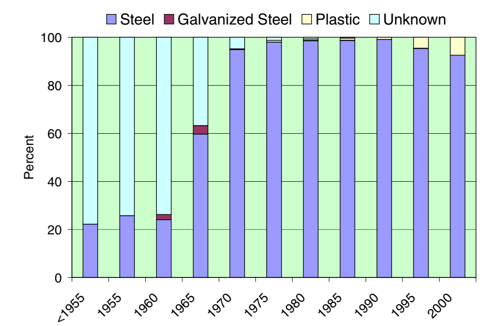

Figure 3. Surface Casing Types Used in Drilled Water Wells

2.3.4 Dry Water Test Holes

In the M.D., there are 13,502 records in the groundwater database. Of these 13,502 records, 131 (less than 1% of the total number of test holes drilled) are indicated as being dry or abandoned with “insufficient water”. Also included in these dry test holes is any record that includes comments that state the water well goes dry in dry years. The 131 “dry” test hole records located throughout the M.D., and clustered near the communities of Cochrane and Chestermere, were drilled or completed in the bedrock.

2.3.5 Requirements for Licensing

Water wells used for household needs in excess of 1,250 cubic metres per year (748 imperial gallons per day[7]) and all other groundwater use must be licensed. The only groundwater users that do not need licensing are (1) household use of up to 1,250 m³/year and (2) groundwater with total dissolved solids in excess of 4,000 mg/L. In the last update from the Alberta Environment (AENV) groundwater database in September 2001, 398 groundwater allocations were shown to be within the M.D., with the most recent groundwater user being licensed in July 2000. Of the 398 licensed groundwater users, 275 (**which is 69% of all licensed water wells**) could be linked to the AENV groundwater database. Of the 398 licensed groundwater users, 236 are for agricultural purposes, 115 are for municipal purposes, 19 are for commercial purposes, 19 are for recreational, and the remaining nine are for dewatering, industrial, exploration or management purposes. The total maximum authorized diversion from the water wells associated with these licences is 29,039 cubic metres per day (m³/day), although actual use could be less. Of the 29,039 m³/day, 19,614 m³/day (68%) is authorized for dewatering purposes from four water wells. The remaining 9,425 m³/day (32%) is allotted for municipal, agricultural, commercial, exploration or management use as shown in Table 1 on the following page. A figure showing the locations of the licensed users is in Appendix A (page A-6) and on the CD-ROM. Table 1 also shows a breakdown of the 398 licensed groundwater allocations by the aquifer in which the water well is completed. The

[7] see conversion table on page 54

largest total licensed allocations are in the Lower Sand and Gravel Aquifer. Of the 20,709 m³/day licensed groundwater use in the Lower Sand and Gravel Aquifer, 95% of the groundwater use is from a dewatering water well in SE 08-022-28 W4M.

Aquifer **	No. of Diversions	Licensed Groundwater Users* (m³/day) Agricultural	Municipal	Commercial	Dewatering	Recreation	Industrial	Exploration	Management	Total	Percentage
Upper Sand and Gravel	1	3	0	0	0	0	0	0	0	3	0
Lower Sand and Gravel	25	224	3	828	19,614	40	0	0	0	20,709	71
Bedrock	5	83	10	0	0	0	0	0	0	93	0
Disturbed Belt	64	319	101	0	0	12	0	35	0	467	2
Dalehurst	176	1,095	1,580	78	0	76	20	507	0	3,356	12
Lacombe	83	651	1,081	86	0	7	0	0	0	1,825	6
Haynes	25	147	872	1	0	0	0	0	0	1,020	4
Upper Scollard	9	47	17	68	0	0	0	0	0	132	0
Unknown	10	13	217	24	0	1	0	0	1,179	1,434	5
Total	398	2,582	3,881	1,085	19,614	136	20	542	1,179	29,039	100
Percentage		9	13	4	68	0	0	2	4	100	

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

Table 1. Licensed Groundwater Diversions

Based on the 1996 Agriculture Census, the calculated water requirement for 534,237 livestock for the M.D. is in the order of 14,855 m³/day. This value includes intensive livestock use but not domestic animals. Of the 14,855 m³/day average calculated livestock use, AENV has licensed a groundwater diversion of 2,582 m³/day (17%) and licensed a surface-water diversion of 6,808 m³/day (46%). The remaining 37% of the calculated livestock use would have to be from unlicensed sources. A census of the animals conducted by the M.D. in 1999 estimated the number to be 434,351 animals; this includes domestic animals but not intensive livestock operations.

2.3.6 Groundwater Chemistry and Base of Groundwater Protection

Groundwaters from the surficial deposits can be expected to be chemically hard, with a high dissolved iron content. Of the available chemical data for the surficial aquifers, there were no nitrate + nitrite (as N) concentrations that exceeded 10 mg/L; a plot of nitrate + nitrite (as N) in surficial aquifers is on the accompanying CD-ROM. The TDS concentrations in the groundwaters from the upper bedrock in the M.D. range from less than 500 to more than 3,000 mg/L (page A-34). Elevated nitrate + nitrite (as N) concentrations were evident in 2% of the available chemical data for the upper bedrock aquifer(s). Groundwaters from the bedrock aquifers frequently are chemically soft, with generally low concentrations of dissolved iron. The chemically soft groundwater is high in concentrations of sodium. Less than ten percent of the chemical analyses indicate a fluoride concentration above 1.5 mg/L, with most of the exceedances occurring in the southern and east-central part of the M.D. (see CD-ROM).

The minimum, maximum and median[8] concentrations of TDS, sodium, sulfate, chloride and fluoride in the groundwaters from water wells completed in the upper bedrock in the M.D. have been compared to the Summary of Guidelines for Canadian Drinking Water Quality (SGCDWQ) in Table 2. Of the five constituents compared to the SGCDWQ, median values of TDS and sodium concentrations exceed the guidelines; maximum values of all five constituents exceed the guidelines.

The maximum TDS and sulfate values shown in the adjacent table are from a domestic water well tap sample drilled in SW 07-024-28 W4M and completed 45 metres below ground surface in the Lacombe Aquifer.

Constituent	Range for M.D. in mg/L Minimum	Maximum	Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	186	7,949	1019	500
Sodium	2	1,500	294	200
Sulfate	0	5,248	407	500
Chloride	0	354	10	250
Fluoride	0	10	0.8	1.5

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

SGCDWQ - Summary of Guidelines for Canadian Drinking Water Quality
Federal-Provincial Subcommittee on Drinking Water, March 2001

Table 2. Concentrations of Constituents in Groundwaters from Upper Bedrock Aquifer(s)

8 see glossary

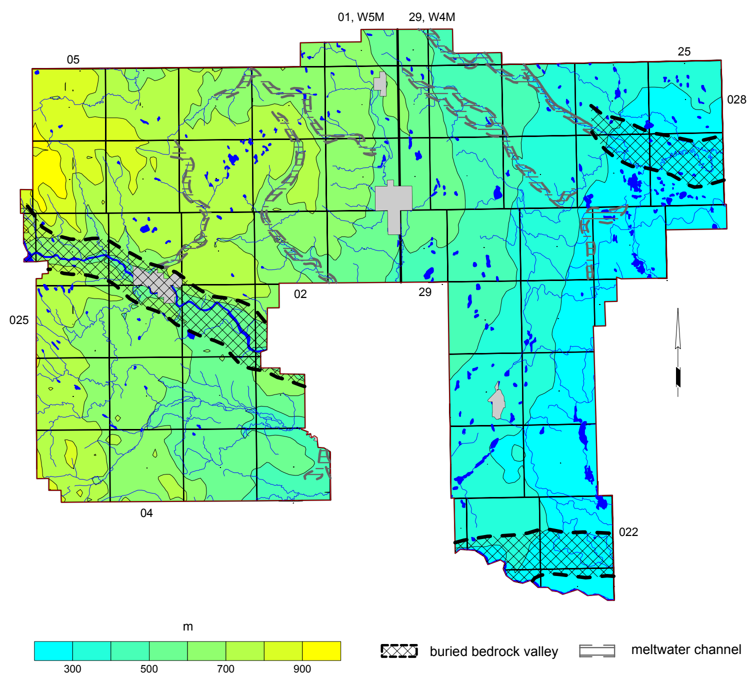

Figure 4. Depth to Base of Groundwater Protection (after EUB, 1995)

In general, Alberta Environment defines the Base of Groundwater Protection as the elevation below which the groundwater will have more than 4,000 mg/L of total dissolved solids. By using the ground elevation, formation elevations, and Alberta Energy and Utilities Board (EUB) information indicating the formations containing the deepest useable water for agricultural needs, a value for the depth to the Base of Groundwater Protection can be determined. These values are gridded using the Kriging[9] method to prepare a depth to the Base of Groundwater Protection surface. This depth, for the most part, would be the maximum drilling depth for a water well for agricultural purposes or for a potable water supply. If a water well has total dissolved solids exceeding 4,000 mg/L, the groundwater use does not require licensing by AENV. In the M.D., the depth to Base of Groundwater Protection ranges from less than 300 metres in the eastern part of the M.D. to more than 800 metres below ground level in the western part of the M.D., as shown on Figure 4 and on some cross-sections presented in Appendix A and on the CD-ROM.

There are 10,975 water wells with completed depth data, of which none are completed below the Base of Groundwater Protection. In the M.D., the Base of Groundwater Protection is below the Upper Scollard Formation (see Figures A-14, A-15, A-19 and A-20).

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

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

[9] See glossary

3. Terms

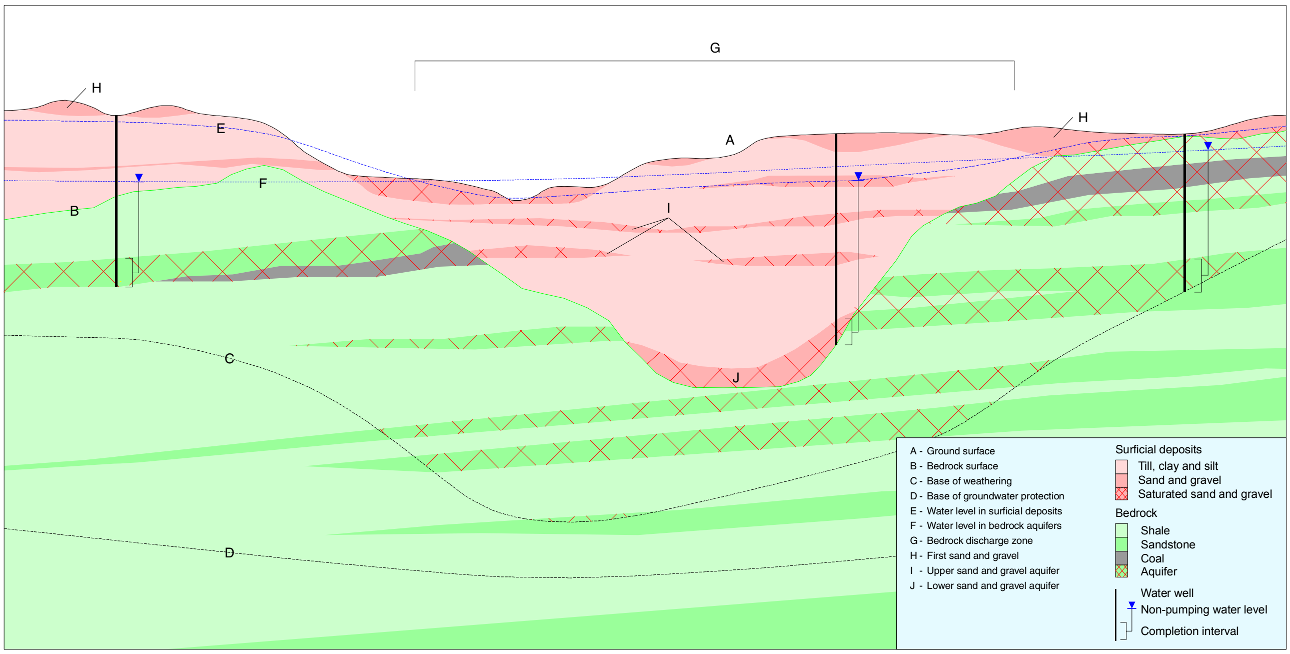

Figure 5. Generalized Cross-Section (for terminology only)

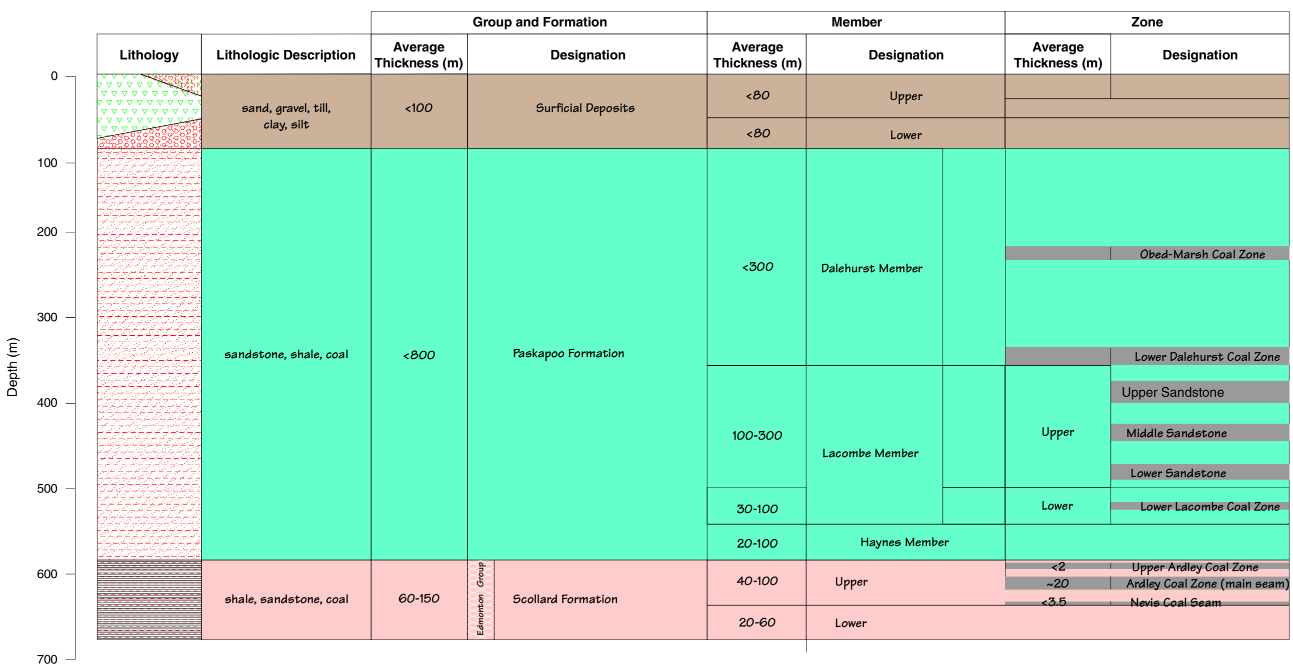

Figure 6. Geologic Column

4. Methodology

4.1 Data Collection and Synthesis

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

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

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

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

The present project uses the 10TM coordinate system based on the NAD27 datum. This means that a record for the NE ¼ of section 30, township 025, range 28, W4M, would have a horizontal coordinate with an Easting of 77,332 metres and a Northing of 5,666,287 metres, the centre of the quarter section. If the water well has been repositioned by AAFC-PFRA using orthorectified aerial photos, the location will be more accurate, possibly within several tens of metres of the actual location. Once the horizontal coordinates are determined for a record, a ground elevation for that record is obtained from the 1:20,000 Digital Elevation Model (DEM); AltaLis Ltd. provides the DEM.

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

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

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

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

Also, where sufficient information is available, values for apparent transmissivity[11] and apparent yield[12] are calculated, based on the aquifer test summary data supplied on the water well drilling reports. Where valid detailed aquifer test results exist, the interpreted data provide values for aquifer transmissivity and effective transmissivity. Since the last regional hydrogeological map covering at least a part of the M.D. was published in 1978 (Ozoray and Barnes, 1978)-see CD-ROM, 3,989 values for apparent transmissivity and 3,280 values for apparent yield have been added to the groundwater database. With the addition of the apparent yield values, including a 0.1-m^3/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 M.D (Figure 7). The map is based on groundwater being obtained from all aquifers and has been prepared to allow direct comparison with the results provided on the Alberta Research Council hydrogeological maps.

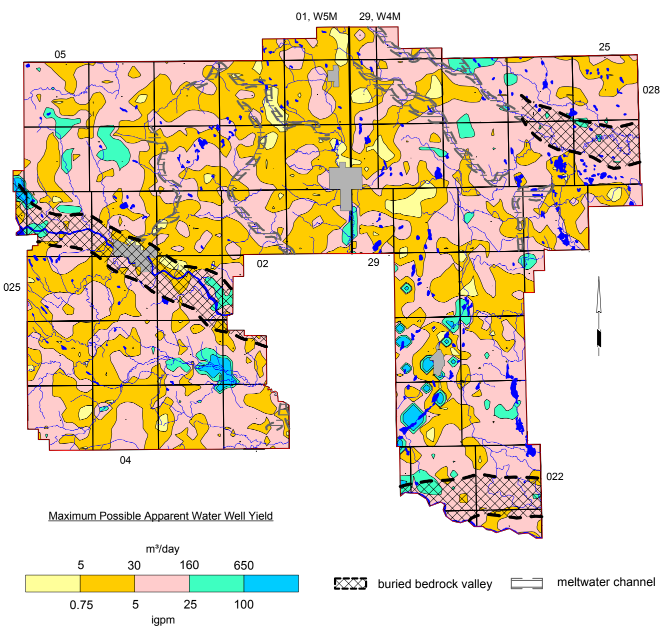

Figure 7. Hydrogeological Map

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

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

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

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

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

4.2 Spatial Distribution of Aquifers

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

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

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

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

4.3 Hydrogeological Parameters

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

After the water wells are assigned to a specific aquifer, the parameters from the water well records are assigned to the individual aquifers. The parameters include non-pumping (static) water level (NPWL), apparent transmissivity, and apparent water well yield. The total dissolved solids, sulfate and chloride concentrations from the chemical analysis of the groundwater are also assigned to applicable aquifers. In addition, chemical parameters of nitrate + nitrite (as N) are assigned to surficial aquifers and fluoride is assigned to upper bedrock aquifer(s). **Since 1986, Alberta Health and Wellness has restricted access to chemical analysis data, and hence the database includes only limited amounts of chemical data since 1986.**

Once the values for the various parameters of the individual aquifers are established, the spatial distribution of these parameters must be determined. The distribution of individual parameters involves the same process as the distribution of geological surfaces. This means establishing a representative data set and then preparing a grid. The representative data set included using the available data from townships 021 to 029, ranges 25 to 29, W4M and townships 023 to 029, ranges 01 to 06, W5M, plus a buffer area of at least one township. 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.

4.4 Maps and Cross-Sections

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

Once the appropriate grids are available, the maps are prepared by contouring the grids. The areal extent of individual parameters is outlined by “masks” to delineate individual aquifers. For the upper bedrock aquifer(s) where areas of insufficient data are available from the groundwater database, prepared maps have been masked with a solid brown color to indicate this area. These brown masks have been added to the Lacombe, Haynes and Upper Scollard aquifers. Appendix A includes page-size maps from the text, plus additional page-size maps and figures that support the discussion in the text. A list of maps and figures that are included on the CD-ROM is given in Appendix B.

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

Once the technical details of a cross-section are correct, the drawing file is moved to the software package CorelDraw! for simplification and presentation in a hard-copy form. Ten cross-sections are presented in Appendix A of this report and as poster-size drawings forwarded with this report; only two (A-A’ and G-G’) 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.

4.5 Software

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

- Acrobat 4.0
- ArcView 3.2
- AutoCAD 2000
- CorelDraw! 10.0
- Microsoft Office XP
- Surfer 7.0

5. Aquifers

5.1 Background

An aquifer is a permeable rock that is saturated. In this context, rock refers to subsurface materials, such as sand, gravel, sandstone and coal. If the non-pumping water level is above the top of the rock, this type of aquifer is an artesian aquifer. If the rock is not entirely saturated and the water level is below the top of the rock, this type of aquifer is a water-table aquifer. These types of aquifers occur in one of two general geological settings in the M.D. 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. 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.

5.1.1 Surficial Aquifers

Surficial deposits in the M.D. are mainly less than 50 metres thick, except in areas of linear bedrock lows where the thickness of the surficial deposits can exceed 100 metres. The Buried Calgary Valley is the main linear bedrock low in the M.D; a second unnamed buried bedrock valley is present in the northeastern part of the M.D. Other linear bedrock lows are present in the form of meltwater channels (Shetsen, 1987). The south-north cross-section G-G', Figure 8 shown below, passes across the Buried Calgary Valley and shows the surficial deposits being less than 50 metres thick.

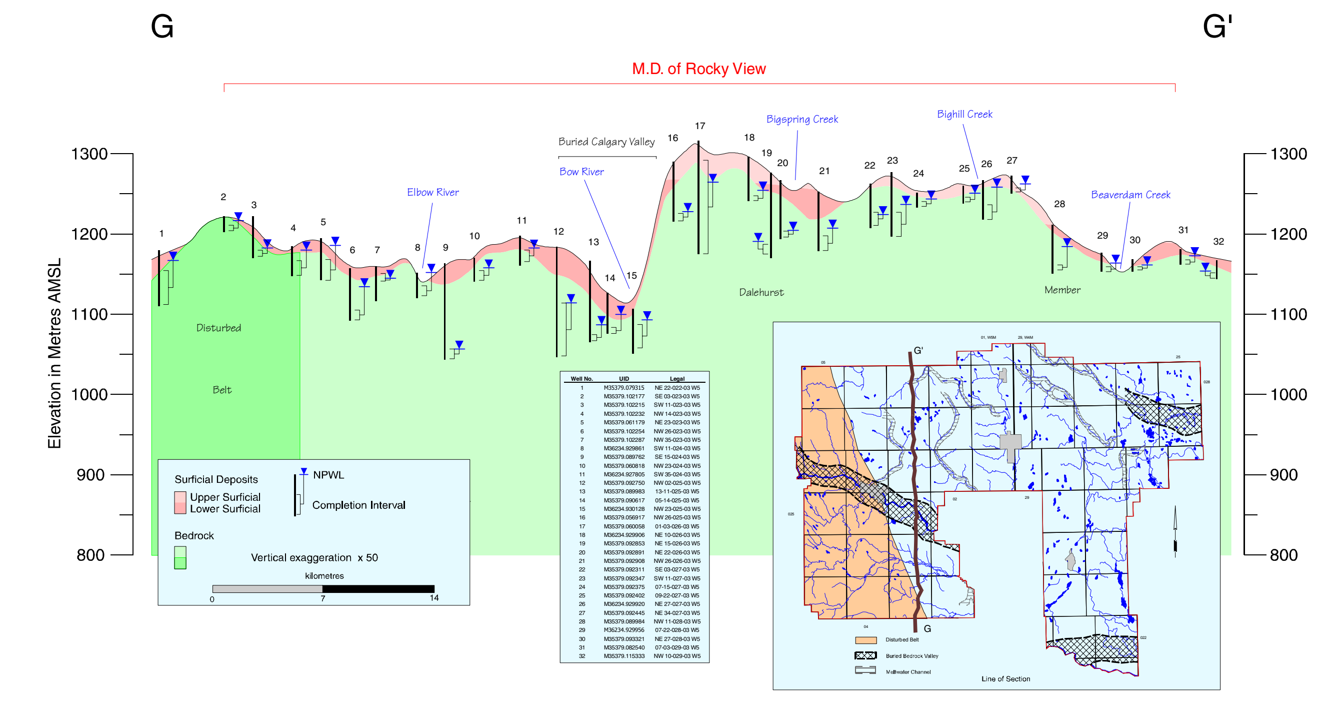

Figure 8. Cross-Section G - G'

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.

For a water well with a small-diameter casing to be effective in surficial deposits and to provide sand-free groundwater, the water well must be completed with a water well screen. Some water wells completed in the surficial deposits are completed in low-permeability aquifers and have a large-diameter casing. The large-diameter water wells may have been hand dug or bored and because they are completed in very low permeability aquifers, most of these water wells would not benefit from water well screens. The groundwater from an aquifer in the surficial deposits usually has a chemical hardness of at least a few hundred mg/L and a dissolved iron concentration such that the groundwater must be treated before being used for domestic needs. Within the M.D., casing-diameter information is available for 202 of the 222 water wells completed in the surficial deposits; only one water well has a casing diameter of more than 275 millimetres, and is assumed to be a bored or dug water well.

5.1.2 Bedrock Aquifers

In the M.D., the upper bedrock includes the Disturbed Belt along the western edge of the M.D., the Paskapoo and the Upper Scollard formations. Cross-section A-A' (Figure 9) shows that the aquifers in which water wells are completed are mainly within 200 metres of the ground surface. Some of this bedrock contains saturated rocks that are permeable enough to transmit groundwater for a specific need. Water wells completed in bedrock aquifers usually do not require water well screens, although some of the sandstones may be friable[13] and water well screens are a necessity. The groundwater from the bedrock aquifers is usually chemically soft.

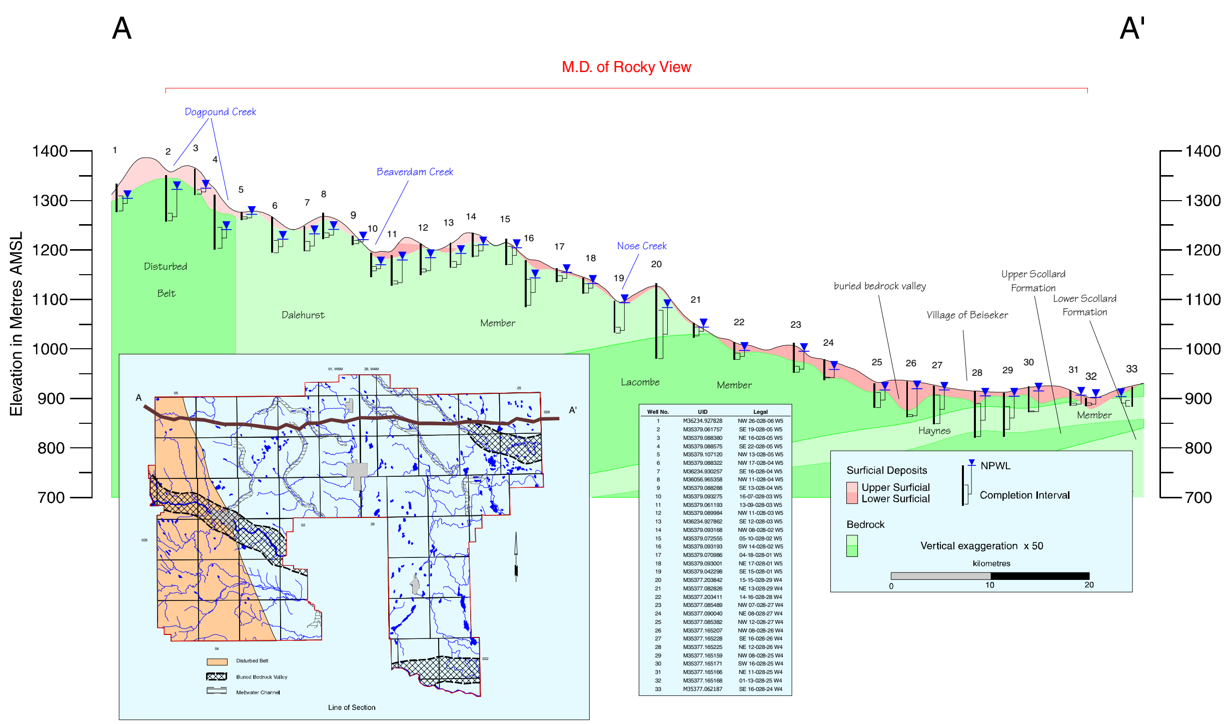

Figure 9. Cross-Section A - A'

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

13 See glossary

5.2 Aquifers in Surficial Deposits

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. The *lower surficial deposits* include pre-glacial fluvial[14] and lacustrine[15] deposits. The lacustrine deposits include clay, silt and fine-grained sand. The *upper surficial deposits* include the more traditional glacial deposits of till[16] and meltwater deposits. Pre-glacial materials are expected to be mainly present in the eastern two-thirds of the M.D., and in association with the buried bedrock valleys. The glacial meltwater channels (Shetsen, 1987) are primarily in the northern half of the M.D.

5.2.1 Geological Characteristics of Surficial Deposits

While the surficial deposits are treated as one hydrogeologic unit, they consist of three hydraulic parts. The first unit is the sand and gravel deposits of the lower surficial deposits, 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. For a graphical depiction of the above description, please refer to Figure 5, page 8. While the unsaturated deposits are not technically an aquifer, they are significant as they provide a pathway for liquid contaminants to move downward into the groundwater.

The base of the surficial deposits is the bedrock surface, represented by the bedrock topography as shown on the adjacent map.

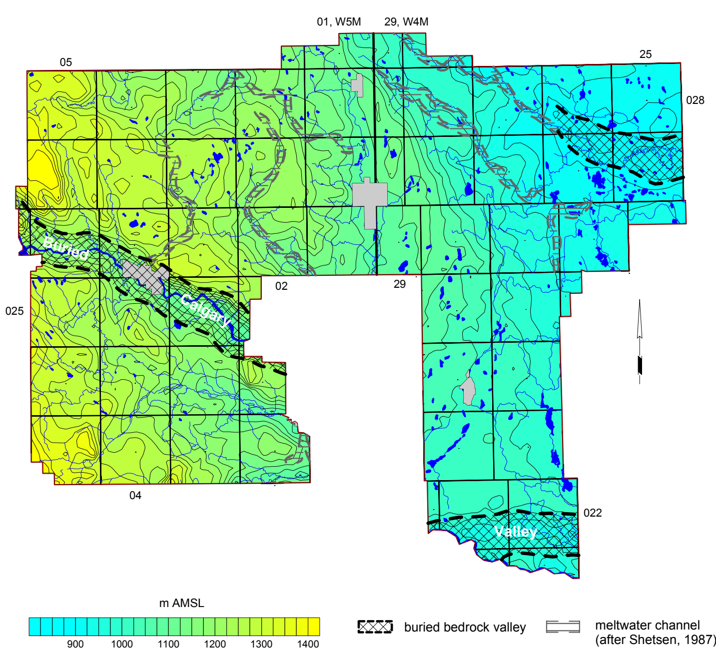

Figure 10. Bedrock Topography

Over the majority of the M.D., the surficial deposits are less than 50 metres thick (page A-22). The exceptions are mainly in association with areas where buried bedrock valleys are present, where the deposits can have a maximum thickness of more than 50 metres. The main linear bedrock low in the M.D. is northwest-southeast-trending and has been designated as the Buried Calgary Valley; the unnamed buried bedrock valley in the northeastern part of the M.D. is a tributary valley to the Buried Calgary Valley in Special Areas 2.

The Buried Calgary Valley is present in the southern part of the M.D., and is coincidental with the present-day Bow River. The Valley is six to nine kilometres wide within the M.D., with local bedrock relief being up to 75 metres. Sand and gravel deposits can be expected in association with this bedrock low, with the sand and gravel deposits expected to be mainly less than 15 metres thick.

The buried bedrock valley present in the northeastern part of the M.D. mainly parallels the stretch of present-day Rosebud River between the villages of Beiseker and Irricana. The Valley is less than nine kilometres wide within

14 See glossary
15 See glossary
16 See glossary

the M.D., with local bedrock relief being up to 40 metres. Sand and gravel deposits can be expected in association with this bedrock low, with the thickness of the sand and gravel deposits being mainly less than 15 metres.

The lower surficial deposits are composed mostly of fluvial and lacustrine deposits. Lower surficial deposits occur mainly in the linear bedrock lows and in the eastern two-thirds of the M.D. The total thickness of the lower surficial deposits is mainly less than 30 metres, but can be more than 50 metres in the buried bedrock valleys. The lowest part of the lower surficial deposits includes pre-glacial sand and gravel deposits. These deposits would generally be expected to directly overlie the bedrock surface in the buried bedrock valleys. The lowest sand and gravel deposits are of fluvial origin, are usually less than five metres thick and may be discontinuous.

In the M.D., several meltwater channels mainly overlie linear bedrock lows. Because sediments associated with the lower surficial deposits are indicated as being present in many of these linear bedrock lows, it is possible that the bedrock lows were originally tributaries to the buried bedrock valleys as shown in the bedrock topography map on Figure 10.

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. Because the meltwater channels are mainly an erosional feature, the sand and gravel deposits associated with these features are considered not to be significant aquifers. The major meltwater channels in the M.D. have been outlined by Shetsen (1987). The thickness of the upper surficial deposits is mainly less than 30 metres, but can be more than 30 metres in the northwestern and southwestern parts of the M.D. Upper surficial deposits are mainly absent from the buried bedrock valleys (see CD-ROM).

Sand or gravel deposits (Figure 11) are reported in association with the Buried Calgary Valley and the unnamed bedrock low that occurs in the northeastern part of the M.D. In addition to the major bedrock lows, sand or gravel deposits are reported at a few other locations in the M.D. The main occurrence of sand or gravel in the M.D. not associated with linear bedrock lows occurs along a line from the northwestern corner of the City of Calgary to the northwestern corner of the M.D. This sand or gravel deposit occurs along a topographically high area and is indicated as being an “ice contact deposit”. Within this area, sand or gravel deposits are up to 20 metres thick and have a lateral extent of approximately eight kilometres.

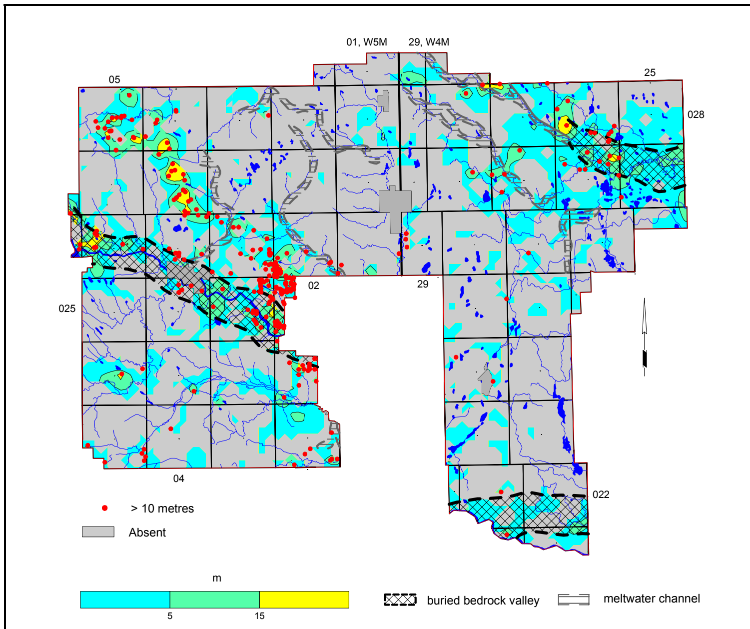

Figure 11. Thickness of Sand and Gravel Deposits

The combined thickness of all sand and gravel deposits has been determined as a function of the total thickness of the surficial deposits. Over approximately 40% of the M.D. where sand and gravel deposits are present, the sand and gravel deposits are more than 30% of the total thickness of the surficial deposits (page A-25). The areas where sand and gravel deposits constitute more than 30% of the total thickness of the surficial deposits are mainly in the areas associated with the buried bedrock valleys and along a line from the northwestern corner of the City of Calgary to the northwestern corner of the M.D.

5.2.2 Sand and Gravel Aquifer(s)

One source of groundwater in the M.D. includes aquifers in the surficial deposits. Since the sand and gravel aquifer(s) are not everywhere, the actual aquifer that is developed at a given location is usually dictated by the aquifer that is present. In the M.D., the thickness of the sand and gravel aquifer(s) is generally less than five metres, but can be more than 15 metres in the area northwest of Calgary (page A-26).

From the present hydrogeological analysis, 295 water wells are completed in aquifers in the surficial deposits. Of the 295 water wells, 118 are completed in aquifers in the upper surficial deposits and 177 are completed in aquifers in the lower surficial deposits. This number of water wells is slightly more than the number (222) 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.

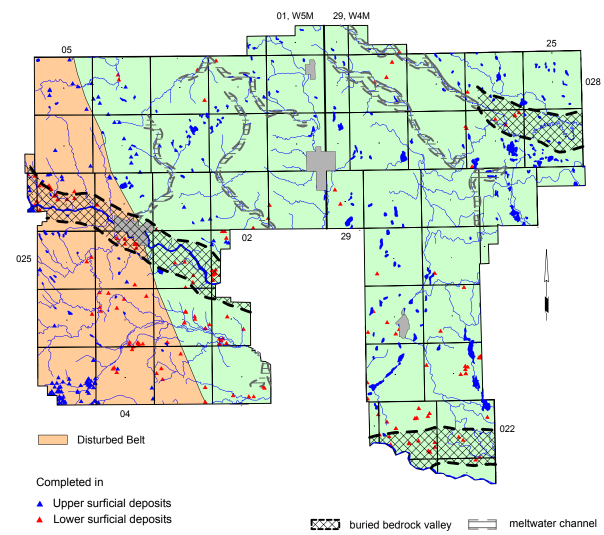

Figure 12. Water Wells Completed in Surficial Deposits

Water wells completed in the upper surficial deposits occur mainly near or within the Disturbed Belt area and in the southwestern part of the M.D. Water wells completed in the lower surficial deposits occur mainly in the vicinity of streams and linear bedrock lows (Figure 12).

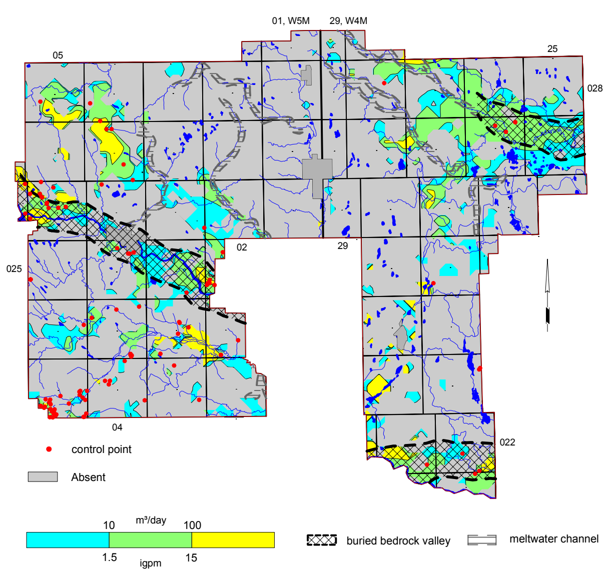

Figure 13. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

The adjacent map shows expected yields for water wells completed in sand and gravel aquifers(s). Over approximately 70% of the M.D., the sand and gravel deposits are not present, or if present, are not saturated; these areas are designated as grey on the map.

Based on the aquifers that have been developed by existing water wells, these data show that water wells with yields of less than 100 m³/day from sand and gravel aquifer(s) can be expected in most of the M.D. The most notable areas where yields of more than 100 m³/day are expected are mainly in association with the buried bedrock valleys, but can also occur in the northwestern part of the M.D. In the M.D., there are approximately 110 records for surficial water wells with apparent yield data.

There are no records for water wells completed in the sand and gravel aquifer(s) that indicate 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 apparent yield grid if the saturated sand and gravel deposits had a thickness of less than 0.1 metres.

5.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

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

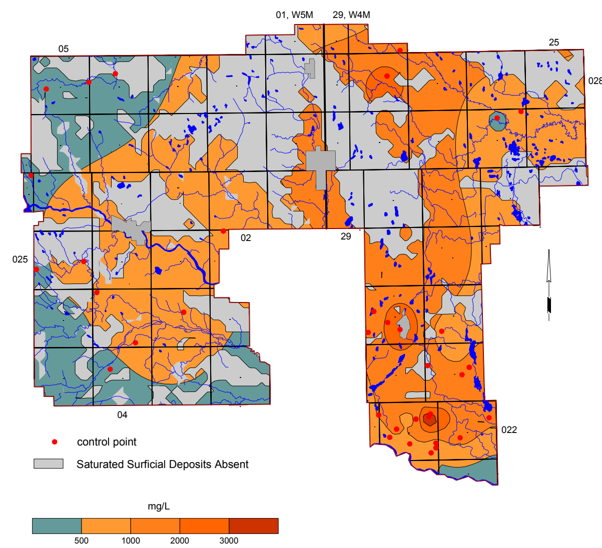

Figure 14. Total Dissolved Solids in Groundwater from Surficial Deposits

The Piper tri-linear diagram[17] (page A-32) for surficial deposits shows the groundwaters have no dominant cation but are mainly bicarbonate-type waters. Nearly 80% of the groundwaters from the surficial deposits have a TDS concentration of more than 500 mg/L. Groundwaters having TDS concentrations of less than 500 mg/L occur mainly in the Disturbed Belt area and have a completion depth of less than 30 metres. Seventy-five percent of the groundwaters from the surficial deposits are reported to have dissolved iron concentrations of less than one mg/L. However, many iron analysis results are questionable due to varying sampling and analytical methodologies.

There are groundwaters with sulfate as the main anion. The groundwaters with elevated levels of sulfate generally occur in areas where there are elevated levels of total dissolved solids. There are very few groundwaters from the surficial deposits with appreciable concentrations of the chloride ion and in 95% of the samples analyzed for surficial deposits in the M.D., the chloride ion concentration is less than 50 mg/L (see CD-ROM).

Constituent	Range for M.D. in mg/L Minimum	Maximum	Median	Recommended Maximum Concentration SGCDWQ
Total Dissolved Solids	166	5158	782	500
Sodium	5	510	106	200
Sulfate	0	2069	189	500
Chloride	1	86	7	250
Nitrate + Nitrite (as N)	0	4	0.0	10

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

Table 3. Concentrations of Constituents in Groundwaters from Surficial Aquifers

In the M.D., the nitrate + nitrite (as N) concentrations in the groundwaters from the surficial deposits are below the maximum acceptable concentrations (MAC) of ten mg/L in all of the samples. However, a recent study indicated that nitrates from water wells completed in the surficial deposits exceeded the SGCDWQ in 67% of the 81 untreated groundwater samples analyzed in the Bragg Creek Area (BSc Environmental Science, 2000).

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

[17] See glossary

5.2.3 Upper Sand and Gravel Aquifer

The Upper Sand and Gravel Aquifer includes saturated sand and gravel deposits in the upper surficial deposits. Typically, these aquifers are present within the surficial deposits at no particular depth. Saturated sand and gravel deposits in the upper surficial deposits are not usually continuous over large areas but are expected over approximately 5% of the M.D.

5.2.3.1 Aquifer Thickness

The thickness of the Upper Sand and Gravel Aquifer is a function of two parameters: (1) the elevation of the non-pumping water-level surface associated with the surficial deposits; and (2) the depth to the bedrock surface or the depth to the top of the lower surficial deposits when present. In the M.D., the thickness of the Upper Sand and Gravel Aquifer is generally less than ten metres, but can be more than 20 metres in township 027, range 04, W5M (see CD-ROM).

5.2.3.2 Apparent Yield

The permeability of the Upper Sand and Gravel Aquifer can be high. The high permeability combined with significant thickness leads to an extrapolation of high yields for water wells; however, because the sand and gravel deposits occur mainly as hydraulically discontinuous pockets, the long-term yields of the water wells are expected to be less than the apparent yields. The long-term yields for water wells completed through this Aquifer are expected to be mainly less than those shown on the adjacent figure. Apparent yields of greater than 100 m³/day may be encountered in the northwestern part of the M.D.

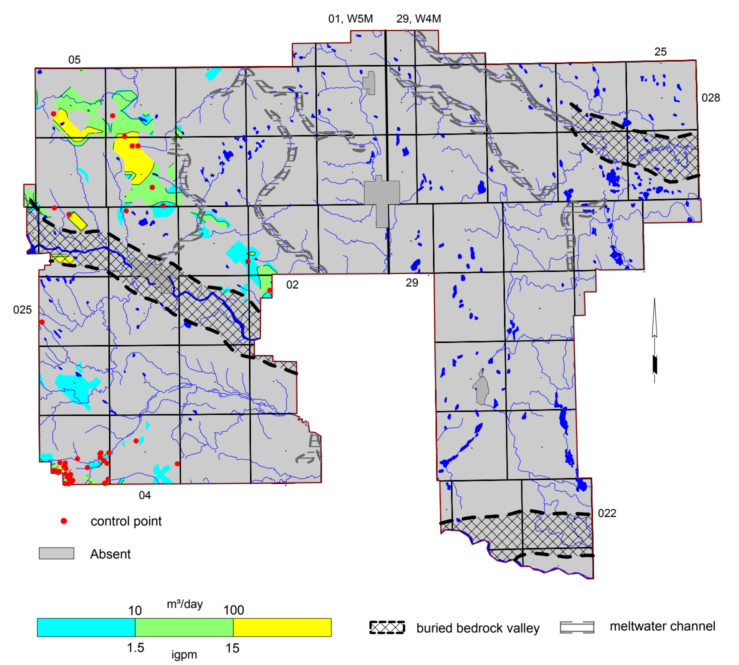

Figure 15. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

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

In the M.D., there is one licensed water well that is completed through the Upper Sand and Gravel Aquifer, with an authorized diversion of 3.4 m³/day. This water supply well in 03-10-024-05 W5M is licensed for agricultural purposes but could not be linked to a water well in the AENV groundwater database.

An aquifer test conducted by HCL with a water test hole in SW 18-025-05 W5M completed in the Upper Sand and Gravel Aquifer indicated that a projected long-term yield for this water test hole was 16 m³/day (HCL, 1981).

5.2.4 Lower Sand and Gravel Aquifer

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

5.2.4.1 Aquifer Thickness

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

5.2.4.2 Apparent Yield

Apparent yields for water wells completed in the Lower Sand and Gravel Aquifer range from less than 10 m³/day to more than 100 m³/day. The most notable areas where yields of more than 100 m³/day are expected are mainly in association with the buried bedrock valleys, but can also occur in the northwestern part of the M.D.

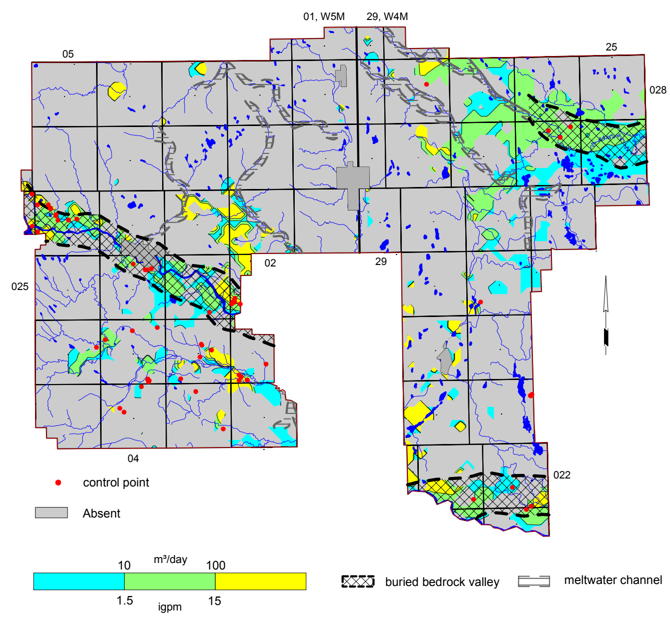

Figure 16. Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer

In the M.D., there are 25 licensed water wells that are completed through the Lower Sand and Gravel Aquifer, for a total authorized diversion of 20,709 m³/day, of which 95% is used for dewatering purposes.

Eleven of the 25 licensed water wells completed through the Lower Sand and Gravel Aquifer could be linked to a water well in the AENV groundwater database.

The Sam Livingston Fish Hatchery in the City of Calgary is licensed to divert 15,430 m³/day from eleven water supply wells completed in the Lower Sand and Gravel Aquifer. Eight of the water supply wells have a priority date of 1971 and the remaining three have a priority date of 1994. These three water supply wells were drilled in the 1950s to be used by the Village of Forest Lawn. Results of aquifer tests conducted in 1981 indicated to the consultant that the three Forest Lawn water supply wells had a direct hydraulic connection with the Bow River. However, data were not available that would confirm that a direct hydraulic connection exists between the Lower Sand and Gravel Aquifer and the Bow River. The Forest Lawn water supply wells are reported to have a combined pumping capacity of 7,855 m³/day (Brisbin Gates & Partners, 1981). Attempts to obtain groundwater monitoring records for the eleven water supply wells were unsuccessful.

5.3 Bedrock

5.3.1 Geological Characteristics

In the M.D., the upper bedrock comprises the Disturbed Belt, and the Paskapoo and Upper Scollard formations.

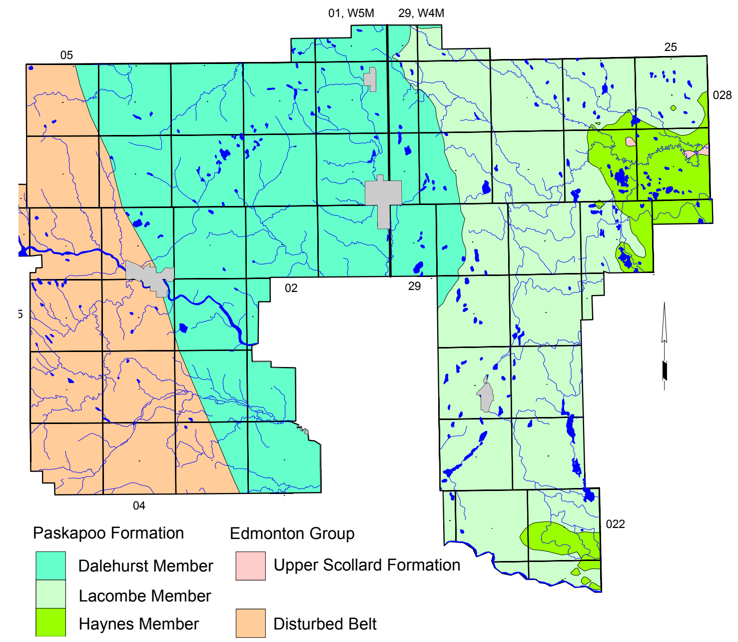

Figure 17. Bedrock Geology

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

The Paskapoo Formation consists of cycles of thick, tabular sandstone, siltstone and mudstone layers (Glass, 1990). The maximum thickness of the Paskapoo Formation is generally less than 800 metres, but in the M.D., the thickness can be as much as 1,100 metres. A generalized geologic column is illustrated on Figure 5, in Appendix A and on the CD-ROM showing the Paskapoo Formation overlying the Scollard Formation. The Paskapoo Formation subcrops in all of the M.D., with the exception of the area in the foothills region that is referred to as the Disturbed Belt.

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

The Dalehurst Member subcrops mainly west of the 5th Meridian but also subcrops east to parts of range 28, W4M. This Member has a maximum thickness of 800 metres within the M.D. and is mostly composed of shale and siltstone with sandstone, bentonite and coal seams or zones. Two prominent coal zones within the Dalehurst are the Obed-Marsh Coal (up to 30 metres thick) and the Lower Dalehurst Coal (up to 50 metres thick). The bottom of the Lower Dalehurst Coal is the border between the Dalehurst and Lacombe members (Demchuk and Hills, 1991).

The Lacombe Member underlies the Dalehurst Member and subcrops east of the 5th Meridian, within the M.D. border. The maximum thickness of the Lacombe Member is generally less than 350 metres. The upper part of the Lacombe Member is mostly composed of shale interbedded with sandstone and has a maximum thickness of 250 metres. The lower part of the Lacombe Member is composed of sandstone and coal layers. In the middle of the lower part of the Lacombe Member there is a coal zone, which can be up to five metres thick. The lower part of the Lacombe Member has a maximum thickness of 100 metres. Within the M.D., the Lacombe Member has a maximum thickness of 250 metres.

The Haynes Member underlies the Lacombe Member, has a maximum thickness of 100 metres and is composed mainly of sandstone with some siltstone, shale and coal. In the M.D., the Haynes Member has a maximum thickness of 50 metres.

The Scollard Formation underlies the Haynes Member, has a maximum thickness of 160 metres and has two separate designations: Upper and Lower. The Upper Scollard consists mainly of sandstone, siltstone, shale and coal seams or zones. Two prominent coal zones within the Upper Scollard are the Ardley Coal (up to 20 metres thick) and the Nevis Coal (up to 3.5 metres thick). The bottom of the Nevis Coal Seam is the border between the Upper and Lower Scollard formations. In the M.D., the Upper Scollard has a maximum thickness of 100 metres; the Lower Scollard Formation has an average thickness of 40 metres, and is composed mainly of shale and sandstone.

There will be no direct review of the Lower Scollard Formation in the text of this report because there are no water wells in the M.D. that are completed in the Lower Scollard Formation; the only maps associated with the Lower Scollard Formation to be included on the CD-ROM will be structure-contour maps.

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

5.3.2 Aquifers

Geologic Unit	No. of Bedrock Water Wells
Disturbed Belt	1,373
Dalehurst	4,007
Lacombe	2,912
Haynes	203
Upper Scollard	38
Multiple Completions	218
Total	8,751

Table 4. Completion Aquifer

Of the 11,578 water wells in the database, 7,041 were defined as being completed below the top of bedrock and 222 completed in surficial aquifers, based on lithologic information and water well completion details. However, at least a reported completion depth is available for the majority of the remaining 4,315 water wells. Assigning the water well to specific geologic units is possible only if the completion interval is identified. In order to make use of additional information within the groundwater database, it was assumed that if the total drilled depth of a water well was more than ten metres below the top of a particular geologic unit, the water well was assigned to the particular geologic unit. With this assumption, it has been possible to designate the specific bedrock aquifer of completion for 8,533 water wells. The remaining 218 of the total 8,751 bedrock water wells are identified as being completed in more than one bedrock aquifer. The bedrock water wells are mainly completed in the Dalehurst and Lacombe aquifers, as shown in the table above.

There are 3,819 records for bedrock water wells that have apparent yield values, which is 44% of the 8,751 bedrock water wells. In the M.D., yields for water wells completed in the upper bedrock aquifer(s) are mainly between 10 and 75 m³/day. Some of the areas with yields of more than 75 m³/day are in association with linear bedrock lows, as shown on the adjacent figure. These areas where higher yields are expected may identify locations of increased permeability resulting from the weathering process. The areas where lower yields are present, for example near Airdrie, may be due to decreased fracture permeability in the bedrock. In addition to the 3,819 records for bedrock water wells, there are 131 records that indicate that the water well 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 131 dry holes prior to gridding. A similar value has been assigned to all dry holes in bedrock aquifers.

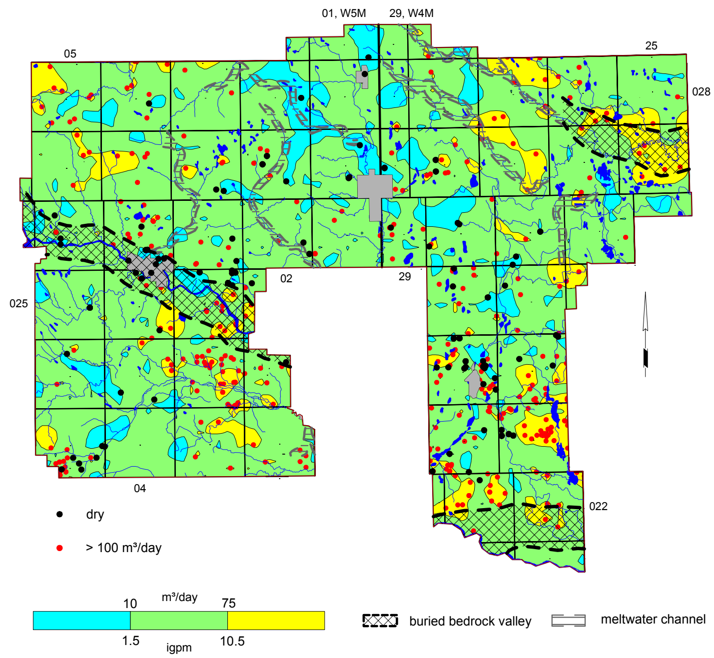

Figure 18. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

Of the 3,819 water well records with apparent yield values, 3,765 have been assigned to aquifers associated with specific geologic units. Thirty-three percent (1,248) of the 3,819 water wells completed in the bedrock aquifers have apparent yields that are less than 10 m³/day, 42% (1,599) have apparent yield values that range from 10 to 75 m³/day, and 25% (972) have apparent yields that are greater than 75 m³/day, as shown in Table 5.

Aquifer	No. of Water Wells with Values for Apparent Yield	Number of Water Wells with Apparent Yields <10 m³/day	10 to 75 m³/day	>75 m³/day
Disturbed	705	249	313	143
Dalehurst	1,531	549	628	354
Lacombe	1,380	390	581	409
Haynes	126	21	55	50
Upper Scollard	23	6	8	9
Multiple Completions	54	33	14	7
Totals	3,819	1,248	1,599	972

Table 5. Apparent Yields of Bedrock Aquifers

5.3.3 Chemical Quality of Groundwater

The Piper tri-linear diagram for bedrock aquifers (page A-32) shows that all chemical types of groundwater occur in the bedrock aquifers. However, the majority of the groundwaters are sodium-bicarbonate or sodium-sulfate types.

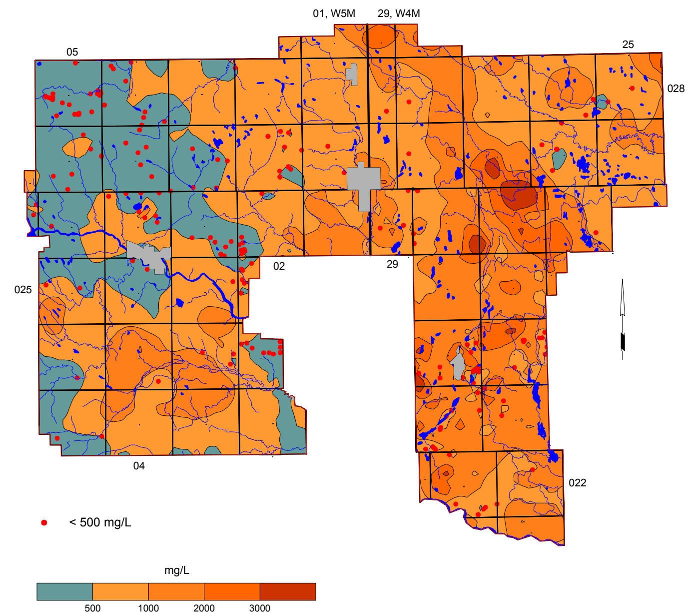

Figure 19. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

The TDS concentrations in the groundwaters from the upper bedrock aquifer(s) range from less than 500 to more than 3,000 mg/L. Most of the groundwaters with lower TDS concentrations occur in the western part of the M.D.

The lower TDS concentrations in the Disturbed Belt and Dalehurst aquifers may be a result of more active flow systems and shorter flow paths due to the pronounced local relief.

The relationship between TDS and sulfate concentrations shows that when TDS values in the groundwaters from the upper bedrock aquifer(s) exceed 1,200 mg/L, the sulfate concentrations exceed 400 mg/L. The sulfate concentrations in groundwaters from upper bedrock aquifer(s) were compared to the distance of completion depth from the top of the Lacombe Member. Groundwaters from bedrock water wells mainly completed within 200 metres below the top of the Lacombe Member tend to have higher sulfate concentrations than groundwaters from water wells completed outside that range, as shown below in Figure 20.

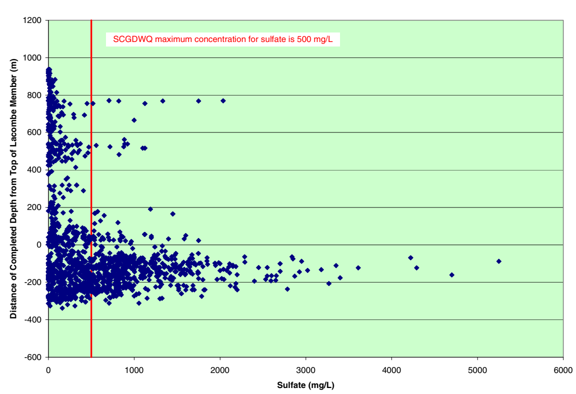

Figure 20. Distance from Top of Lacombe Member vs Sulfate in Groundwaters from Upper Bedrock Aquifer(s)

In the M.D., 98% of the chloride concentrations in the groundwaters from the upper bedrock aquifer(s) are less than 100 mg/L. Chloride values of greater than 100 mg/L are mainly in the Lacombe Aquifer. The nitrate + nitrite (as N) concentrations are less than 0.1 mg/L in 65% of the chemical analyses for upper bedrock water wells. Forty percent of the total hardness values in the groundwaters from the upper bedrock aquifer(s) are greater than 200 mg/L. The higher values of total hardness occur mainly west of the 5th Meridian in the Dalehurst Aquifer (see CD-ROM).

In the M.D., approximately 40% of the groundwater samples from upper bedrock aquifer(s) have fluoride concentrations that are too low (less than 0.5 mg/L) to meet the recommended daily needs of people. Approximately 25% of the groundwater samples from the entire M.D. are between 0.5 and 1.5 mg/L and approximately 35% exceed the maximum acceptable concentration for fluoride of 1.5 mg/L. The fluoride values of greater than 1.5 mg/L occur mainly east of the 5th Meridian in the Lacombe Aquifer (page A-36). In general, when total hardness is less than 150 mg/L, fluoride can be variable, but as total hardness increases, fluoride decreases.

5.3.4 Disturbed Belt Aquifer

The Disturbed Belt Aquifer comprises the permeable parts of the Disturbed Belt, as defined for the present program. Structure contours have not been prepared for the top and bottom of the Disturbed Belt, which underlies the extreme western part of the M.D. The regional groundwater flow direction in the Disturbed Belt Aquifer is toward the Bow River (see CD-ROM).

5.3.4.1 Depth to Top

The depth to the top of the Disturbed Belt is mainly less than 30 metres and is a reflection of the thickness of the surficial deposits.

5.3.4.2 Apparent Yield

The apparent yields for individual water wells completed through the Disturbed Belt Aquifer are mainly in the range of 10 to 75 m³/day. Also shown on the adjacent map are the locations of the 26 dry test holes. The areas showing water wells with yields of greater than 100 m³/day are mainly associated with the edge of the Disturbed Belt.

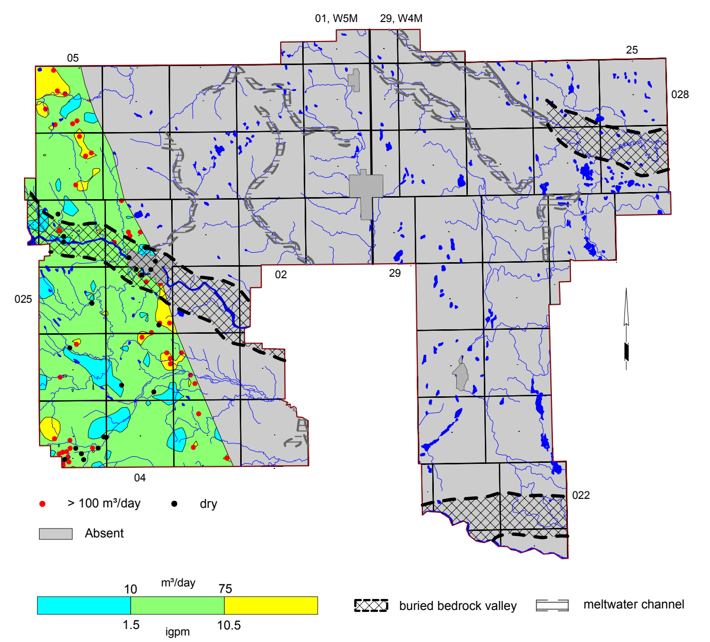

Figure 21. Apparent Yield for Water Wells Completed through Disturbed Belt Aquifer

There are 64 licensed water wells completed through the Disturbed Belt Aquifer, for a total of 467 m³/day; the largest single diversion of 35 m³/day is licensed to a subdivision for a water well in NE 15-023-05 W5M. Thirty-six of the 64 licensed water wells could be linked to a water well in the AENV groundwater database.

