Sturgeon County

Part of the North Saskatchewan River Basin
Parts of Tp 053 to 058, R 20 to 28, W4M & Tp 054 to 057, R 01, W5M
Regional Groundwater Assessment

Prepared for

Sturgeon
County

In conjunction with

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

Canada

Prepared by
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B. Maps and Figures on CD-ROM
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D. Maps and Figures Included as Large Plots
E. Water Wells Recommended for Field Verification

1. Project Overview

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

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

The regional groundwater assessment will:

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

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

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[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 Sturgeon County, (b) the processes used for the present project, and (c) the groundwater characteristics in the County.

Additional technical details are available from files on the CD-ROM to be provided with the final version of this report. The files include the geo-referenced electronic groundwater database, maps showing distribution of various hydrogeological parameters, the groundwater query, 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.

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.

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[3] See glossary

2. Introduction

2.1 Setting

Sturgeon County is situated in central Alberta. This area is part of both the Low Boreal Mixedwood and the Aspen Parkland regions. The County is within the North Saskatchewan River basin; the County's eastern boundary is the North Saskatchewan River. The other County boundaries follow township or section lines. The area includes parts of the area bounded by township 053, range 01, W5M in the southwest and township 058, range 20, W4M in the northeast.

Regionally, the topographic surface varies between 580 and 780 metres above mean sea level (AMSL). The lowest elevations occur in the northeastern part of the County along the North Saskatchewan River and Sturgeon River valleys and the highest are in the southwestern and northwestern parts of the County as shown on Figure 1 and page A-3.

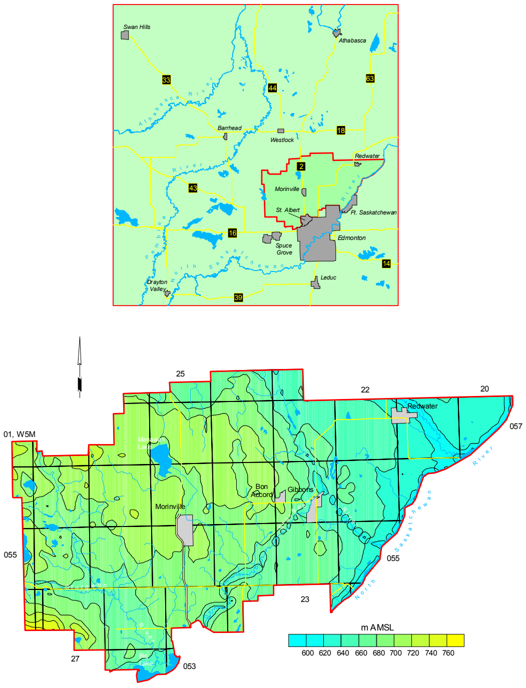

Figure 1. Index Map

2.2 Climate

Sturgeon County lies within the Dfb climate boundary. This classification is based on potential evapotranspiration[4] values determined using the Thornthwaite method (Thornthwaite and Mather, 1957), combined with the distribution of natural ecoregions in the area. The ecoregions map (Strong and Legatt, 1981) shows that the County 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 and severe winters. The mean monthly temperature drops below -3° C in the coolest month, and exceeds 10° C in the warmest month.

The mean annual precipitation averaged from five meteorological stations, two from within the County and three from outside the County borders, measured 471 millimetres (mm), based on data from 1961 to 1993. The mean annual temperature averaged 2.8° C, with the mean monthly temperature reaching a high of 16.5° C in July, and dropping to a low of –12.9° C in January. The calculated annual potential evapotranspiration is 504 millimetres.

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[4] See glossary

2.3 Background Information

2.3.1 Number, Type and Depth of Water Wells

There are currently records for 6,469 water wells in the groundwater database for the County. Of the 6,469 water wells, 5,798 are for domestic/stock purposes. The remaining 671 water wells were completed for a variety of uses, including industrial, municipal, observation, injection, irrigation, investigation and dewatering. Based on a rural population of 15,945 (Phinney, 2001), there are 1.4 domestic/stock water wells per family of four. It is unknown how many of these water wells may still be active. The domestic or stock water wells vary in depth from 1.2 to 198 metres below ground level. Details for lithology[5] are available for 3,335 water wells.

2.3.2 Number of Water Wells in Surficial and Bedrock Aquifers

There are 2,426 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 2,426 water wells for which aquifers could be defined, 549 are completed in surficial aquifers, with 75% having a completion depth of more than 20 metres below ground level. The adjacent map shows that the water wells completed in the surficial deposits occur throughout the County, but mainly in the vicinity of linear bedrock lows.

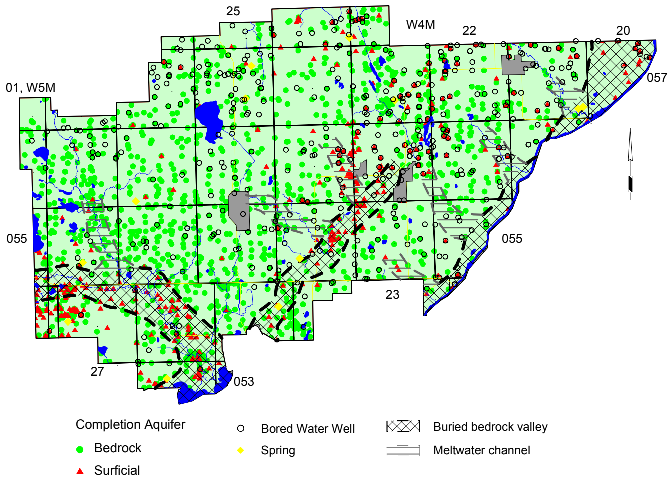

Figure 2. Location of Water Wells and Springs

The 1,877 water wells that have the top of their completion interval deeper than the top of the bedrock are referred to as bedrock water wells. From Figure 2, it can be seen that water wells completed in bedrock aquifers occur throughout the County.

There are currently records for 12 springs in the groundwater database for which there are only two available chemical analyses. The chemical values for springs indicate the groundwaters have total hardness concentrations of less than 200 milligrams per litre (mg/L) and total dissolved solids (TDS) concentrations ranging from 934 to 3,650 mg/L.

2.3.3 Casing Diameter and Type

Data for casing diameters are available for 2,936 water wells, with 2,449 (83%) indicated as having a diameter of less than 275 mm and 487 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. The locations of the 487 water wells with large-diameter casings are shown on Figure 2 as bored water wells. Bored water wells are generally completed in surficial deposits. Figure 2 shows that bored water wells occur throughout the County but mainly in groupings in the northern half of the County.

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[5] See glossary

Until the mid-1950s, the percentage of bored water wells nearly equaled the number of drilled water wells completed in the County. From 1960 to 1990, the percentage of bored water wells decreased to an average of 19%, and since the mid-1990s has decreased to only 2%.

In the County, 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 two percent of the water wells being drilled in the County in the late-1990s.

Galvanized steel surface casing was used in a maximum of 19% of the drilled water wells from the early 1960s to the early 1990s. Galvanized steel was last used in December 1992. Plastic casing was first used in December 1971. The percentage of water wells with plastic casing has increased and in the late-1990s, plastic casing was used in 97% of the drilled water wells in the County.

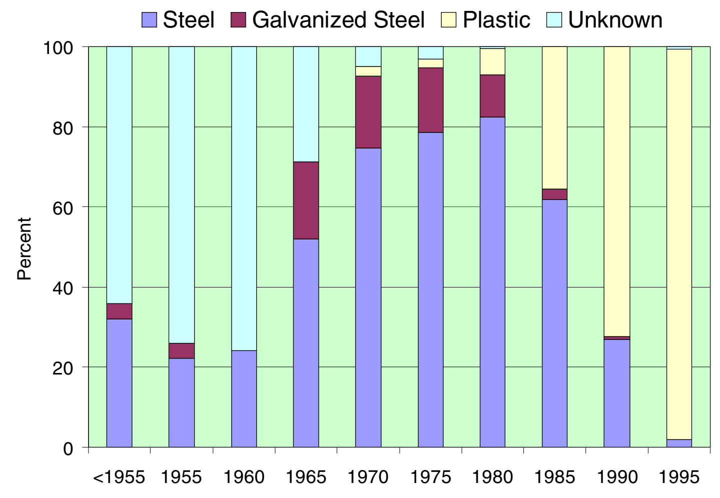

Figure 3. Surface Casing Types Used in Drilled Water Wells

2.3.4 Requirements for Licensing

Water wells used for household needs in excess of 1,250 cubic metres per year and all other groundwater use must be licensed. The only groundwater uses 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. At the end of 1999, 107 groundwater allocations were licensed in the County. Of the 107 licensed groundwater users, 71 could be linked to the Alberta Environment (AENV) groundwater database. Of the 107 licensed groundwater users, 66 are for agricultural purposes, and the remaining 41 are for commercial, municipal, recreation, fishery, irrigation or dewatering purposes. The total maximum authorized diversion from the water wells associated with these licences is 13,899 cubic metres per day (m³/day), although actual use could be less. Of the 13,899 m³/day, 10,578 m³/day (76%) is authorized for dewatering purposes from 12 dewatering wells as shown in Table 1 on the following page. Of the remaining 3,322 m³/day, 46% is allotted for commercial use, 28% is allotted for municipal use, 21% is allotted for agricultural use, and the remaining 5% is allotted for recreation, fishery and irrigation use. A figure showing the locations of the licensed users is in Appendix A (page A-5) and on the CD-ROM.

The largest single potable groundwater allocation within the County is for the Cardiff Golf and Country Club, having a diversion of 520 m³/day. This water supply well, used for commercial purposes, is completed in the Upper Sand and Gravel Aquifer.

The table below shows a breakdown of the 107 licensed groundwater allocations by the aquifer in which the water well is completed. The largest total licensed allocations are in the Lower Sand and Gravel Aquifer; the largest total licensed allocations not used for dewatering purposes are in the Upper Sand and Gravel Aquifer.

Aquifer **	Diversions	Agricultural	Commerical	Municipal	Recreation	Fishery	Irrigation	Dewatering	Total	Percentage
Upper Sand and Gravel	19	12	1,021	561	95	0	0	0	1,688	12
Lower Sand and Gravel	23	32	520	247	0	8	0	10,578	11,385	82
Lower Horseshoe Canyon	42	411	0	81	0	20	0	0	512	4
Bearpaw	10	88	0	0	0	0	20	0	108	1
Oldman	12	165	0	0	0	0	0	0	165	1
Unknown	1	0	0	41	0	0	0	0	41	0
Total	107	708	1,541	929	95	29	20	10,578	13,899	100
Percentage		5	11	7	1	0	0	76	100	

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

Table 1. Licensed Groundwater Diversions

Based on the 1996 Agriculture Census, the calculated water requirement for livestock for the County is in the order of 7,085 m³/day. Of the 7,085 m³/day average calculated livestock use, AENV has licensed a groundwater diversion of 708 m³/day (10%) and a surface-water diversion of 463 m³/day (6%). The remaining 84% of the calculated livestock use would have to be from unlicensed sources.

2.3.5 Groundwater Chemistry and Base of Groundwater Protection

Groundwaters from the surficial deposits can be expected to be chemically hard, with a high dissolved iron content. High nitrate + nitrite (as N) concentrations were evident in 13% of the available chemical data for the surficial aquifers and 2% of the available chemical data for the upper bedrock aquifer(s); a plot of nitrate + nitrite (as N) in surficial aquifers is on the accompanying CD-ROM. The TDS concentrations in the groundwaters from the upper bedrock in the County range from less than 500 to more than 2,000 mg/L (page A-29). 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. Ten percent of the chemical analyses indicate a fluoride concentration above 1.5 mg/L, with most of the exceedances occurring in the northeastern part of the County (see CD-ROM).

The minimum, maximum and average concentrations of TDS, sodium, sulfate, chloride and fluoride in the groundwaters from water wells completed in the upper bedrock in the County have been compared to the Guidelines for Canadian Drinking Water Quality (GCDWQ) in Table 2. Of the five constituents compared to the GCDWQ, average values of TDS and sodium concentrations exceed the guidelines; maximum values of all five constituents exceed the guidelines. Of the 2,271 TDS values from water wells completed in the upper bedrock, 32 have TDS concentrations exceeding 4,000 mg/L.

Constituent	Range for County in mg/L Minimum	Maximum	Average	Recommended Maximum Concentration GCDWQ
Total Dissolved Solids	35	13,965	1424	500
Sodium	0	3,676	366	200
Sulfate	0	9,500	318	500
Chloride	0	4,400	186	250
Fluoride	0	13	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)

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

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

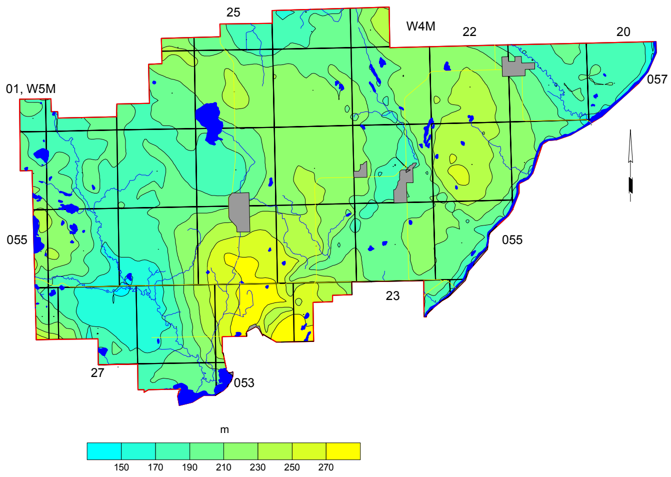

Figure 4. Depth to Base of Groundwater Protection (modified after EUB, 1995)

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[6] method to prepare a depth to the Base of Groundwater Protection surface. This depth, for the most part, would be the maximum drilling depth for a water well for agricultural purposes or for a potable water supply. If a water well has total dissolved solids exceeding 4,000 mg/L, the groundwater use does not require licensing by AENV. In the County, the depth to Base of Groundwater Protection ranges from less than 150 metres to more than 270 metres below ground level, as shown on Figure 4 and on each cross-section.

Of the 6,805 water wells with completed depth data, sixteen are completed below the Base of Groundwater Protection. These sixteen water wells are completed deeper than 1,100 metres below ground level and are used for industrial purposes.

Proper management of the groundwater resource requires water-level data. These data are often collected from observation water wells. At the present time, there are no AENV-operated observation water wells within the County. Additional data can be obtained from some of the licensed groundwater diversions. In the past, the data for licensed diversions have been difficult to obtain from AENV, in part because of the failure of the licensee to provide the data.

However, even with the available sources of data, the number of water-level data points relative to the size of the County is too few to provide a reliable groundwater budget (see section 6.0 of this report). The most cost-efficient method to collect additional groundwater monitoring data would be to have the water well owners measuring the water level in their own water well on a regular basis.

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[6] See glossary

3. Terms

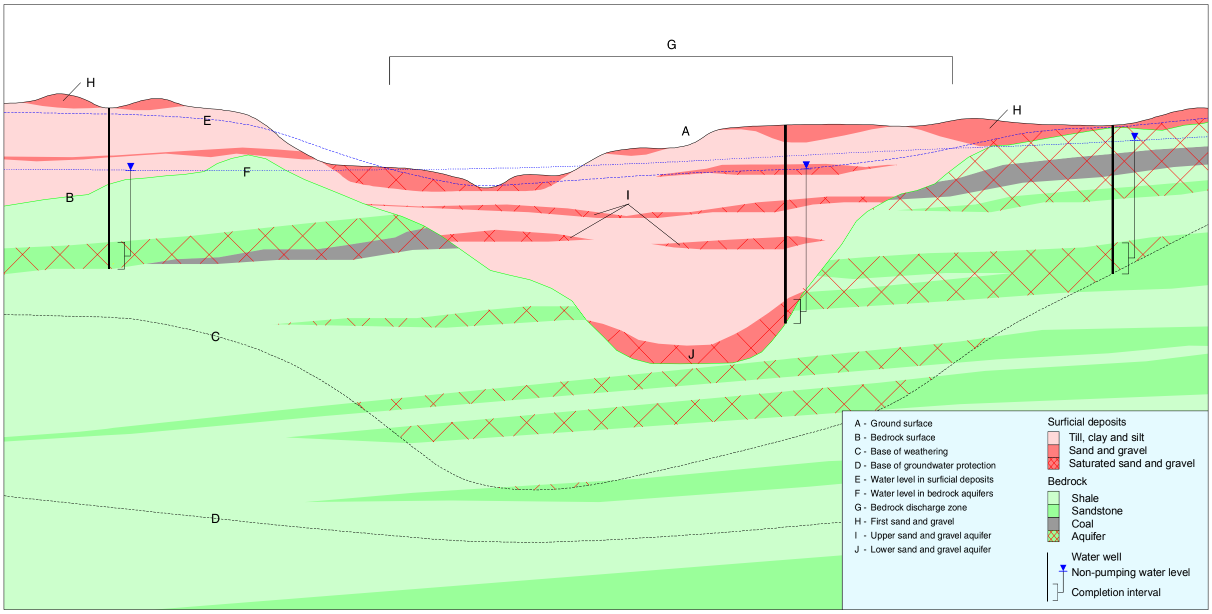
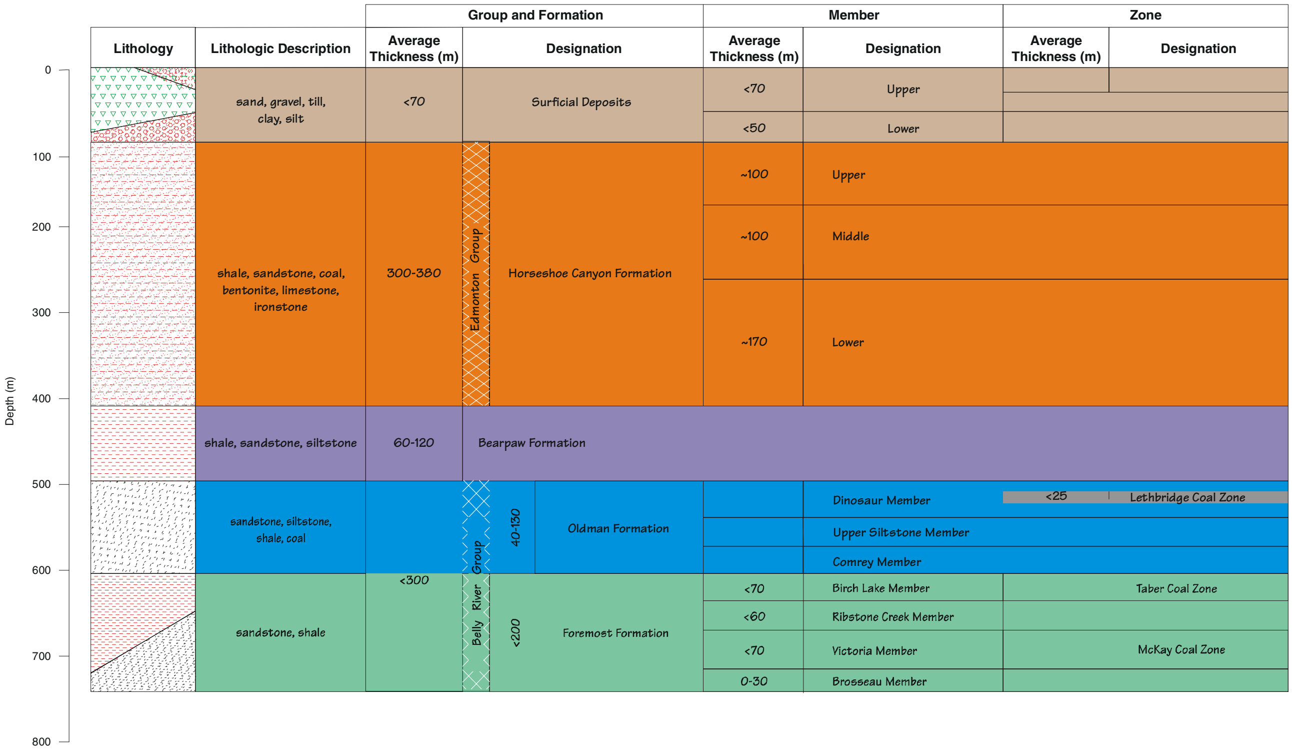


Figure 5. Generalized Cross-Section (for terminology only)



Lithology	Lithologic Description	Group and Formation				Member		Zone	
		Average Thickness (m)			Designation	Average Thickness (m)	Designation	Average Thickness (m)	Designation
	sand, gravel, till, clay, silt	<70			Surficial Deposits	<70	Upper		
						<50	Lower		
	shale, sandstone, coal, bentonite, limestone, ironstone	300-380	Edmonton Group		Horseshoe Canyon Formation	~100	Upper		
						~100	Middle		
						~170	Lower		
	shale, sandstone, siltstone	60-120			Bearpaw Formation				
	sandstone, siltstone, shale, coal	<300	Belly River Group	40-130	Oldman Formation		Dinosaur Member	<25	Lethbridge Coal Zone
							Upper Siltstone Member		
							Comrey Member		
	sandstone, shale			<200	Foremost Formation	<70	Birch Lake Member		Taber Coal Zone
						<60	Ribstone Creek Member		
						<70	Victoria Member		McKay Coal Zone
						0-30	Brosseau Member		

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) water well locations determined during water well surveys
6) chemical analyses for some groundwaters
7) location of some flowing shot holes
8) location of 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 County 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. This means that a record for the NW ¼ of section 32, township 054, range 27, W4M, would have a horizontal coordinate with an Easting of 69,141 metres and a Northing of 5,949,398 metres, the centre of the quarter section. If the water well has been repositioned by PFRA using orthorectified aerial photos, the location will be more accurate, possibly within several tens of metres of the actual location. Once the horizontal coordinates are determined for a record, a ground elevation for that record is obtained from the 1:20,000 Digital Elevation Model (DEM); AltaLis Ltd. provides the DEM.

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

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

Where possible, determinations are made from individual records for the following:

1) depth to bedrock
2) total thickness of sand and gravel
3) total thickness of saturated sand and gravel
4) depth to the top and bottom of completion intervals.

Also, where sufficient information is available, values for apparent transmissivity[7] and apparent yield[8] 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 the majority of the County was published in 1974 (Bibby, 1974), 1,610 values for apparent transmissivity and 1,423 values for apparent yield have been added to the groundwater database. With the addition of the apparent yield values, a hydrogeological map has been prepared to help illustrate the general groundwater availability across the County. The anticipated groundwater apparent yield is based on the expected yield of a single water well obtaining water from the total accessible stratigraphic section.

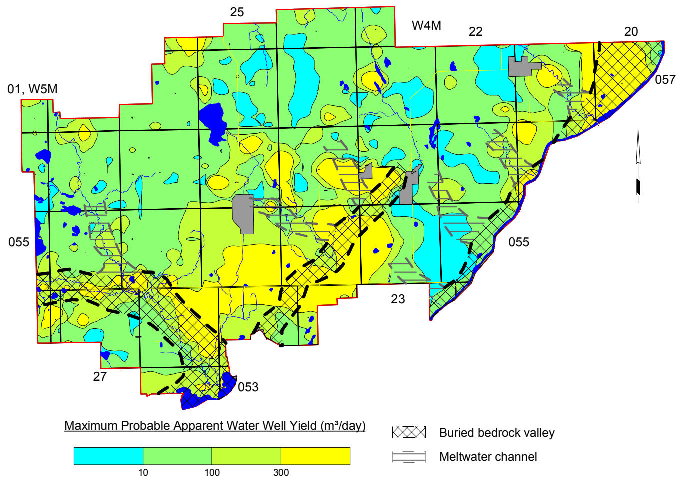


Figure 7. Hydrogeological Map

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.

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[7] For definitions of Transmissivity, see glossary
[8] 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 if neither aquifer nor effective transmissivity values are available. The total dissolved solids, sulfate and chloride concentrations from the chemical analysis of the groundwater are also assigned to applicable aquifers. In addition, chemical parameters of nitrate + nitrite (as N) are assigned to surficial aquifers and fluoride is assigned to upper bedrock aquifer(s). Since 1986, Alberta Health and Wellness has restricted access to chemical analysis data, and hence the database includes only limited amounts of chemical data since 1986.

Once the values for the various parameters of the individual aquifers are established, the spatial distribution of these parameters must be determined. The distribution of individual parameters involves the same process as the distribution of geological surfaces. This means establishing a representative data set and then preparing a grid. Even when only limited data are available, grids are prepared. However, the grids prepared from the limited data must be used with extreme caution because the gridding process can be unreliable.

4.3.1 Risk Criteria

The main source of groundwater contamination involves activities on or near the land surface. The risk of groundwater contamination is high when the near-surface materials are porous and permeable, and low when the materials are less porous and less permeable. The sources of data for the risk analysis include (a) a determination of when sand and gravel is or is not present within one metre of the ground surface, and (b) the surficial geology and/or the soil map. The presence or absence of sand and gravel within one metre of the land surface is based on a geological surface prepared from the data supplied on the water well drilling reports. The information available on the surficial geology and/or the soil map is categorized based on relative permeability. The information from these sources is combined to form the risk assessment map. The criteria used in the classification of risk are given in the above table.

Surface Permeability	Sand or Gravel Present - Top Within One Metre Of Ground Surface	Groundwater Contamination Risk
Low	No	Low
Moderate	No	Moderate
High	No	High
Low	Yes	High
Moderate	Yes	High
High	Yes	Very High

Table 3. Risk of Groundwater Contamination Criteria

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 no data are available from the groundwater database, prepared maps have been masked with a solid brown color to indicate these areas. These brown masks have been added to the Bearpaw, Oldman and Birch Lake 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. Four cross-sections are presented in this report and as poster-size drawings forwarded with this report. The cross-sections are also included in Appendix A, and are included on the CD-ROM; page-size maps of the poster-size cross-sections are included in Appendix D of this report.

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 Professional Office 2000
- Surfer 7.0

5. Aquifers

5.1 Background

An aquifer is a permeable rock that is saturated. If the non-pumping water level is above the top of the rock unit, this type of aquifer is an artesian aquifer. If the rock unit is not entirely saturated and the water level is below the top of the unit, this type of aquifer is a water-table aquifer. These types of aquifers occur in one of two general geological settings in the County. The first geological setting includes the sediments that overlie the bedrock surface. In this report, these 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 County are mainly less than 30 metres thick, except in areas of linear bedrock lows where the thickness of the surficial deposits can exceed 50 metres. The Buried Beverly Valley, the Buried Sturgeon Valley and the Buried Onoway Valley are the main linear bedrock lows in the County. The west-east cross-section A-A', Figure 8 shown below, passes across all three of the main buried valleys and shows the surficial deposits being mainly less than 50 metres thick within the buried valleys.

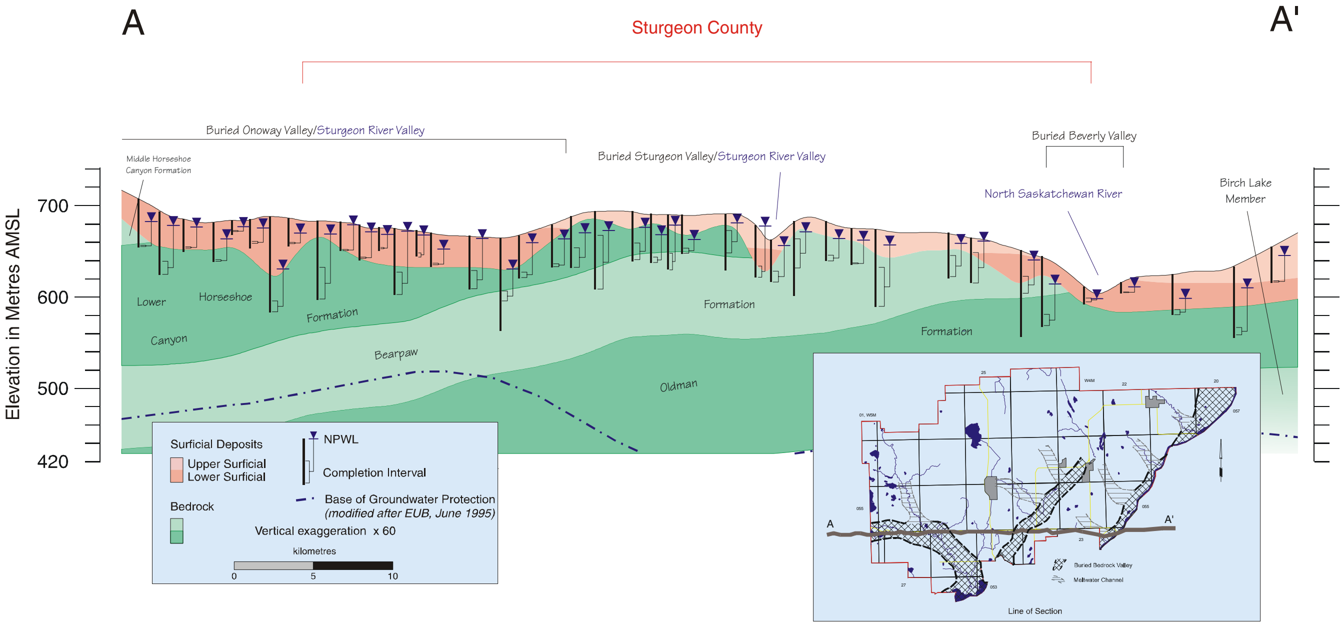

Figure 8. Cross-Section A - A'

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 County, casing-diameter information is available for 485 of the 549 water wells completed in the surficial deposits; 15 percent of these have a casing diameter of more than 275 millimetres, and are assumed to be bored or dug water wells.

5.1.2 Bedrock Aquifers

In the County, the upper bedrock includes the Horseshoe Canyon, Bearpaw and Oldman formations, and the Birch Lake Member equivalent of the Foremost Formation. Cross-section B-B’ (Figure 9) shows the aquifers in which water wells are completed are 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[9] and water well screens are a necessity. The groundwater from the bedrock aquifers is usually chemically soft.

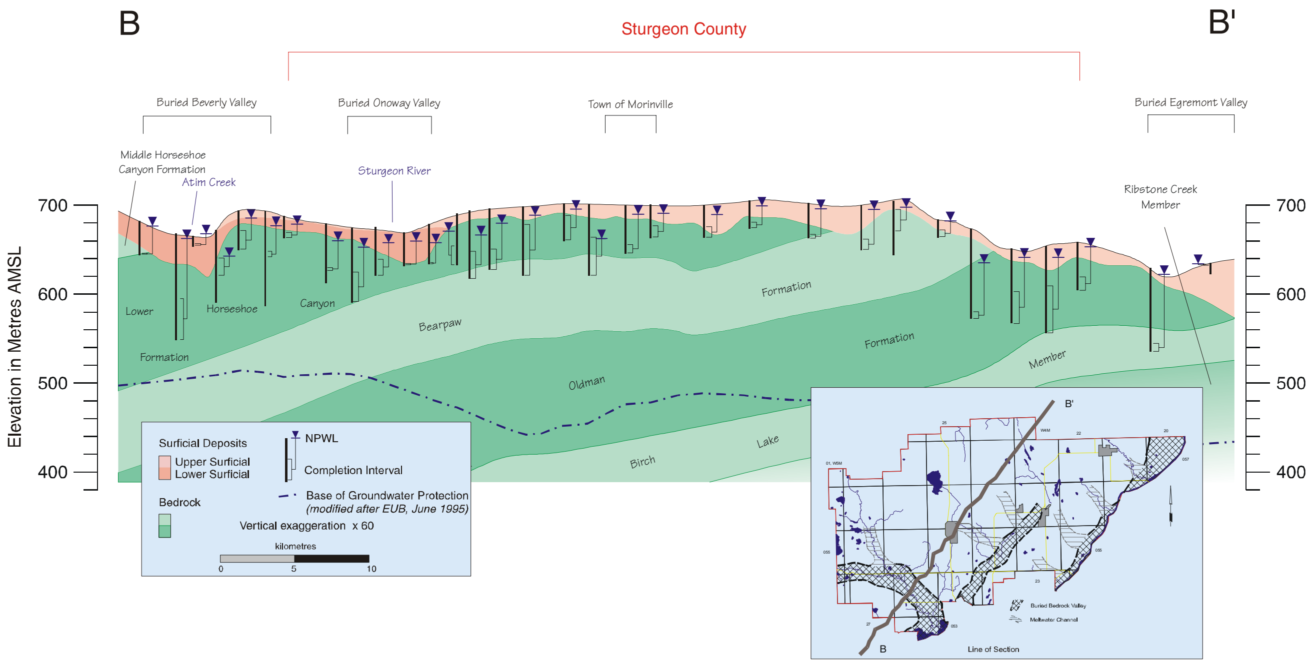

Figure 9. Cross-Section B - B'

The data for 1,877 water wells show that the top of the water well completion interval is below the bedrock surface, indicating that the water wells are completed in at least one bedrock aquifer. Within the County, casing-diameter information is available for 1,575 of the 1,877 water wells completed below the top of bedrock. Of these 1,575 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 109 bedrock water wells completed with a water well screen.

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[9] 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[10] and lacustrine[11] deposits. The lacustrine deposits include clay, silt and fine-grained sand. The *upper surficial deposits* include the more traditional glacial deposits of till[12] and meltwater deposits. In the County, pre-glacial materials are expected to be mainly present in association with the Buried Beverly Valley, the Buried Sturgeon Valley and the Buried Onoway Valley.

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.

Over the majority of the County, the surficial deposits are less than 30 metres thick (page A-16). The exceptions are mainly in association with areas where buried bedrock valleys are present, where the deposits can have a maximum thickness of close to 50 metres. The main linear bedrock lows in the County are southwest-northeast-trending or west-east-trending bedrock lows that have been designated as the Buried Beverly, Sturgeon and Onoway valleys, as shown on Figure 10.

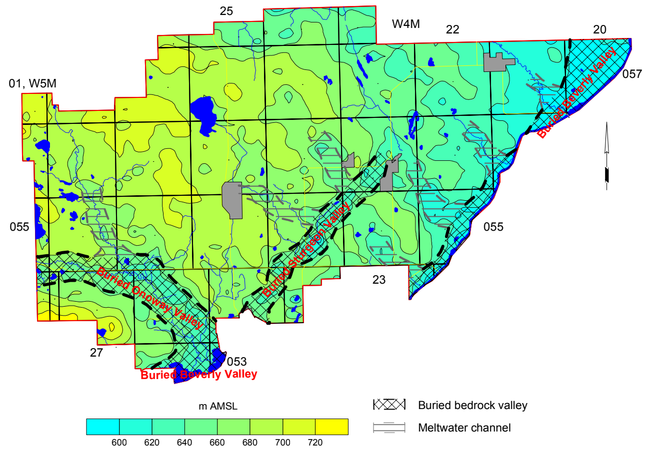

Figure 10. Bedrock Topography

The Buried Beverly Valley is present in the eastern and extreme southern parts of the County, and mainly parallels the present-day North Saskatchewan River. The Valley is two to eight kilometres wide within the County, with local bedrock relief being up to 60 metres. Sand and gravel deposits can be expected in association with this bedrock low, but the thickness of the sand and gravel deposits is expected to be mainly less than ten metres.

The Buried Sturgeon Valley is present in the south-central part of the County, and mainly parallels the stretch of present-day Sturgeon River between St. Albert and Gibbons. The Valley is mainly less than three kilometres wide within the County, with local bedrock relief being up to 60 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 25 metres.

The Buried Onoway Valley is present in the southwestern part of the County, and mainly parallels the stretch of present-day Sturgeon River northwest from St. Albert to Calahoo and the County border. The Valley is two to

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[10] See glossary
[11] See glossary
[12] See glossary

eight kilometres wide within the County, with local bedrock relief being up to 60 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 25 metres.

The Buried Egremont Valley, present immediately north of the County, is a tributary valley to the Buried Beverly Valley. The Buried Egremont Valley, a southwest-northeast-trending linear bedrock low in Thorhild County, joins the Buried Beverly Valley in township 057, range 20, W4M. The thickness of the sand and gravel deposits associated with the Buried Egremont Valley can be expected to be mainly less than 25 metres

The lower surficial deposits are composed mostly of fluvial and lacustrine deposits. Lower surficial deposits occur mainly in the Buried Beverly, Sturgeon and Onoway valleys. The total thickness of the lower surficial deposits is mainly less than 30 metres, but can be more than 30 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 County, there are a number of linear bedrock lows that trend mainly northwest to southeast and are indicated as being of meltwater origin. 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. The thickness of the upper surficial deposits is mainly less than 30 metres, but can be more than 30 metres in the meltwater channel associated with the Buried Sturgeon Valley and in the Buried Beverly Valley. Upper Surficial deposits are mainly absent from the Buried Onoway Valley (see CD-ROM).

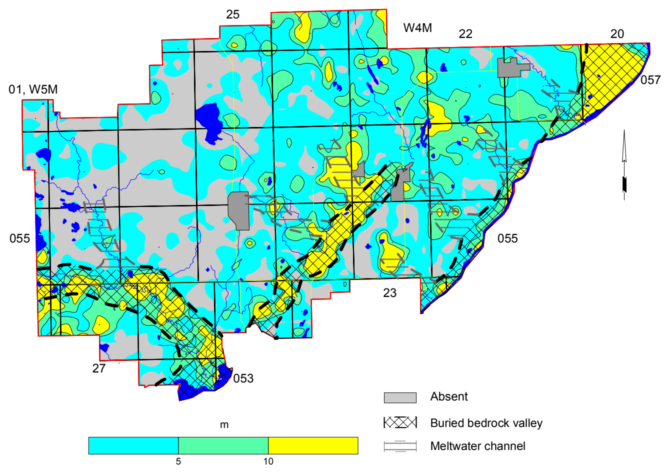

Figure 11. Thickness of Sand and Gravel Deposits

Sand and gravel deposits can occur throughout the surficial deposits. The total thickness of sand and gravel deposits is generally less than ten metres but can be more than 25 metres in association with the buried bedrock valleys.

The combined thickness of all sand and gravel deposits has been determined as a function of the total thickness of the surficial deposits (Figure 11). Over approximately 50% of the County 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-18). The areas where sand and gravel deposits constitute more than 30% of the total thickness of the surficial deposits is mainly in the areas associated with the buried bedrock valleys and meltwater channels and in the northeastern part of the County.

5.2.2 Sand and Gravel Aquifer(s)

One source of groundwater in the County includes aquifers in the surficial deposits. Since the sand and gravel aquifer(s) are not everywhere, the actual aquifer that is developed at a given location is usually dictated by the aquifer that is present. In the County, the thickness of the sand and gravel aquifer(s) is generally less than five metres, but can be more than ten metres in the vicinity of the buried bedrock lows (page A-20).

From the present hydrogeological analysis, 1,516 water wells are completed in aquifers in the surficial deposits. Of the 1,516 water wells, 1,097 are completed in aquifers in the upper surficial deposits and 419 are completed in aquifers in the lower surficial deposits. This number of water wells is nearly two times the number (549) 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.

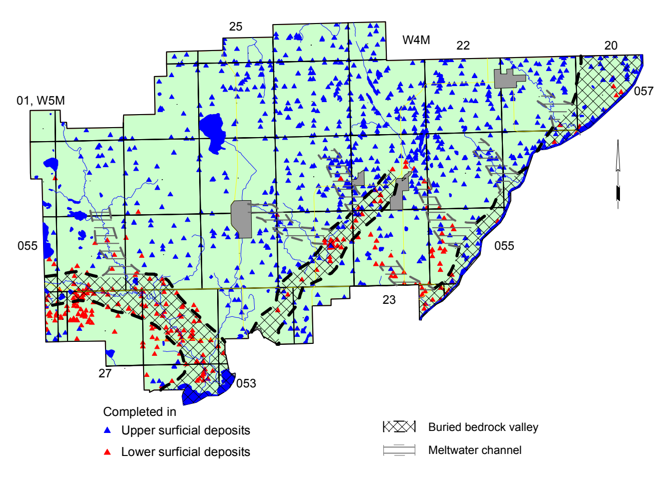

Figure 12. Water Wells Completed in Surficial Deposits

Water wells completed in the upper surficial deposits occur throughout the County. In the area underlain by the Buried Sturgeon and Onoway valleys, there are a large number of water wells completed in the lower surficial deposits (Figure 12).