An extended aquifer test with a water test hole drilled for subdivision purposes and completed in the Disturbed Aquifer in NW 33-022-04 W5M indicated a long-term yield of 60 m³/day based on an effective transmissivity of 5.5 metres squared per day (m²/day) (UMA, 1976).

The results of an extended aquifer test and a mathematical model conducted with a water well completed in a sandstone layer located within the Disturbed Belt in SW 15-026-04 W5M indicated a long-term yield of 30 m³/day (HCL, December 1986).

5.3.4.3 Quality

The groundwaters from the Disturbed Belt Aquifer are mainly a bicarbonate-type with no dominant cation (see Piper diagram on CD-ROM), with 90% of the groundwater samples having TDS concentrations of less than 1,000 mg/L. The sulfate concentrations are mainly less than 100 mg/L. Chloride concentrations from the Disturbed Belt Aquifer are mainly less than ten mg/L.

The groundwater from the water well in SW 15-026-04 W5M has a TDS concentration of 632 mg/L, a sulfate concentration of 175 and a chloride concentration of 2 mg/L (HCL, December 1986). The groundwater from this water test hole is a sodium-bicarbonate-type.

5.3.5 Dalehurst Aquifer

The Dalehurst Aquifer comprises the permeable parts of the Dalehurst Member, as defined for the present program. The top of the Dalehurst Member is the bedrock surface where the Dalehurst Member is present under the middle third of the M.D. The Dalehurst Member has a thickness that is in the order of 800 metres. The non-pumping water-level surface in the Dalehurst Aquifer is a subdued replica of the bedrock surface (see CD-ROM).

5.3.5.1 Depth to Top

The depth to the top of the Dalehurst Member is a function of the thickness of the surficial deposits, which ranges from less than ten to more than 30 metres (page A-40).

5.3.5.2 Apparent Yield

The apparent yields for individual water wells completed through the Dalehurst Aquifer are mainly in the range of 10 to 75 m³/day, with 20% of the values being more than 100 m³/day. Also shown on the adjacent map are the locations of the 40 dry test holes. The higher yields near the Disturbed Belt may be a reflection of the greater thickness and not the higher permeability of the Dalehurst Aquifer materials.

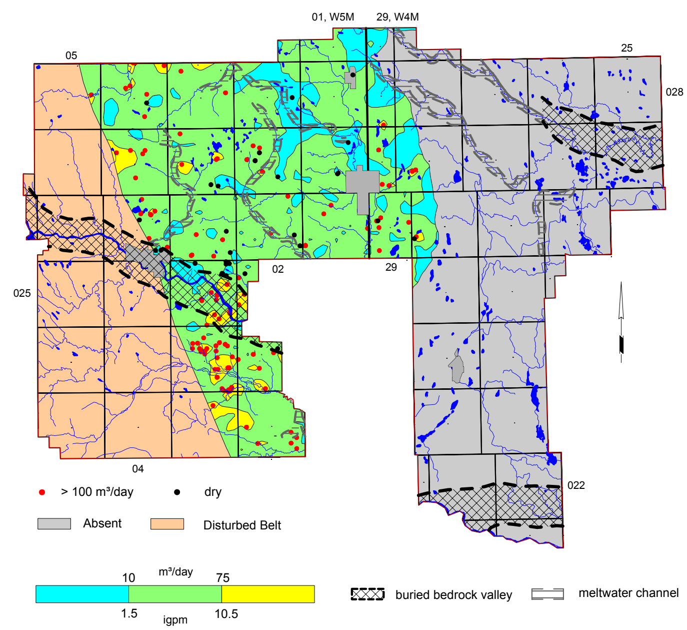

Figure 22. Apparent Yield for Water Wells Completed through Dalehurst Aquifer

In the M.D., there are 176 licensed groundwater water wells completed through the Dalehurst Aquifer, for a total of 3,356 m³/day; the highest diversions are for seven water supply wells in SW 12-025-03 W5M that are licensed to divert a total 1,400 m³/day for municipal purposes. One hundred and thirty-two licensed water wells could be linked to a water well in the AENV groundwater database.

The results of an extended aquifer test conducted with a water well completed in the Dalehurst Aquifer in SW 28-024-03 W5M indicated a predicted safe yield of 150 m³/day (Sabatini GeoEnvironmental Inc., 1999); however, this water well is completed through two separate sandstone layers.

Extended aquifer testing was conducted with three water test holes completed in the Dalehurst Aquifer in 07-22-025-03 W5M. Initial results of the testing indicated that the safe yield from one of the water test holes would be more than approximately 250 m³/day; however, because a projected full recovery was not expected, the safe yield was reduced to a conservative value of 1.6 m³/day (HCL, October 1971).

5.3.5.3 Quality

The groundwaters from the Dalehurst Aquifer are mainly a bicarbonate-to-sulfate type, with calcium-magnesium or sodium as the main cation (see Piper diagram on CD-ROM). TDS concentrations are mainly less than 1,000 mg/L, with lower values near the Disturbed Belt as a result of shorter groundwater flow paths (see CD-ROM). The sulfate concentrations are mainly below 500 mg/L and the chloride concentrations are mainly less than ten mg/L. The fluoride concentrations are mainly below 0.5 mg/L.

5.3.6 Lacombe Aquifer

The Lacombe Aquifer comprises the porous and permeable parts of the Lacombe Member that underlie the Dalehurst Member, and subcrops under the surficial deposits in the eastern half of the M.D. Structure contours have been prepared for the top of the Member. The structure contours show the Lacombe Member having a maximum thickness of in the order of 250 metres. The non-pumping water level in the Lacombe Aquifer is downdip to the east and toward the Bow River in the southern part of the M.D.

5.3.6.1 Depth to Top

The depth to the top of the Lacombe Member ranges from less than ten metres below ground level where the Member subcrops in the eastern part of the M.D. to more than 700 metres in the western part of the M.D. The greatest depth is in areas where the Dalehurst Member is also present (page A-43).

5.3.6.2 Apparent Yield

The apparent yields for individual water wells completed through the Lacombe Aquifer range mainly from 10 to 75 m³/day. Also shown on the adjacent map are the locations of the 51 dry test holes. The largest number of dry test holes appears to be in the vicinity of Chestermere; however, in this area, there are also a number of water wells where yields of more than 100 m³/day are expected. The adjacent map indicates that water wells with apparent yields of more than 75 m³/day are expected in a number of areas. In these areas, weathering processes may be increasing the local permeability. There are no data from the groundwater database for the Aquifer west of the fifth meridian.

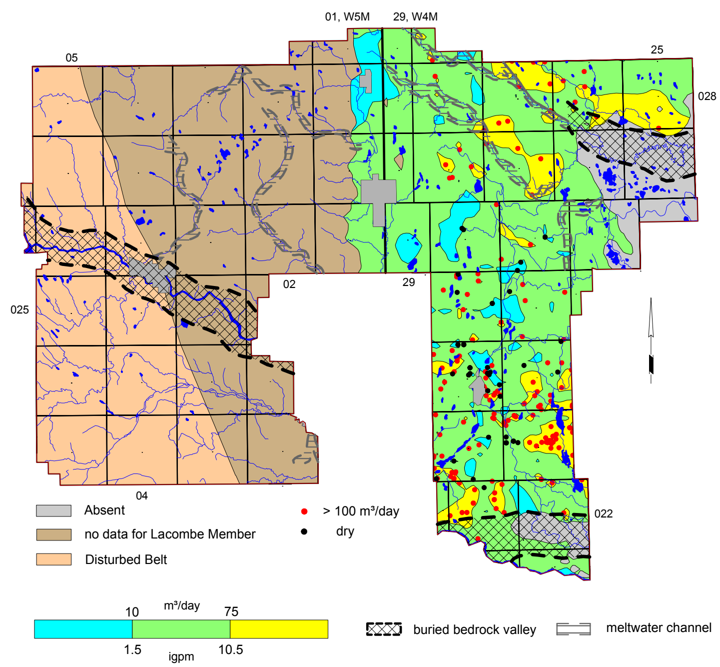

Figure 23. Apparent Yield for Water Wells Completed through Lacombe Aquifer

In the M.D., there are 83 licensed water wells that are completed in the Lacombe Aquifer, for a total of 1,825 m³/day; the highest single allocation is 487 m³/day for a water well used to supply groundwater to a subdivision in 11-23-023-27 W4M. The next highest allocations of more than 80 m³/day are for two water wells used for municipal purposes, one in 04-07-024-27 W4M and one in NE 19-024-28 W4M. Sixty-six licensed water wells could be linked to a water well in the AENV groundwater database.

5.3.6.3 Quality

The groundwaters from the Lacombe Aquifer are mainly sodium-sulfate types (see Piper diagram on CD-ROM). Total dissolved solids concentrations are expected to be mainly greater than 1,000 mg/L. When TDS values in the groundwaters from the Lacombe Aquifer exceed 1,100 mg/L, the sulfate concentrations exceed 400 mg/L. The indications are that chloride concentrations in the Lacombe Aquifer are expected to be mainly less than 50 mg/L. In general, when total hardness values in the groundwaters from the Lacombe Aquifer are less than 100 mg/L, the fluoride concentrations exceed 0.5 mg/L.

5.3.7 Haynes Aquifer

The Haynes Aquifer comprises the porous and permeable parts of the Haynes Member that underlie the Lacombe Member. The Haynes Member subcrops under the surficial deposits in the northeastern part of the M.D and in the extreme southeastern part of the M.D. Structure contours have been prepared for the top of the Member, which underlies most of the M.D. The structure contours show the Haynes Member having an average thickness of in the order of 50 metres. Groundwater flow in the Haynes Aquifer is downdip to the northeast and toward the Bow River (see CD-ROM).

5.3.7.1 Depth to Top

The depth to the top of the Haynes Member ranges from less than 15 metres below ground level where the Member subcrops in the eastern part of the M.D. to more than 1,000 metres in the western part of the M.D. (page A-46).

5.3.7.2 Apparent Yield

The apparent yields for individual water wells completed through the Haynes Aquifer range mainly from 10 to 75 m³/day, as shown in Figure 24. Also shown on the adjacent map are the locations of the two dry test holes.

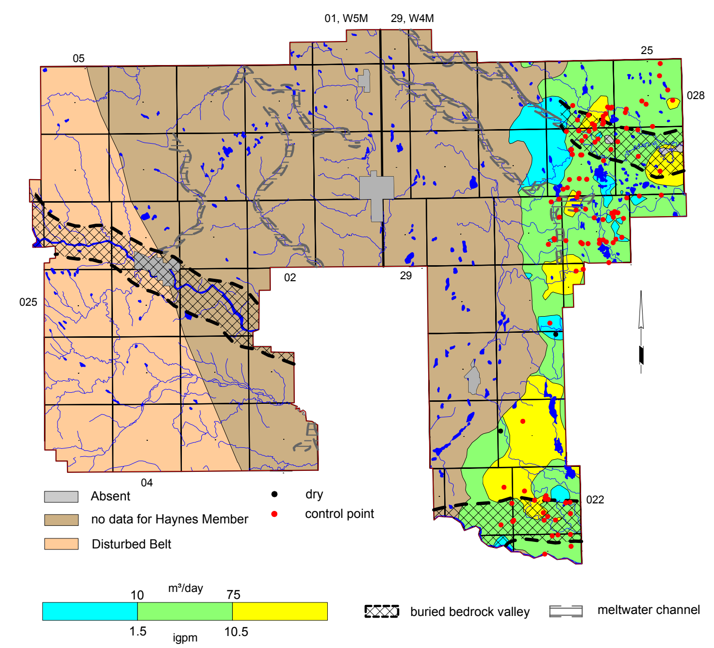

Figure 24. Apparent Yield for Water Wells Completed through Haynes Aquifer

In the M.D., there are 25 licensed water wells that are completed in the Haynes Aquifer, for a total of 1,020 m³/day; the highest single allocation is 338 m³/day for a Village of Beiseker water supply well in 01-03-028-26 W4M for municipal purposes. In addition, the Village has three water supply wells in township 028, range 26, W4M that are licensed for a total of 213 m³/day. The Village of Irricana has three water supply wells in 06-21-027-26 W4M that are licensed for a total of 321 m³/day for municipal purposes. Twenty-one licensed water wells could be linked to a water well in the AENV groundwater database.

Extended aquifer tests conducted with water wells completed in the Haynes Aquifer in the Beiseker area in the mid-1970s by various consultants indicated that long-term yields ranging from 160 to 230 m³/day could be expected.

5.3.7.3 Quality

The groundwaters from the Haynes Aquifer are mainly a sodium-bicarbonate or sulfate type (see Piper diagram on CD-ROM). Total dissolved solids concentrations are mainly less than 1,000 mg/L. The sulfate concentrations are mainly below 500 mg/L. The indications are that chloride concentrations in the Haynes Aquifer are expected to be mainly less than 50 mg/L. More than 30% of the 66 analyses for fluoride concentrations exceed 1.5 mg/L.

A 1984 groundwater sample from the Village of Beiseker WSW No. 7 in 01-03-028-26 W4M has a TDS concentration of 787 mg/L, a chloride concentrations of 26 mg/L, a sulfate concentration of 143 mg/L, and a fluoride concentration of 0.38 mg/L.

5.3.8 Upper Scollard Aquifer

The Upper Scollard Aquifer comprises the porous and permeable parts of the Upper Scollard Formation that underlie the Haynes Member, and subcrops under the surficial deposits only in a very small area of township 027, ranges 26 and 27, W4M. Structure contours have been prepared for the top of the Upper Scollard Formation, which underlies all of the M.D. The structure contours show the Upper Scollard having an average thickness in the M.D. of 100 metres. The main regional groundwater flow in the Upper Scollard Aquifer is downdip toward the northeastern part of the M.D. (see CD-ROM).

5.3.8.1 Depth to Top

The depth to the top of the Upper Scollard Formation is variable, ranging from less than 25 metres to more than 1,100 metres in the northwestern part of the M.D. (page A-49).

5.3.8.2 Apparent Yield

The apparent yields for individual water wells completed through the Upper Scollard Aquifer are mainly in the range of 10 to 75 m³/day. There were no dry test holes. The higher yields in townships 022 and 023, W4M are a reflection of the control points east of the M.D.

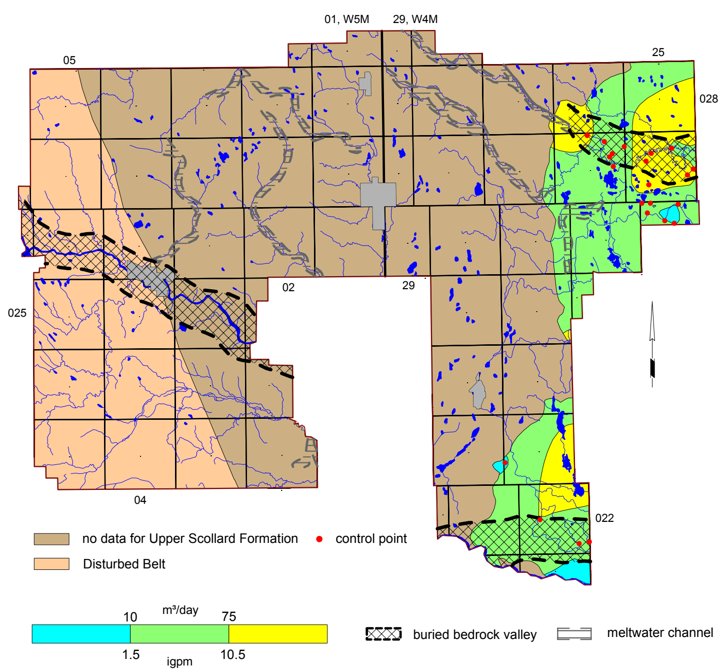

Figure 25. Apparent Yield for Water Wells Completed through Upper Scollard Aquifer

In the M.D., there are nine licensed water wells completed in the Upper Scollard Aquifer, for a total of 132 m³/day; the highest single diversion of 68 m³/day is for the SulFer Works Inc. water source well in 16-33-027-26 W4M used for commercial purposes. Three licensed water wells could be linked to a water well in the AENV groundwater database.

SulFer Works Inc. drilled three water test holes in 1996 that were completed in the Haynes Aquifer. Although extended long-term yields of more than 400 m³/day were calculated (AGRA, 1996), these water test holes were never licensed because interference with domestic water well users was anticipated. Therefore, two additional water test holes were drilled and completed in the Upper Scollard Aquifer, one licensed for 68 m³/day and the other used as an observation water well. From 1999 to 2001, the average daily production at the SulFer Works Inc. facility was 14 m³/day.

5.3.8.3 Quality

The groundwaters from the Upper Scollard Aquifer are mainly a sodium-bicarbonate or sulfate type (see Piper diagram on CD-ROM). Total dissolved solids and sulfate concentrations increase in the direction of groundwater flow. The sulfate concentrations are mainly below 500 mg/L. The indications are that chloride concentrations in the Upper Scollard Aquifer are expected to be mainly less than 100 mg/L.

6. Groundwater Budget

6.1 Hydrographs

In the M.D., there is one observation water well that is part of the AENV regional groundwater-monitoring network where water levels are being measured and recorded with time. This observation water well, AENV Obs WW No. 223, is located in 04-28-027-26 W4M near Irricana, and is completed from 45.7 to 46.9 metres below ground level in the Haynes Aquifer.

In 1996, the Wildrose Country Ground Water Monitoring Association undertook a pilot project in the Beiseker/Irricana area that involved monitoring the groundwater levels in 26 water wells. The Beiseker/Irricana area was selected as the site for the pilot project because of the high level of interest in groundwater issues during the summer of 1996 (HCL, March 1998). The interest was in part a response to proposed industrial development and in part a response to water-level declines that had been observed by some water well owners in the area.

In an area where there are no pronounced seasonal uses of groundwater, the highest water level will usually occur in late spring/early summer and the lowest water level will be in late winter/early spring. In the Wildrose Country Ground Water Monitoring Association pilot study, it was noted that the highest water levels occur in late winter/early spring and the lowest water levels are in late summer/early fall (HCL, March 1998), as shown in the hydrograph for the AENV Obs WW No. 223 (Figure 26). This situation is a result of the significant increase in groundwater use by the villages of Irricana and Beiseker during the summer months. The villages of Irricana and Beiseker have a combined total of ten licensed water supply wells that are completed in the Haynes Aquifer. The present data indicate that water levels in the Beiseker/Irricana Area are continuing to decline at an average of 0.8 metres per year. The decline has been recorded for 15 years in the AENV Obs WW No. 223, which is two kilometres northwest of the Village of Irricana. None of the existing hydrographs of the water wells associated with the WIldrose study show water-level rises that can be related to recharge events. This does not mean there is no recharge, only that there are no data that can be used to quantify the recharge (HCL, March 2001).

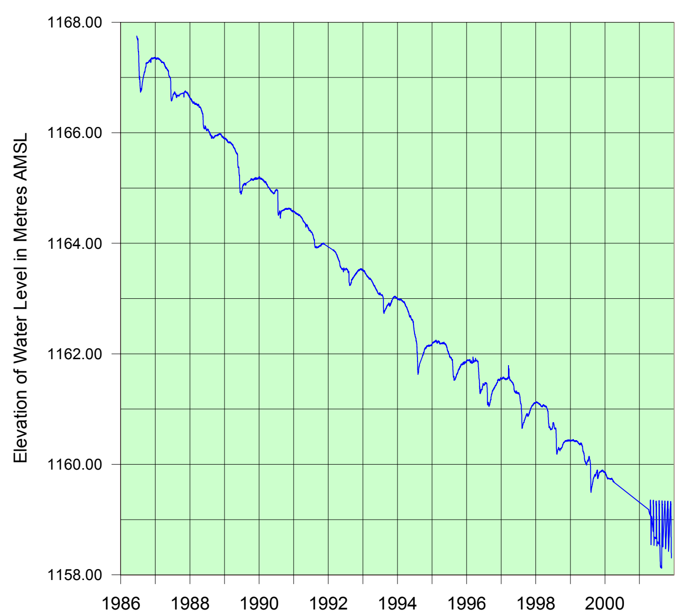

Figure 26. Hydrograph - AENV Obs WW No. 223

The Andrews Water Well is one of the sites that is being monitored as part of the Wildrose Country pilot project. The Andrews WW in NW 27-027-26 W4M is completed from 64.0 to 73.2 metres below ground surface in the Haynes Aquifer. The hydrograph (Figure 27) shows that in 1996 and 1997, water levels have tended to decline during the summer followed by a rise in water level throughout the winter. However, in 1998, 1999 and 2001, the annual pattern of water-level fluctuation changed and the water levels declined in the summer and continued to decline during the winter. The net result is that the water level declined nearly three metres. In 1998, a water-level decline of up to 1.9 metres was also recorded in five other water wells, including four domestic water wells and the Village of Beisker WSW No. 7.

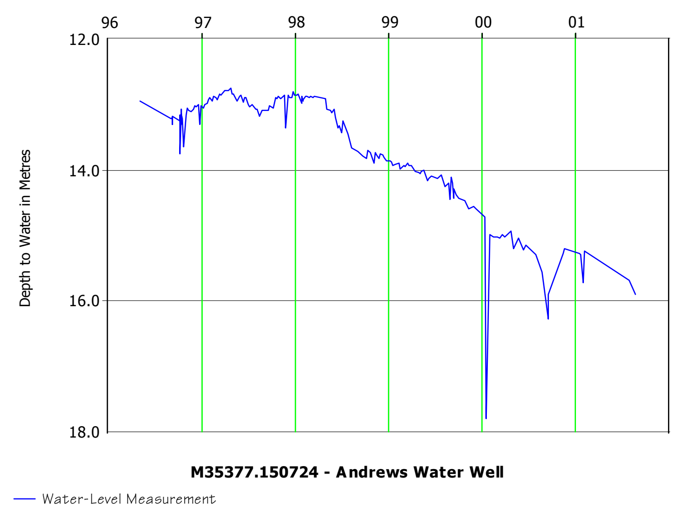

Figure 27. Hydrograph – Andrews Water Well

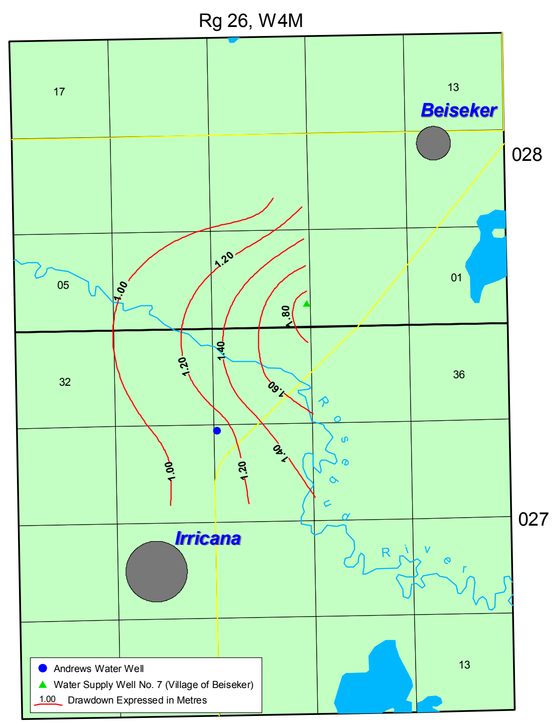

Figure 28. Map of 1998 Drawdown

When the 1998 water-level decline is plotted on a map, the maximum decline can be seen to occur in the SE corner of 03-028-26 W4M. The contour map shown in Figure 28 does not provide the location where the maximum decline has occurred because water-level data are not available from the eastern part of the area. However, Beiseker Water Supply Well No. 7 is located close to the area where the maximum decline is occurring.

Records of the groundwater diversion from the Village of Beiseker WSW No. 7 are available from November 1996 to March 1999. In an attempt to determine if the pumping from WSW No. 7 was the cause of the water-level decline, a mathematical simulation using a model aquifer was completed. The model aquifer was used to calculate the water levels at the Andrews Water Well, based on the production from WSW No. 7. Despite the limited data available, a reasonable match was obtained between measured and calculated water levels between November 1996 and June 1998. However, from June 1998 to March 1999, the calculated water level is up to one metre above the measured water level. The difference between measured and calculated water levels indicates that, from the present understanding of the local hydrogeology, the increase in water-level decline that has occurred since June 1998 is not a result of increased diversion from Beiseker WSW No. 7. This assumes that the production data from Beiseker WSW No. 7 are accurate.

The aquifer model used in the simulation does not take groundwater recharge into account. Therefore, if there were a decrease in recharge to the groundwater, a water-level decline could occur and the simulation would not account for the change. However, if a second water supply well is added to the groundwater simulation, diverting 180 m³/day starting 08 June 1998 and increasing to 225 m³/day on 01 Jan 1999, the calculated water level is very similar to the measured water level, as shown in Figure 29.

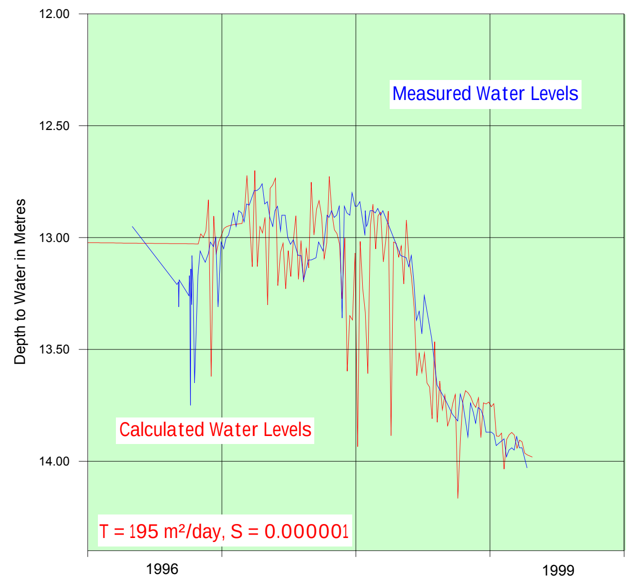

Figure 29. Water-Level Comparison – Andrews Water Well

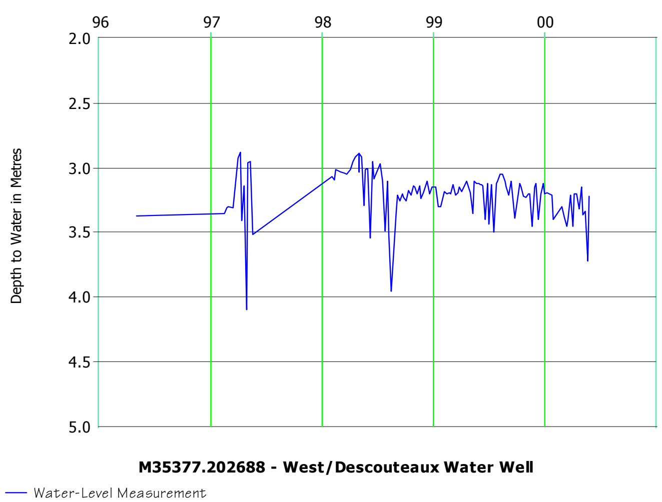

Figure 30. Hydrograph – West/Descouteaux Water Well

The West/Descouteaux Water Well in 04-34-027-26 W4M is completed from 12.2 to 18.3 metres below ground surface in the Lower Sand and Gravel Aquifer. The hydrograph for the West/Descouteaux Water Well (Figure 30) shows that there has been an overall decline in the water level of less than 0.5 metres since on-going groundwater monitoring was initiated in 1998.

The results of the Wildrose Country pilot project have shown the importance of water-level data in the management of the groundwater resource. The groundwater diversion by the Village of Beiseker has had an impact on the water levels in some area water wells; groundwater monitoring is the only method of quantifying that effect.

6.2 Estimated Water Use from Unlicensed Groundwater Users

An estimate of the quantity of groundwater removed from each geologic unit in the M.D. of Rocky View must include both the licensed diversions and the unlicensed use. As stated previously on page 6 of this report, the daily water requirement for livestock for the M.D. based on the 1996 census is estimated to be 14,855 cubic metres. Of the 14,855 m³/day required for livestock, 9,390 m³/day has been licensed by Alberta Environment, which includes both surface water and groundwater. To obtain an estimate of the quantity of groundwater being diverted from the individual geologic units, it has been assumed that the remaining 5,465 m³/day of water required for livestock watering is obtained from unlicensed groundwater use. In the groundwater database for the M.D., there are records for 10,856 water wells that are used for domestic/stock purposes. These 10,856 water wells include both licensed and unlicensed water wells. Of the 10,856 water wells, 947 water wells are used for stock, 997 are used for domestic/stock purposes, and 8,912 are for domestic purposes only.

There are 1,944 water wells that are used for stock or domestic/stock purposes (Table 6). There are 236 licensed groundwater users for agricultural (stock) purposes, giving 1,708 unlicensed stock water wells. (Please refer to Table 1 on page 6 for the breakdown by aquifer of the 236 licensed stock groundwater users). By dividing the number of unlicensed stock and domestic/stock water wells (1,708) into the quantity of groundwater required for stock purposes that is not licensed (5,465 m³/day), the average unlicensed water well diverts 3.2 m³/day for stock purposes. Because of the limitations of the data, no attempt has been made to compensate for dugouts, springs or inactive water wells, and the average stock use is considered to be 3.2 m³/day per stock water well.

Groundwater for household use does not require licensing. Under the Water Act, a residence is protected for up to 3.4 m³/day. However, the standard groundwater use for household purposes is 1.1 m³/day. Since there are 9,909 water wells serving a population of 23,326, the domestic use per water well is 0.6 m^3/day.

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

Domestic 0.6 m³/day
Stock 3.2 m³/day
Domestic/stock 3.8 m³/day

Based on using all available domestic, domestic/stock, and stock water wells and corresponding calculations, the following table was prepared. The table shows a breakdown of the 10,856 unlicensed and licensed water wells used for domestic, stock, or domestic/stock purposes by the geologic unit in which each water well is completed. The final column in the table equals the total amount of unlicensed groundwater that is being used for both domestic and stock purposes. The data provided in the table below indicate that most of the 9,583 m³/day, estimated to be diverted from unlicensed domestic, stock, or domestic/stock water wells, is from the Dalehurst and Lacombe aquifers. In the case of the Lower Sand and Gravel Aquifer, there is slightly more licensed than is projected to be used.

	Unlicensed and Licensed Groundwater Diversions							*Licensed Groundwater Diversions*	*Unlicensed Groundwater Diversions*
Aquifer Designation	Number of Domestic	Daily Use (0.6 m³/day)	Number of Stock	Daily Use (3.2 m³/day)	Number of Domestic and Stock	Daily Use (3.8 m³/day)	Totals m³/day	Totals (m³/day)	Totals m³/day
Upper Sand/Gravel	94	56	11	35	7	27	118	3	115
Lower Sand/Gravel	123	74	16	51	16	61	186	224	-38 (0)
Bedrock	174	104	18	58	38	144	306	83	223
Disturbed Belt	1,070	642	158	506	115	437	1,585	319	1,266
Dalehurst	2,975	1,785	502	1,606	450	1,710	5,101	1,095	4,006
Lacombe	2,364	1,418	199	637	303	1,151	3,206	651	2,555
Haynes	112	67	25	80	34	129	276	147	129
Upper Scollard	14	8	5	16	11	42	66	47	19
Lower Scollard	1	1	0	0	0	0	1	0	1
Unknown	1,985	1,191	13	42	23	87	1,320	13	1,307
Totals	8,912	5,346	947	3,031	997	3,788	12,165	2,582	9,583 (9,621)

Table 6. Unlicensed and Licensed Groundwater Diversions

By assigning 0.6 m³/day for domestic use, 3.2 m³/day for stock use and 3.8 m³/day for domestic/stock use, and using the total maximum authorized diversion associated with any licensed water well that can be linked to a record in the database, a map has been prepared that shows the estimated groundwater use in terms of volume (licensed plus unlicensed) per section per day for the M.D. (not including springs).

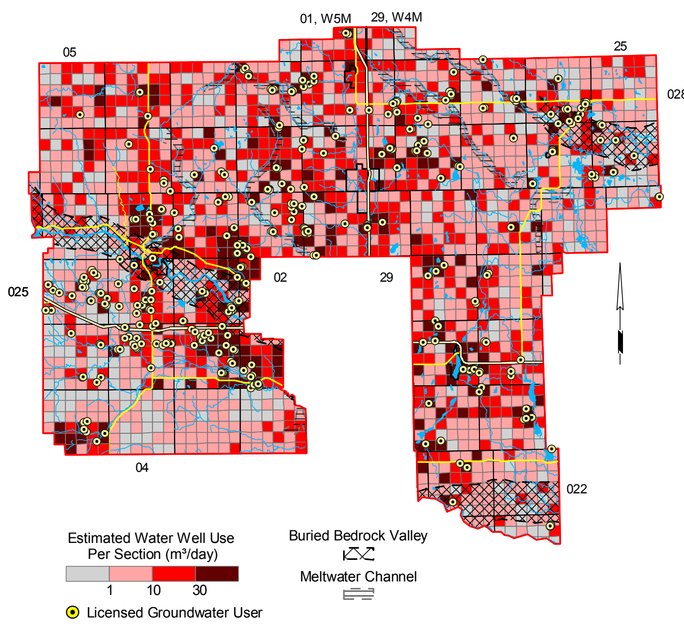

Figure 31. Estimated Water Well Use Per Section

There are 1,891 sections in the M.D. In 23% (437) of the sections in the M.D., there is no domestic or stock or licensed groundwater user. The range in groundwater use for the remaining 1,454 sections with groundwater use is from 0.6 m³/day to more than 19,000 (dewatering) m³/day, with an average use per section of 34 m³/day (5.2 igpm). Without the inclusion of the dewatering well, the average use per section is 20.5 m³/day. The estimated water well use per section can be more than 30 m³/day in 195 of the 1,454 sections. There is at least one licensed groundwater user in 93 of the 195 sections. The most notable areas where water well use of more than 30 m³/day is expected occur mainly in the vicinity of linear bedrock lows and near Calgary, as shown on Figure 31.

Groundwater Use within the M.D. of Rocky View (m³/day)		%
Domestic/Stock (licensed and unlicensed)	12,165	*31*
Municipal (licensed)	3,881	*10*
Commercial/Dewatering/Exploration et al (licensed)	22,576	*58*
Total	38,622	*100*

Table 7. Total Groundwater Diversions

In summary, the estimated total groundwater use within the M.D. of Rocky View is 38,622 m³/day, with the breakdown as shown in the adjacent table. An estimated 2,754 m³/day is being withdrawn from unknown aquifer units. The remaining 35,868 m³/day has been assigned to specific aquifer units. Approximately 75% of the total estimated groundwater use is from licensed water wells.

6.3 Groundwater Flow

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

The flow through each aquifer assumes that by taking a large enough area, an aquifer can be considered as homogeneous, the average gradient can be estimated from the non-pumping water-level surface, and flow takes place through the entire width of the aquifer; flow through the aquifers takes into consideration hydrogeological conditions outside the M.D. border. Based on these assumptions, the estimated lateral groundwater flow through the individual aquifers has been summarized in Table 8:

Aquifer/Area	Trans (m²/day)	Gradient (m/m)	Width (m)	Flow (m³/day)	Aquifer Flow (m³/day)	Licensed Diversion (m³/day)	Unlicensed Diversion (m³/day)	Total (m³/day)
Lower Sand and Gravel					14,600	20,709	0	20,709
Calgary Valley								
east	1200	0.0048	2,500	14383				
Unnamed (northeast)								
southeast	30	0.0023	2,500	174				
Disturbed Belt					22,500	467	1,266	1,733
North								
east	37	0.016	8,000	4625				
Central								
south	27	0.020	15,000	8100				
northeast	12	0.020	15,000	3600				
South								
northeast	22	0.009	30,000	6188				
Dalehurst					109,200	3,356	4,006	7,362
Northcentral								
east	15	0.020	20,000	6000				
west	15	0.010	20,000	3000				
Northwest Central								
east	16	0.007	20,000	2286				
west	16	0.007	10,000	1143				
Northwest								
west	29	0.021	30,000	18125				
northwest	29	0.021	15,000	9063				
southeast	29	0.021	15,000	9063				
north	29	0.021	25,000	15104				
south	29	0.007	25,000	5179				
east	29	0.006	29,000	5256				
West Central								
northeast	22	0.015	15,000	4950				
southwest	22	0.020	15,000	6600				
Southwest 1								
northeast	52	0.010	15,000	8125				
southwest	52	0.010	15,000	8125				
Southwest 2								
northeast	23	0.010	15,000	3594				
southwest	23	0.010	15,000	3594				
Lacombe					12,000	1,825	2,555	4,380
Northeast								
north-northeast	16	0.008	35,000	4667				
Southeast								
East-southeast	49	0.005	30,000	7350				
Haynes					12,030	1,020	129	1,149
Northeast								
Northeast	30.6	0.004	25,000	2732				
Southeast								
northeast	31	0.004	6,000	775				
west	31	0.008	15,000	3875				
south	31	0.010	15,000	4650				
Upper Scollard					210	132	19	151
Northeast								
Northeast	2.5	0.003	20,000	125				
Southeast								
south	2	0.003	12,000	80				

Table 8. Groundwater Budget

Table 8 indicates that there is more groundwater flowing through the aquifers than has been authorized to be diverted from the individual aquifers, except for the Lower Sand and Gravel Aquifer. However, even where use is less than the calculated aquifer flow, there can still be local impacts on water levels as shown by the groundwater monitoring in the Beiseker/Irricana area. The calculations of flow through individual aquifers as presented in the above table are very approximate and are intended only as a guide for future investigations.

6.3.1 Quantity of Groundwater

An estimate of the volume of groundwater stored in the surficial deposits is 0.3 to 1.6 cubic kilometres. This volume is based on an areal extent of 1,100 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).

The adjacent water-level map has been prepared from water levels associated with water wells completed in aquifers in the surficial deposits. The water levels from these water wells were used for the calculation of the saturated thickness of the surficial deposits. In areas where the elevation of the water-level surface is below the bedrock surface, the surficial deposits are not saturated (indicated by grey areas on the map). The water-level map for the surficial deposits shows a general flow direction toward the buried bedrock valleys.

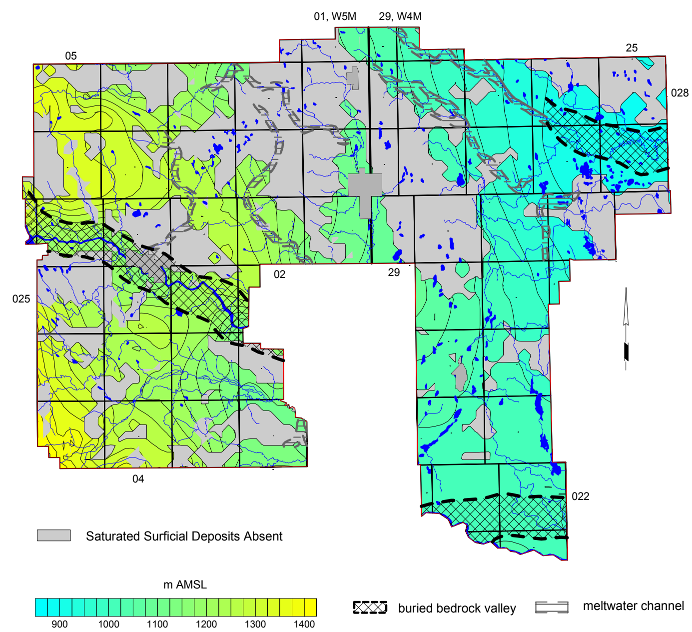

Figure 32. Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep

6.3.2 Recharge/Discharge

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

6.3.2.1 Bedrock Aquifers

Recharge to the bedrock aquifers within the M.D. takes place from the overlying surficial deposits and from flow in the aquifer from outside the M.D. On a regional basis, calculating the quantity of water involved is not possible because of the complexity of the geological setting and the limited amount of data.

In the absence of sufficient water-level data in the surficial deposits, a reasonable hydraulic gradient between the surficial deposits and the upper bedrock aquifer(s) could not be determined. Therefore, the first objective was to determine the location of 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 topographic 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 15 metres below ground surface. The discharge areas are where the water level in the upper bedrock aquifer(s) is less than ten metres below ground surface. When the depth to water level in the upper bedrock aquifer(s) is between ten and 15 metres below ground surface, the area is classified as a transition, that is, no recharge and no discharge.

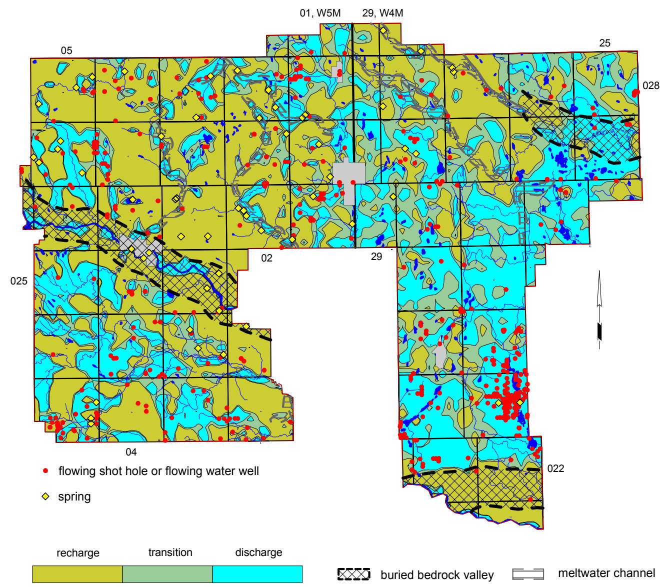

Figure 33. Recharge/Discharge Areas in Upper Bedrock Aquifer(s)

Figure 33 shows that, in more than 60% of the M.D., there is a downward hydraulic gradient from the surficial deposits toward the upper bedrock aquifer(s) (i. e. recharge). Areas where there is an upward hydraulic gradient from the bedrock to the surficial deposits (i. e. discharge) are mainly in the vicinity of creeks and river valleys and major meltwater channels. The remaining parts of the M.D. 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 60% of the M.D. land area being one of recharge to the bedrock, and the average precipitation being 441 mm per year, 5.8% of the precipitation is sufficient to provide the total calculated quantity of groundwater flowing through the upper bedrock aquifer(s).

6.4 Areas of Groundwater Decline

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

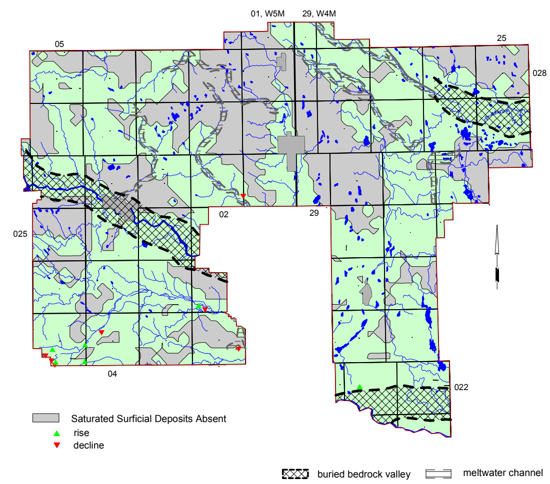

Figure 34. Changes in Water Levels in Sand and Gravel Aquifer(s)

Of the 149 water wells completed in the sand and gravel aquifer(s) with a NPWL and test date, there were only 13 control points. Due to limited control points, the data were not contoured, only posted as shown on the adjacent map. The map shows that the majority of the control points are in the southwestern part of the M.D., and there were approximately the same number of locations where the water level rose, as declined.

The areas of groundwater decline in the bedrock aquifers have been calculated by determining the frequency of non-pumping water level control points per five-year periods from 1925 to 2000. Of the 8,230 bedrock water wells with a non-pumping water level and date, 3,089 are from water wells completed before 1980 and 2,954 are from water wells completed after 1989; the remaining 2,187 are from water wells completed between 1980 and 1990. Where the earliest water level (before 1980) is at a higher elevation than the latest water level (after 1989), there is the possibility that some groundwater decline has occurred. Where the earliest water level is at a lower elevation than the latest water level, there is the possibility that the groundwater has risen at that location. The water level may have risen as a result of recharge in wetter years or may be a result of the water well being completed in a different bedrock aquifer. In order to determine if the water-level decline is a result of groundwater use by licensed users, the licensed groundwater users were posted on the maps.

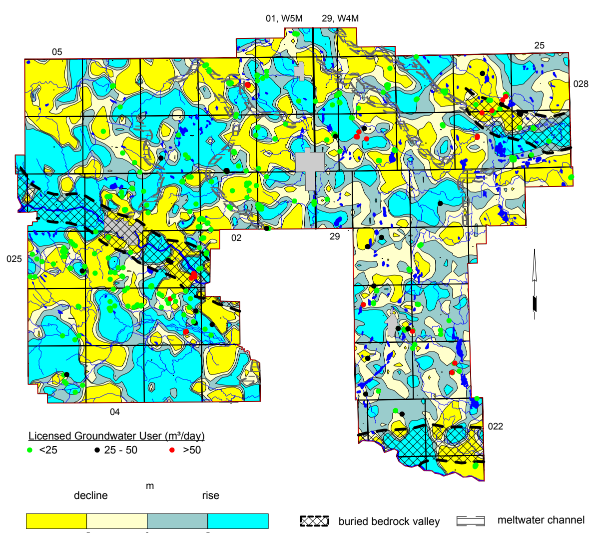

Figure 35. Changes in Water Levels in Upper Bedrock Aquifer(s)

Figure 35 indicates that in 60% of the M.D., it is possible that the non-pumping water level has declined. Of the 362 licensed groundwater users completed in upper bedrock aquifer(s), most occur in areas where a water-level decline may exist. Twenty-eight percent of the areas where there has been a water-level decline of more than five metres corresponds to where the estimated water well use is between 10 and 30 m³/day per section; 11% of the declines occurred where the estimated water well use is more than 30 m³/day per section; 41% of the declines occurred where the estimated water well use is less than 10 m³/day per section; the remaining 20% occurred where there is no groundwater use per section, as shown previously on Figure 31. From this analysis, one area of water-level decline in upper bedrock aquifer(s) is in the Beiseker/Irricana area; local groundwater monitoring by the Wildrose County Ground Water Monitoring Association confirms the water-level decline.

6.5 Discussion on Specific Study Areas

As per the Request for Proposal, the M.D. of Rocky View requested that comments be made, where possible, on the following study areas and issues. The issue is stated at the beginning of each of the following sections. Figure 36 shows the five specific study areas in the M.D.; in Figure 37, the five specific study areas have been color outlined on the bedrock geology map; Figure 38 shows the apparent yield for water wells completed in the Sand and Gravel Aquifer(s); and Figure 39 shows the apparent yield for water wells completed in the Upper Bedrock Aquifer(s).

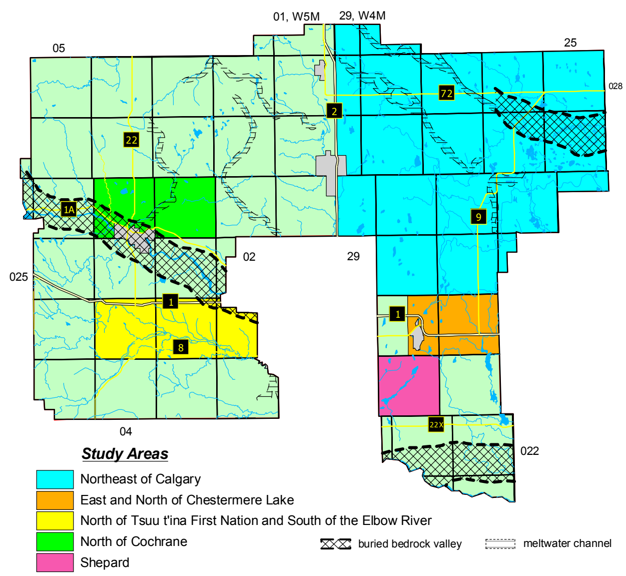

Figure 36. Specific Study Areas

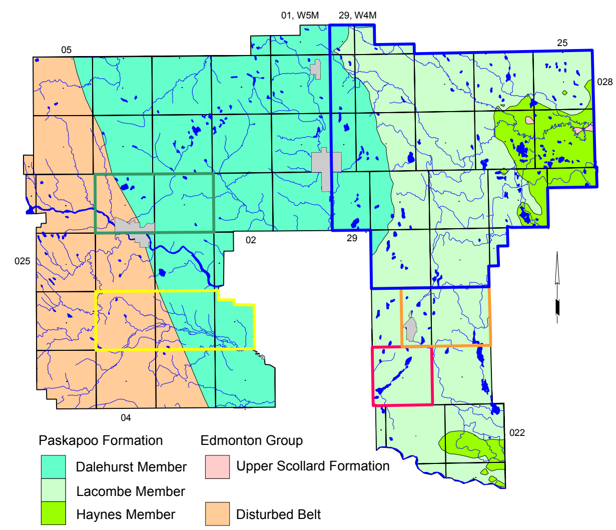

Figure 37. Bedrock Geology of Specific Study Areas

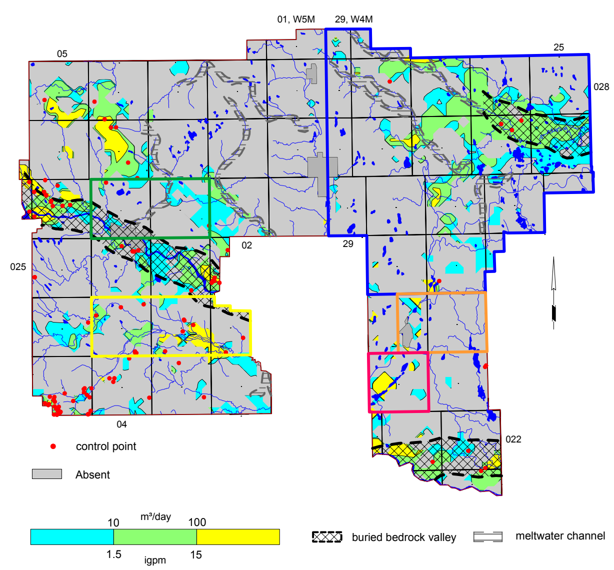

Figure 38. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s) - Specific Study Areas

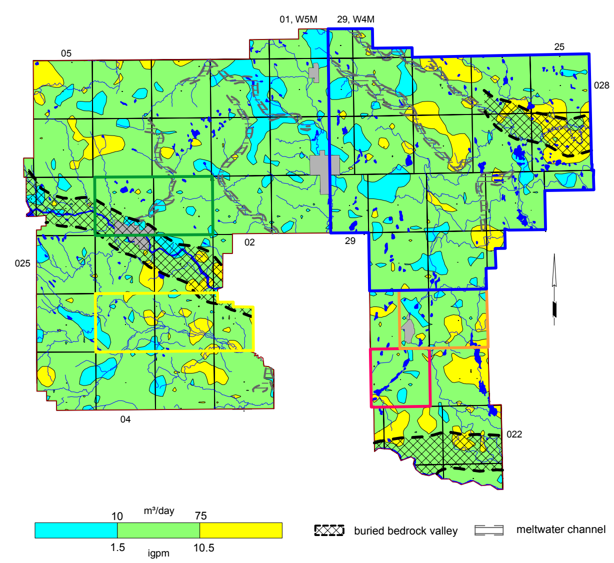

Figure 39. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s) - Specific Study Areas

6.5.1 Area to the Northeast of Calgary

What is the approximate extent and potential (yield and water quality) of the aquifers? Has the drilling of shallow sour gas wells had an effect on water quality and yield?

Although the Lower Sand and Gravel Aquifer is present in parts of the Area, it is primarily the upper bedrock aquifer(s) that are utilized for water supplies. The upper bedrock aquifer(s) include mainly the Dalehurst, Lacombe and Haynes members as shown on Figure 37. Lower apparent yields tend to be present where the Dalehurst Aquifer is the upper bedrock, and the higher yields are associated with the Lacombe and Haynes aquifers, particularly in areas of linear bedrock lows.

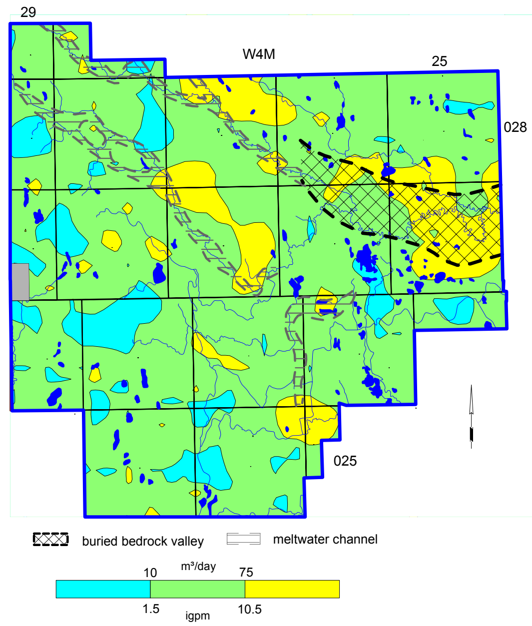

Figure 40. Area Northeast of Calgary - Apparent Yield in Upper Bedrock Aquifer(s)

Groundwaters from water wells completed in the upper bedrock aquifer(s) in this Area are expected to have TDS concentrations of more than 500 mg/L, with TDS concentrations of more than 3,000 mg/L present in parts of townships 026 and 027, ranges 27 and 28, W4M.

In the area to the northeast of Calgary, there are 410 gas wells in the EUB database. Of the 410 gas wells, 13 have a surface casing depth that is less than the maximum depth of an existing water well. These 13 gas wells have a surface casing depth of less than 80 metres and are located primarily in townships 026 and 027, range 25, W4M as shown in the figure below. Of the 410 gas wells, 388 (95%) have a surface casing depth that is above the Base of Groundwater Protection.

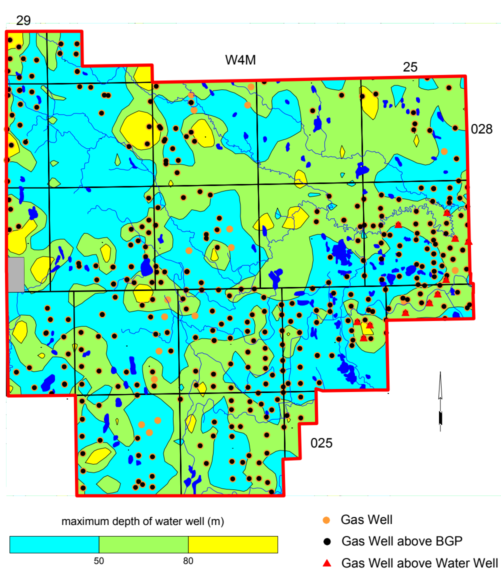

Figure 41. Area Northeast of Calgary - Location of Gas Wells

An investigation for BP Canada Inc. in 1988 (HCL, 1988) was related to lost circulation from their hydrocarbon well in 14-04-048-02 W5M. The investigation showed that a temporary rise in water levels could occur in an aquifer when there is lost circulation. In the BP case, the fluid losses were in the order of 5 cubic metres and the water level was measured in an observation water well at a distance of 125 metres from the hydrocarbon well where the lost circulation occurred. The rise in water level in the observation water well was 0.88 metres over an 11.5-hour interval. The water level declined to its pre-disturbed level within 84 hours. As a result of the lost circulation, there was no detectable change in the chemical quality of the groundwater from a spring located halfway between the hydrocarbon well and the observation water well, where the change in water level was recorded.

The present indications are that the drilling of gas wells does not pose any undue threat to groundwater supplies being used in the area nor to the aquifers from which the water supplies are being obtained.

6.5.2 Area East and North of Chestermere Lake

What is the approximate extent and potential (yield and water quality) of the aquifers?

The Sand and Gravel Aquifer(s) are absent from township 024, range 27, W4M, the township adjacent to the east of Chestermere Lake. Apparent yields in the Sand and Gravel Aquifer(s) are expected to be less than ten m³/day in the Chestermere Lake Area.

Groundwaters from water wells completed in the Chestermere Lake Area in the surficial deposits are expected to have TDS concentrations of more than 500 mg/L.

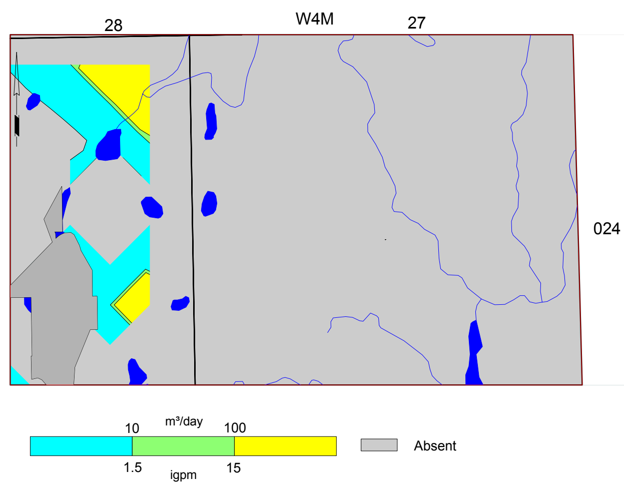

Figure 42. Area East and North of Chestermere Lake - Apparent Yield in Sand and Gravel Aquifer(s)

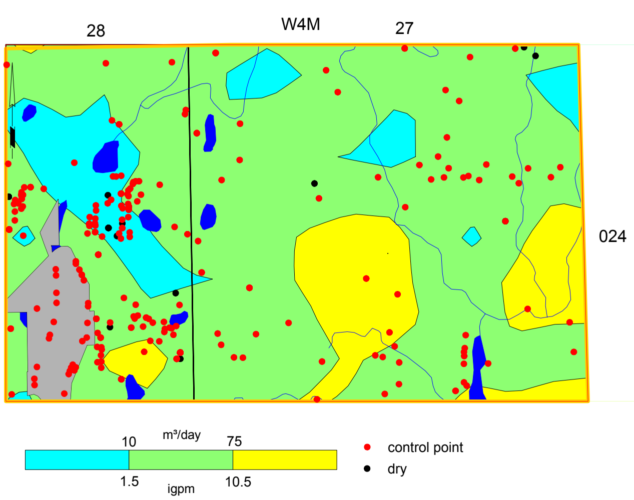

Figure 43. Area East and North of Chestermere Lake - Apparent Yield in Upper Bedrock Aquifer(s)

The upper bedrock in the Area is the Lacombe Member (see Figure 37). The apparent yields in the Lacombe Aquifer immediately northeast of Chestermere Lake are expected to be less than ten m³/day; there are a number of control points within the Town of Chestermere and the data indicate that apparent yields are expected to be between 10 and 75 m³/day. However, higher yields may be encountered in the Lacombe Aquifer in the township east of the Town of Chestermere.

In township 024, range 27, W4M, the largest potable groundwater allocation is 84 m³/day for Rocky View School Div. 41; this water well is used for municipal purposes. In township 024, range 28, W4M, the largest potable groundwater allocation is 30 m³/day for a subdivision water well used for municipal purposes.

Groundwaters from water wells completed in the Chestermere Lake Area in the upper bedrock aquifer(s) are expected to have TDS concentrations of more than 500 mg/L but less than 2,000 mg/L.

6.5.3 Area North of Tsuu t'ina First Nation and South of the Elbow River

What is the approximate extent and potential (yield and water quality) of the aquifers?

The Sand and Gravel Aquifer(s) are present in 30% of the Tsuu t'ina First Nation Area. In the Area, sand and gravel deposits are expected to be less than five metres thick. Shetsen (1987) shows that the main occurrence of sand and gravel deposits in this Area appear to be nearly perpendicular to the Buried Calgary Valley.

In the Area, apparent yields in the Sand and Gravel Aquifer(s) range from less than ten m³/day to more than 100 m³/day with the higher yields in association with a linear bedrock low, coincidental with the Elbow River.

Groundwaters from water wells completed in the Tsuu t'ina First Nation Area in the surficial deposits are expected to have TDS concentrations of less than 1,000 mg/L.

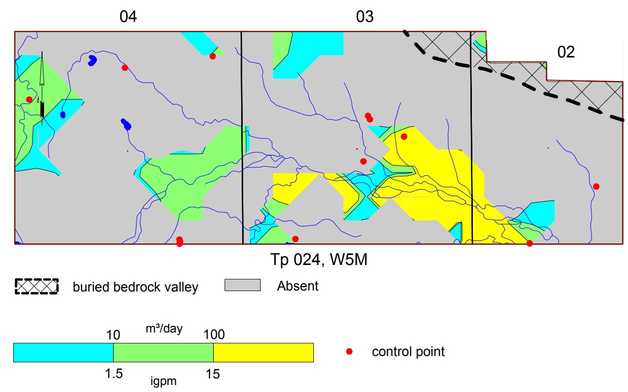

Figure 44. Area North of Tsuu t'ina First Nation and South of the Elbow River - Apparent Yield in Sand and Gravel Aquifer(s)

In the Tsuu t'ina First Nation Area, there are 14 licensed water wells completed in the surficial deposits, of which the largest single potable groundwater allocation is for a water well licensed to Allred's Golf Course in 07-05-024-02 W5M that is authorized to divert 507 m³/day for commercial purposes.

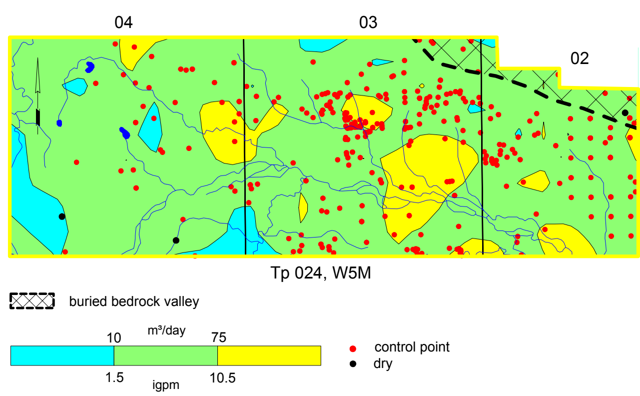

Figure 45. Area North of Tsuu t'ina First Nation and South of the Elbow River - Apparent Yield in Upper Bedrock Aquifer(s)

The upper bedrock in the Area is the Disturbed Belt and the Dalehurst Member (see Figure 37). The higher apparent yields tend to be in water wells completed in the Dalehurst Aquifer. The majority of the control points are in township 024, ranges 02 and 03, W5M (Figure 45). The higher yields south of the Elbow River are expected in the southwestern part of township 024, range 02, W5M and in the southeastern part of township 024, range 03, W5M.

In the Tsuu t'ina First Nation Area, there are 40 licensed water wells completed in the upper bedrock aquifer(s). The highest single allocation of for a water supply well completed in upper bedrock aquifer(s) is 85 m³/day. This water supply well, completed in the Dalehurst Aquifer, is licensed to Elbow River Estates in SW 08-024-02 W5M for municipal purposes.

Groundwaters from water wells completed in the Tsuu t'ina First Nation Area in the upper bedrock aquifer(s) are expected to have TDS concentrations of less than 1,000 mg/L, with the lower TDS concentrations in association with the Buried Calgary Valley.

It might be beneficial to the Tsuu t'ina First Nation to field-verify the water wells within the Area. The level of verification should include obtaining meaningful horizontal coordinates for the water wells and verifying the water level and completed depth.

6.5.4 Area North of Cochrane

What is the approximate extent and potential (yield and water quality) of the aquifers?

The Sand and Gravel Aquifer(s) are mainly absent in the area north of Cochrane. Apparent yields in the Sand and Gravel Aquifer(s), where present, are mainly less than ten m³/day; however, there is only one control point within the Cochrane Area.

Groundwaters from water wells completed in the Cochrane Area in the surficial deposits are expected to have TDS concentrations of between 500 and 1,000 mg/L.

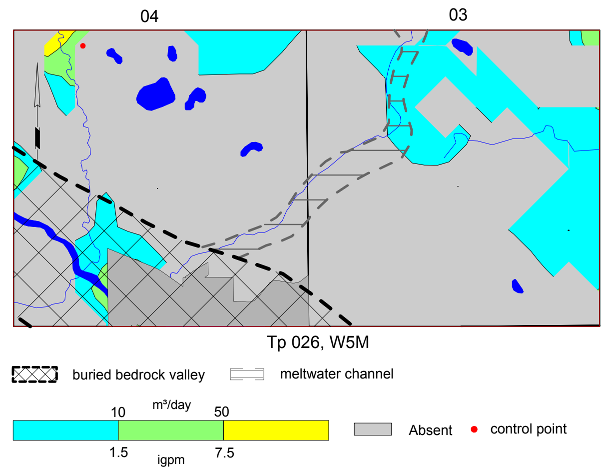

Figure 46. Area North of Cochrane - Apparent Yield in Sand and Gravel Aquifer(s)

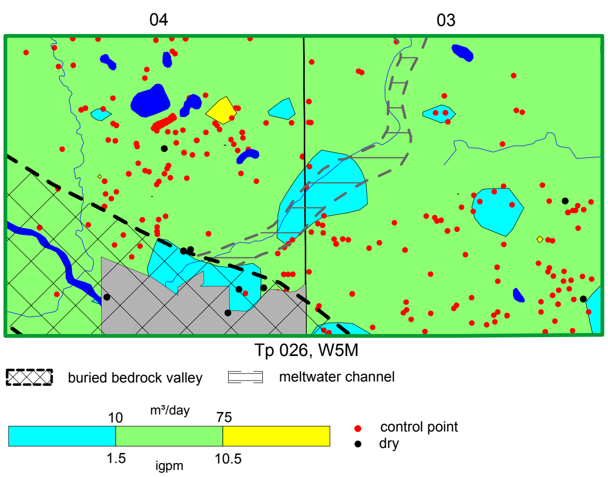

Figure 47. Area North of Cochrane - Apparent Yield in Upper Bedrock Aquifer(s)

The upper bedrock in the Area is the Disturbed Belt and the Dalehurst Member (see Figure 37). The apparent yields are mainly between 10 and 100 m³/day. The majority of the control points are north and east of the northern limits of Cochrane (Figure 45).

The largest potable groundwater allocation is 23.6 m³/day for a water well used for municipal purposes. This water well is completed in the Disturbed Belt in 11-21-026-04 W5M.

Groundwaters from water wells completed in the Cochrane Area in the upper bedrock aquifer(s) are expected to have TDS concentrations of less than 1,000 mg/L, with the lower TDS concentrations associated with the Dalehurst Aquifer.

6.5.5 Shepard Area

Comment on the apparent water quality problems (high fluoride, iron, and sodium) in existing water wells in this area.

In the Shepard Area, there are no chemistry data in the groundwater database for water wells completed in the surficial deposits. Based on the gridding procedure used to process the data points outside of the Shepard Area, TDS concentrations from water wells completed in the surficial deposits are expected to range between 1,000 and 2,000 mg/L.

Based on the results of the gridding procedure from control points outside the Shepard Area, the groundwater quality for surficial water wells in the Shepard Area is similar to other areas in the M.D., with the possible exception of nitrate + nitrite (as N) concentrations, which may be slightly higher in the Shepard Area (see CD-ROM).

The upper bedrock in the Shepard Area is the Lacombe Member (see Figure 37).

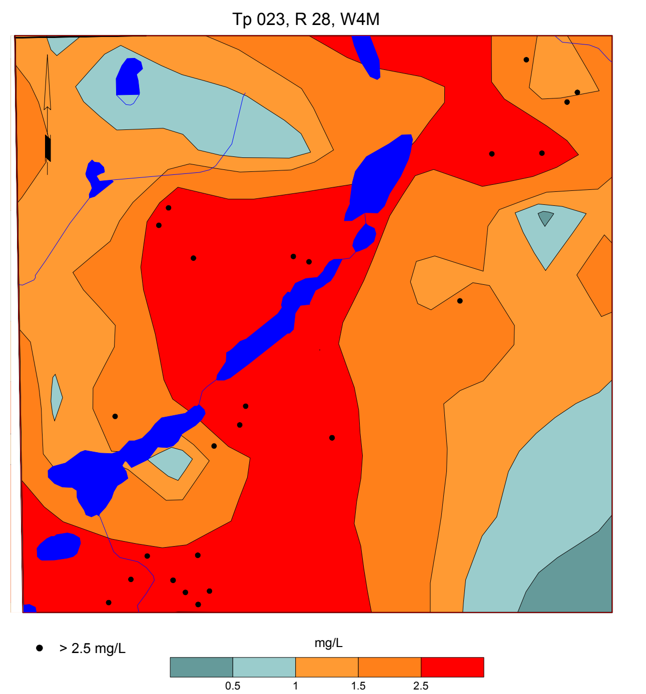

Figure 48. Shepard Area – Fluoride in Upper Bedrock Aquifer(s)

Groundwaters from water wells completed in the Shepard Area in the upper bedrock aquifer(s) are expected to have TDS concentrations mainly of less than 1,000 mg/L. In the Shepard Area, most bedrock water wells are completed within 200 metres of the top of the Lacombe Member, and therefore, higher sulfate concentrations occur. These higher sulfate concentrations are consistent with the results of the regional analysis shown on Figure 20 on page 24 of this report. The TDS and chloride concentrations from bedrock water wells in the Shepard Area are also similar to other groundwater-quality trends found in the Lacombe Aquifer in other parts of the M.D.

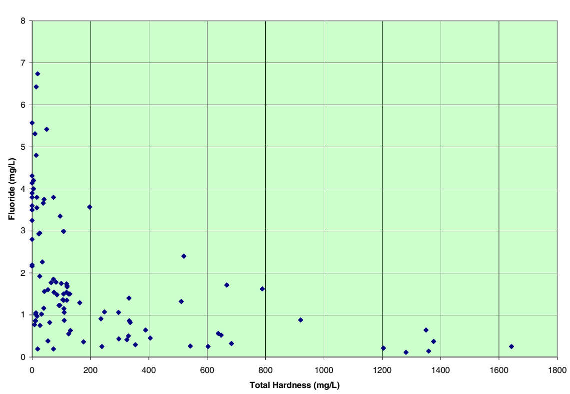

Figure 49. Shepard Area – Total Hardness vs. Fluoride in Upper Bedrock Aquifer(s)

In the Shepard Area, approximately 30% of the groundwater samples from upper bedrock aquifer(s) have fluoride concentrations that are greater than 2.5 mg/L. The fluoride values of greater than 2.5 mg/L occur mainly in the north-central part of the Area. In general, when total hardness is less than 150 mg/L, fluoride can be up to 7 mg/L; for total hardness values of greater than 100 mg/L, fluoride concentrations are mainly less than 1.0 mg/L, as shown in Figure 49.

7. 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 264 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 two water wells for which the M.D. has responsibility, neither one of which satisfies the above criteria; the two M.D.-operated water wells are shown in Appendix E. It is recommended that these two M.D.-operated water wells plus the 264 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 264 water wells listed in Appendix E for which water well drilling reports are available, plus the two M.D.–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 27 or some other system that will allow conversion to 10TM NAD 27 coordinates.
2) A four-hour aquifer test (two hours of pumping and two hours of recovery) should be performed with the water well to obtain a realistic estimate for the transmissivity of the aquifer in which the water well is completed.
3) Water samples should be collected for chemical analysis after five and 115 minutes of pumping, and analyzed for major and minor ions.

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 266 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 about 70% successful in this study (see CD-ROM). About 30% of licensed 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 licensed water wells are completed.

While there are a few areas where water-level data are available, on the overall, there are an insufficient number of water levels to set up a groundwater budget. Water well owners in the Irricana – Beiseker Area were provided with a tax credit if they accurately measured the water level in their water well once per week for a year. The pilot project indicated that approximately five years of records are required to obtain a reasonable data set. It is recommended that water well owners who are stakeholders in the groundwater resource in other parts of the M.D., particularly in areas of potential water-level decline, initiate a similar project. 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 (Appendix C). It is recommended that the regular monitoring of water levels in domestic and stock water wells be continued in the Irricana-Beiseker area and to expand the program to other parts of the M.D. Of the 264 water wells recommended for field verification, 55 of the 255 bedrock water wells are in areas of water-level decline. Because the flow through the Lower Sand and Gravel Aquifer is less than the total of the licensed and unlicensed diversions, it is recommended that a groundwater-monitoring program be established.

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. M.D. personnel and/or local residents could measure the water levels in the water wells regularly.

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

There is also a need to provide the water well drillers with feedback on the reports they are submitting to the regulatory agencies. The feedback is necessary to allow for a greater degree of uniformity in the reporting process. This is particularly true when trying to identify the bedrock surface. One method of obtaining uniformity would be to have the water well drilling reports submitted to the AENV Resource Data Division in an electronic form. The money presently being spent by AENV 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 M.D. 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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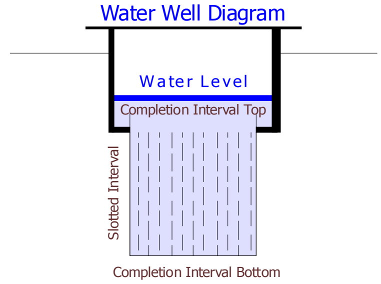
9. Conversions

Multiply	by	To Obtain
Length/Area		
feet	0.304 785	metres
metres	3.281 000	feet
hectares	2.471 054	acres
centimetre	0.032 808	feet
centimetre	0.393 701	inches
acres	0.404 686	hectares
inchs	25.400 000	millimetres
miles	1.609 344	kilometres
kilometer	0.621 370	miles (statute)
square feet (ft^2)	0.092 903	square metres (m^2)
square metres (m^2)	10.763 910	square feet (ft^2)
square metres (m^2)	0.000 001	square kilometres (km^2)
Concentration		
grains/gallon (UK)	14.270 050	parts per million (ppm)
ppm	0.998 859	mg/L
mg/L	1.001 142	ppm
Volume (capacity)		
acre feet	1233.481 838	cubic metres
cubic feet	0.028 317	cubic metres
cubic metres	35.314 667	cubic feet
cubic metres	219.969 248	gallons (UK)
cubic metres	264.172 050	gallons (US liquid)
cubic metres	1000.000 000	litres
gallons (UK)	0.004 546	cubic metres
imperial gallons	4.546 000	litres
Rate		
litres per minute (lpm)	0.219 974	UK gallons per minute (igpm)
litres per minute	1.440 000	cubic metres/day (m^3/day)
igpm	6.546 300	cubic metres/day (m^3/day)
cubic metres/day	0.152 759	igpm

10. Glossary

AAFC-PFRA	Prairie Farm Rehabilitation Administration arm of Agriculture and Agri-Food Canada
Aquifer	a formation, group of formations, or part of a formation that contains saturated permeable rocks capable of transmitting groundwater to water wells or springs in economical quantities
Aquitard	a confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer
Available Drawdown	in a confined aquifer, the distance between the non-pumping water level and the top of the aquifer in an unconfined aquifer (water table aquifer), two thirds of the saturated thickness of the aquifer
Borehole	includes all "work types" except springs
Completion Interval	see diagram
Dewatering	the removal of groundwater from an aquifer for purposes other than use
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.

Water Well Diagram



Completion Interval

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
Hydraulic Conductivity	the rate of flow of water through a unit cross-section under a unit hydraulic gradient; units are length/time
km	kilometre
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
m	metres
mm	millimetres
m^2/day	metres squared per day
m^3	cubic metres

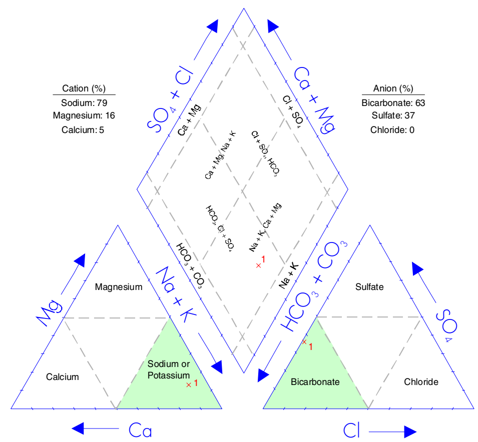
m³/day — cubic metres per day

mg/L — milligrams per litre

Median — the value at the center of an ordered range of numbers

Obs WW — Observation Water Well

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

Surficial Deposits — includes all sediments above the bedrock

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

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

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

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

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

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

Water Well — a hole in the ground for the purpose of obtaining groundwater; “work type” 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

Long-Term Yield: based on effective transmissivity

AENV — Alberta Environment

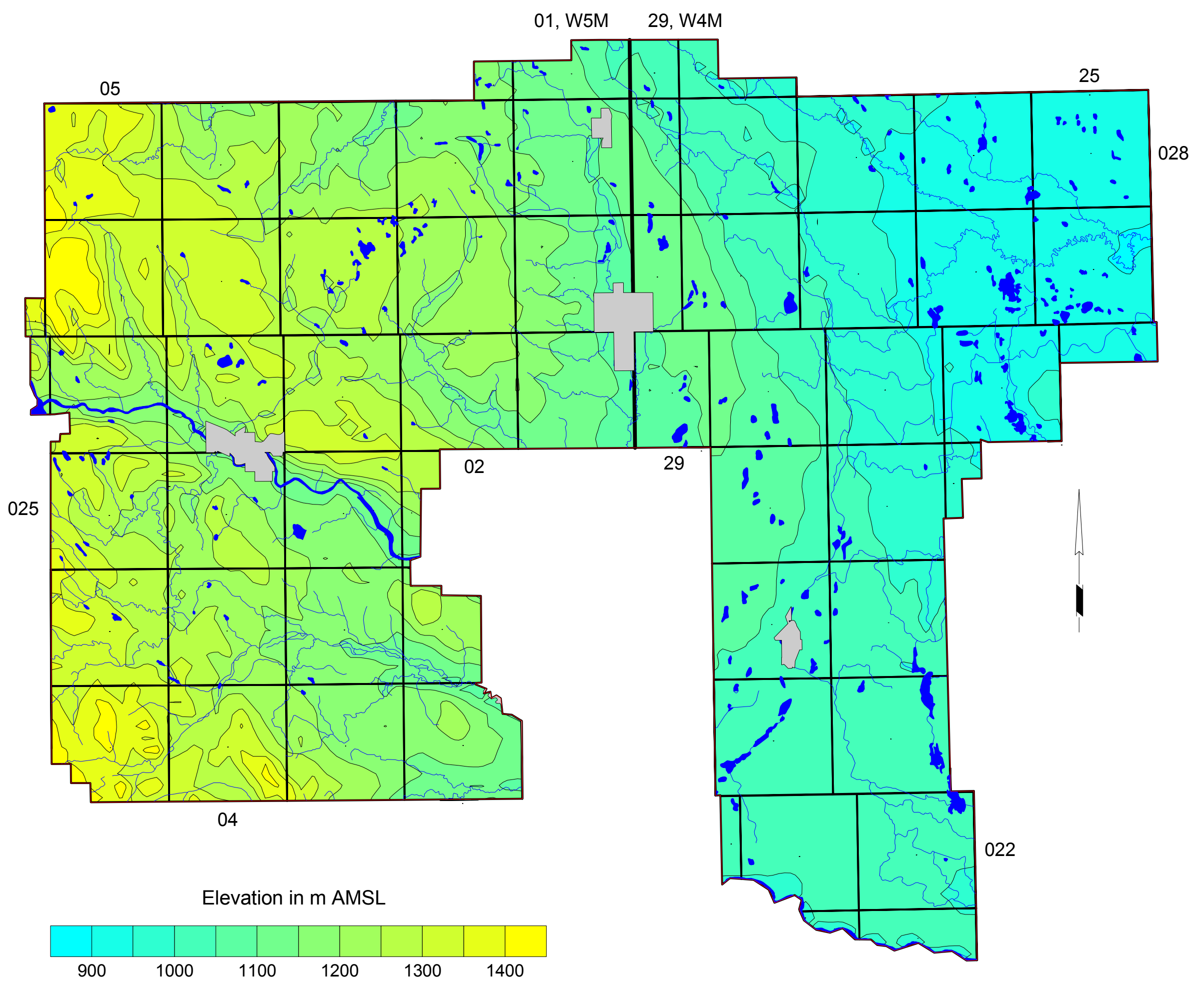
AMSL	above mean sea level
BGP	Base of Groundwater Protection
DEM	Digital Elevation Model
DST	drill stem test
EUB	Alberta Energy and Utilities Board
GCDWQ	Guidelines for Canadian Drinking Water Quality
NPWL	non-pumping water level
TDS	Total Dissolved Solids
WSW	Water Source Well or Water Supply Well

M.D. OF ROCKY VIEW NO. 44

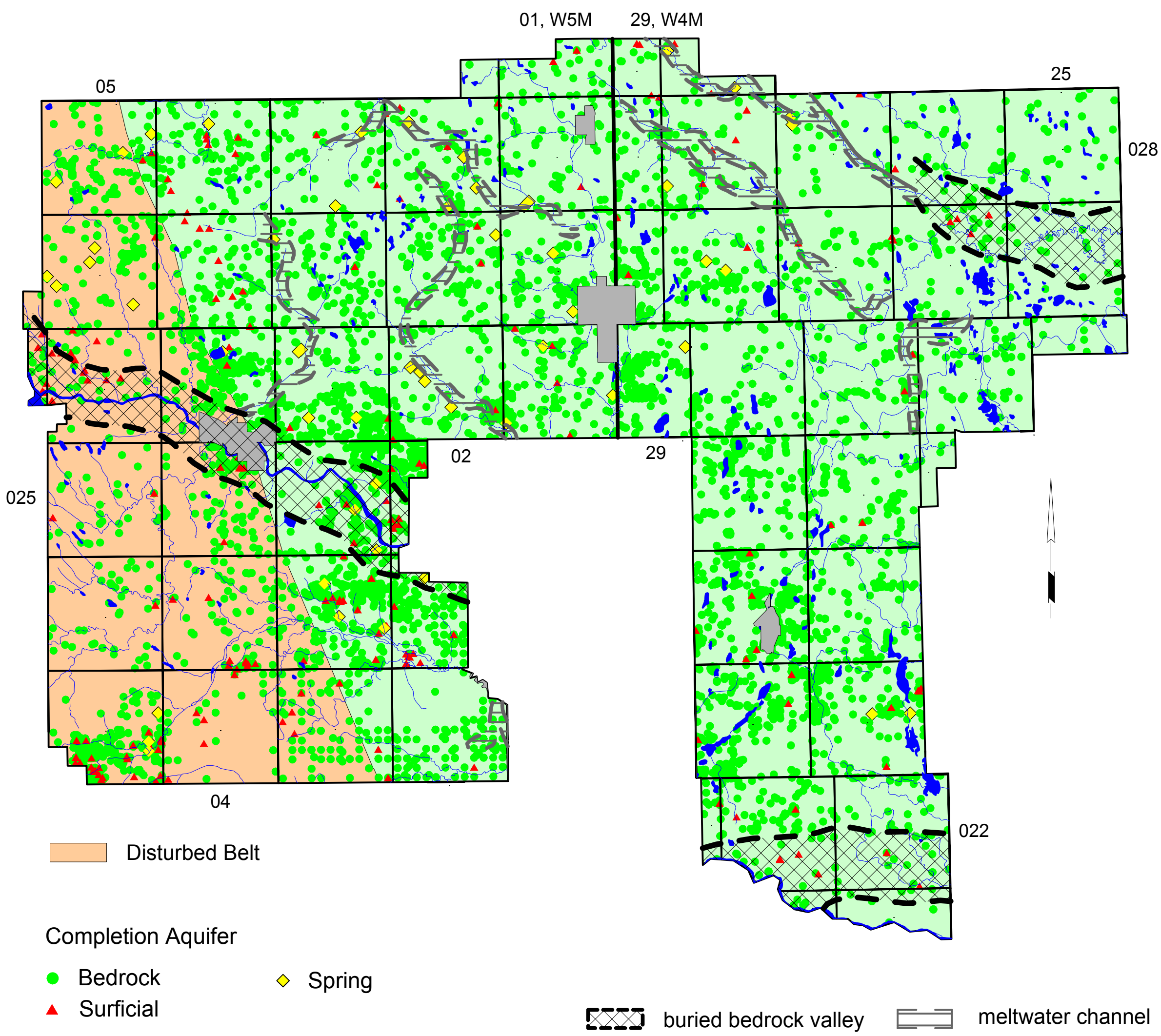
Appendix A

Hydrogeological Maps and Figures

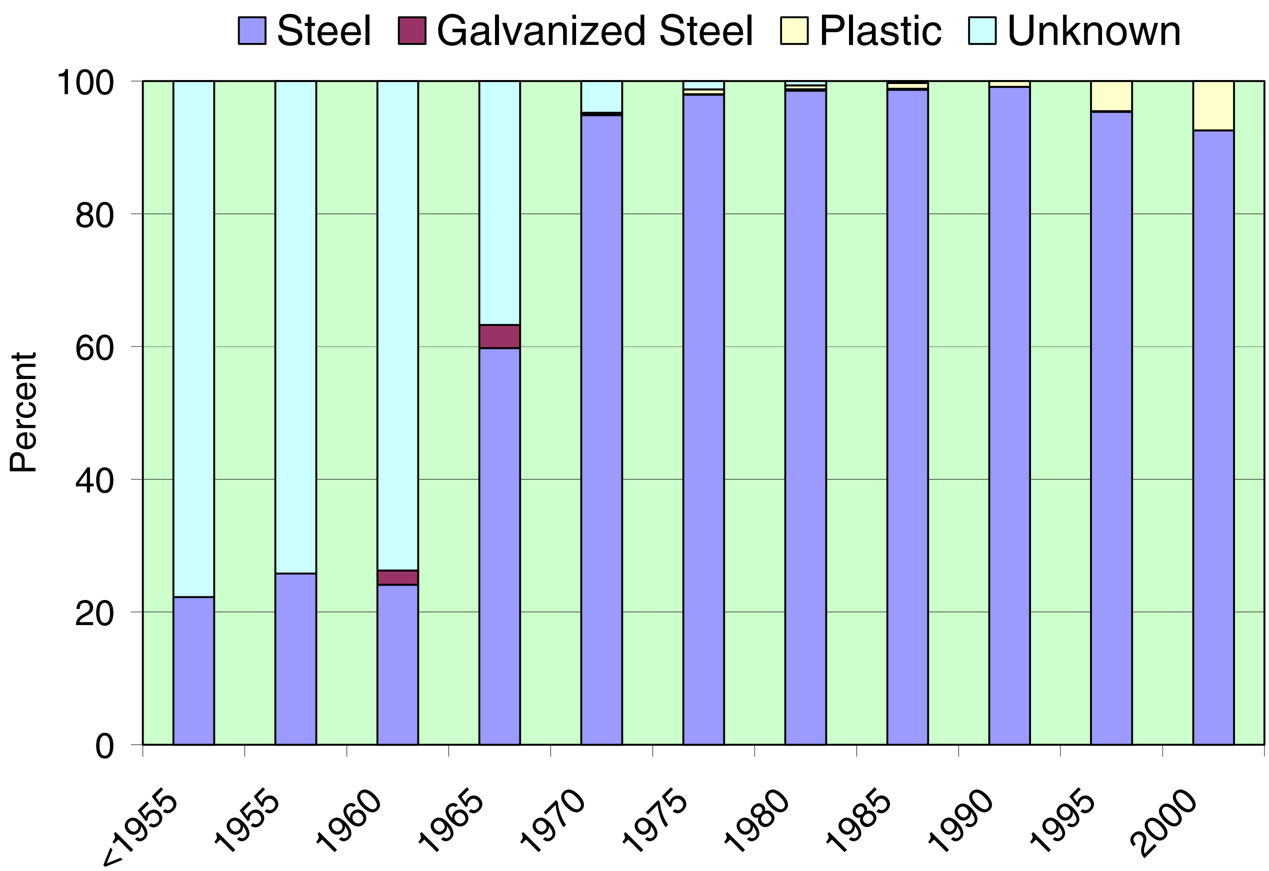
Surface Topography



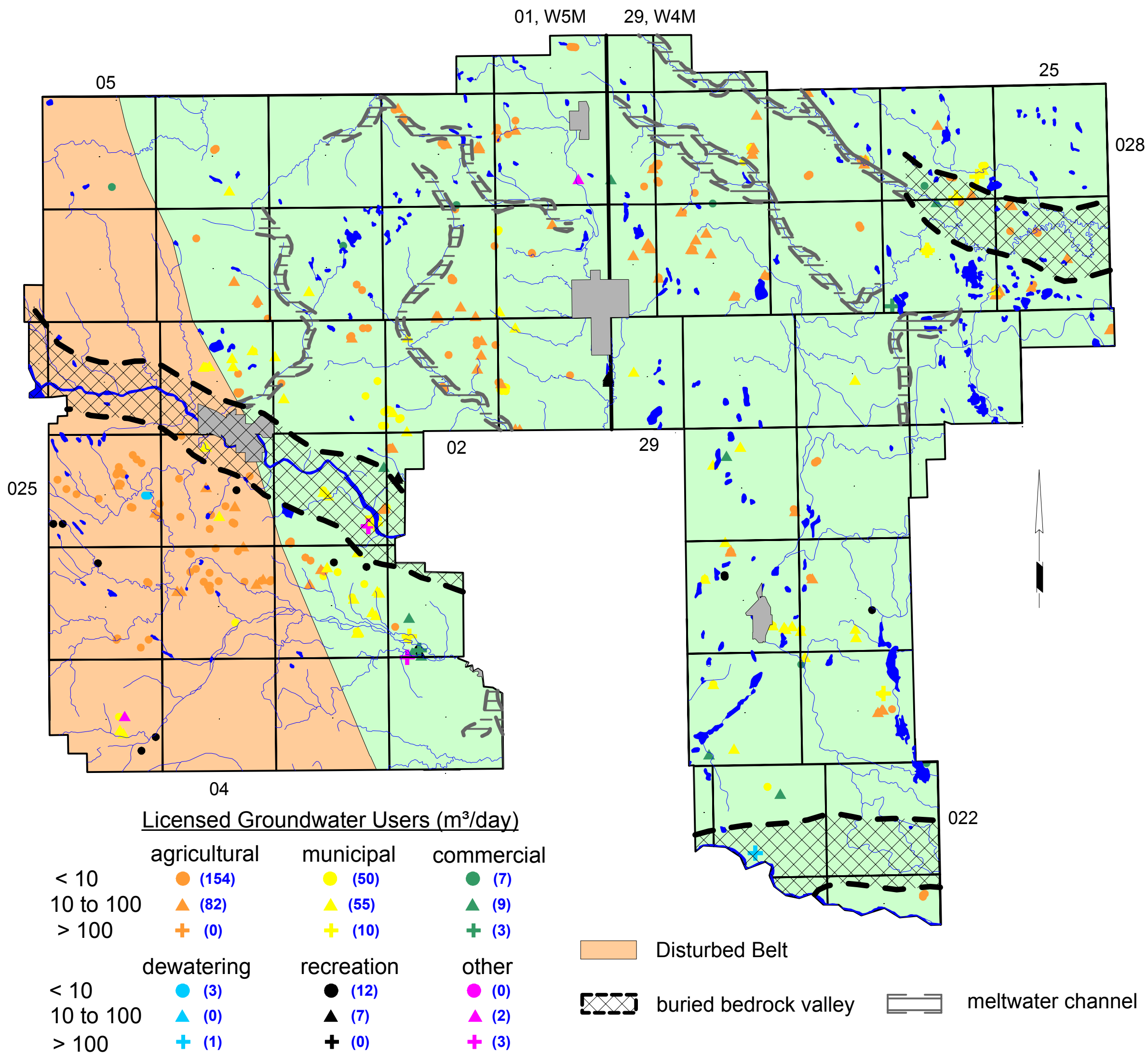
Location of Water Wells and Springs



Surface Casing Types used in Drilled Water Wells

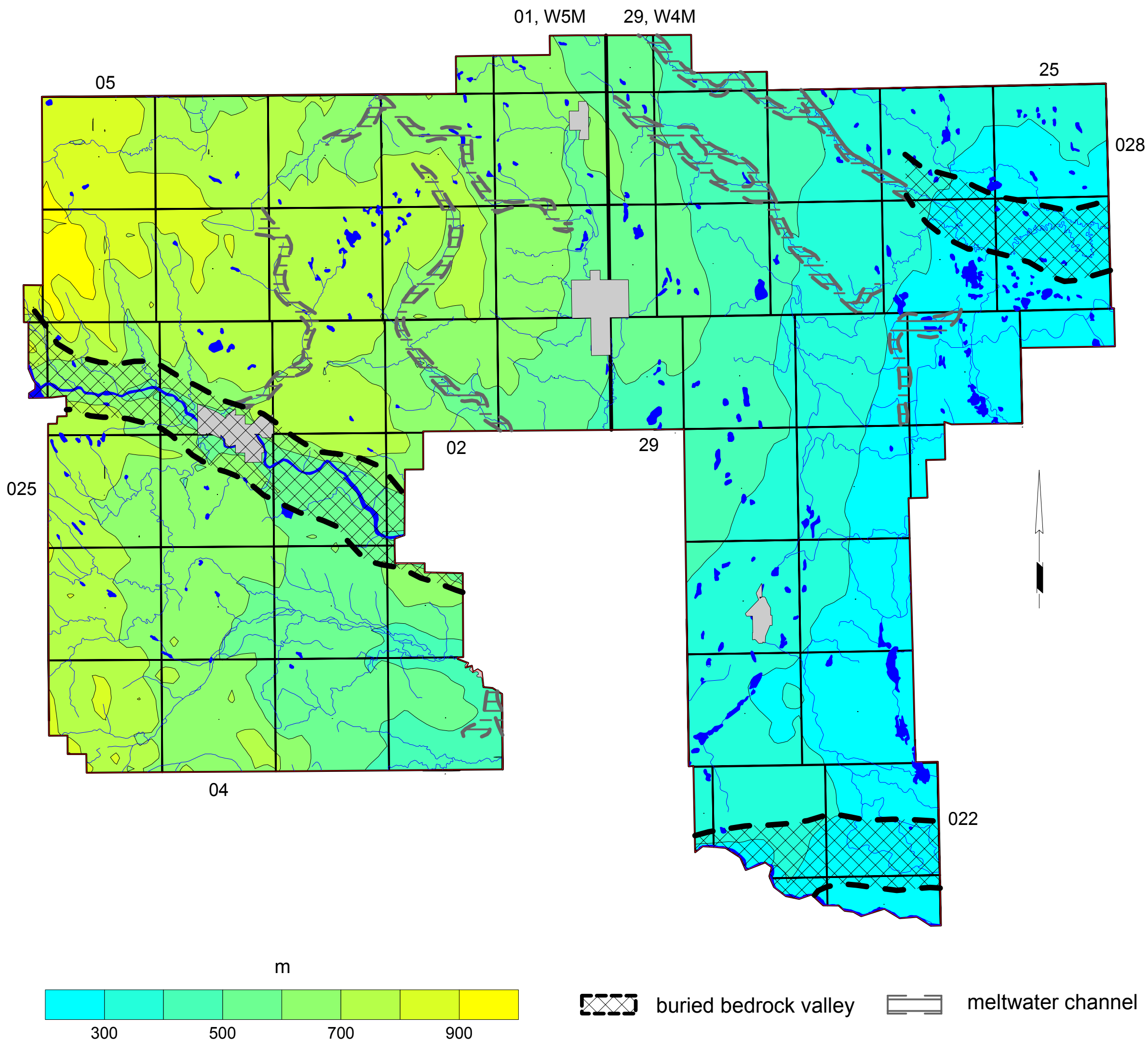


Licensed Water Wells



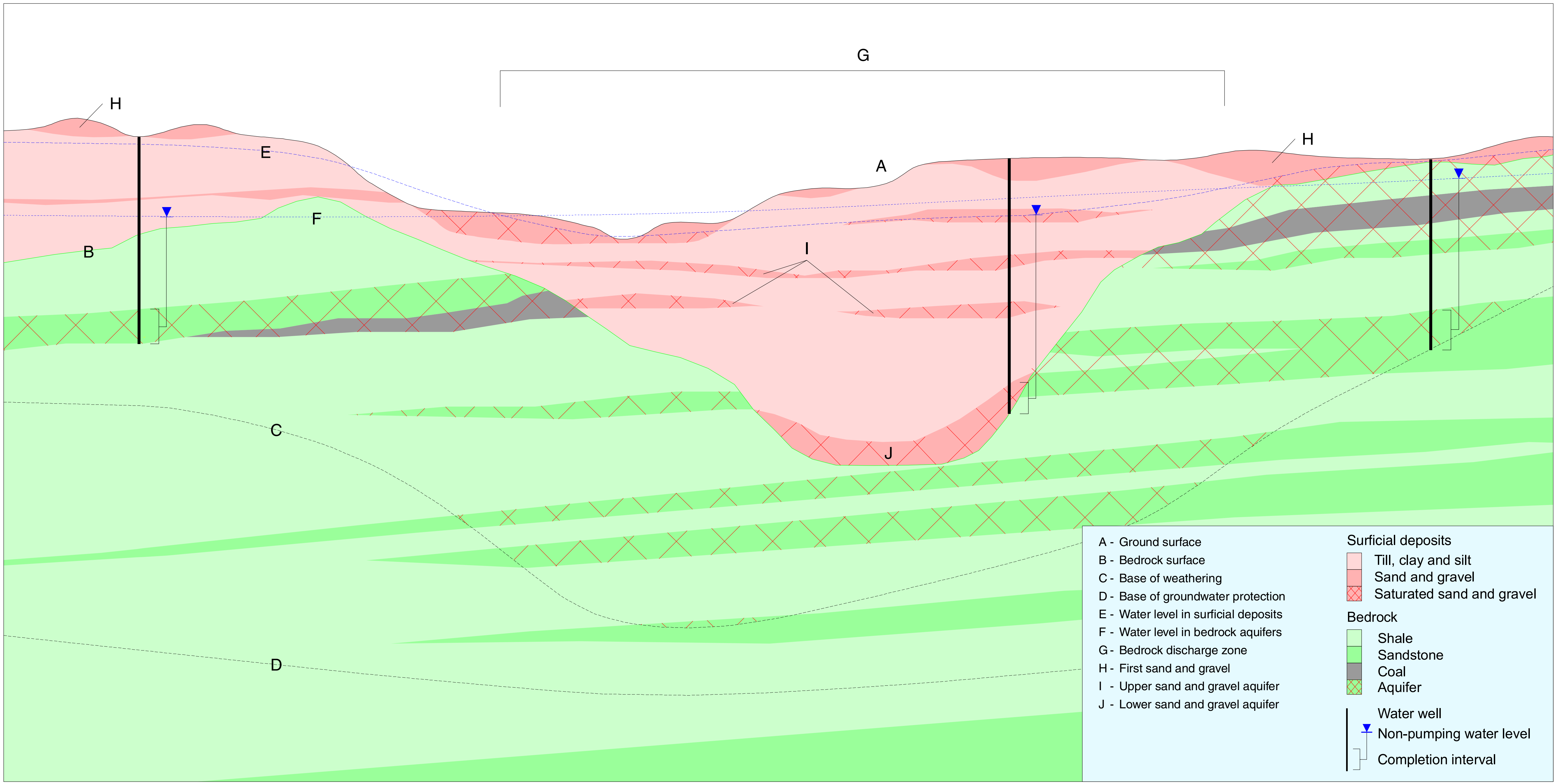
Depth to Base of Groundwater Protection

(modified after EUB, 1995)



Generalized Cross-Section

(for terminology only)

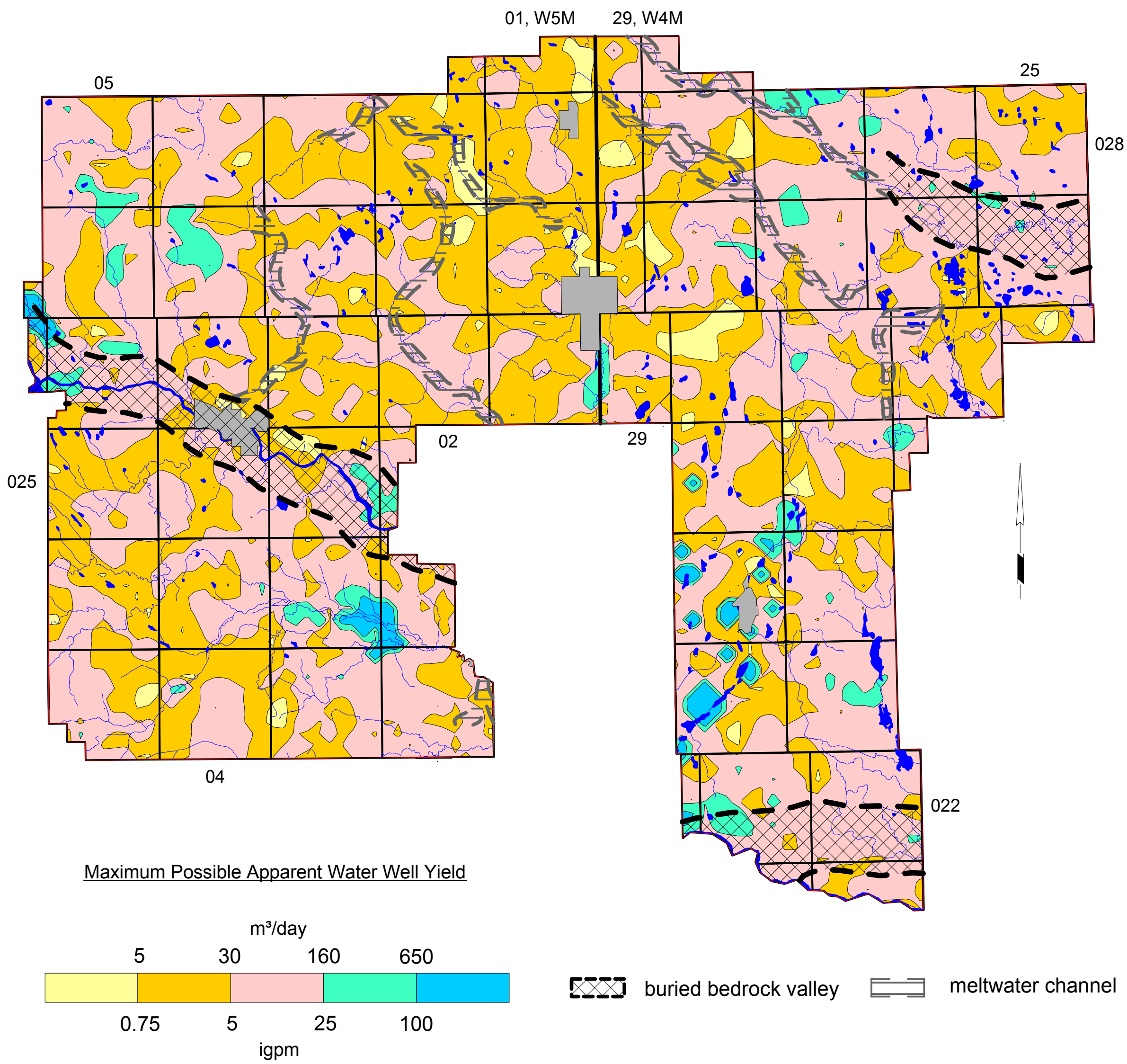


Geologic Column

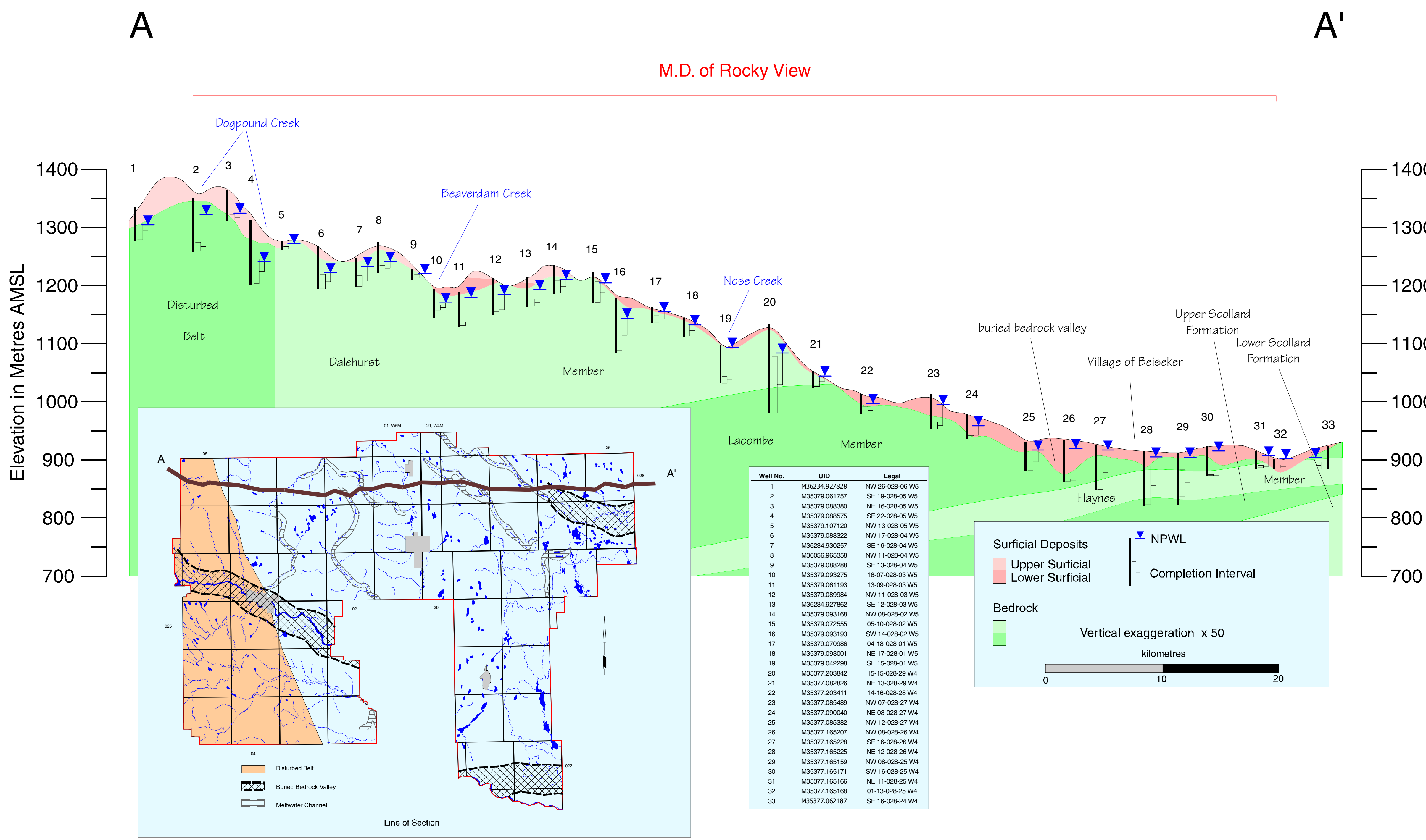
Lithology	Lithologic Description	Group and Formation: Average Thickness (m)	Group and Formation: Designation	Member: Average Thickness (m)	Member: Designation	Zone: Average Thickness (m)	Zone: Designation
	sand, gravel, till, clay, silt	<100	Surficial Deposits	<80	Upper		
				<80	Lower		
	sandstone, shale, coal	<800	Paskapoo Formation	<300	Dalehurst Member		Obed-Marsh Coal Zone
							Lower Dalehurst Coal Zone
				100-300	Lacombe Member	Upper	Upper Sandstone
							Middle Sandstone
							Lower Sandstone
				30-100		Lower	Lower Lacombe Coal Zone
				20-100	Haynes Member		
	shale, sandstone, coal	60-150	Edmonton Group; Scollard Formation	40-100	Upper	<2	Upper Ardley Coal Zone
						~20	Ardley Coal Zone (main seam)
						<3.5	Nevis Coal Seam
				20-60	Lower		

Depth (m): 0, 100, 200, 300, 400, 500, 600, 700

Hydrogeological Map



Cross-Section A - A'



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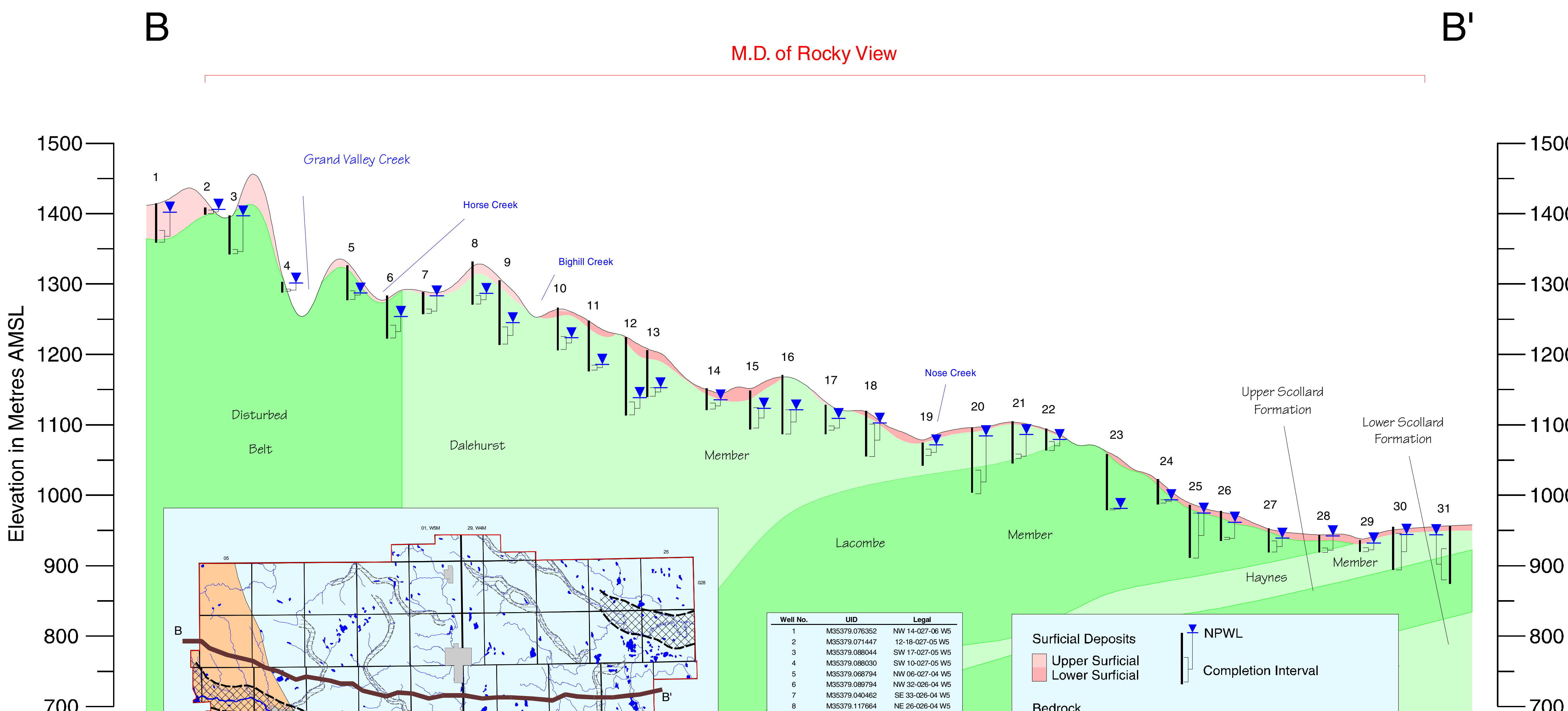
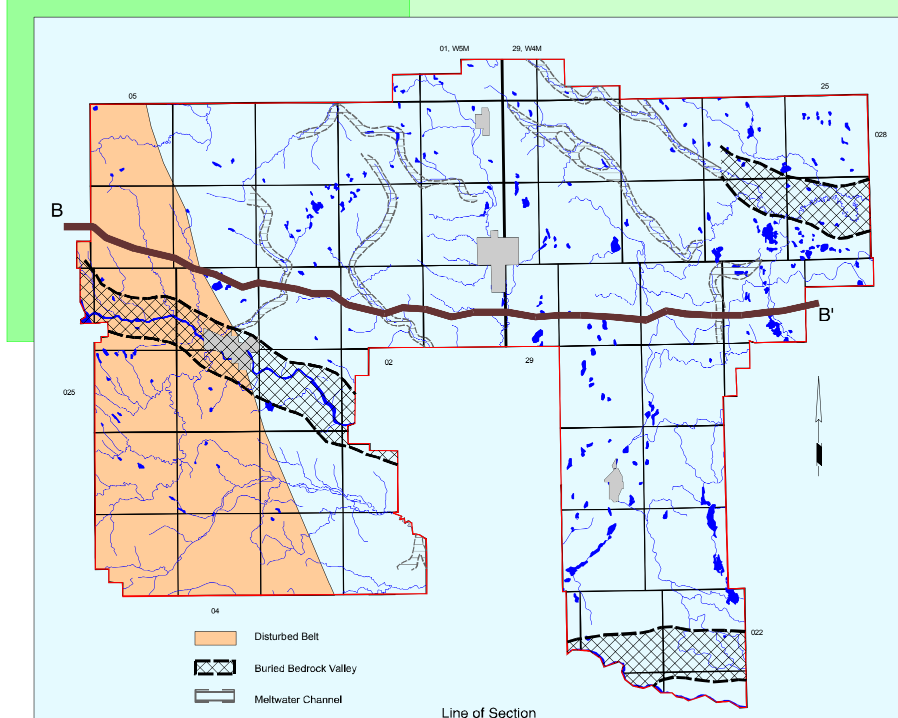
3	M35379.088380	NE 16-028-05 W5
4	M35379.088575	SE 22-028-05 W5
5	M35379.107120	NW 13-028-05 W5
6	M35379.088322	NW 17-028-04 W5
7	M36234.930257	SE 16-028-04 W5
8	M36056.965358	NW 11-028-04 W5
9	M35379.088288	SE 13-028-04 W5
10	M35379.093275	16-07-028-03 W5
11	M35379.061193	13-09-028-03 W5
12	M35379.089984	NW 11-028-03 W5
13	M36234.927862	SE 12-028-03 W5
14	M35379.093168	NW 08-028-02 W5
15	M35379.072555	05-10-028-02 W5
16	M35379.093193	SW 14-028-02 W5
17	M35379.070986	04-18-028-01 W5
18	M35379.093001	NE 17-028-01 W5
19	M35379.042298	SE 15-028-01 W5
20	M35377.203842	15-15-028-29 W4
21	M35377.082826	NE 13-028-29 W4
22	M35377.203411	14-16-028-28 W4
23	M35377.085489	NW 07-028-27 W4
24	M35377.090040	NE 08-028-27 W4
25	M35377.085382	NW 12-028-27 W4
26	M35377.165207	NW 08-028-26 W4
27	M35377.165228	SE 16-028-26 W4
28	M35377.165225	NE 12-028-26 W4
29	M35377.165159	NW 08-028-25 W4
30	M35377.165171	SW 16-028-25 W4
31	M35377.165166	NE 11-028-25 W4
32	M35377.165168	01-13-028-25 W4
33	M35377.062187	SE 16-028-24 W4

hydrogeological consultants ltd.

Cross-Section B - B'





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4	M35379.088030	SW 10-027-05 W5
5	M35379.068794	NW 06-027-04 W5
6	M35379.089794	NW 32-026-04 W5
7	M35379.040462	SE 33-026-04 W5
8	M35379.117664	NE 26-026-04 W5
9	M35379.092923	NW 30-026-03 W5
10	M35379.117790	SE 28-026-03 W5
11	M35379.092891	NE 22-026-03 W5
12	M35379.092896	NW 24-026-03 W5
13	M35379.091449	NE 18-026-02 W5
14	M35379.091439	SW 15-026-02 W5
15	M35379.091433	NE 14-026-02 W5
16	M35379.092394	NW 18-026-01 W5
17	M35379.090942	SW 16-026-01 W5
18	M35379.090926	SE 15-026-01 W5
19	M35377.091670	SW 16-026-29 W4
20	M35377.083843	SW 14-026-29 W4
21	M35377.223407	NW 07-026-28 W4
22	M35377.130387	16-08-026-28 W4
23	M35377.223427	NW 11-026-28 W4
24	M35377.223281	NE 07-026-27 W4
25	M35377.223333	01-17-026-27 W4
26	M35377.223321	03-15-026-27 W4
27	M35377.223293	NW 12-026-27 W4
28	M35377.183085	NW 08-026-26 W4
29	M36234.923202	SW 15-026-26 W4
30	M35377.223225	02-14-026-26 W4
31	M35377.223187	12-17-026-25 W4

Surficial Deposits
Upper Surficial
Lower Surficial

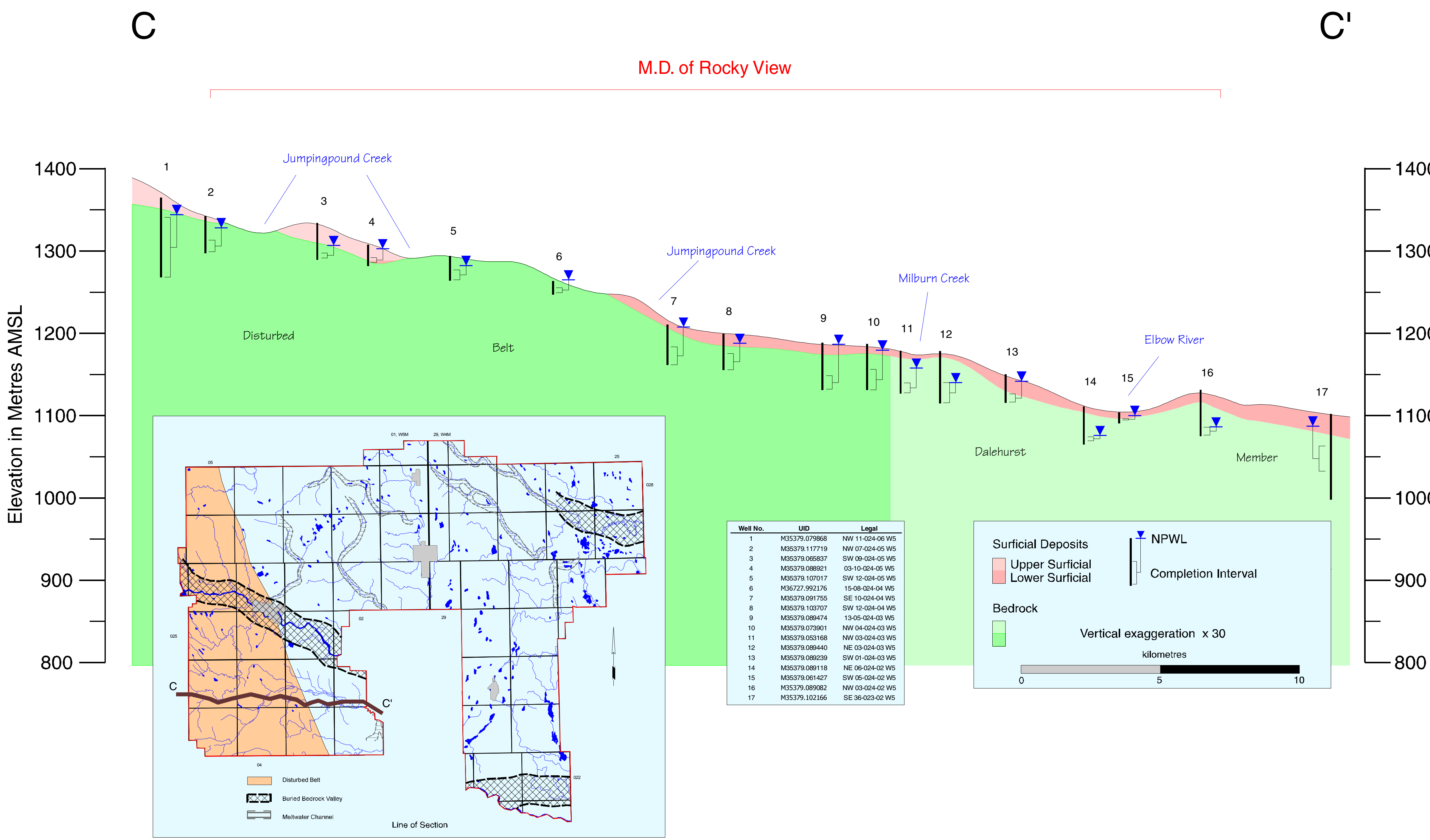
NPWL
Completion Interval

Bedrock

Vertical exaggeration x 50

kilometres
0 10 20

Cross-Section C - C'



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5	M35379.107017	SW 12-024-05 W5
6	M36727.992176	15-08-024-04 W5
7	M35379.091755	SE 10-024-04 W5
8	M35379.103707	SW 12-024-04 W5
9	M35379.089474	13-05-024-03 W5
10	M35379.073901	NW 04-024-03 W5
11	M35379.053168	NW 03-024-03 W5
12	M35379.089440	NE 03-024-03 W5
13	M35379.089239	SW 01-024-03 W5
14	M35379.089118	NE 06-024-02 W5
15	M35379.061427	SW 05-024-02 W5
16	M35379.089082	NW 03-024-02 W5
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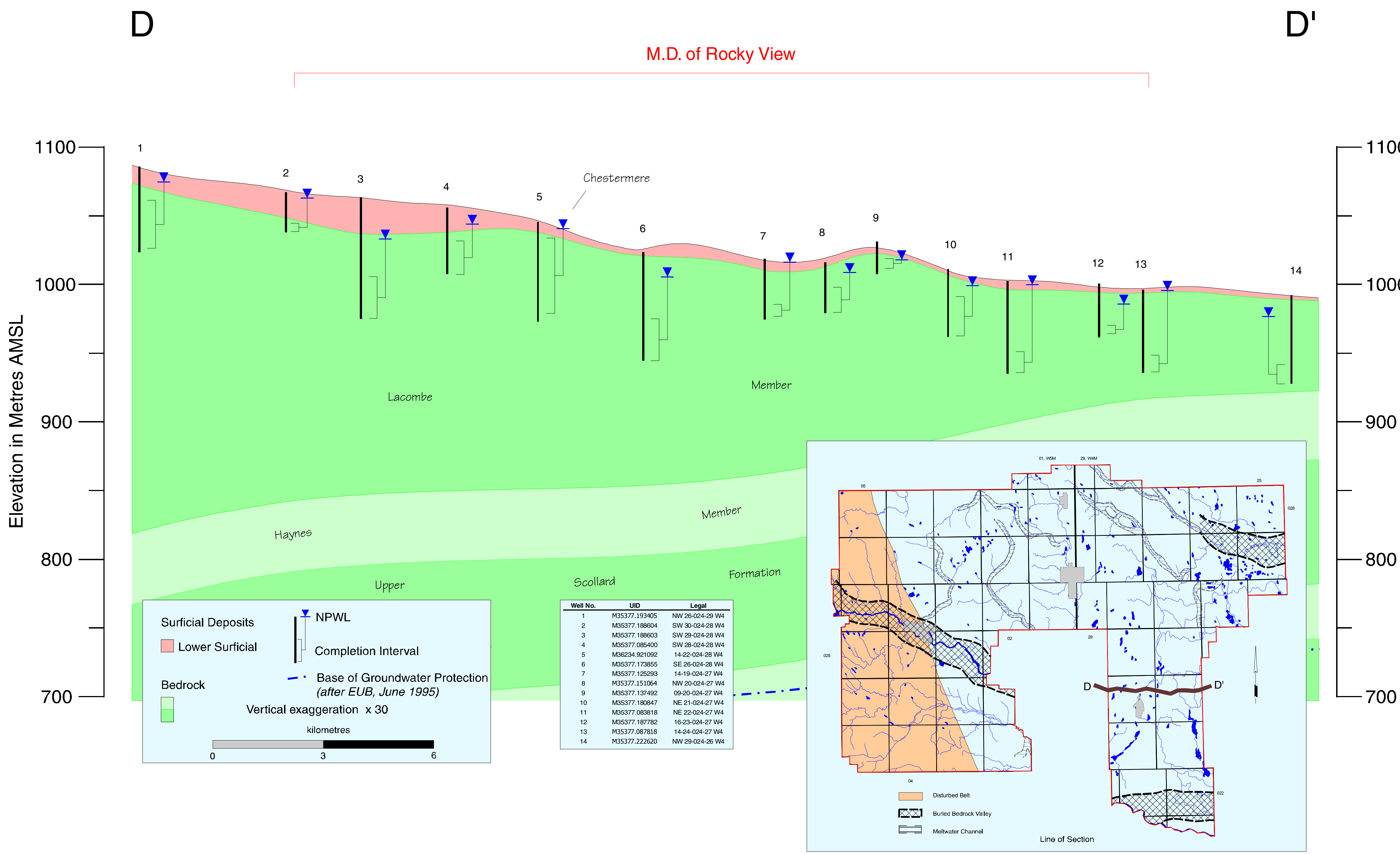
Cross-Section D - D'



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4	M35377.085400	SW 28-024-28 W4
5	M36234.921092	14-22-024-28 W4
6	M35377.173855	SE 26-024-28 W4
7	M35377.125293	14-19-024-27 W4
8	M35377.151064	NW 20-024-27 W4
9	M35377.137492	09-20-024-27 W4
10	M35377.180847	NE 21-024-27 W4
11	M35377.083818	NE 22-024-27 W4
12	M35377.187782	16-23-024-27 W4
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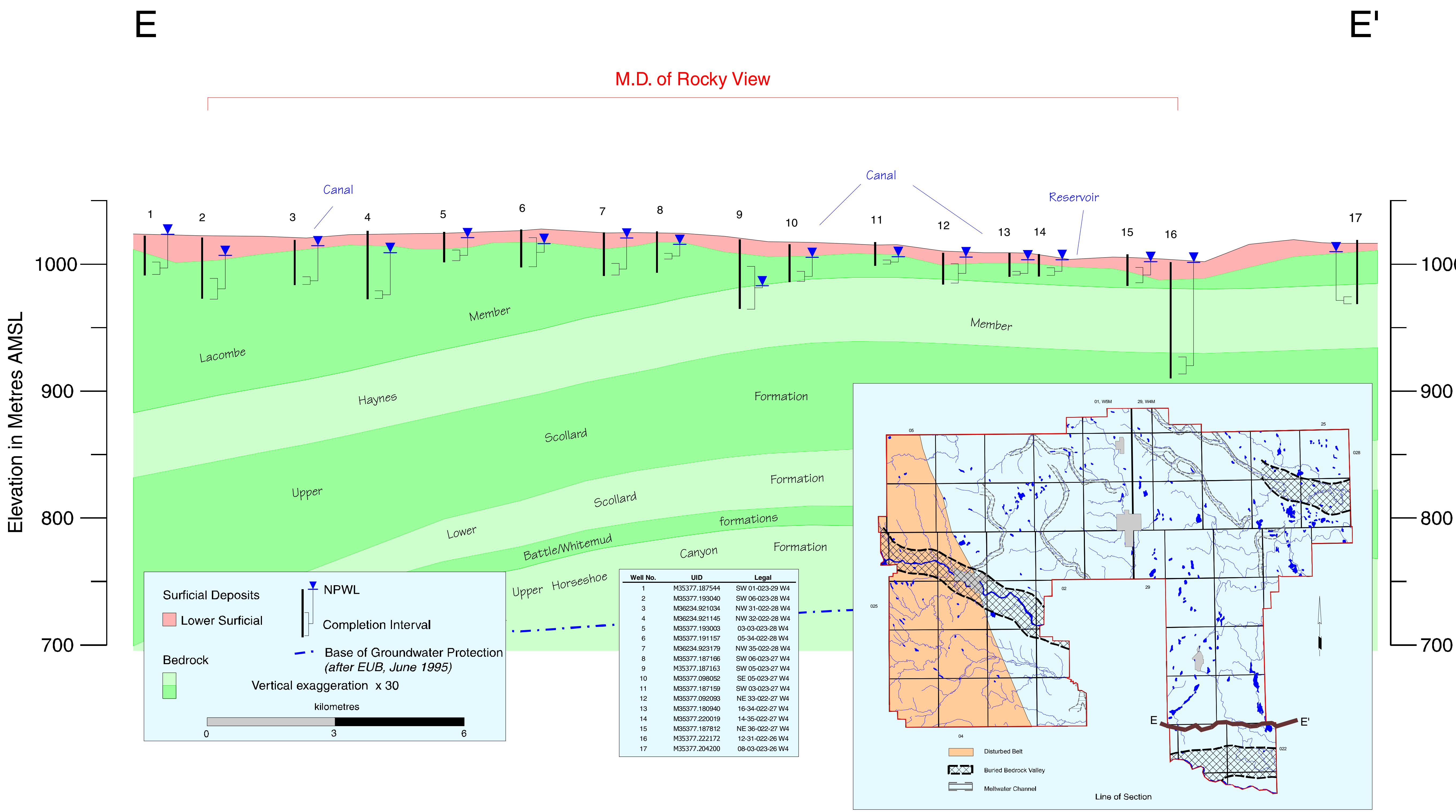
14	M35377.222620	NW 29-024-26 W4