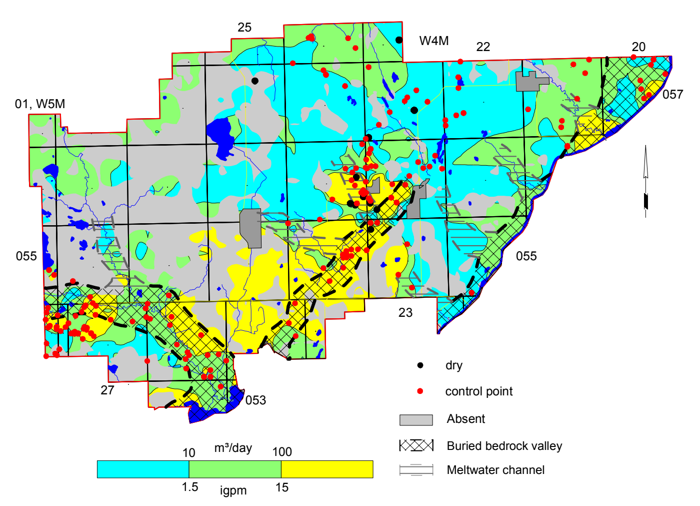

Figure 13. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

The map to the left shows expected yields for water wells completed in sand and gravel aquifers(s). Over approximately 30% of the County, the sand and gravel deposits are not present, or if present, are not saturated.

Based on the aquifers that have been developed by existing water wells, these data show that water wells with yields of more than 100 m³/day from sand and gravel aquifer(s) can be expected in several areas of the County. The most notable areas where yields of more than 100 m³/day are expected are in association with the Buried Sturgeon and Onoway valleys. In addition to the 219 records for surficial water wells with apparent yield data, there are 22 records 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 22 dry holes prior to gridding. Also included in these postings is any record that includes comments that state the water well goes dry in dry years.

5.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

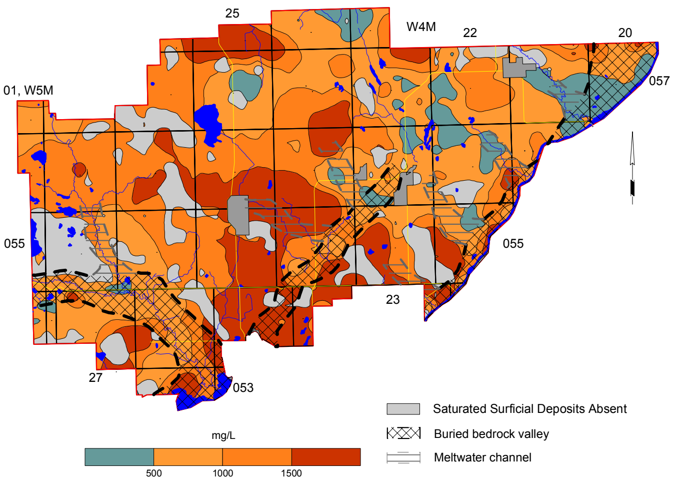

Figure 14. Total Dissolved Solids in Groundwater from Surficial Deposits

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

The Piper tri-linear diagrams[13] (page A-27) show the groundwaters from the surficial deposits are mainly calcium-magnesium-bicarbonate or calcium-magnesium-sulfate type waters. The records with the sodium-bicarbonate waters were individually checked in the database to confirm the completion aquifer. Seventy percent of the groundwaters from the surficial deposits have a TDS concentration of more than 500 mg/L. The water wells completed in aquifers associated with the buried bedrock valleys can expect to have groundwaters with TDS concentrations of mainly less than 1,000 mg/L as shown on Figure 14, possibly as a result of active, local flow systems. 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 93% of the samples analyzed in the County, the chloride ion concentration is less than 100 mg/L (see CD-ROM).

	Range for County in mg/L			Recommended Maximum Concentration
Constituent	Minimum	Maximum	Average	GCDWQ
Total Dissolved Solids	39	7827	996	500
Sodium	<9	2067	123	200
Sulfate	0	5500	300	500
Chloride	0	1687	36	250
Nitrate + Nitrite (as N)	0	650	7.0	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)
GCDWQ - Guidelines for Canadian Drinking Water Quality, Sixth Edition
Minister of Supply and Services Canada, 1996

Table 4. Concentrations of Constituents in Groundwaters from Surficial Aquifers

In the County, the nitrate + nitrite (as N) concentrations in the groundwaters from the surficial deposits exceed the maximum acceptable concentrations (MAC) of ten mg/L in 10% of the samples. Groundwaters with a nitrate + nitrite (as N) concentration exceeding the IMAC (10 mg/L) have been posted on the nitrate + nitrite (as N) map (see CD-ROM). The map shows the exceedances are mainly in the northeastern half of the County.

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

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[13] 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 but are expected over approximately 50% of the County.

5.2.3.1 Aquifer Thickness

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

5.2.3.2 Apparent Yield

The permeability of the Upper Sand and Gravel Aquifer can be high. The high permeability combined with significant thickness leads to an extrapolation of high yields for water wells; however, because the sand and gravel deposits occur mainly as hydraulically discontinuous pockets, the apparent yields of the water wells are limited. The apparent yields for water wells completed through this Aquifer are expected to be mainly less than 100 m³/day, except adjacent to the meltwater channel near Bon Accord, as shown on Figure 15. The yields present in the western part of the County could be a result of the gridding procedure used to process a limited number of data points. In addition to the 83 records for Upper Sand and Gravel Aquifer water wells with apparent yield data, there are 18 records that indicate dry or abandoned surficial water wells with "insufficient water". In order to depict a more accurate yield map, an apparent yield of 0.1 m³/day was assigned to the dry holes prior to gridding.

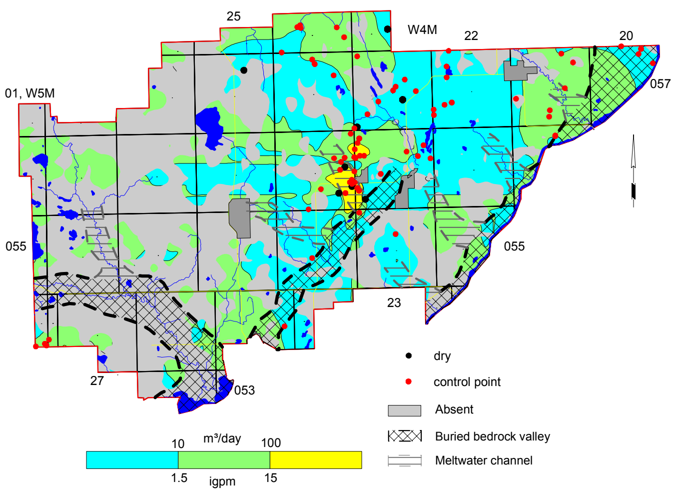

Figure 15. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

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 yields and quality of groundwater from the bedrock aquifer(s) are suitable.

In the County, there are 19 licensed water wells that are completed through the Upper Sand and Gravel Aquifer, with a total authorized diversion of 1,688 m^3/day. The highest allocation of 520 m^3/day is for a water well for the Cardiff Golf and Country Club in SW 24-055-25 W4M used for commercial purposes. The second highest allocation of 415 m³/day is for a Town of Bon Accord water well in 01-13-056-24 W4M for municipal purposes.

Ten of the 19 licensed water wells completed through the Upper Sand and Gravel Aquifer could be linked to a water well in the AENV groundwater database.

5.2.4 Lower Sand and Gravel Aquifer

The Lower Sand and Gravel Aquifer is a saturated sand and gravel deposit that occurs at or near the base of the surficial deposits in the deeper part of the linear bedrock lows. The top of the lower surficial deposits is based on more than 1,000 control points across Alberta. In the County, there are thirteen control points provided by Allong (1967), Edwards (1984) and Fox (1984).

5.2.4.1 Aquifer Thickness

The thickness of the Lower Sand and Gravel Aquifer is mainly less than ten 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 m^3/day to more than 100 m^3/day. Yields of more than 100 m^3/day are consistently expected in the Lower Sand and Gravel Aquifer associated with the Buried Sturgeon Valley. In addition to the 136 water well records for Lower Sand and Gravel Aquifer water wells with apparent yield data, there are four records that indicate dry, or abandoned with "insufficient water". In order to depict a more accurate yield map, an apparent yield of 0.1 m^3/day was assigned to the four dry holes prior to gridding.

In the County, there are 23 licensed water wells that are completed through the Lower Sand and Gravel Aquifer, for a total authorized diversion of 11,385 m^3/day, of which 93% is used for dewatering purposes by the gravel industry.

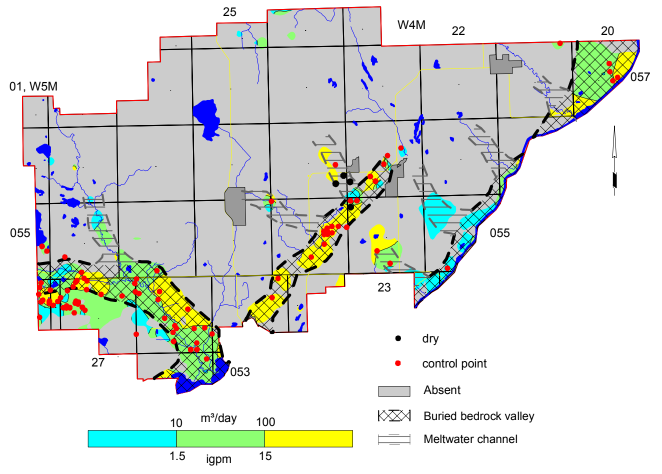

Figure 16. Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer

Only six of the 23 licensed water wells completed through the Lower Sand and Gravel Aquifer could be linked to a water well in the AENV groundwater database.

A water test hole/observation water well and a production water well were completed within the Lower Sand and Gravel Aquifer associated with the Buried Sturgeon Valley in 09-08-056-23 W4M near Gibbons as part of a detailed study conducted for Alberta Environment (Geoscience Consulting Ltd., March 26, 1975). As a result, it was determined that the "aquifer appeared to be capable of yielding several hundred gallons per minute to a single well." These high yields of 2,290 m^3/day (350 igpm) were based on a transmissivity value of 300 m^2/day and corresponding storativity of 6.5×10^{-4}. The aquifer parameters are based on an aquifer test consisting of 48 hours of pumping 336 litres per minute (74 igpm) and 48 hours of recovery.

The groundwater from the production water well in 09-08-056-23 W4M had a TDS concentration of 724 mg/L, a sulfate concentration of 149 mg/L, a chloride concentration of 5 mg/L, and a total hardness of 462 mg/L.

5.3 Bedrock

5.3.1 Geological Characteristics

The upper bedrock in the County includes part of the Edmonton Group, the Bearpaw Formation and the Belly River Group. The Edmonton Group in the County includes only the Horseshoe Canyon Formation. The Belly River Group subcrop in the County includes the Oldman Formation and the Birch Lake Member of the Foremost Formation. The adjacent bedrock geology map, showing the subcrop of different geological units, has been prepared in part from the interpretation of geophysical logs related to oil and gas activity. A generalized geologic column is illustrated in Figure 6, in Appendix A and on the CD-ROM.

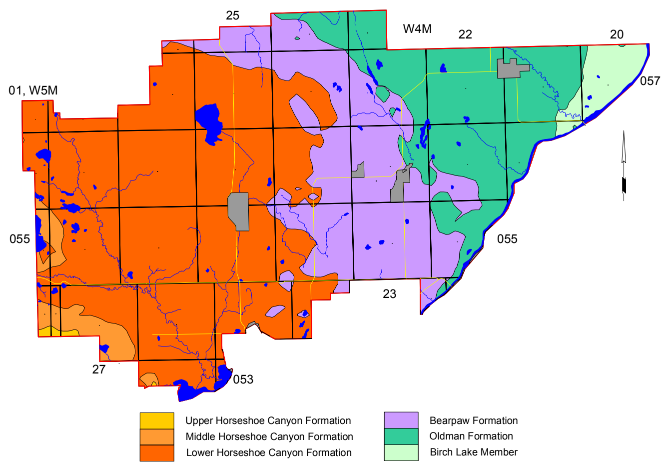

Figure 17. Bedrock Geology

The Horseshoe Canyon Formation is the lower part of the Edmonton Group. The Horseshoe Canyon Formation has a maximum thickness of 350 metres and has three separate units: Upper, Middle and Lower. The Upper Horseshoe Canyon, which can be up to 100 metres thick, is the upper bedrock in the extreme southwestern part of the County. The Middle Horseshoe Canyon, which is up to 70 metres thick, is the upper bedrock also in the extreme southwestern part of the County. The Lower Horseshoe Canyon, which can be up to 170 metres thick, is less than 140 metres thick within the County and is the upper bedrock in the western half of the County.

The Horseshoe Canyon Formation consists of deltaic[14] and fluvial sandstone, siltstone and shale with interbedded coal seams, bentonite and thin nodular beds of limestone and ironstone. Because of the low-energy environment in which deposition occurred, the sandstone, when present, tends to be finer grained. The lower 60 to 70 metres and the upper 30 to 50 metres of the Horseshoe Canyon Formation can include coarser grained sandstone deposits. In the County, the main aquifers in the Horseshoe Canyon Formation are fractured coal seams. If the coal layers are not fractured, the main aquifers are clayey and/or bentonitic sandstones.

The Bearpaw Formation underlies the Horseshoe Canyon Formation, is in the order of 80 to 100 metres thick and is the upper bedrock in the north-central part of the County. The Bearpaw Formation includes transgressive, shallow marine (shoreface) and open marine facies[15] deposits. In Sturgeon County, the Bearpaw Formation is composed mainly of shale and coal.

The Belly River Group includes the Oldman Formation and the Birch Lake, Ribstone Creek, Victoria and Brosseau members of the Foremost Formation. The Foremost Formation includes the continental facies within the County. The Belly River Group in the County has a maximum thickness of 200 metres. In the County, only the Oldman Formation and the Birch Lake Member are present as the upper bedrock.

The Oldman Formation is present as the upper bedrock in most of the northern part of the County and is mainly less than 130 metres thick. The Oldman Formation is composed of continental deposits, sandstone, siltstone, shale and coal. The Oldman Formation is the upper part of the Belly River Group.

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[14] See glossary
[15] See glossary

The *continental* Foremost Formation has been eroded in most of the County and subcrops in the extreme northern part of the County. The *continental* Foremost Formation is less than 160 metres thick and is between the overlying Oldman Formation and the underlying Lea Park Formation. In the *continental* Foremost Formation, individual members have been identified. The members include both sandstone and shale units. Coal zones occur within the *continental* Foremost Formation, with the main ones referred to as the McKay and the Taber Coal zones. There are also minor amounts of ironstone, a chemical deposit. For the present project, the individual members are identified by the designation given to the sandstone members associated with the marine facies, with the underlying shale member being considered as the shale facies of the member. For example, in this report the Birch Lake Member includes the Birch Lake Member (a sandstone deposit, or its equivalent) and the underlying shale deposit. The Taber Coal Zone is associated with the Birch Lake Member. Eastward, the sandstone layers of individual members grade into marine deposits.

The present breakdown of the Foremost Formation would not be possible without identifying a continuous top for the Lea Park Formation. The top of the Lea Park Formation represents a geologic time border between the marine environment of the Lea Park Formation and the mostly continental environment of the Foremost Formation.

The top of the Lea Park Formation is the bottom of the higher resistivity layer that occurs within a few metres below a regionally identifiable bentonite marker, as shown in the adjacent e-log. This marker occurs approximately 100 metres above the Milk River Shoulder.

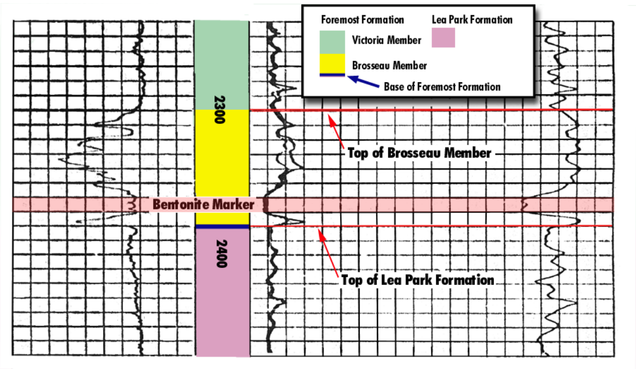

Figure 18. E-Log showing Base of Foremost Formation

There will be no direct review of either the Upper Horseshoe Canyon Formation or the Ribstone Creek Member in the text of this report. Because of the limited amount of hydrogeological information in the County, a complete detailed map set has not been prepared; the only maps associated with the Upper Horseshoe Canyon Formation or the Ribstone Creek Member to be included on the CD-ROM will be structure-contour maps.

In the western part of the County, the Base of Groundwater Protection is below the Bearpaw Formation, in the central part of the County, the Base of Groundwater Protection is below the Oldman Formation, and in the eastern part of the County, the Base of Groundwater Protection is below the Ribstone Creek Member. A map showing the depth to the Base of Groundwater Protection is given on page 7 of this report, in Appendix A, and on the CD-ROM.

5.3.2 Aquifers

Of the 6,469 water wells in the database, 1,877 were defined as being completed below the top of bedrock and 549 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 4,043 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 upper bedrock aquifer of completion for 4,341 water wells. The remaining 411 of the total 4,685 bedrock water wells are identified as being completed in more than one bedrock aquifer.

Geologic Unit	No. of Bedrock Water Wells
Upper Horseshoe Canyon	2
Middle Horseshoe Canyon	65
Lower Horseshoe Canyon	2,152
Bearpaw	936
Oldman	1,129
Birch Lake	50
Ribstone Creek	7
Saline	1
Multiple Completions	410
Total	4,685

Table 5. Completion Aquifer

The bedrock water wells are mainly completed in the Lower Horseshoe Canyon, Bearpaw and Oldman aquifers, as shown in the above table.

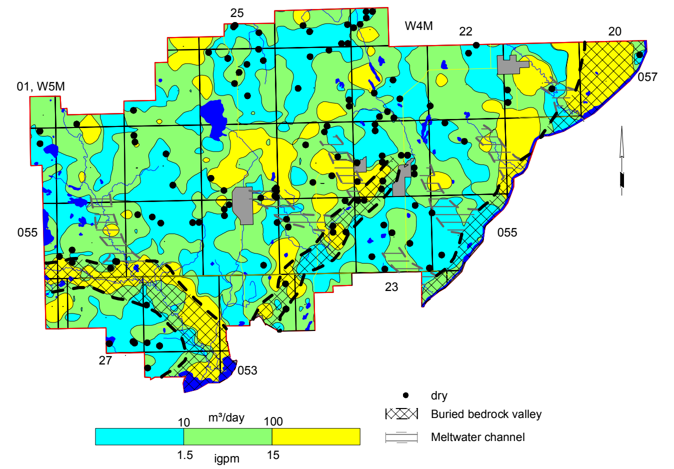

Figure 19. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

There are 1,559 records for bedrock water wells that have apparent yield values, which is 33% of the 4,685 bedrock water wells. In the County, yields for water wells completed in the upper bedrock aquifer(s) are mainly between 10 and 100 m³/day. Many of the areas with yields of more than 100 m³/day are in association with buried bedrock valleys, as shown on the adjacent figure. These higher yield areas may identify areas of increased permeability resulting from the weathering process. In addition to the 1,559 records for bedrock water wells, there are 139 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 139 dry holes prior to gridding. A similar value has been assigned to all dry holes completed in upper bedrock aquifer(s).

Of the 1,559 water well records with apparent yield values, 1,450 have been assigned to aquifers associated with specific geologic units. Forty-seven percent (728) of the 1,559 water wells completed in the bedrock aquifers have apparent yields that are less than 10 m³/day, 41% (634) have apparent yield values that range from 10 to 100 m³/day, and 12% (197) have apparent yields that are greater than 100 m³/day, as shown in the adjacent table.

Aquifer	No. of Water Wells with Values for Apparent Yield	Number of Water Wells with Apparent Yields <10 m³/day	10 to 100 m³/day	>100 m³/day
Upper Horseshoe Canyon	1	0	1	0
Middle Horseshoe Canyo	40	8	25	7
Lower Horseshoe Canyon	829	386	331	112
Bearpaw	259	101	115	43
Oldman	305	142	137	26
Birch Lake	16	7	6	3
Multiple Completions	109	84	19	6
Totals	1,559	728	634	197

Table 6. Apparent Yields of Bedrock Aquifers

5.3.3 Chemical Quality of Groundwater

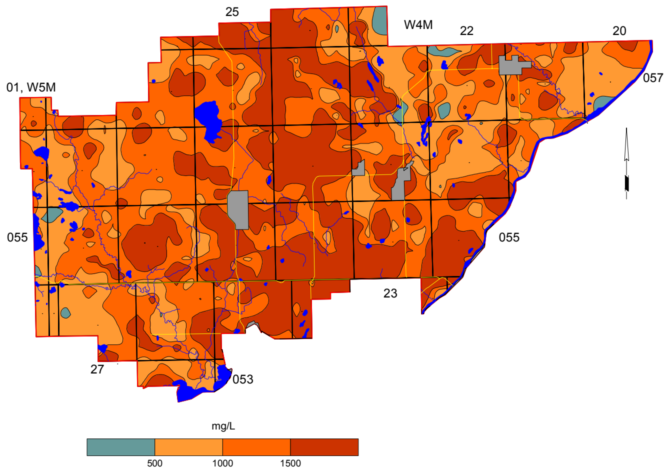

Figure 20. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

The TDS concentrations in the groundwaters from the upper bedrock aquifer(s) range from less than 500 to more than 3,500 mg/L. In approximately 35% of the area, TDS values are more than 1,500 mg/L, with only a few small areas having a TDS concentration of less than 500 mg/L.

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 chloride concentrations in the groundwaters from the upper bedrock aquifer(s) are less than 100 mg/L in approximately 70% of the County. Chloride values of greater than the GCDWQ of 250 mg/L are mainly in vicinity of the buried bedrock valleys and in the north-central part of the County. The nitrate + nitrite (as N) concentrations are less than 0.1 mg/L in 76% of the chemical analyses for bedrock water wells. Total hardness values in the groundwaters from the upper bedrock aquifer(s) are mainly less than 200 mg/L. The higher total hardness values occur mainly in the vicinity of the buried bedrock valleys (see CD-ROM).

In the County, approximately 43% of the groundwater samples from upper bedrock aquifer(s) have fluoride concentrations that are too low (less than 0.5 mg/L) to meet the recommended daily needs of people. Approximately 44% of the groundwater samples from the entire County are between 0.5 and 1.5 mg/L and approximately 13% exceed the maximum acceptable concentration for fluoride of 1.5 mg/L. The fluoride values of greater than 1.5 mg/L occur mainly in the Oldman Aquifer where the Oldman Formation is the upper bedrock, and also sporadically in the southwestern part of the County (page A-30).

The Piper tri-linear diagrams (page A-27) show that all chemical types of groundwater occur in the bedrock aquifers. However, the majority of the groundwaters are sodium-bicarbonate types.

5.3.4 Middle Horseshoe Canyon Aquifer

The Middle Horseshoe Canyon Aquifer comprises the permeable parts of the Middle Horseshoe Canyon Formation that underlies the extreme southwestern part of the County. The thickness of the Middle Horseshoe Canyon Formation is less than 70 metres; in the majority of the County, the Middle Horseshoe Canyon Formation has been eroded.

5.3.4.1 Depth to Top

The depth to top of the Middle Horseshoe Canyon Formation is mainly less than 30 metres below ground level and is a function of the thickness of the surficial deposits (page A-32).

5.3.4.2 Apparent Yield

The apparent yields for individual water wells completed through the Middle Horseshoe Canyon Aquifer are mainly in the range of 10 to 100 m³/day. There are 40 water well records with apparent yield values, of which seven have apparent yields of more than 100 m³/day. The areas where apparent yields are greater than 100 m³/day are mainly where the depth of burial is more than 30 metres. In addition to the 40 water well records, there is one record that indicates dry, or abandoned with "insufficient water".

In the County, there are no licensed water wells that are completed in the Middle Horseshoe Canyon Aquifer.

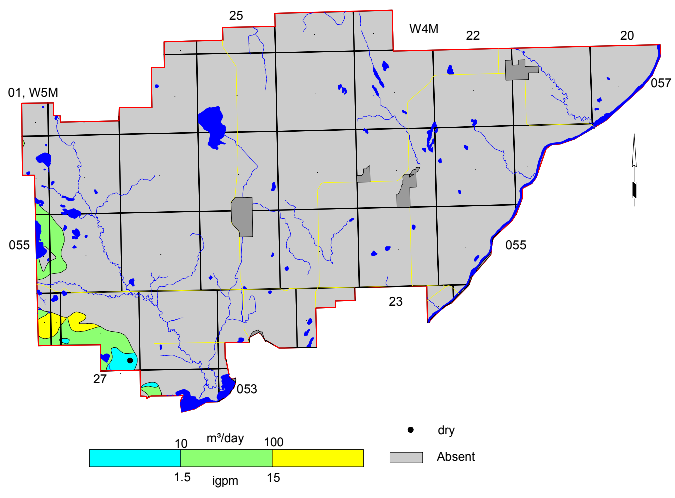

Figure 21. Apparent Yield for Water Wells Completed through Middle Horseshoe Canyon Aquifer

5.3.4.3 Quality

The groundwaters from the Middle Horseshoe Canyon Aquifer are mainly a sodium-bicarbonate-type (see Piper diagram on CD-ROM), with TDS concentrations ranging mainly between 500 and 1,000 mg/L. The sulfate concentrations are mainly below 500 mg/L. Chloride concentrations from the Middle Horseshoe Canyon Aquifer are mainly less than ten mg/L. There are no analyses where fluoride concentrations exceed 1.5 mg/L, and 12 out of 17 fluoride analyses are less than 0.5 mg/L.

5.3.5 Lower Horseshoe Canyon Aquifer

The Lower Horseshoe Canyon Aquifer comprises the permeable parts of the Lower Horseshoe Canyon Formation that underlies the western half of the County. The thickness of the Lower Horseshoe Canyon Formation is less than 140 metres; in the northeastern half of the County, the Lower Horseshoe Canyon Formation has been eroded.

5.3.5.1 Depth to Top

The depth to top of the Lower Horseshoe Canyon Formation is mainly less than 30 metres below ground level and is a function of the thickness of the surficial deposits. Along the southwestern edge of the County, the depth to the top of the Lower Horseshoe Canyon Formation is more than 50 metres below ground level (page A-35). In these areas, water well depths would need to be in the order of 130 metres to fully penetrate the lower part of the Formation.

5.3.5.2 Apparent Yield

The apparent yields for individual water wells completed through the Lower Horseshoe Canyon Aquifer are mainly less than ten m^3/day. There are 829 water well records with apparent yield values, of which 46% have apparent yields of less than ten m^3/day. One area where apparent yields are greater than 100 m^3/day is along the northern part of the Buried Onoway Valley. In addition to the 829 water well records with apparent yields, there are 34 records that indicate dry, or abandoned with “insufficient water”.

An extended aquifer test conducted with a water supply well completed in the Lower Horseshoe Canyon Aquifer in NE 34-056-27 W4M indicated a long-term yield of 66 m^3/day, based on an effective transmissivity of 29 m^2/day (HCL, 1999).

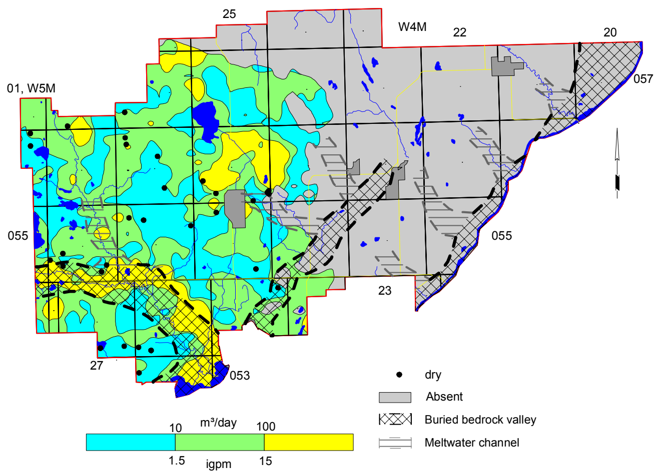

Figure 22. Apparent Yield for Water Wells Completed through Lower Horseshoe Canyon Aquifer

In the County, there are 42 licensed water wells that are completed in the Lower Horseshoe Canyon Aquifer. The highest allocation is 44 m^3/day for an Alcomdale Local Developers water supply well in 01-31-056-26 W4M. Thirty-six of the 42 licensed water wells completed through the Lower Horseshoe Canyon Aquifer could be linked to a water well in the AENV groundwater database.

5.3.5.3 Quality

The groundwaters from the Lower Horseshoe Canyon Aquifer are mainly a sodium-bicarbonate-type or sodium-sulfate-type (see Piper diagram on CD-ROM), with TDS concentrations ranging from less than 500 to more than 1,500 mg/L. The higher TDS concentrations occur mainly at the edge of the Aquifer. The sulfate concentrations are mainly below 500 mg/L, with the exception of the eastern edge of the Aquifer. Chloride concentrations from the Lower Horseshoe Canyon Aquifer are mainly less than 250 mg/L. There are 61 out of 820 analyses where fluoride concentrations exceed 1.5 mg/L.

The groundwater from the licensed Alcomdale water supply well in 01-31-056-26 W4M that is completed in the Lower Horseshoe Canyon Aquifer has a TDS concentration of 1,038 mg/L, a sulfate concentration of 92 mg/L, and a chloride concentration of 21 mg/L. The groundwater from this water supply well is a sodium-bicarbonate-type.

5.3.6 Bearpaw Aquifer

The Bearpaw Aquifer comprises the permeable parts of the Bearpaw Formation that underlies the southwestern two-thirds of the County; however, data are available for the central part of the County only. The Bearpaw Formation generally ranges from 80 to 100 metres thick; in the northeastern one-third of the County, the Bearpaw Formation has been eroded.

5.3.6.1 Depth to Top

The depth to the top of the Bearpaw Formation is mainly less than 100 metres below ground level, except where the Formation underlies the Lower Horseshoe Canyon Formation. The largest area where the top of the Bearpaw Formation is more than 100 metres below ground level is in the southwestern part of the County.

5.3.6.2 Apparent Yield

The apparent yields for individual water wells completed through the Bearpaw Aquifer are mainly in the range of 10 to 100 m³/day. There are 259 water well records with apparent yield values, of which 115 have apparent yields in the range of 10 to 100 m³/day. In addition to the 259 water well records with apparent yields, there are 50 records that indicate dry, or abandoned with “insufficient water”.

In the County, there are ten licensed water wells that are completed in the Bearpaw Aquifer. The highest allocation is 20 m^3/day for a water supply well licensed for irrigation purposes in 05-07-057-23 W4M.

All ten licensed water wells completed through the Bearpaw Aquifer could be linked to a water well in the AENV groundwater database.

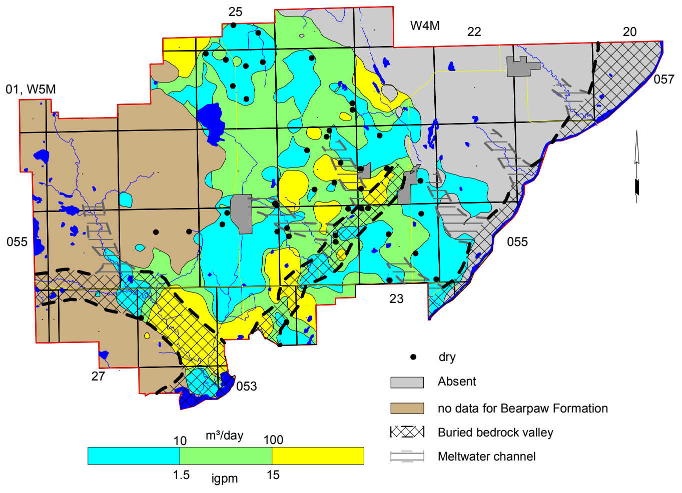

Figure 23. Apparent Yield for Water Wells Completed through Bearpaw Aquifer

5.3.6.3 Quality

The groundwaters from the Bearpaw Aquifer are mainly a sodium-bicarbonate-type (see Piper diagram on CD-ROM), with TDS concentrations ranging from less than 500 to more than 1,500 mg/L, with the lower concentrations occurring along the Aquifer edge. The sulfate concentrations are mainly below 500 mg/L. Chloride concentrations from the Bearpaw Aquifer are mainly less than 250 mg/L; the areas where the chloride concentrations exceed 250 mg/L occur mainly where the depth to burial is greater than 40 metres. There are 13 out of 370 analyses where fluoride concentrations exceed 1.5 mg/L.

The groundwater from the licensed water supply well in 05-07-057-23 W4M that is completed in the Bearpaw Formation has a TDS concentration of 934 mg/L, a sulfate concentration of 20 mg/L, and a chloride concentration of <1 mg/L. The groundwater from this water supply well is a sodium-bicarbonate-type.

5.3.7 Oldman Aquifer

The Oldman Aquifer comprises the permeable parts of the Oldman Formation. The Oldman Formation is present under most of the County, being absent only in a small area in the northeastern part of the County. The thickness of the Oldman Formation is in the order of 130 metres in most of the County. In the northeastern part of the County, the Oldman Formation subcrops below the surficial deposits and the thickness decreases to zero in areas where the underlying Birch Lake Member subcrops.

5.3.7.1 Depth to Top

The depth to the top of the Oldman Formation is mainly less than 40 metres in the eastern half of the County where it subcrops. In the southwestern part of the County, where the Oldman is below the Bearpaw and the Middle and Lower Horseshoe Canyon formations, the depth to the top of the Oldman Formation can be more than 300 metres.

5.3.7.2 Apparent Yield

The apparent yields for individual water wells completed through the Oldman Aquifer are mainly less than ten m³/day. There are 305 water well records with apparent yield values, of which 142 have an apparent yield of less than ten m³/day. In addition to the 305 water well records, there are 41 records that indicate dry, or abandoned with "insufficient water". The large area of lower yields shown around Gibbons is based almost entirely on dry test holes.

An extended aquifer test conducted with a water supply well completed in the Oldman Aquifer in NE 26-056-23 W4M indicated a long-term yield of 72 m³/day (HCL, 1976).

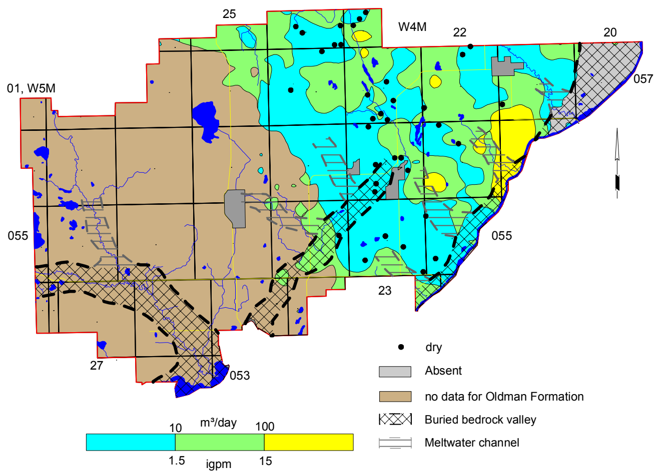

Figure 24. Apparent Yield for Water Wells Completed through Oldman Aquifer

In the County, there are 12 licensed water wells that are completed in the Oldman Aquifer. The highest allocation is 34 m^3/day for an Alsask Processors Co. Ltd. water supply well used for agricultural purposes in 01-08-057-23 W4M. Nine of the 12 licensed water wells completed through the Oldman Aquifer could be linked to a water well in the AENV groundwater database.

5.3.7.3 Quality

The groundwaters from the Oldman Aquifer are mainly a sodium-bicarbonate-type (see Piper diagram on CD-ROM). Total dissolved solids concentrations are expected to range mainly from 500 to 1,500 mg/L, with higher concentrations expected between Gibbons and Morinville. The sulfate concentrations are mainly below 500 mg/L. The indications are that chloride concentrations in the Oldman Aquifer are expected to be mainly greater than 250 mg/L. There are 128 out of 487 analyses where fluoride concentrations exceed 1.5 mg/L. There is a higher percentage of fluoride exceedances in the Oldman Aquifer than in the other bedrock aquifers within the County (see CD-ROM).

The groundwater from the water supply well in NE 26-056-23 W4M that is completed in the Oldman Aquifer has a TDS concentration of 911 mg/L, a sulfate concentration of 33 mg/L, a chloride concentration of 26 mg/L and a fluoride of 2.35 mg/L. The groundwater from this water supply well is a sodium-bicarbonate-type.

5.3.8 Birch Lake Aquifer

The Birch Lake Aquifer comprises the permeable parts of the Birch Lake Member and subcrops in a small area on the northeastern part of the County. Structure contours have been prepared for the top of the Member, which underlies all of the County. The structure contours show the Member being mostly less than 60 metres thick.

5.3.8.1 Depth to Top

The depth to the top of the Birch Lake Member is variable, ranging from less than 20 metres in the northeastern part of the County to more than 400 metres in the southwestern part of the County.

5.3.8.2 Apparent Yield

There are 16 water well records in the database with sufficient information to calculate apparent yields for individual water wells completed through the Birch Lake Aquifer. Of the 16 water well records, seven have apparent yields of less than 10 m^3/day, six have apparent yields that range from 10 to 100 and three are greater than 100 m^3/day. There are six records that indicate dry, or abandoned with “insufficient water”. In Sturgeon County, there are no licensed water wells completed in the Birch Lake Aquifer.

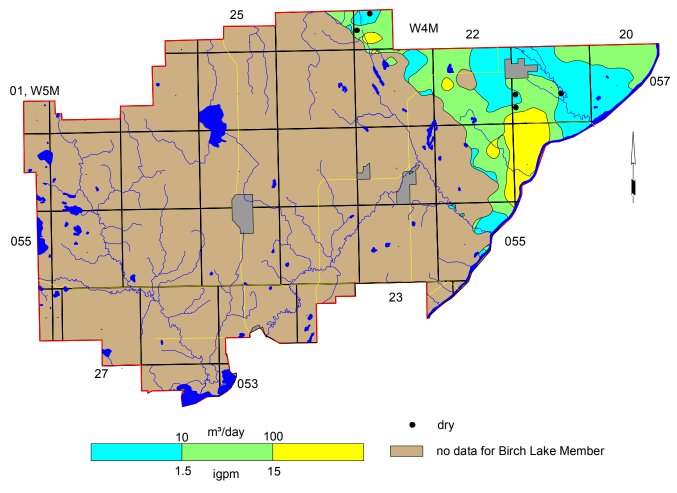

Figure 25. Apparent Yield for Water Wells Completed through the Birch Lake Aquifer

5.3.8.3 Quality

The groundwaters from the Birch Lake Aquifer are mainly a sodium-bicarbonate-type (see Piper diagram on CD-ROM). Total dissolved solids concentrations are mainly greater than 1,000 mg/L. The indications are that chloride concentrations in the Birch Lake Aquifer are expected to be mainly more than 250 mg/L. There are five out of 30 analyses where fluoride concentrations exceed 1.5 mg/L.