Cross-Section E - E'



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4	M36234.921145	NW 32-022-28 W4
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6	M35377.191157	05-34-022-28 W4
7	M36234.923179	NW 35-022-28 W4
8	M35377.187166	SW 06-023-27 W4
9	M35377.187163	SW 05-023-27 W4
10	M35377.098052	SE 05-023-27 W4
11	M35377.187159	SW 03-023-27 W4
12	M35377.092093	NE 33-022-27 W4
13	M35377.180940	16-34-022-27 W4
14	M35377.220019	14-35-022-27 W4
15	M35377.187812	NE 36-022-27 W4
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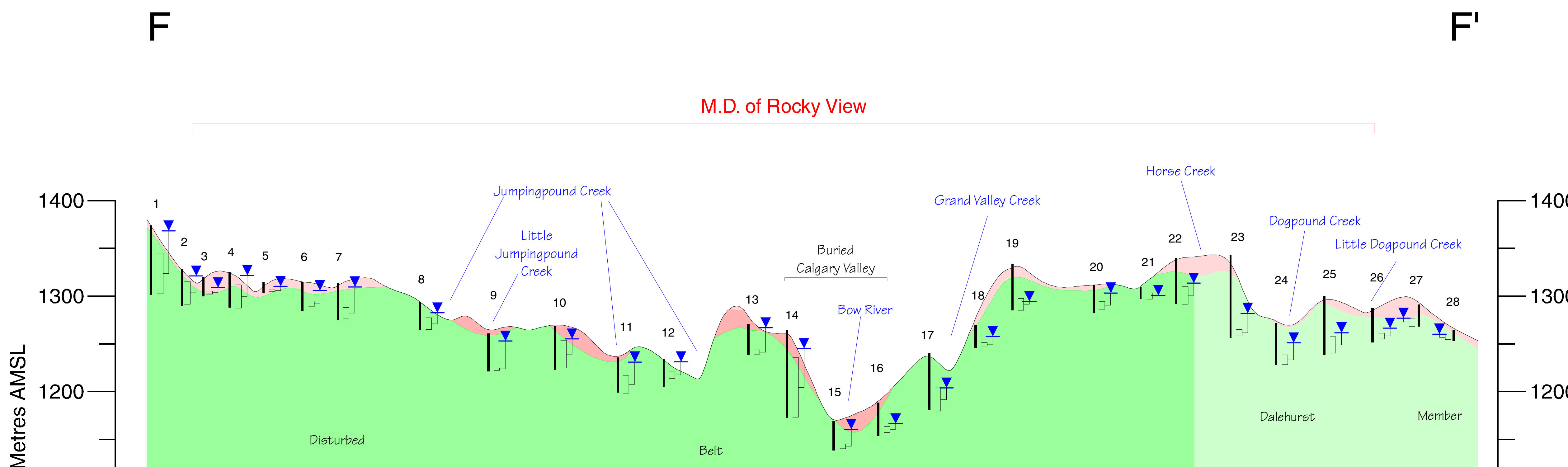
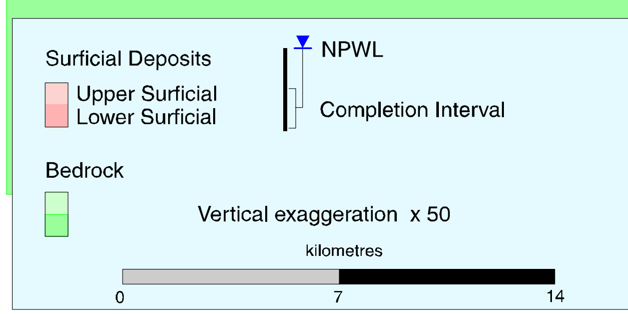
Cross-Section F - F'





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6	M35379.117384	NE 24-023-05 W5
7	M35379.089535	NE 25-023-05 W5
8	M35379.107017	SW 12-024-05 W5
9	M35379.054143	SE 24-024-05 W5
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11	M35379.090697	SE 13-025-05 W5
12	M35379.090725	SE 24-025-05 W5
13	M35379.092333	NW 36-025-05 W5
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15	M35379.115208	SE 14-026-05 W5
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18	M36056.965383	NW 36-026-05 W5
19	M35379.068794	NW 06-027-04 W5
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21	M35379.088106	NE 25-027-05 W5
22	M35379.088165	NE 36-027-05 W5
23	M35379.088298	NE 12-028-05 W5
24	M35379.088594	01-24-028-05 W5
25	M35379.088658	NE 25-028-05 W5
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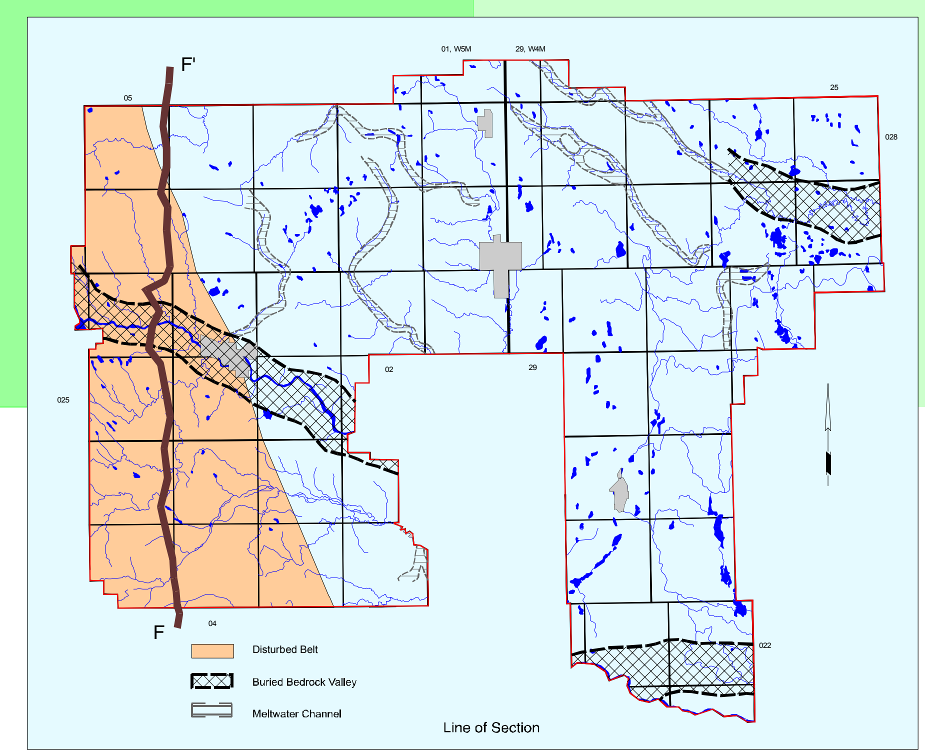
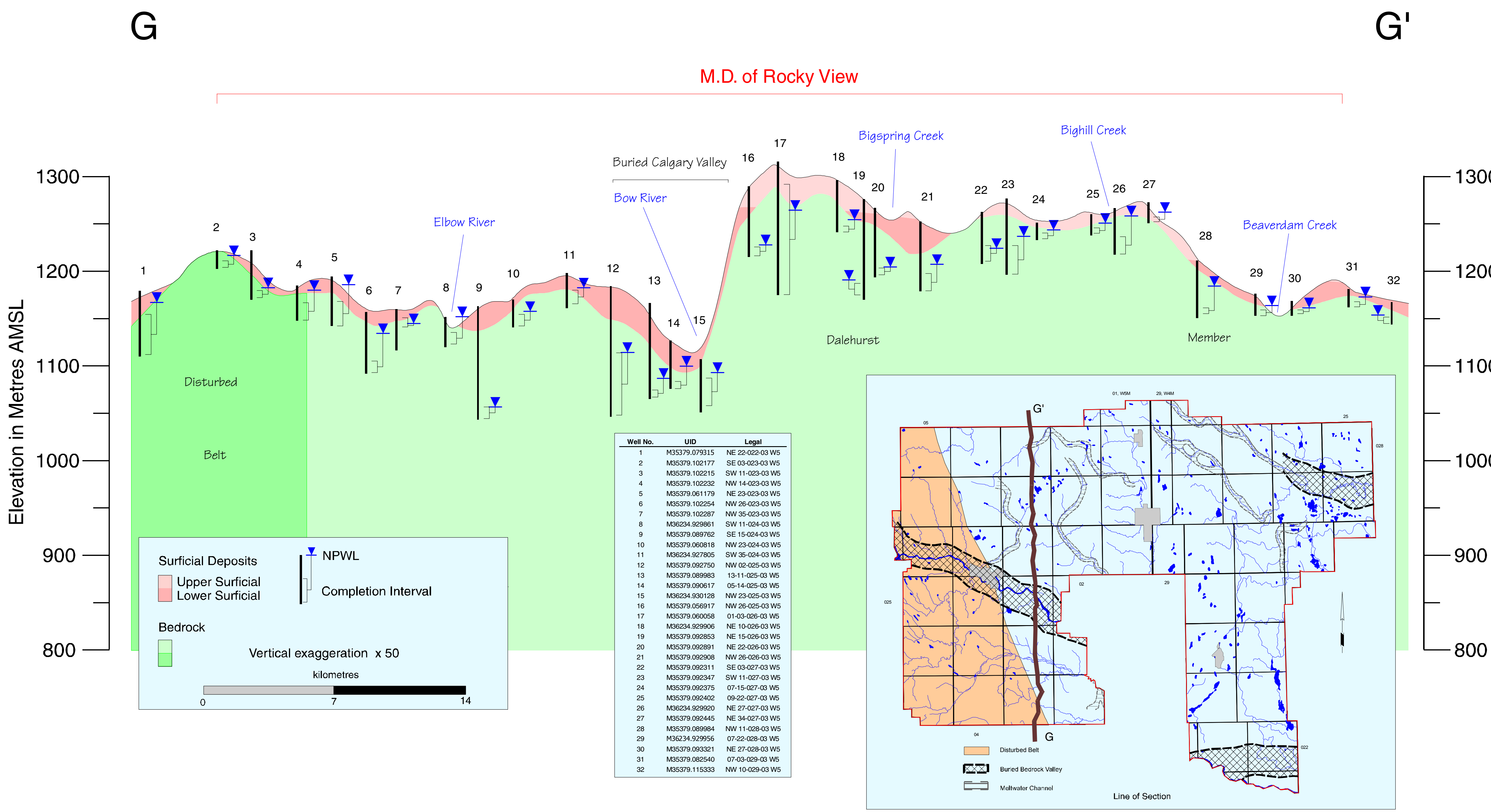


Cross-Section G - G'



Well No.	UID	Legal
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5	M35379.061179	NE 23-023-03 W5
6	M35379.102254	NW 26-023-03 W5
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8	M36234.929861	SW 11-024-03 W5
9	M35379.089762	SE 15-024-03 W5
10	M35379.060818	NW 23-024-03 W5
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15	M36234.930128	NW 23-025-03 W5
16	M35379.056917	NW 26-025-03 W5
17	M35379.060058	01-03-026-03 W5
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20	M35379.092891	NE 22-026-03 W5
21	M35379.092908	NW 26-026-03 W5
22	M35379.092311	SE 03-027-03 W5
23	M35379.092347	SW 11-027-03 W5
24	M35379.092375	07-15-027-03 W5
25	M35379.092402	09-22-027-03 W5
26	M36234.929920	NE 27-027-03 W5
27	M35379.092445	NE 34-027-03 W5
28	M35379.089984	NW 11-028-03 W5
29	M36234.929956	07-22-028-03 W5
30	M35379.093321	NE 27-028-03 W5
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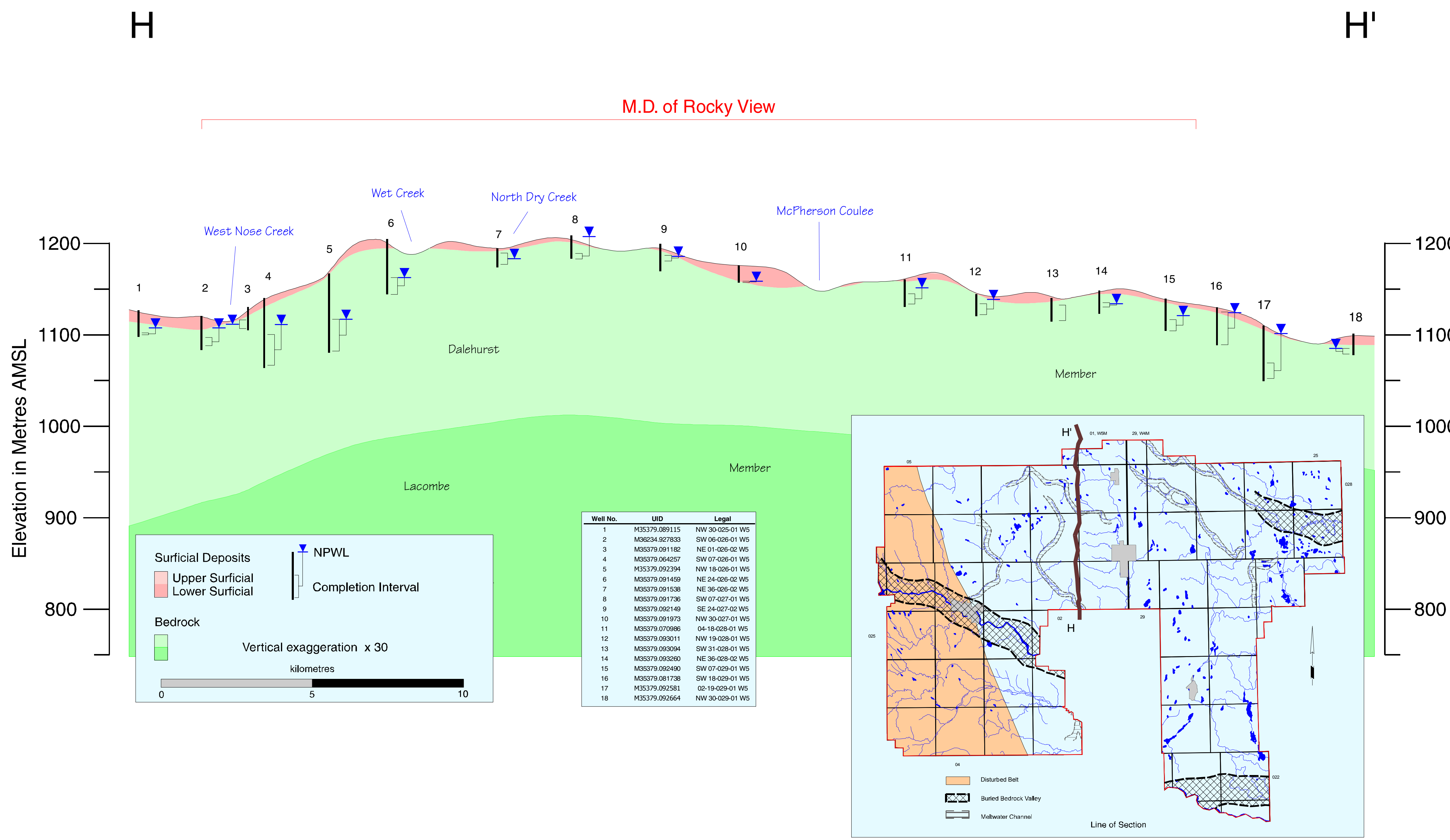
Cross-Section H - H'



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5	M35379.092394	NW 18-026-01 W5
6	M35379.091459	NE 24-026-02 W5
7	M35379.091538	NE 36-026-02 W5
8	M35379.091736	SW 07-027-01 W5
9	M35379.092149	SE 24-027-02 W5
10	M35379.091973	NW 30-027-01 W5
11	M35379.070986	04-18-028-01 W5
12	M35379.093011	NW 19-028-01 W5
13	M35379.093094	SW 31-028-01 W5
14	M35379.093260	NE 36-028-02 W5
15	M35379.092490	SW 07-029-01 W5
16	M35379.081738	SW 18-029-01 W5
17	M35379.092581	02-19-029-01 W5
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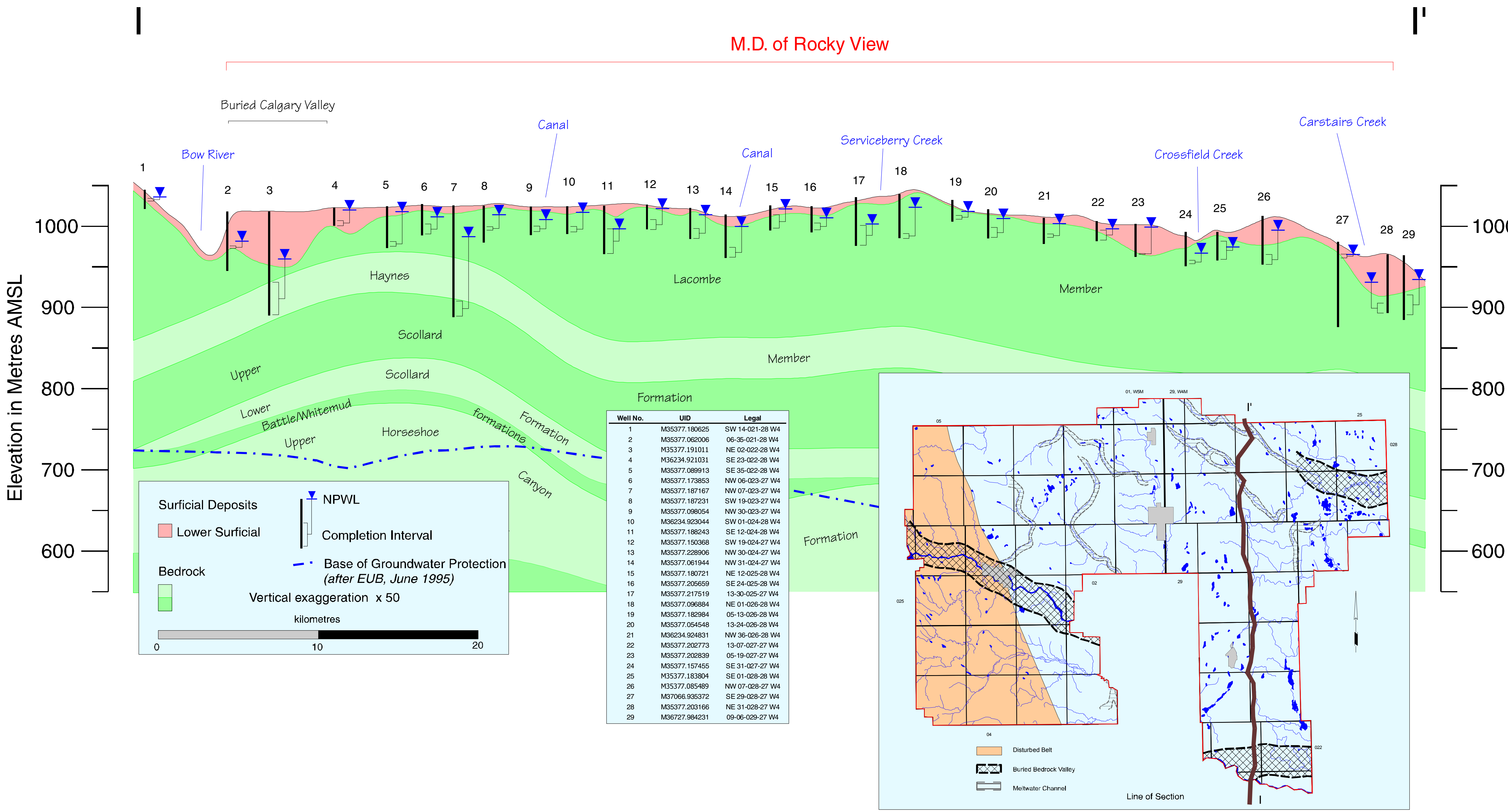
Cross-Section I - I'



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4	M36234.921031	SE 23-022-28 W4
5	M35377.089913	SE 35-022-28 W4
6	M35377.173853	NW 06-023-27 W4
7	M35377.187167	NW 07-023-27 W4
8	M35377.187231	SW 19-023-27 W4
9	M35377.098054	NW 30-023-27 W4
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11	M35377.188243	SE 12-024-28 W4
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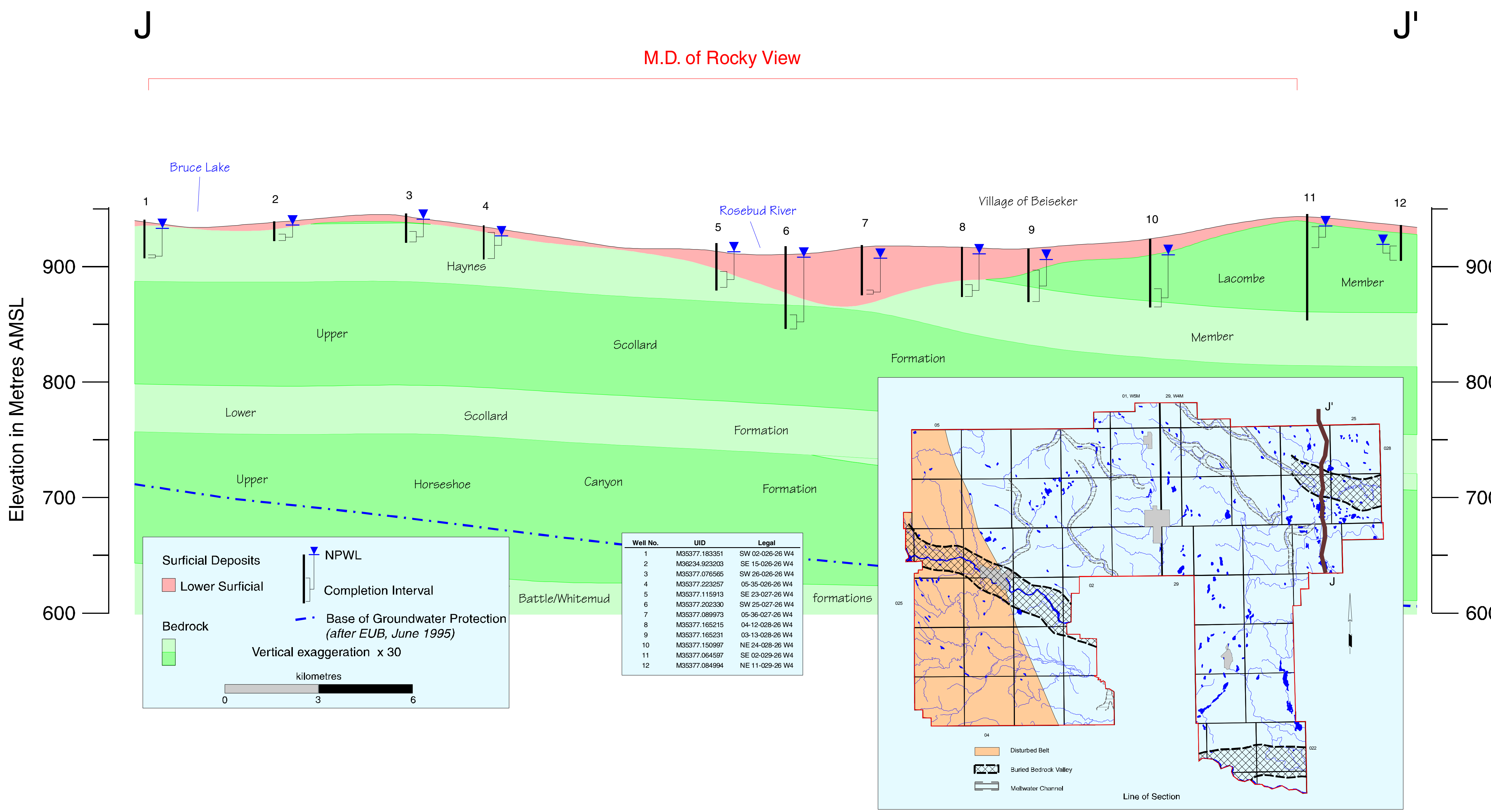
13	M35377.228906	NW 30-024-27 W4
14	M35377.061944	NW 31-024-27 W4
15	M35377.180721	NE 12-025-28 W4
16	M35377.205659	SE 24-025-28 W4
17	M35377.217519	13-30-025-27 W4
18	M35377.096884	NE 01-026-28 W4
19	M35377.182984	05-13-026-28 W4
20	M35377.054548	13-24-026-28 W4
21	M36234.924831	NW 36-026-28 W4
22	M35377.202773	13-07-027-27 W4
23	M35377.202839	05-19-027-27 W4
24	M35377.157455	SE 31-027-27 W4
25	M35377.183804	SE 01-028-28 W4
26	M35377.085489	NW 07-028-27 W4
27	M37066.935372	SE 29-028-27 W4
28	M35377.203166	NE 31-028-27 W4
29	M36727.984231	09-06-029-27 W4

Cross-Section J - J'



Well No.	UID	Legal
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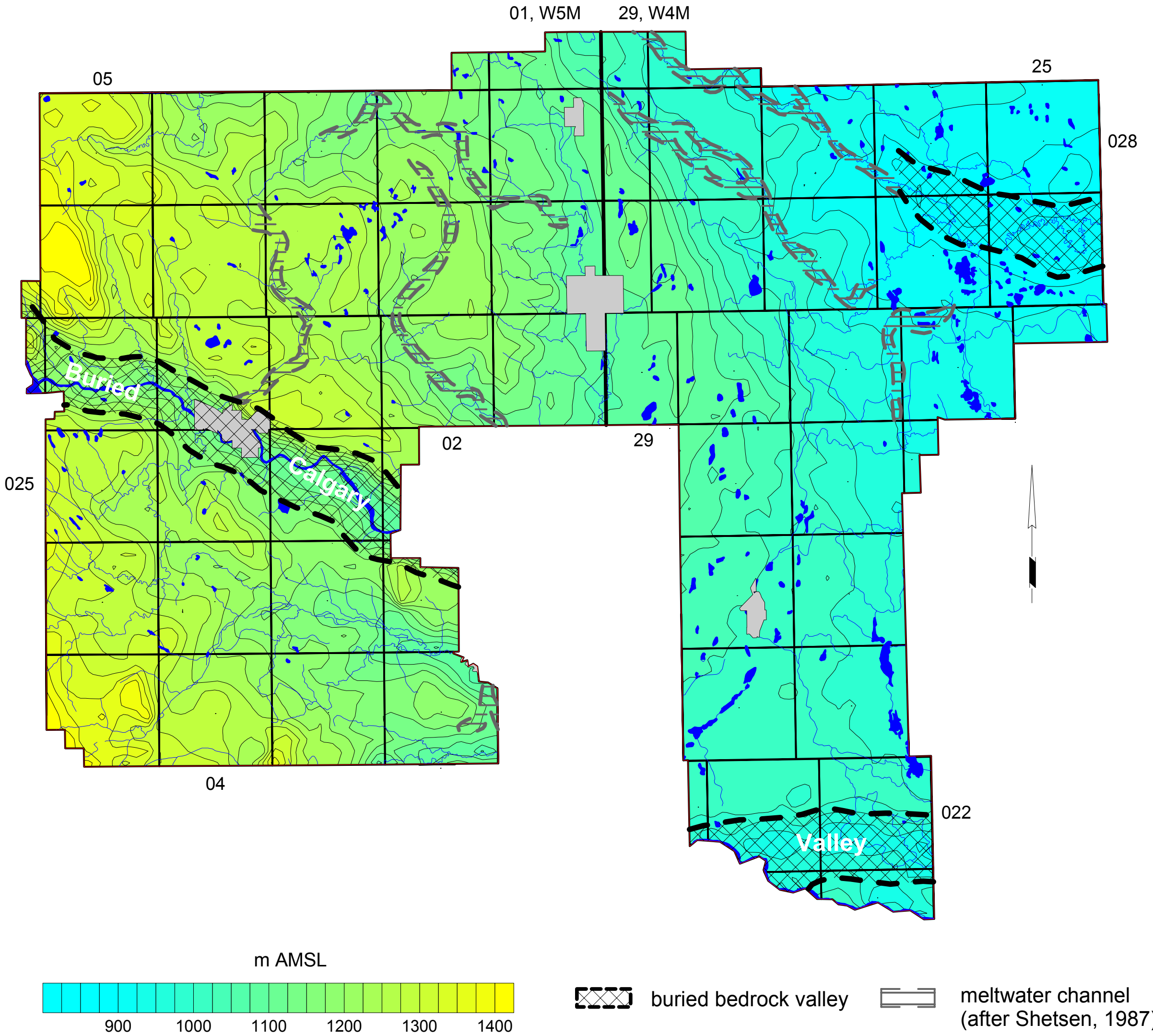
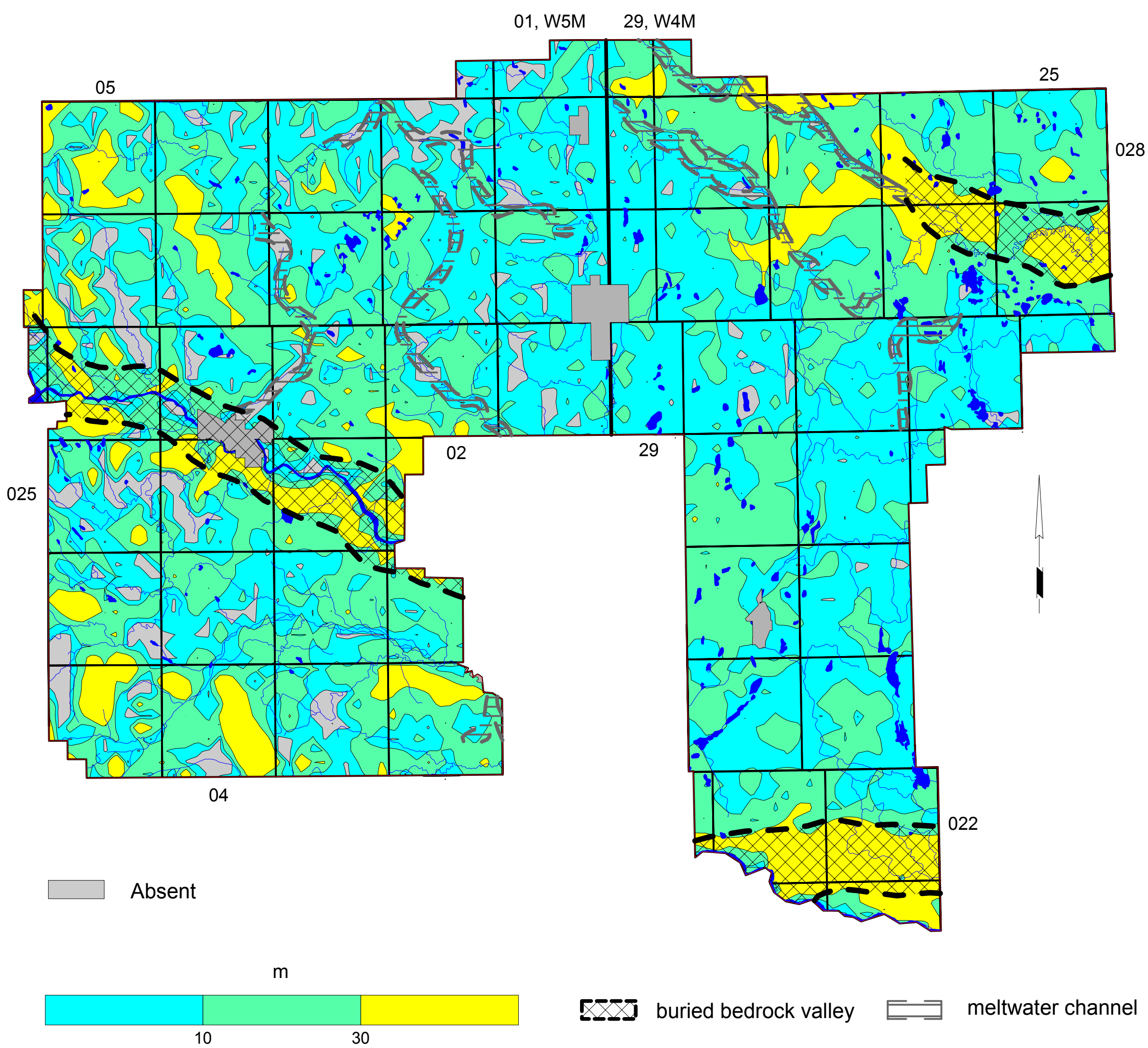
4	M35377.223257	05-35-026-26 W4
5	M35377.115913	SE 23-027-26 W4
6	M35377.202330	SW 25-027-26 W4
7	M35377.089973	05-36-027-26 W4
8	M35377.165215	04-12-028-26 W4
9	M35377.165231	03-13-028-26 W4
10	M35377.150997	NE 24-028-26 W4
11	M35377.064597	SE 02-029-26 W4
12	M35377.084994	NE 11-029-26 W4

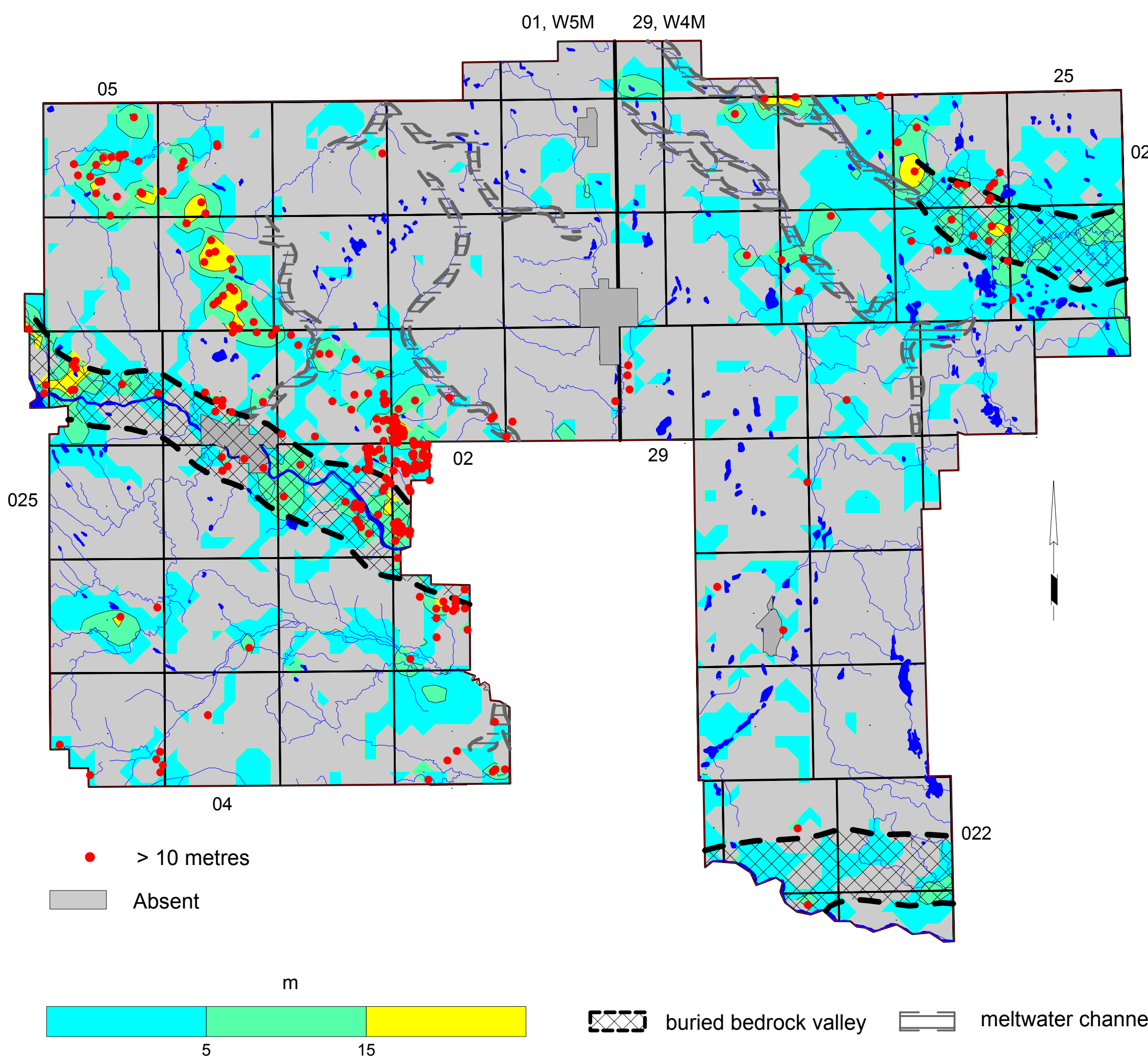
Bedrock Topography



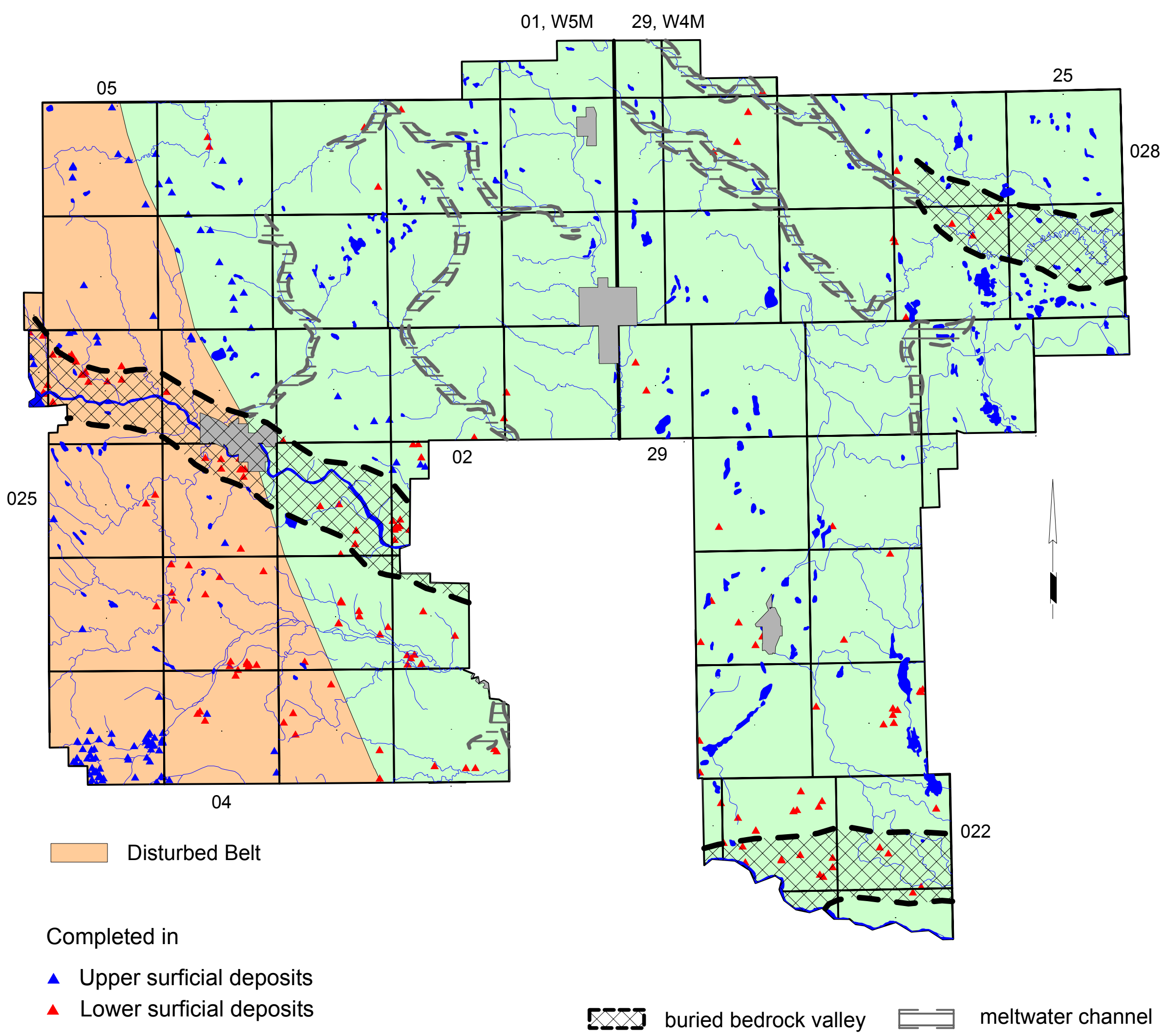
Thickness of Surficial Deposits



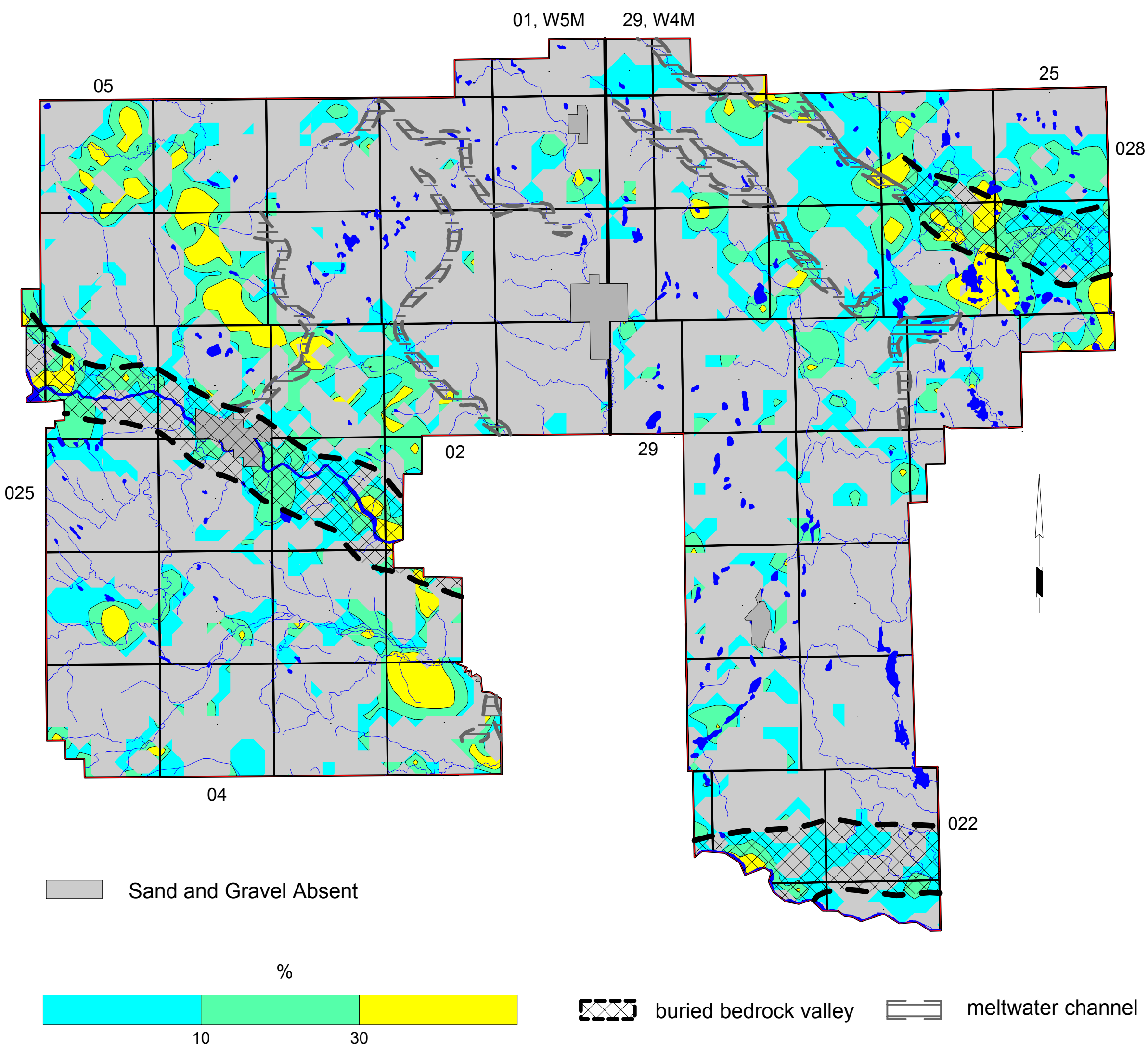
Thickness of Sand and Gravel Deposits



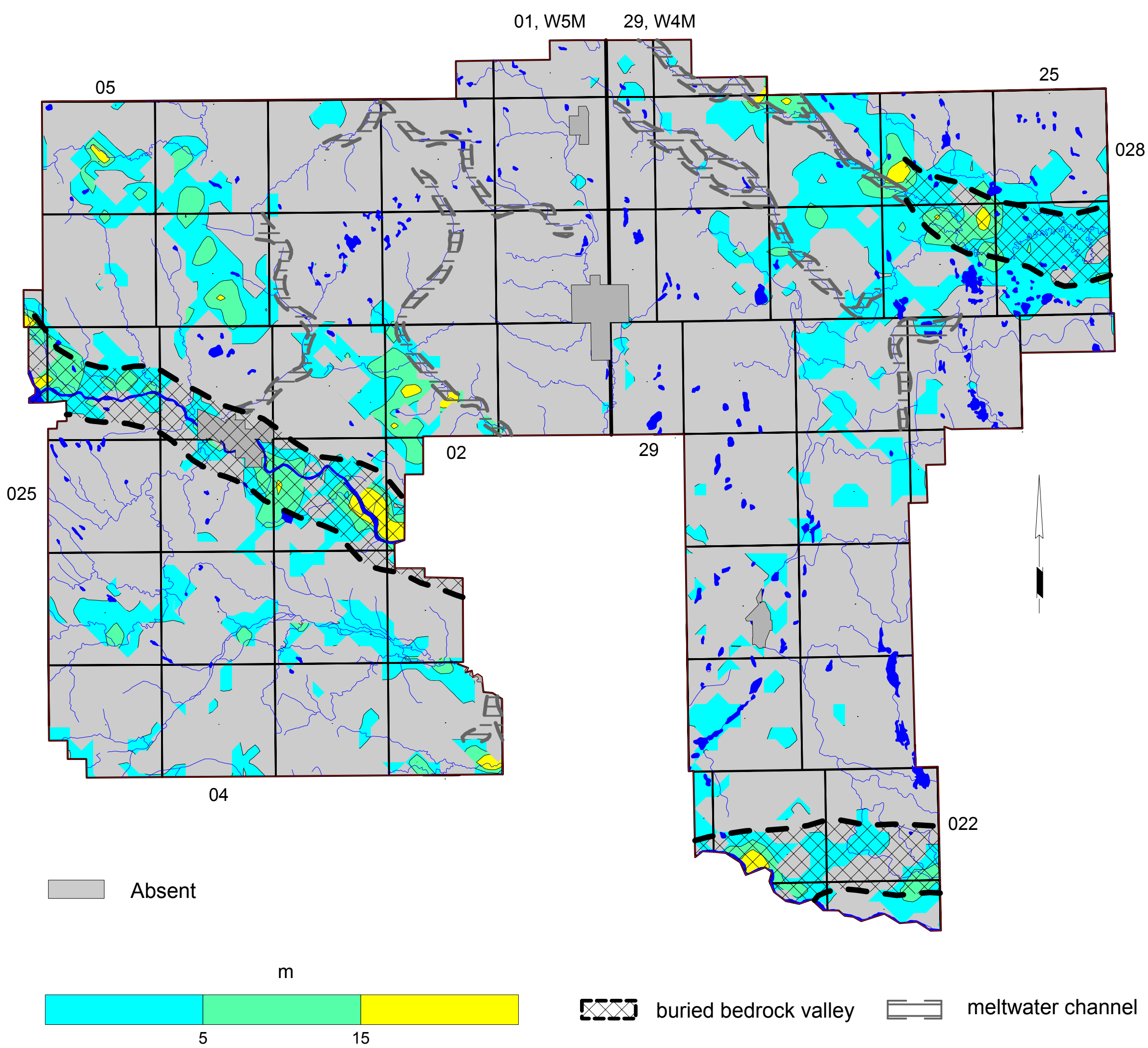
Water Wells Completed In Surficial Deposits



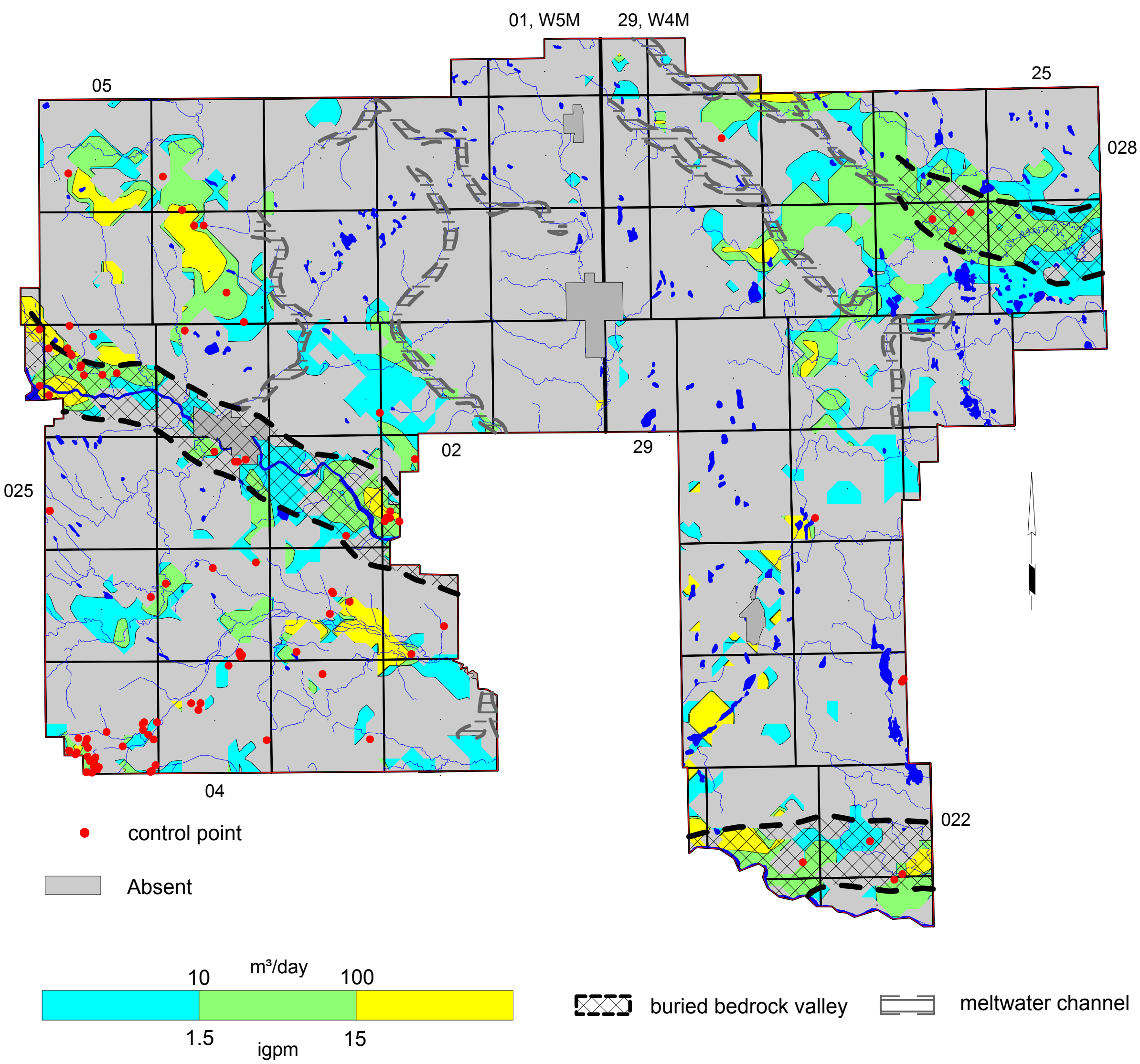
Amount of Sand and Gravel in Surficial Deposits



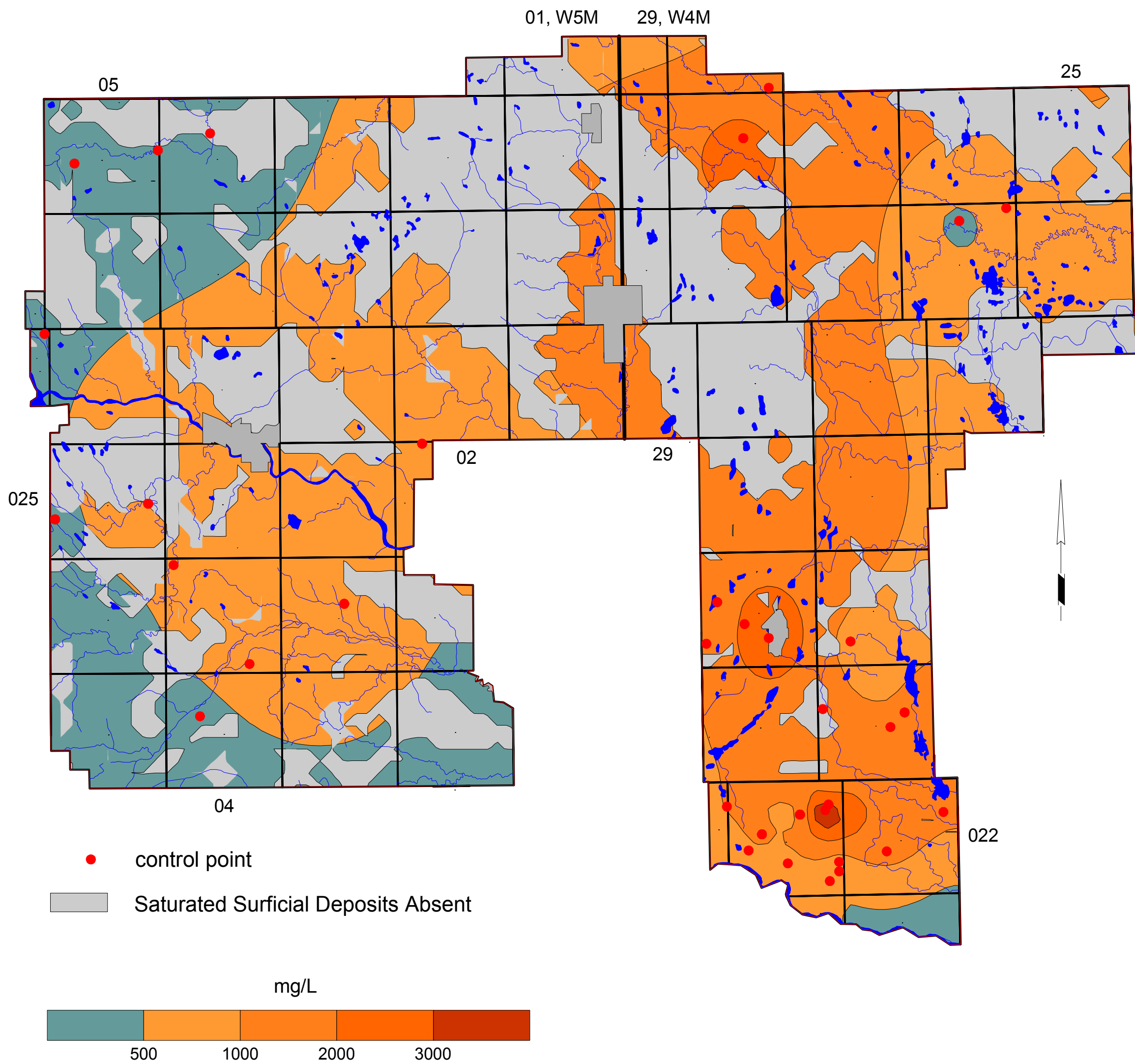
Thickness of Sand and Gravel Aquifer(s)



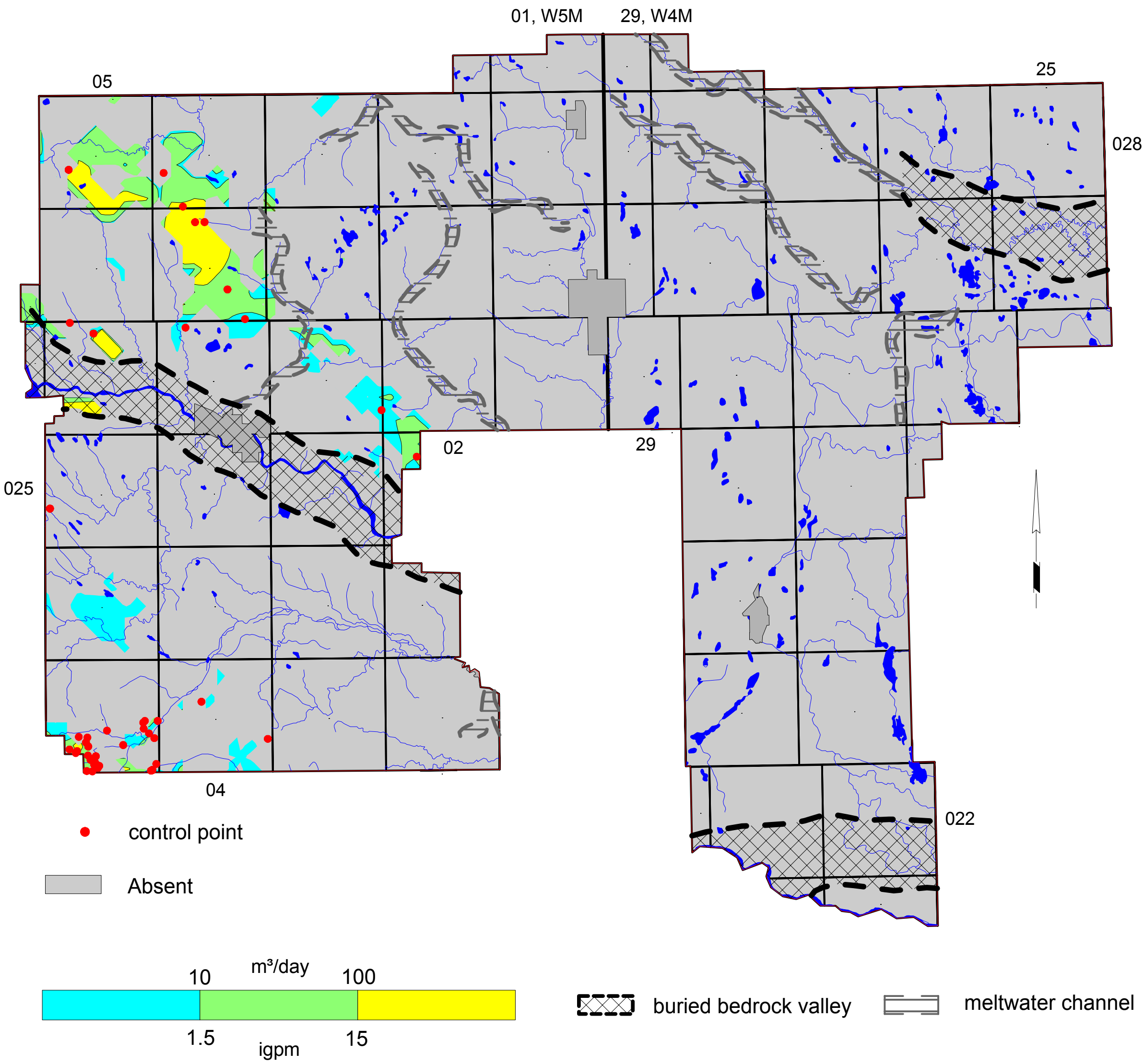
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)



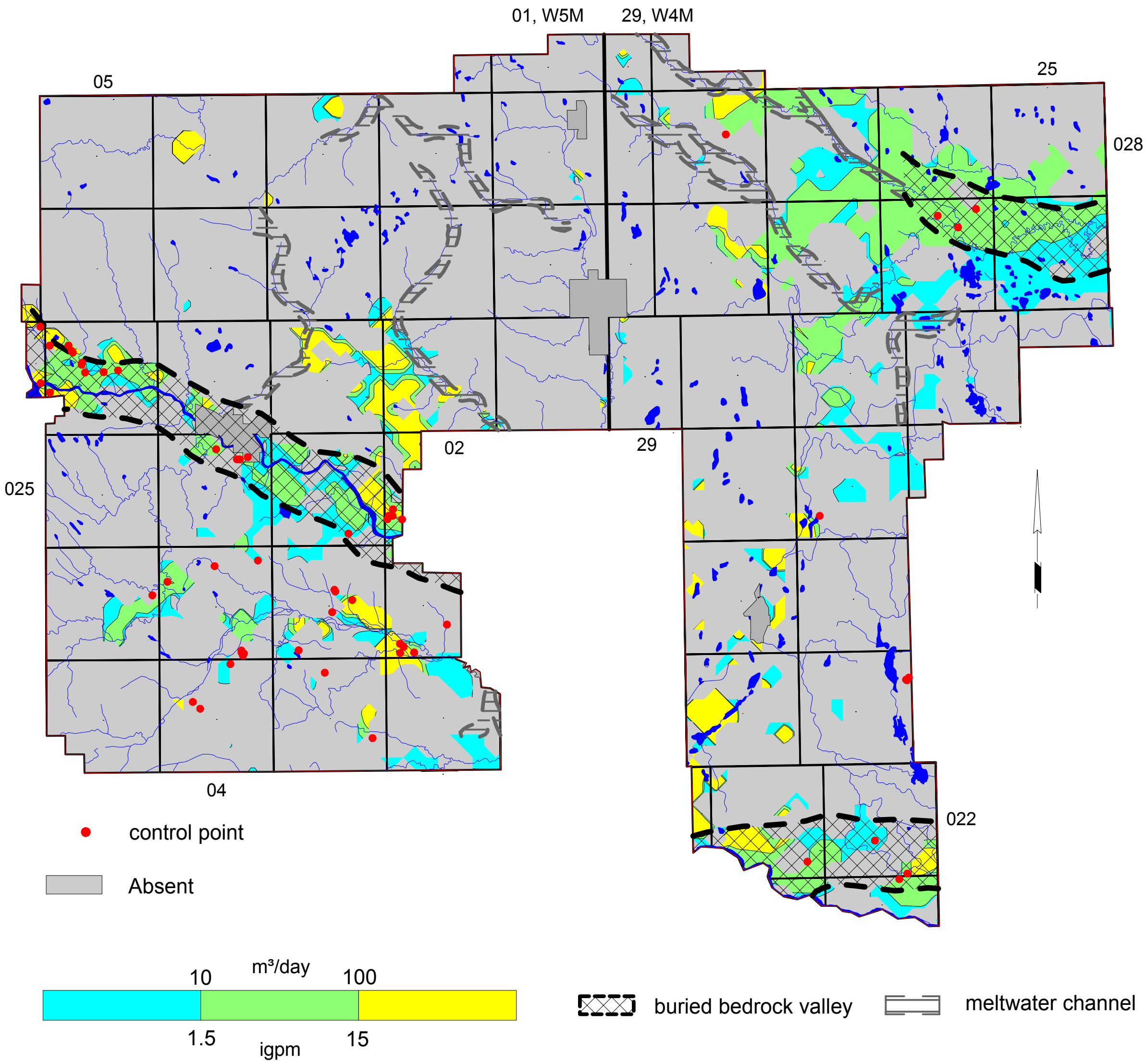
Total Dissolved Solids in Groundwater from Surficial Deposits



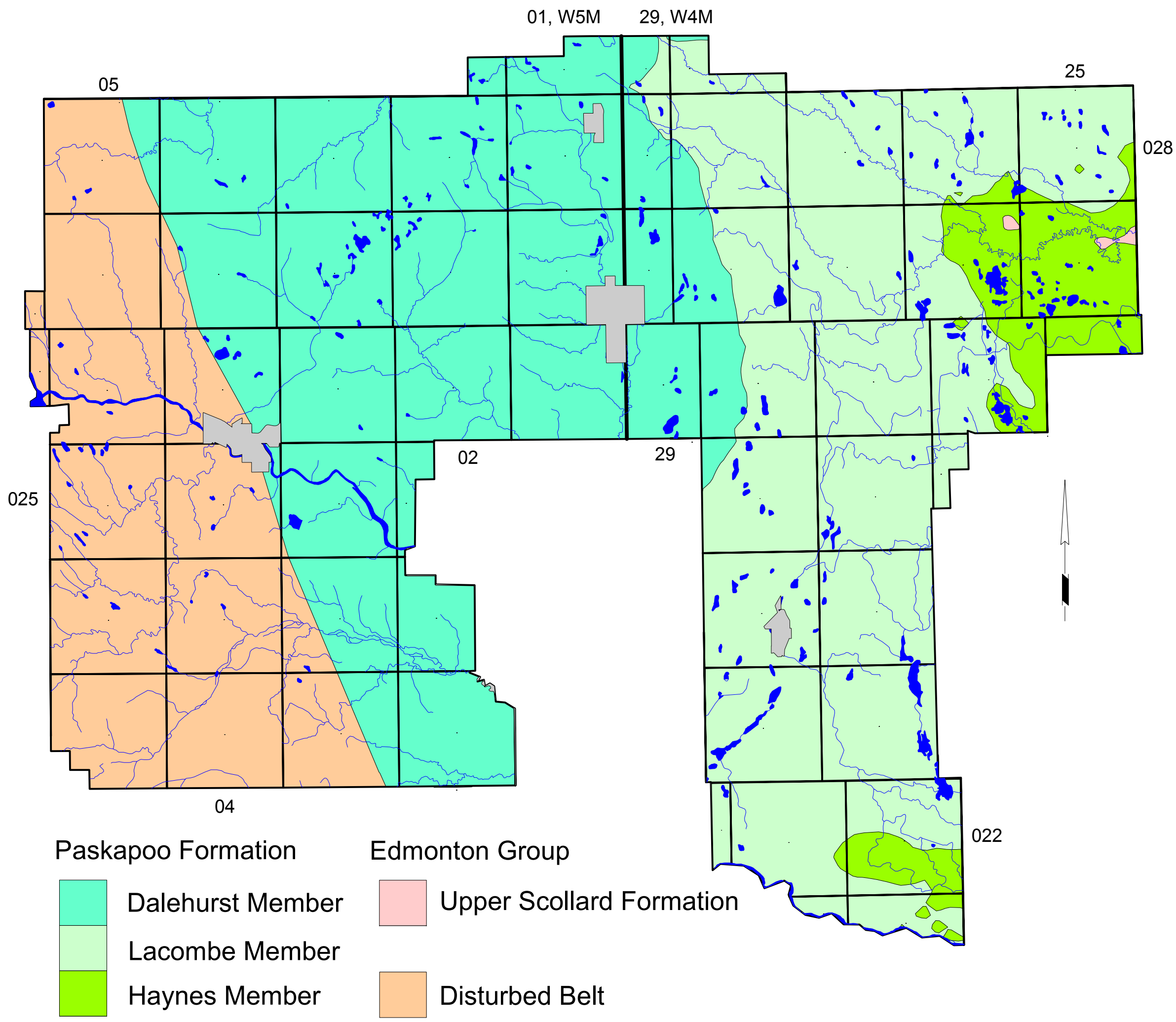
Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer



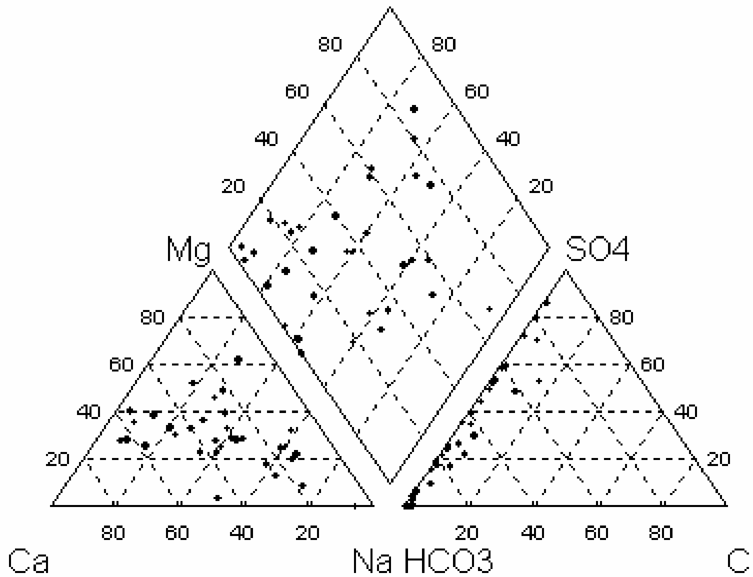
Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer



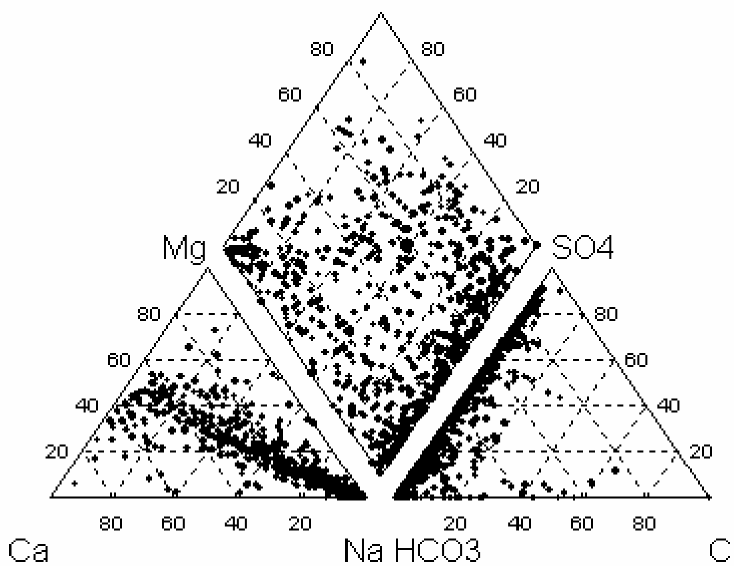
Bedrock Geology



Piper Diagrams

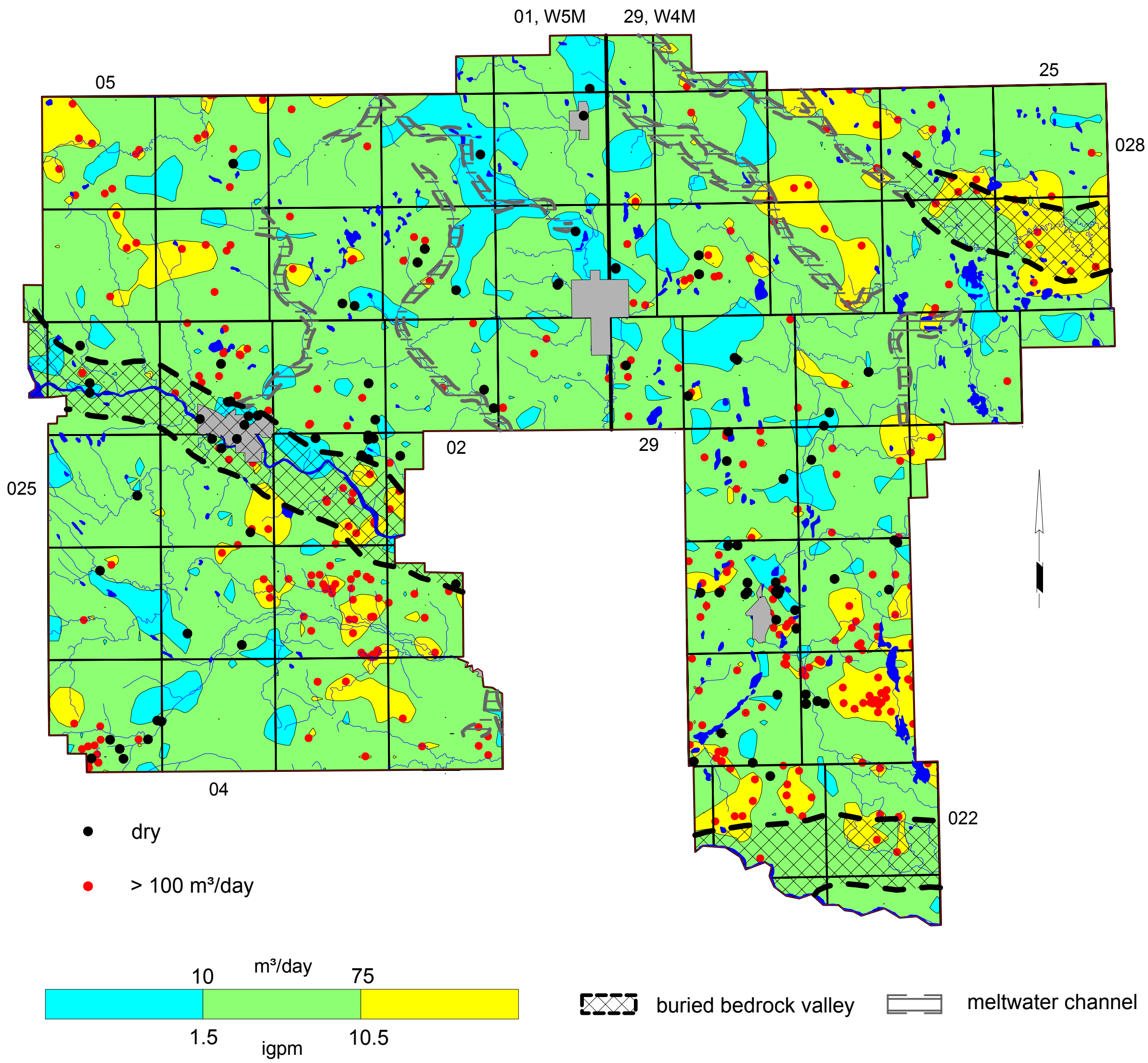


Surficial Deposits

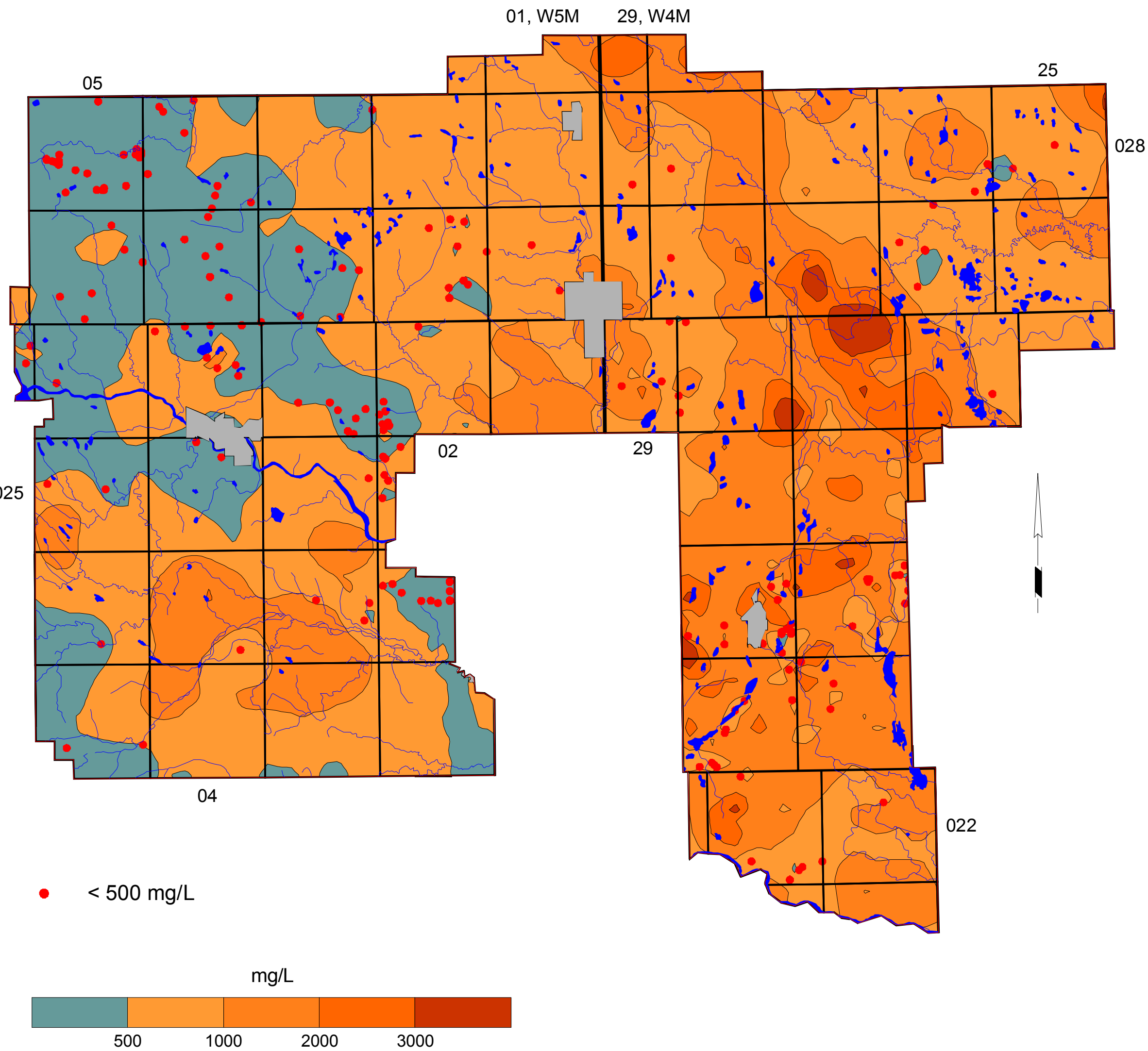


Bedrock Aquifers

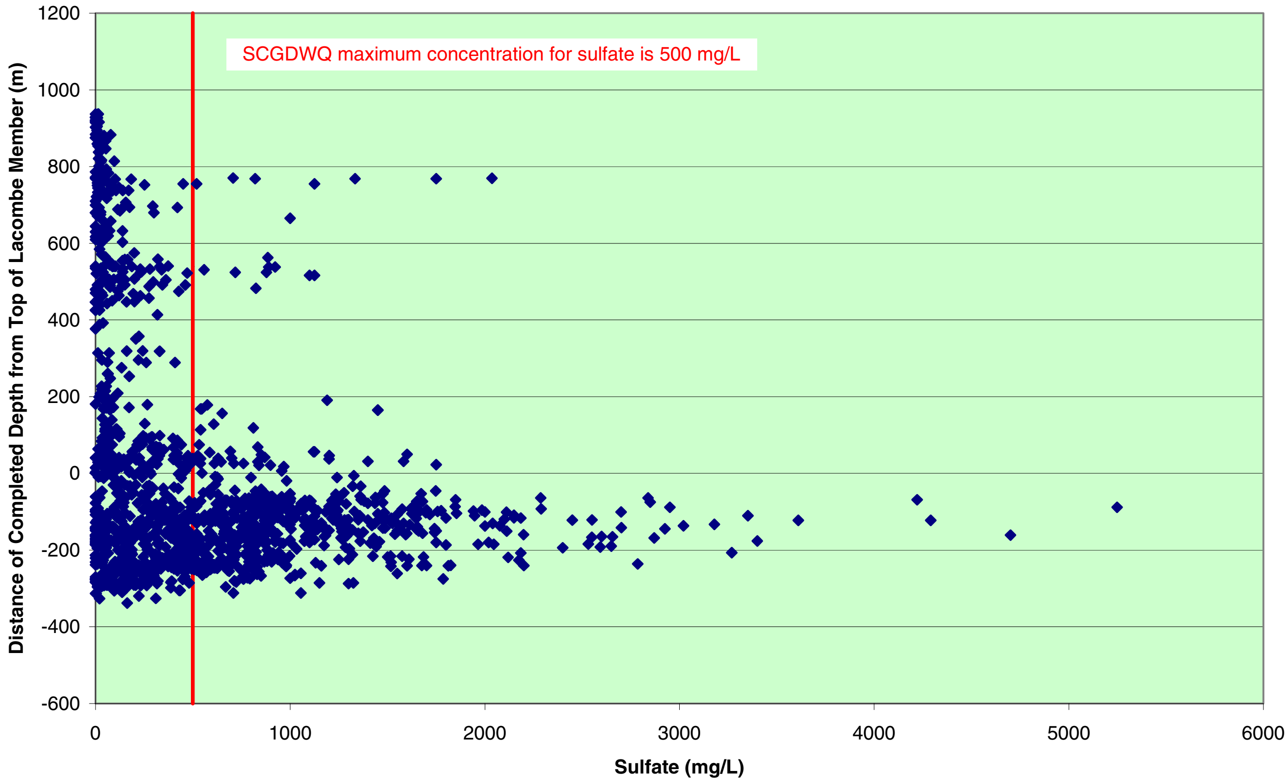
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)



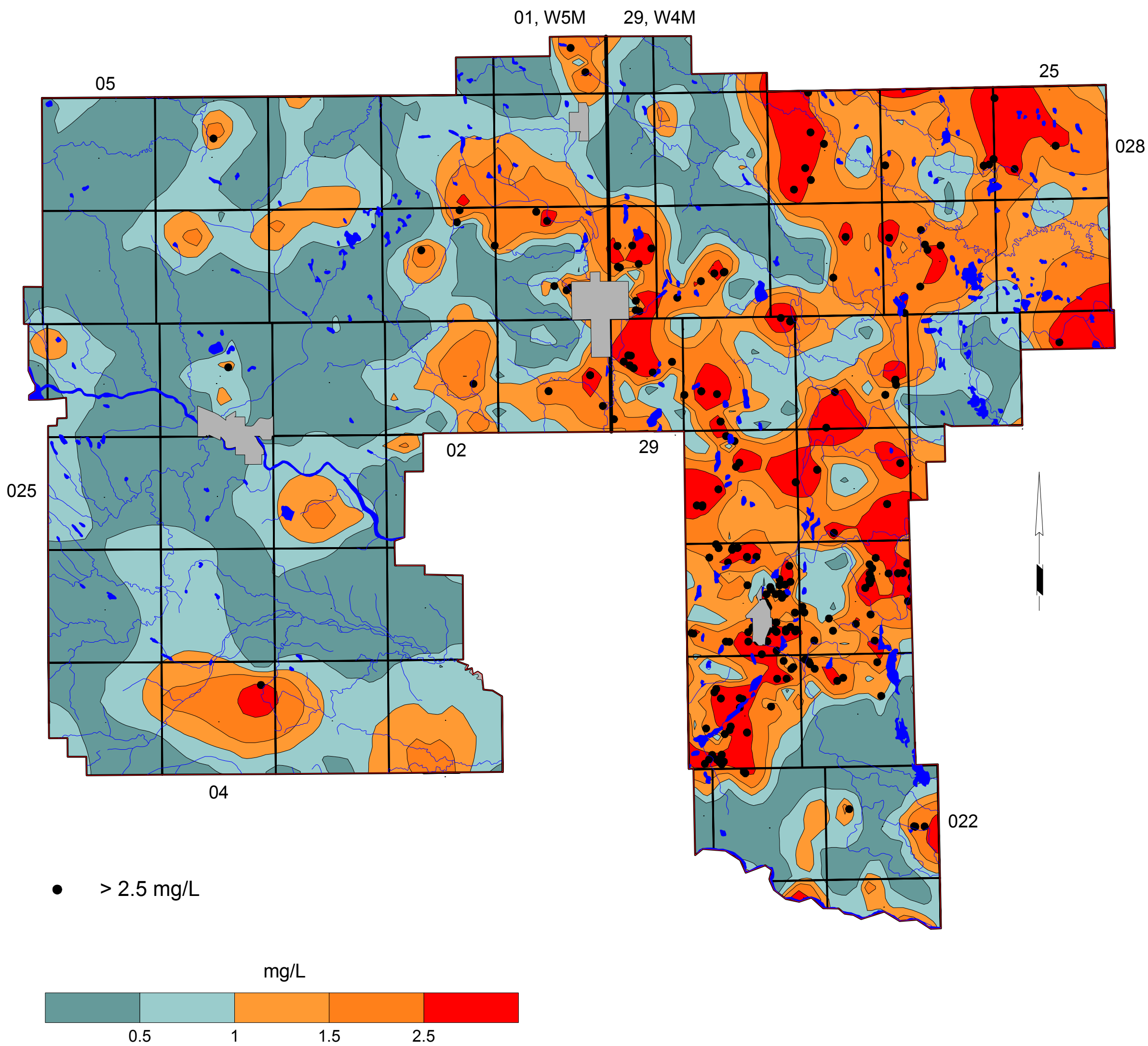
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)



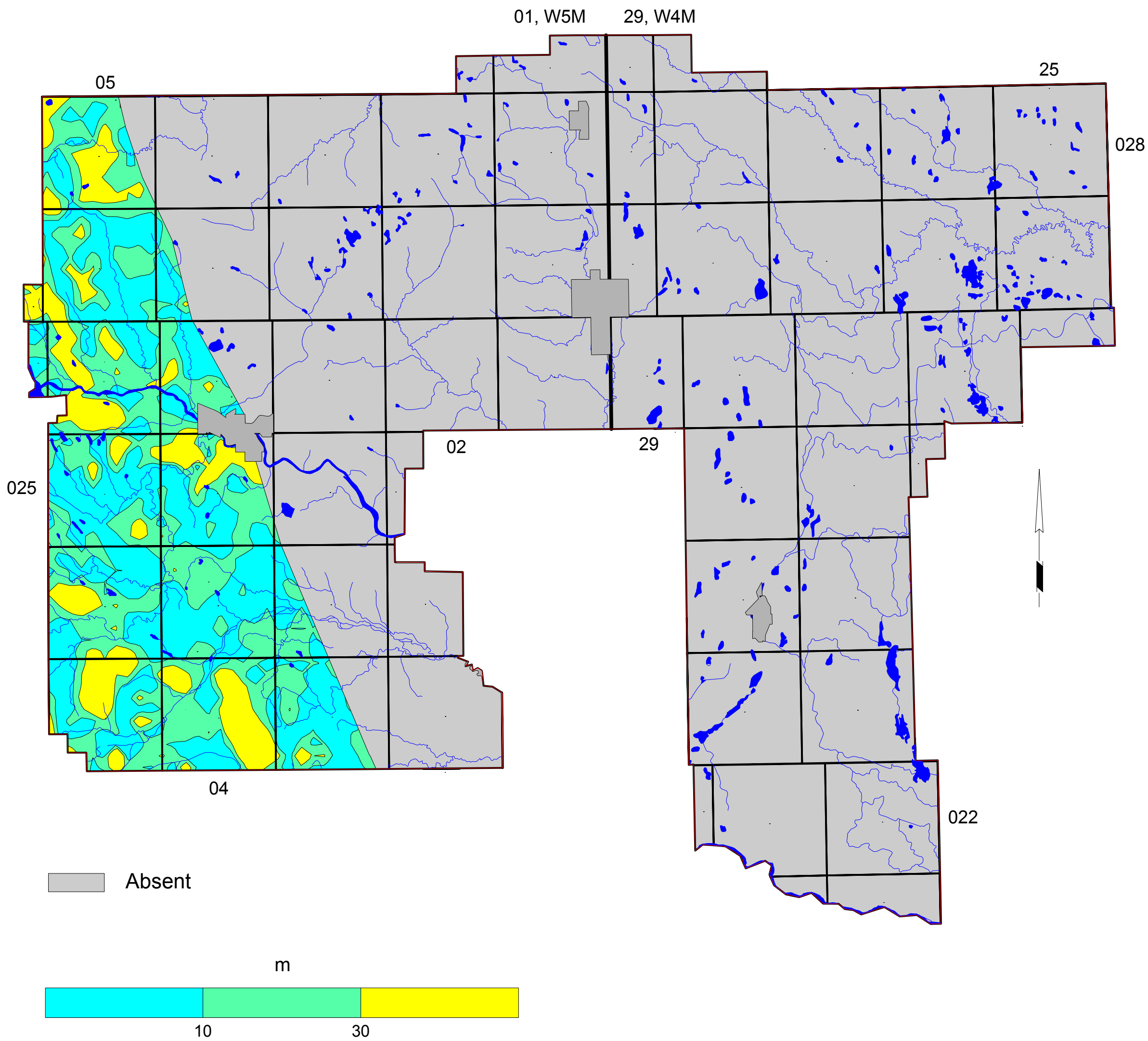
Distance from Top of Lacombe Member vs. Sulfate in Groundwater from Upper Bedrock Aquifer(s)



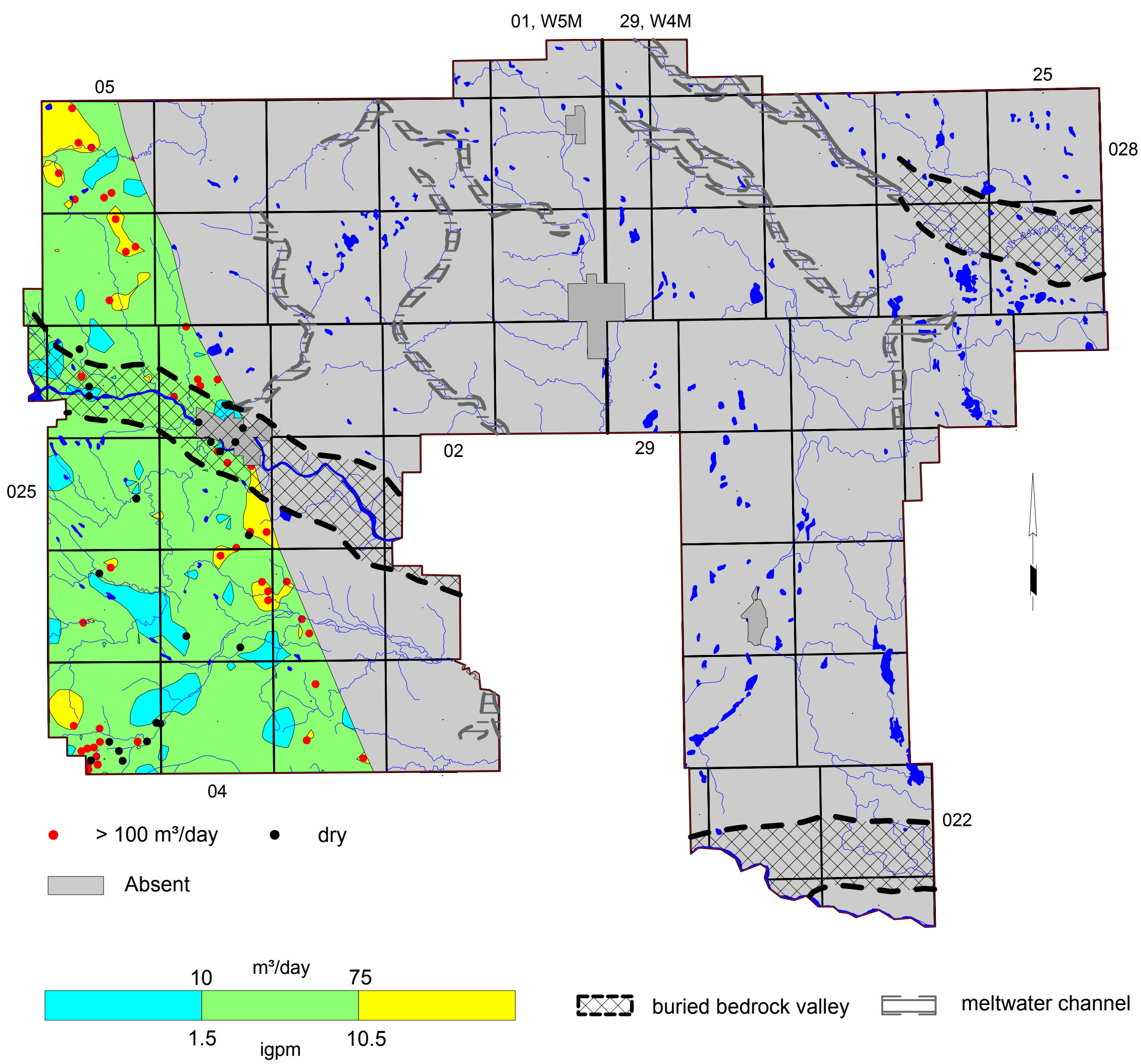
Fluoride in Groundwater from Upper Bedrock Aquifer(s)



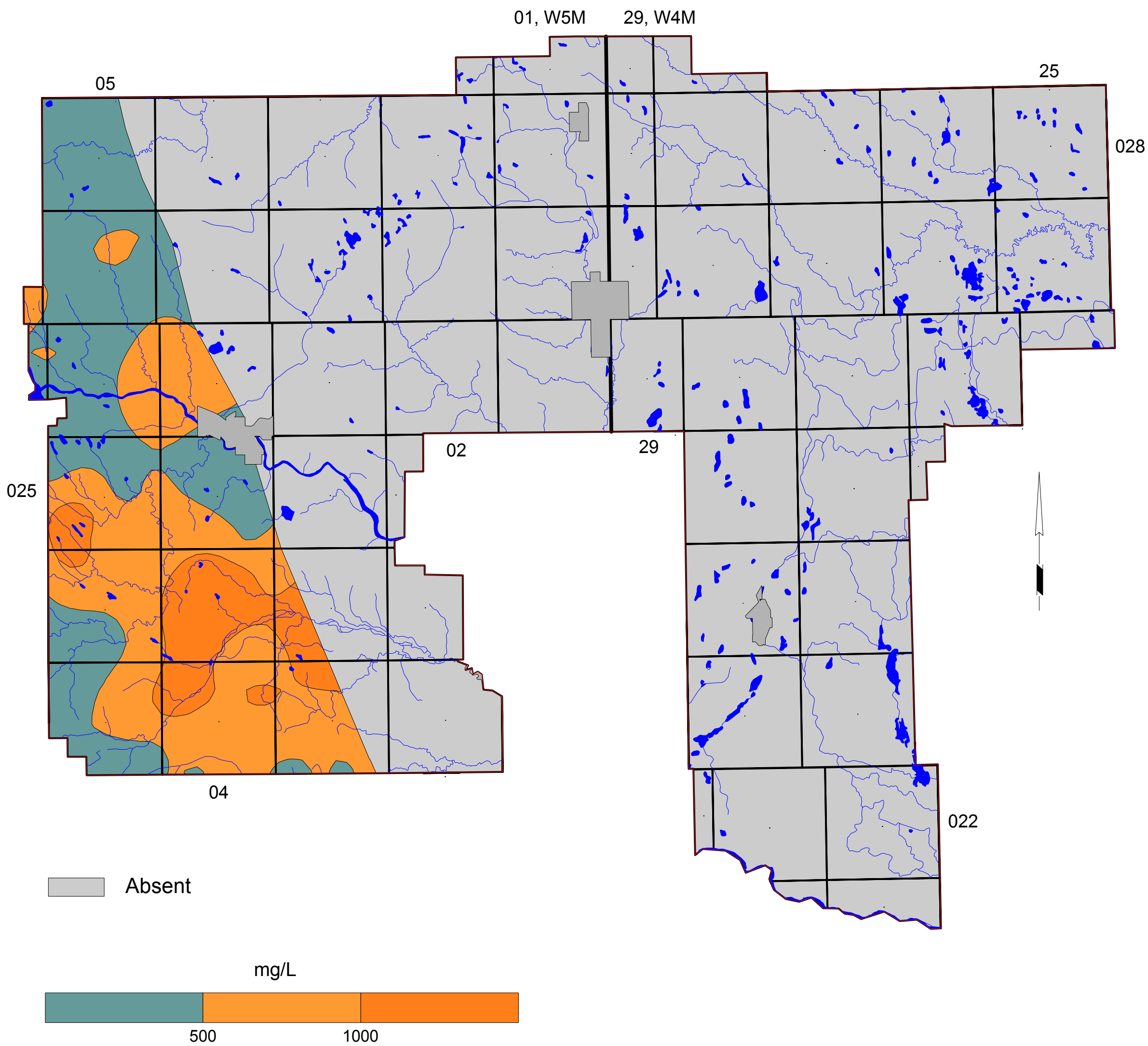
Depth to Top of Disturbed Belt



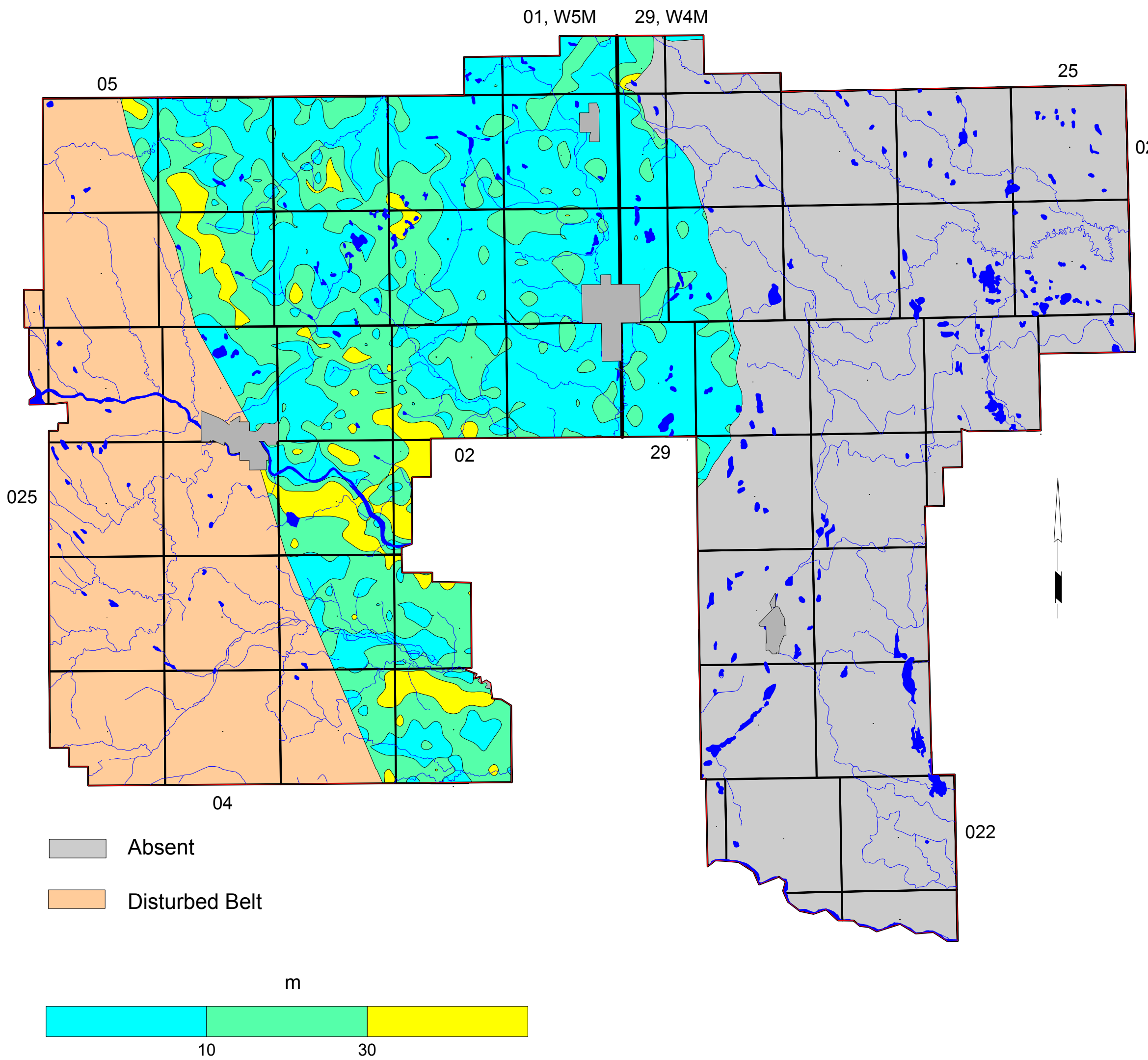
Apparent Yield for Water Wells Completed through Disturbed Belt Aquifer



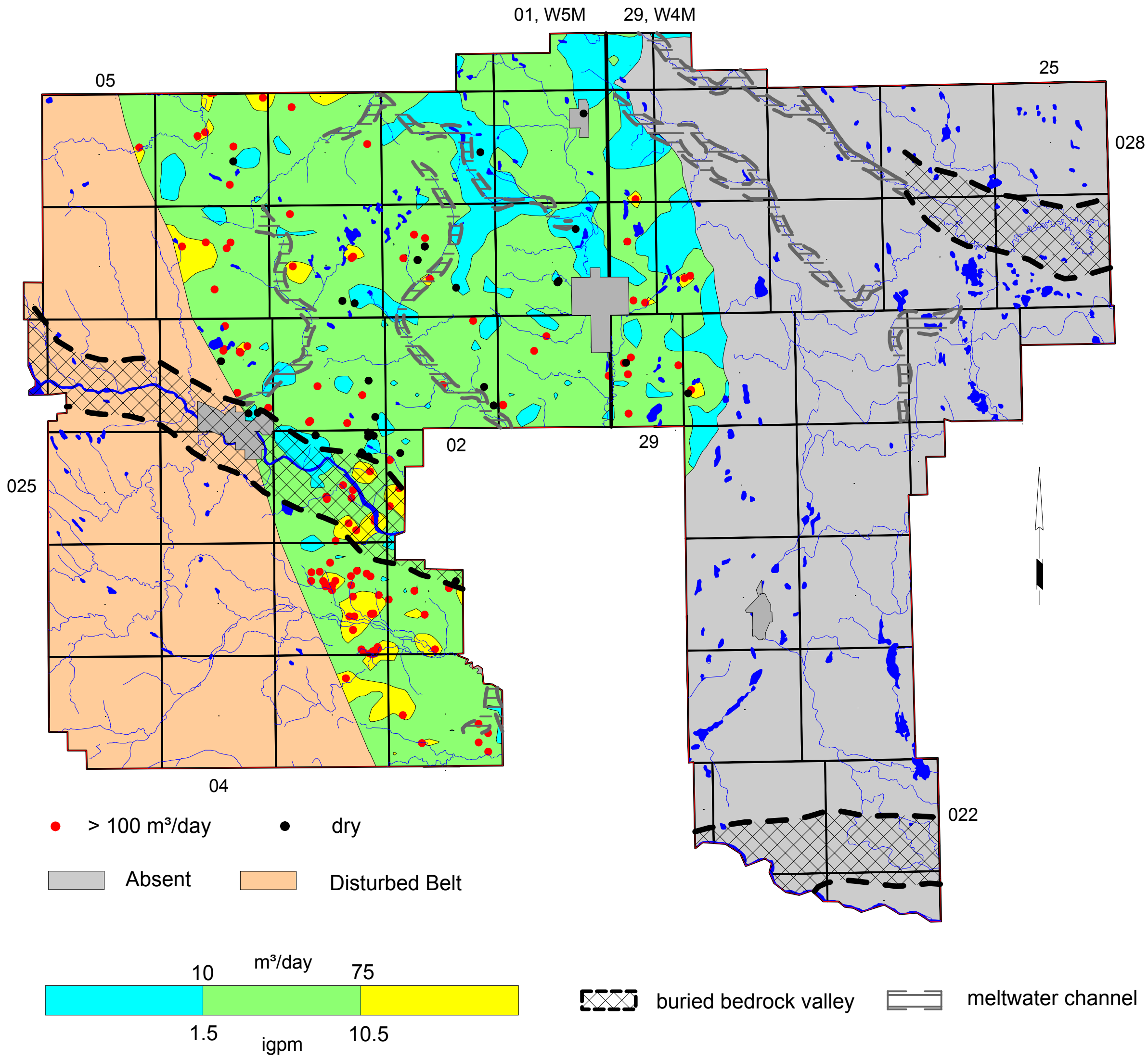
Total Dissolved Solids in Groundwater from Disturbed Belt Aquifer



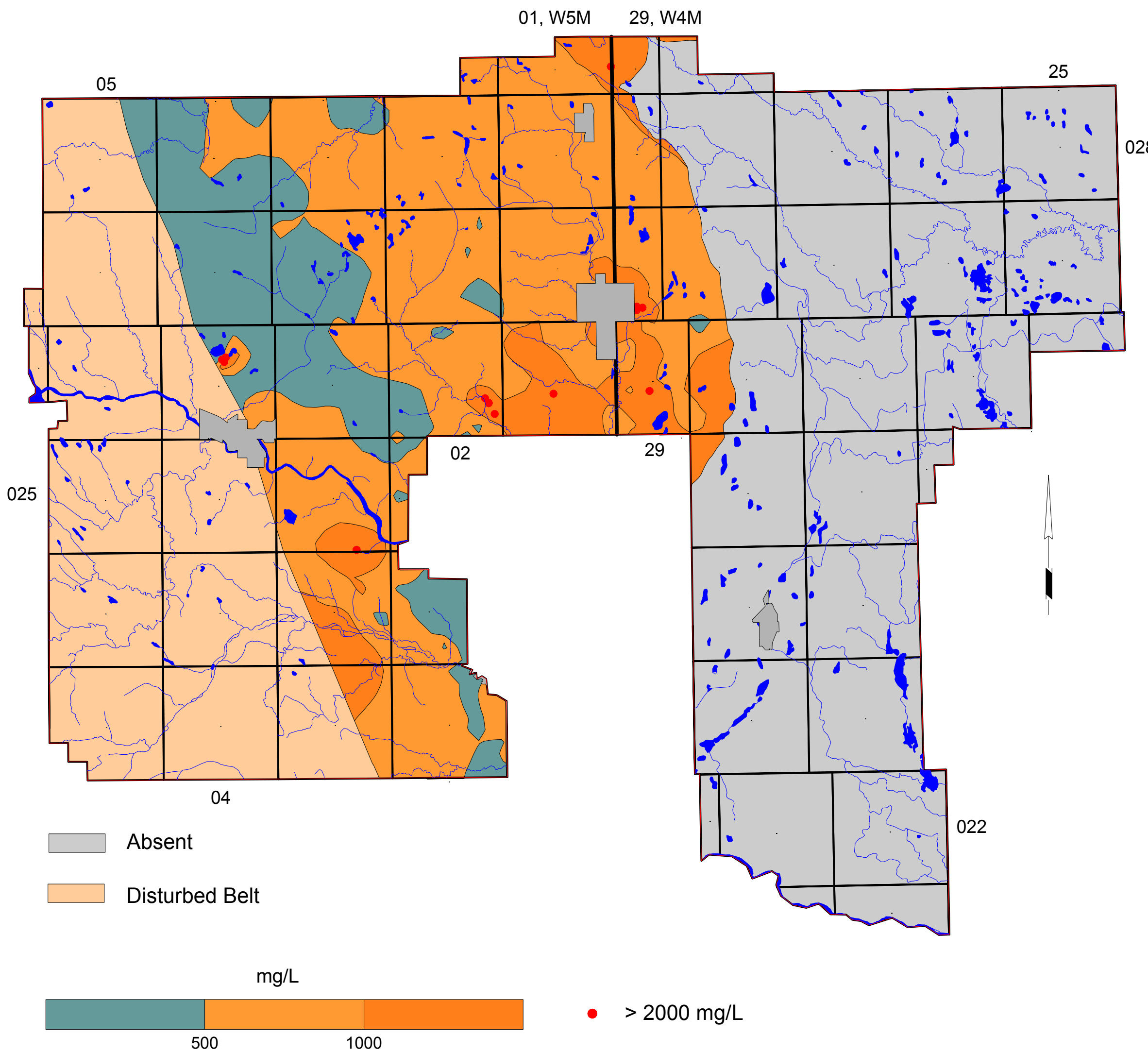
Depth to Top of Dalehurst Member



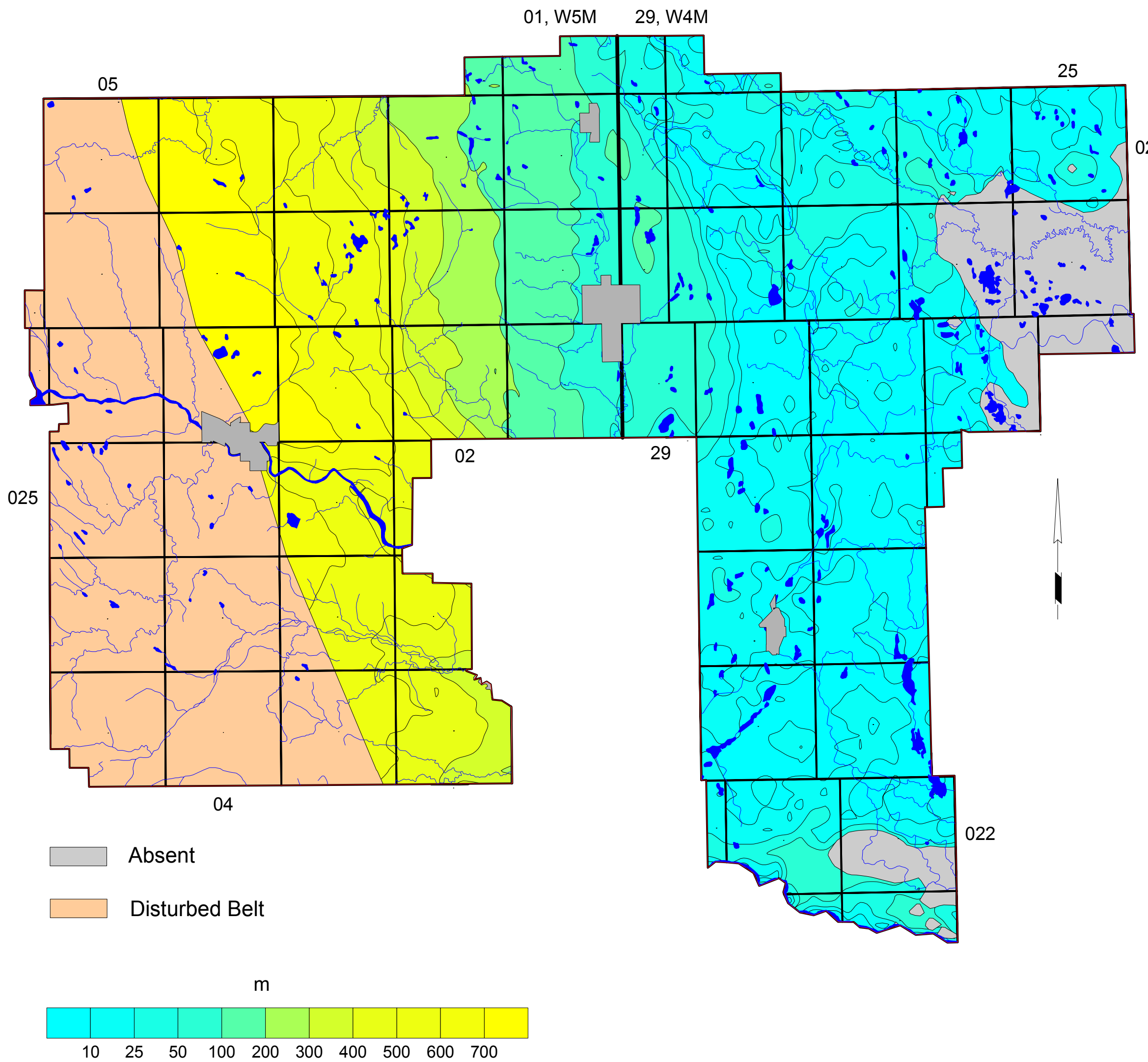
Apparent Yield for Water Wells Completed through Dalehurst Aquifer



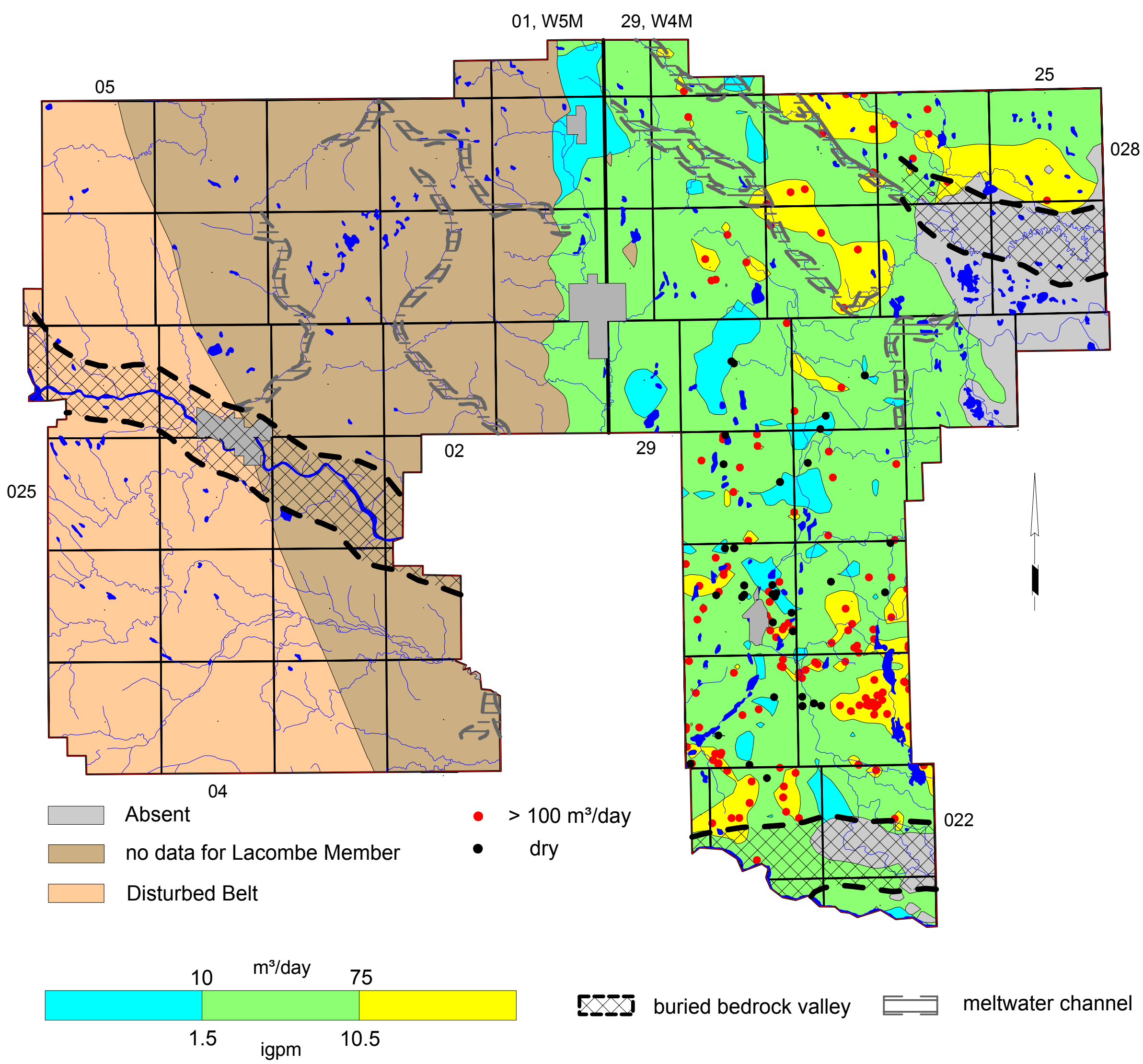
Total Dissolved Solids in Groundwater from Dalehurst Aquifer



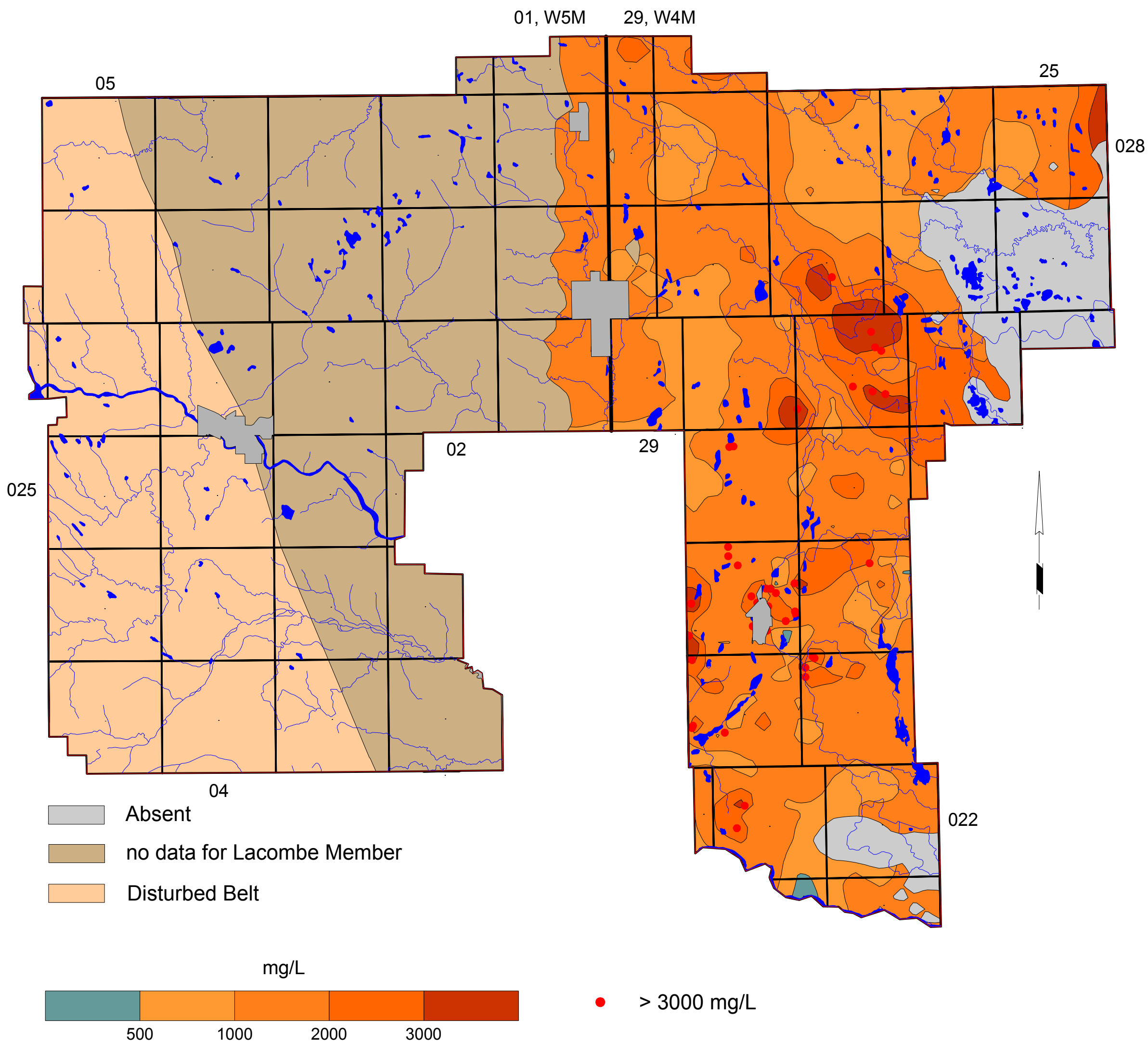
Depth to Top of Lacombe Member



Apparent Yield for Water Wells Completed through Lacombe Aquifer



Total Dissolved Solids in Groundwater from Lacombe Aquifer



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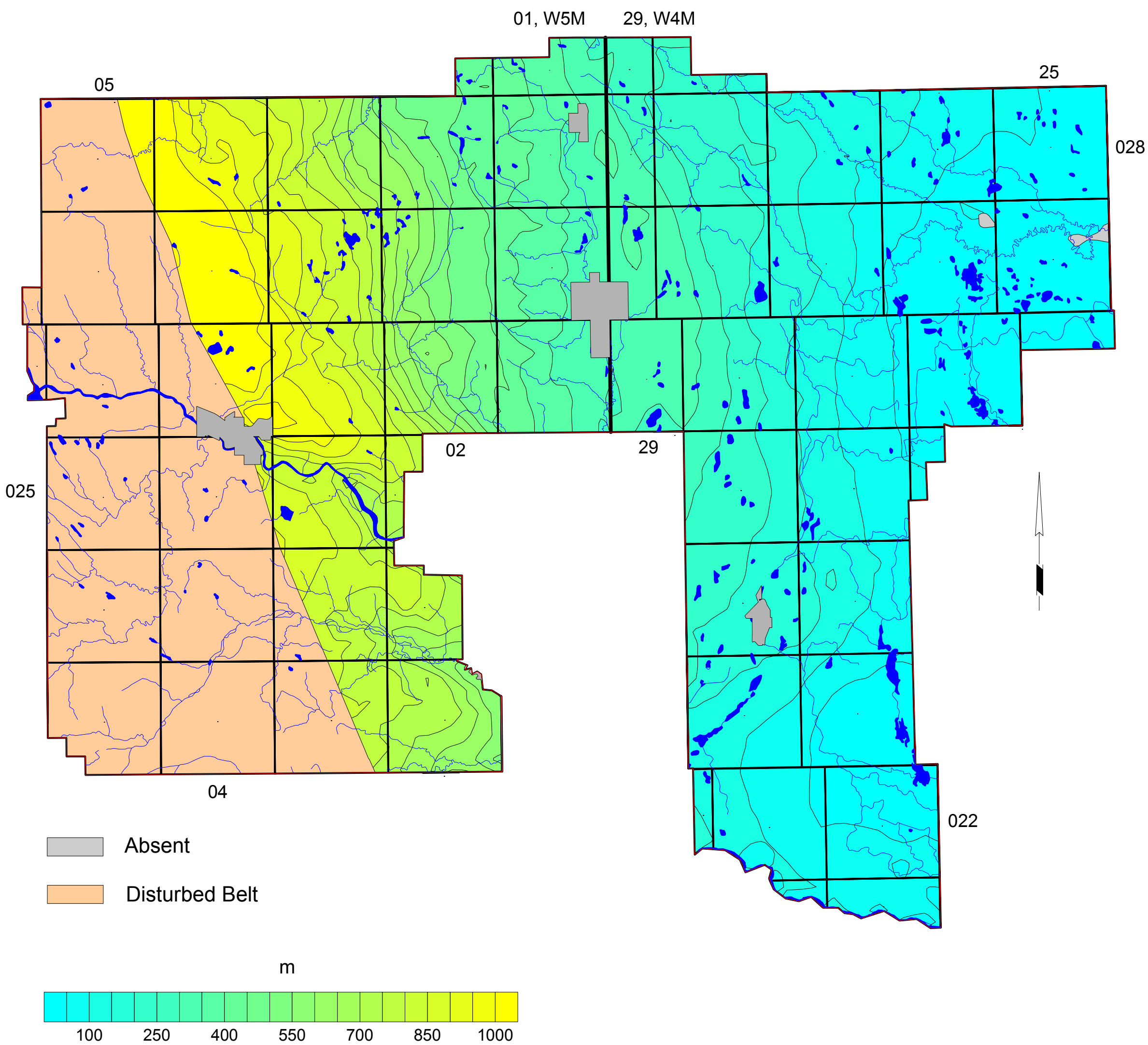
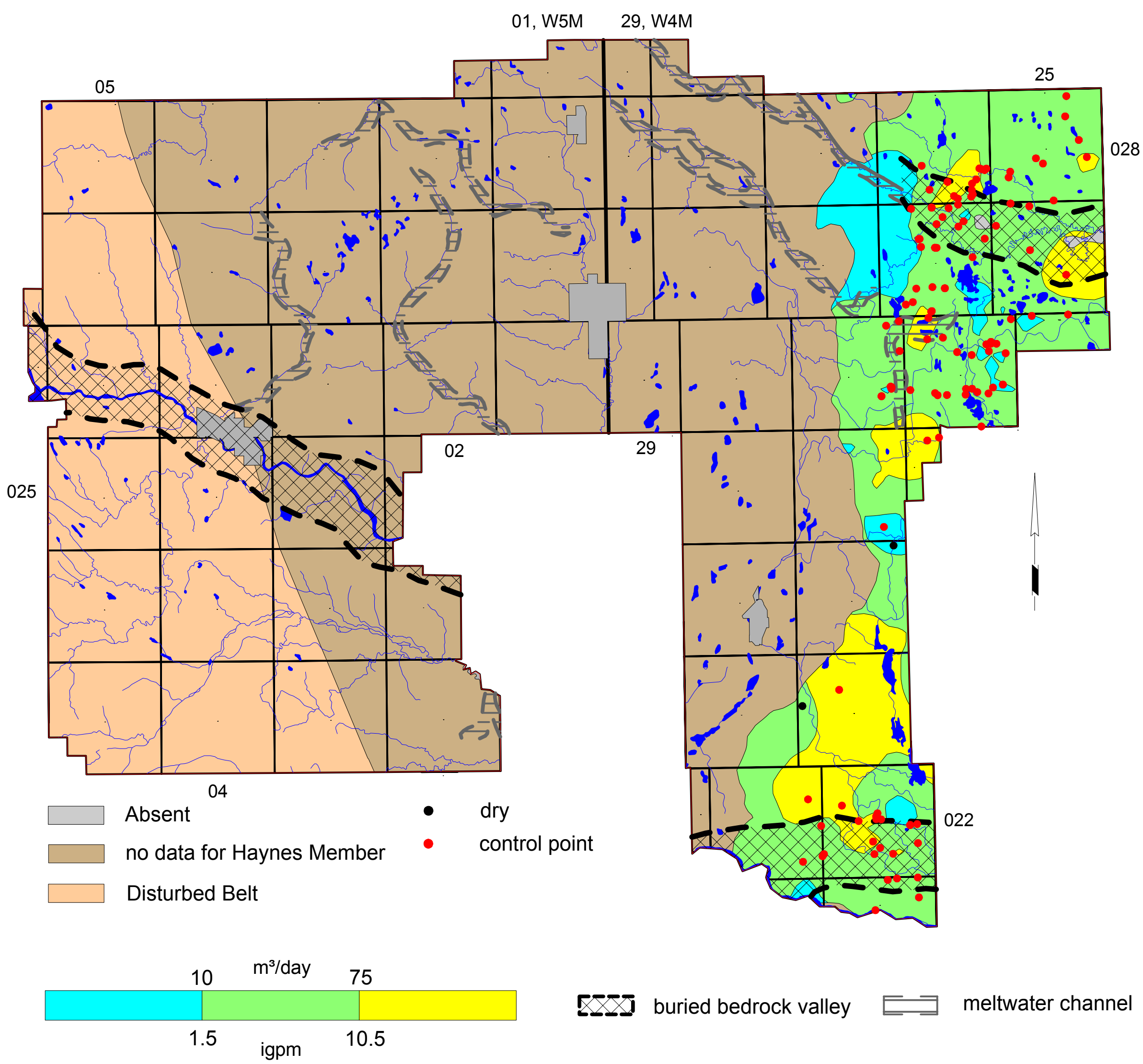
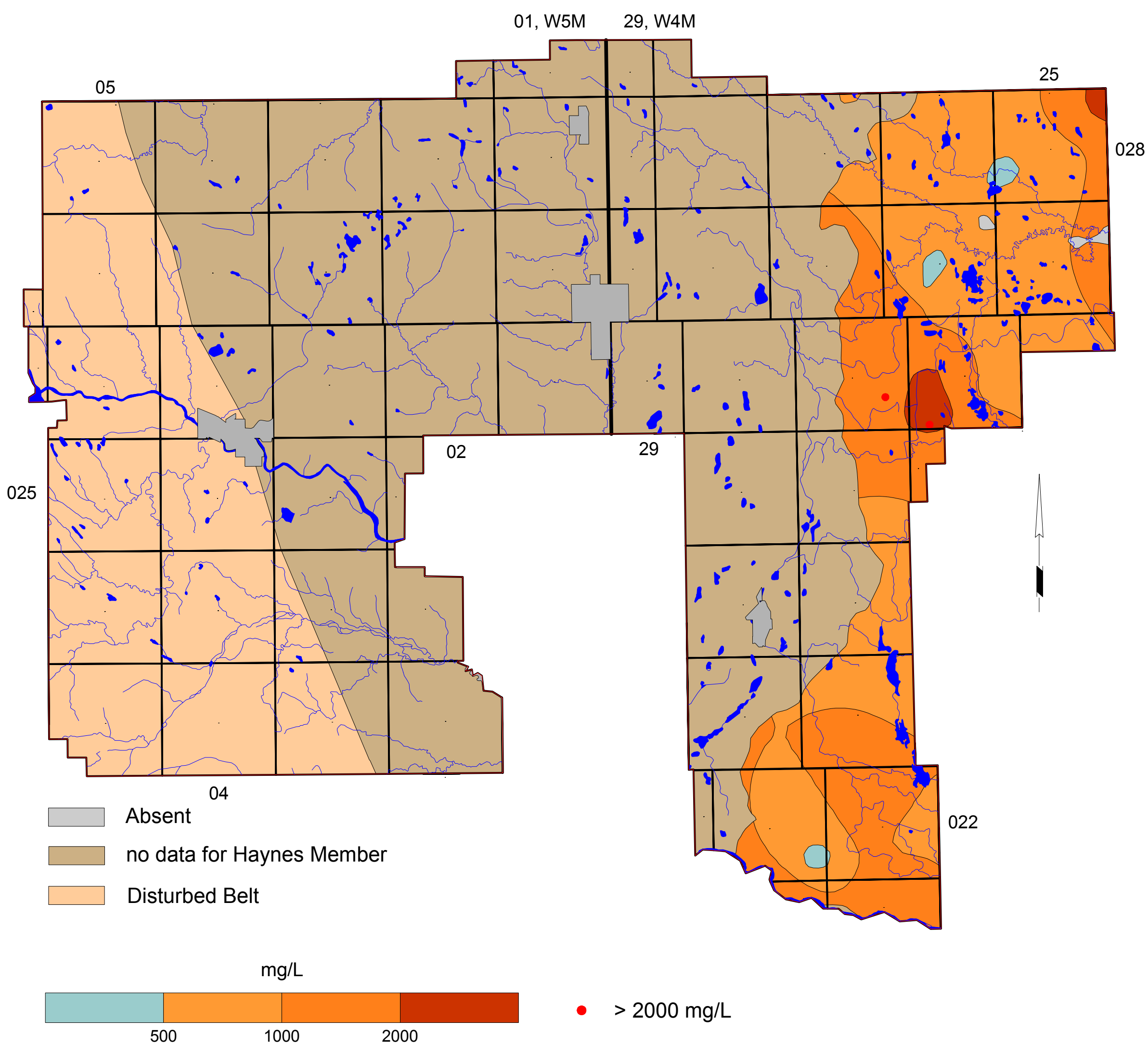
Depth to Top of Haynes Member