5.3.9 Other Foremost Aquifers

There are seven water wells that are completed in the Ribstone Creek Aquifer, with four located in the vicinity of Redwater and three in the vicinity of Legal, with drilled depths ranging from 91 to 198 metres below ground level. There are no apparent long-term yields for water wells completed in the Ribstone Creek Aquifer within the County. There are results of 15 chemical analyses available and 12 have TDS concentrations of more than 1,000 mg/L. A detailed discussion of this Aquifer has not been completed because of the limited amount of hydrogeological information in the County.

There is even less information available for the Victoria and Brosseau aquifers than for the Ribstone Creek Aquifer.

6. Groundwater Budget

6.1 Estimated Water Use from Unlicensed Groundwater Users

An estimate of the quantity of groundwater removed from each geologic unit in Sturgeon County must include both the licensed diversions and the unlicensed use. As stated previously on page 6 of this report, the daily water requirement for livestock for the County based on the 1996 census is estimated to be 7,085 cubic metres. Of the 7,085 m³/day required for livestock, 1,171 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 5,914 m³/day of water required for livestock watering is obtained from unlicensed groundwater use. In the groundwater database for the County, there are records for 5,798 water wells that are used for domestic/stock purposes. These 5,798 water wells include both licensed and unlicensed water wells. Of the 5,798 water wells, 689 water wells are used for stock, 1,120 are used for domestic/stock purposes, and 3,989 are for domestic purposes only.

There are 1,809 water wells that are used for stock or domestic/stock purposes. There are 66 licensed groundwater users for agricultural (stock) purposes, giving 1,743 unlicensed stock water wells. (Please refer to Table 1 on page 6 for the breakdown by aquifer of the 66 licensed stock groundwater users). By dividing the number of unlicensed stock and domestic/stock water wells (1,743) into the quantity of groundwater required for stock purposes that is not licensed (5,914 m³/day), the average unlicensed water well diverts 3.4 m³/day. 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 3.4 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.

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

Domestic	1.1 m³/day
Stock	3.4 m³/day
Domestic/stock	4.5 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 5,798 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 10,804 m³/day, estimated to be diverted from unlicensed domestic, stock, or domestic/stock water wells, is from the Lower Horseshoe Canyon and Upper Sand and Gravel aquifers.

	Unlicensed and Licensed Groundwater Diversions							***Licensed Groundwater Diversions***	***Unlicensed Groundwater Diversions***
Aquifer Designation	Number of Domestic WWs	Daily Use (1.1 m³/day)	Number of Stock WWs	Daily Use (3.4 m³/day)	Number of Domestic and Stock WWs	Daily Use (4.5 m³/day)	Totals m³/day	Totals (m³/day)	Totals m³/day
Upper Sand/Gravel	513	564	113	383	338	1,519	2,466	12	2,454
Lower Sand/Gravel	278	306	34	115	55	247	668	32	636
Bedrock	271	298	28	95	40	180	573	0	573
Upper Horseshoe Canyon	2	2	0	0	0	0	2	0	2
Middle Horseshoe Canyon	53	58	2	7	1	4	70	0	70
Lower Horseshoe Canyon	1,355	1,491	291	987	346	1,555	4,032	411	3,622
Bearpaw	624	686	88	299	160	719	1,704	88	1,616
Oldman	720	792	121	63	163	732	1,587	165	1,422
Birch Lake	40	44	3	10	3	13	68	0	68
Ribstone Creek	4	4	2	7	1	4	16	0	16
Unknown	129	142	37	126	13	58	326	0	326
Totals	3,989	4,388	719	2,092	1,120	5,032	11,512	708	10,804

Table 7. Unlicensed and Licensed Groundwater Diversions

By assigning 1.1 m³/day for domestic use, 3.4 m³/day for stock use and 4.5 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 County.

There are 945 sections in the County. The estimated water well use per section can be more than 30 m³/day in 73 of the 945 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 populated centres, as shown on Figure 26.

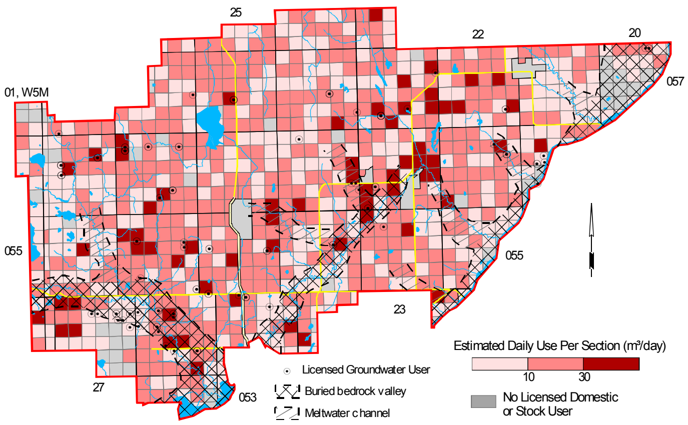

Figure 26. Estimated Water Well Use Per Section

In summary, the estimated total groundwater use within Sturgeon County is 24,704 m³/day, with the breakdown as shown in the adjacent table. Approximately 367 m³/day is being withdrawn from unknown aquifer units. The remaining 24,337 m³/day could be assigned to specific aquifer units.

Groundwater Use within Sturgeon County (m³/day)		%
Domestic/Stock (licensed and unlicensed)	11,512	47
Municipal (licensed)	929	4
Commercial/Dewatering et al (licensed)	12,263	50
Total	24,704	100

Table 8. Total Groundwater Diversions

The range in groundwater use per section is from 1.1 to more than 600 m³/day. The average groundwater use per section across the County is in the order of 16 m³/day (2.4 igpm).

Approximately 56% of the total estimated groundwater use is from licensed water wells.

6.2 Groundwater Flow

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

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

Aquifer/Area	Trans (m^2/day)	Gradient (m/m)	Width (m)	Flow (m^3/day)	Aquifer Flow (m^3/day)	Licensed Diversion (m^3/day)	Unlicensed Diversion (m^3/day)	Total (m^3/day)
Lower Sand and Gravel					2,000	11,385	636	12,021
Onoway Valley								
southeast	100	0.0010	5,000	500				
Sturgeon Valley								
southwest	200	0.0019	3,000	1125				
Upper Sand and Gravel					1,100	1,688	2,454	4,142
Western								
Southwest	3	0.0025	13,000	98				
East	3	0.0013	6,000	23				
Northeast	3	0.0050	16,000	240				
Eastern								
northeast	3	0.0040	14,000	168				
Southern								
northwest	3	0.0040	13,000	156				
northeast	3	0.0060	6,000	108				
southeast	3	0.0023	16,000	111				
Northern								
north	3	0.0030	22,000	198				
Lower Horseshoe Canyon					2,500	512	3,622	4,134
North Saskatchewan Valley								
southeast	6	0.003	20,000	400				
Western								
southwest	6	0.006	25,000	900				
northeast	6	0.006	15,000	540				
north-northeast	6	0.006	8,000	288				
southeast	6	0.004	7,000	168				
Central								
northeast	6	0.001	25,000	214				
Bearpaw					2,900	108	1,616	1,724
Central								
northeast	7	0.006	20,000	840				
southwest	0.4	0.004	12,000	19				
northwest	0.4	0.003	12,000	12				
Southern								
southeast	7	0.007	20,000	933				
northwest	7	0.007	18,000	840				
northeast	7	0.006	5,000	210				
southwest	0.4	0.003	8,000	10				
Oldman					900	165	1,422	1,587
Central								
southwest	0.4	0.003	15,000	15				
southeast	0.4	0.005	8,000	17				
northeast	0.4	0.006	15,000	38				
north	0.4	0.009	8,000	27				
Southern								
northwest	0.4	0.006	15,000	36				
southeast	0.4	0.005	15,000	30				
northeast	0.4	0.017	6,000	40				
Eastern								
northeast	0.4	0.003	25,000	30				
southwest	3	0.007	25,000	500				
southeast	3	0.006	8,000	150				
Birch Lake					30	0	68	68
southeast	1	0.001	25,000	34				

Table 9. Groundwater Budget

The above table indicates that the total of the licensed and unlicensed diversions from the individual aquifers is significantly more than the groundwater flowing through the aquifers, except for the Bearpaw Aquifer. 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.

6.2.1 Quantity of Groundwater

An estimate of the volume of groundwater stored in the sand and gravel aquifers in the surficial deposits is 0.5 to 3.0 cubic kilometres. This volume is based on an areal extent of 2,200 square kilometres and a saturated sand and gravel thickness of five metres. The variation in the total volume is based on the value of porosity that is used for the sand and gravel. One estimate of porosity is 5%, which gives the low value of the total volume. The high estimate is based on a porosity of 30% (Ozoray, Dubord and Cowen, 1990).

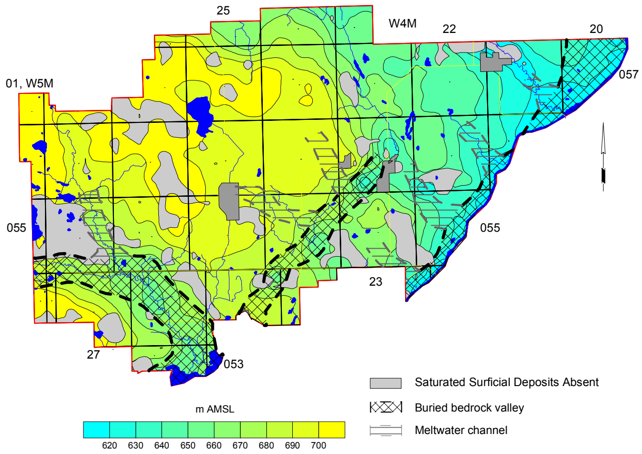

Figure 27. Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep

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. The water-level map for the surficial deposits shows a general flow direction toward the buried bedrock valleys.

6.2.2 Recharge/Discharge

The hydraulic relationship between the groundwater in the surficial deposits and the groundwater in the bedrock aquifers is given by the non-pumping water-level surface associated with each of the hydraulic units. Where the water level in the surficial deposits is at a higher elevation than the water level in the bedrock aquifers, there is the opportunity for groundwater to move from the surficial deposits into the bedrock aquifers. This condition would be considered as an area of recharge to the bedrock aquifers and an area of discharge from the surficial deposits. The amount of groundwater that would move from the surficial deposits to the bedrock aquifers is directly related to the vertical permeability of the sediments separating the two aquifers. In areas where the surficial deposits are unsaturated, the extrapolated water level for the surficial deposits is used.

When the hydraulic gradient is from the bedrock aquifers to the surficial deposits, the condition is a discharge area from the bedrock aquifers, and a recharge area to the surficial deposits.

6.2.2.1 Surficial Deposits/Bedrock Aquifers

The hydraulic gradient between the surficial deposits and the upper bedrock aquifer(s) has been determined by subtracting the elevation of the non-pumping water-level surface associated with all water wells completed in the upper bedrock aquifer(s) from the elevation of the non-pumping water-level surface determined for all water wells in the surficial deposits. The recharge classification shown on Figure 28 includes those areas where the water-level surface in the surficial deposits is more than five metres above the water-level surface in the upper bedrock aquifer(s). The discharge areas are where the water level in the surficial deposits is more than five metres lower than the water level in the bedrock. When the water level in the surficial deposits is between five metres above and five metres below the water level in the bedrock, the area is classified as a transition.

The adjacent map shows that, in more than 40% of the County, there is a downward hydraulic gradient from the surficial deposits toward the upper bedrock aquifer(s).

This percentage is lower than in other parts of Alberta, and is mainly due to the lack of water-level data for surficial water wells in many of the areas where there is a transition condition. The few areas where there is an upward hydraulic gradient (i.e. discharge) from the bedrock to the surficial deposits are mainly in the vicinity of linear bedrock lows The remaining parts of the County are areas where there is a transition condition.

Because of the paucity of data, a calculation of the volumes of groundwater entering and leaving the surficial deposits has not been attempted.

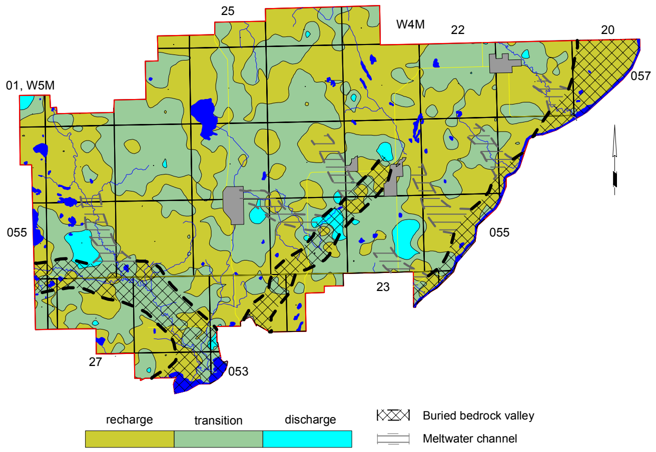

Figure 28. Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)

6.2.2.2 Bedrock Aquifers

Recharge to the bedrock aquifers within the County takes place from the overlying surficial deposits and from flow in the aquifer from outside the County. The recharge/discharge maps show that generally for most of the County, there is a downward hydraulic gradient from the surficial deposits to the bedrock, i.e. recharge to the bedrock aquifers. 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. However, because of the generally low permeability of the upper bedrock materials, the volume of water is expected to be small.

The hydraulic relationship between the surficial deposits and the Bearpaw Aquifer indicates that in more than 40% of the County where the Bearpaw Aquifer is present and there is data control, there is a downward hydraulic gradient (i.e. recharge). Discharge areas for the Bearpaw Aquifer are mainly associated with the edge of the Aquifer or in areas of linear bedrock lows.

The hydraulic relationship between the surficial deposits and the remainder of the bedrock aquifers indicates there is mainly a downward hydraulic gradient (see CD ROM).

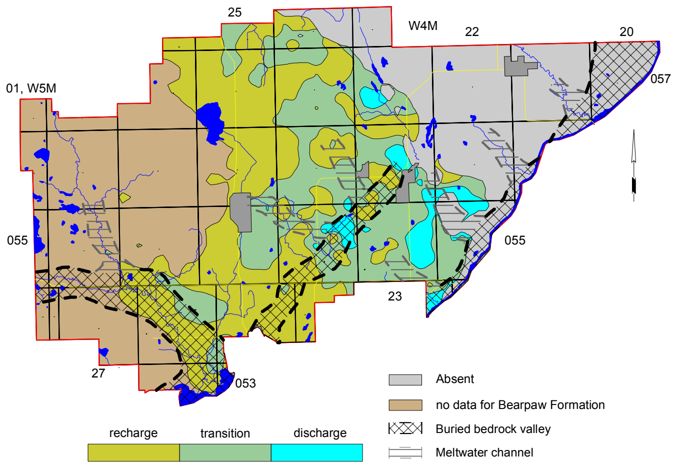

Figure 29. Recharge/Discharge Areas between Surficial Deposits and Bearpaw Aquifer

6.3 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. Because major development began occurring in the 1970s, the changes in water-level maps are based on the differences between water-level elevations available before 1970 and after 1984. Where the earliest water level is at a higher elevation than the latest water level, 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.

Of the 464 water wells completed in the sand and gravel aquifer(s) with a non-pumping water level and test date, 243 are from water wells completed before 1970 and 64 are from water wells completed after 1984. As a result of the disproportionate amount and location of control points prior to and after major development, the “Changes in Water Levels in Sand and Gravel Aquifer(s)” figure has not been included in the report or on the CD-ROM. In August and September 1999, an unpublished water well survey was conducted by Mow-Tech Ltd. that included measuring the water level in water wells located in ranges 26 and 27, W4M in Sturgeon County. There were six water wells completed in Sand and Gravel Aquifer(s) where access allowed a water level to be measured by Mow-Tech Ltd. and an original NPWL existed in the groundwater database. Of these six water wells, three water levels had declined by a maximum of 1.7 metres over a twenty-two year interval, one water level had risen 1.40 metres over a nine-year interval, and two water levels remained the same as shown in the adjacent table.

Date Drilled	NPWL (m)	Date Survey	NPWL (m)	Change (m)
26-Apr-77	0.9	12-Aug-99	2.6	-1.7
11-Oct-89	24.4	12-Sep-99	24.4	0.0
06-Sep-90	21.9	12-Sep-99	20.6	1.4
06-Jan-92	1.8	12-Aug-99	2.0	-0.2
22-Oct-92	0.9	12-Aug-99	0.9	0.0
30-Apr-93	5.5	12-Aug-99	5.8	-0.3

Table 10. Changes in Water Levels in Sand and Gravel Aquifer(s)

Of the 3,058 bedrock water wells with a non-pumping water level and test date, 455 are from water wells completed before 1970 and 1,068 are from water wells completed after 1984. The adjacent map indicates that in 60% of the County, it is possible that the non-pumping water level has declined. Of the 59 licensed groundwater users, most occur in areas where a water-level decline exists.

Fifty-three percent of the areas where there has been a water-level decline of more than five metres in upper bedrock aquifer(s) correspond to where the estimated water well use is between 10 and 30 m³/day; 8% of the declines occurred where the estimated water well use is more than 30 m³/day; 32% of the declines occurred where the estimated water well use is less than 10 m³/day; the remaining 7% occurred where there is no groundwater use shown on Figure 26.

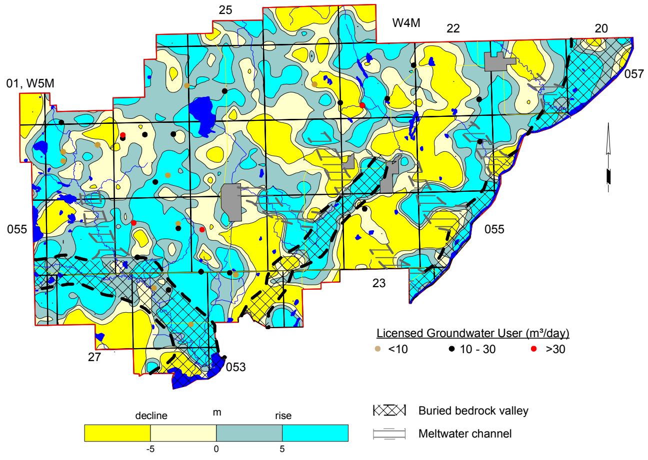

Figure 30. Changes in Water Levels in Upper Bedrock Aquifer(s)

7. Potential For Groundwater Contamination

The most common sources of contaminants that can impact groundwater originate on or near the ground surface. The contaminant sources can include leachate from landfills, effluent from leaking lagoons or from septic fields, and petroleum products from storage tanks or pipeline breaks. Additional agricultural activities that generate contaminants include the improper spreading of fertilizers, pesticides, herbicides and manure. The spreading of highway salt can also degrade groundwater quality.

When activities occur that can or do produce a liquid that could contaminate groundwater, it is prudent (from a hydrogeological point of view) to locate the activities where the risk of groundwater contamination is minimal. Alternatively, if the activities must be located in an area where groundwater can be more easily contaminated, the necessary action must be taken to minimize the risk of groundwater contamination.

The potential for groundwater contamination is based on the concept that the easier it is for a liquid contaminant to move downward, the easier it is for the groundwater to become contaminated. In areas where there is groundwater discharge, liquid contaminants cannot enter the groundwater flow systems to be distributed throughout the area. In areas of groundwater recharge, low-permeability materials impede the movement of liquid contaminants downward. Therefore, if the soils develop on a low-permeability parent material of till or clay, the downward migration of a contaminant is slower relative to a high-permeability parent material such as sand and gravel of fluvial origin. Once a liquid contaminant enters the subsurface, the possibility for groundwater contamination increases if it coincides with a higher permeability material within one metre of the land surface.

To determine the nature of the materials on the land surface, the Agricultural Region of Alberta Soil Inventory Database (AGRASID) (CAESA, 1998) has been reclassified based on the relative permeability. The classification of materials is as follows:

1) high permeability - sand and gravel
2) moderate permeability - silt, sand with clay, gravel with clay, and bedrock
3) low permeability - clay and till.

To identify the areas where sand and gravel can be expected within one metre of the ground surface, all groundwater database records with lithologies were reviewed. From a total of 3,871 records with lithological descriptions in the area of the County, 542 have the top of a sand and gravel deposit present within one metre of ground level. In the remaining 3,329 records, the first sand and gravel deposit is deeper than one metre or not present. This information was gridded to prepare a distribution of where the first sand and gravel deposit could be expected within one metre of ground level.

7.1.1 Risk of Groundwater Contamination Map

The information from the reclassification of the soil map is the basis for preparing the initial risk map. The depth to the first sand and gravel is then used to modify the initial map and to prepare the final map. The criteria used for preparing the final Risk of Groundwater Contamination map are outlined in the adjacent table.

Surface Permeability	Sand or Gravel Present - Top Within One Metre Of Ground Surface	Groundwater Contamination Risk
Low	No	Low
Moderate	No	Moderate
High	No	High
Low	Yes	High
Moderate	Yes	High
High	Yes	Very High

Table 11. Risk of Groundwater Contamination Criteria

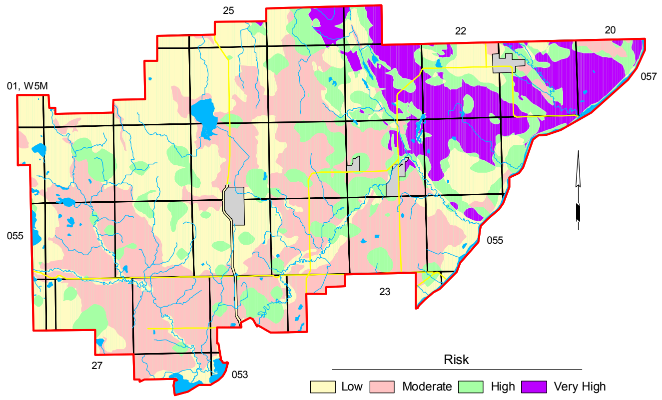

Figure 31. Risk of Groundwater Contamination

The Risk of Groundwater Contamination map shows that, in 32% of the County, there is a high or very high risk for the groundwater to be contaminated. These areas would be considered the least desirable ones for a development that has a product or by-product that could cause groundwater contamination. However, because the map has been prepared as part of a regional study, the designations are a guide only. Detailed hydrogeological studies must be completed at any proposed development site to ensure the groundwater is protected from possible contamination. At all locations, good environmental practices should be exercised in order to ensure that contaminants will not affect groundwater quality.

8. Recommendations

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

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

The quality of the data in the groundwater database is affected by two factors: a) the technical training of the persons collecting the data, and b) the quality control of the data. The possible options to upgrade the database include the creation of a "super" database, which includes only verified data. The first step would be to field-verify the 261 existing water wells listed in Appendix E. These water well records indicate that a complete water well drilling report is available along with at least a partial chemical analysis. The level of verification would have to include identifying the water well in the field, obtaining meaningful horizontal coordinates for the water well and the verification of certain parameters such as water level and completed depth. Even though the two water wells for which the County has responsibility do not satisfy the above criteria, it is recommended that the water wells be field-verified, water levels be measured, a water sample be collected for analysis, and a short aquifer test be conducted; the two County-operated water wells are also included in Appendix E. An attempt to update the quality of the entire database is not recommended.

An attempt in this study to link the AENV groundwater and licensing databases was about 65% successful. About one-third 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. One method to obtain additional water-level data is to solicit the assistance of the water well owners who are stakeholders in the groundwater resource. In the M.D. of Rocky View and in Flagstaff County, water well owners are being provided with a tax credit if they accurately measure the water level in their water well once per week for a year. A pilot project indicated that approximately five years of records are required to obtain a reasonable data set. The cost of a five-year project involving 50 water wells would be less than the cost of one drilling program that may provide two or three observation water wells. Monitoring of water levels in domestic and stock water wells is a practice that is recommended by PFRA in the "Water Wells That Last for Generations" manual and accompanying videos (Alberta Agriculture, Food And Rural Development, 1996). Of the 261 water wells recommended for field verification, 194 of the bedrock water wells and 67 of the surficial water wells are in areas of water-level decline. Because the flow through the individual aquifers is significantly less than the total of the licensed and unlicensed diversions, it is strongly recommended that a groundwater-monitoring program be established. The cost of establishing such a groundwater-monitoring program for Sturgeon County would be in the order of $50,000.

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

In general, for the next level of study, the database needs updating. It requires more information from existing water wells, and additional information from new ones.

Before an attempt is made to provide a major upgrade to the level of interpretation provided in this report and the accompanying maps and groundwater query, it is recommended that the 261 water wells for which water well drilling reports are available be subjected to the following actions (see pages C-2 to C-3):

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

A list of the 261 water wells that could be considered for the above program is given in Appendix E.

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

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

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

Groundwater is a renewable resource and it must be managed.

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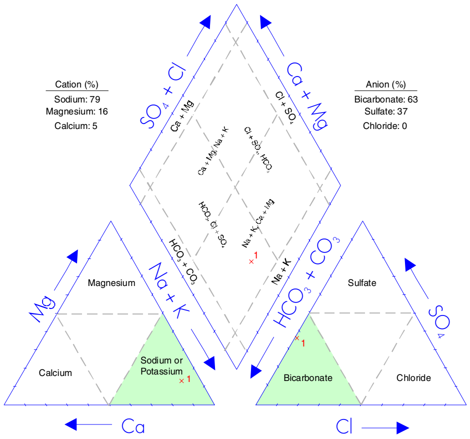
10. Conversions

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

11. Glossary

Aquifer	a formation, group of formations, or part of a formation that contains saturated permeable rocks capable of transmitting groundwater to water wells or springs in economical quantities
Available Drawdown	in a confined aquifer, the distance between the non-pumping water level and the top of the aquifer in an unconfined aquifer (water table aquifer), two thirds of the saturated thickness of the aquifer
Borehole	includes all “work types” except springs
Dewatering	the removal of groundwater from an aquifer for purposes other than use
Deltaic	a depositional environment in standing water near the mouth of a river
Dfb	climate classification that relates to long, cool summers and severe winters (Thornthwaite and Mather, 1957)
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
m^3/day	cubic metres per day
mg/L	milligrams per litre
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
PFRA	Prairie Farm Rehabilitation Administration
TDS	Total Dissolved Solids
WSW	Water Source Well or Water Supply Well

STURGEON COUNTY

Appendix A

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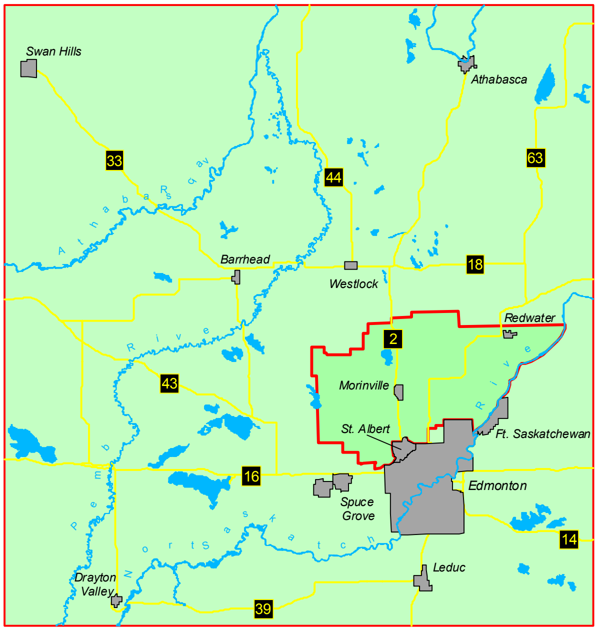
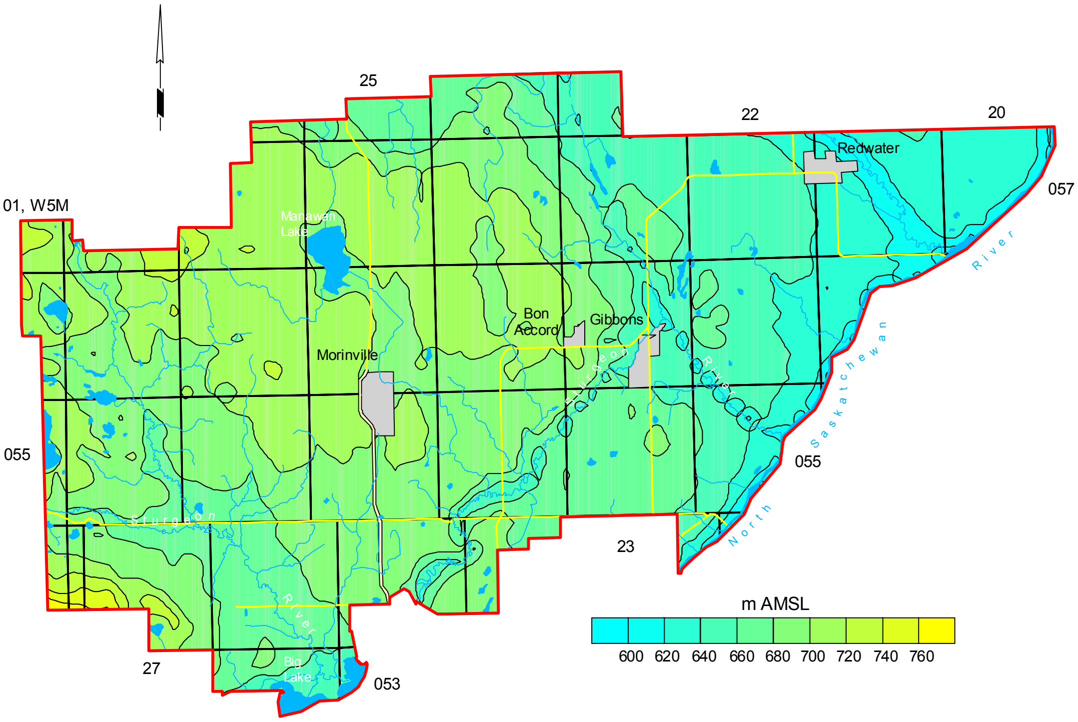
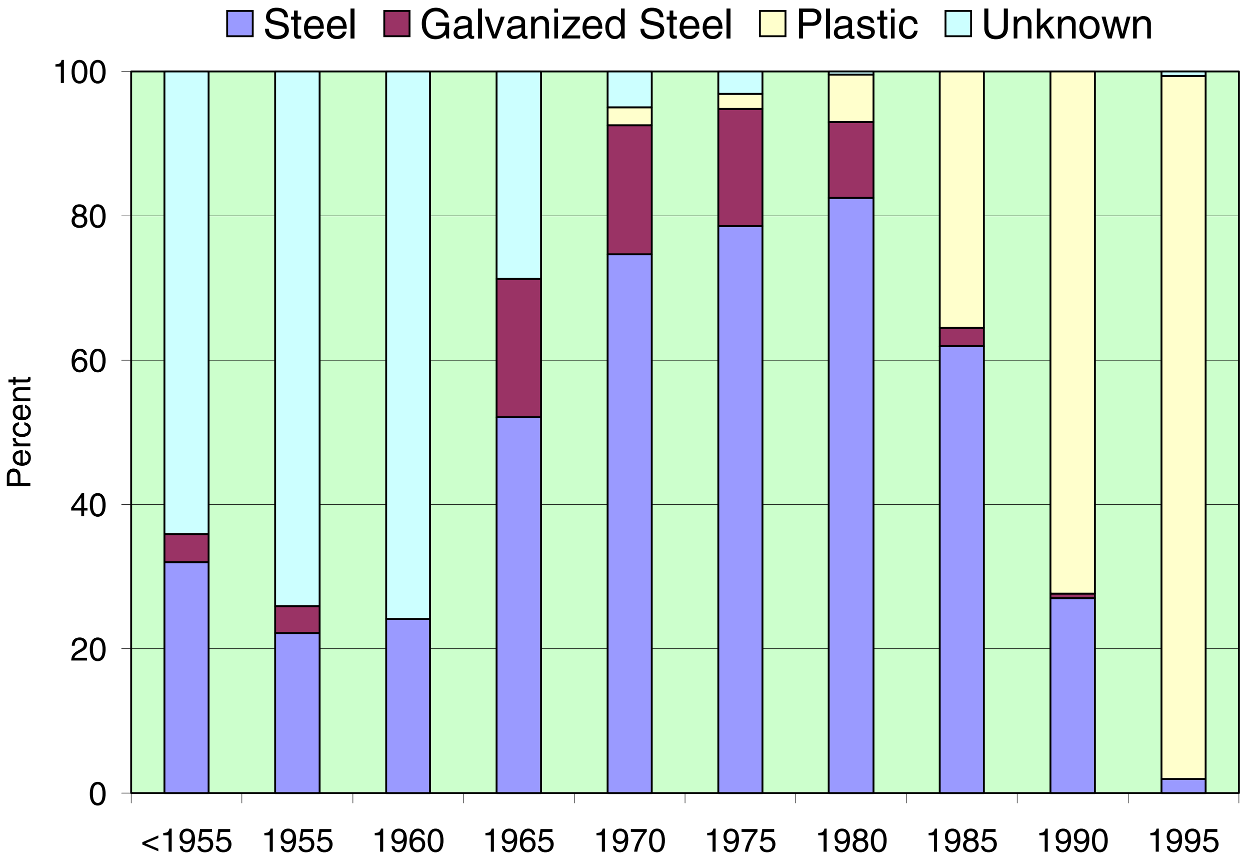
Index Map / Surface Topography



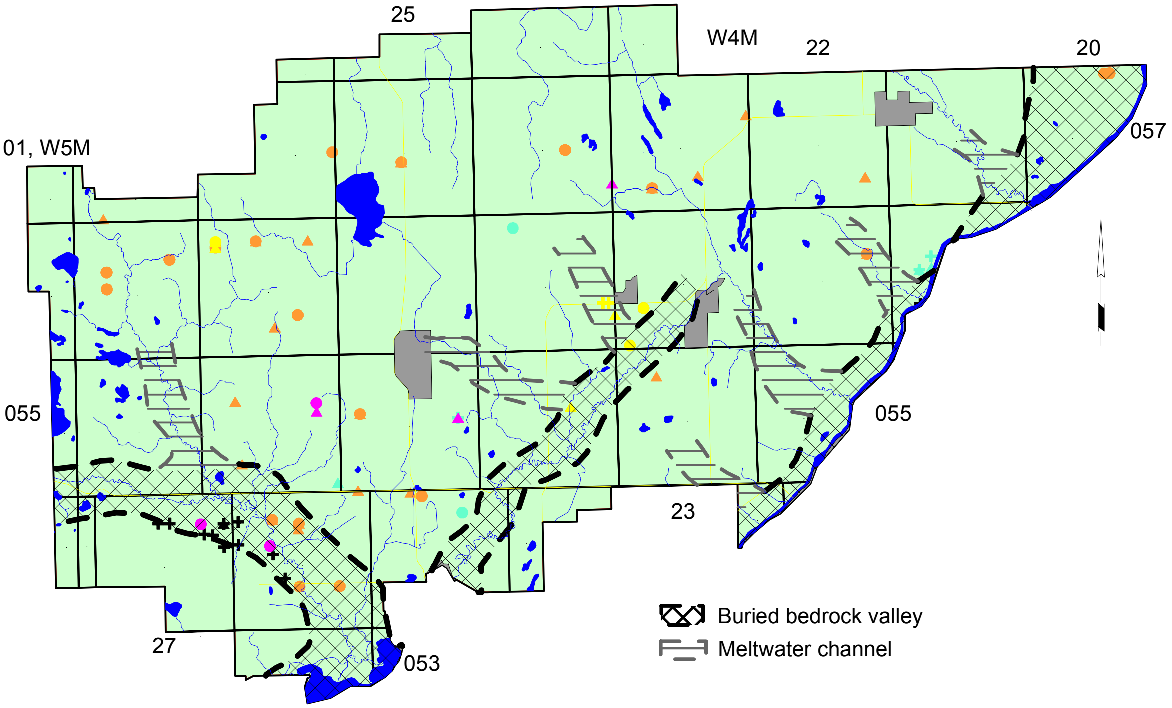


Sturgeon County

Surface Casing Types used in Drilled Water Wells



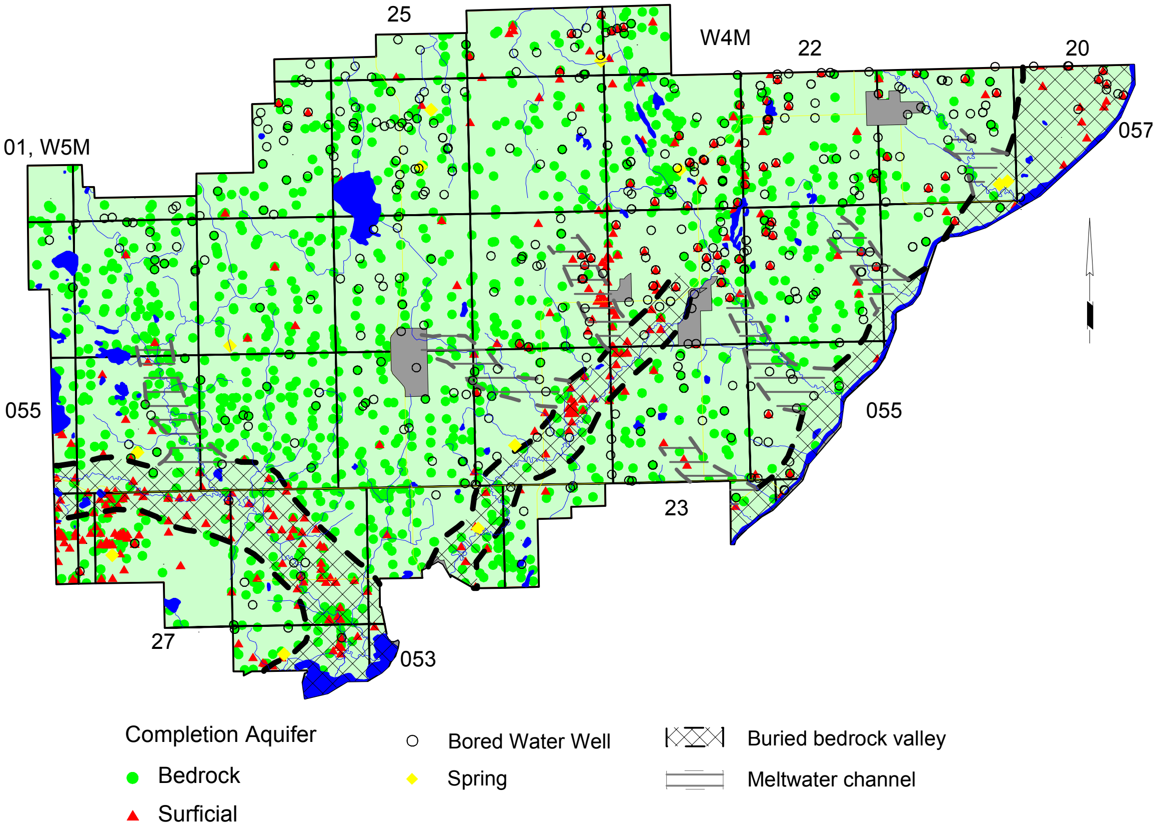
Licensed Water Wells



Licensed Groundwater Users (m^3/day)