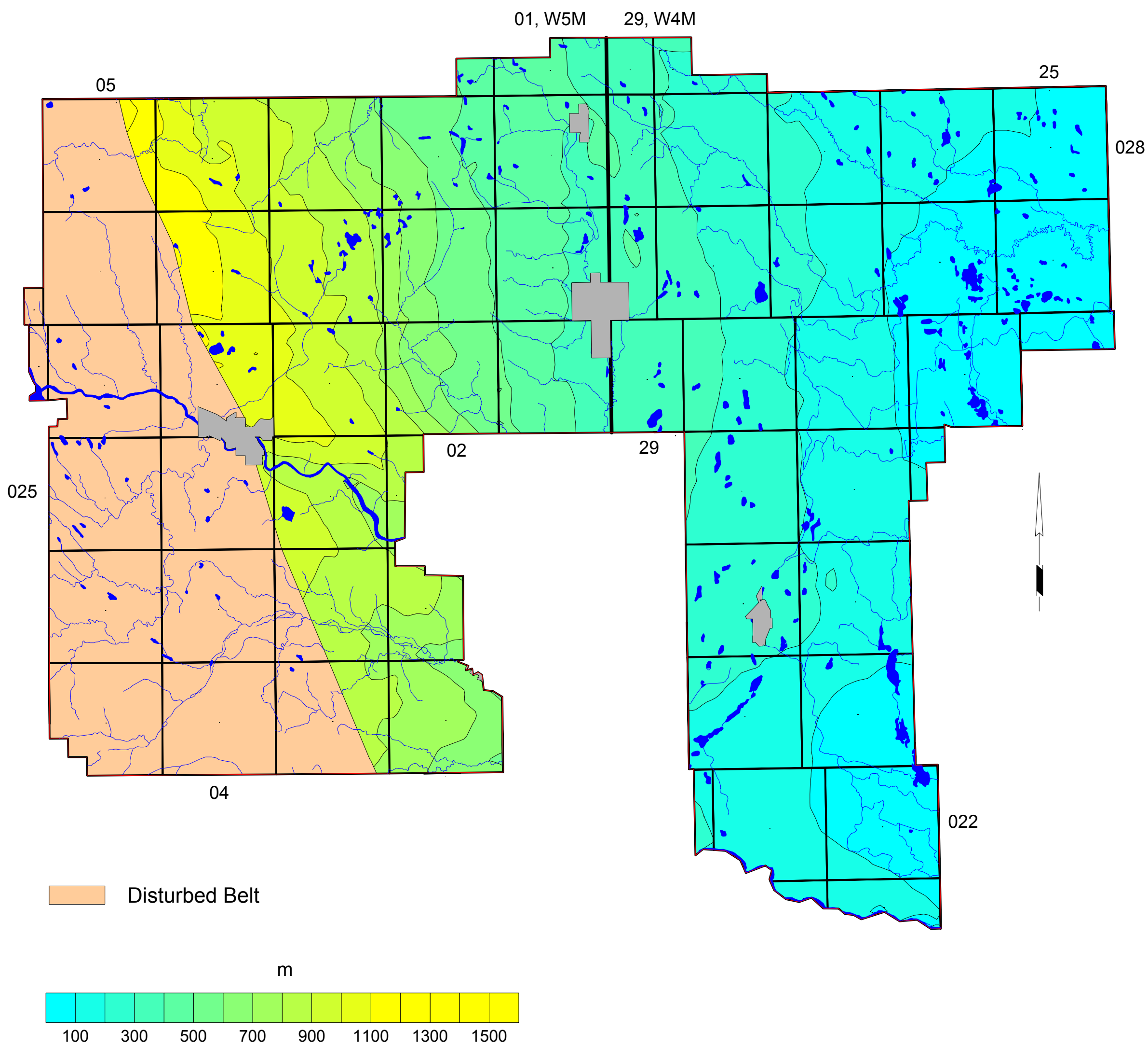
Apparent Yield for Water Wells Completed through Haynes Aquifer



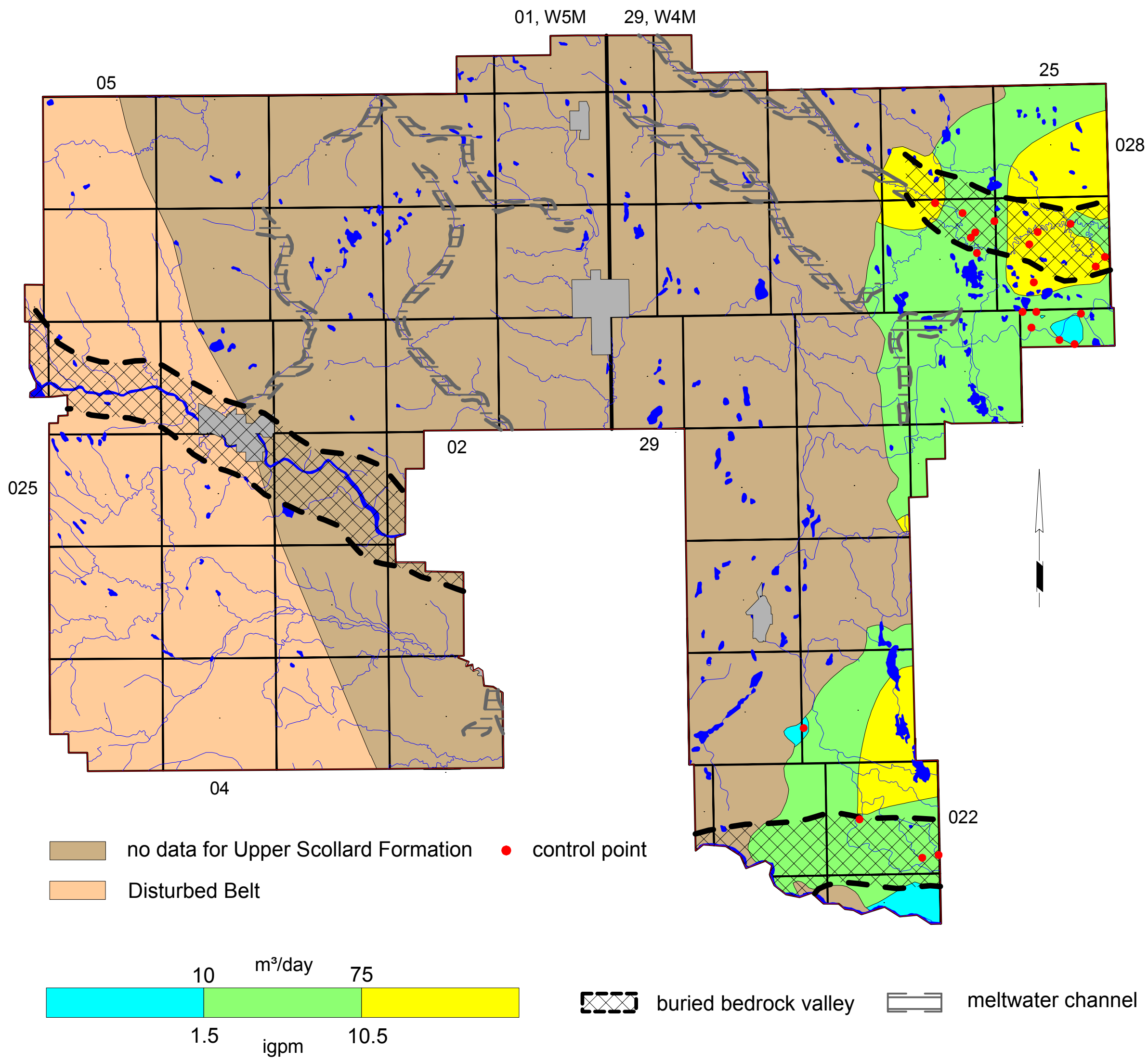
Total Dissolved Solids in Groundwater from Haynes Aquifer



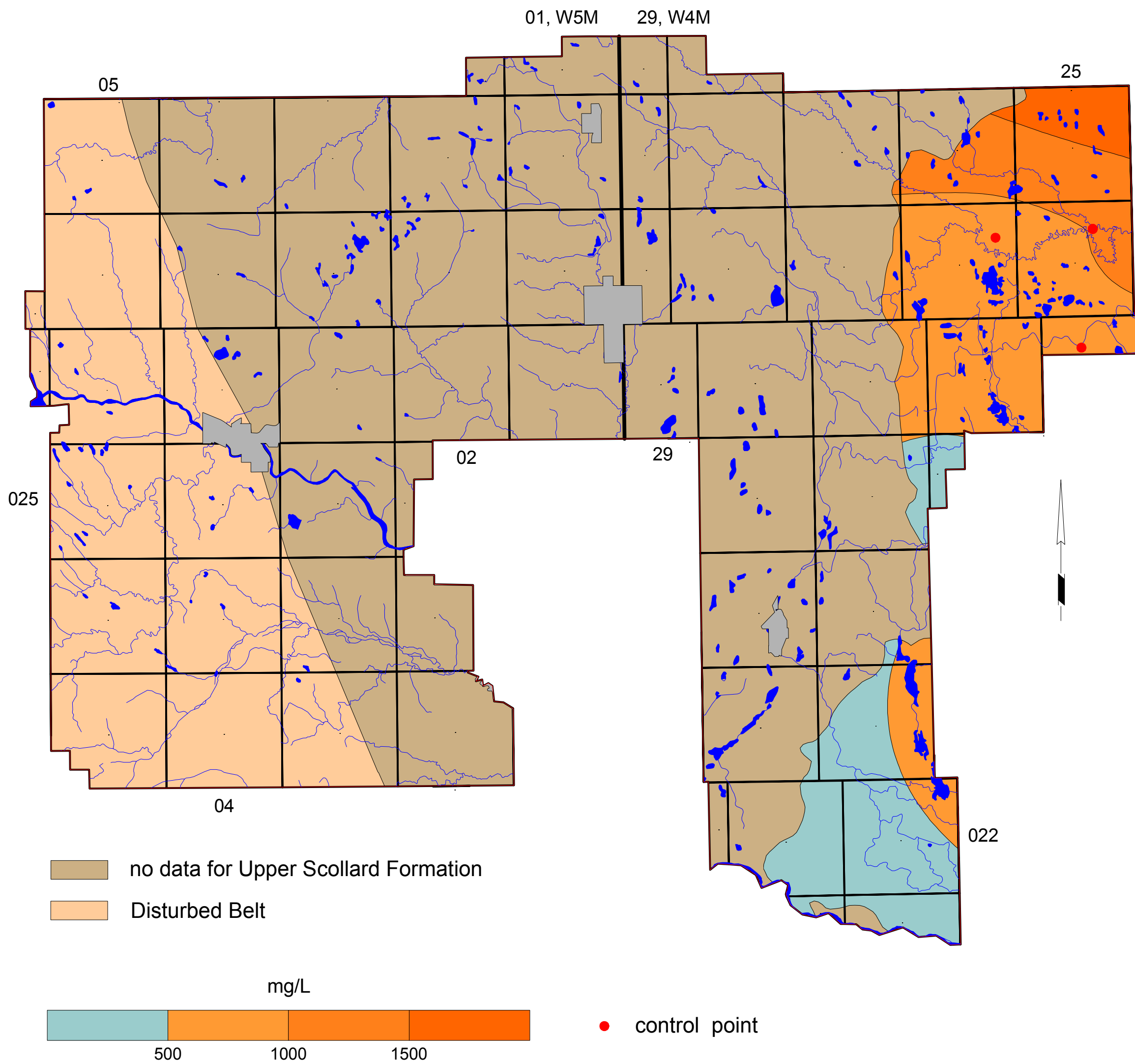
Depth to Top of Upper Scollard Formation



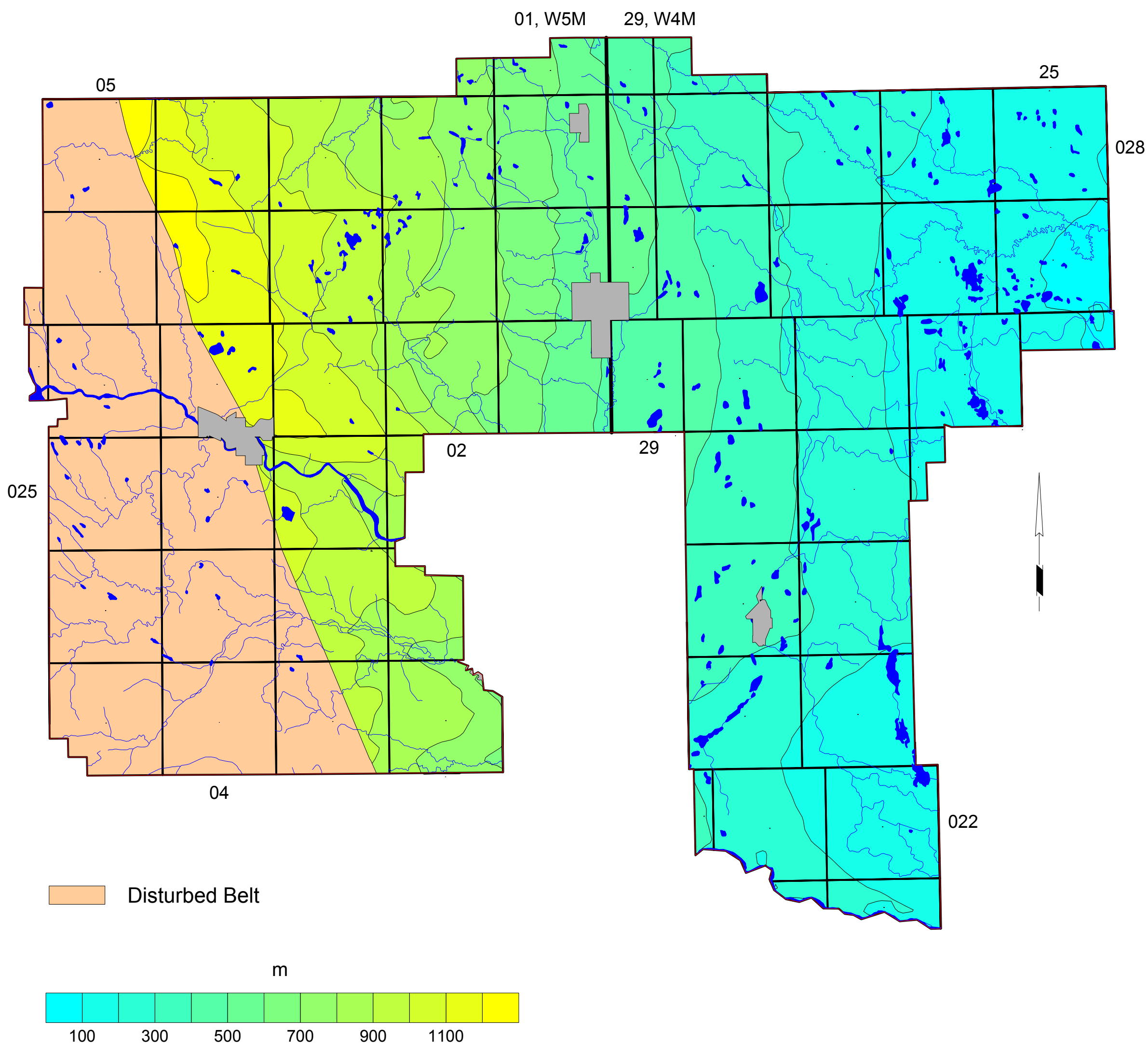
Apparent Yield for Water Wells Completed through Upper Scollard Aquifer



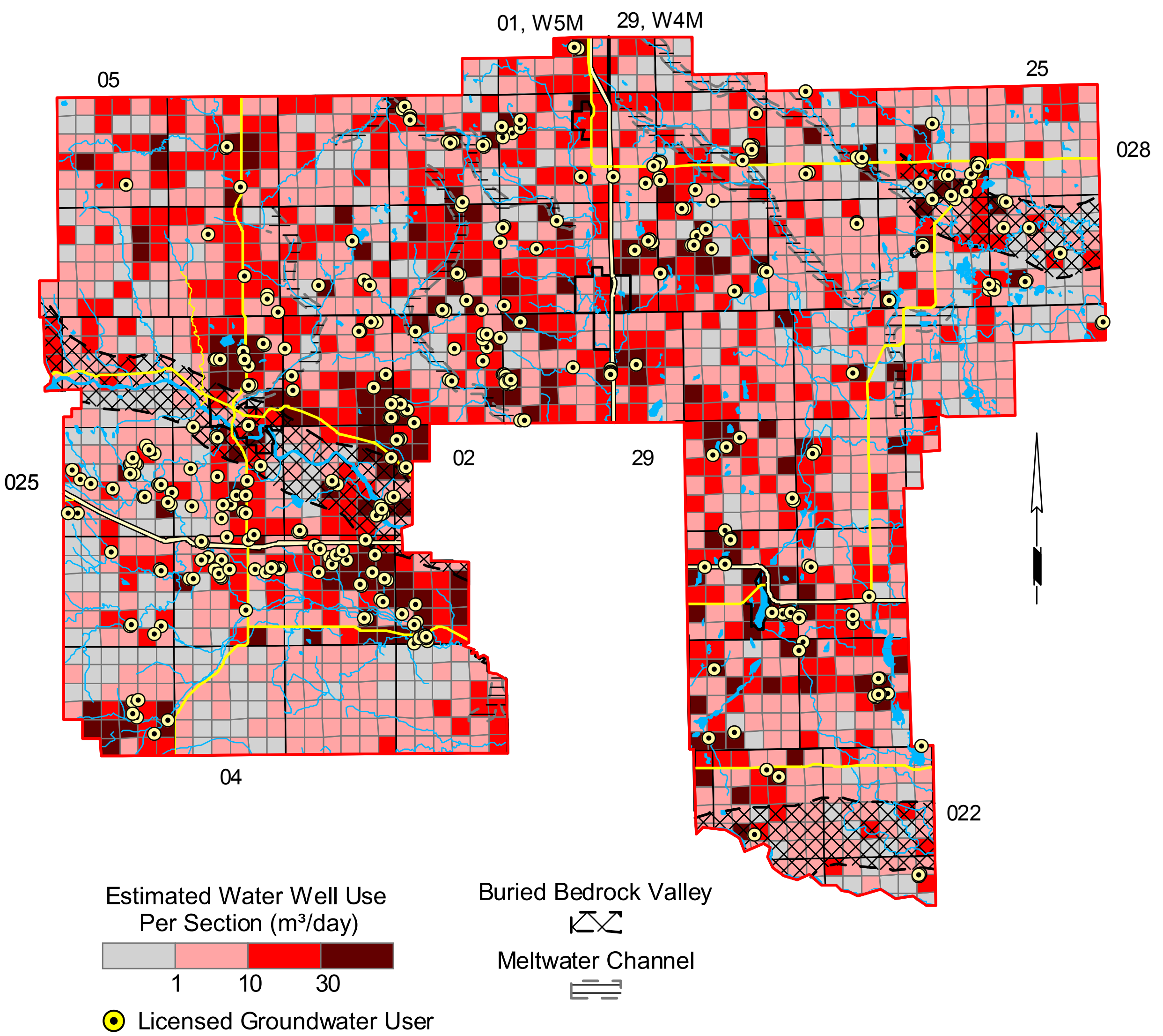
Total Dissolved Solids in Groundwater from Upper Scollard Aquifer



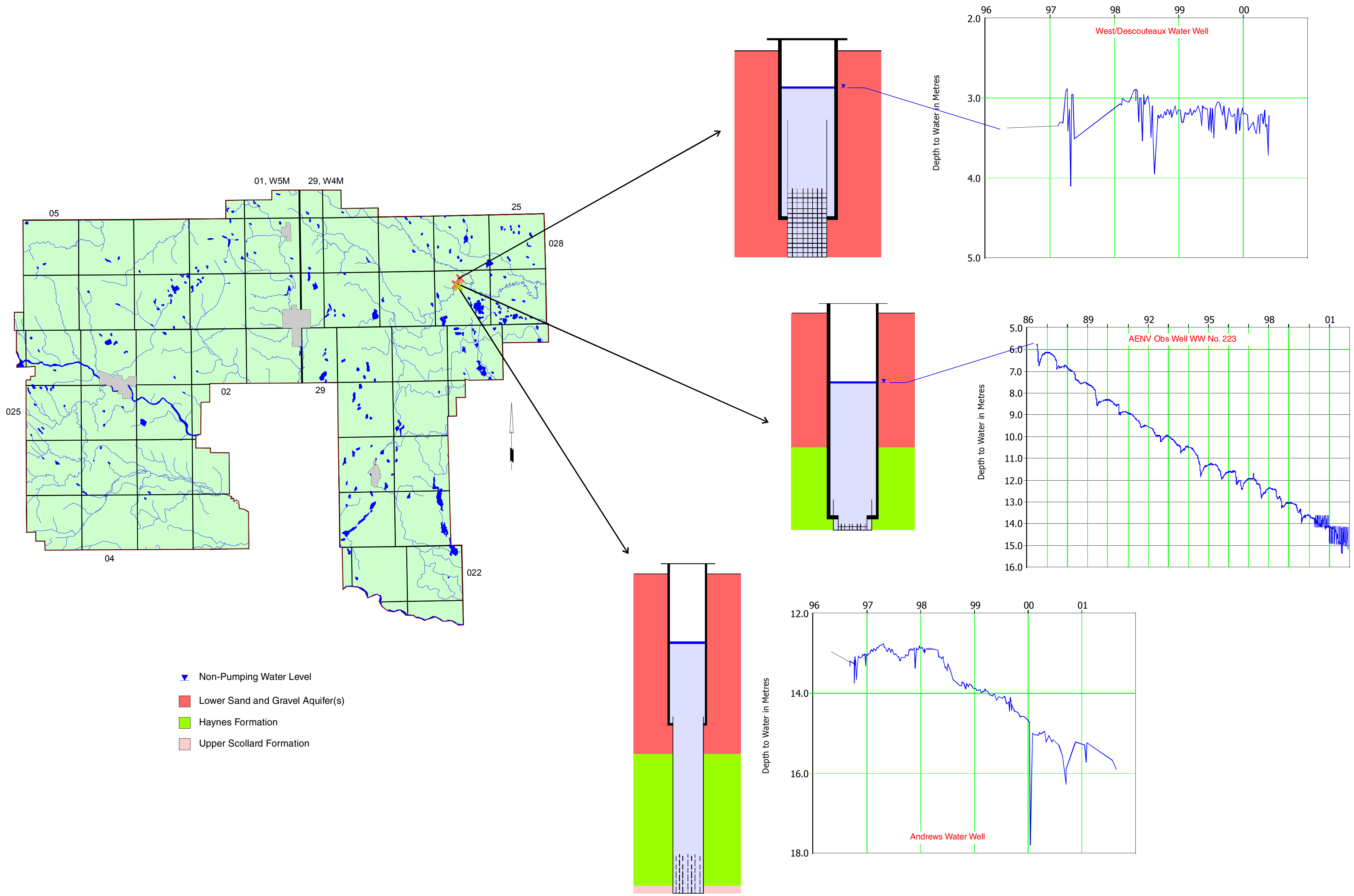
Depth to Top of Lower Scollard Formation



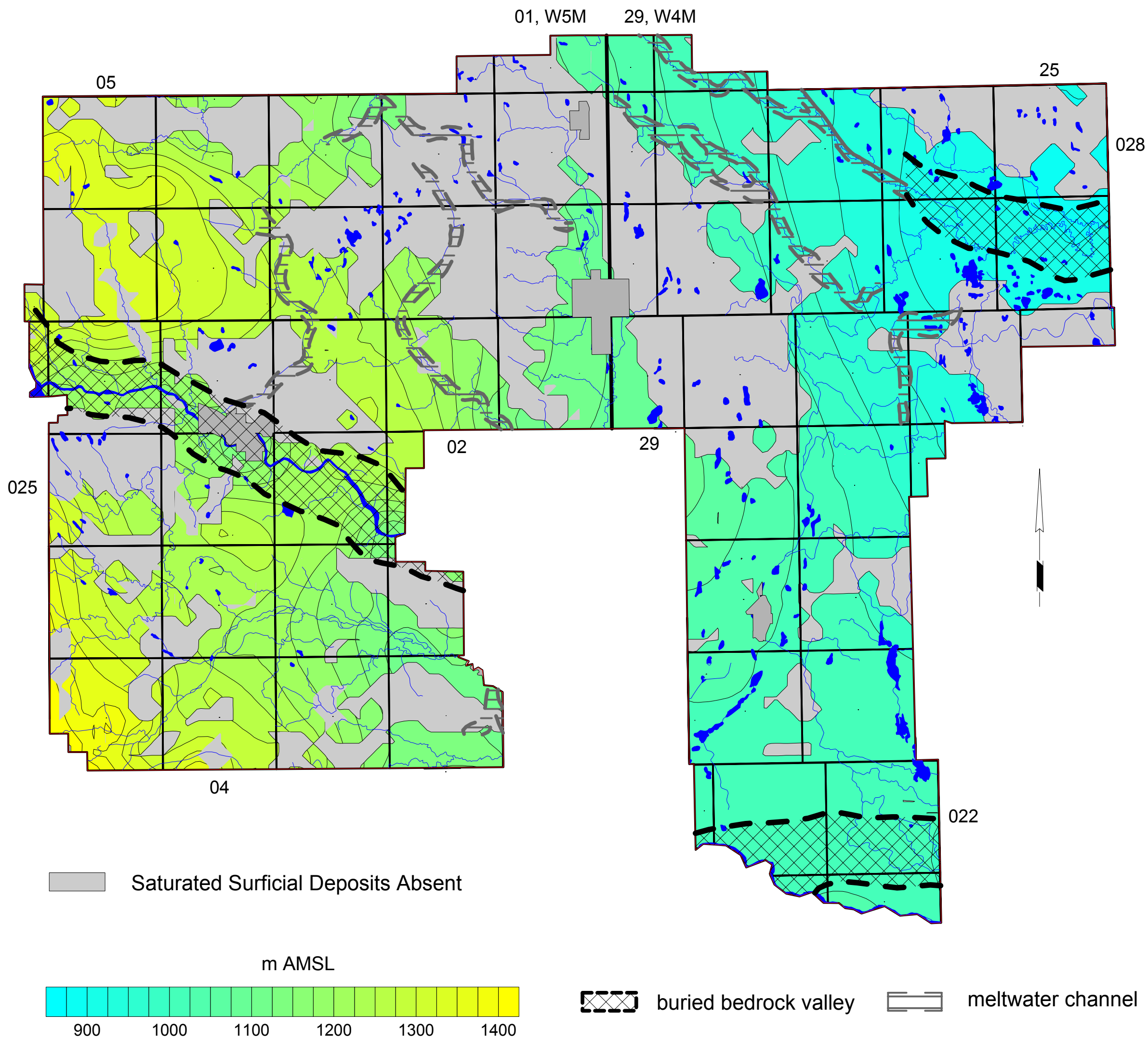
Estimated Water Well Use Per Section



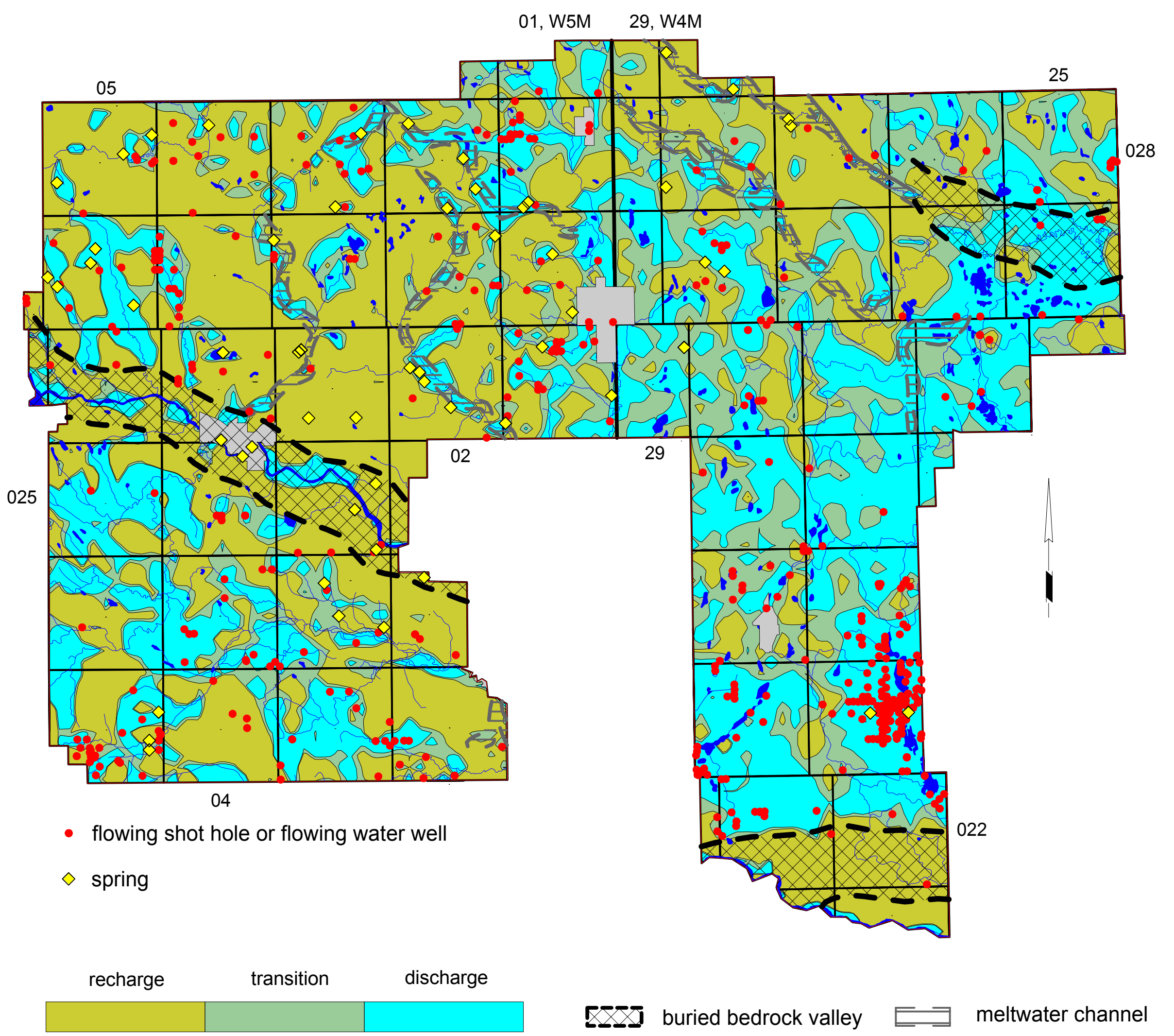
Hydrographs



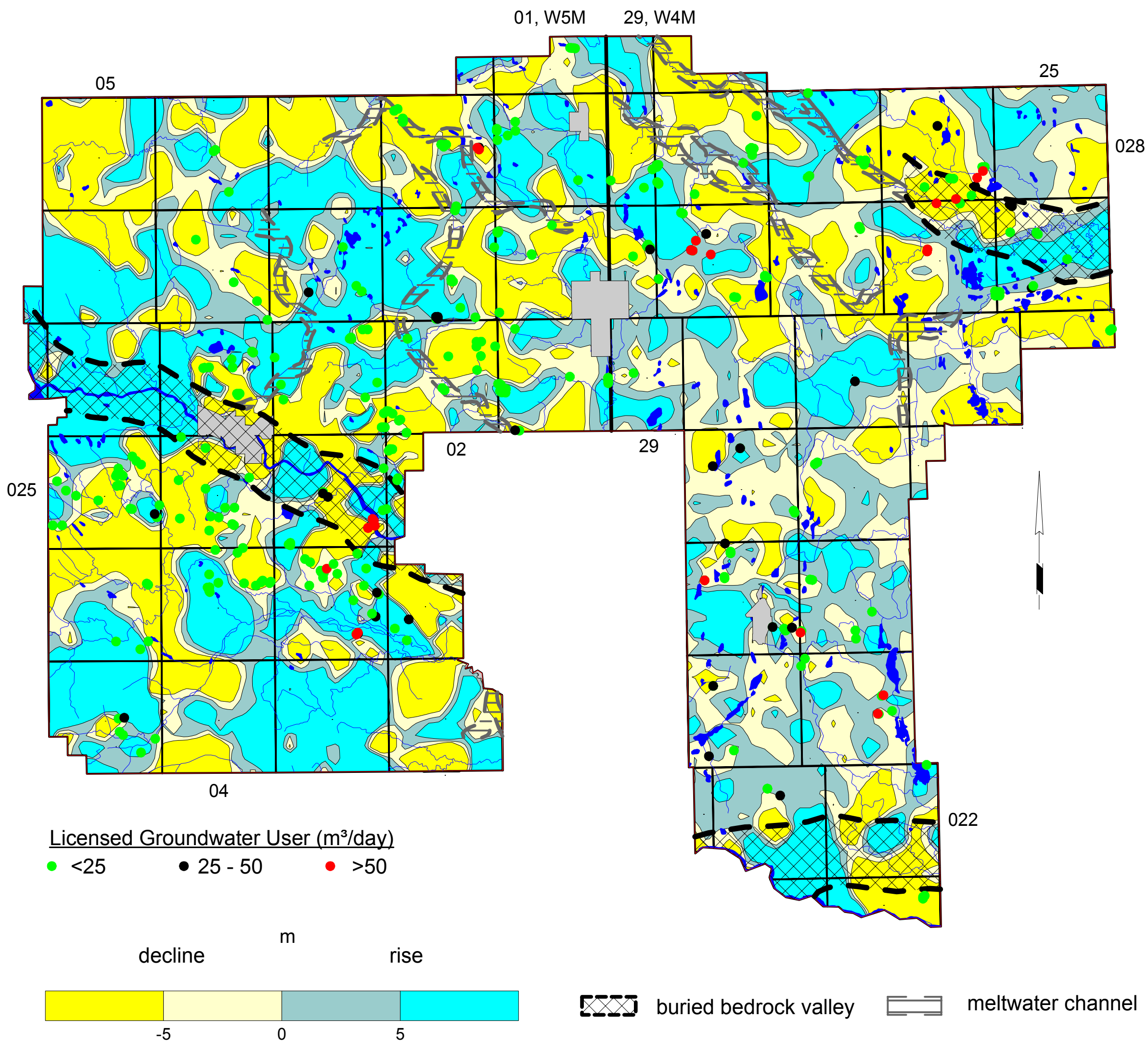
Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep



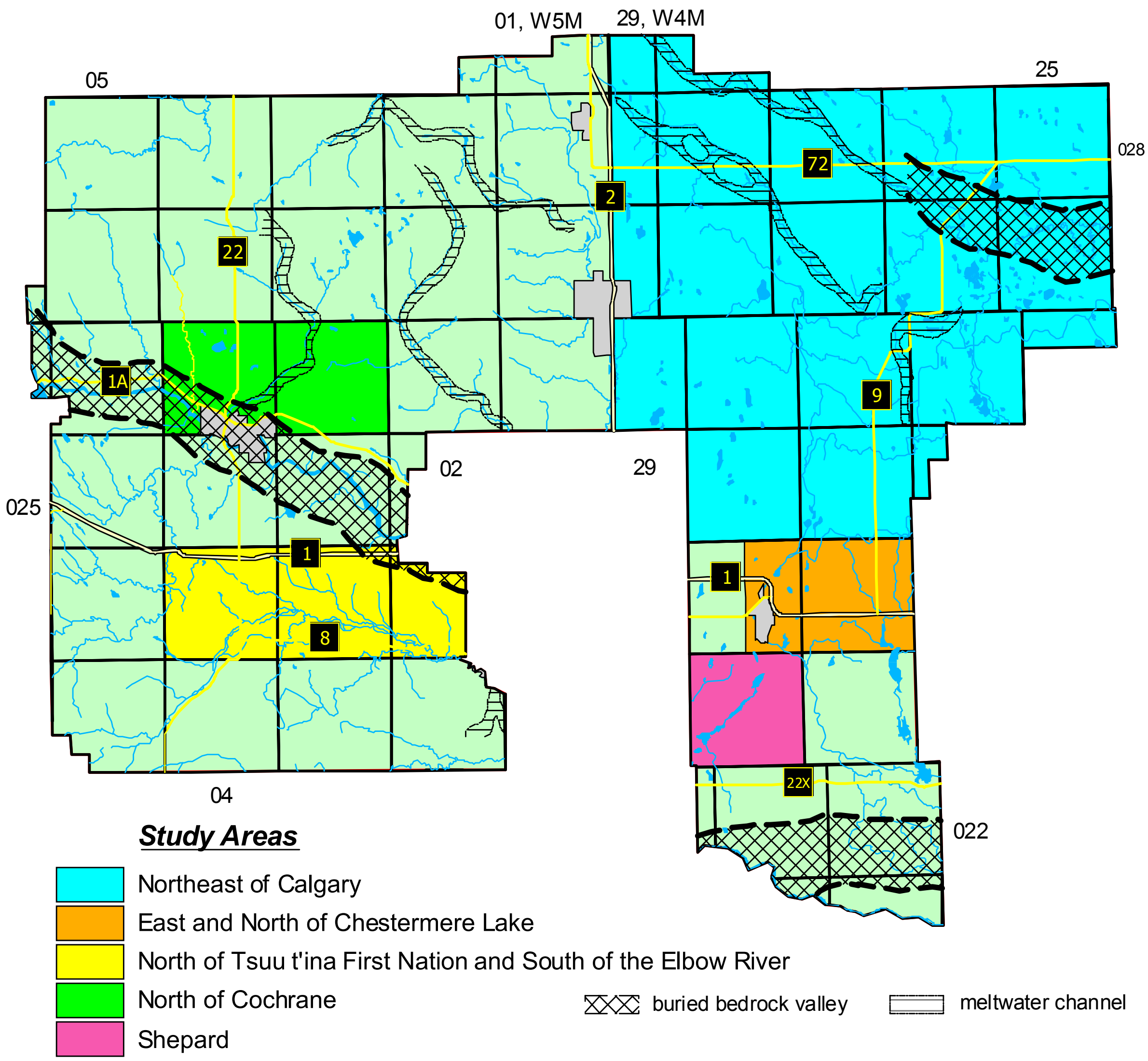
Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)



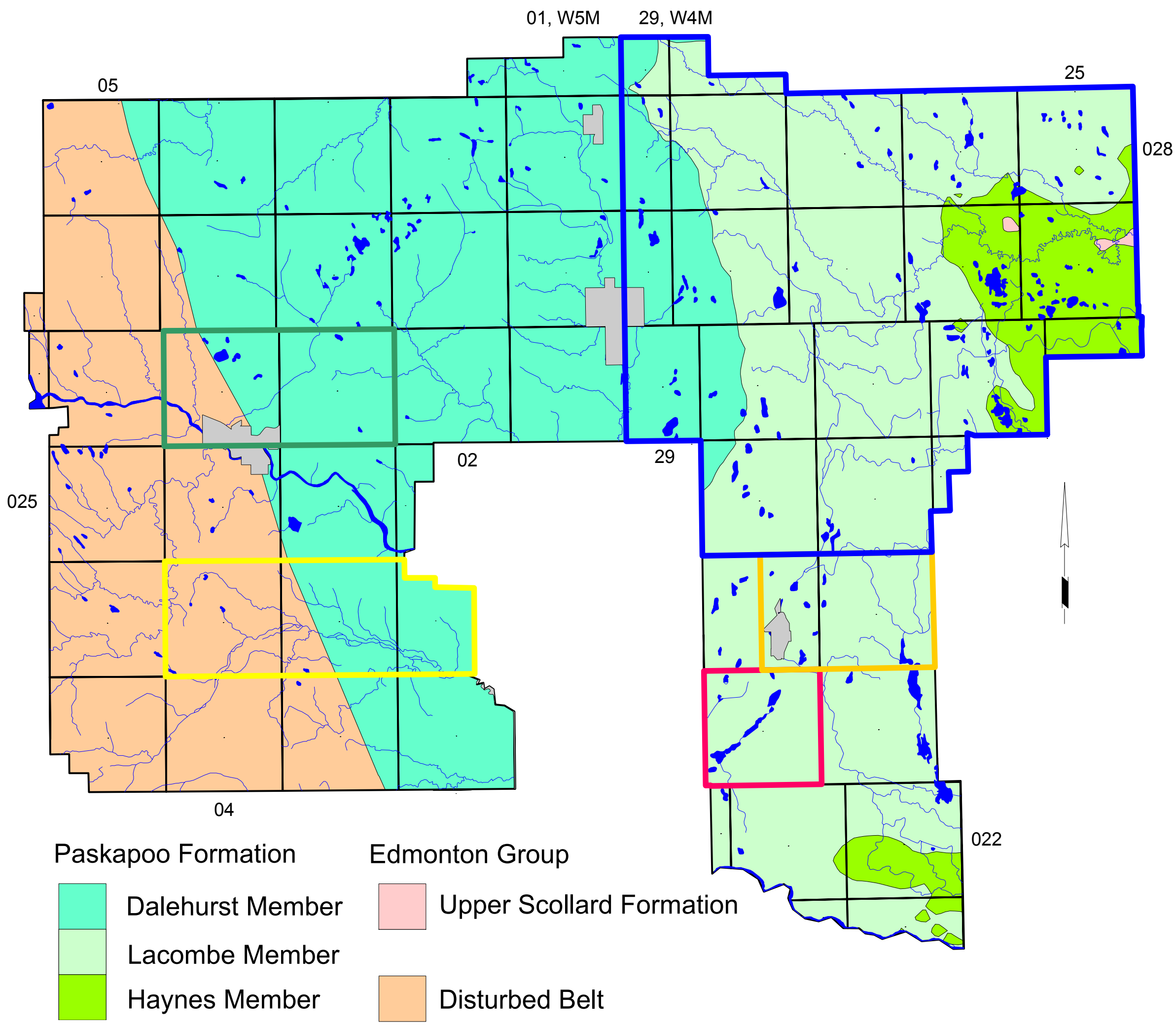
Changes in Water Levels in Upper Bedrock Aquifer(s)



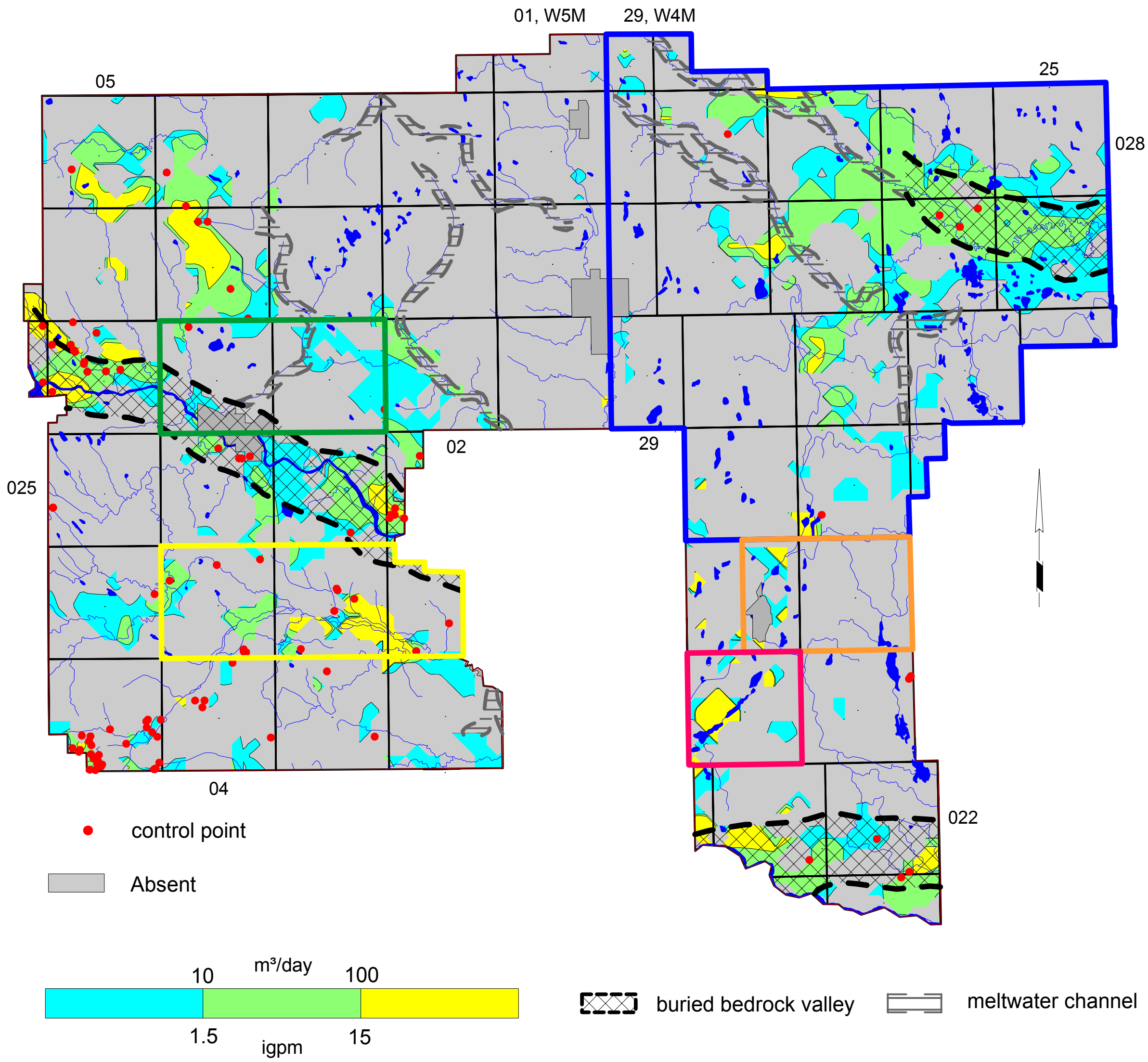
Specific Study Areas



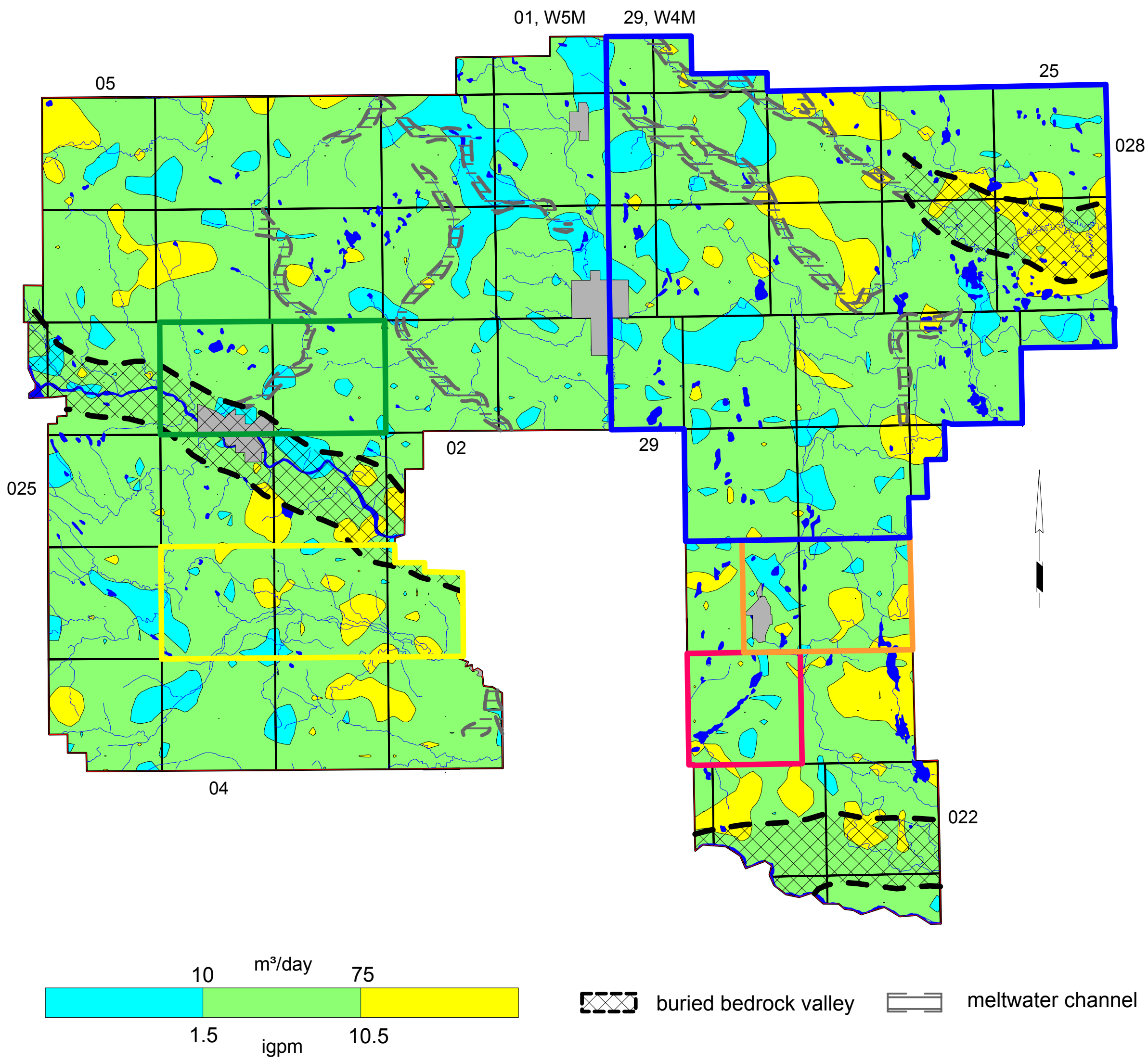
Bedrock Geology of Specific Study Areas



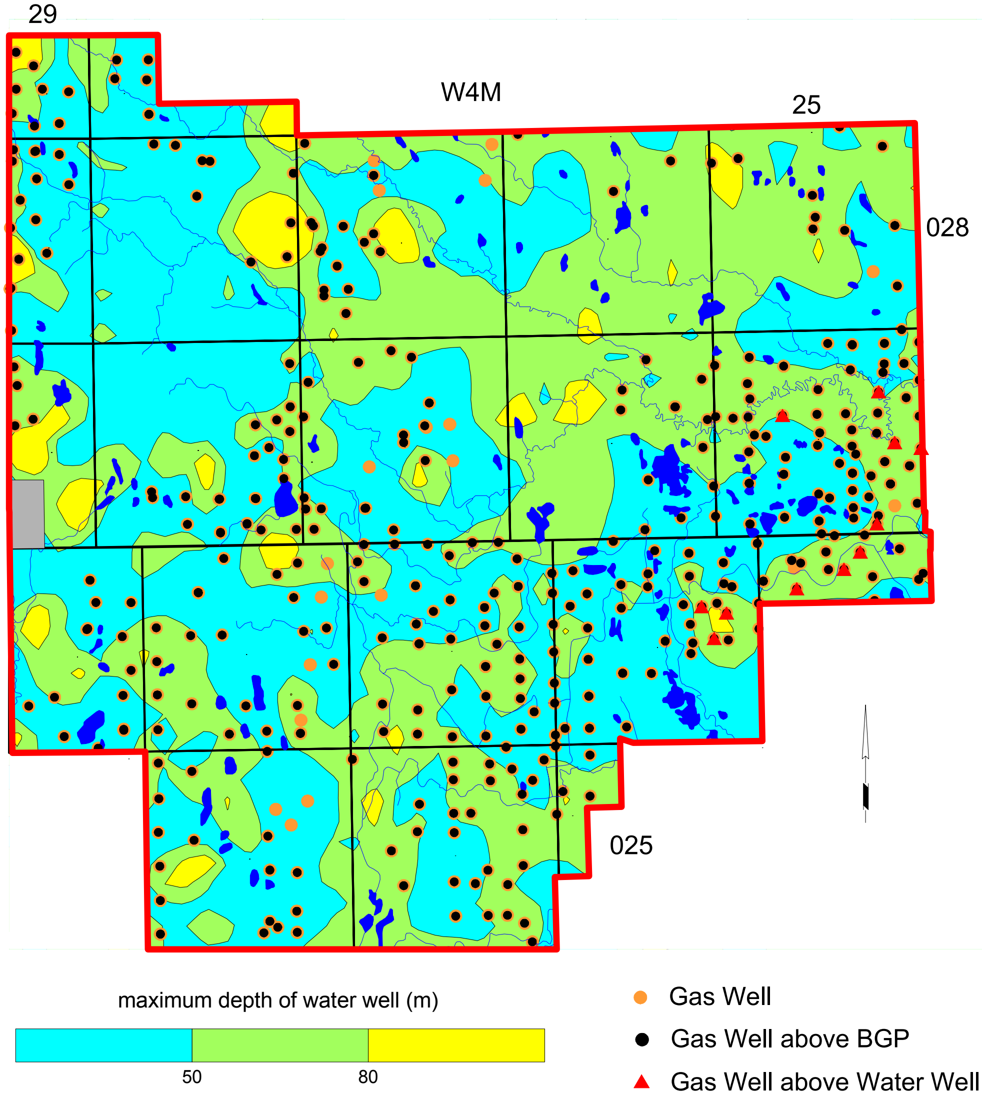
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s) – Specific Study Areas



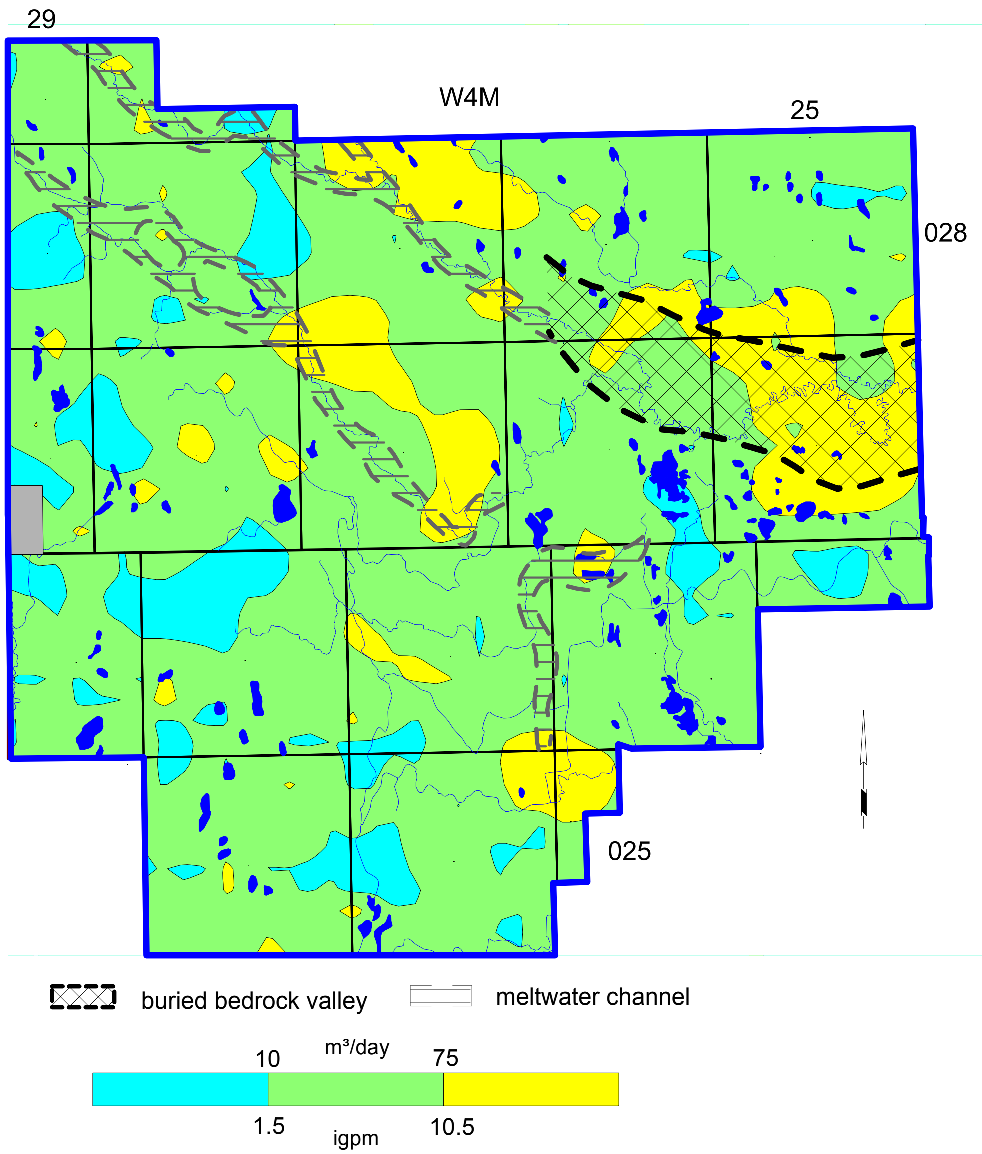
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s) – Specific Study Areas



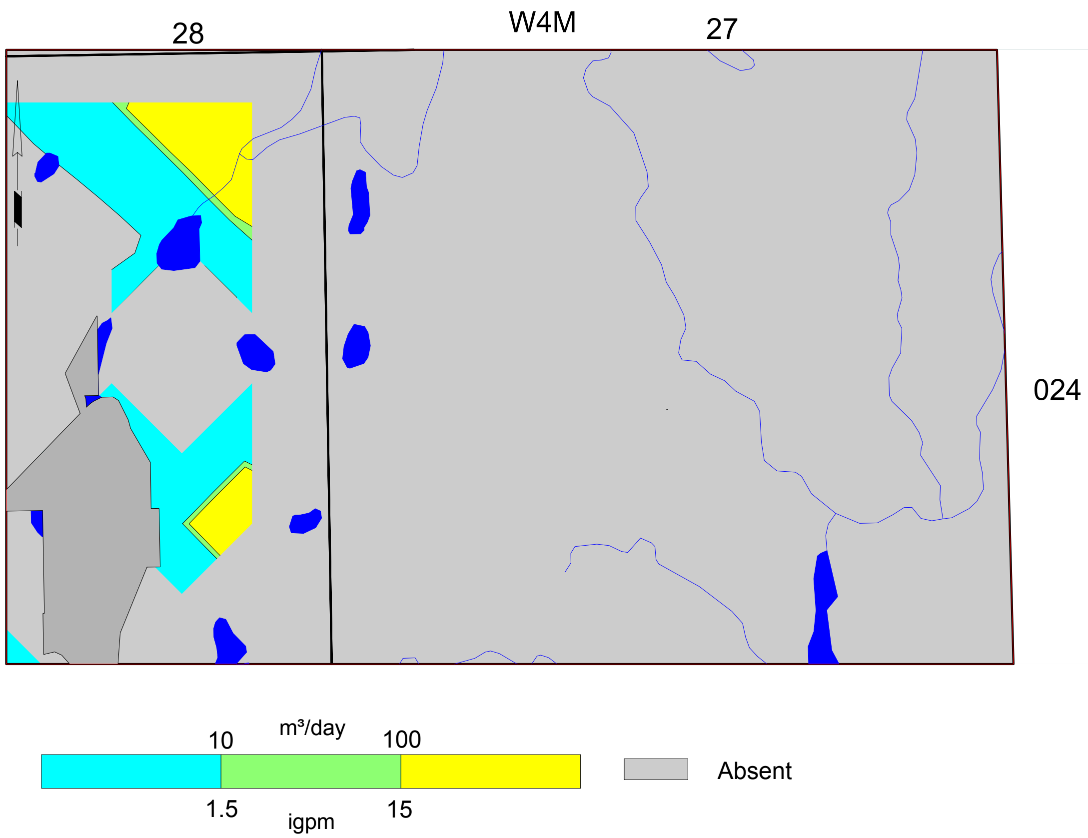
Area Northeast of Calgary – Location of Gas Wells



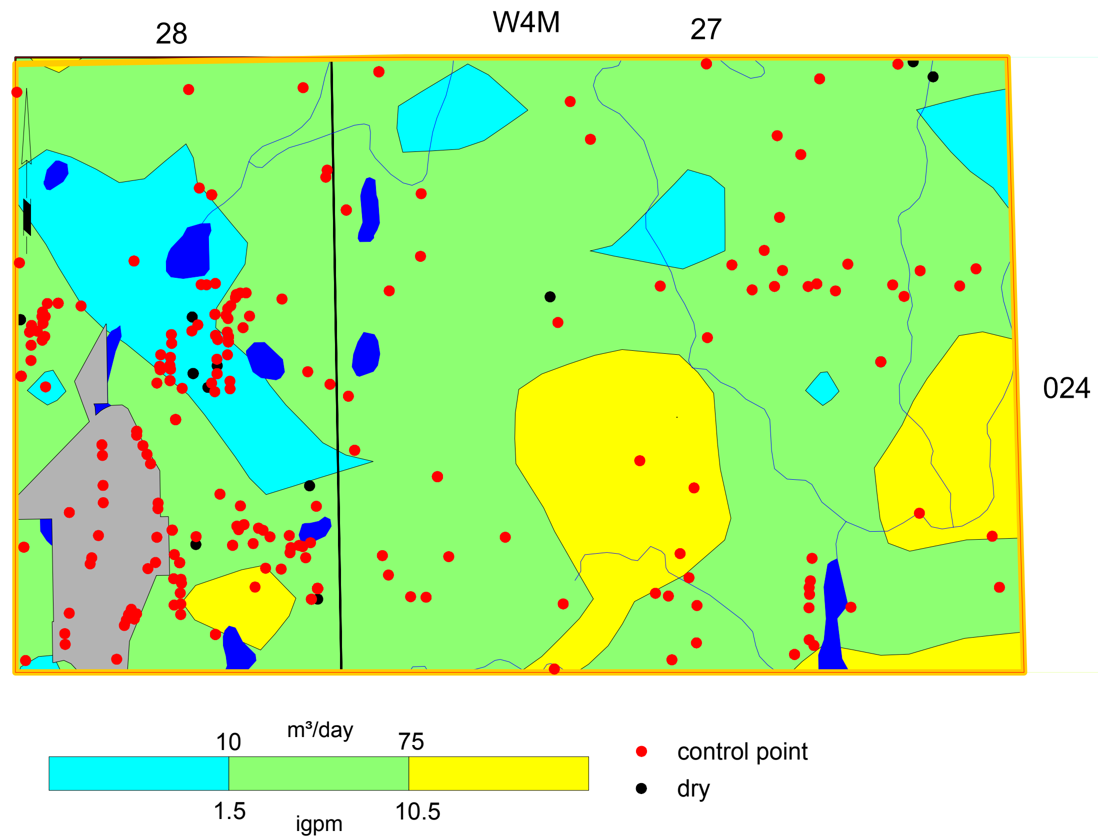
Area Northeast of Calgary – Apparent Yield in Upper Bedrock Aquifer



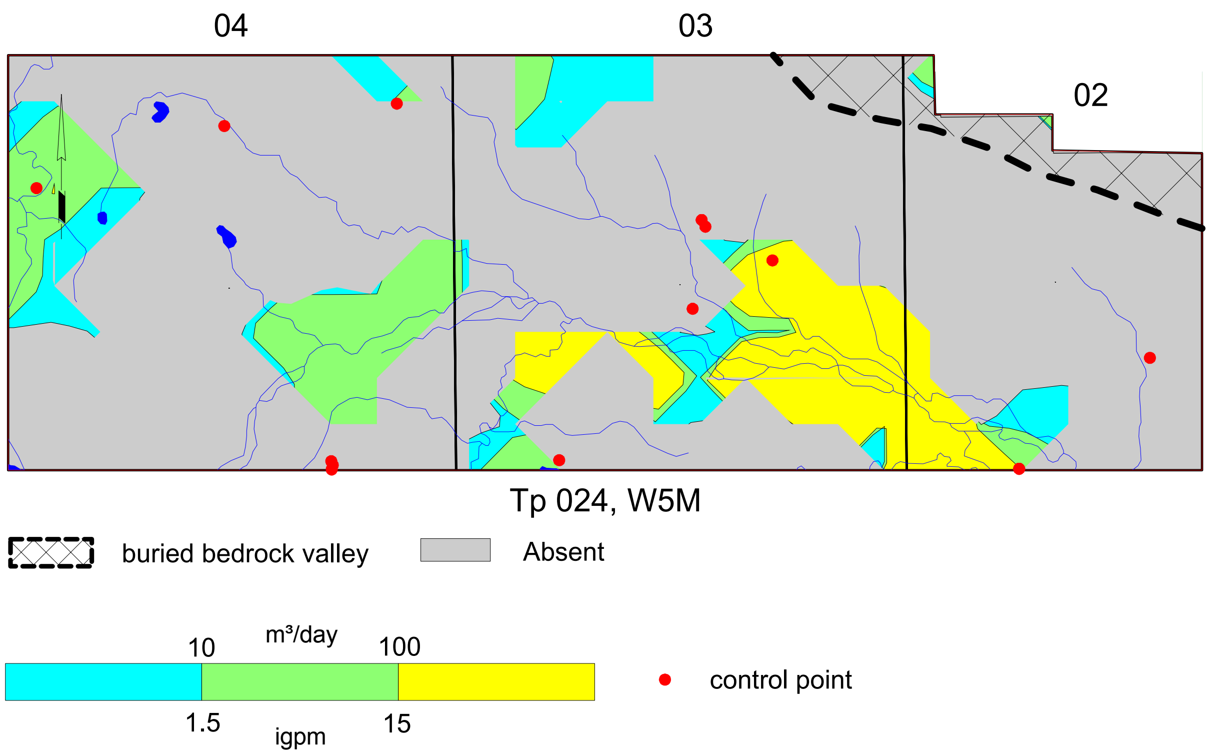
Area East and North of Chestermere Lake – Apparent Yield in Sand and Gravel Aquifer(s)



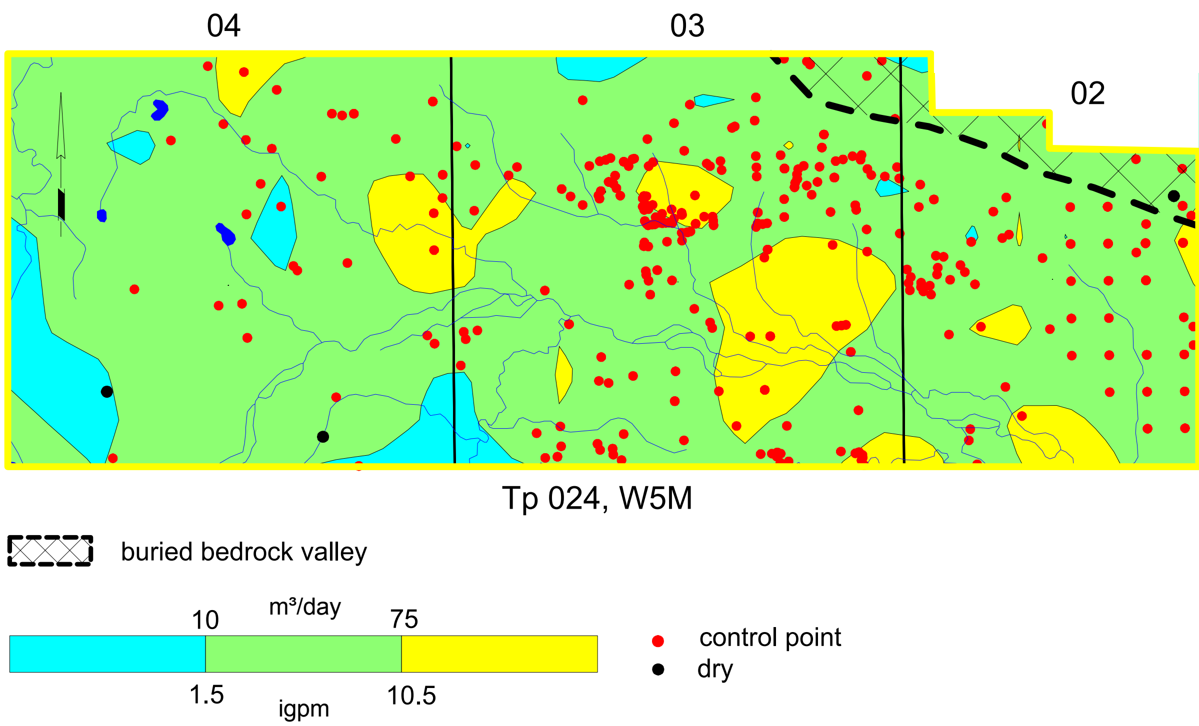
Area East and North of Chestermere Lake – Apparent Yield in Upper Bedrock Aquifer(s)



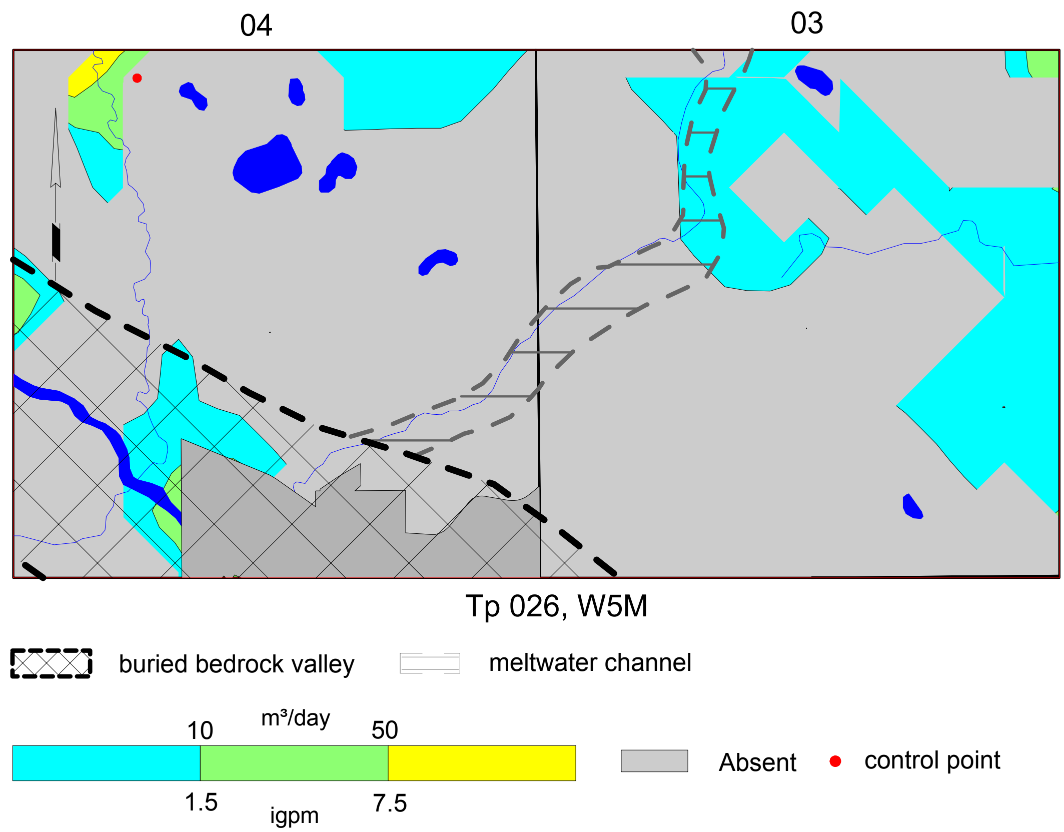
Area North of Tsuu t'ina Nation and South of the Elbow River – Apparent Yield in Sand and Gravel Aquifer(s)



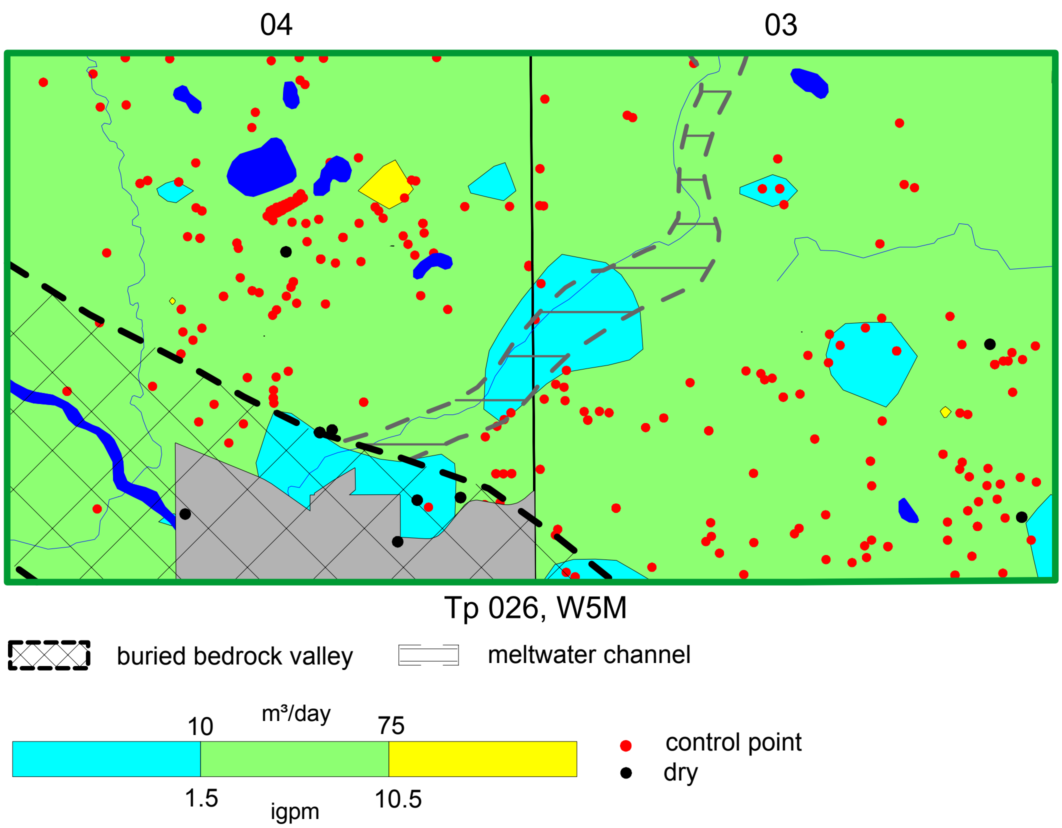
Area North of Tsuu t'ina Nation and South of the Elbow River – Apparent Yield in Upper Bedrock Aquifer(s)



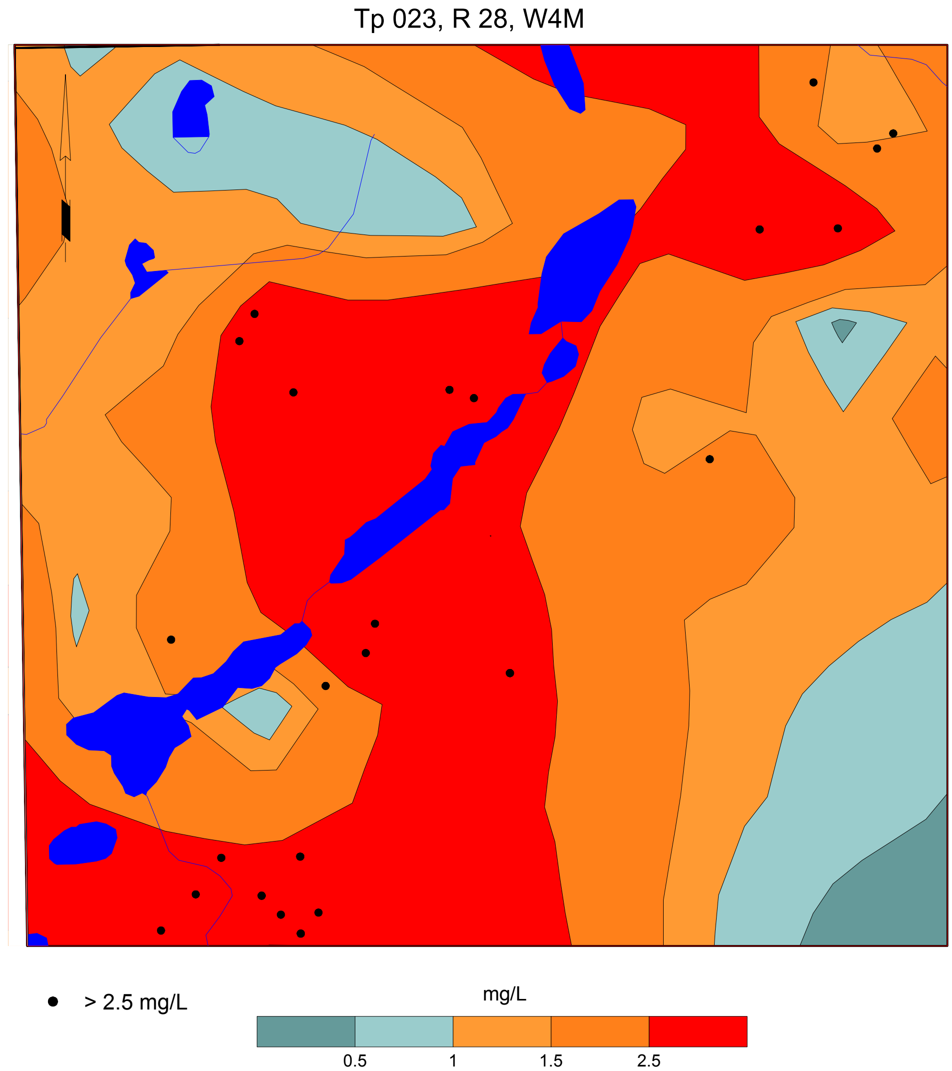
Area North of Cochrane – Apparent Yield in Sand and Gravel Aquifer(s)



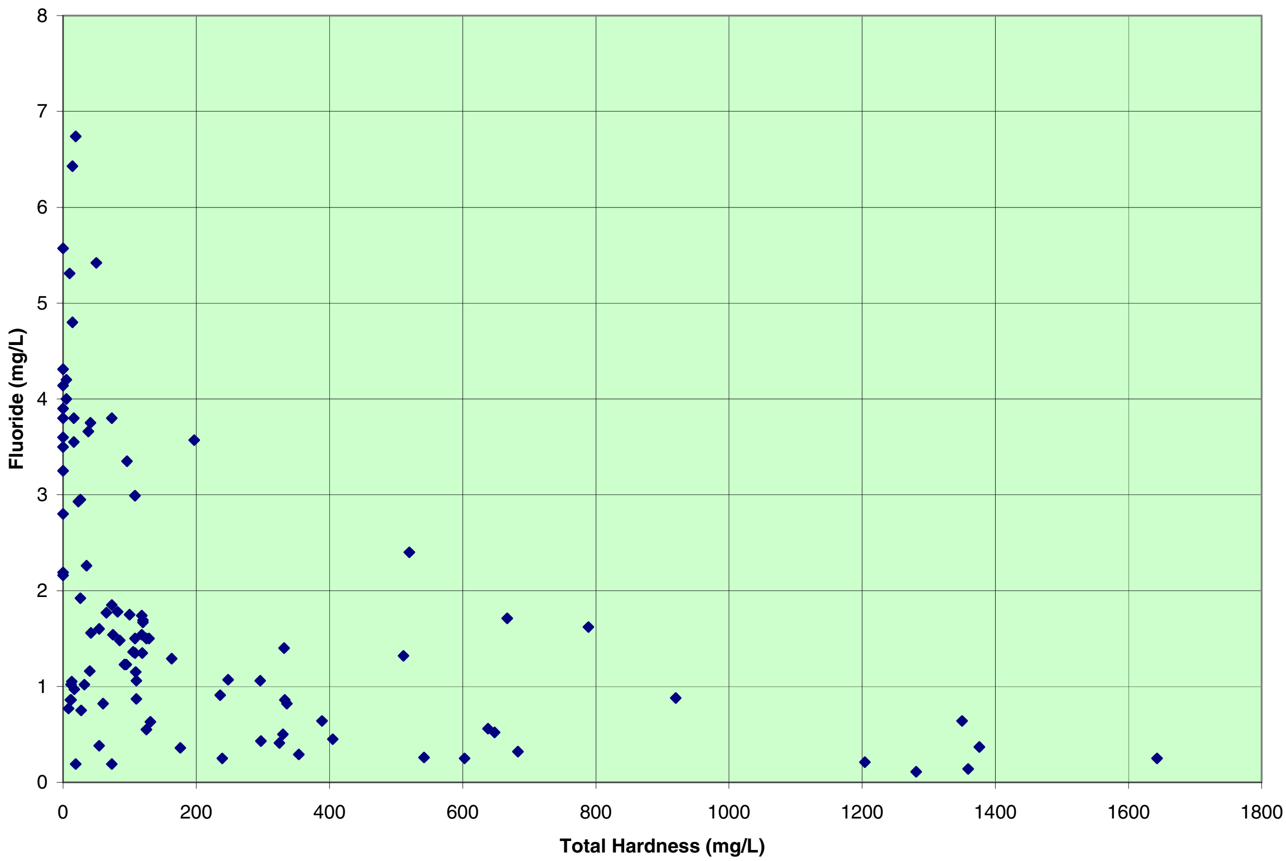
Area North of Cochrane – Apparent Yield in Upper Bedrock Aquifer(s)



Shepard Area – Fluoride in Upper Bedrock Aquifer(s)



Shepard Area –
Total Hardness vs. Fluoride in Upper Bedrock Aquifer(s)



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Appendix B

Maps and Figures on CD-ROM

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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

EXTRACT FROM THE
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ALBERTA REGULATION 205/98

Water Act

WATER (MINISTERIAL) REGULATION

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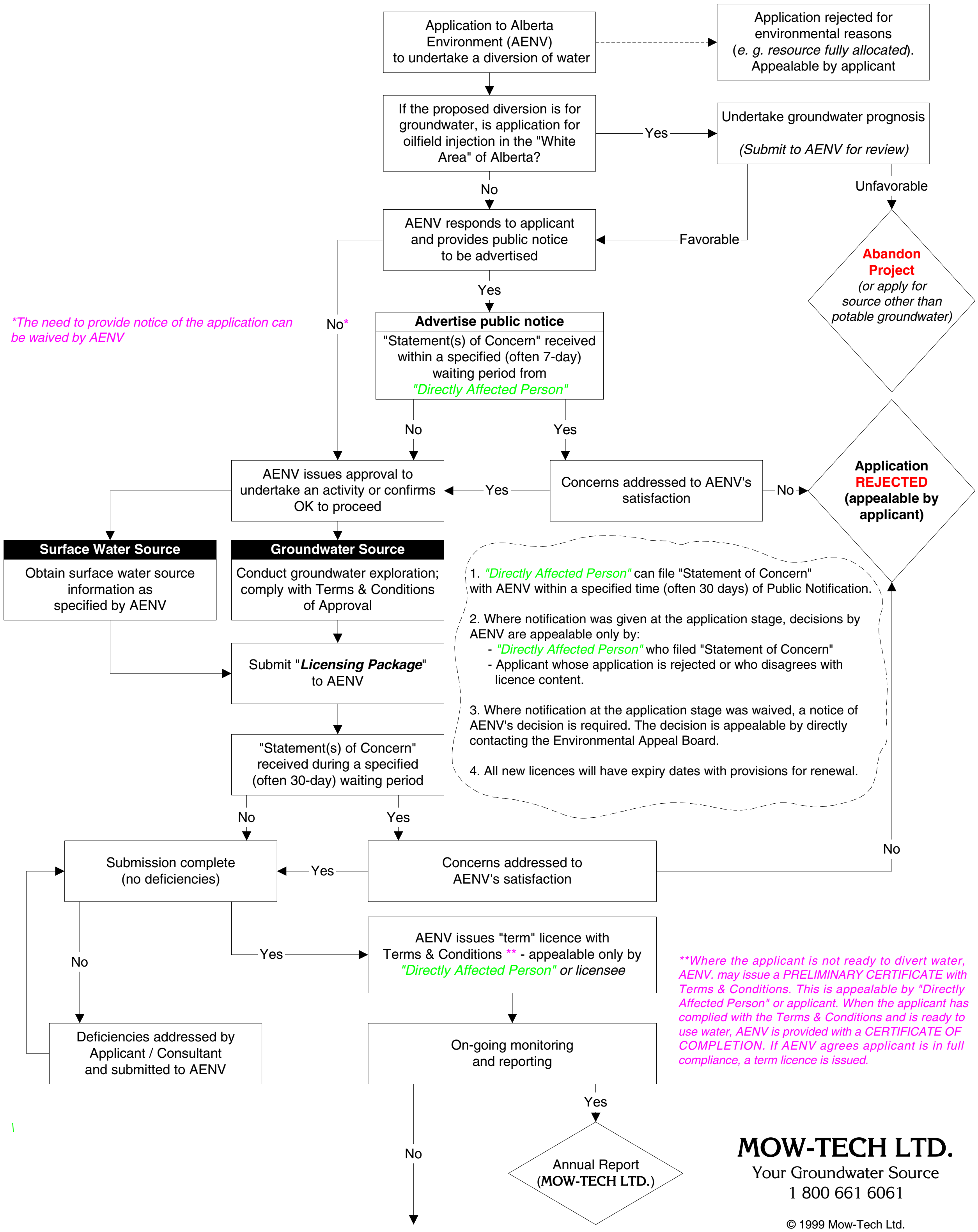
1

Water Act – Flowchart



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

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)

ALBERTA ENVIRONMENT

WATER WELL INSPECTORS

Jennifer McPherson (Edmonton: 780-427-6429)

WATER WELL LICENSING

Claude Eckert (Calgary: 403-297-6649)

GEOPHYSICAL INSPECTION SERVICE

Edmonton: 780-427-3932

COMPLAINT INVESTIGATIONS

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

UNIVERSITY OF ALBERTA – Department of Earth and Atmospheric Sciences - Hydrogeology

Carl Mendoza (Edmonton: 780-492-2664)

UNIVERSITY OF CALGARY – Department of Geology and Geophysics - Hydrogeology

Larry Bentley (Calgary: 403-220-4512)

FARMERS ADVOCATE

Paul Vasseur (Edmonton: 780-427-2433)

PRAIRIE FARM REHABILITATION ADMINISTRATION (PFRA) ARM OF AGRICULTURE AND AGRI-FOOD CANADA (AAFC)

Glen Brandt (Red Deer: 403-340-4290)
Terry Dash (Calgary: 403-292-5719)

WILDROSE COUNTRY GROUND WATER MONITORING ASSOCIATION

Dave Andrews (Irricana: 403-935-4478)

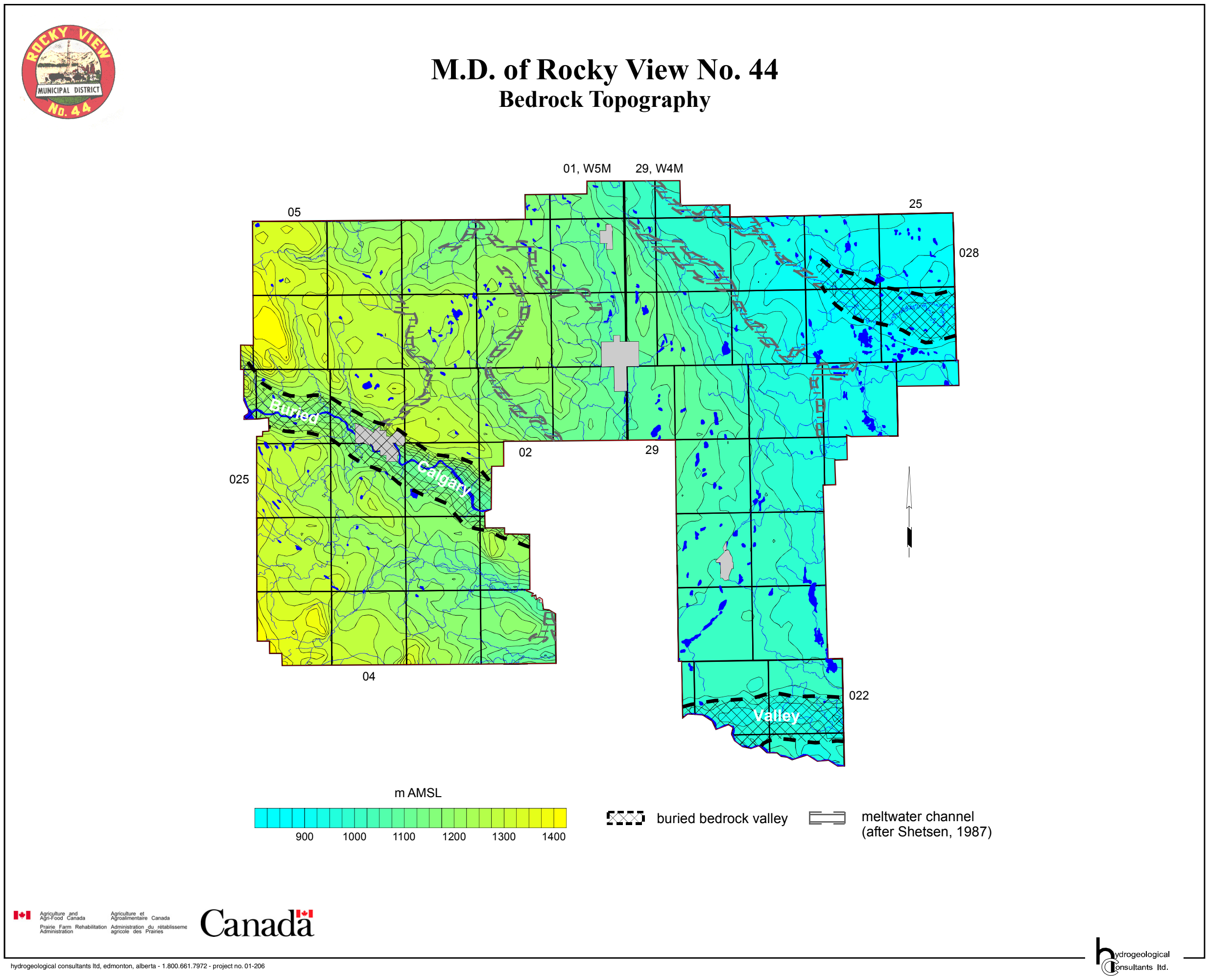
LOCAL HEALTH DEPARTMENTS

M.D. OF ROCKY VIEW NO. 44

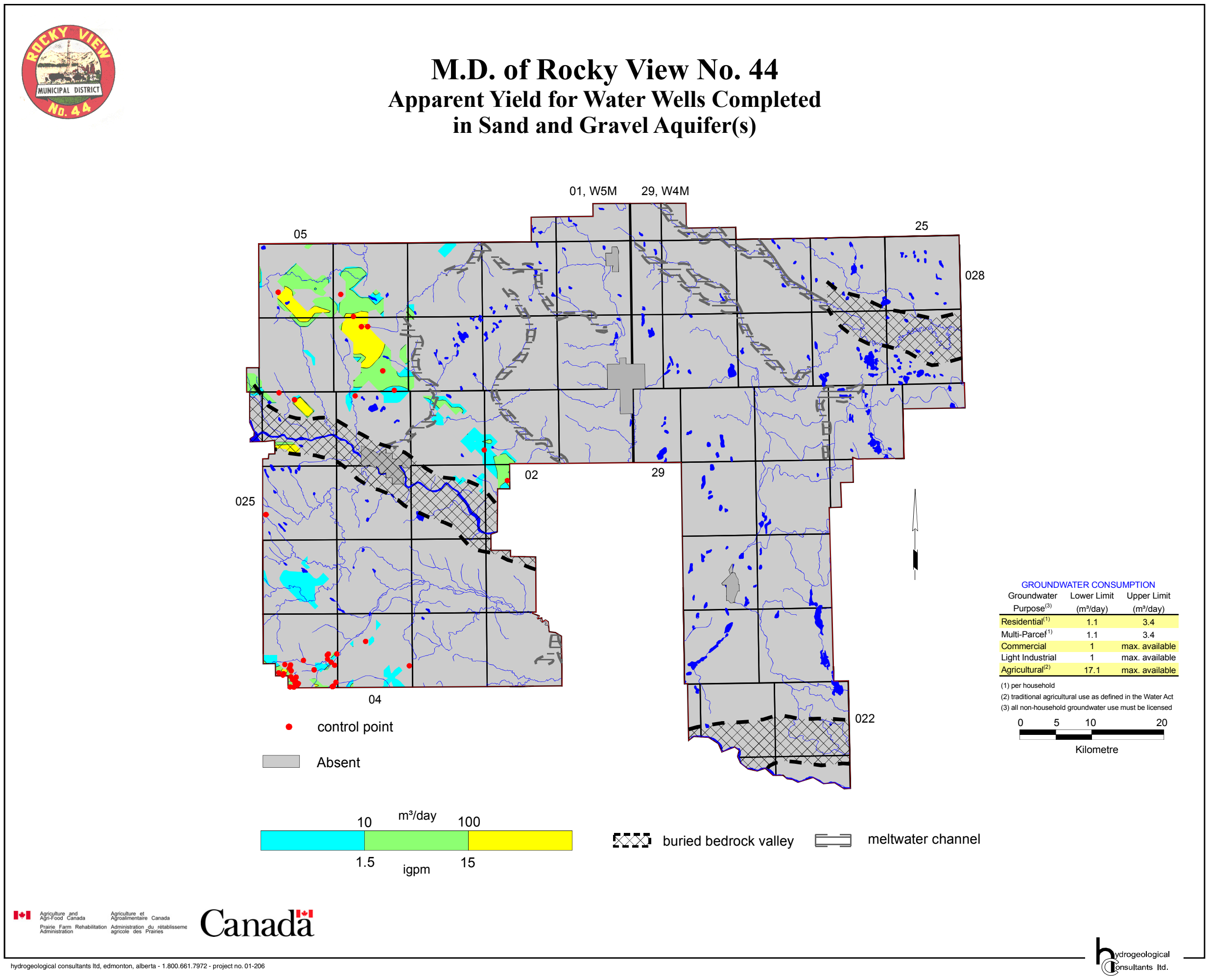
Appendix D

Maps and Figures Included as Large Plots

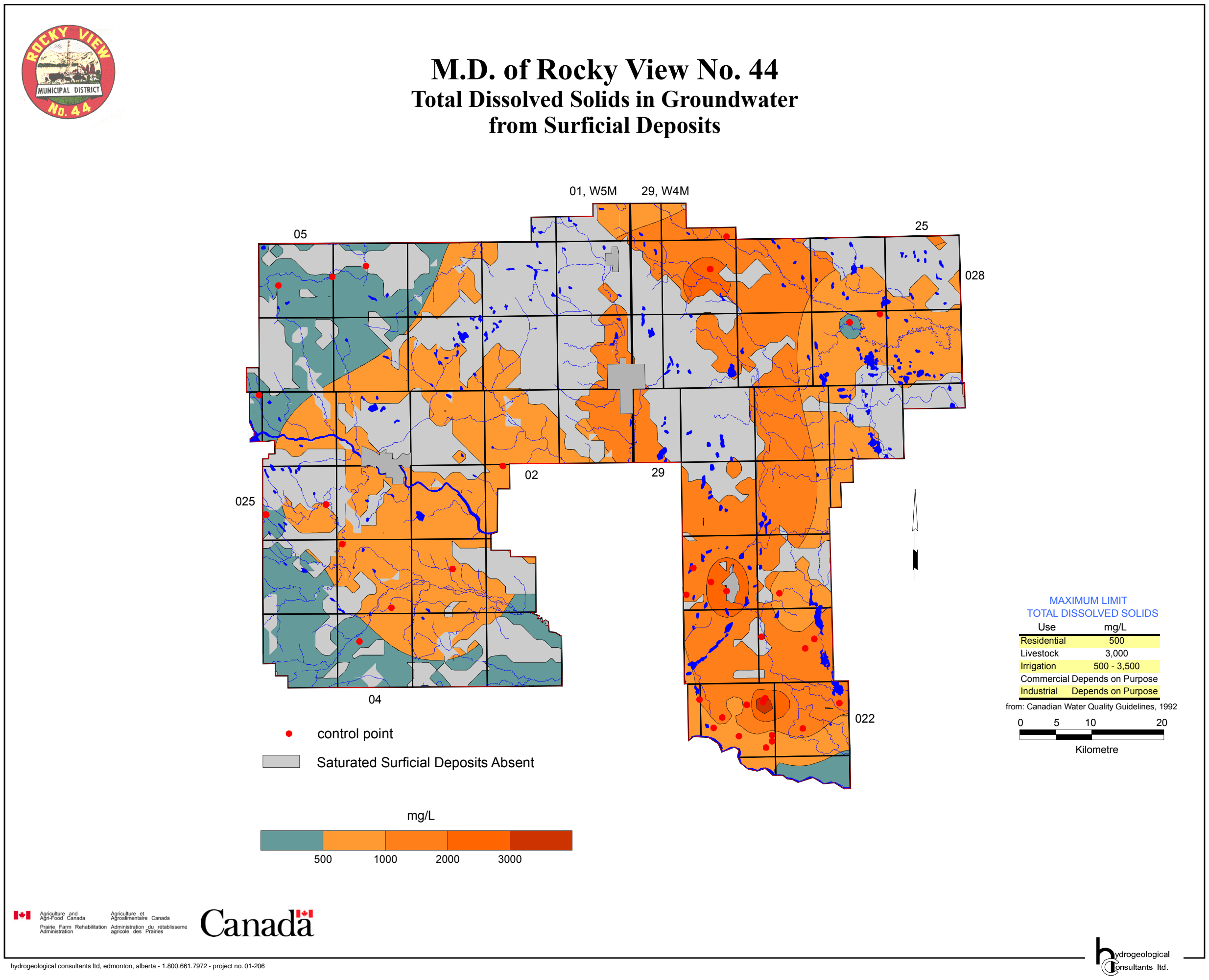
Bedrock Topography



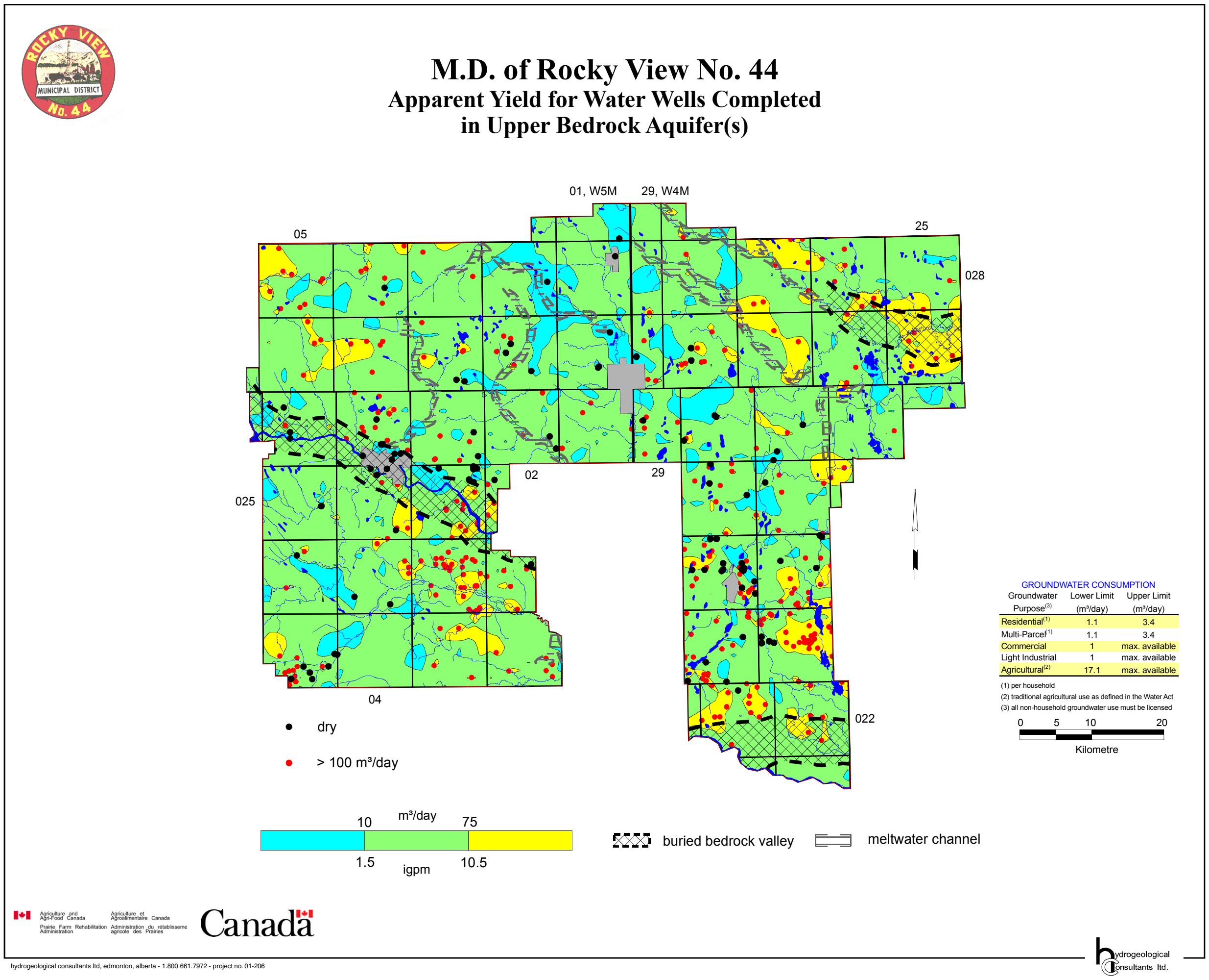
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)



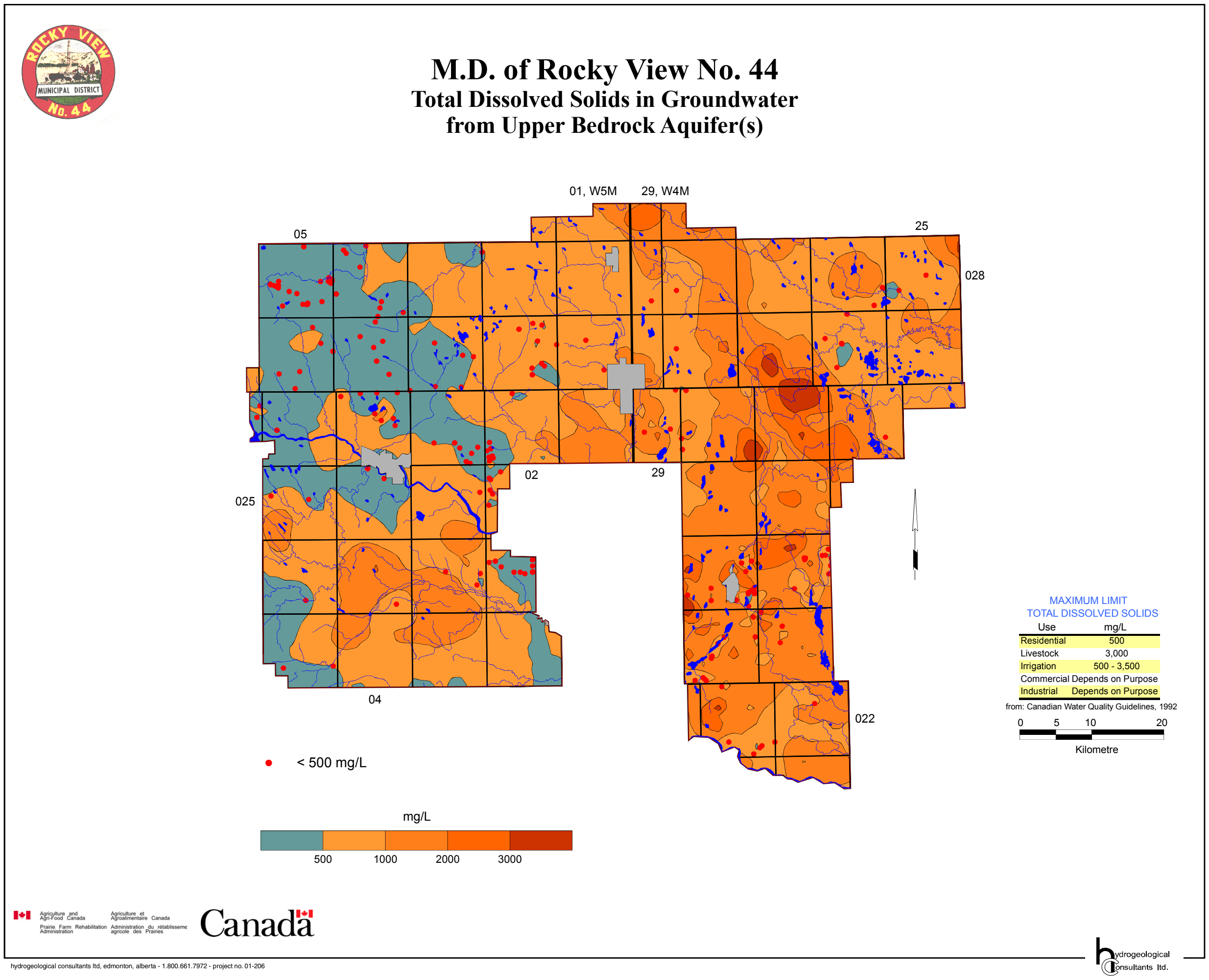
Total Dissolved Solids in Groundwater from Surficial Deposits



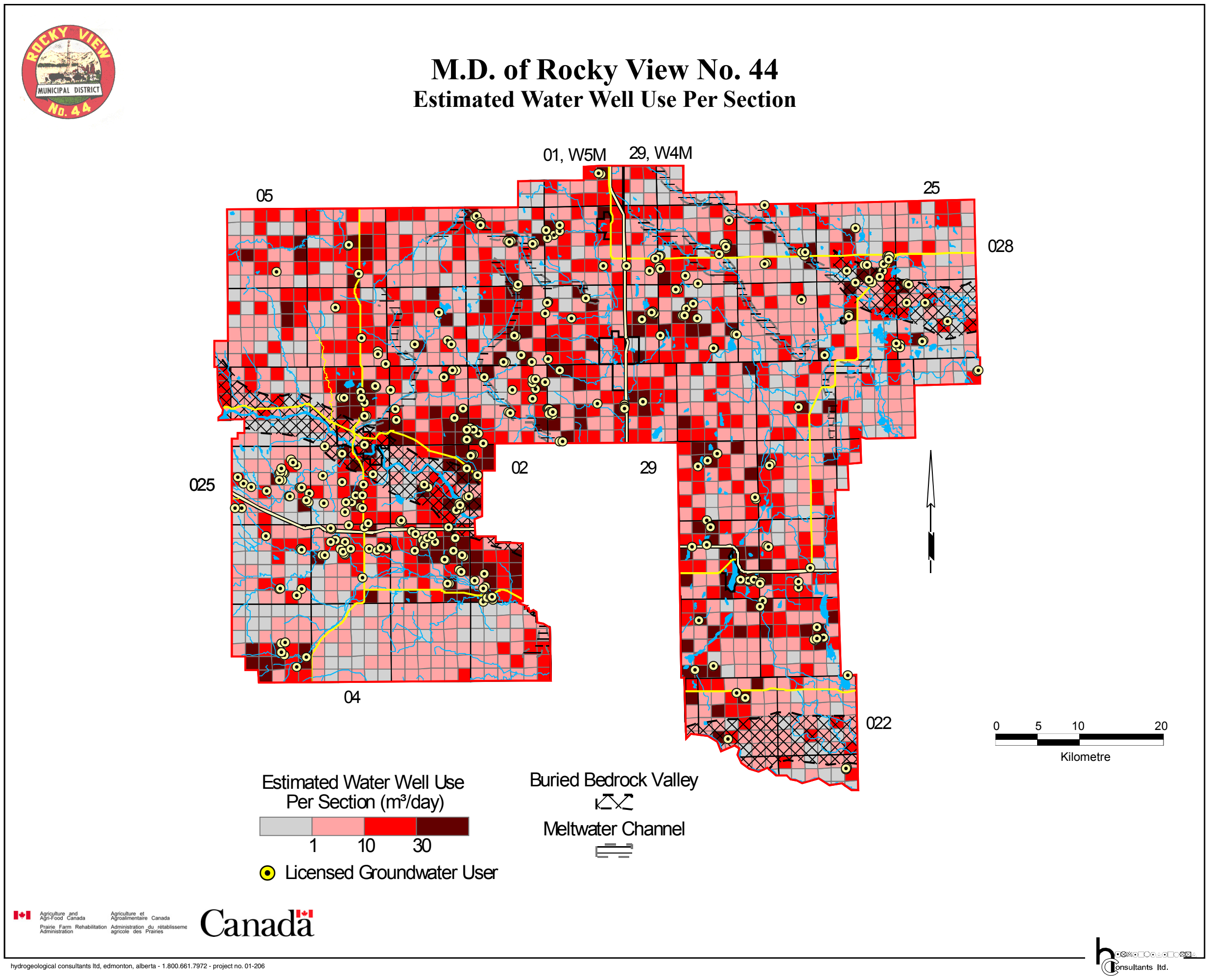
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)



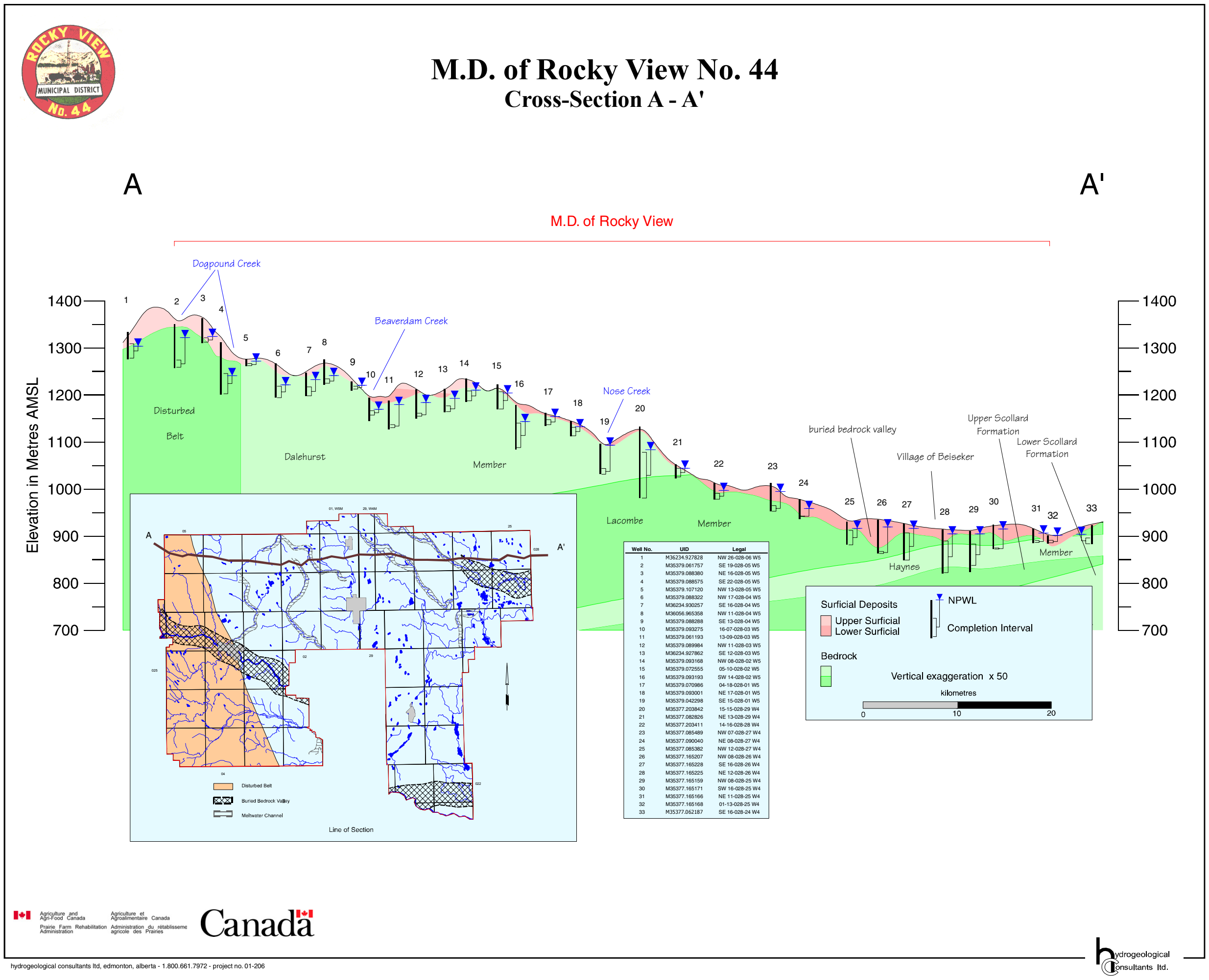
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)



Estimated Water Well Use Per Section



Cross-Section A - A'



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27	M35377.165228	SE 16-028-26 W4
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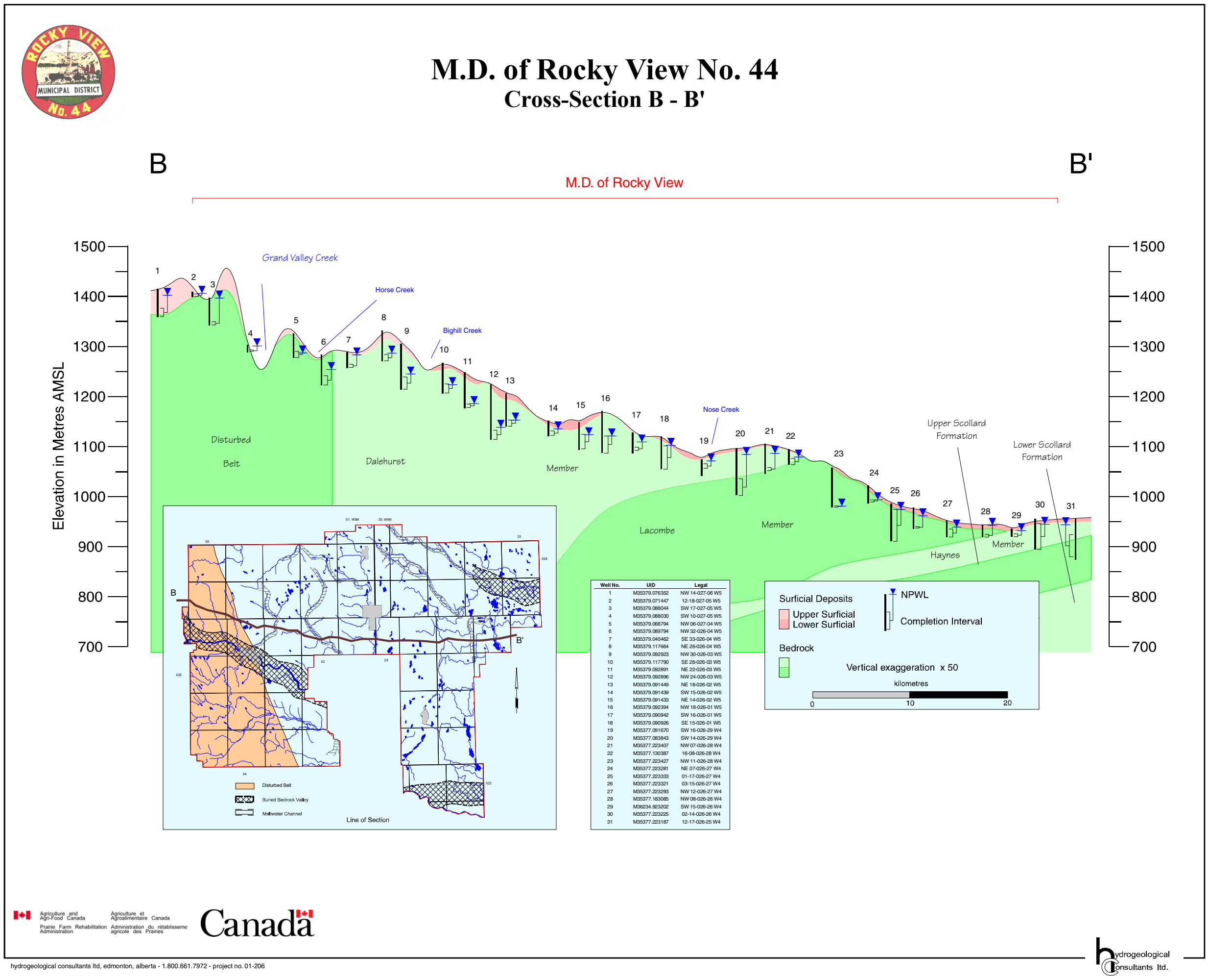
Cross-Section B - B'



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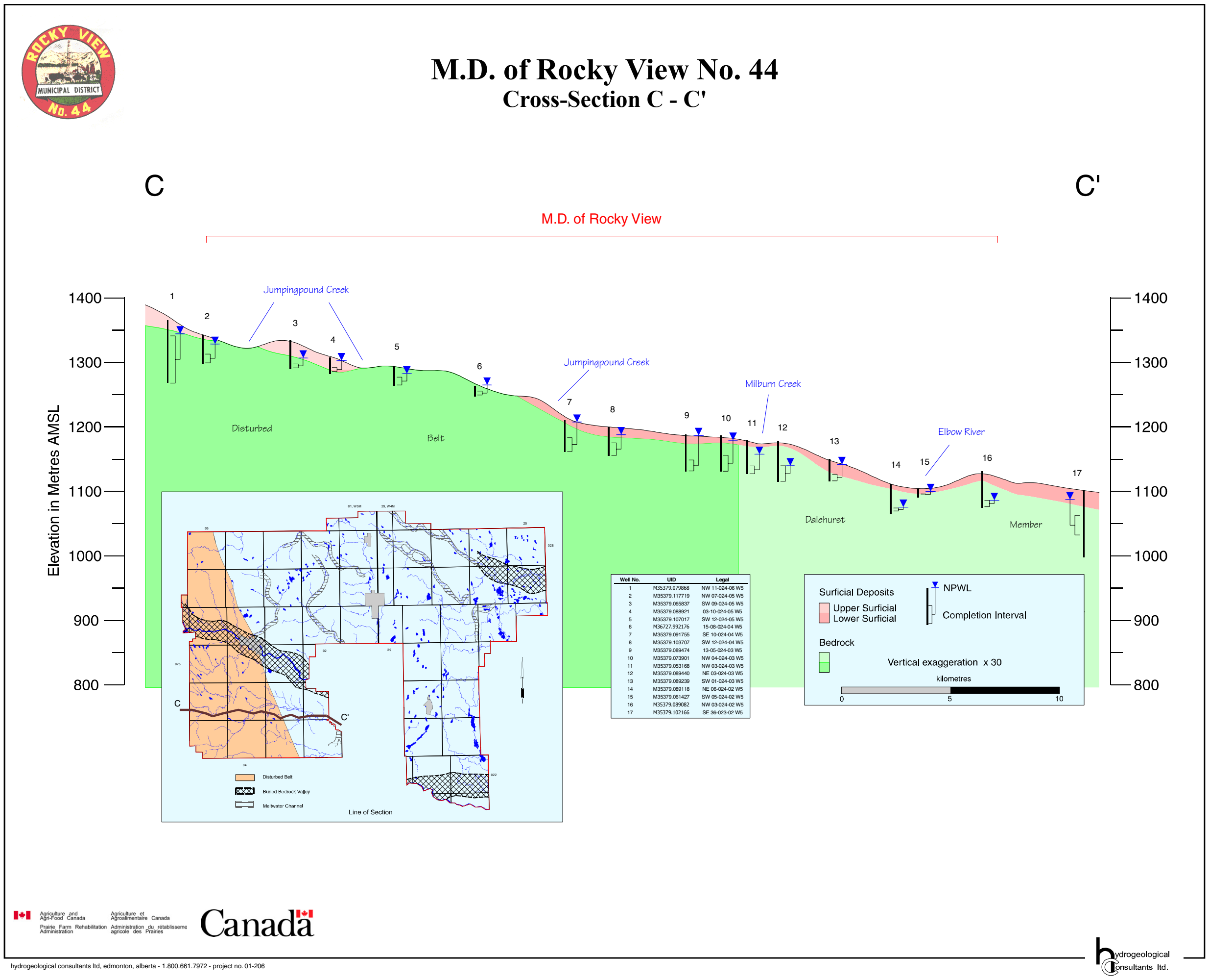

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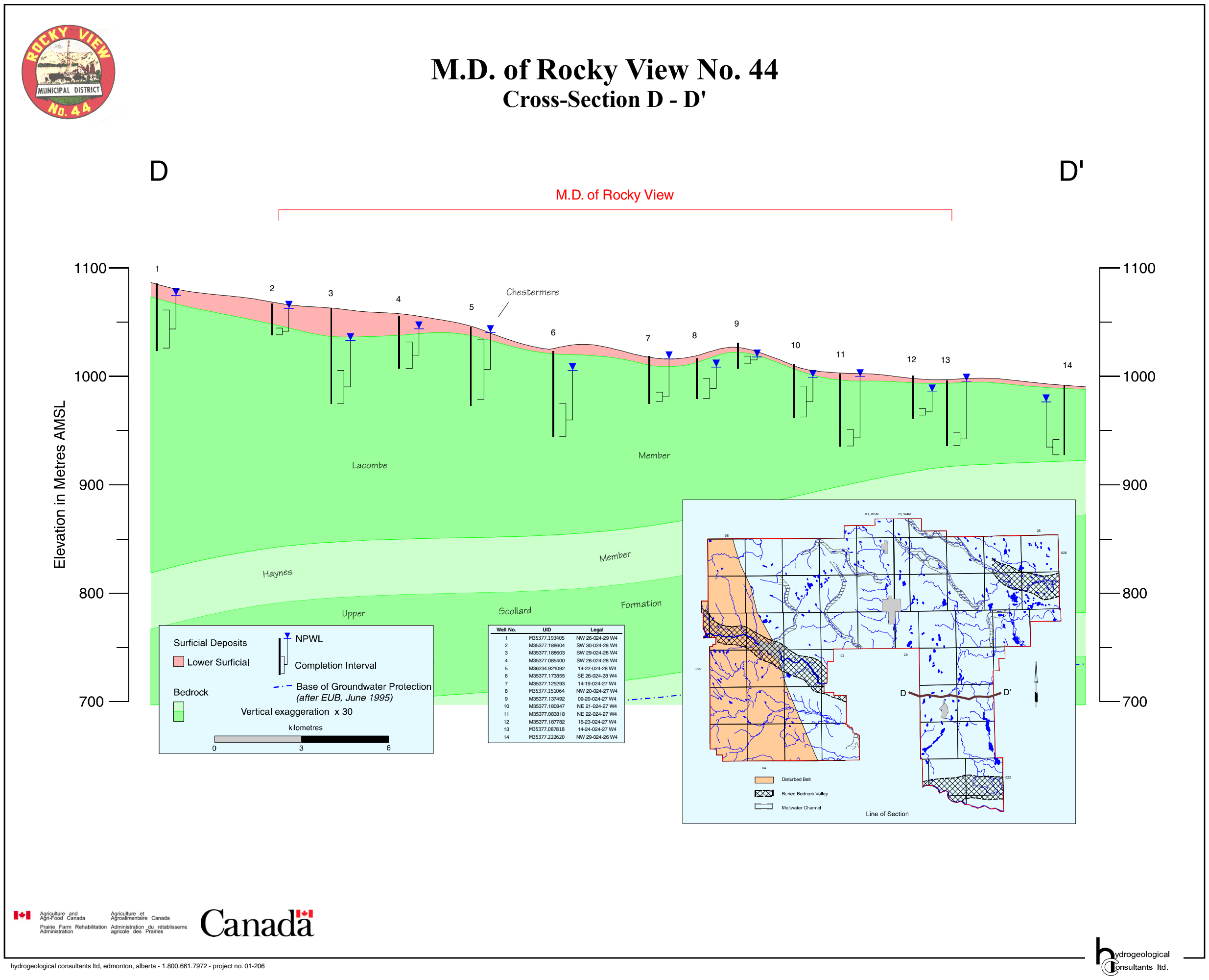
Cross-Section D - D’



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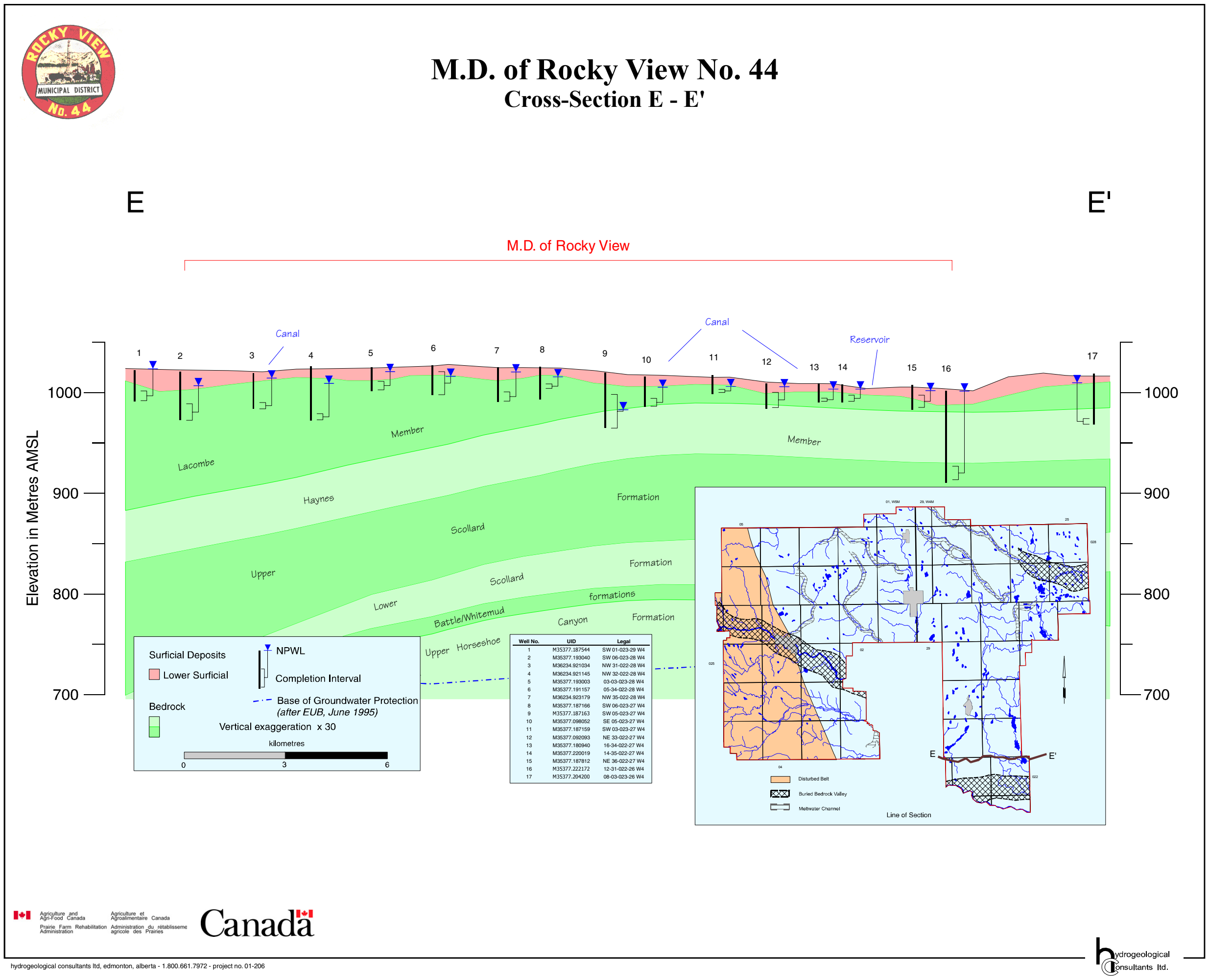
Cross-Section E - E'