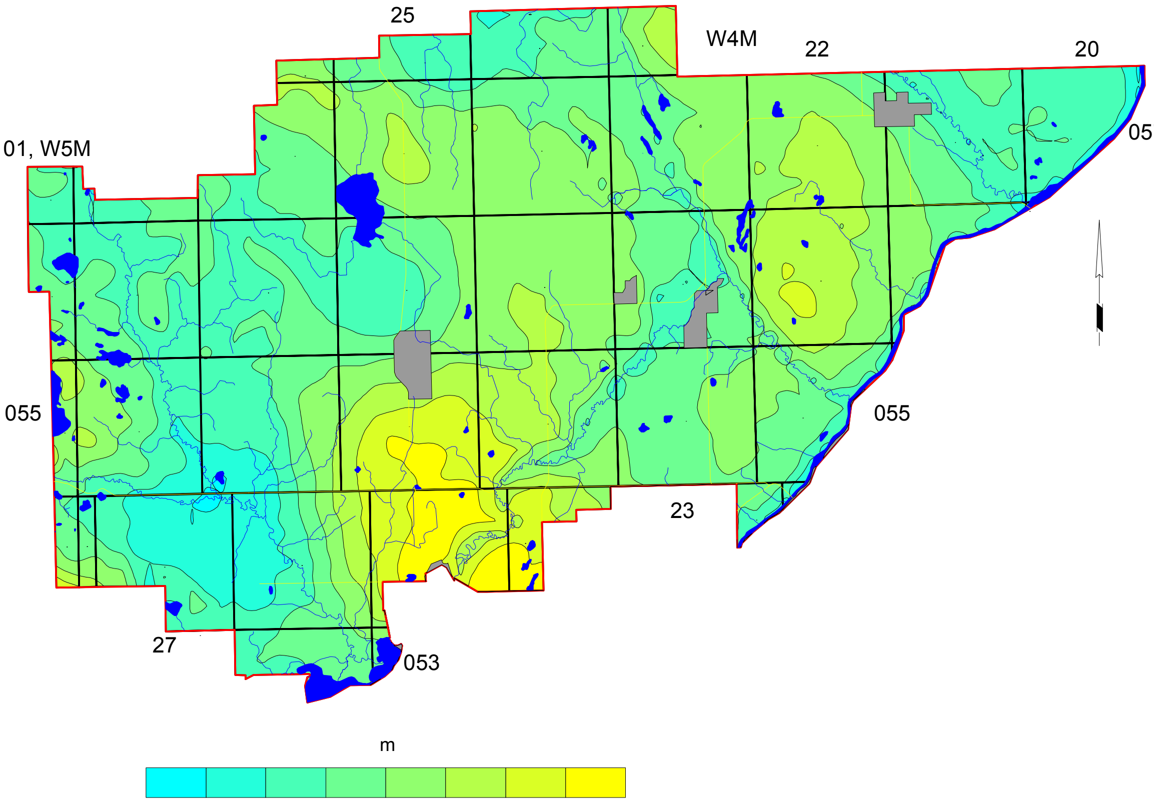
	agricultural	municipal	dewatering	commercial	other
< 10	● (36)	● (3)	● (0)	● (2)	● (3)
10 to 100	▲ (30)	▲ (6)	▲ (1)	▲ (5)	▲ (3)
> 100	+ (0)	+ (3)	+ (11)	+ (4)	+ (0)

Location of Water Wells and Springs



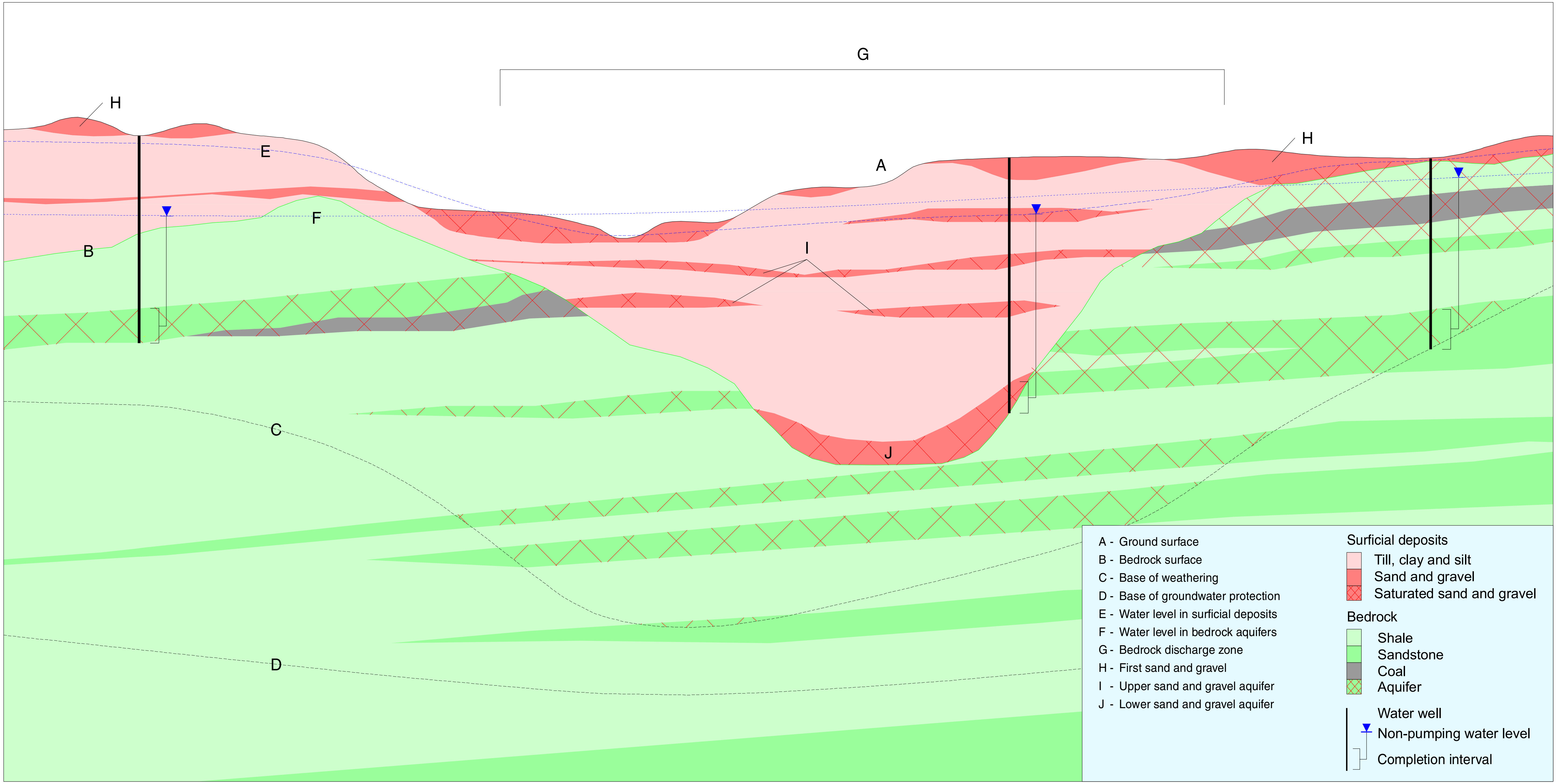
Depth to Base of Groundwater Protection

(modified after EUB, 1995)

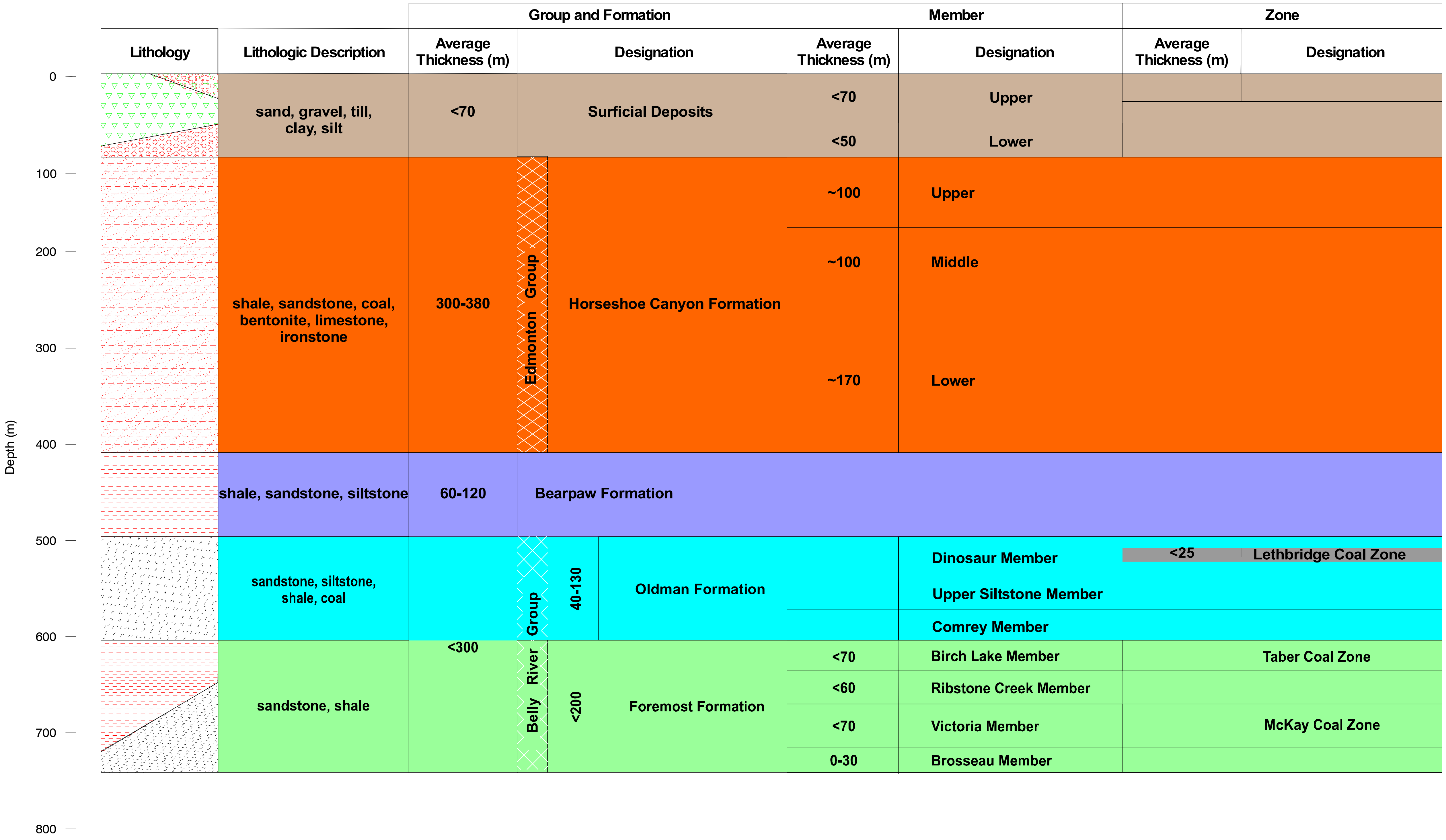


Generalized Cross-Section

(for terminology only)

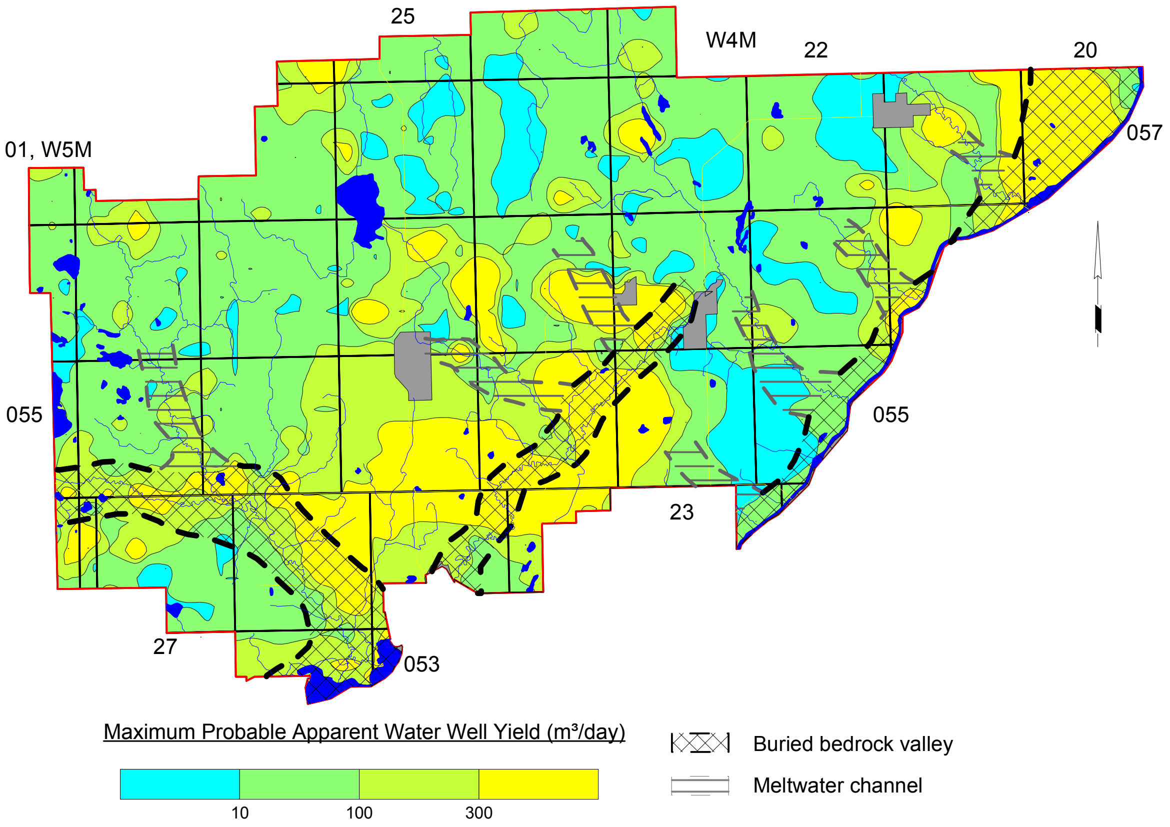


Geologic Column

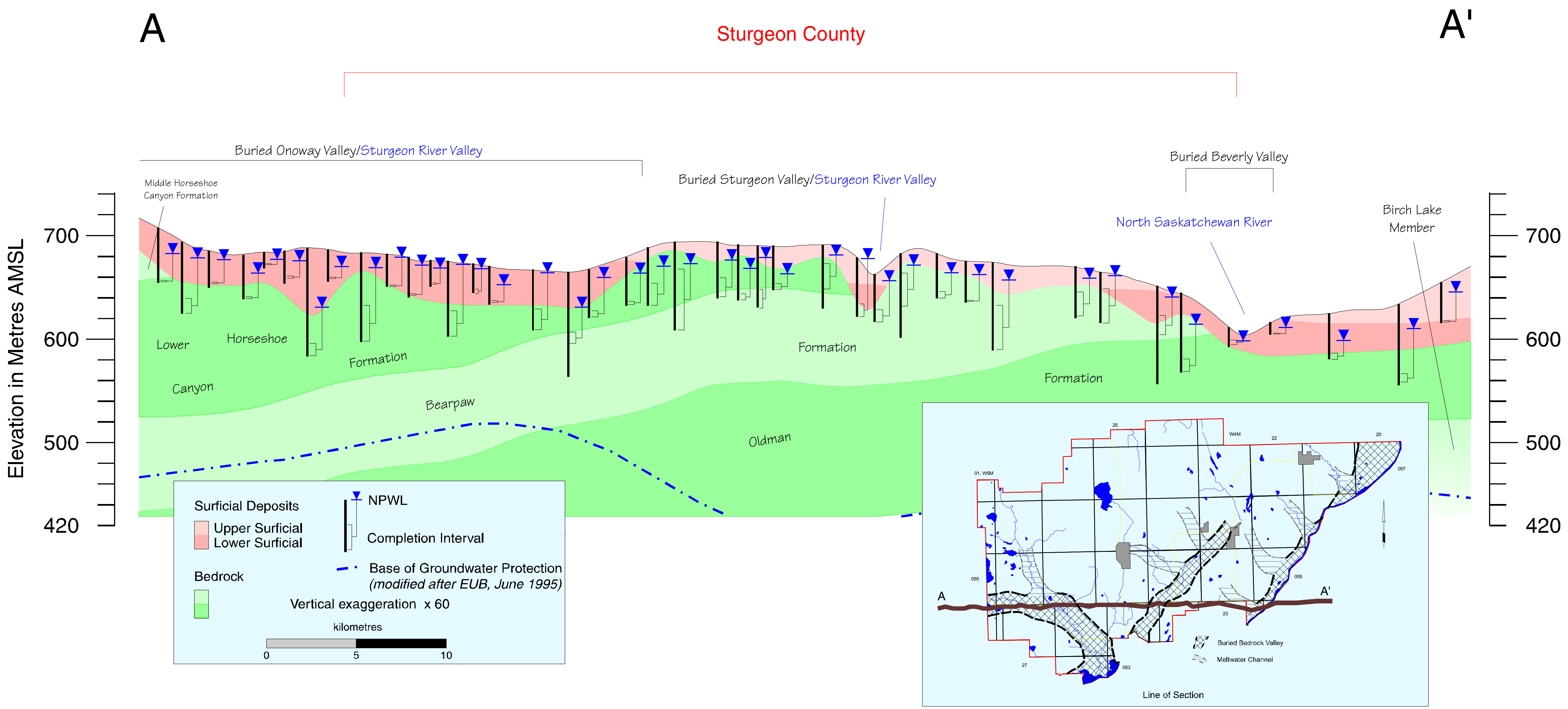


Lithology	Lithologic Description	Group and Formation: Average Thickness (m)	Group and Formation: Designation	Member: Average Thickness (m)	Member: Designation	Zone: Average Thickness (m)	Zone: Designation
	sand, gravel, till, clay, silt	<70	Surficial Deposits	<70	Upper		
				<50	Lower		
	shale, sandstone, coal, bentonite, limestone, ironstone	300-380	Edmonton Group Horseshoe Canyon Formation	~100	Upper		
				~100	Middle		
				~170	Lower		
	shale, sandstone, siltstone	60-120	Bearpaw Formation				
	sandstone, siltstone, shale, coal	40-130	Belly River Group Oldman Formation		Dinosaur Member	<25	Lethbridge Coal Zone
					Upper Siltstone Member		
					Comrey Member		
	sandstone, shale	<300 <200	Foremost Formation	<70	Birch Lake Member		Taber Coal Zone
				<60	Ribstone Creek Member		
				<70	Victoria Member		McKay Coal Zone
				0-30	Brosseau Member		

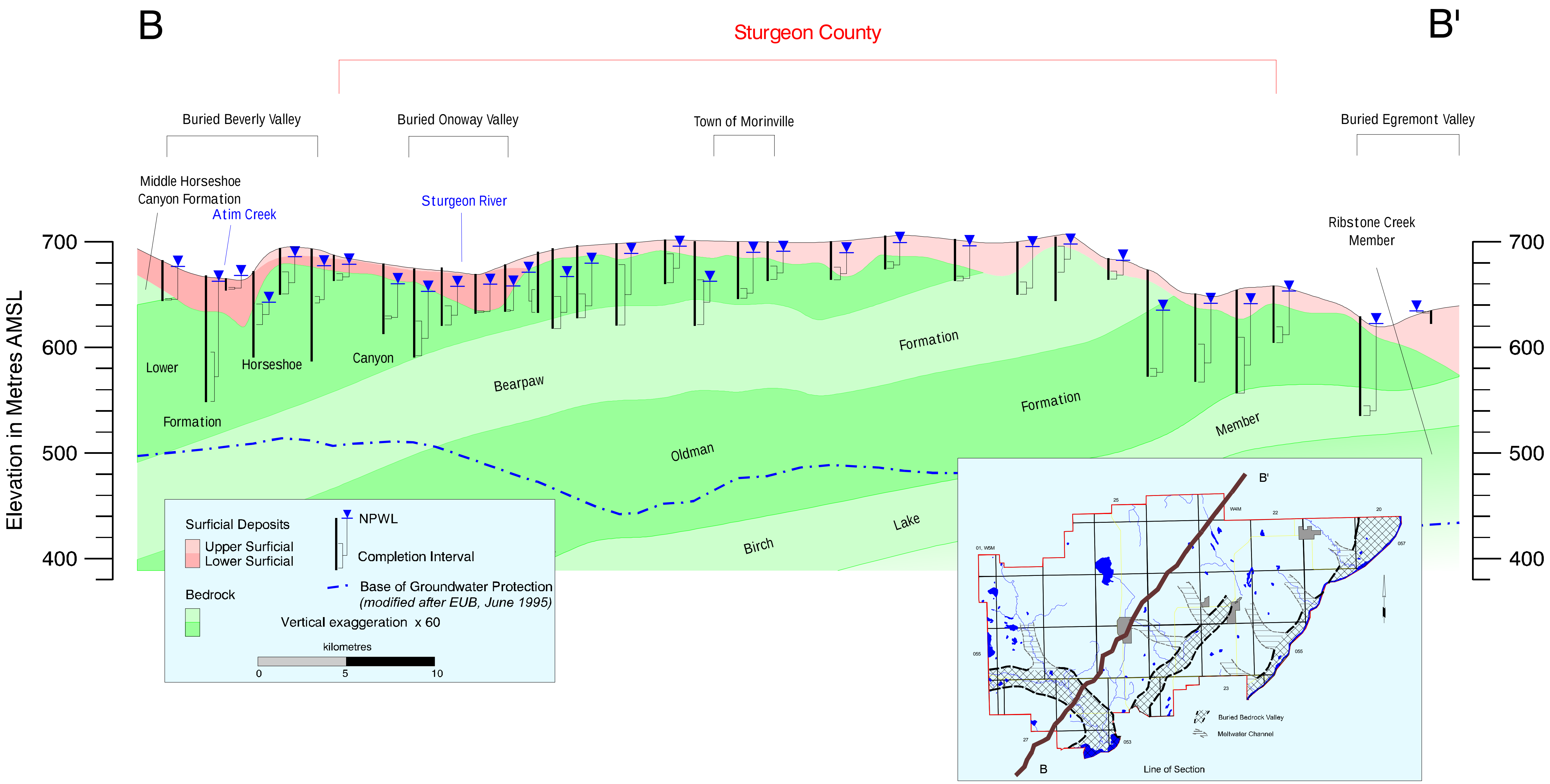
Hydrogeological Map



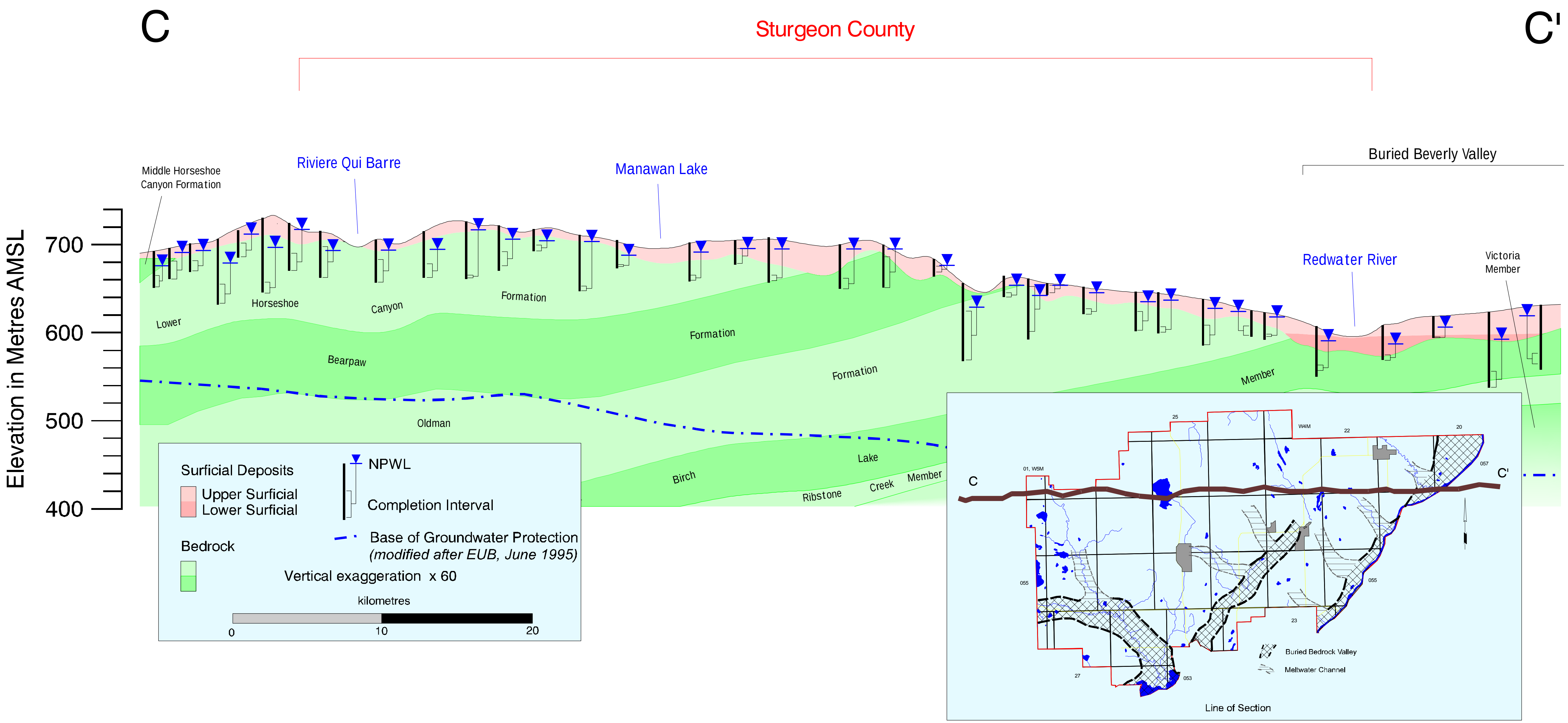
Cross-Section A - A'



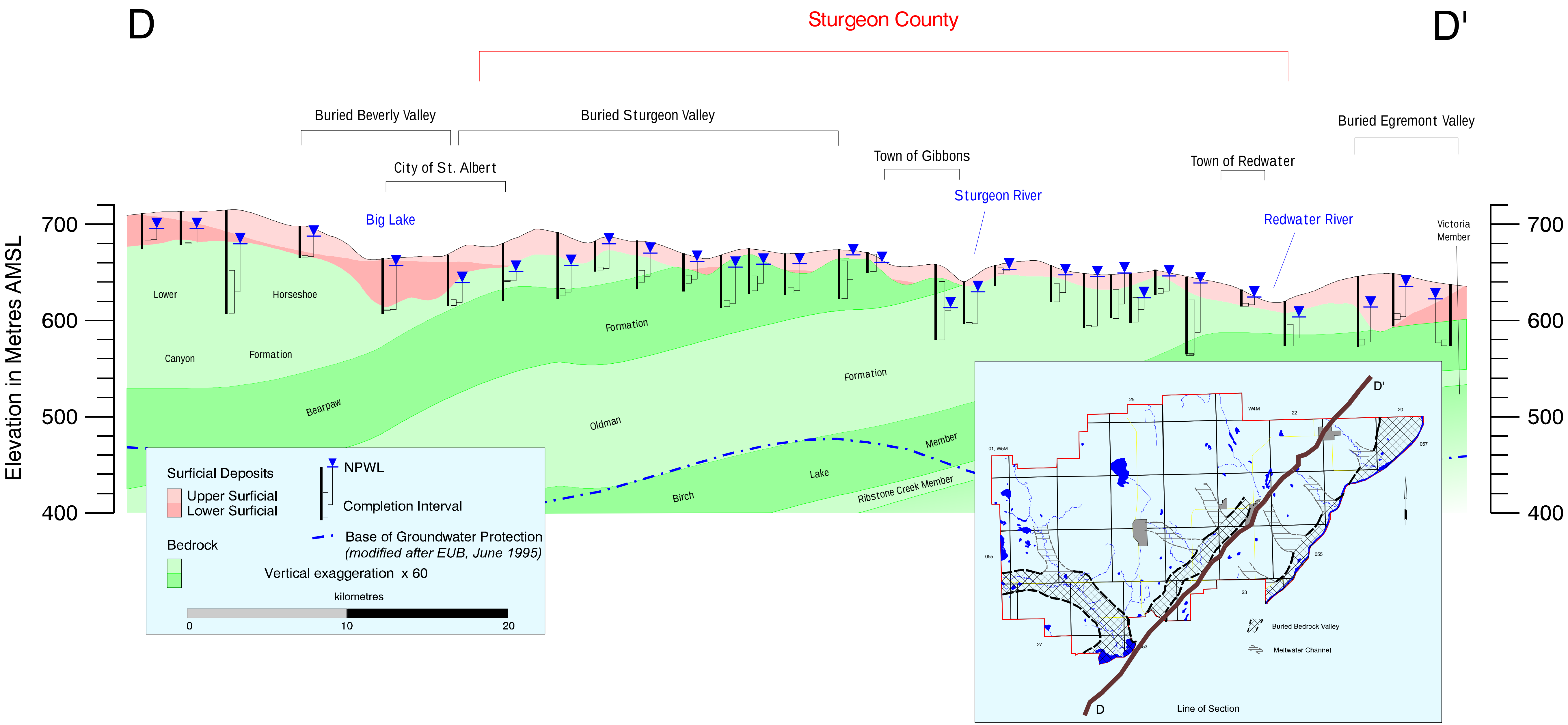
Cross-Section B - B'



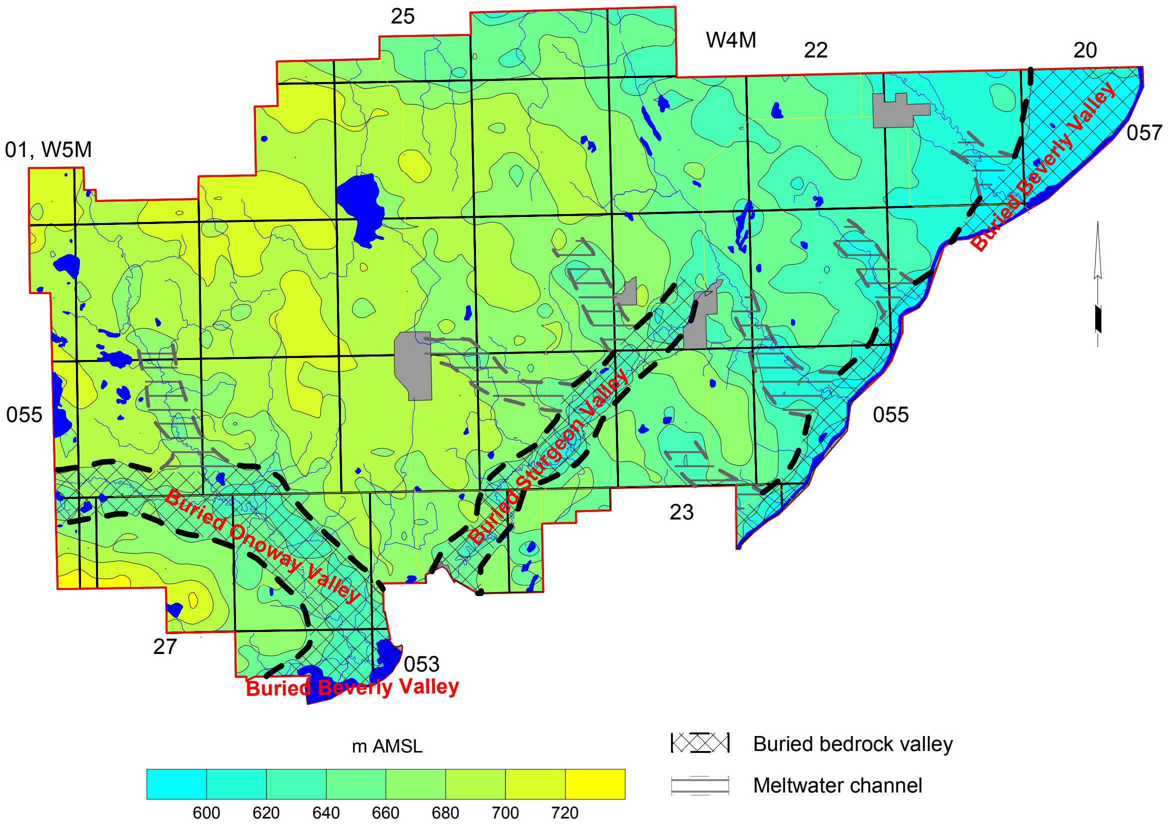
Cross-Section C - C'



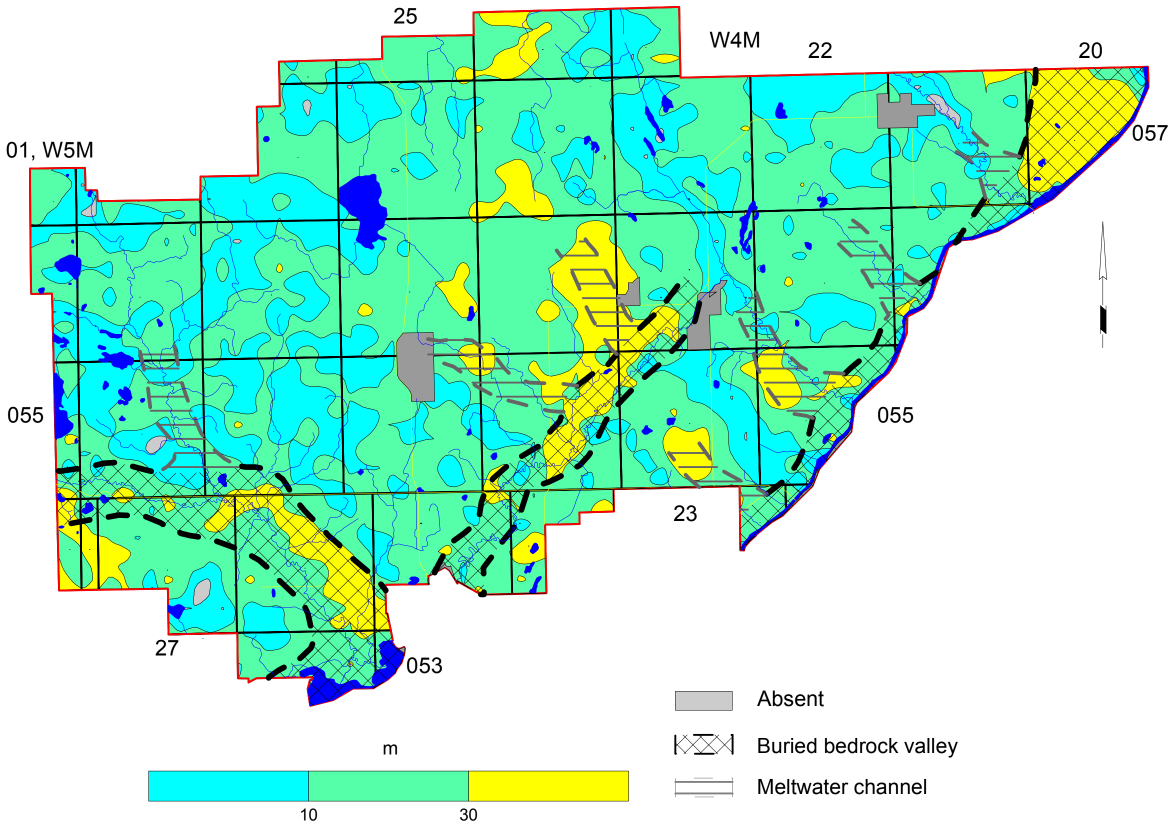
Cross-Section D - D'