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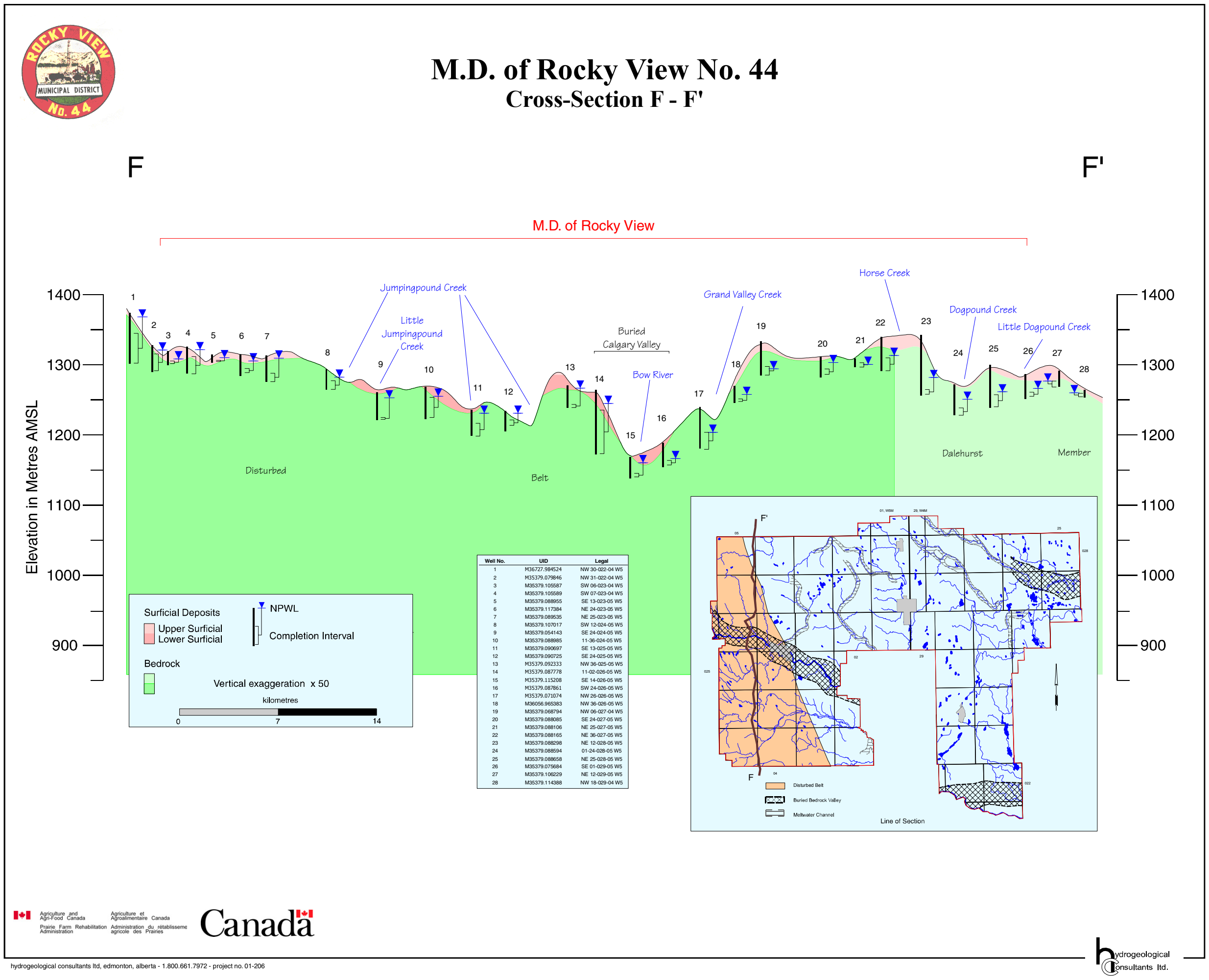
Cross-Section F - F'



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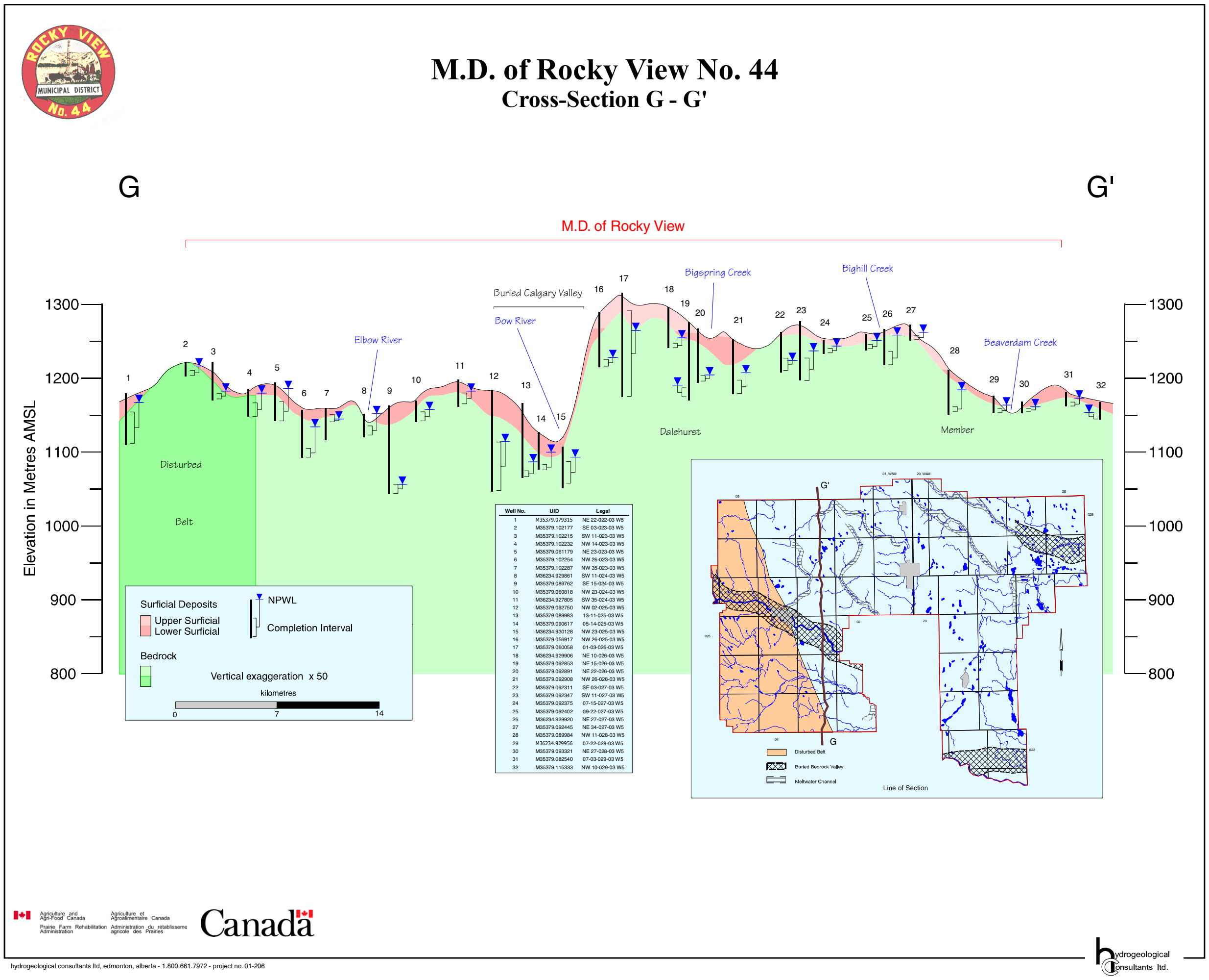
Cross-Section G - G'



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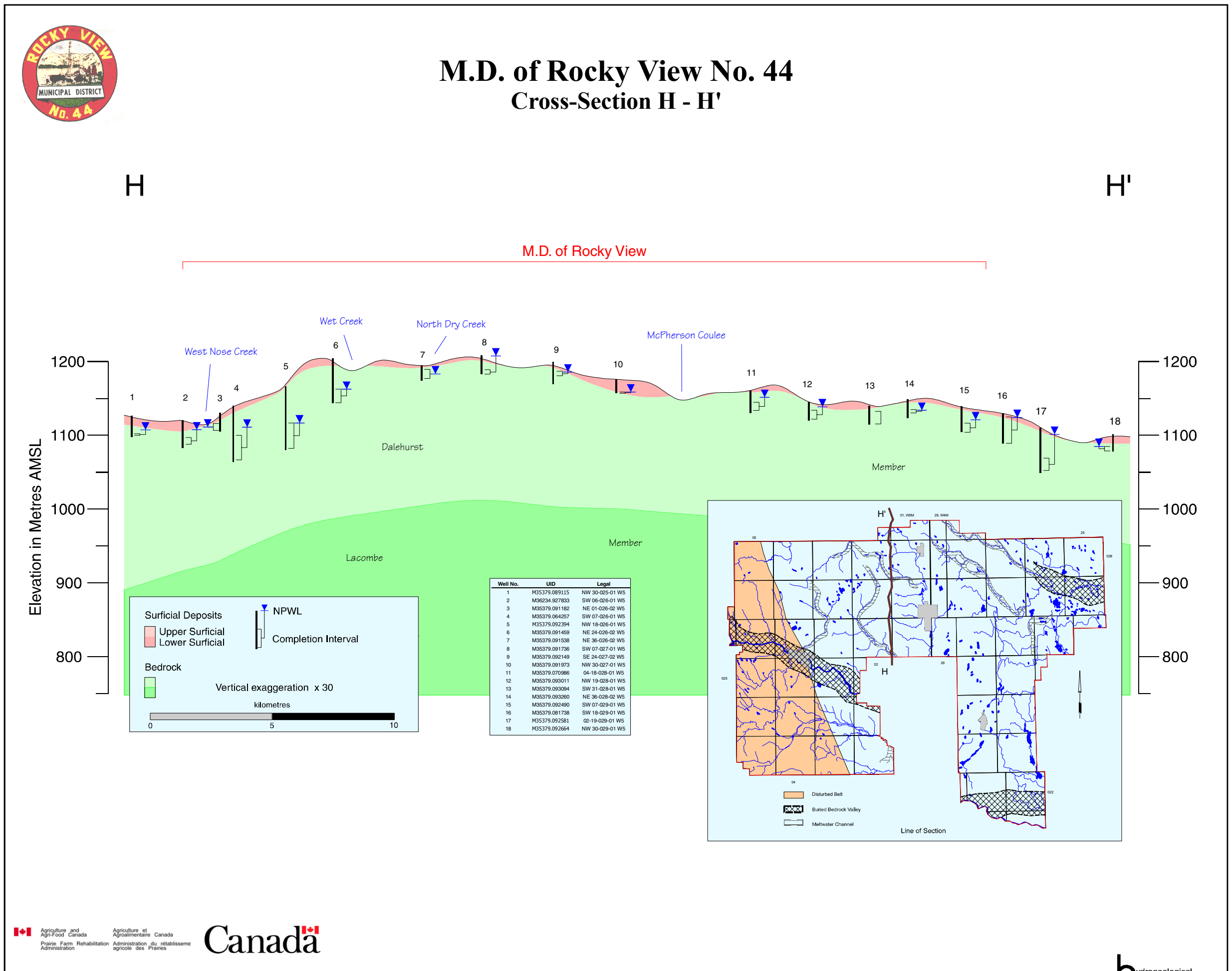

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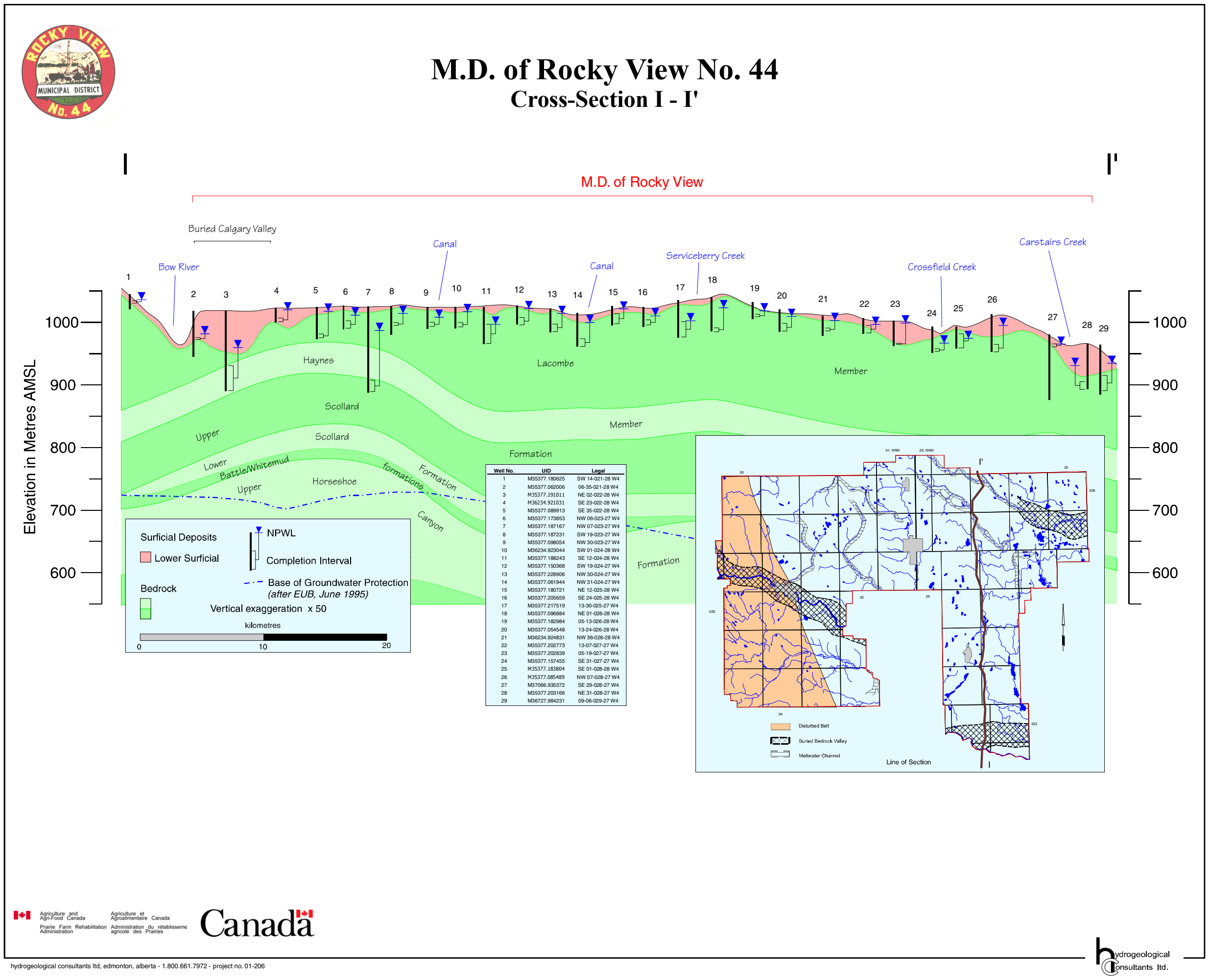

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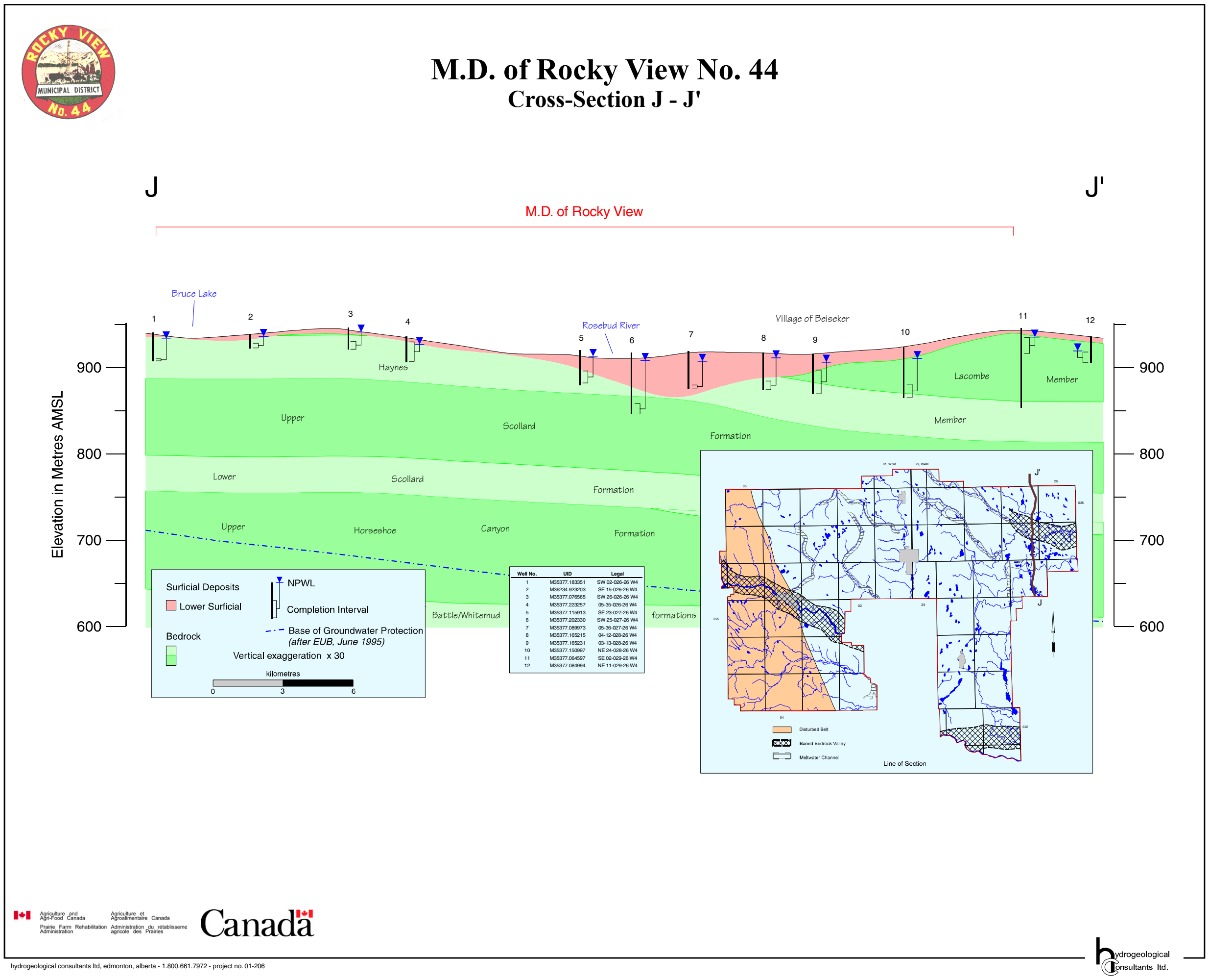
12	M35377.150368	SW 19-024-27 W4
13	M35377.228906	NW 30-024-27 W4
14	M35377.061944	NW 31-024-27 W4
15	M35377.180721	NE 12-025-28 W4
16	M35377.205659	SE 24-025-28 W4
17	M35377.217519	13-30-025-27 W4
18	M35377.096884	NE 01-026-28 W4
19	M35377.182984	05-13-026-28 W4
20	M35377.054548	13-24-026-28 W4
21	M36234.924831	NW 36-026-28 W4
22	M35377.202773	13-07-027-27 W4
23	M35377.202839	05-19-027-27 W4
24	M35377.157455	SE 31-027-27 W4
25	M35377.183804	SE 01-028-28 W4
26	M35377.085489	NW 07-028-27 W4
27	M37066.935372	SE 29-028-27 W4
28	M35377.203166	NE 31-028-27 W4
29	M36727.984231	09-06-029-27 W4

Cross-Section J - J'



Well No.	UID	Legal
1	M35377.183351	SW 02-026-26 W4
2	M36234.923203	SE 15-026-26 W4
3	M35377.076565	SW 26-026-26 W4
4	M35377.223257	05-35-026-26 W4
5	M35377.115913	SE 23-027-26 W4
6	M35377.202330	SW 25-027-26 W4
7	M35377.089973	05-36-027-26 W4
8	M35377.165215	04-12-028-26 W4
9	M35377.165231	03-13-028-26 W4
10	M35377.150997	NE 24-028-26 W4
11	M35377.064597	SE 02-029-26 W4
12	M35377.084994	NE 11-029-26 W4

M.D. OF ROCKY VIEW NO. 44

Appendix E

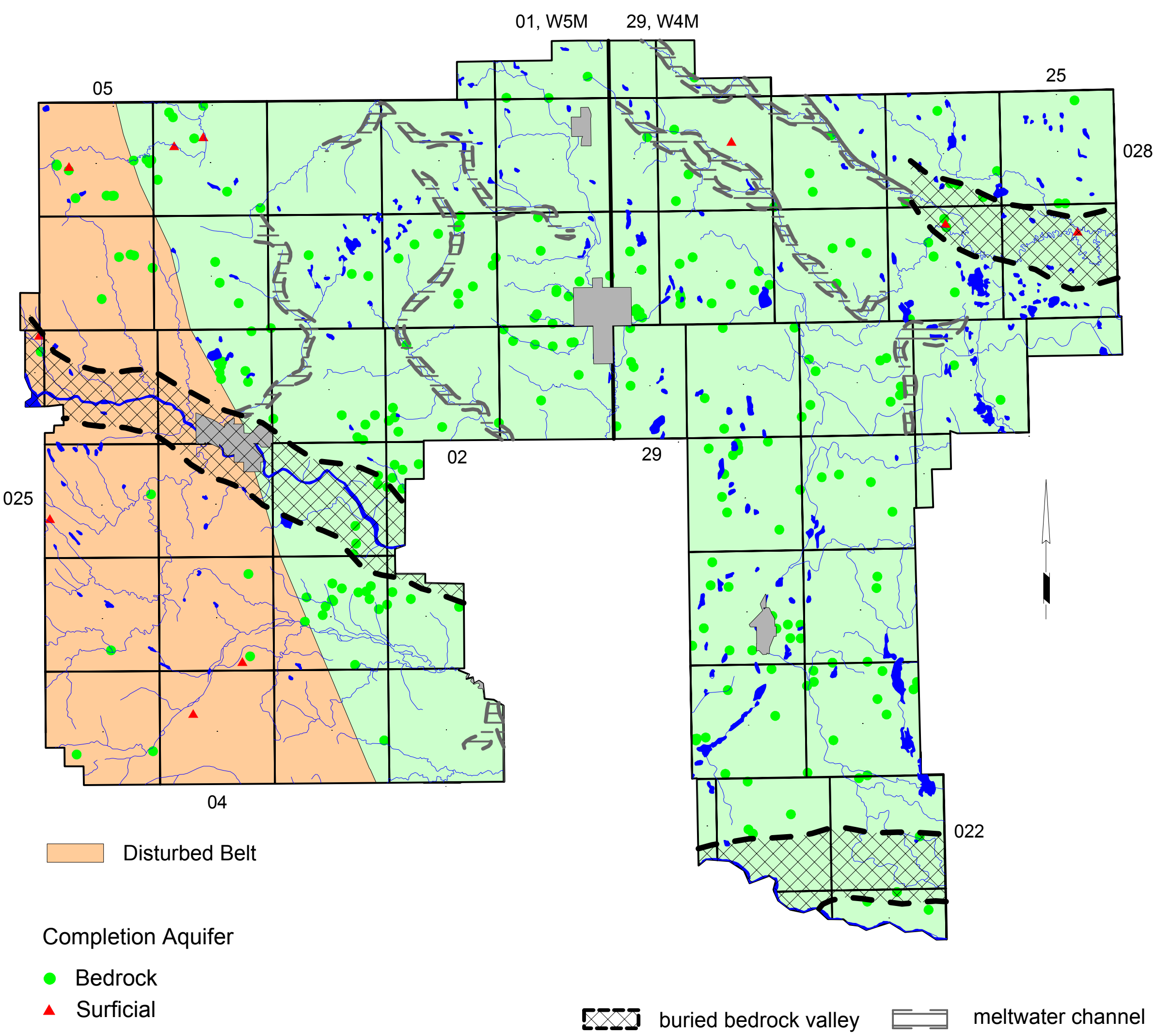
Water Wells Recommended for Field Verification

and

M. D.-Operated Water Wells

Water Wells Recommended for Field Verification

(details on following pages)



WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

Owner	Location	Aquifer Name	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet	UID
123301 Holdings Ltd.	NW 14-024-28 W4M	Lacombe	07-Apr-83	42.97	141.0	15.48	50.8	M35377.188294
Acres DevelopmentLtd.	SW 23-023-28 W4M	Lacombe	01-May-72	50.29	165.0	14.63	48.0	M35377.183787
Adlington, Bruce	NW 07-028-04 W5M	Dalehurst	24-May-84	62.48	205.0	48.77	160.0	M35379.115221
Adlington, Bruce	NW 07-028-04 W5M	Dalehurst	01-Nov-84	54.25	178.0	45.72	150.0	M35379.115222
Adrian, C. J.	SE 13-024-28 W4M	Lacombe	04-Oct-83	42.67	140.0	5.49	18.0	M35377.188272
Alberta Housing & Public Works	SW 18-025-05 W5M	Upper Surficial	19-Jun-81	28.50	93.5	9.75	32.0	M35379.092326
Aleksander, Harvey	13-35-027-02 W5M	Dalehurst	31-Aug-79	35.05	115.0	24.38	80.0	M35379.092263
Anderson, Jim	NW 08-023-27 W4M	Lacombe	21-Apr-80	21.33	70.0	12.8	42.0	M35377.187168
Backs, Tony	01-08-029-28 W4M	Lacombe	25-Aug-81	30.48	100.0	7.62	25.0	M35377.223980
Baggs, J. B.	NE 33-028-04 W5M	Dalehurst	20-Mar-73	19.81	65.0	13.41	44.0	M35379.089067
Balderson, C. L.	08-34-028-25 W4M	Lacombe	28-Aug-78	22.55	74.0	4.88	16.0	M35377.165193
Banakovitch, J.	NW 07-026-02 W5M	Dalehurst	30-Oct-74	64.00	210.0	45.72	150.0	M35379.091296
Bane, George	SW 30-024-02 W5M	Dalehurst	10-May-77	25.30	83.0	13.72	45.0	M35379.090065
Batdorf, Wayne	NW 22-026-04 W5M	Dalehurst	20-Oct-82	53.34	175.0	36.57	120.0	M35379.090210
Bateman, Bill	03-10-024-05 W5M	Disturbed Belt	08-Jun-82	21.33	70.0	4.57	15.0	M35379.088921
Bates, C. W.	SW 05-024-27 W4M	Lacombe	15-Feb-68	25.91	85.0	7.62	25.0	M35377.187692
Beattie, Roger	01-26-026-27 W4M	Lacombe	17-Jun-81	60.96	200.0	24.38	80.0	M35377.223349
Beiseker, Ufa	16-12-028-26 W4M	Haynes	24-Mar-84	48.77	160.0	7.31	24.0	M35377.165226
Bennett, E.	SW 01-027-29 W4M	Dalehurst	12-Feb-86	47.55	156.0	14.93	49.0	M35377.090582
Bernakavith, Joe	SW 07-026-02 W5M	Dalehurst	17-May-79	54.56	179.0	48.77	160.0	M35379.078073
Bierlie, John	SE 15-027-28 W4M	Lacombe	13-Dec-74	18.29	60.0	9.14	30.0	M35377.207790
Bishop, Irvine W.	SE 28-028-04 W5M	Lower Surficial	18-Aug-78	7.62	25.0	1.83	6.0	M35379.088467
Bonham, Keith	NE 28-026-01 W5M	Dalehurst	02-Apr-75	30.48	100.0	16.76	55.0	M35379.091050
Boothay, Bill	SE 23-026-04 W5M	Dalehurst	15-May-80	16.46	54.0	7.31	24.0	M35379.087947
Born, Jake	NE 25-023-27 W4M	Lacombe	01-Jun-74	13.72	45.0	6.1	20.0	M35377.187388
Boukall, Gerry	SE 29-027-02 W5M	Dalehurst	16-Jul-84	45.72	150.0	38.1	125.0	M35379.092216
Bowen, E. O.	04-14-027-01 W5M	Dalehurst	23-Mar-77	21.33	70.0	7.62	25.0	M35379.091861
Braunworth, E.	SW 06-023-27 W4M	Lacombe	28-Jan-74	28.95	95.0	15.24	50.0	M35377.187165
Bromlay, Herb	SW 08-027-28 W4M	Dalehurst	20-Sep-73	30.48	100.0	9.14	30.0	M35377.207736
Brooker, D. G.	SW 32-025-28 W4M	Lacombe	01-Jun-73	32.00	105.0	6.1	20.0	M35377.205531
Brown, Jerry	16-05-028-05 W5M	Disturbed Belt	29-Sep-78	47.24	155.0	21.33	70.0	M35379.088233
Burns, John	SW 27-026-04 W5M	Dalehurst	23-Mar-76	33.53	110.0	16.76	55.0	M35379.090214
Bushfield, Roy	SW 16-026-01 W5M	Dalehurst	28-Oct-75	36.57	120.0	19.81	65.0	M35379.090942
Cameron, Don	SW 02-025-03 W5M	Dalehurst	29-Apr-74	44.19	145.0	28.95	95.0	M35379.115124
Cameron, Lou	NE 20-025-27 W4M	Lacombe	11-Aug-78	41.15	135.0	16.76	55.0	M35377.193332
Capithorne, Lloyd	SW 07-026-03 W5M	Dalehurst	15-Apr-82	35.05	115.0	27.43	90.0	M35379.115168
Cardellini, G.	NE 27-024-27 W4M	Lacombe	01-May-78	35.96	118.0	3.35	11.0	M35377.187799
Carlson, Bob	NW 30-023-27 W4M	Lacombe	26-Jul-75	24.38	80.0	11.28	37.0	M35377.187419
Chaudy, Dr.	SE 31-026-01 W5M	Dalehurst	08-Aug-72	18.29	60.0	14.02	46.0	M35379.091071
Chernesky, Richard	NE 24-025-03 W5M	Dalehurst	27-Jun-96	54.86	180.0	38.37	125.9	M36056.965413
Chernos, Rod	NE 07-024-28 W4M	Lacombe	11-Aug-73	22.55	74.0	15.24	50.0	M35377.188114
Chitwood, Helen	13-34-026-29 W4M	Dalehurst	10-Jul-78	28.95	95.0	15.24	50.0	M35377.201309
Circle J Ranch	04-06-027-03 W5M	Dalehurst	07-Nov-84	39.62	130.0	28.95	95.0	M35379.092325
Circle J Ranch	13-21-027-03 W5M	Dalehurst	15-Nov-75	21.33	70.0	9.75	32.0	M35379.092387
Cissell, Joe	SE 30-028-28 W4M	Lacombe	25-Feb-75	24.38	80.0	15.24	50.0	M35377.203481
Clark, Paul	SW 15-027-27 W4M	Lacombe	10-Dec-75	27.43	90.0	15.85	52.0	M35377.202814
Clark, Paul	04-15-027-27 W4M	Lacombe	04-Oct-84	30.48	100.0	19.81	65.0	M35377.202819
Classen, S.	SW 33-025-28 W4M	Lacombe	01-Jun-73	36.57	120.0	9.14	30.0	M35377.205664
Clayton, R.	NW 21-027-01 W5M	Dalehurst	01-Dec-72	18.29	60.0	12.19	40.0	M35379.091891
Coffman, Mike	NE 25-023-27 W4M	Lacombe	01-Sep-73	25.91	85.0	2.13	7.0	M35377.187391
Coles, Fred	NE 20-024-03 W5M	Dalehurst	28-Mar-81	39.01	128.0	24.38	80.0	M35379.090220
Cornforth, Ben	SE 10-028-04 W5M	Dalehurst	10-Aug-79	17.68	58.0	8.23	27.0	M35379.088252
Corradetti, Pasquale	NE 22-024-27 W4M	Lacombe	16-Sep-80	30.48	100.0	0.91	3.0	M35377.187769

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION (continued)

Owner	Location	Aquifer Name	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet	UID
Couture, Marcel	13-22-028-27 W4M	Lacombe	02-May-80	56.69	186.0	31.09	102.0	M35377.203050
Creasser, Jim	NW 22-026-29 W4M	Dalehurst	15-May-73	42.67	140.0	10.67	35.0	M35377.201026
D & S Investments ments Ltd.	SW 30-025-02 W5M	Dalehurst	04-Nov-72	52.42	172.0	45.72	150.0	M35379.115111
D & S Investments Ltd.	NE 06-026-02 W5M	Dalehurst	31-Jul-75	49.38	162.0	42.06	138.0	M35379.078034
Davies, Wayne A.	SW 11-027-04 W5M	Dalehurst	05-May-78	47.85	157.0	23.77	78.0	M35379.087977
Davis, Jim & Betty	SE 05-023-28 W4M	Lacombe	23-Apr-99	36.57	120.0	4.82	15.8	M36727.982773
Degens, Brad & Katie	NE 13-028-05 W5M	Dalehurst	01-Jun-84	21.03	69.0	11.58	38.0	M35379.088328
Deuce Builders Ltd.	14-14-027-03 W5M	Dalehurst	30-Apr-81	35.05	115.0	27.43	90.0	M35379.092368
Dicky, Ernie	SW 07-026-02 W5M	Dalehurst	08-Feb-71	40.84	134.0	30.48	100.0	M35379.115151
Dodginghorse, Sarah	NE 20-023-04 W5M	Lower Surficial	03-Nov-87	16.76	55.0	10.06	33.0	M35379.105606
Domshy, E.	NE 19-025-02 W5M	Dalehurst	24-Sep-75	64.61	212.0	57.3	188.0	M35379.116562
Durnin, Pat	NW 23-026-27 W4M	Lacombe	28-Oct-81	36.57	120.0	10.97	36.0	M35377.223346
Ephgrave, Paul	13-22-027-27 W4M	Lacombe	12-Apr-76	22.86	75.0	6.1	20.0	M35377.202844
Esau, Scott	NW 35-025-28 W4M	Lacombe	26-Jan-99	41.15	135.0	7.22	23.7	M36727.982823
Evans, Ernie	NW 23-027-05 W5M	Disturbed Belt	17-Jun-80	41.15	135.0	29.87	98.0	M35379.088072
Fenton, D.	SE 24-027-05 W5M	Disturbed Belt	25-Aug-82	18.29	60.0	12.19	40.0	M35379.088086
Fenton, John	SE 31-028-04 W5M	Dalehurst	16-Nov-70	40.54	133.0	21.03	69.0	M35379.088515
Fenton, Lynn	SE 24-027-05 W5M	Disturbed Belt	22-Jul-74	25.91	85.0	9.14	30.0	M35379.088085
Fletcher, Allen	NW 23-027-29 W4M	Dalehurst	17-Sep-73	16.76	55.0	6.1	20.0	M35377.207693
Foothills Feeders	NE 20-027-28 W4M	Dalehurst	13-Sep-72	10.67	35.0	7.62	25.0	M35377.207846
Foothills Foundry	SE 18-023-28 W4M	Lacombe	01-Jan-81	16.76	55.0	2.47	8.1	M35377.093422
Fowler, Alvin	NW 04-027-01 W5M	Dalehurst	12-Mar-73	22.86	75.0	21.33	70.0	M35379.091717
Fowler, Bruce	SW 12-026-03 W5M	Dalehurst	28-Nov-72	74.67	245.0	60.96	200.0	M35379.115184
Fowler, Melvin	08-05-027-01 W5M	Dalehurst	08-Apr-76	28.95	95.0	13.72	45.0	M35379.091720
Friesen, Leonard	NW 31-026-01 W5M	Dalehurst	02-Nov-78	22.86	75.0	11.28	37.0	M35379.091083
Galbruck, Don	04-13-026-27 W4M	Lacombe	26-Apr-82	22.55	74.0	4.88	16.0	M35377.223307
Gaskarth, Bill	NE 29-023-28 W4M	Lacombe	27-Feb-69	25.30	83.0	6.71	22.0	M35377.193207
Gerdts, Eric	NE 11-024-28 W4M	Lacombe	21-Apr-86	22.86	75.0	4.27	14.0	M35377.188229
Gibson, David	NE 18-028-05 W5M	Disturbed Belt	19-Dec-73	33.53	110.0	15.24	50.0	M35379.088556
Giles Ranches	NW 13-027-03 W5M	Dalehurst	25-May-84	45.72	150.0	27.43	90.0	M35379.092361
Giles, Terry	NE 19-027-02 W5M	Dalehurst	12-Jun-78	54.25	178.0	44.19	145.0	M35379.092116
Gilmour, Les	SE 04-029-01 W5M	Dalehurst	23-Jan-84	12.19	40.0	3.66	12.0	M35379.092472
Golden Key Realty Ltd.	NW 10-027-01 W5M	Dalehurst	25-Oct-73	57.91	190.0	54.86	180.0	M35379.092006
Golden Key Realty Ltd.	NE 24-027-02 W5M	Dalehurst	30-Nov-72	13.11	43.0	10.67	35.0	M35379.092156
Gorril, Gordon	NW 02-025-03 W5M	Dalehurst	30-Apr-76	49.07	161.0	41.15	135.0	M35379.093953
Goss, M.	SW 27-026-04 W5M	Dalehurst	29-Sep-79	24.38	80.0	15.24	50.0	M35379.090215
Gough, Merville	SE 33-027-26 W4M	Haynes	20-Dec-75	39.62	130.0	4.27	14.0	M35377.202681
Grad, Stan	NW 33-027-01 W5M	Dalehurst	01-Aug-73	54.86	180.0	42.67	140.0	M35379.091980
Green, Albert	NE 23-027-05 W5M	Disturbed Belt	20-Jul-76	30.48	100.0	19.81	65.0	M35379.088082
Greier, Floyd	10-11-026-26 W4M	Haynes	16-Apr-77	22.86	75.0	6.1	20.0	M35377.223222
Gross, D.	SW 27-026-29 W4M	Dalehurst	01-Aug-70	38.10	125.0	9.14	30.0	M35377.201249
Groves, W. G.	10-08-023-05 W5M	Disturbed Belt	22-Jun-87	46.94	154.0	28.95	95.0	M36727.990579
Guler, M.	SW 27-026-04 W5M	Dalehurst	13-Dec-79	20.73	68.0	15.24	50.0	M35379.088621
Haakenson, Puglia & Rapine	NW 08-027-28 W4M	Dalehurst	12-May-75	27.43	90.0	6.1	20.0	M35377.091939
Hagel, Jake	SE 33-028-26 W4M	Lacombe	05-Feb-77	23.47	77.0	7.92	26.0	M35377.165248
Hagel, Jerome F.	SE 10-028-26 W4M	Haynes	28-Apr-83	43.89	144.0	16.76	55.0	M35377.165212
Hallett, John	NE 10-027-02 W5M	Dalehurst	06-Nov-75	28.95	95.0	19.81	65.0	M35379.092058
Hand, Ken	SE 33-025-28 W4M	Lacombe	26-Oct-85	27.74	91.0	10.67	35.0	M35377.205557
Hardstaff, B.	NE 17-024-03 W5M	Disturbed Belt	23-Nov-78	27.43	90.0	20.73	68.0	M35379.091544
Harriman, H. G.	15-32-022-28 W4M	Lacombe	21-Jul-79	68.58	225.0	12.19	40.0	M35377.191156
Hassen, S.	SE 32-026-01 W5M	Dalehurst	01-Oct-71	24.38	80.0	3.35	11.0	M35379.091099
Hein Real Estate Corp Ltd.	SW 28-024-28 W4M	Lacombe	01-Jun-71	36.57	120.0	3.66	12.0	M35377.188578
Henker, Gordon	SE 24-024-03 W5M	Dalehurst	16-Dec-77	35.66	117.0	25.91	85.0	M35379.090356
Henry Macleod Contracting	SE 33-025-28 W4M	Lacombe	20-Aug-76	22.86	75.0	7.62	25.0	M35377.205542
High, Larry	09-06-028-28 W4M	Lacombe	26-Jul-82	38.10	125.0	24.38	80.0	M35377.203261
Hilton, Ron	SE 03-025-25 W4M	Lacombe	31-Oct-74	41.15	135.0	15.24	50.0	M35377.223492
Hodgman, Paul	SE 20-022-28 W4M	Lacombe	08-Aug-75	22.25	73.0	4.57	15.0	M35377.191085

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION (continued)

Owner	Location	Aquifer Name	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet	UID
Hodgson, Allan	NW 24-024-03 W5M	Dalehurst	15-Nov-80	45.11	148.0	33.53	110.0	M35379.090370
Holmes, Dennis	NW 22-027-04 W5M	Dalehurst	01-Dec-73	36.88	121.0	32.61	107.0	M35379.088274
Howden, Grant	NE 08-028-27 W4M	Lacombe	13-Jul-82	37.49	123.0	20.42	67.0	M35377.090040
Hudson, Allen	NE 32-022-27 W4M	Lacombe	01-Mar-74	18.29	60.0	9.75	32.0	M35377.187495
Hurt, Gerald & Ron S.	SE 11-029-01 W5M	Dalehurst	21-Nov-75	42.67	140.0	13.72	45.0	M35379.071418
Hyhiill Land DevelopmentLtd.	SE 24-024-03 W5M	Dalehurst	01-Jul-79	16.76	55.0	6.1	20.0	M35379.090290
Indelco Financial Corporation Ltd.	SW 22-026-04 W5M	Disturbed Belt	03-Aug-78	57.91	190.0	50.29	165.0	M35379.087812
Jakubiz, Al	NE 36-026-06 W5M	Lower Surficial	18-Mar-99	29.87	98.0	23.44	76.9	M36727.992199
James, Ron	SW 23-026-01 W5M	Dalehurst	01-Apr-73	39.62	130.0	21.33	70.0	M35379.091004
Jerome Farms Ltd.	01-10-028-26 W4M	Haynes	07-Nov-95	51.81	170.0	27.4	89.9	M35377.067085
Jessey, Dave	NW 35-023-27 W4M	Lacombe	06-Dec-75	32.00	105.0	2.44	8.0	M35377.187533
Johannisman, Gerry	SW 27-026-04 W5M	Dalehurst	24-Oct-79	16.76	55.0	9.14	30.0	M35379.088616
Johns, Max	SE 01-028-04 W5M	Dalehurst	11-Oct-69	14.02	46.0	10.06	33.0	M35379.088345
Kaczmer, Ray	NE 17-028-05 W5M	Upper Surficial	17-Sep-79	22.86	75.0	18.29	60.0	M35379.088446
Kaschuk, George	SE 29-025-28 W4M	Lacombe	19-Nov-76	29.26	96.0	5.46	17.9	M35377.205661
Kathryn Farms	NE 11-026-27 W4M	Haynes	15-Jan-86	94.79	311.0	13.11	43.0	M35377.223291
Keizer, Bud	NW 20-025-27 W4M	Lacombe	29-May-72	30.48	100.0	12.19	40.0	M35377.193325
Kemna, Klaus	SW 01-027-01 W5M	Dalehurst	28-May-68	38.10	125.0	14.63	48.0	M35379.091704
Kimber, R. L.	NE 02-026-03 W5M	Dalehurst	01-Mar-72	41.15	135.0	33.53	110.0	M35379.115158
Kjersem, G.	SW 27-026-04 W5M	Dalehurst	14-Jun-76	27.43	90.0	15.24	50.0	M35379.090751
Knight, Mervin	03-06-028-27 W4M	Lacombe	18-May-84	30.78	101.0	10.67	35.0	M35377.202884
Knight, R.	09-23-027-27 W4M	Lacombe	03-Nov-82	29.56	97.0	6.71	22.0	M35377.202851
Koloff, Bob	NE 23-027-05 W5M	Disturbed Belt	10-May-75	28.95	95.0	13.72	45.0	M35379.088083
Krenzler, Jack	SW 03-028-25 W4M	Haynes	10-Feb-78	36.57	120.0	10.06	33.0	M35377.165154
Kroeker, Frank	SW 16-025-28 W4M	Lacombe	29-Dec-84	35.36	116.0	13.41	44.0	M35377.188432
Kufer, R.	SW 31-023-27 W4M	Lacombe	20-Sep-78	39.62	130.0	13.41	44.0	M35377.187432
Lambert, Gordon	SE 35-024-04 W5M	Disturbed Belt	13-May-81	25.91	85.0	12.19	40.0	M35379.089196
Lambertson, B.	NE 02-027-29 W4M	Dalehurst	14-Nov-73	27.43	90.0	12.19	40.0	M35377.207565
Lapp, Ken	SE 27-022-28 W4M	Lacombe	02-Sep-77	14.93	49.0	5.79	19.0	M35377.087035
Law, Larry L.	SE 21-024-03 W5M	Dalehurst	09-Mar-73	23.16	76.0	9.14	30.0	M35379.090224
Lee, Pat	SE 10-028-05 W5M	Disturbed Belt	29-Jan-81	44.80	147.0	33.83	111.0	M35379.073856
Leeson, Neil & Judy	NW 11-025-03 W5M	Dalehurst	06-Jul-89	97.53	320.0	54.86	180.0	M35379.066265
Lemon, Geoff	01-26-024-03 W5M	Dalehurst	26-Jun-76	35.66	117.0	25.91	85.0	M35379.090411
Lennox, Alice	SW 02-024-04 W5M	Lower Surficial	29-Jul-96	11.28	37.0	-0.3	-1.0	M36056.965424
Lester, Bill	NW 35-023-28 W4M	Lacombe	16-Jun-72	24.38	80.0	10.67	35.0	M35377.193232
Libbey, C.	SW 07-024-28 W4M	Lacombe	03-Jun-68	45.72	150.0	9.14	30.0	M35377.188101
Litke, Reginald	09-22-028-28 W4M	Lower Surficial	02-Dec-81	27.43	90.0	12.19	40.0	M35377.203441
Logan, Keith	NE 14-028-05 W5M	Disturbed Belt	20-Aug-86	21.33	70.0	-0.61	-2.0	M35379.088335
Lublinkhof, Bernard	NW 20-028-04 W5M	Upper Surficial	15-Aug-73	16.46	54.0	6.1	20.0	M35379.090597
Lucci, Umberto	SW 18-023-28 W4M	Lacombe	03-May-75	36.57	120.0	5.18	17.0	M35377.193095
Lunde, Erling	SE 13-027-28 W4M	Lacombe	09-Nov-70	64.61	212.0	23.9	78.4	M35377.207786
Lunde, Gordy	NW 13-027-28 W4M	Lacombe	27-Jun-84	30.48	100.0	9.14	30.0	M35377.207788
Mackenzie, Roy	NE 02-027-29 W4M	Dalehurst	13-Aug-75	24.38	80.0	15.24	50.0	M35377.207563
Malcolm, Bob	NE 28-027-02 W5M	Dalehurst	08-Apr-76	41.15	135.0	27.43	90.0	M35379.092209
Maldegham Farming Co Ltd.	08-32-021-27 W4M	Lacombe	06-Sep-79	58.52	192.0	27.43	90.0	M35377.180365
Mall, W. F.	SW 30-026-27 W4M	Lacombe	11-Apr-77	28.04	92.0	4.27	14.0	M35377.223359
Mall, W. R.	SE 19-026-27 W4M	Lacombe	01-Mar-75	22.25	73.0	4.27	14.0	M35377.223338
Marks, Mr. & Verbisky, M. J.	NE 29-025-02 W5M	Dalehurst	14-Feb-76	73.15	240.0	45.72	150.0	M35379.108076
Marsh, Jim	NW 04-028-27 W4M	Lacombe	01-May-73	52.73	173.0	21.33	70.0	M35377.157173
Mason, Ron	SW 32-028-04 W5M	Dalehurst	02-Jul-81	31.09	102.0	16.76	55.0	M35379.089056
Mastro, Angelo	NW 04-026-29 W4M	Dalehurst	28-Feb-86	16.76	55.0	10.67	35.0	M35377.198959
Matson, Merv	SE 24-025-28 W4M	Lacombe	06-Apr-77	29.56	97.0	14.93	49.0	M35377.205659
Mattis, Ken	SE 09-027-28 W4M	Lacombe	20-Feb-74	39.62	130.0	27.43	90.0	M35377.207747
Mccormack, Robert	03-13-026-27 W4M	Lacombe	15-Jul-80	13.72	45.0	3.66	12.0	M35377.223304
Mcdonald, Bob	NE 10-024-28 W4M	Lacombe	18-Mar-81	82.29	270.0	10.97	36.0	M35377.193613
Mcgunnes, Paul	SE 13-023-03 W5M	Dalehurst	29-Jun-99	48.16	158.0	7.44	24.4	M36727.992404

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION (continued)

Owner	Location	Aquifer Name	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet	UID
Mckay, Ross	NE 07-026-27 W4M	Lacombe	21-Feb-74	33.53	110.0	28.95	95.0	M35377.223281
Mckendrick, Jim	NW 20-024-02 W5M	Dalehurst	18-May-76	80.77	265.0	51.81	170.0	M35379.089711
Mclean, Roy	NE 01-026-02 W5M	Dalehurst	03-Jun-72	22.86	75.0	18.29	60.0	M35379.091182
Mcpherson, Art & Dana-Lee	SW 15-027-04 W5M	Dalehurst	26-Jun-80	56.39	185.0	33.53	110.0	M35379.065733
Mikkelsen, Wayne	01-27-023-27 W4M	Lacombe	23-Sep-85	30.17	99.0	4.57	15.0	M35377.187402
Mitchell, John	NE 14-022-27 W4M	Lacombe	17-Apr-80	45.72	150.0	28.04	92.0	M35377.187459
Molbak, Neil	NE 04-026-02 W5M	Dalehurst	01-Apr-73	63.09	207.0	53.34	175.0	M35379.091201
Morfitt, G.	01-20-022-28 W4M	Lacombe	01-Jun-74	13.41	44.0	3.05	10.0	M35377.191081
Morril, Al	SE 10-026-03 W5M	Dalehurst	14-Aug-72	38.40	126.0	30.48	100.0	M35379.115172
Mosca, John	SW 29-024-28 W4M	Lacombe	27-Mar-86	34.75	114.0	12.5	41.0	M35377.188600
Murphy, Martin & Connie	NE 10-027-01 W5M	Dalehurst	12-Dec-80	16.76	55.0	17.07	56.0	M35379.091820
Neilson, Ron	SE 22-024-02 W5M	Dalehurst	08-Jul-74	33.53	110.0	15.54	51.0	M35379.089827
Nemeth	SE 27-024-03 W5M	Dalehurst	11-Apr-79	51.81	170.0	27.43	90.0	M35379.090427
Newman, Eric	NE 17-025-28 W4M	Lacombe	15-Oct-80	63.40	208.0	27.43	90.0	M35377.115116
Nielsen, N. S. & Gold Medal Feeds	04-07-026-27 W4M	Lacombe	23-Oct-80	24.38	80.0	6.71	22.0	M35377.223277
Nixdorff, Marvin	16-32-026-28 W4M	Lacombe	14-Jul-77	42.06	138.0	21.94	72.0	M35377.223481
Norman, Alec	NE 25-026-06 W5M	Disturbed Belt	08-Sep-78	21.03	69.0	10.36	34.0	M35379.105993
Obermeyer, Garry	SW 05-027-26 W4M	Haynes	29-Jul-85	57.91	190.0	9.45	31.0	M35377.202207
Olsen, L.	SE 24-027-02 W5M	Dalehurst	29-Jul-82	18.29	60.0	13.11	43.0	M35379.092149
Pagenkopf, Erhard	NW 22-024-03 W5M	Dalehurst	21-Apr-75	22.86	75.0	7.62	25.0	M35379.090250
Pitt, D.	NE 13-028-05 W5M	Dalehurst	20-Jun-74	18.29	60.0	7.31	24.0	M35379.088310
Polara Contracting	NW 03-024-28 W4M	Lacombe	24-Mar-73	19.81	65.0	16.76	55.0	M35377.193609
Pole, Harry	01-04-027-01 W5M	Dalehurst	16-Dec-76	24.38	80.0	15.24	50.0	M35379.091716
Powlesland, Bert	NE 35-026-04 W5M	Dalehurst	29-Dec-73	41.76	137.0	33.83	111.0	M35379.088773
Preet, H.	02-14-027-02 W5M	Dalehurst	12-Oct-73	35.05	115.0	32.61	107.0	M35379.092094
Rachkewich, W.	NW 15-027-29 W4M	Dalehurst	20-Mar-76	30.48	100.0	6.1	20.0	M35377.207660
Rau, James	01-04-028-25 W4M	Lacombe	18-Jun-84	25.30	83.0	4.57	15.0	M35377.165155
Rau, Verlin	09-27-027-25 W4M	Upper Scollard	27-May-83	60.04	197.0	7.92	26.0	M35377.201555
Reseli, Frank	NE 30-025-02 W5M	Dalehurst	22-May-73	90.22	296.0	51.81	170.0	M35379.108078
Ridley, Harold	NE 12-023-05 W5M	Disturbed Belt	27-May-74	10.67	35.0	2.44	8.0	M35379.117380
Rietveld, H.	13-10-027-01 W5M	Dalehurst	13-May-83	44.19	145.0	1.52	5.0	M35379.091770
Robinson, John	SE 24-025-05 W5M	Disturbed Belt	22-Oct-84	21.33	70.0	3.96	13.0	M35379.090725
Rohl, Ed	SE 34-026-01 W5M	Dalehurst	09-Aug-73	16.76	55.0	15.24	50.0	M35379.091134
Rohl, V. c/o D. Estergaurd	NE 22-025-27 W4M	Lacombe	08-Aug-85	19.81	65.0	6.1	20.0	M35377.228867
Roy Banta Farms Ltd.	14-24-028-29 W4M	Lacombe	05-Aug-76	35.05	115.0	21.33	70.0	M35377.203857
Saraceni, L.	08-05-026-28 W4M	Lacombe	30-Mar-76	35.66	117.0	16.76	55.0	M35377.223386
Saunders, Bert	SW 26-024-03 W5M	Dalehurst	09-Mar-74	37.18	122.0	16.76	55.0	M35379.090414
Saunders, Ralph	SW 20-027-28 W4M	Dalehurst	14-Oct-75	21.33	70.0	16.76	55.0	M35377.207843
Savage, Jack	12-21-026-26 W4M	Haynes	26-Sep-77	33.53	110.0	12.19	40.0	M35377.223232
Sawby, Delwood	NW 13-027-29 W4M	Dalehurst	11-May-78	36.57	120.0	12.19	40.0	M35377.207608
Schellenburg, Terry	NE 08-028-28 W4M	Lacombe	25-Aug-75	24.38	80.0	10.67	35.0	M35377.086294
Schmaltz, Baltser	05-01-028-26 W4M	Haynes	26-Jul-76	49.07	161.0	17.68	58.0	M35377.165199
Schnell, Don	NE 11-027-28 W4M	Lacombe	18-Apr-73	21.33	70.0	2.9	9.5	M35377.207780
Schuh, David	NW 30-025-02 W5M	Dalehurst	20-Dec-72	47.24	155.0	36.57	120.0	M35379.115113
Seerup, Peter	SW 23-023-27 W4M	Lacombe	27-Mar-73	20.42	67.0	-0.03	-0.1	M35377.187330
Shepard Comm Hall	SW 18-023-28 W4M	Lacombe	20-Sep-75	16.76	55.0	5.49	18.0	M35377.193100
Shepherd, Bruce	SE 02-027-29 W4M	Dalehurst	23-May-73	34.14	112.0	15.24	50.0	M35377.207560
Shouldice, Russell	NE 33-025-28 W4M	Lacombe	18-Mar-76	16.76	55.0	9.14	30.0	M35377.205596
Shuttleworth, Grant	01-18-026-28 W4M	Lacombe	13-Aug-68	62.18	204.0	9.14	30.0	M35377.223454
Sigurdson, Ron	SE 25-025-03 W5M	Dalehurst	21-Mar-96	54.86	180.0	31.83	104.4	M36056.965411
Simpson Ranches Ltd.	NW 10-027-05 W5M	Disturbed Belt	01-Oct-81	26.21	86.0	4.27	14.0	M35379.088034
Snyder, Gordon	SE 06-029-01 W5M	Dalehurst	26-Oct-74	27.43	90.0	12.19	40.0	M35379.092479
Spensley, Ronald	NE 16-024-03 W5M	Dalehurst	12-Jul-71	32.00	105.0	15.24	50.0	M35379.089783
Sponheimer, Gene	NE 02-027-29 W4M	Dalehurst	01-Nov-73	22.86	75.0	9.14	30.0	M35377.207568
Stacey, R. W.	NW 15-026-29 W4M	Dalehurst	01-Jan-73	31.39	103.0	7.31	24.0	M35377.200031
Stewart, Grant	04-13-026-27 W4M	Lacombe	20-Apr-76	16.76	55.0	4.57	15.0	M35377.223295
Sticler, Jim	NW 13-026-27 W4M	Lacombe	29-Oct-81	35.66	117.0	11.89	39.0	M35377.223311

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION (continued)

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
Strandberg, Bert	SW 02-024-03 W5M	Dalehurst	02-Oct-98	42.67	140.0	8.32	27.3	M36727.992173
Stussi, Hans	SW 27-026-04 W5M	Dalehurst	05-Sep-79	22.86	75.0	18.9	62.0	M35379.088609
Style Properties Ltd.	SW 12-024-28 W4M	Lacombe	22-Mar-77	67.05	220.0	16	52.5	M35377.188245
Style Properties Ltd.	SE 12-024-28 W4M	Lacombe	30-Mar-77	60.96	200.0	15.85	52.0	M35377.205673
Sunderland, Wes	SE 11-025-28 W4M	Lacombe	27-Oct-86	28.65	94.0	13.72	45.0	M35377.205647
Sutherland, Glen	NW 04-024-28 W4M	Lacombe	01-May-72	86.25	283.0	35.05	115.0	M35377.205666
Swalander, J.	SE 17-028-05 W5M	Disturbed Belt	01-Aug-75	54.86	180.0	12.19	40.0	M35379.088408
Szabon, B.	15-11-025-27 W4M	Lacombe	29-Sep-81	30.48	100.0	3.9	12.8	M35377.193297
Tait, Bob	NW 19-025-02 W5M	Dalehurst	07-Oct-74	51.20	168.0	41.15	135.0	M35379.108068
Tanner, R.	NW 31-023-27 W4M	Lacombe	07-Oct-76	39.62	130.0	14.63	48.0	M35377.187501
Taschke, Herbert	01-10-028-05 W5M	Disturbed Belt	06-Jul-71	42.67	140.0	35.05	115.0	M35379.088256
Thomas, Gordon	SW 03-023-27 W4M	Lacombe	23-Oct-75	12.80	42.0	8.53	28.0	M35377.187158
Thomas, Gordon	SW 03-023-27 W4M	Lacombe	01-Apr-70	17.07	56.0	9.75	32.0	M35377.187159
Thompson, Mike	SW 28-028-04 W5M	Dalehurst	04-Oct-79	26.82	88.0	16.76	55.0	M35379.088472
Thorogood, Cliff	NE 02-024-04 W5M	Disturbed Belt	24-May-74	23.47	77.0	0.61	2.0	M35379.088882
Tremblay, Alexander	SE 34-027-02 W5M	Dalehurst	12-Sep-75	54.86	180.0	32	105.0	M35379.092241
Trosch, Ernie	01-10-028-05 W5M	Disturbed Belt	05-Nov-78	60.96	200.0	36.57	120.0	M35379.088259
Valgardson, Ray	SW 08-027-28 W4M	Dalehurst	20-Sep-73	24.38	80.0	10.67	35.0	M35377.207737
Vanderburgh, Leo	NE 33-025-28 W4M	Lacombe	16-Aug-74	28.95	95.0	9.14	30.0	M35377.205597
Verrall, Peter	SE 02-026-03 W5M	Dalehurst	17-Feb-72	77.72	255.0	60.96	200.0	M35379.115156
Wade, Jack	08-06-028-26 W4M	Lacombe	09-Jun-80	46.33	152.0	19.81	65.0	M35377.165203
Wagner, Ervin F.	06-10-027-26 W4M	Haynes	20-Jun-79	41.15	135.0	12.19	40.0	M35377.202244
Watson, J. A.	SW 32-024-28 W4M	Lacombe	16-Apr-79	46.63	153.0	14.02	46.0	M35377.188615
Wearmouth, Walter	SW 02-026-03 W5M	Dalehurst	01-Mar-81	45.72	150.0	39.62	130.0	M35379.115160
Weber, Sally	SE 10-027-02 W5M	Dalehurst	16-Sep-74	17.68	58.0	12.5	41.0	M35379.092049
Wegener, Ralph	SW 10-028-26 W4M	Lacombe	08-Jun-82	50.29	165.0	16.76	55.0	M35377.165213
Wesco Property DevelopmentLtd.	NW 27-024-03 W5M	Dalehurst	21-Jun-76	26.52	87.0	14.32	47.0	M35379.090479
Westenson, Ted	NE 23-026-04 W5M	Dalehurst	01-Jul-74	28.95	95.0	14.93	49.0	M35379.090211
Wheatley, F. R.	SW 03-024-27 W4M	Lacombe	28-Sep-79	40.54	133.0	2.44	8.0	M35377.187677
Wheeler, Arnold	SW 25-024-03 W5M	Dalehurst	14-May-80	32.92	108.0	18.29	60.0	M35379.090396
Wheeler, L.	NW 25-021-27 W4M	Lacombe	22-Jun-77	51.81	170.0	37.79	124.0	M35377.180360
Wiebe, Peter	SW 18-023-28 W4M	Lacombe	27-Jul-85	35.05	115.0	12.19	40.0	M35377.183815
Wiens, Henry	NE 18-028-05 W5M	Disturbed Belt	02-Jul-76	28.95	95.0	12.19	40.0	M35379.088558
Williams, Dan	SE 34-026-01 W5M	Dalehurst	03-May-74	15.24	50.0	12.19	40.0	M35379.091132
Willie, R.	NE 13-028-05 W5M	Dalehurst	15-Aug-75	25.30	83.0	11.58	38.0	M35379.088642
Wilson, Dave	12-22-024-03 W5M	Dalehurst	18-Apr-75	22.86	75.0	6.1	20.0	M35379.090261
Winkler, Everest E.	NW 34-021-27 W4M	Haynes	01-May-74	73.15	240.0	57.91	190.0	M35377.180371
Wise, Wayne	SW 13-024-28 W4M	Lacombe	30-May-77	19.81	65.0	6.1	20.0	M35377.188274
Wray, Doug	05-26-027-27 W4M	Lacombe	27-Mar-81	45.11	148.0	15.85	52.0	M35377.202866
Zillman, Jim	SW 35-027-02 W5M	Dalehurst	10-May-76	18.29	60.0	7.62	25.0	M35379.078027

M.D. of ROCKY VIEW-OPERATED WATER WELLS

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
M.D. of Rockyford #44	SW 13-026-27 W4M	31-Jul-74	Lacombe	13.72	45.0	4.57	15.0	M35377.223299
M.D. Rocky View No. 44	SW 12-025-03 W5M	26-Aug-86	Dalehurst	41.15	135.0	3.66	12.0	M35379.090592