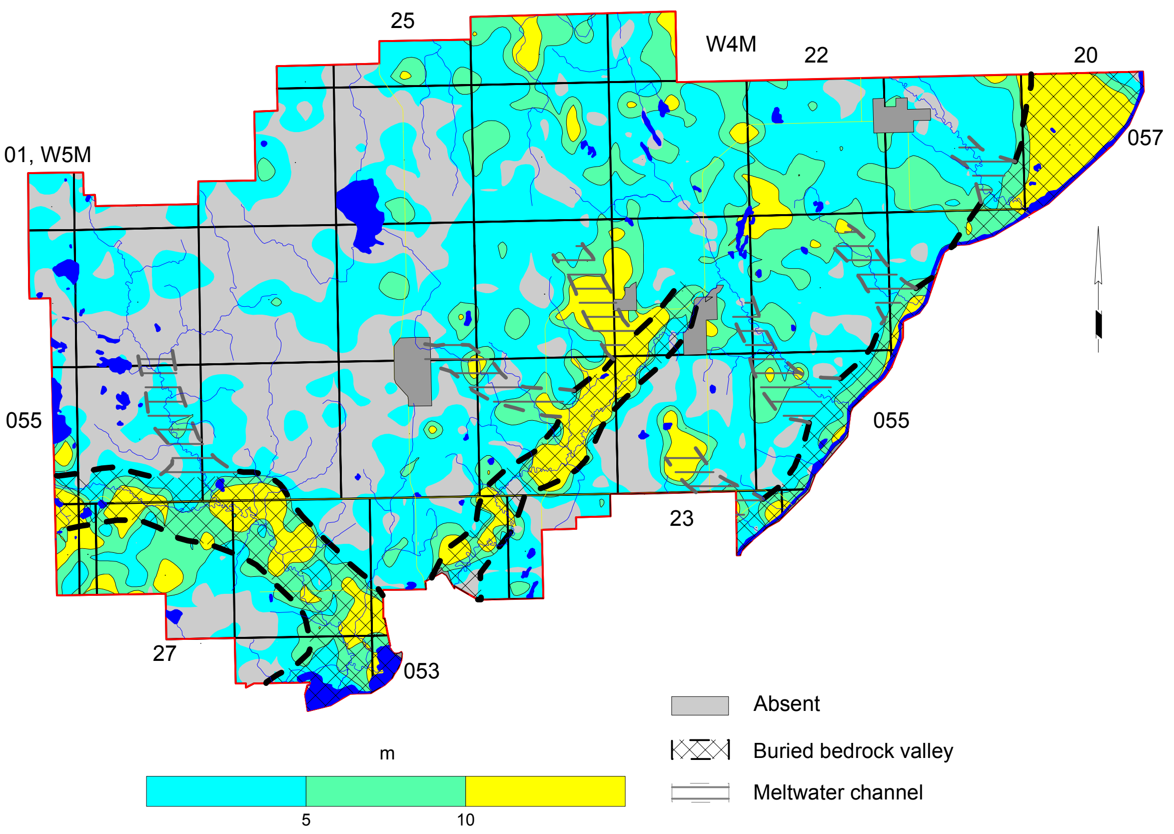
Bedrock Topography



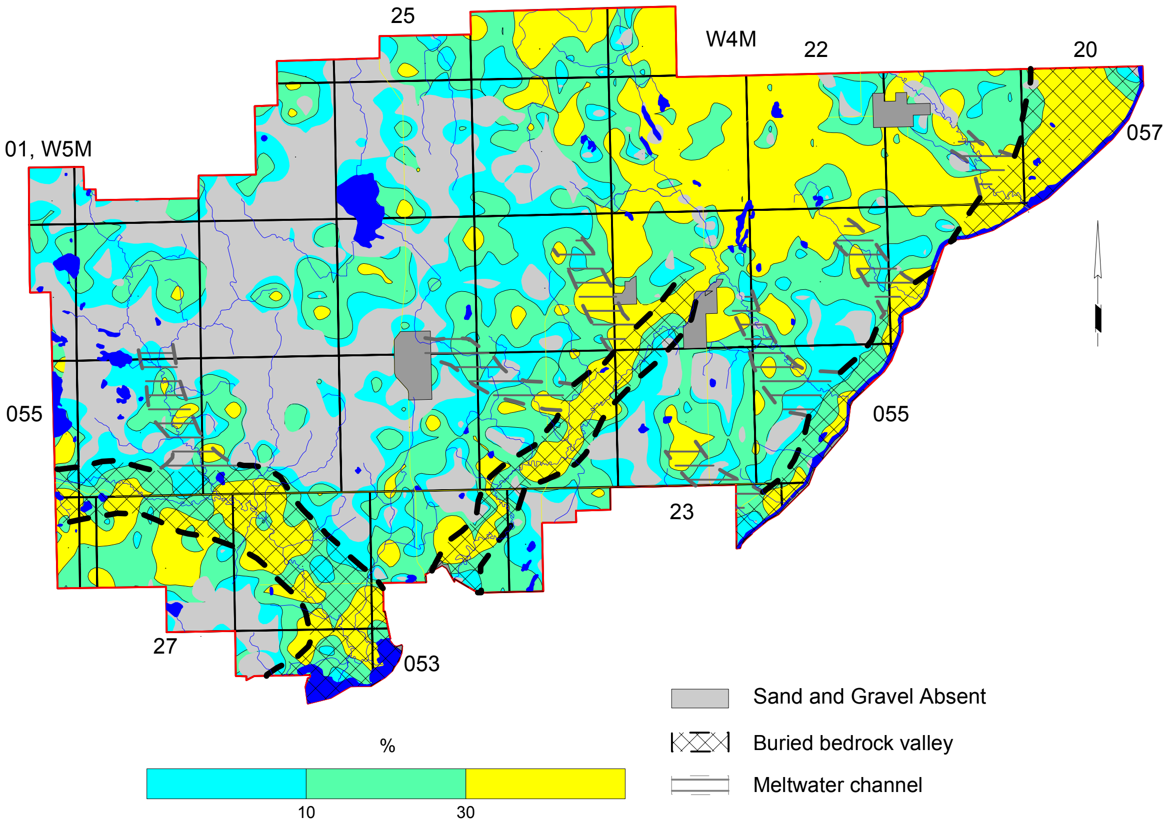
Thickness of Surficial Deposits



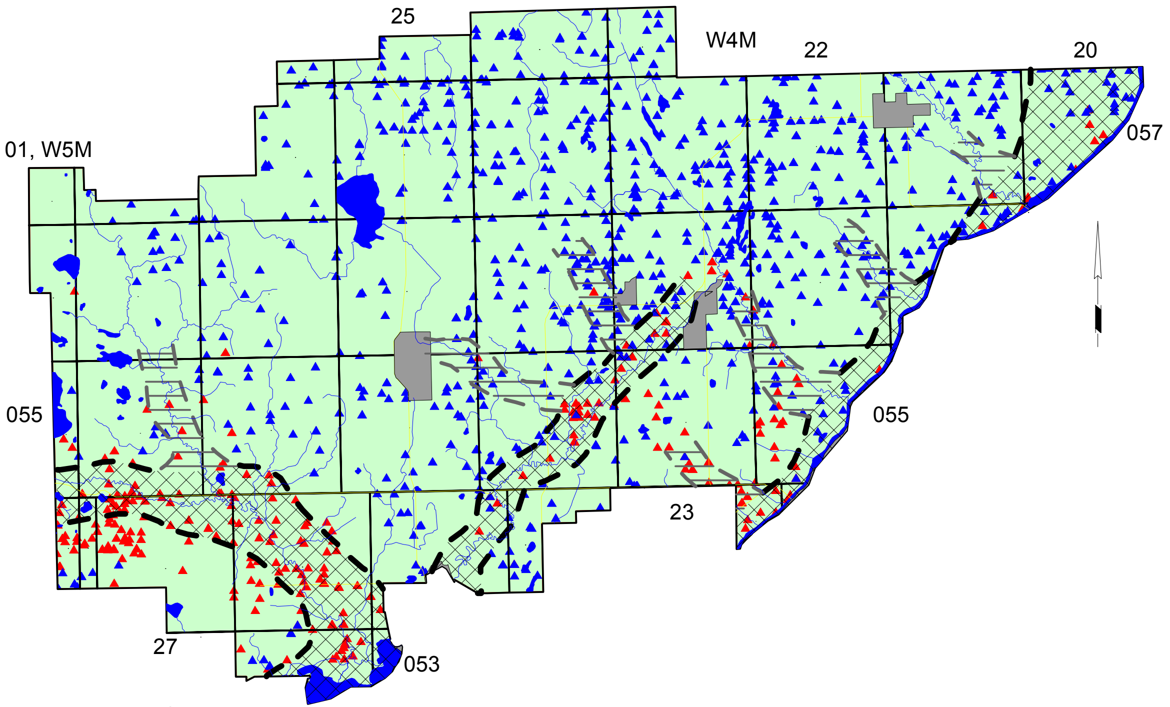
Thickness of Sand and Gravel Deposits



Amount of Sand and Gravel in Surficial Deposits



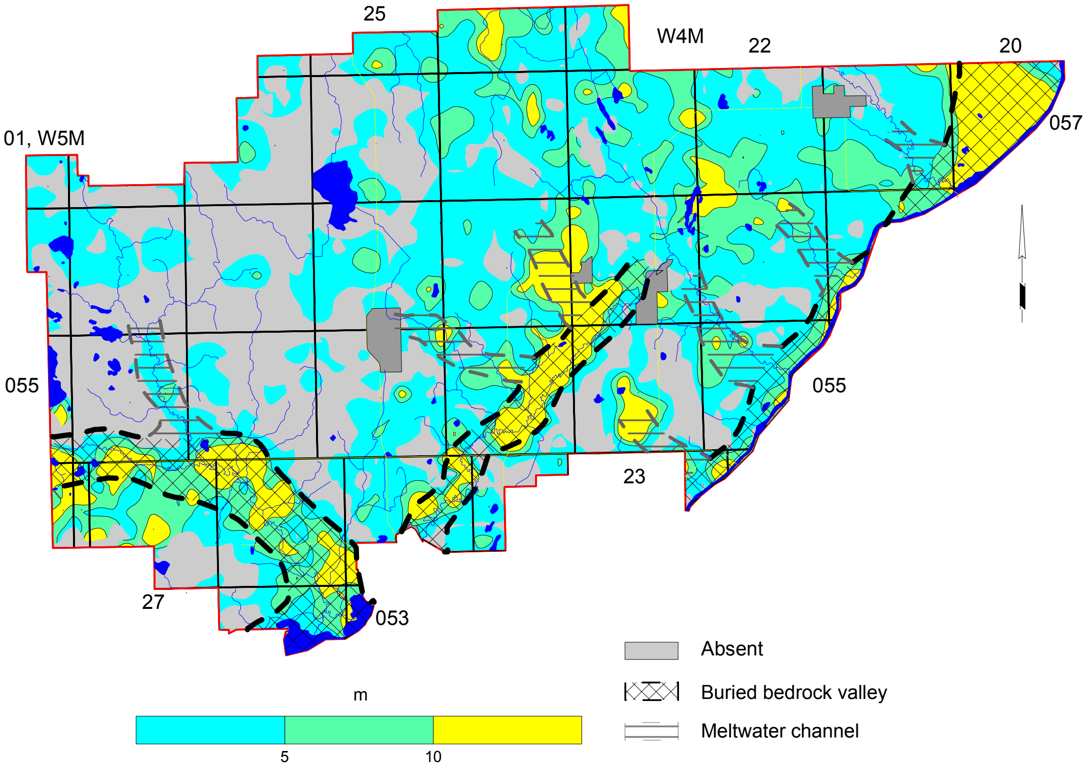
Water Wells Completed In Surficial Deposits



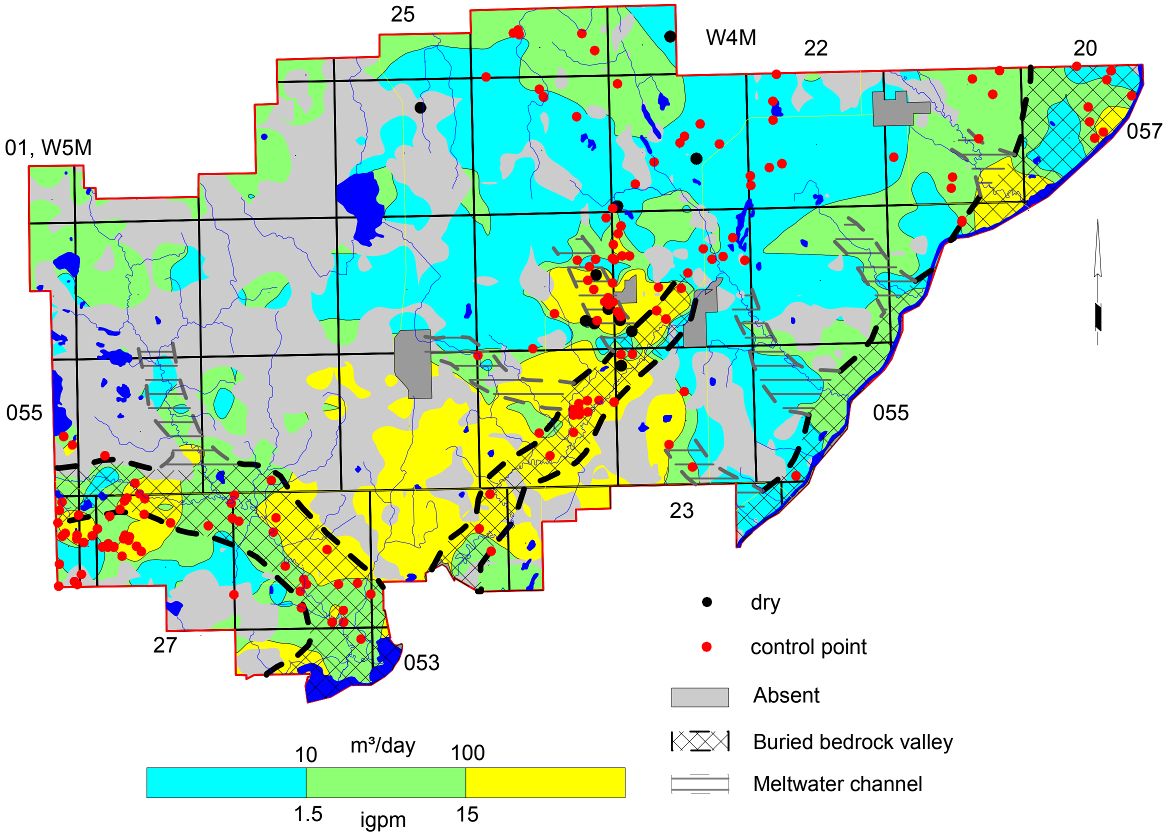
Completed in
▲ Upper surficial deposits
▲ Lower surficial deposits

⊠ Buried bedrock valley
▭ Meltwater channel

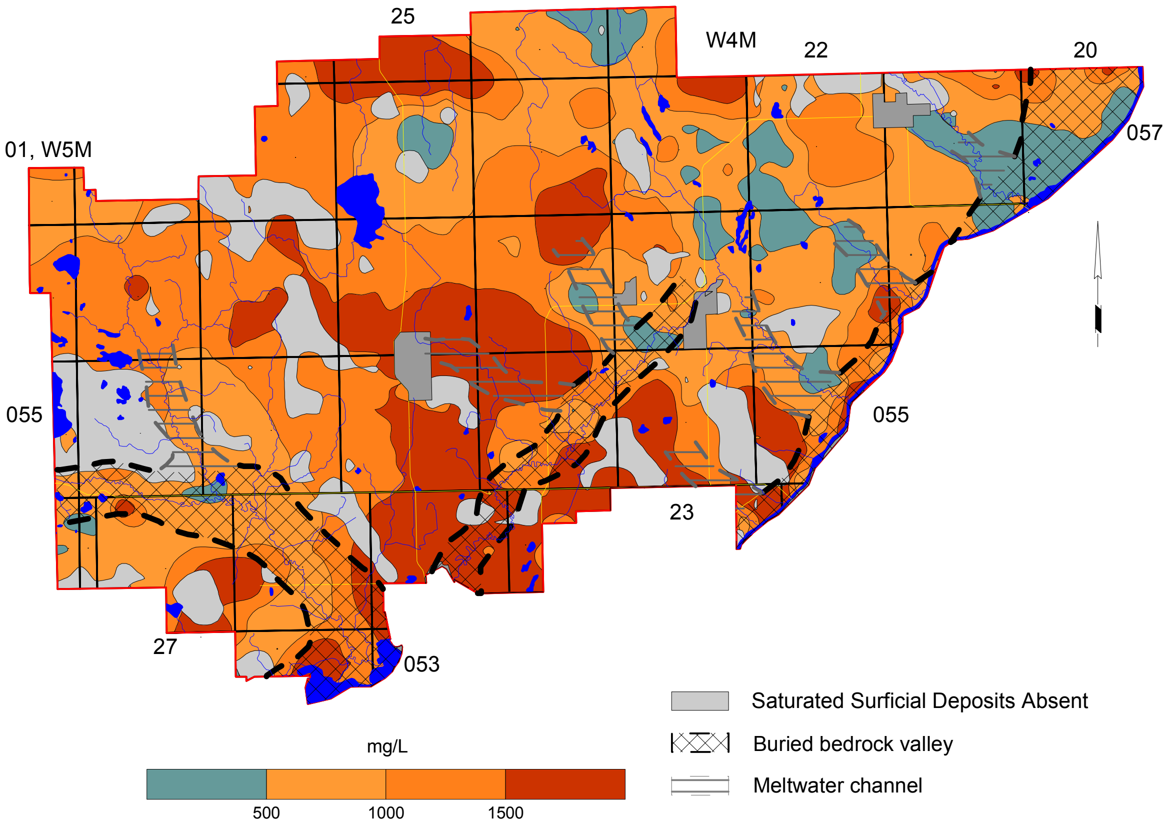
Thickness of Sand and Gravel Aquifer(s)



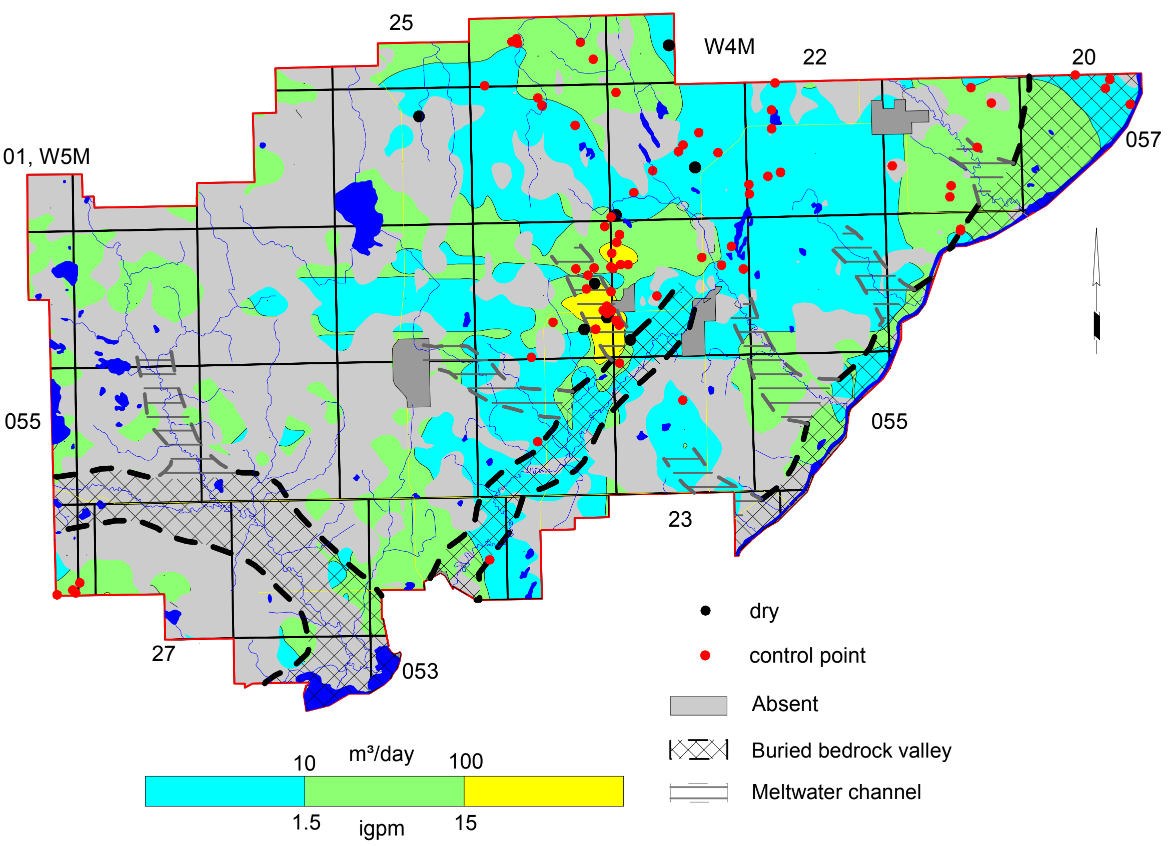
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)



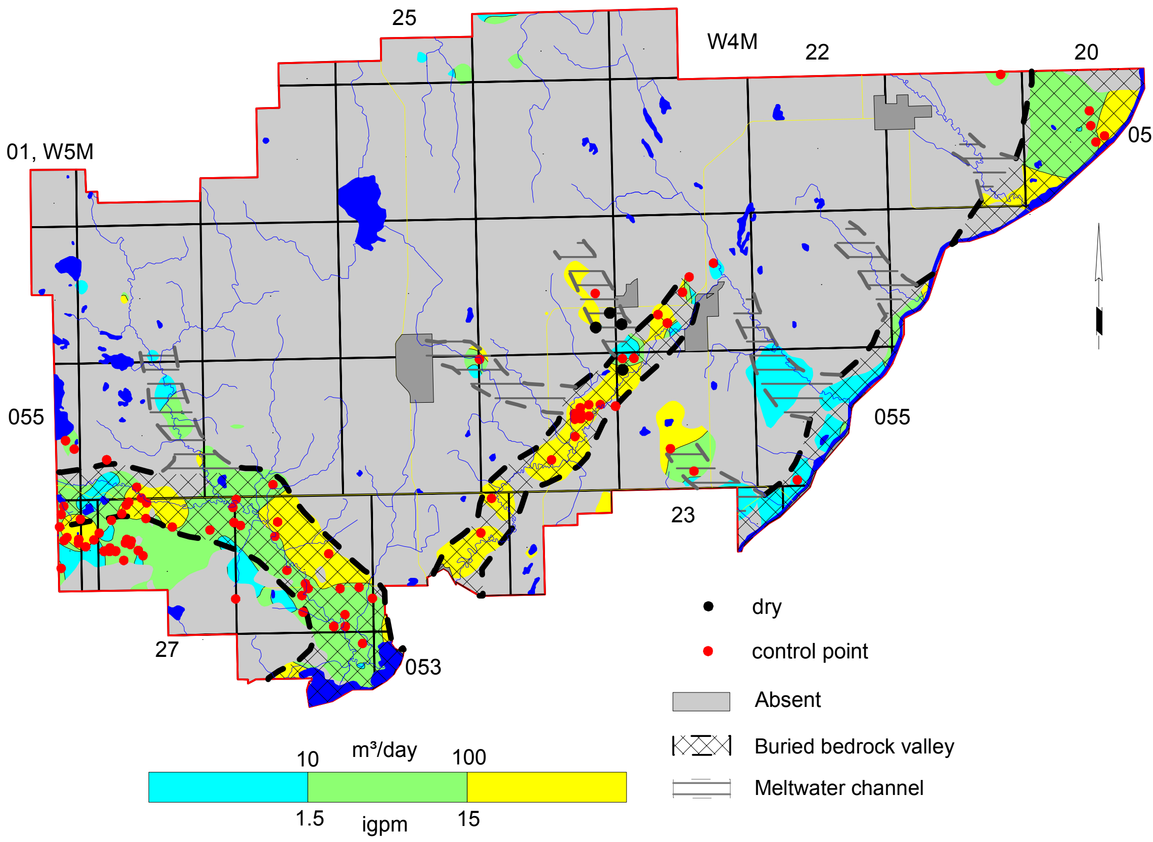
Total Dissolved Solids in Groundwater from Surficial Deposits



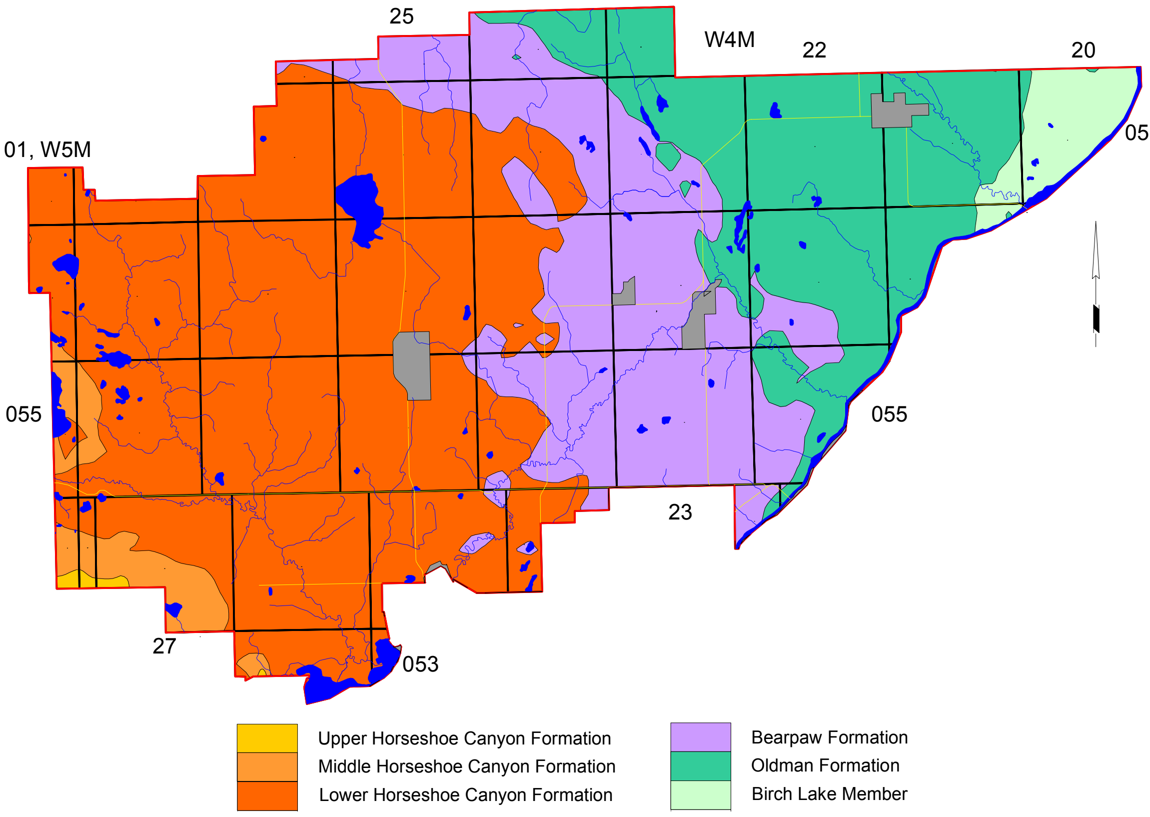
Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer



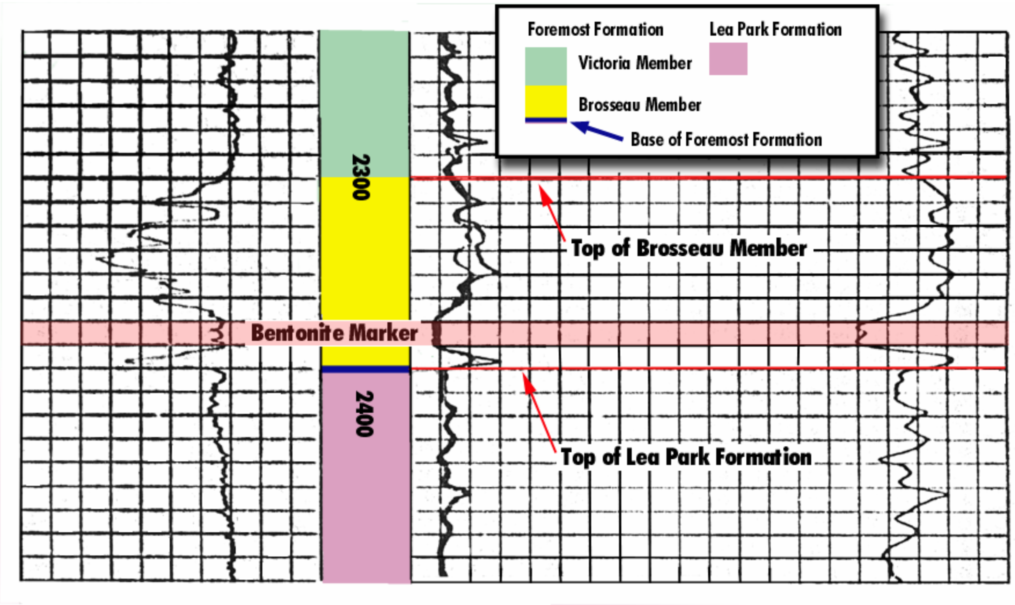
Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer



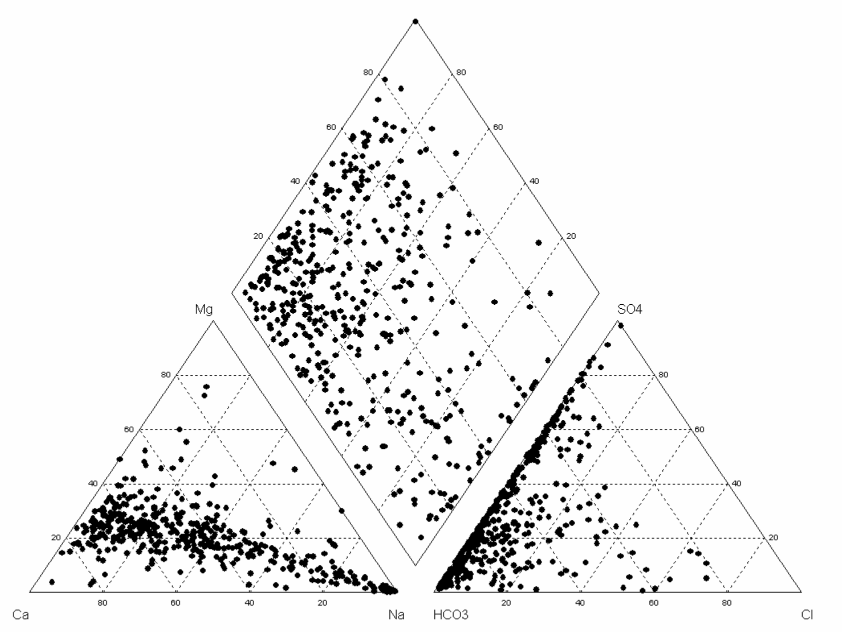
Bedrock Geology



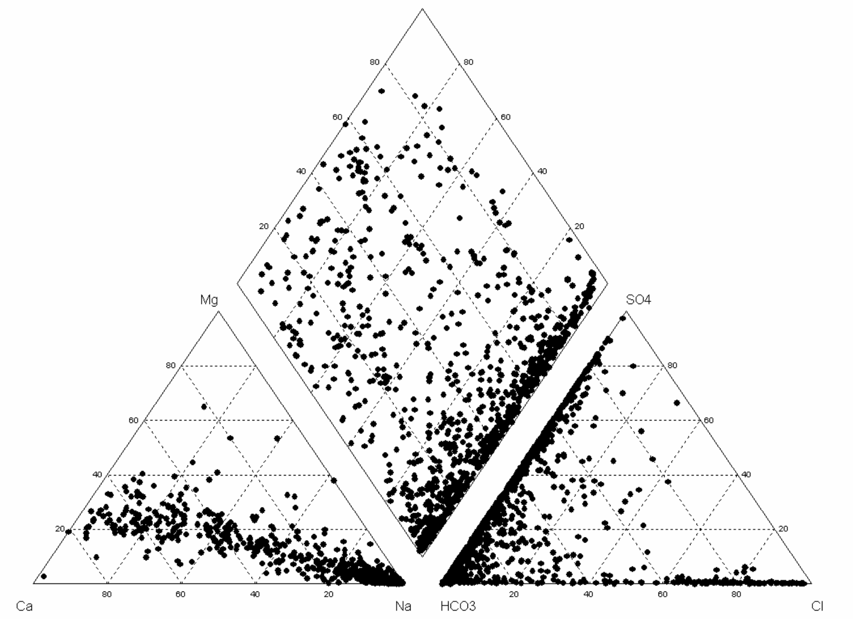
E-Log Showing Base of Foremost Formation



Piper Diagrams

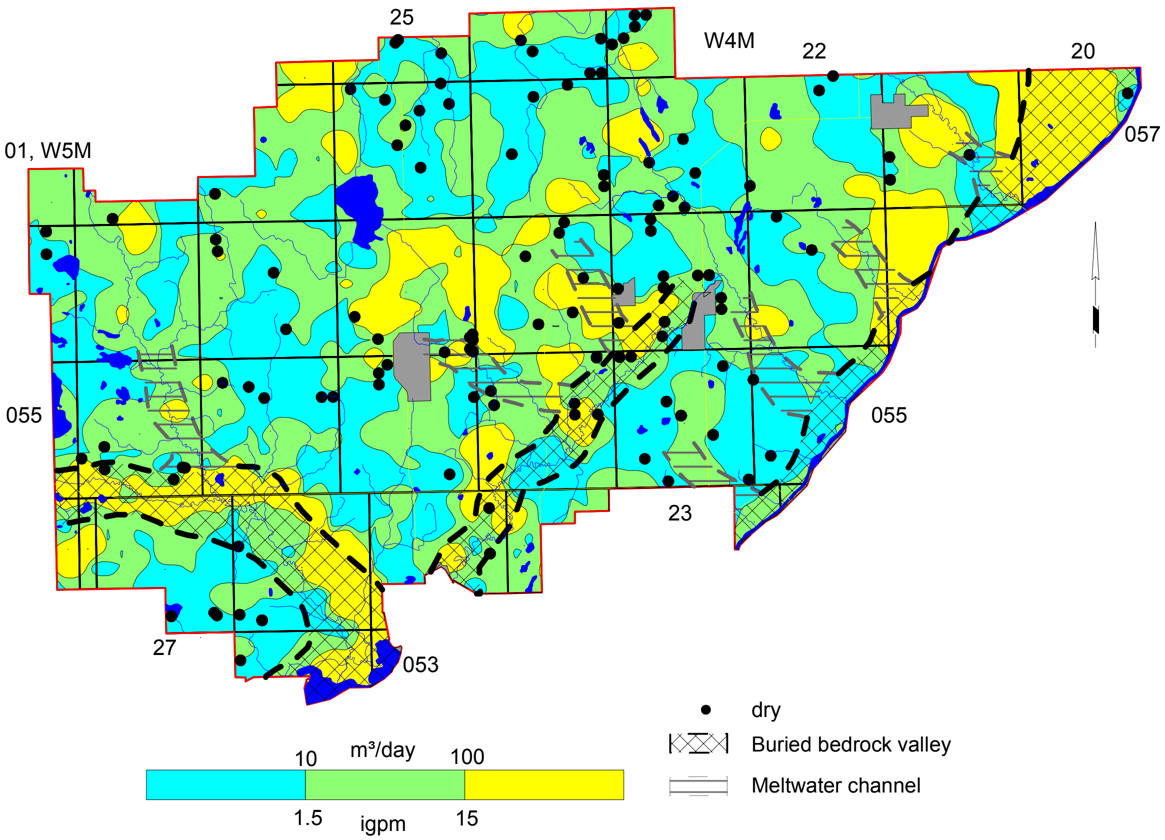


Surficial Deposits

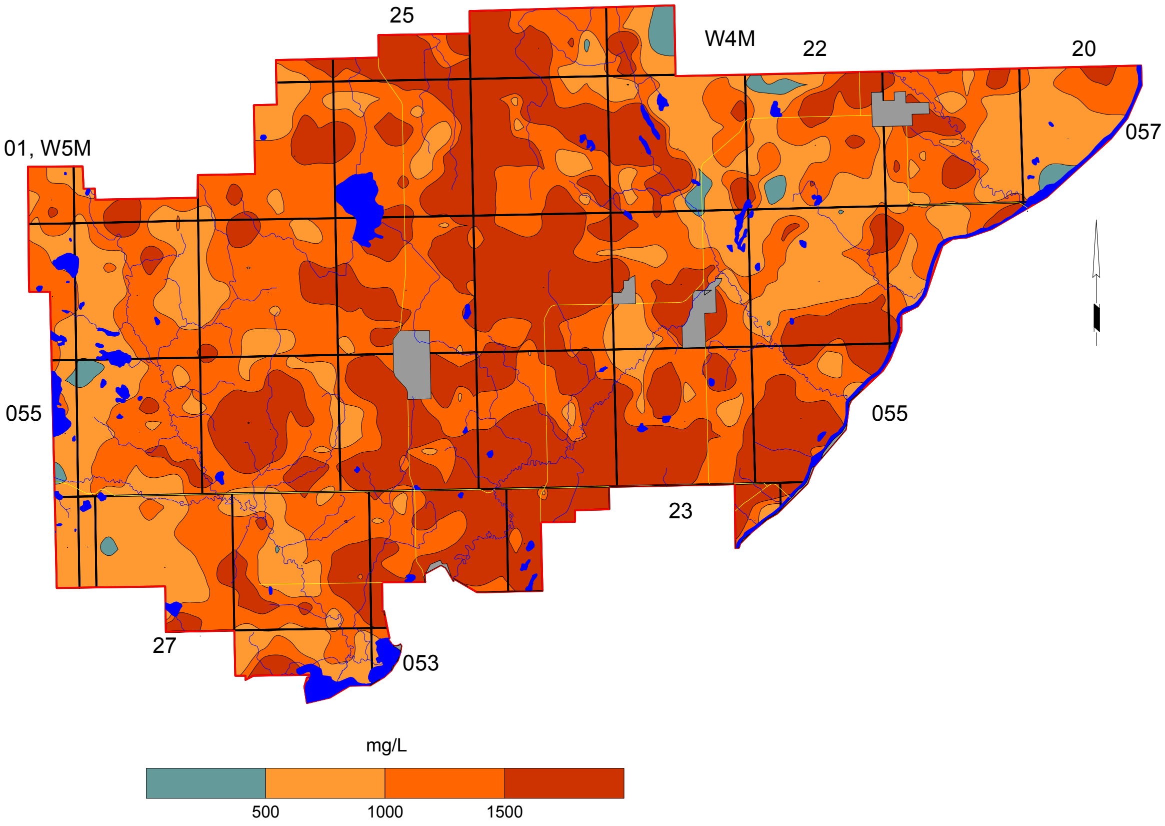


Bedrock Aquifers

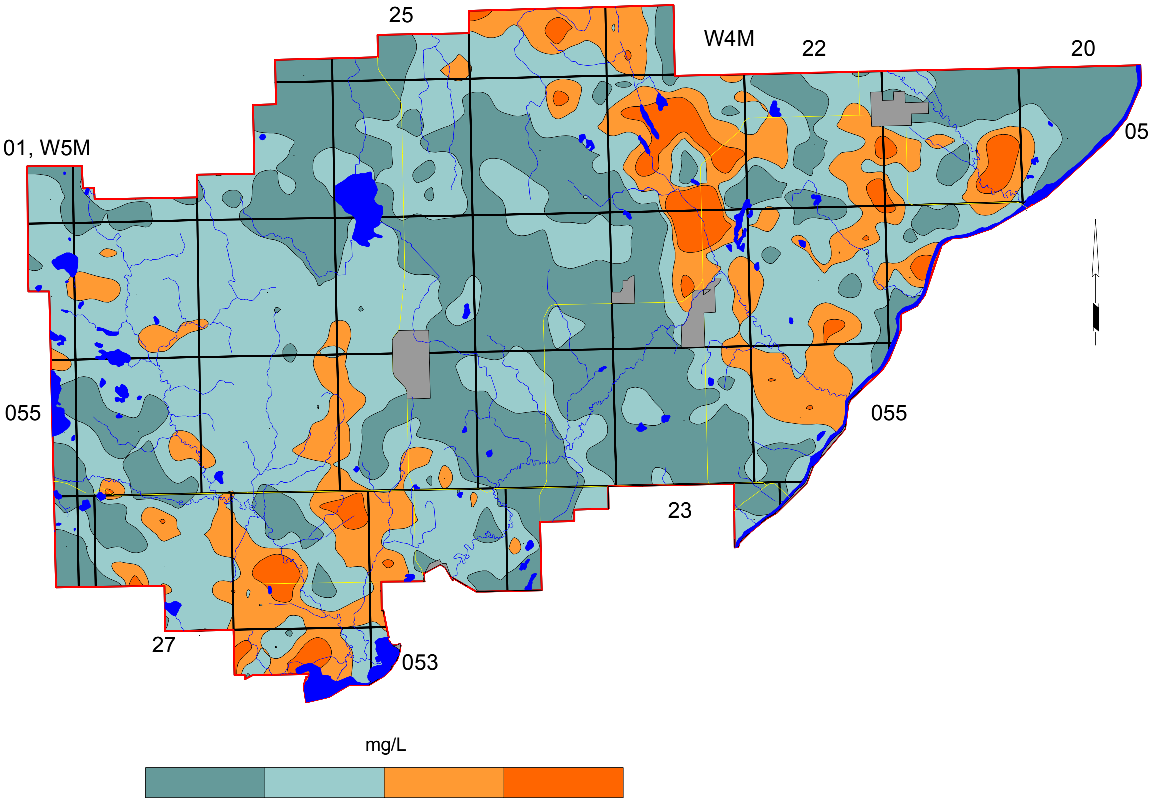
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)



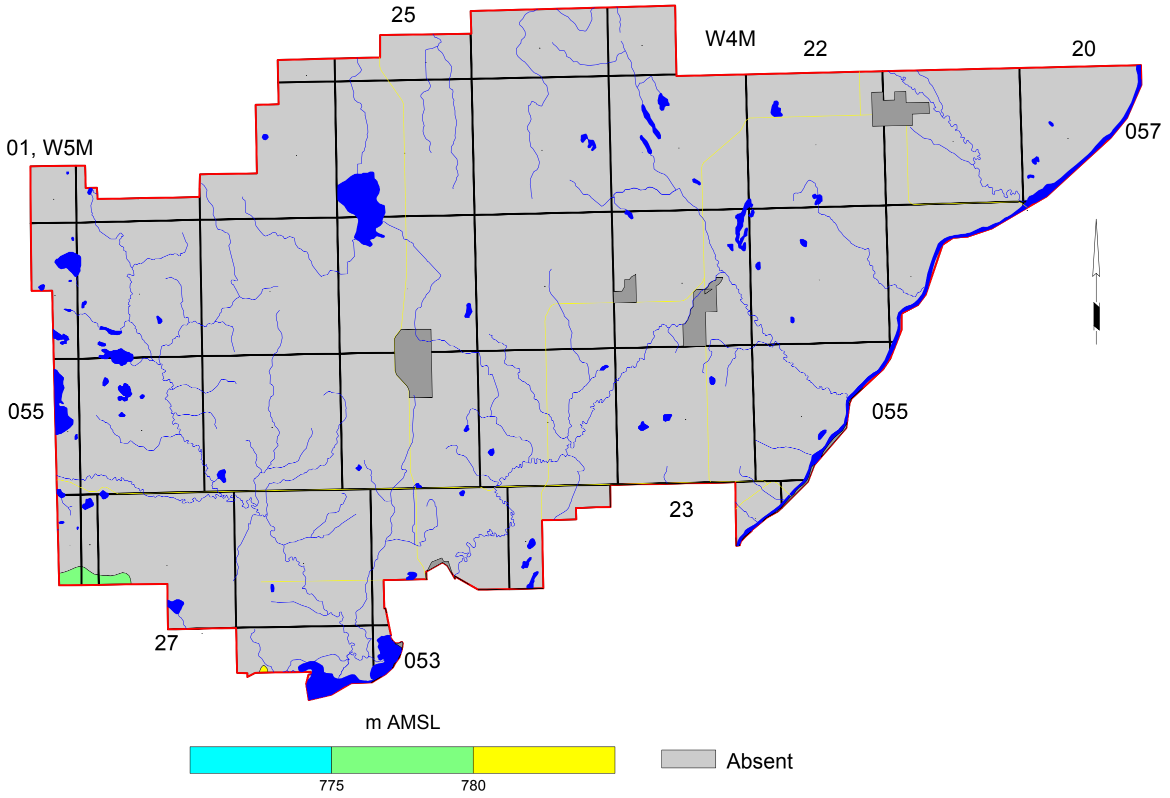
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)



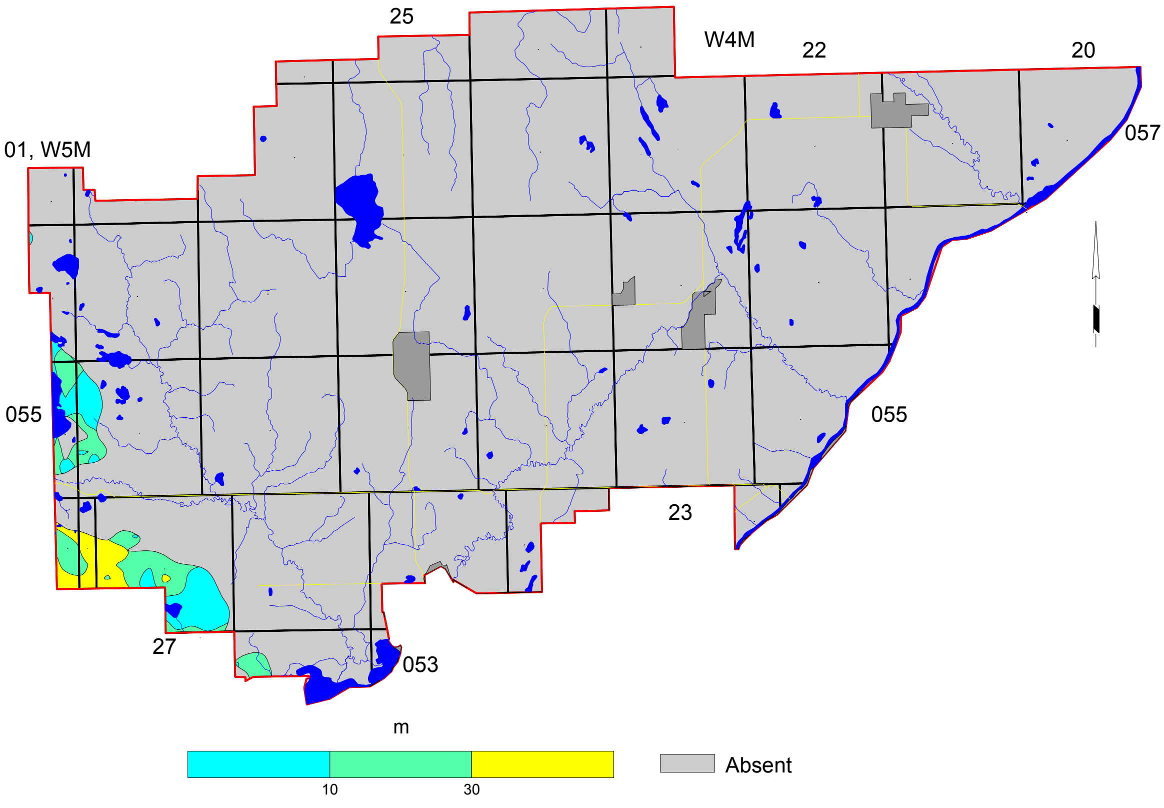
Fluoride in Groundwater from Upper Bedrock Aquifer(s)



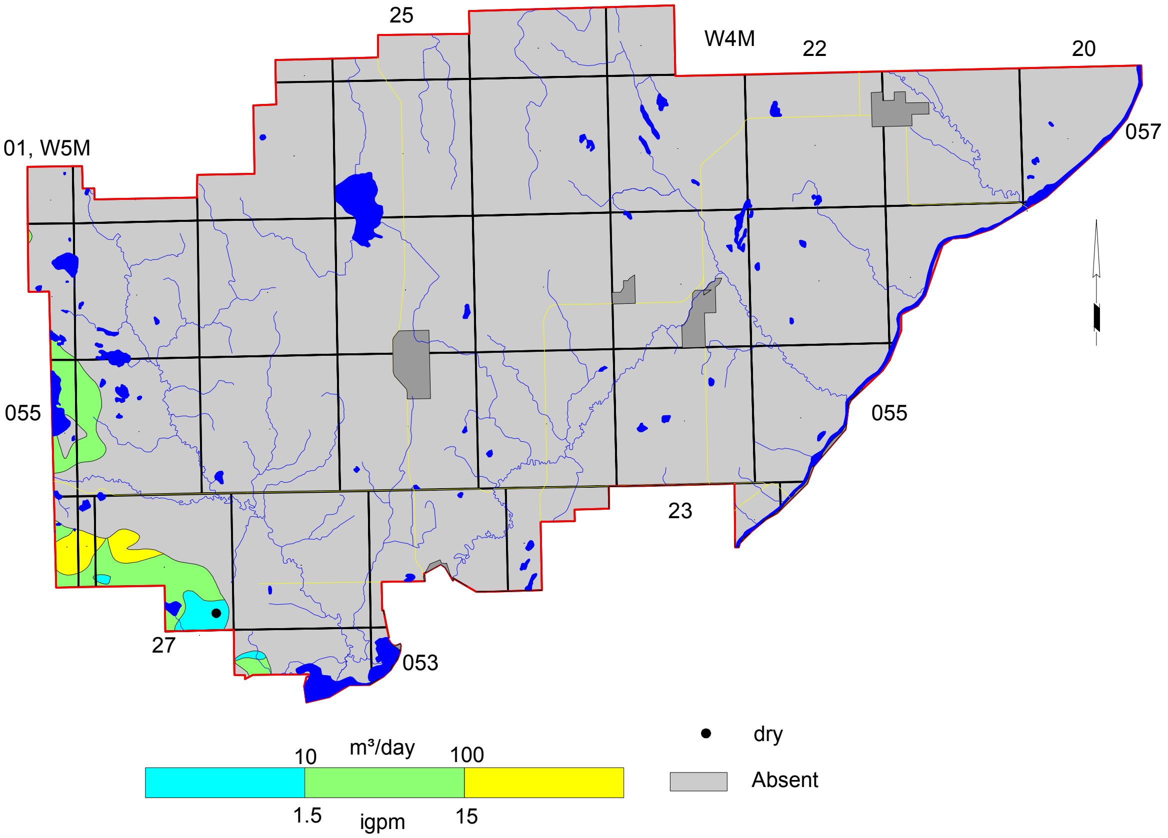
Depth to Top of Upper Horseshoe Canyon Formation



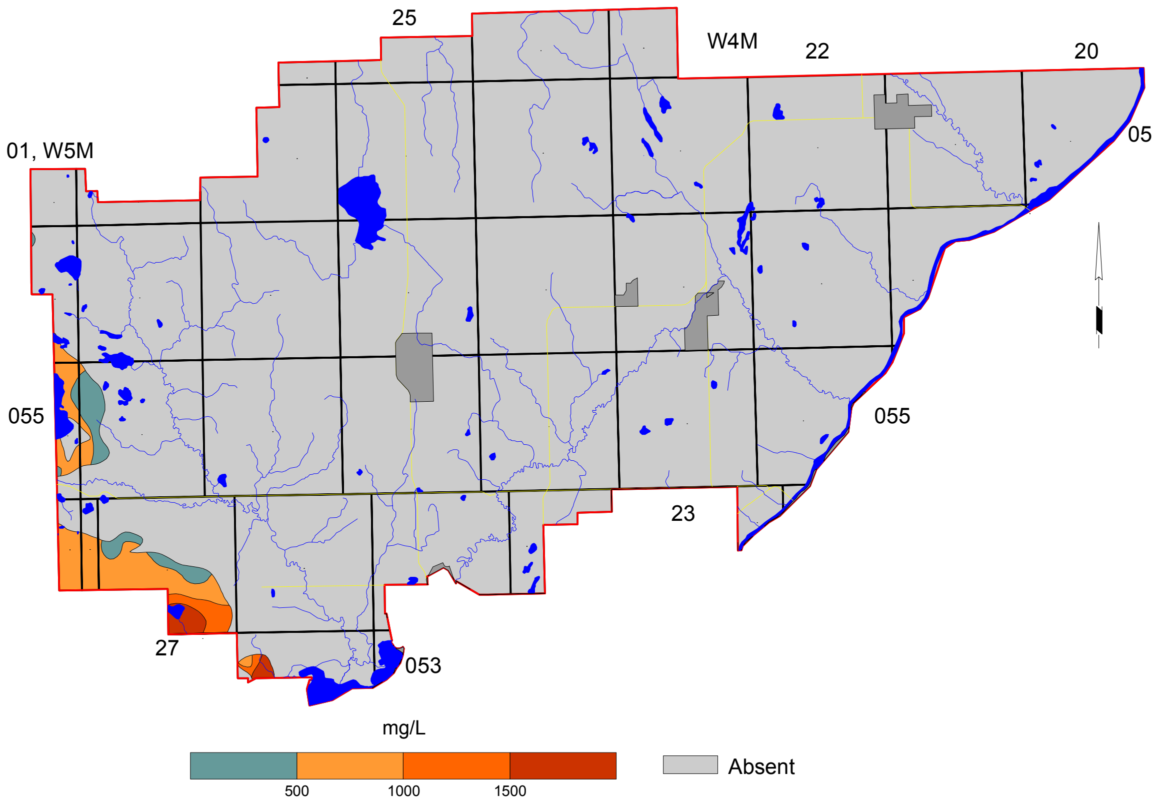
Depth to Top of Middle Horseshoe Canyon Formation



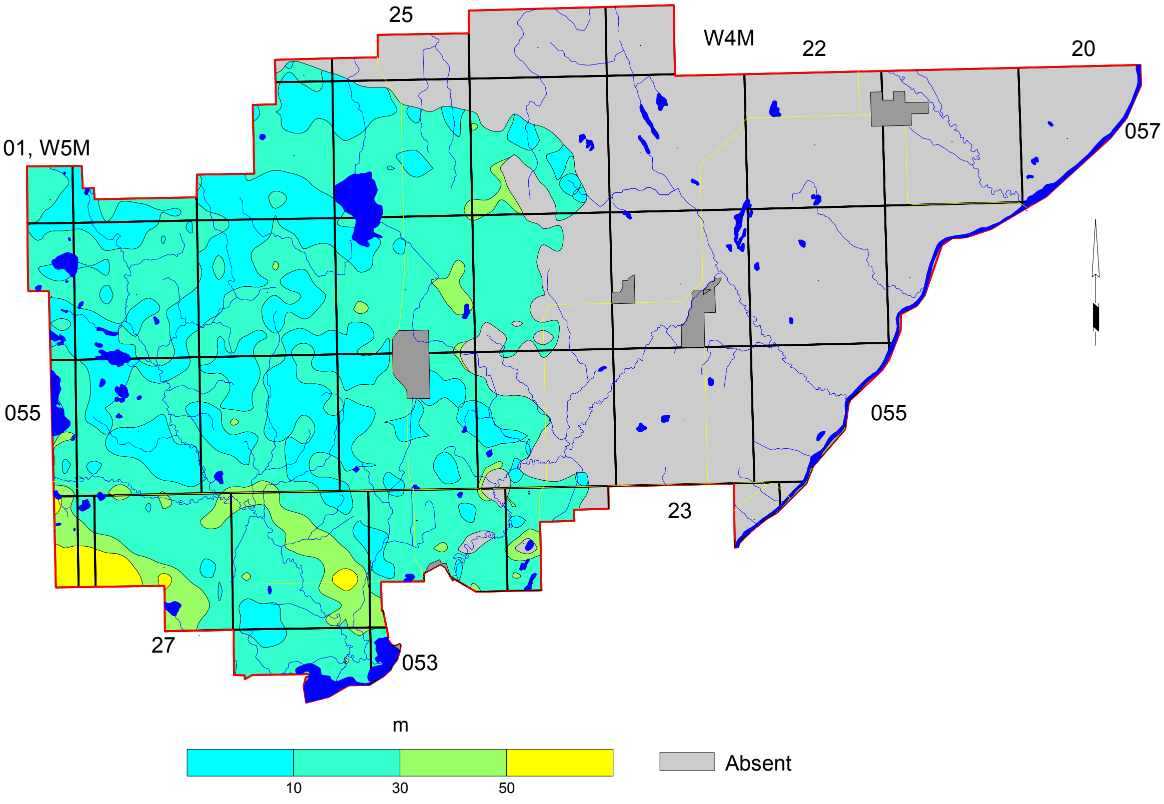
Apparent Yield for Water Wells Completed through Middle Horseshoe Canyon Aquifer



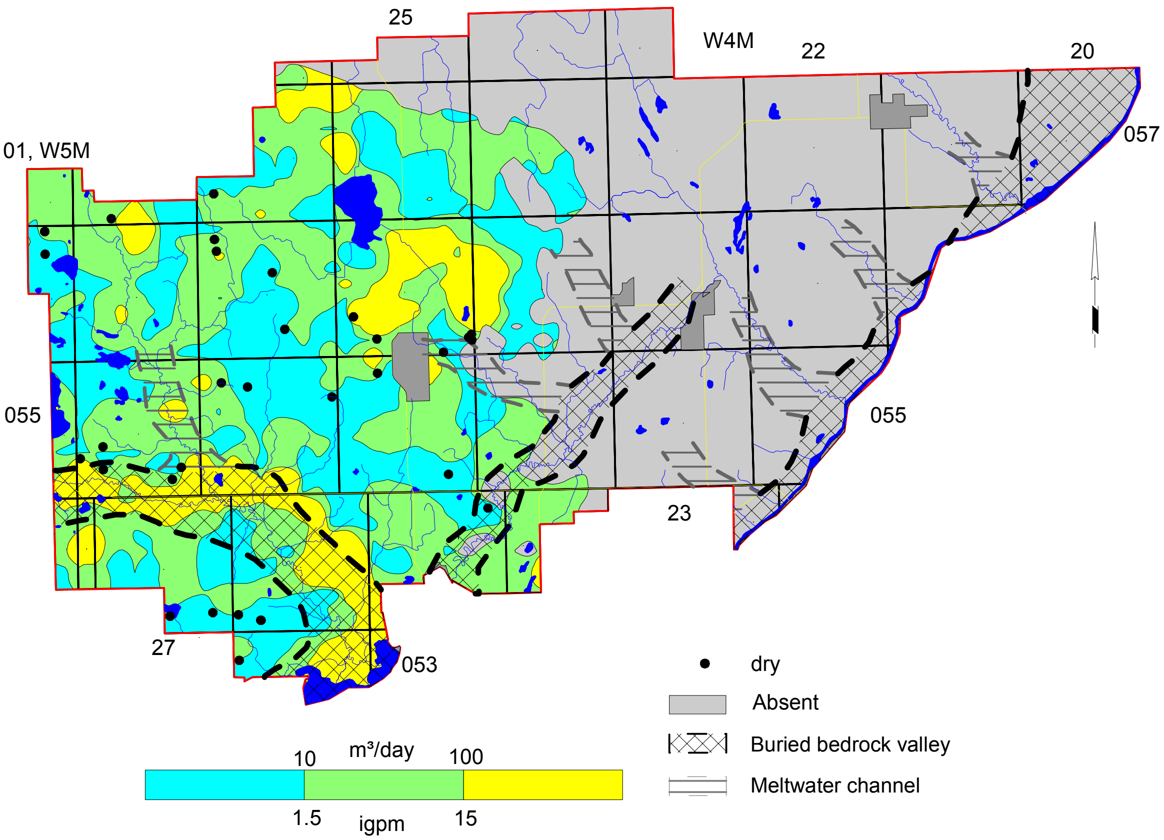
Total Dissolved Solids in Groundwater from Middle Horseshoe Canyon Aquifer



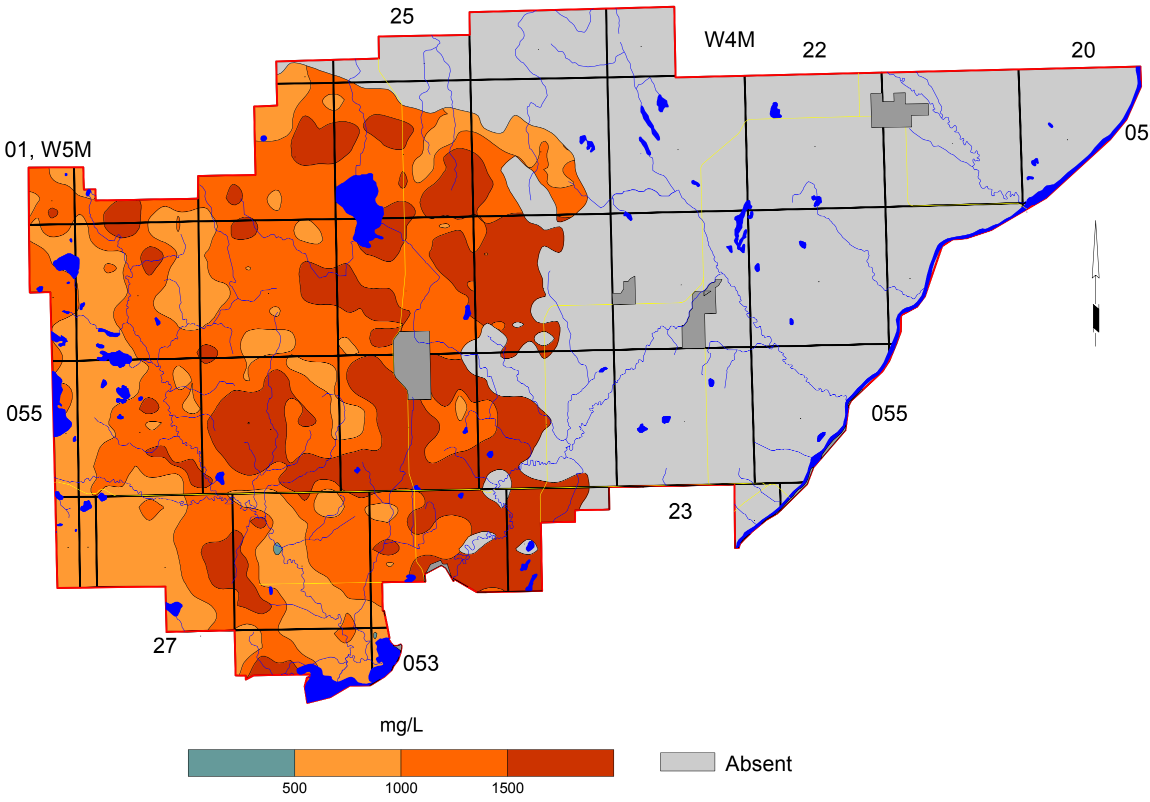
Depth to Top of Lower Horseshoe Canyon Formation



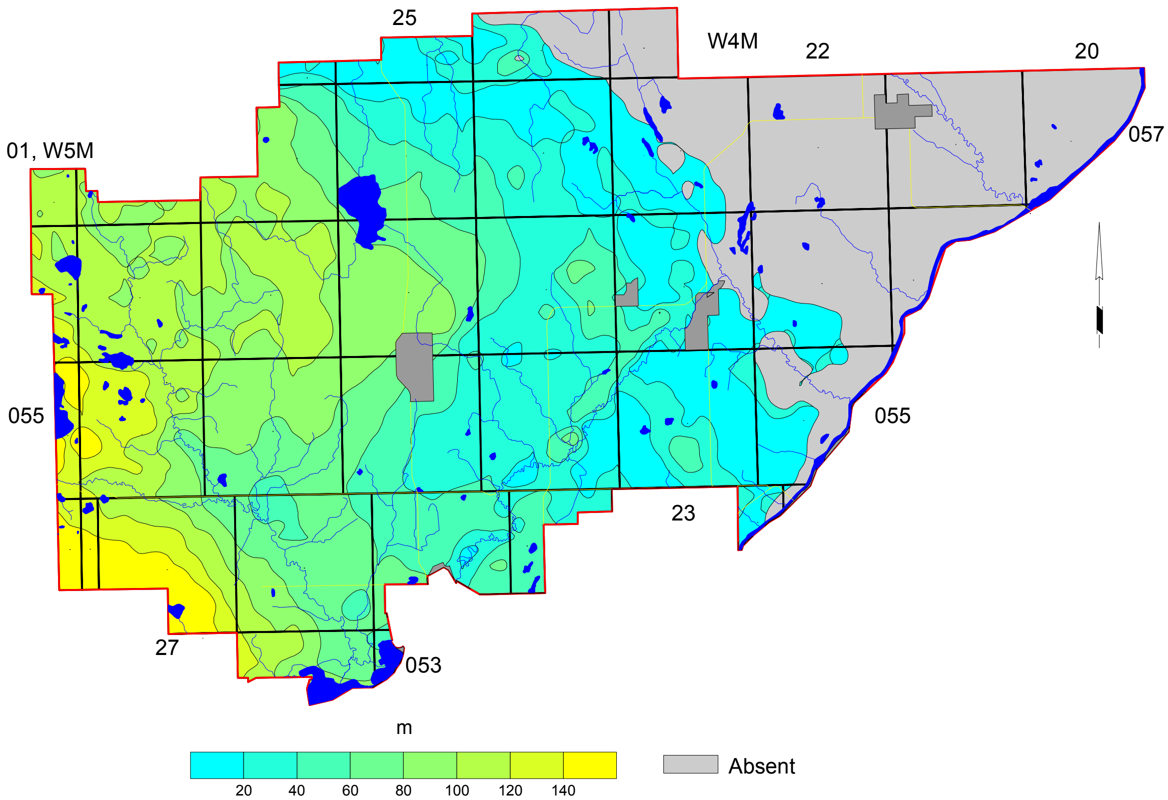
Apparent Yield for Water Wells Completed through Lower Horseshoe Canyon Aquifer



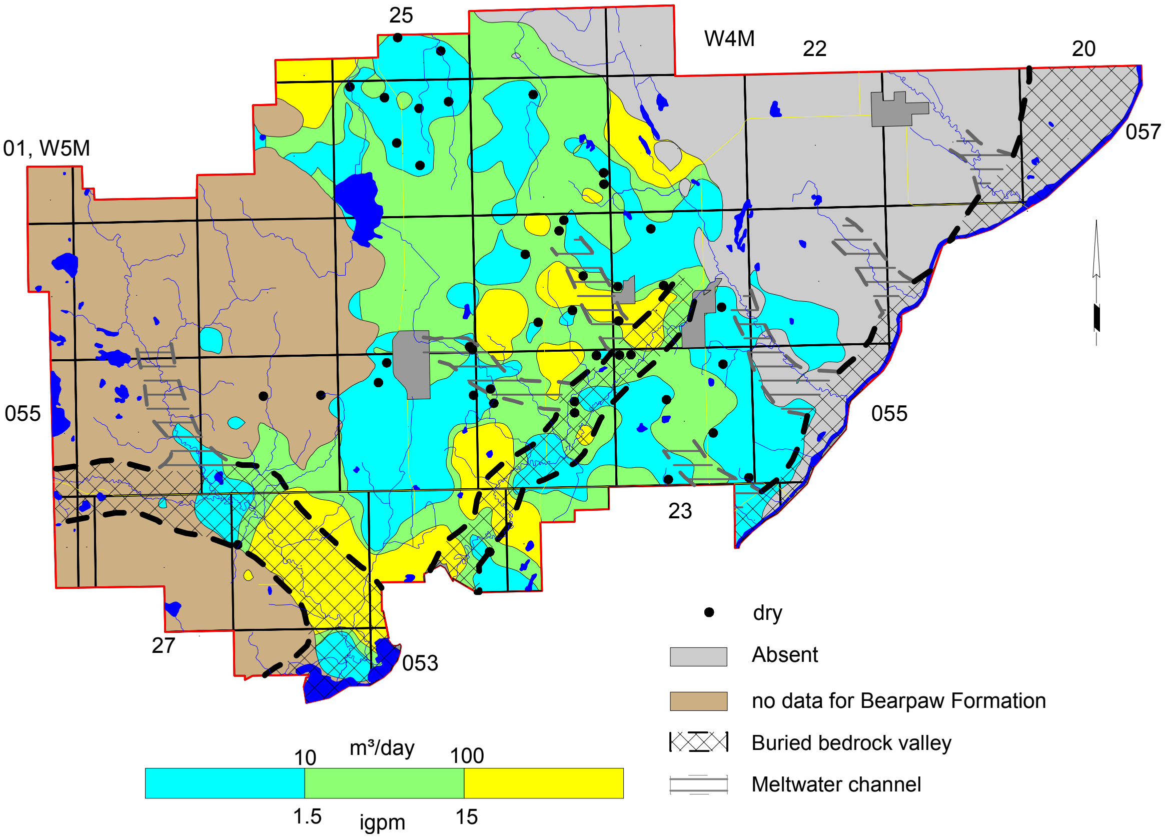
Total Dissolved Solids in Groundwater from Lower Horseshoe Canyon Aquifer



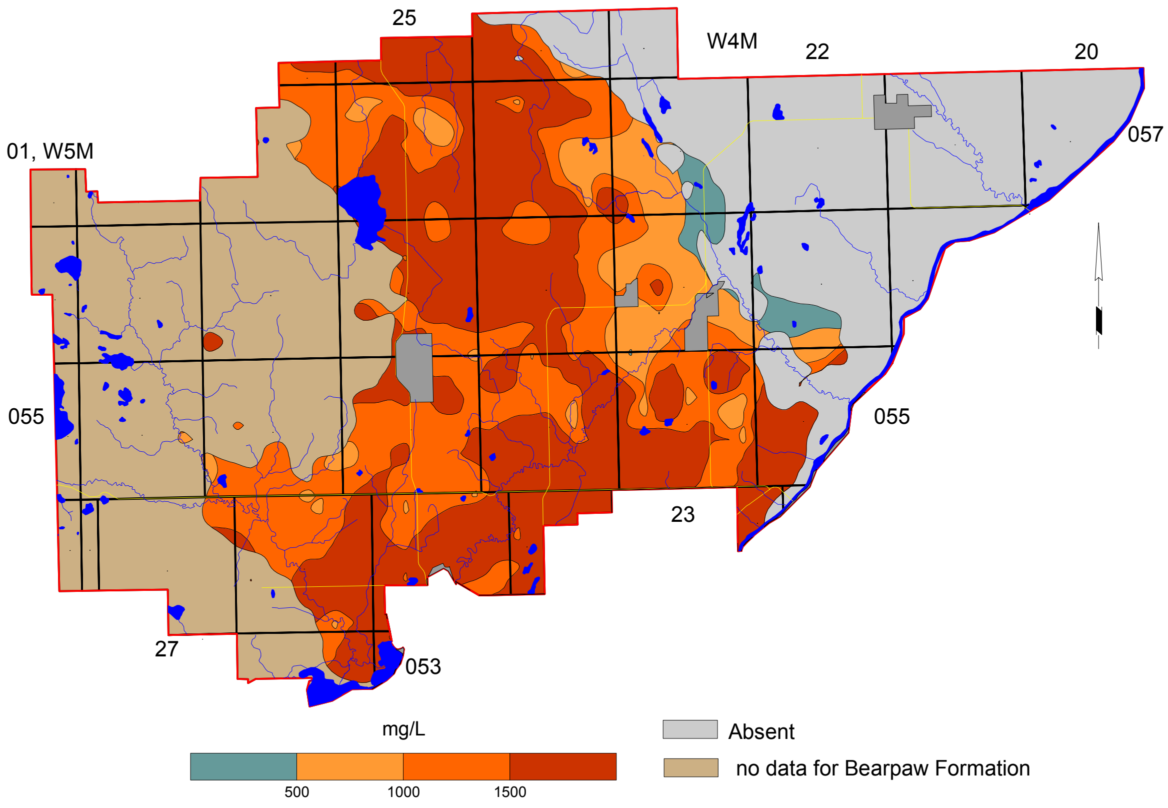
Depth to Top of Bearpaw Formation



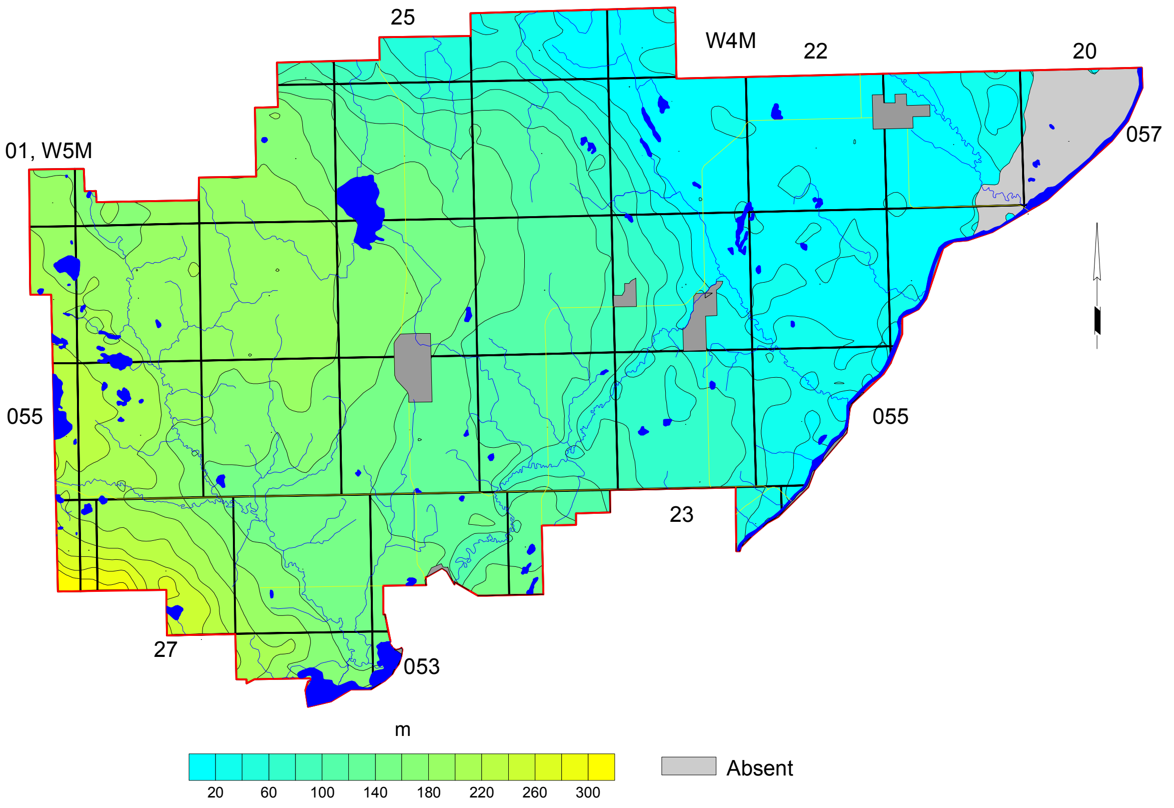
Apparent Yield for Water Wells Completed through Bearpaw Aquifer



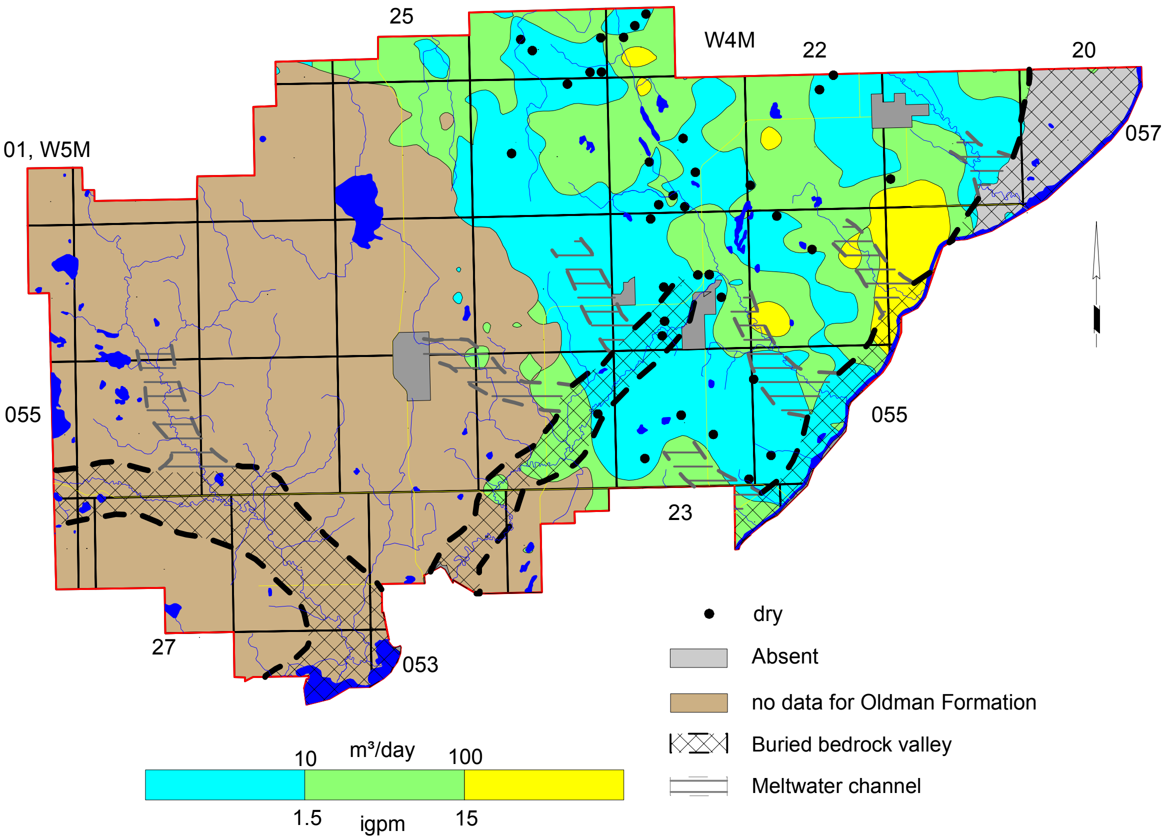
Total Dissolved Solids in Groundwater from Bearpaw Aquifer



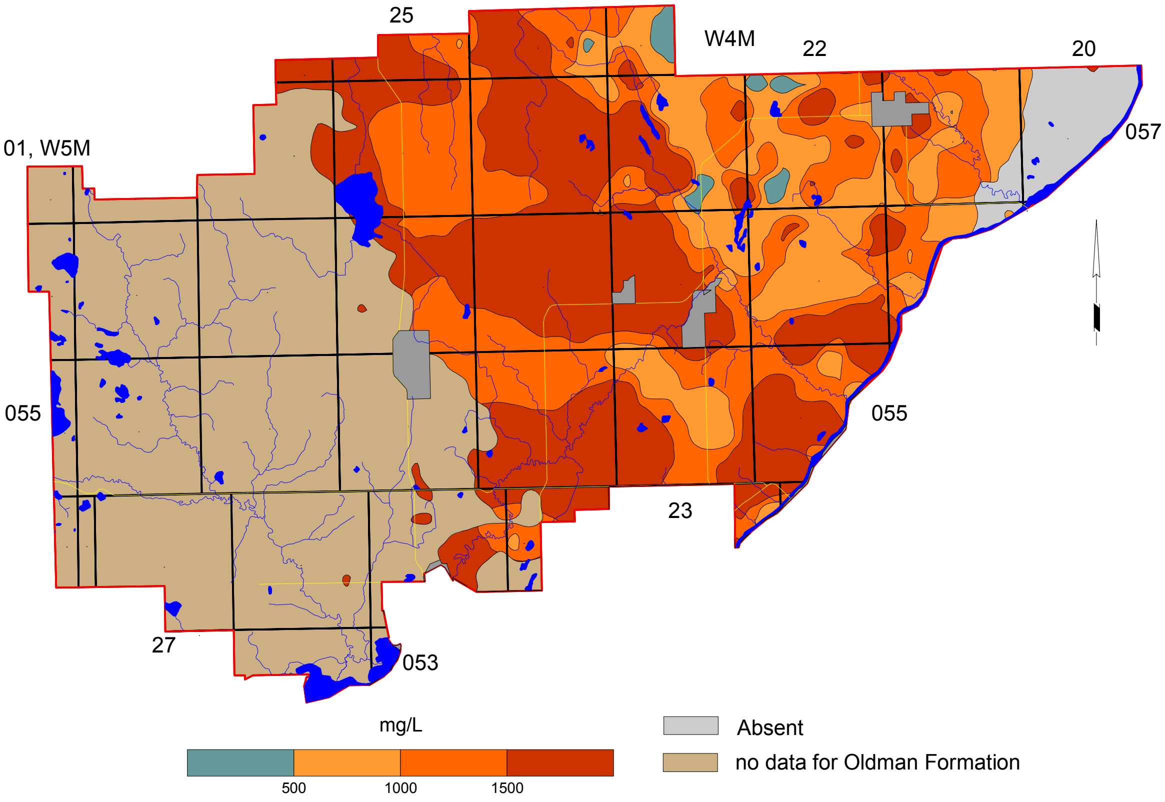
Depth to Top of Oldman Formation



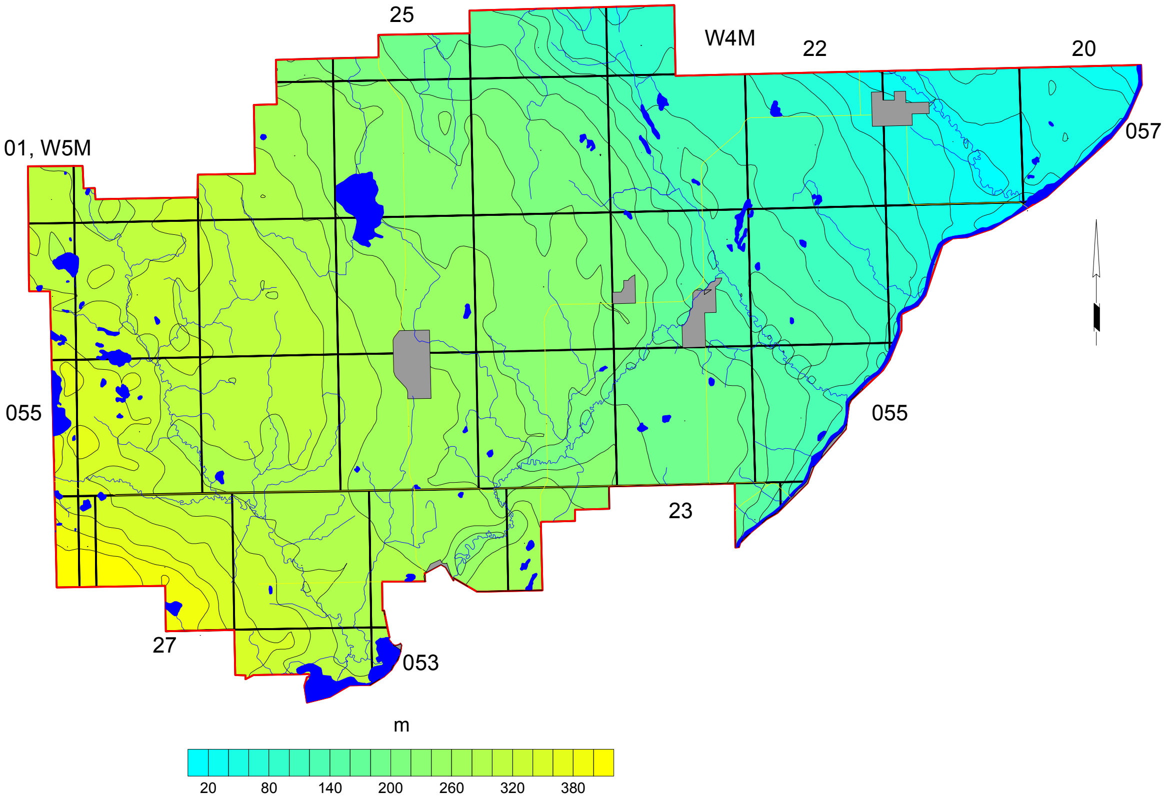
Apparent Yield for Water Wells Completed through Oldman Aquifer



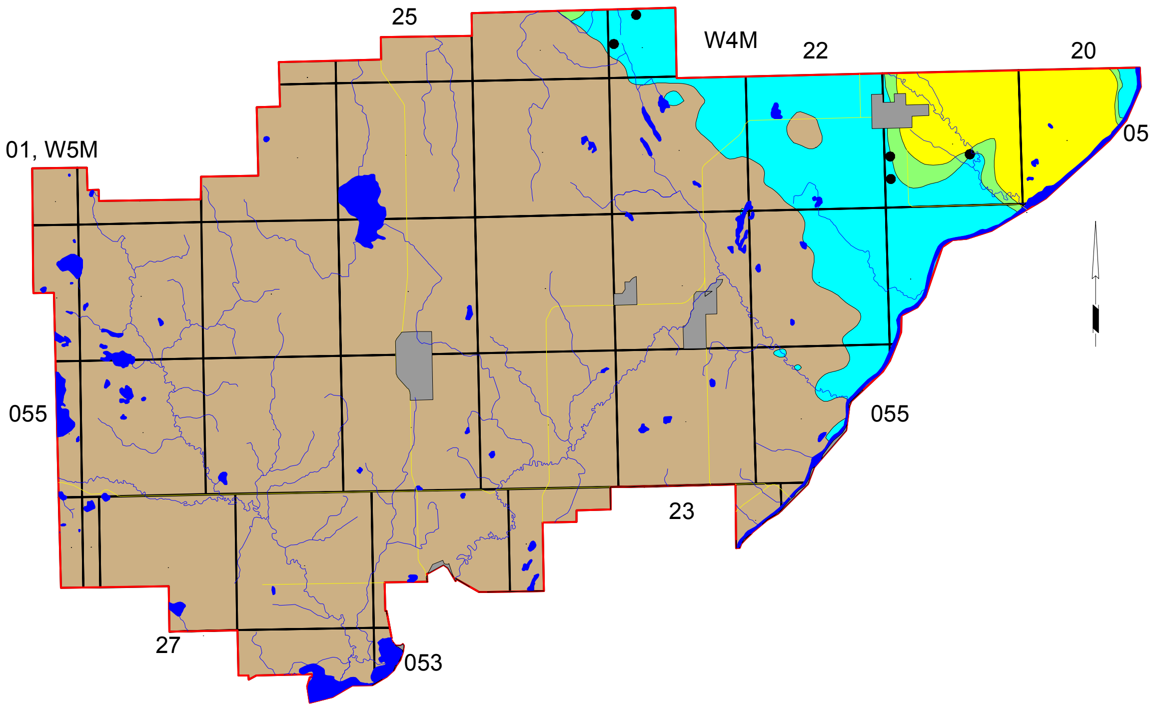
Total Dissolved Solids in Groundwater from Oldman Aquifer



Depth to Top of Birch Lake Member



Apparent Yield for Water Wells Completed through Birch Lake Aquifer

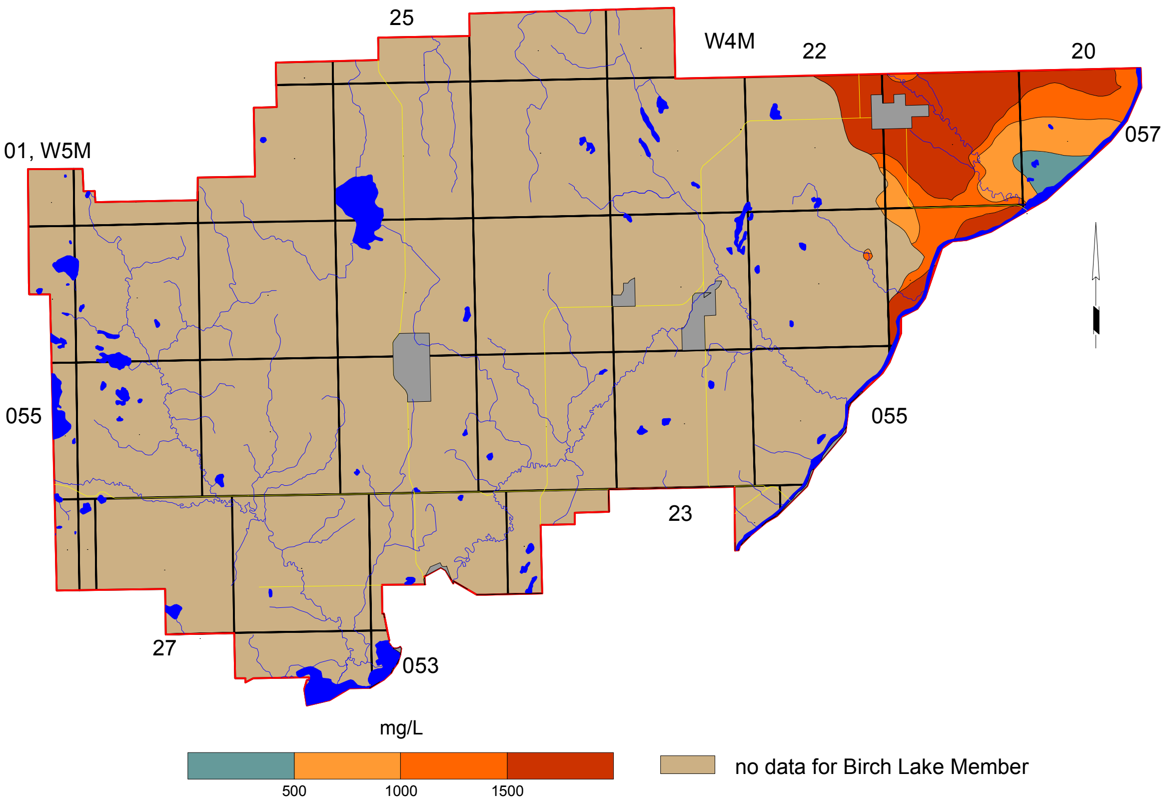


	m³/day	
🟦	🟩	🟨
	10 / 1.5	100 / 15
	igpm	

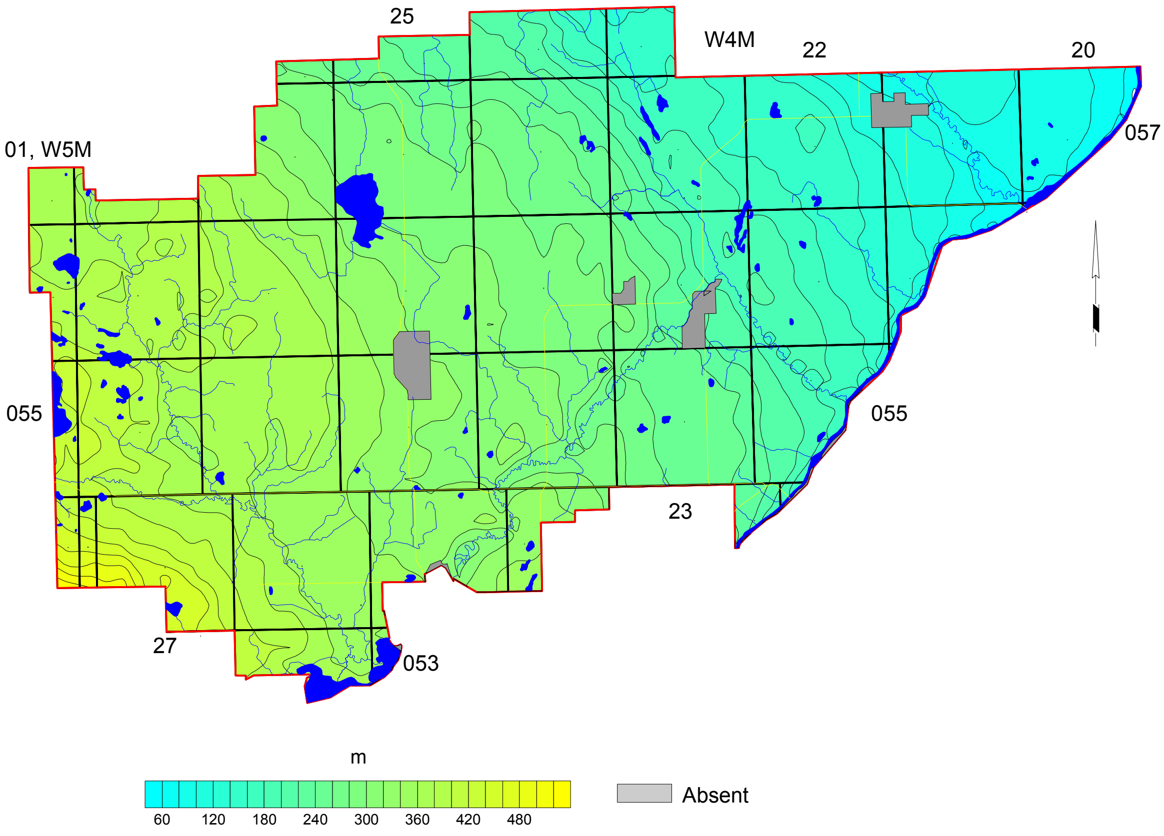
● dry

▨ no data for Birch Lake Member

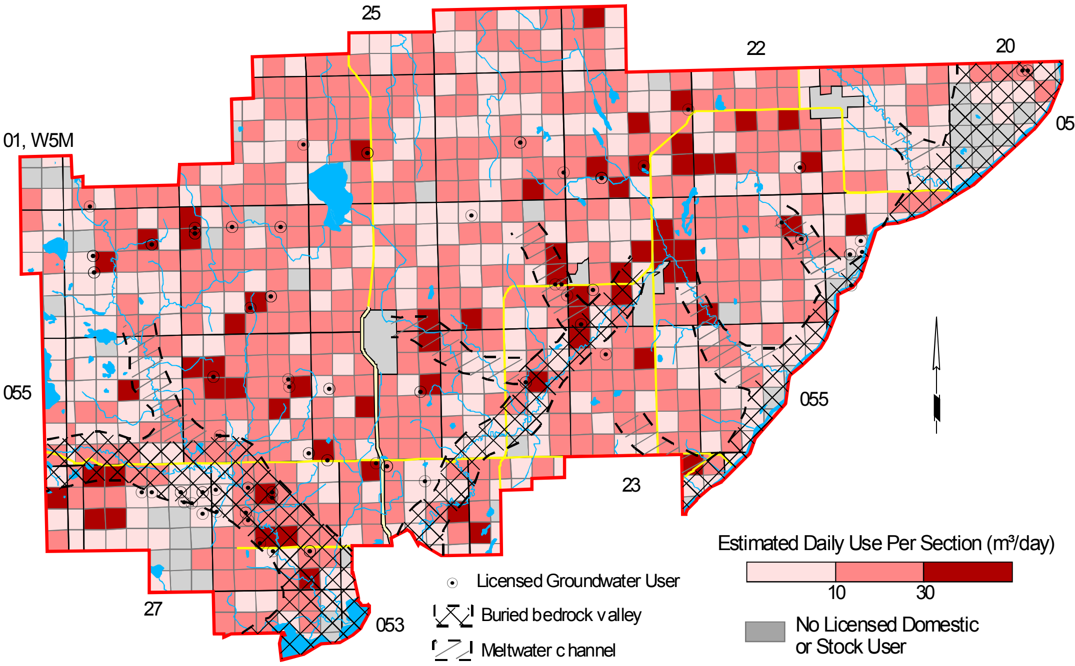
Total Dissolved Solids in Groundwater from Birch Lake Aquifer



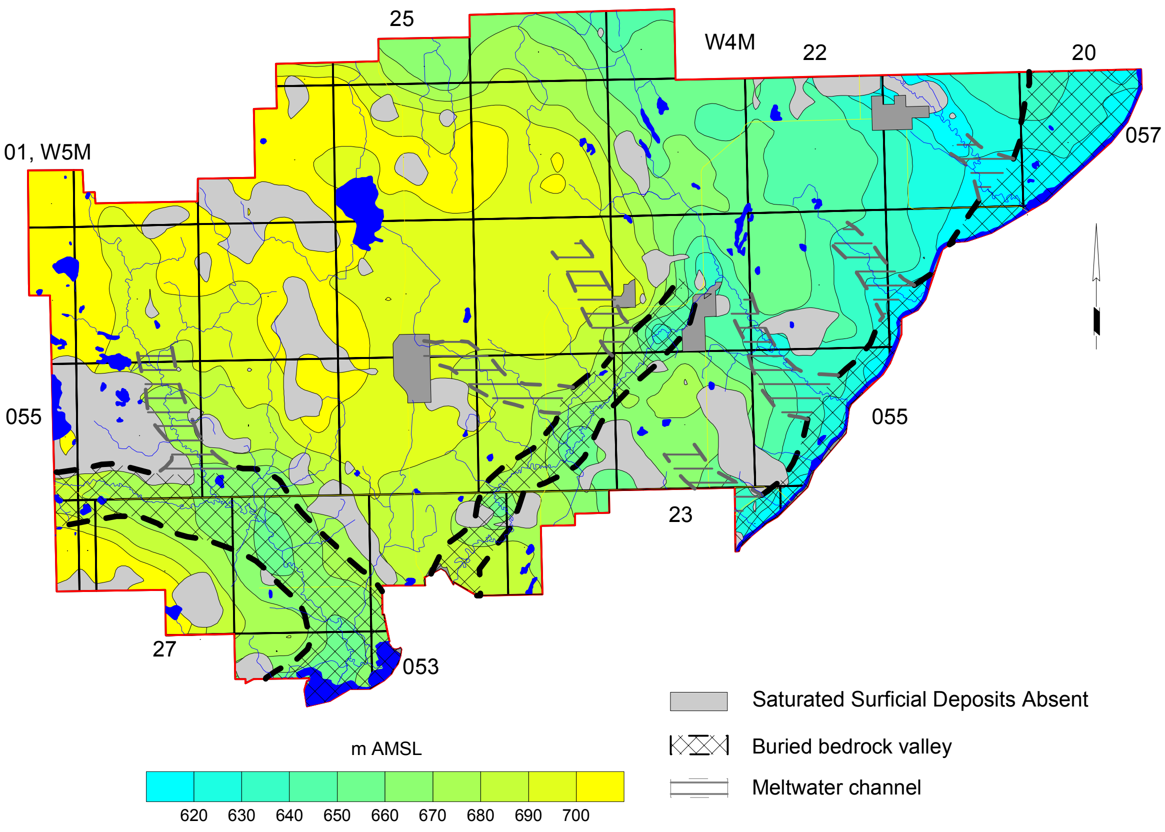
Depth to Top of Ribstone Creek Member



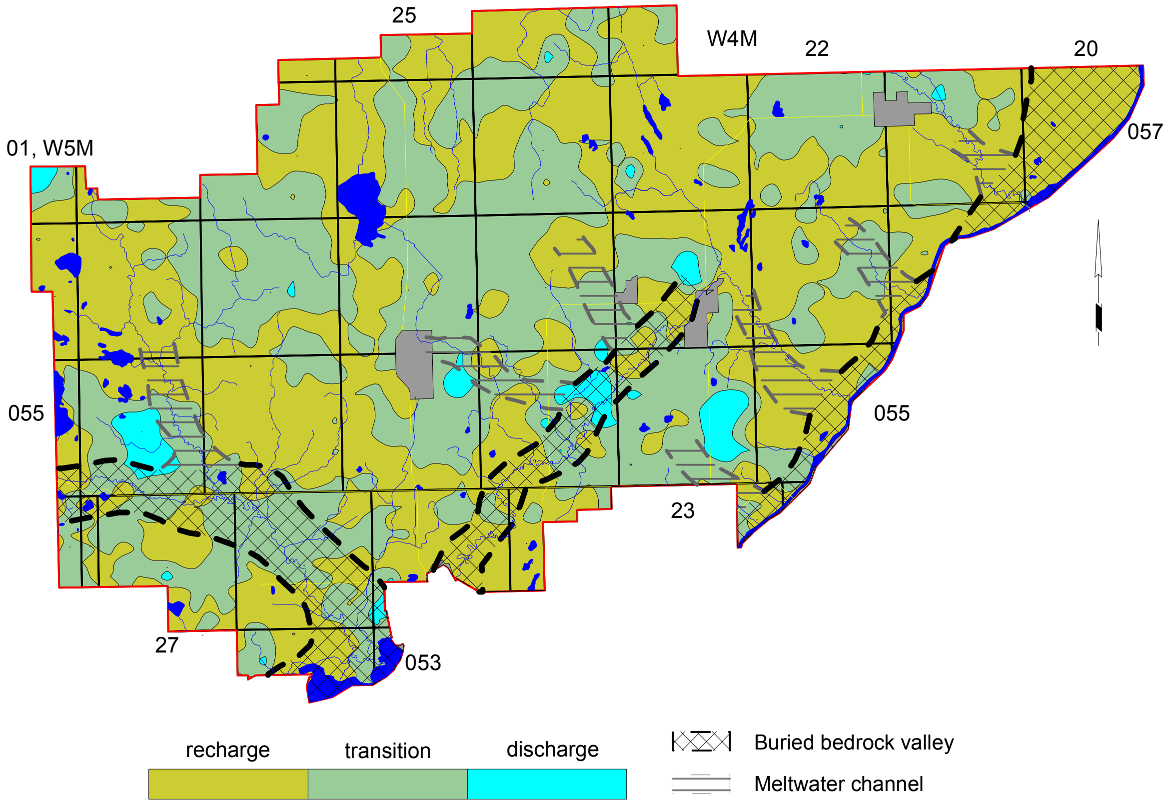
Estimated Water Well Use Per Section



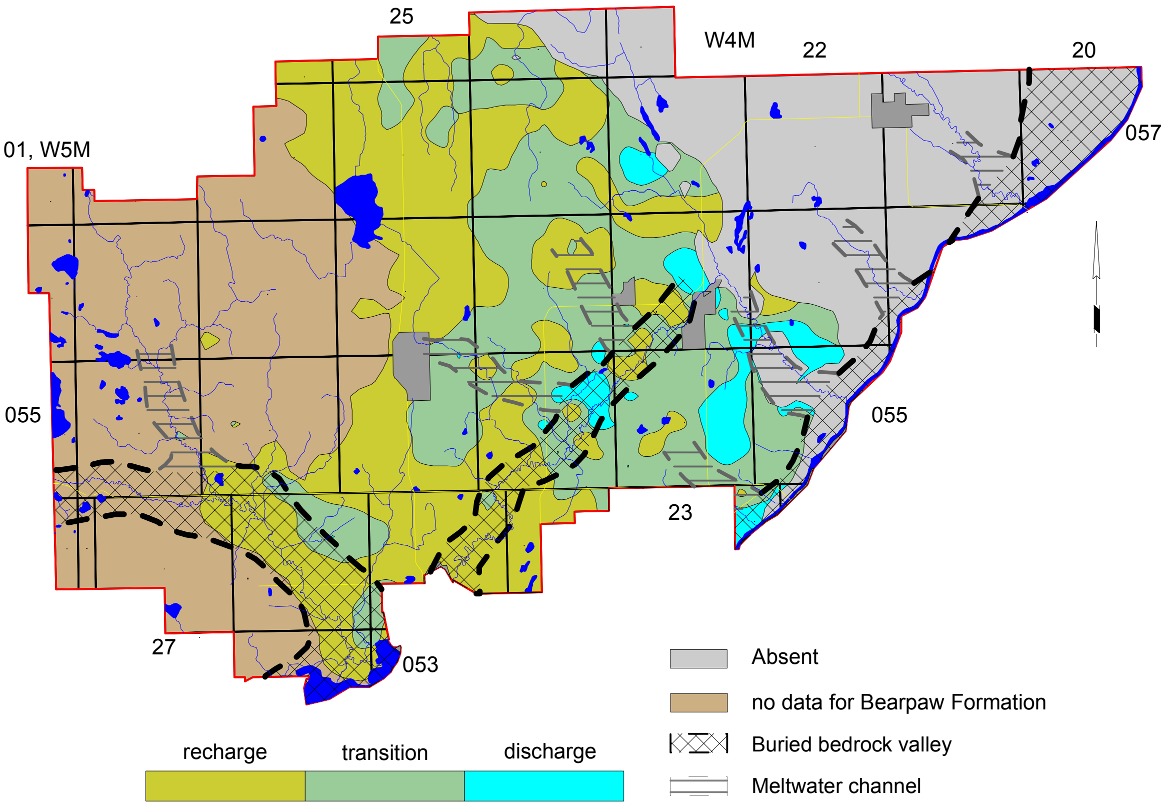
Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep



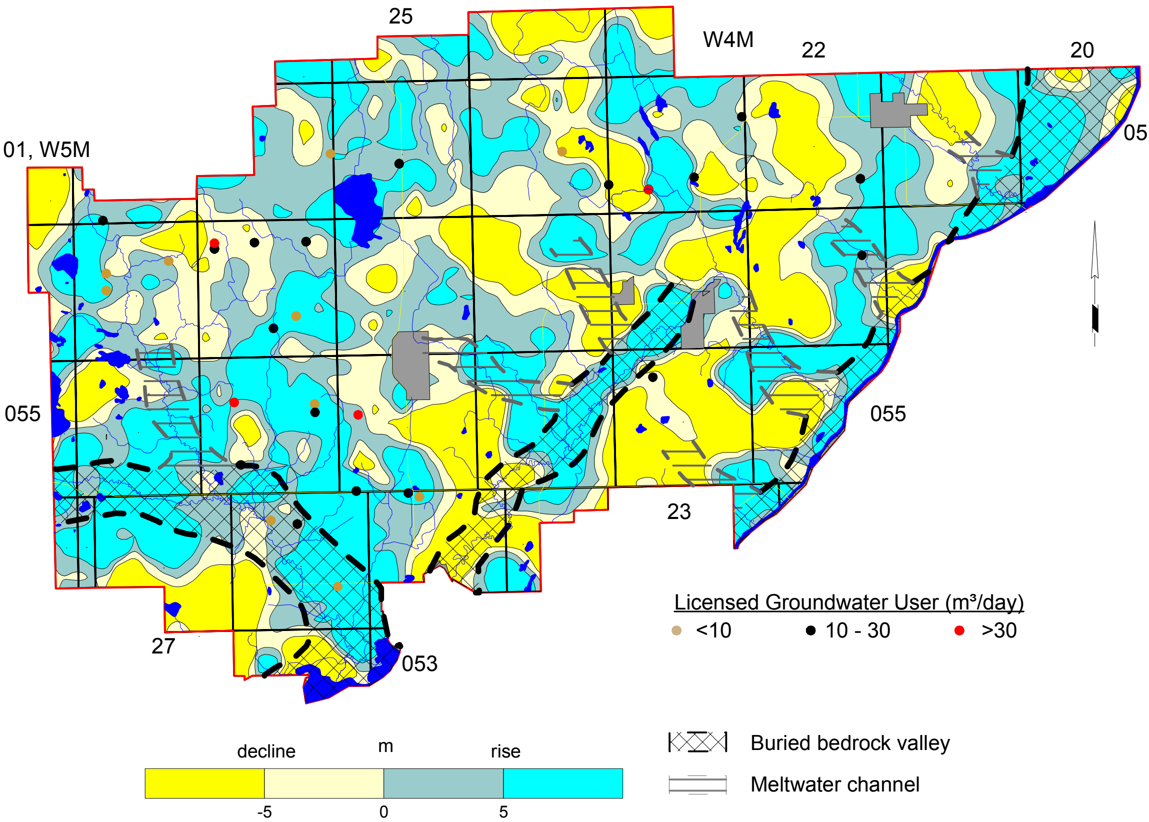
Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)



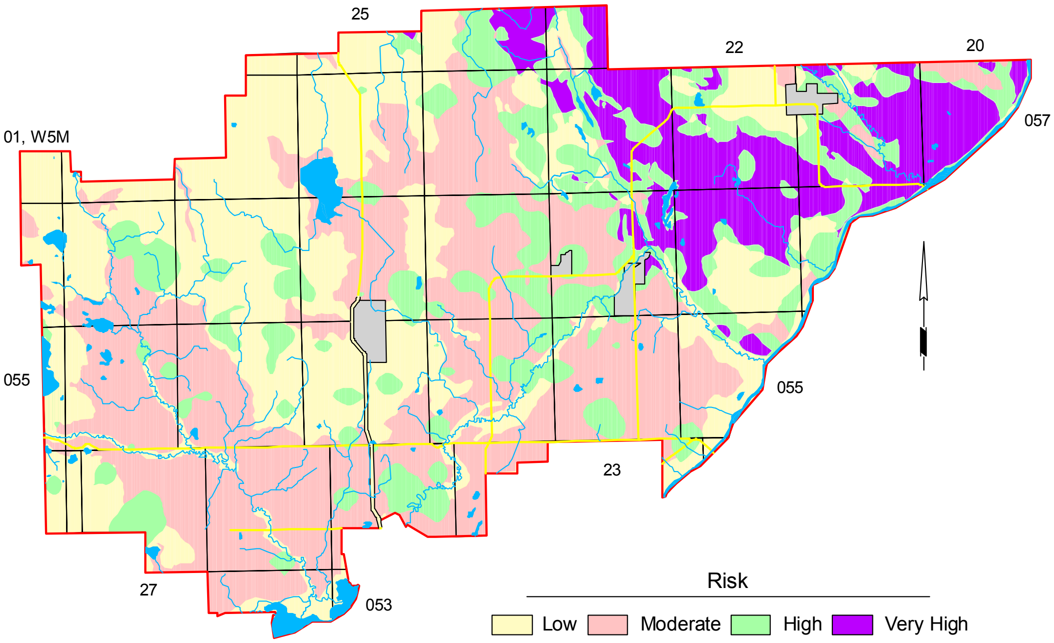
Recharge /Discharge Areas between Surficial Deposits and Bearpaw Aquifer



Changes in Water Levels in Upper Bedrock Aquifer(s)



Risk of Groundwater Contamination



STURGEON COUNTY

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STURGEON COUNTY

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Domestic Water Well Testing

Purpose and Requirements

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

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

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

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

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

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

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

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

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

Procedure

Site Diagrams

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

Surface Details

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

Groundwater Discharge Point

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

Water-Level Measurements

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

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

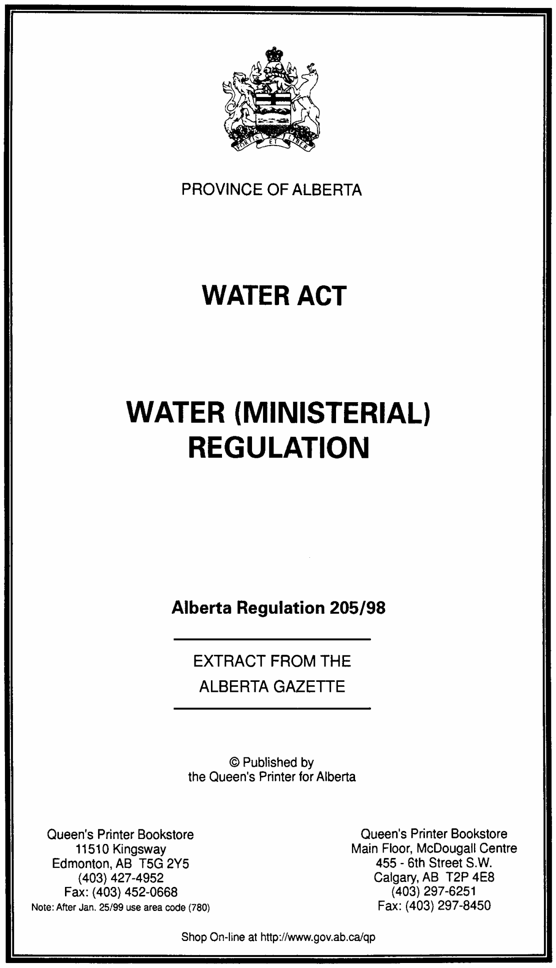
Discharge Measurements

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

Water Samples

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

Water Act - Water (Ministerial) Regulation



PROVINCE OF ALBERTA

WATER ACT

WATER (MINISTERIAL) REGULATION

Alberta Regulation 205/98

EXTRACT FROM THE
ALBERTA GAZETTE

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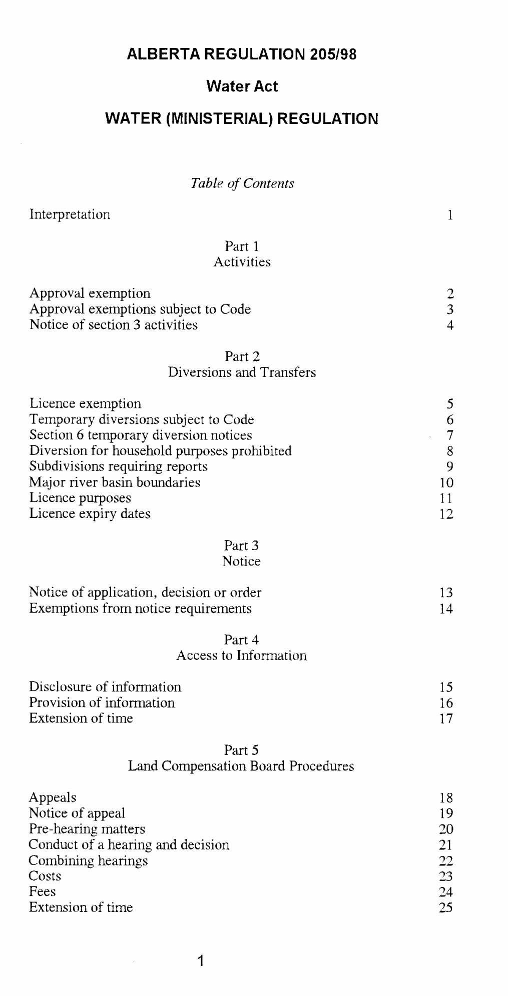

ALBERTA REGULATION 205/98

Water Act

WATER (MINISTERIAL) REGULATION

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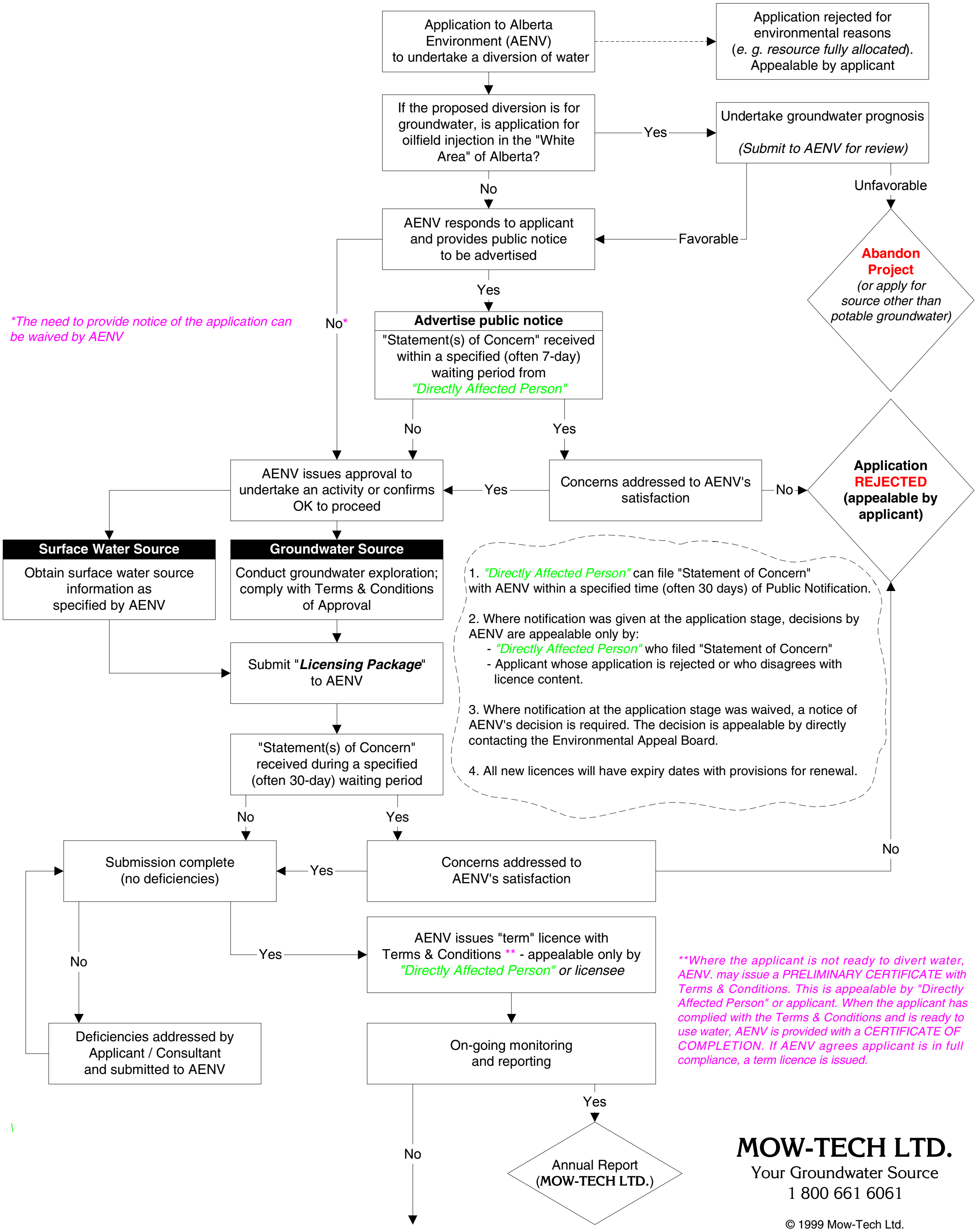


**The need to provide notice of the application can be waived by AENV*

1. *"Directly Affected Person"* can file "Statement of Concern" with AENV within a specified time (often 30 days) of Public Notification.

2. Where notification was given at the application stage, decisions by AENV are appealable only by:
   - *"Directly Affected Person"* who filed "Statement of Concern"
   - Applicant whose application is rejected or who disagrees with licence content.

3. Where notification at the application stage was waived, a notice of AENV's decision is required. The decision is appealable by directly contacting the Environmental Appeal Board.

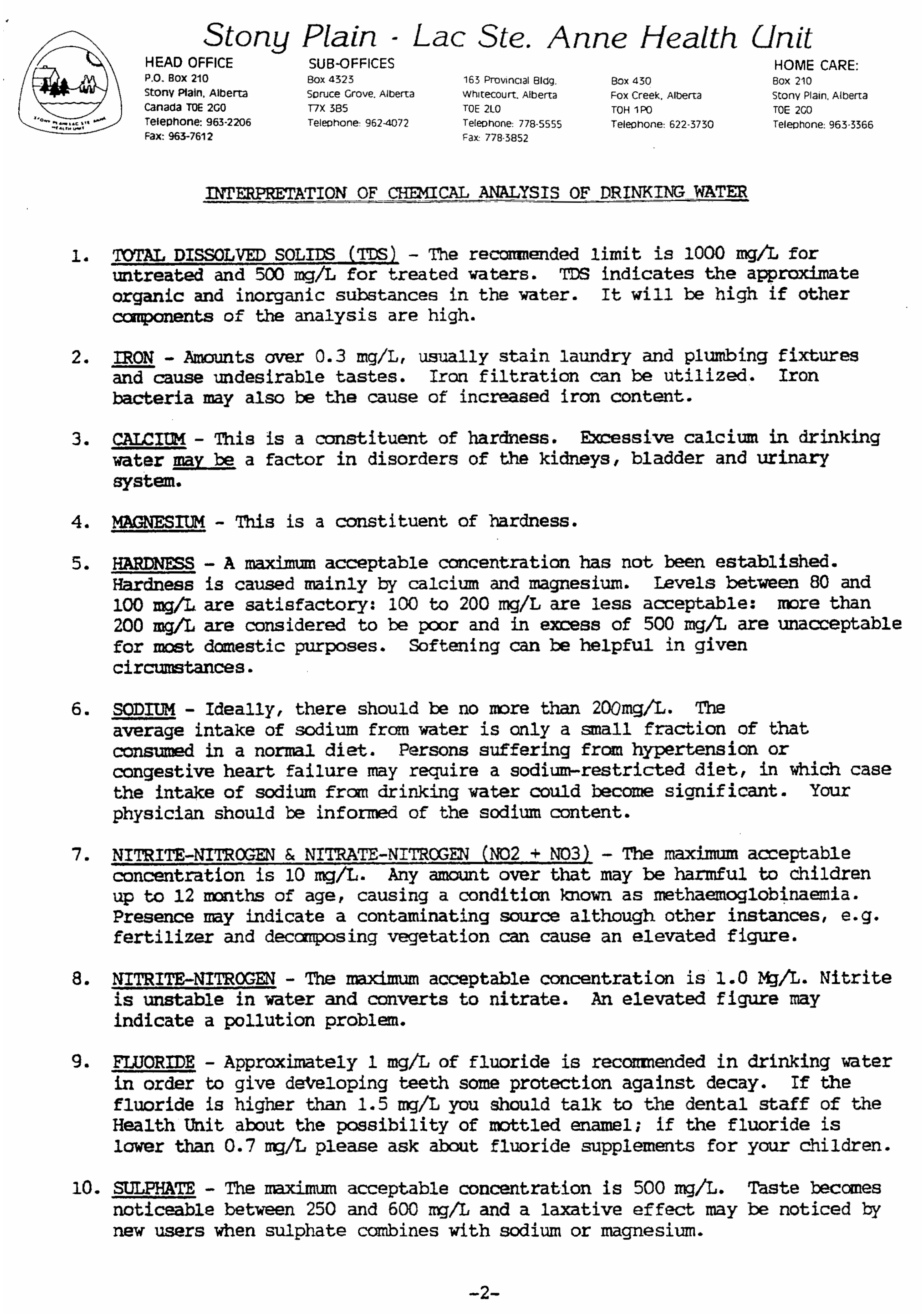
4. All new licences will have expiry dates with provisions for renewal.

***Where the applicant is not ready to divert water, AENV. may issue a PRELIMINARY CERTIFICATE with Terms & Conditions. This is appealable by "Directly Affected Person" or applicant. When the applicant has complied with the Terms & Conditions and is ready to use water, AENV is provided with a CERTIFICATE OF COMPLETION. If AENV agrees applicant is in full compliance, a term licence is issued.*

MOW-TECH LTD.
Your Groundwater Source
1 800 661 6061

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

Interpretation of Chemical Analysis of Drinking Water



Stony Plain - Lac Ste. Anne Health Unit

HEAD OFFICE
P.O. Box 210
Stony Plain, Alberta
Canada T0E 2G0
Telephone: 963-2206
Fax: 963-7612

SUB-OFFICES
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Spruce Grove, Alberta
T7X 3B5
Telephone: 962-4072

163 Provincial Bldg.
Whitecourt, Alberta
T0E 2L0
Telephone: 778-5555
Fax: 778-3852

Box 430
Fox Creek, Alberta
T0H 1P0
Telephone: 622-3730

HOME CARE:
Box 210
Stony Plain, Alberta
T0E 2G0
Telephone: 963-3366

INTERPRETATION OF CHEMICAL ANALYSIS OF DRINKING WATER

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

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

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

4. MAGNESIUM - This is a constituent of hardness.

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

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

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

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

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

10. SULPHATE - The maximum acceptable concentration is 500 mg/L. Taste becomes noticeable between 250 and 600 mg/L and a laxative effect may be noticed by new users when sulphate combines with sodium or magnesium.

11. CHLORIDE - The recommended limit is 250 mg/L. Chloride content is usually low and an increase may indicate a nearby source of pollution (particularly if NO2 and NO3 and nitrite are high). Some wells contain naturally occurring chlorides. A salty taste may be evident.

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

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

NOTE: mg/L = milligrams per litre.

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

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

Additional Information

VIDEOS

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

BOOKLET

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

ALBERTA ENVIRONMENT

WATER WELL INSPECTORS

Jennifer McPherson (Edmonton: 780-427-6429)

GEOPHYSICAL INSPECTION SERVICE

Edmonton: 780-427-3932

COMPLAINT INVESTIGATIONS

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

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

Carl Mendoza (Edmonton: 780-492-2664)

UNIVERSITY OF CALGARY – Department of Geology and Geophysics - Hydrogeology

Larry Bentley (Calgary: 403-220-4512)

FARMERS ADVOCATE

Paul Vasseur (Edmonton: 780-427-2433)

PRAIRIE FARM REHABILITATION ADMINISTRATION

Tony Cowen (Edmonton: 780-495-4911)
Curtis Snell (Vegreville: 780-349-3963)

LOCAL HEALTH DEPARTMENTS

STURGEON COUNTY

Appendix D

Maps and Figures Included as Large Plots

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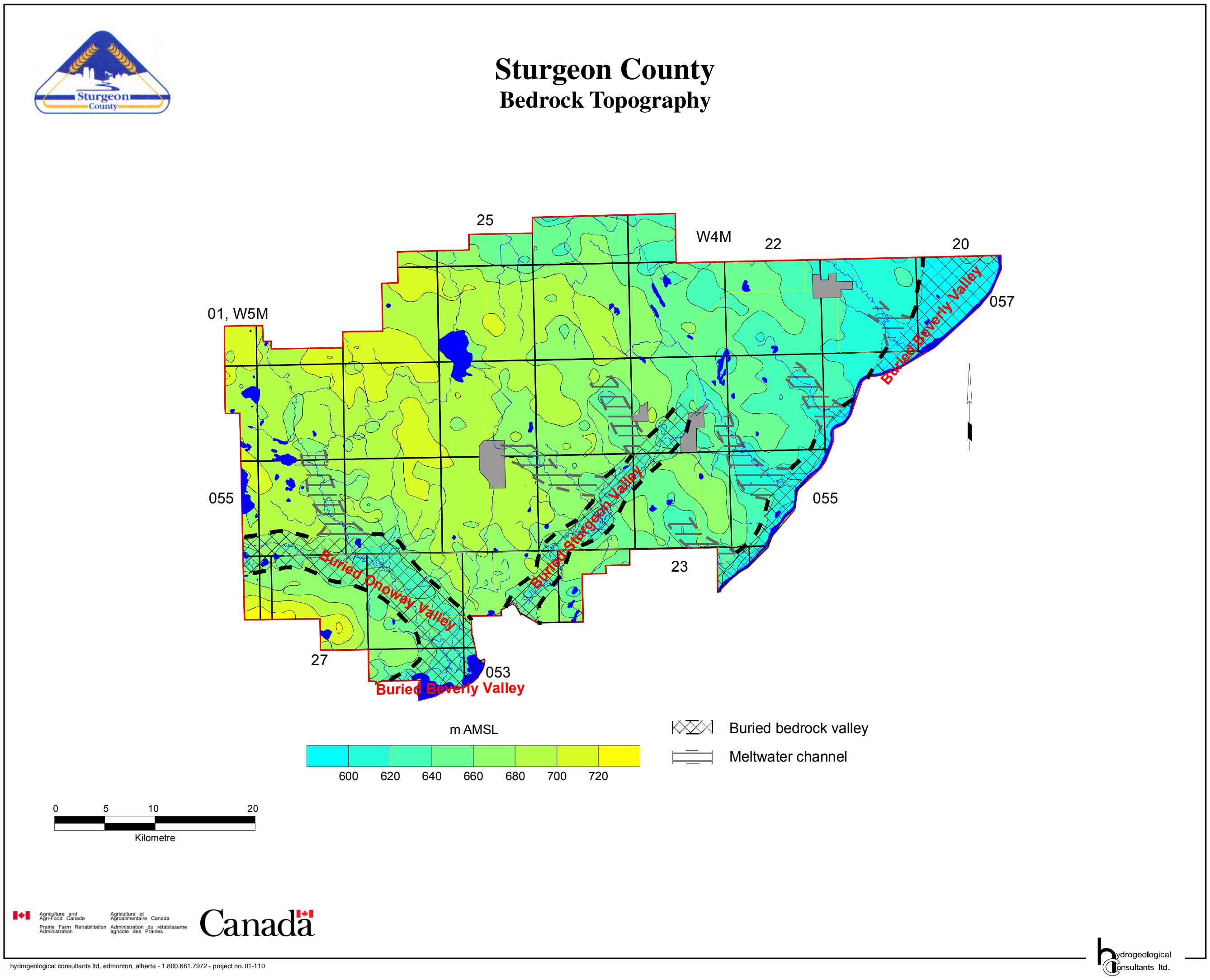
Bedrock Topography



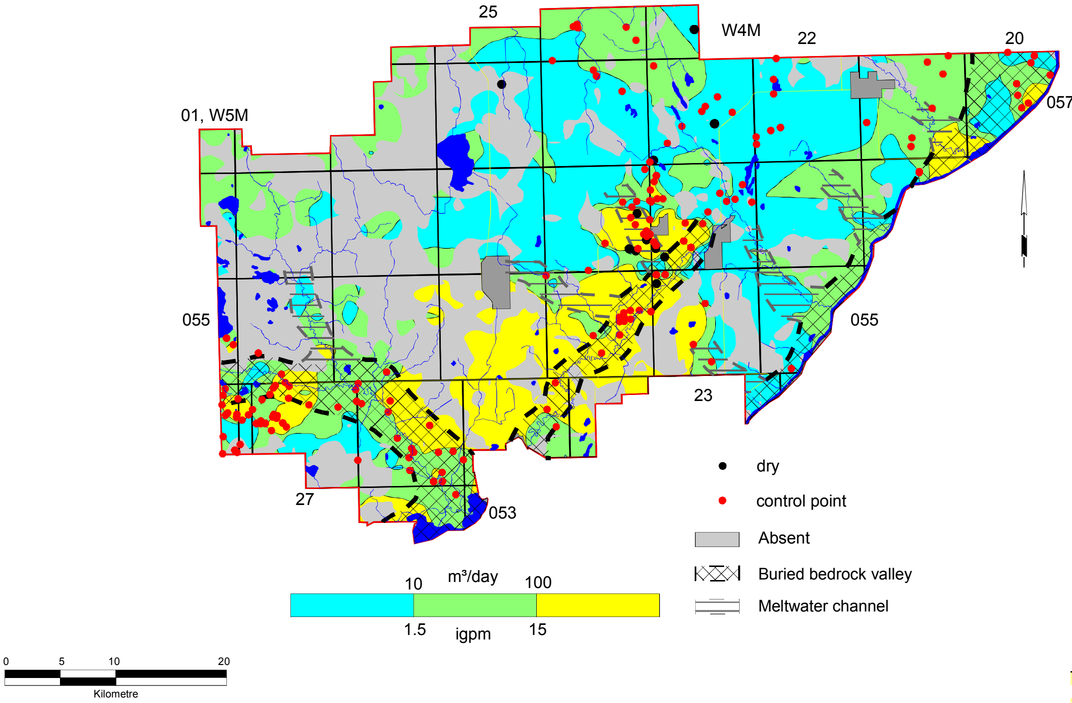
hydrogeological consultants ltd, edmonton, alberta - 1.800.661.7972 - project no. 01-110

WORD

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

Sturgeon County

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



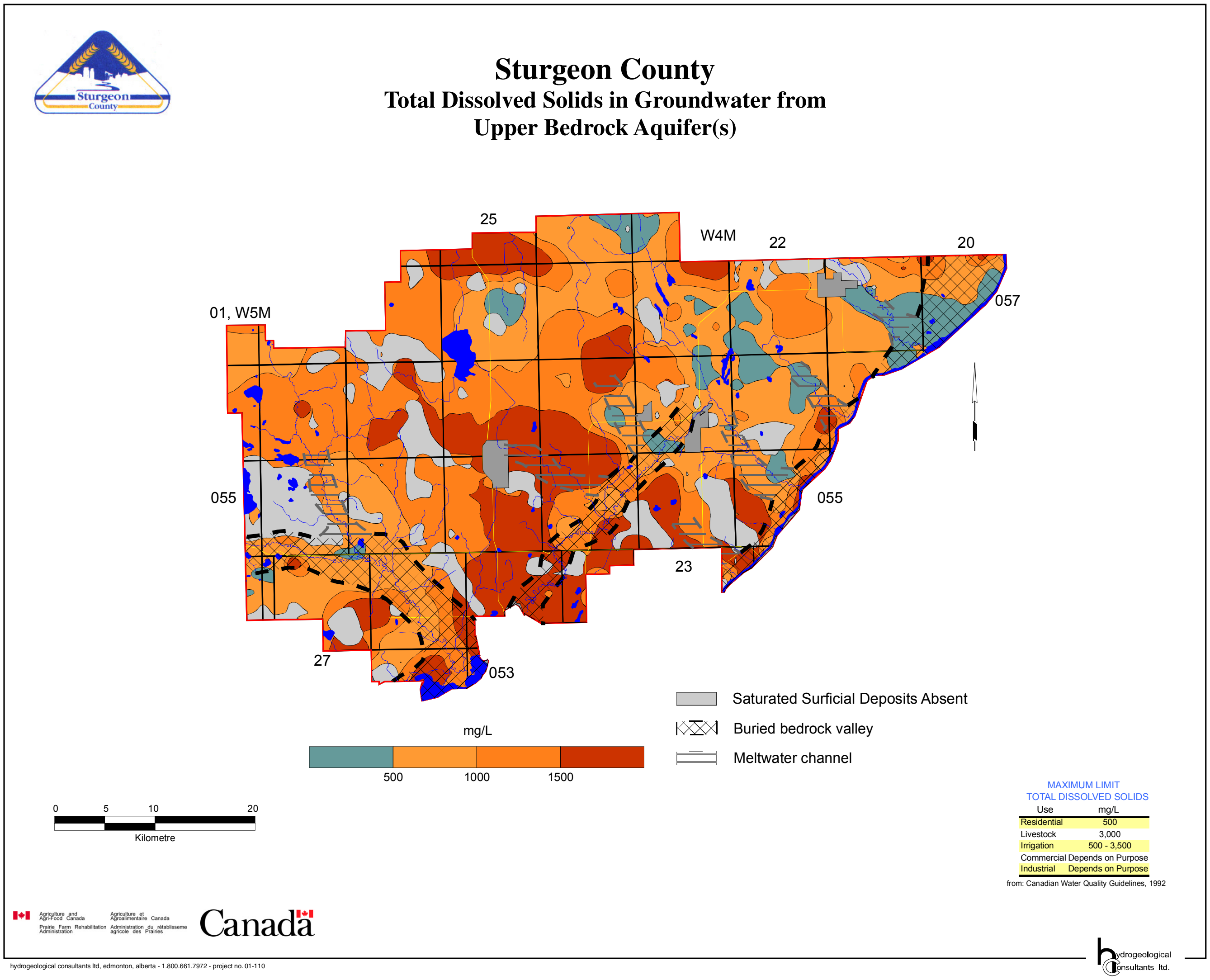
GROUNDWATER CONSUMPTION

Groundwater Purpose[3]	Lower Limit (m³/day)	Upper Limit (m³/day)
Residential[1]	1.1	3.4
Multi Parcel[1]	1.1	3.4
Commercial	1	max. available
Light Industrial	1	max. available
Agricultural[2]	17.1	max. available

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

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

Total Dissolved Solids in Groundwater from Surficial Deposits



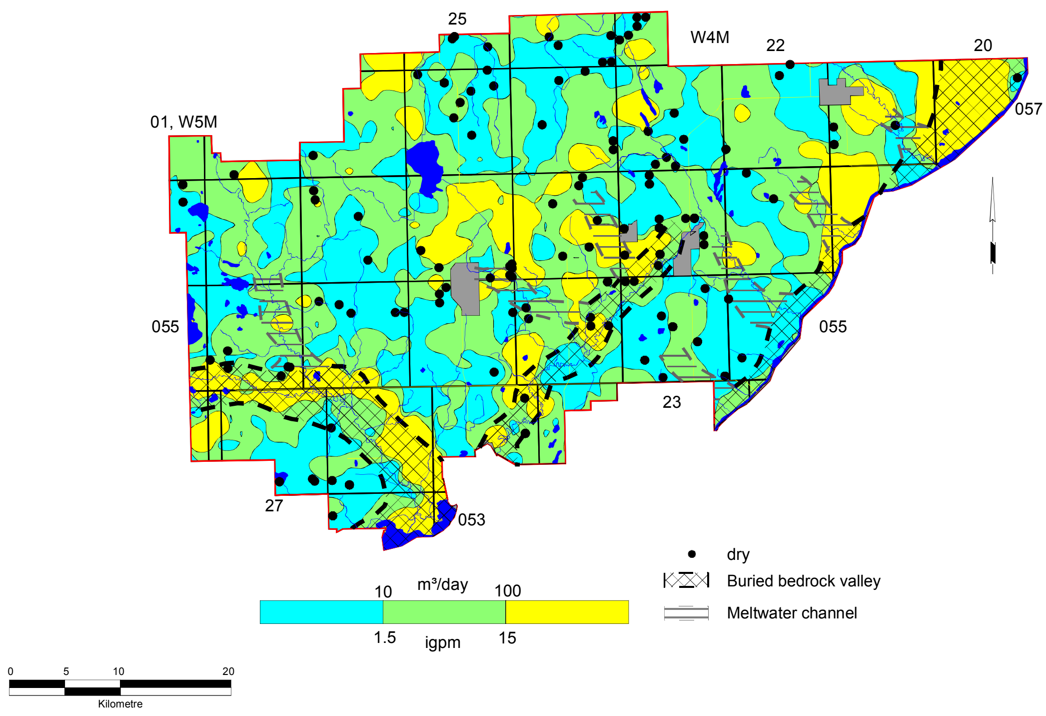
MAXIMUM LIMIT
TOTAL DISSOLVED SOLIDS

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

from: Canadian Water Quality Guidelines, 1992

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

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



GROUNDWATER CONSUMPTION

Groundwater Purpose[3]	Lower Limit (m³/day)	Upper Limit (m³/day)
Residential[1]	1.1	3.4
Multi Parcel[1]	1.1	3.4
Commercial	1	max. available
Light Industrial	1	max. available
Agricultural[2]	17.1	max. available

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

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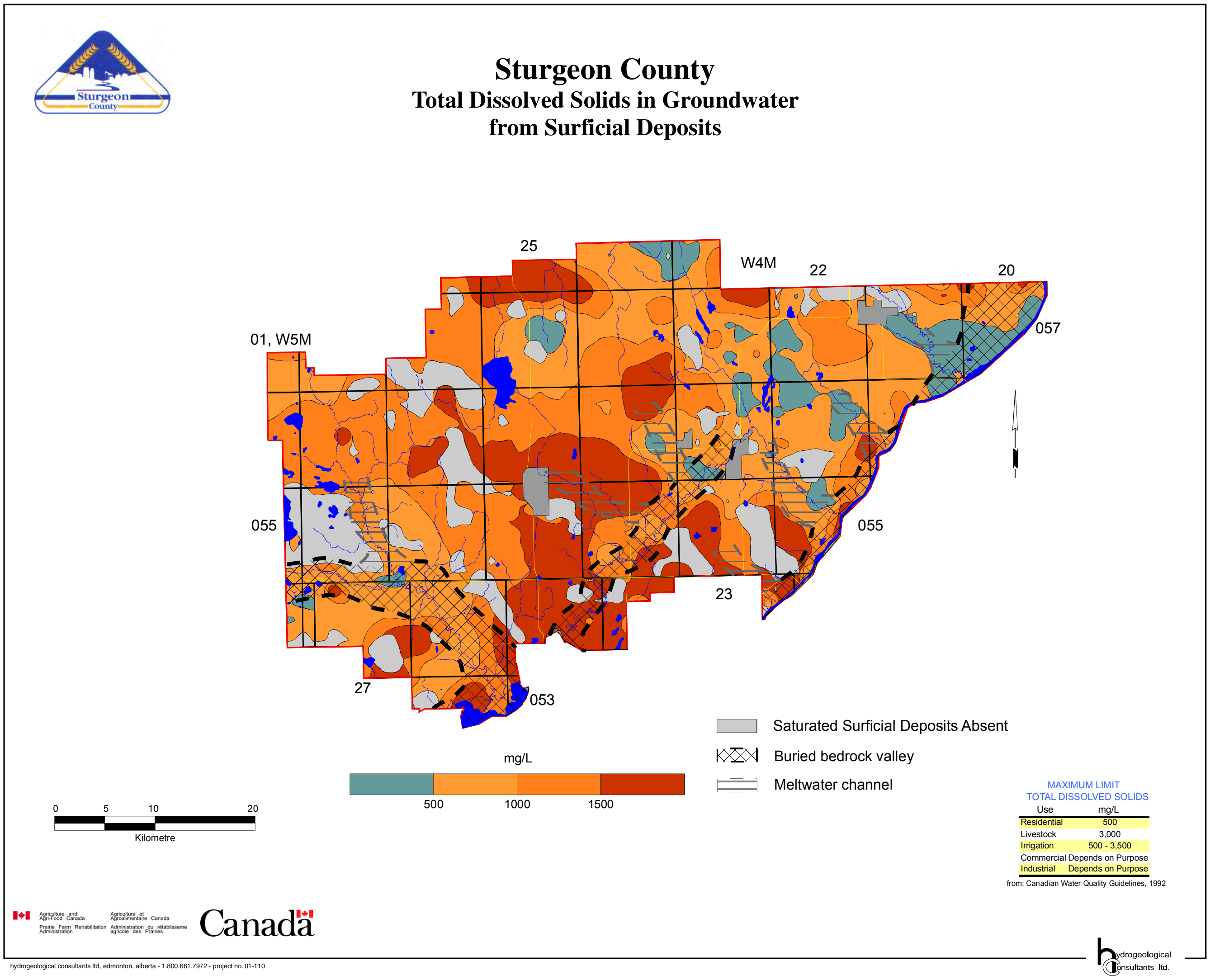
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

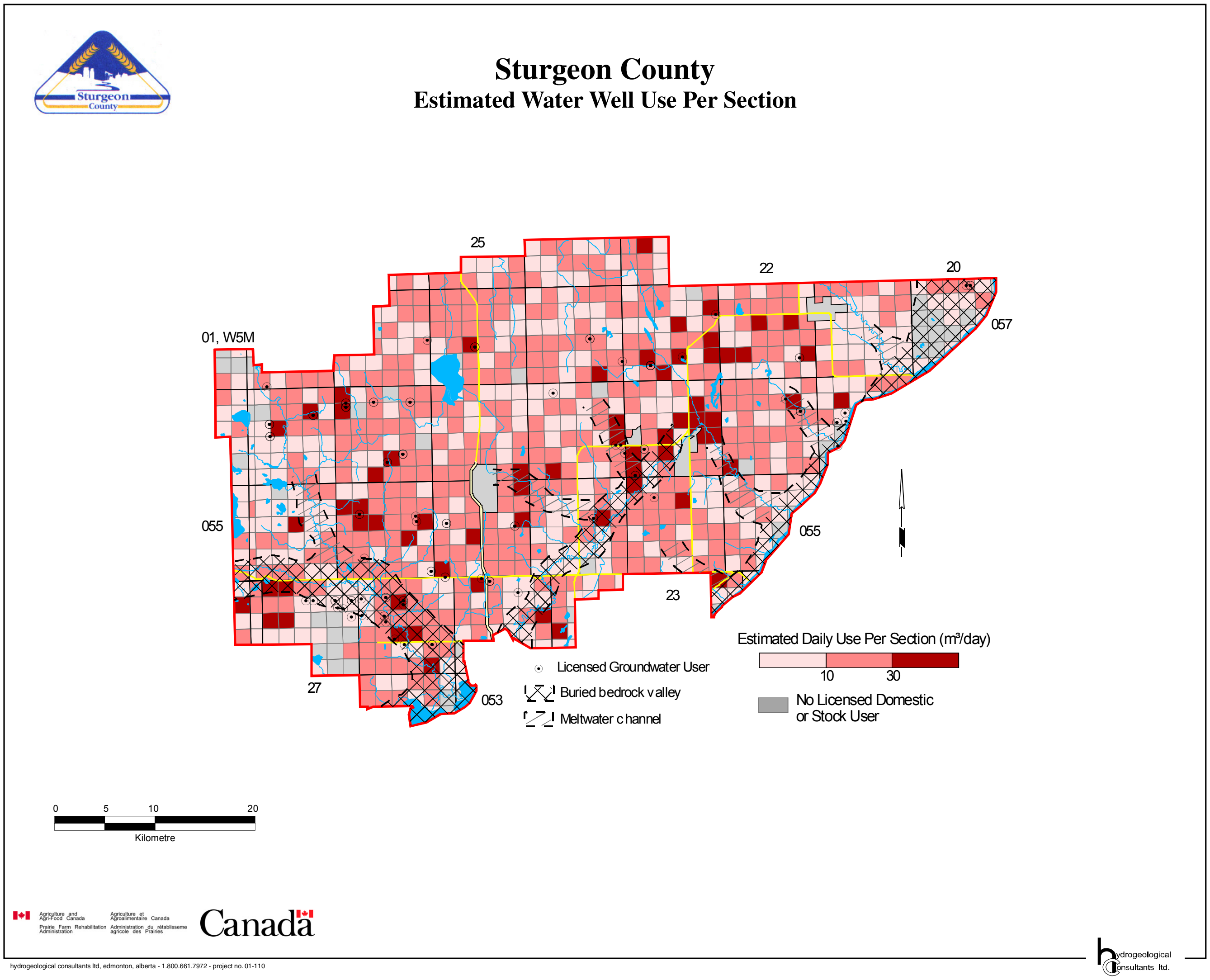


MAXIMUM LIMIT
TOTAL DISSOLVED SOLIDS

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

from: Canadian Water Quality Guidelines, 1992

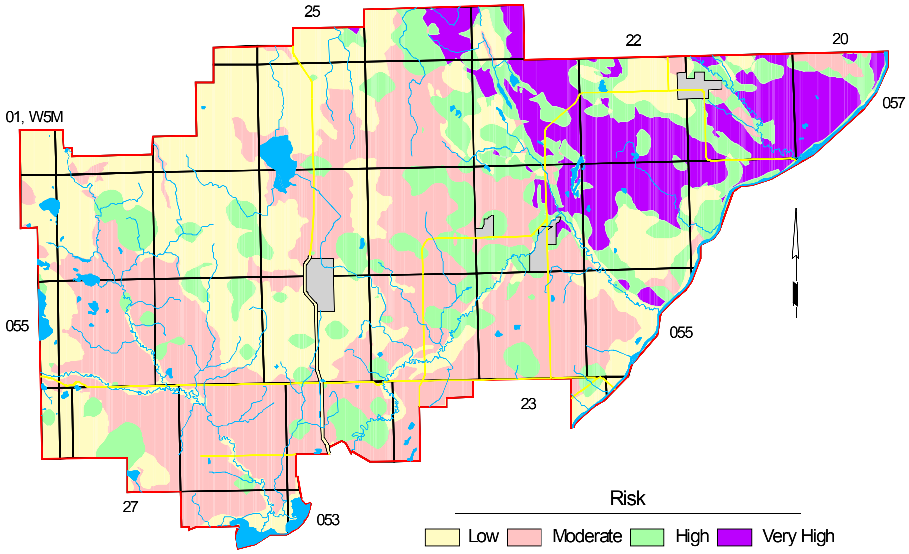
Estimated Water Well Use Per Section



Risk of Groundwater Contamination

Sturgeon County

Risk of Groundwater Contamination



0 5 10 20
Kilometre

Risk of Groundwater Contamination Criteria

Surface Permeability	Sand or Gravel Present - Top Within One Metre Of Ground Surface	Groundwater Contamination Risk
Low	No	Low
Moderate	No	Moderate
High	No	High
Low	Yes	High
Moderate	Yes	High
High	Yes	Very High

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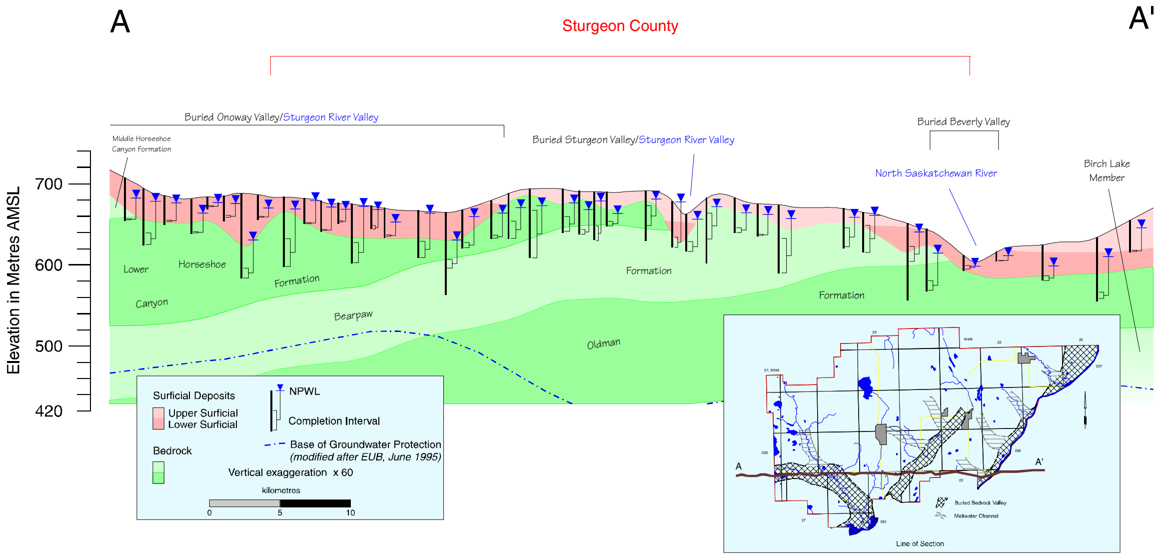
Cross-Section A - A'

Sturgeon County

Cross-Section A - A'



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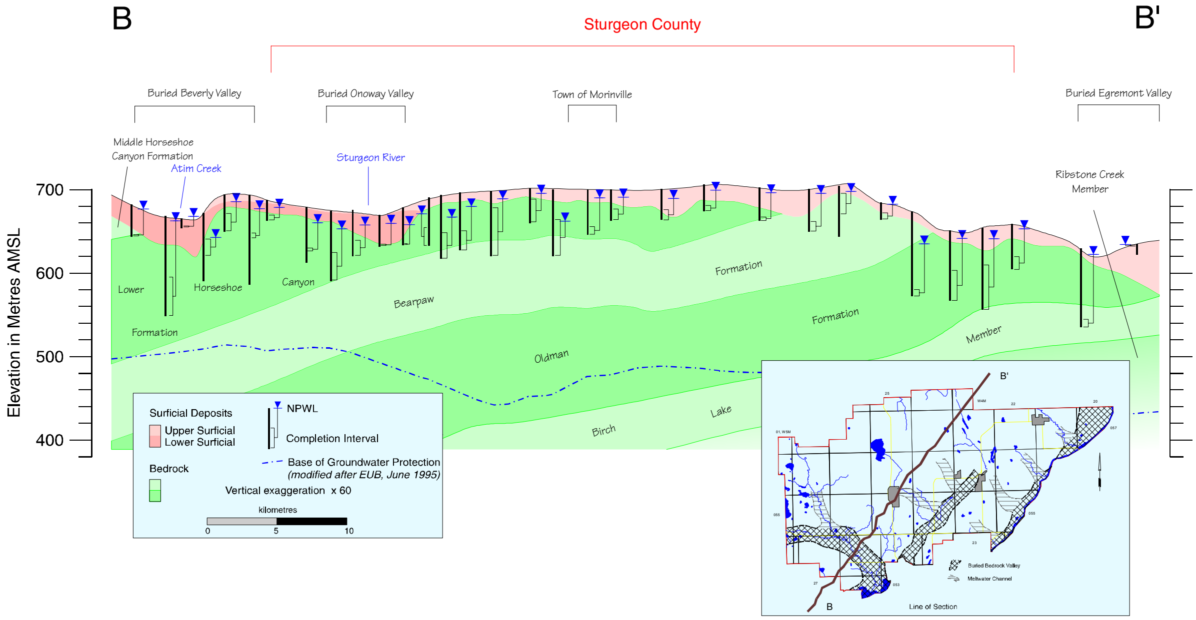
Cross-Section B - B'

Sturgeon County
Cross-Section B - B'



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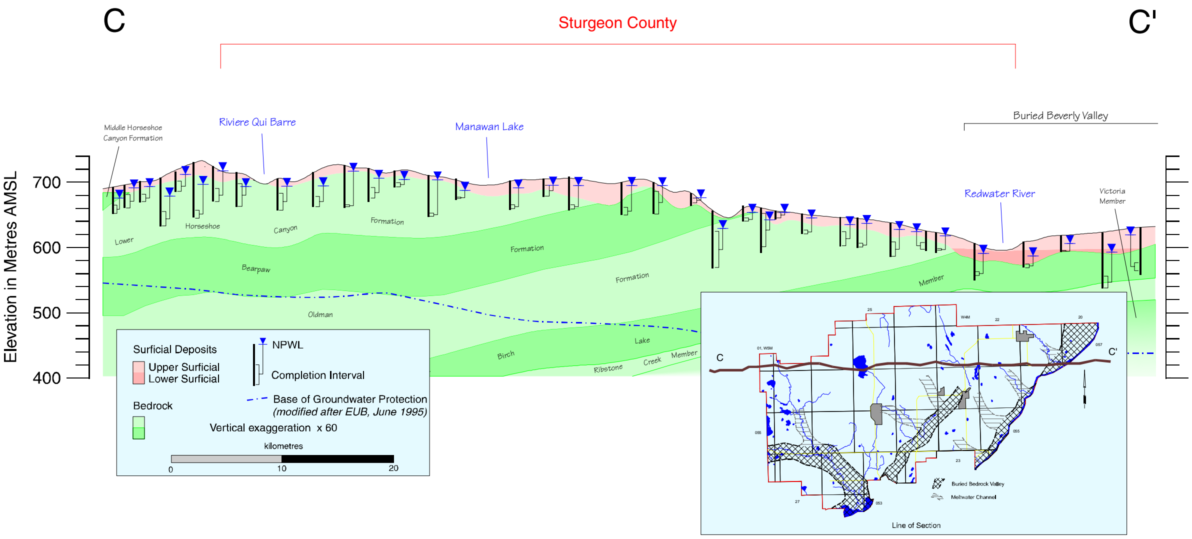
Cross-Section C - C'

Sturgeon County
Cross-Section C - C'



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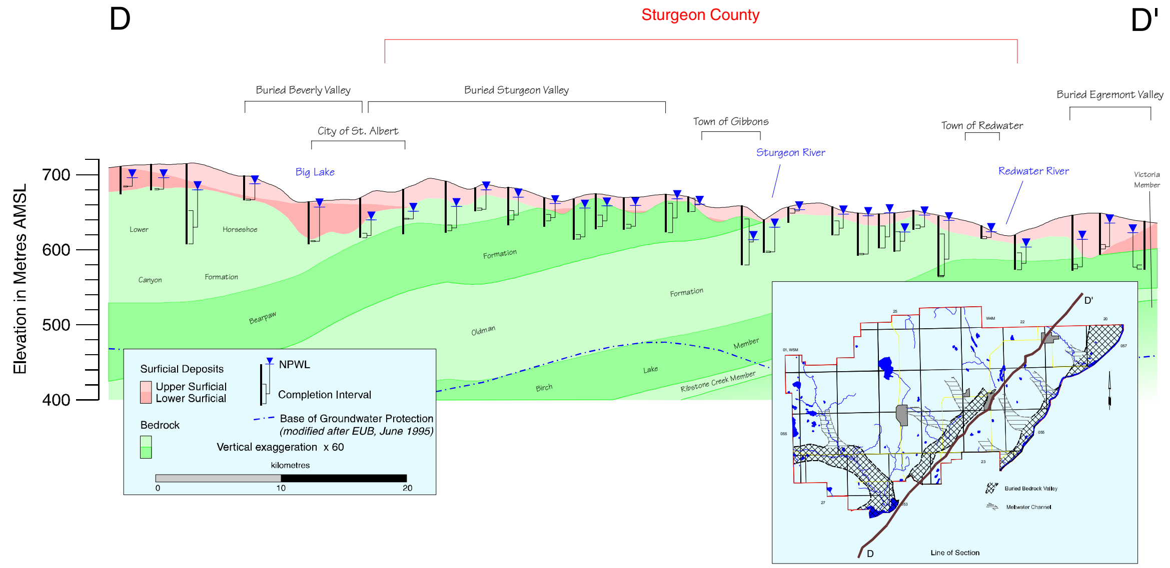
Cross-Section D - D'

Sturgeon County
Cross-Section D - D'



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STURGEON COUNTY

Appendix E

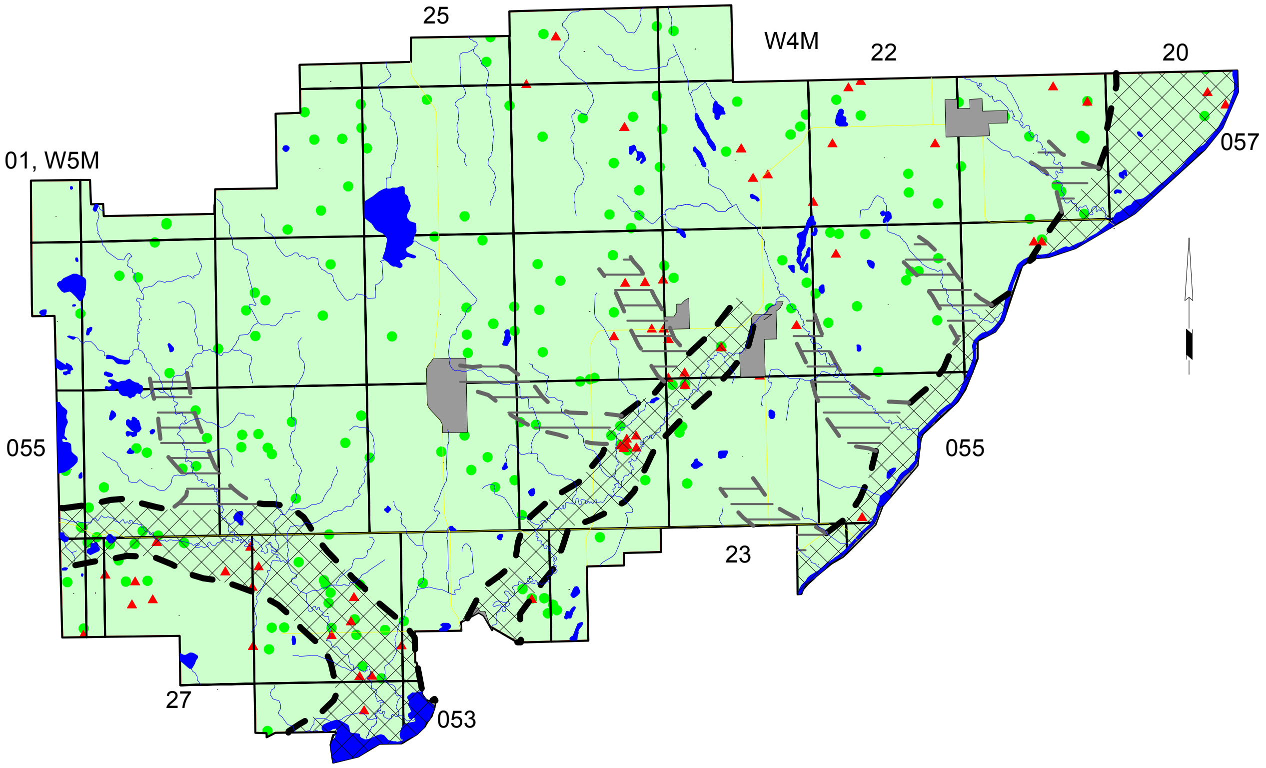
Water Wells Recommended for Field Verification

and

County-Operated Water Wells

Water Wells Recommended for Field Verification

(details on following pages)



Completion Aquifer

● Bedrock

▲ Surficial

▨ Buried bedrock valley

═ Meltwater channel

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

Owner	Location	Aquifer Name	Date Water Well Drilled	Completed Depth		NPWL		UID
				Metres	Feet	Metres	Feet	
Abell, Eric	NW 13-056-23 W4M	Oldman	10-Sep-85	45.7	150.0	12.2	40.0	M35377.057043
Alberta Environment	05-13-056-25 W4M	Lower Horseshoe Canyon	28-Jul-76	48.8	160.0	7.1	23.3	M35377.077229
Alberta Environment	12-07-056-23 W4M	Upper Surficial	04-Mar-75	53.6	176.0	25.1	82.4	M35377.059627
Alberta Wheat Pool	04-34-055-25 W4M	Lower Horseshoe Canyon	24-Sep-80	54.9	180.0	11.3	37.0	M35377.056606
Allen Farms	SE 14-056-22 W4M	Oldman	01-Nov-78	21.9	72.0	4.9	16.0	M35377.055665
Allison, Gordon	NE 25-057-23 W4M	Oldman	21-Jul-82	42.7	140.0	5.5	18.0	M35377.059644
Antoniuk, Robert	SW 30-056-23 W4M	Bearpaw	27-Mar-74	41.2	135.0	10.7	35.0	M35377.059315
Baanstick, S.	12-02-056-27 W4M	Lower Horseshoe Canyon	01-Oct-61	50.3	165.0	12.2	40.0	M35377.056535
Ballachay, Alrin	SE 18-054-26 W4M	Lower Horseshoe Canyon	23-Feb-76	50.3	165.0	18.3	60.0	M35377.050209
Bamford, B.	NE 33-055-24 W4M	Bearpaw	02-May-78	35.1	115.0	16.8	55.0	M35377.054608
Belanger, Ray	SE 36-057-26 W4M	Lower Horseshoe Canyon	06-Sep-86	33.5	110.0	7.0	23.0	M35377.058597
Bennett, Ken	NW 24-057-23 W4M	Oldman	19-Oct-78	67.1	220.0	18.3	60.0	M35377.067292
Berglund, Mel	NW 24-055-26 W4M	Lower Horseshoe Canyon	10-May-77	26.5	87.0	6.1	20.0	M35377.055194
Bergstreiser, Lloyd	SW 05-055-27 W4M	Lower Horseshoe Canyon	11-Nov-87	37.8	124.0	7.0	23.0	M35377.054531
Bergstreiser, Norman	SH 06-055-27 W4M	Lower Horseshoe Canyon	24-May-74	33.2	109.0	6.1	20.0	M35377.054546
Berndt, Hans	NW 24-057-26 W4M	Lower Horseshoe Canyon	24-Jun-85	36.6	120.0	4.0	13.0	M35377.058382
Bilecki, Peter	SE 02-057-24 W4M	Bearpaw	15-Nov-75	32.0	105.0	9.5	31.0	M35377.057885
Blouin, Harvey O.	SW 22-054-26 W4M	Lower Horseshoe Canyon	09-Oct-81	61.0	200.0	18.3	60.0	M35377.055034
Bodoano, D. B.	NW 33-056-22 W4M	Oldman	17-Jul-75	45.7	150.0	4.6	15.0	M35377.056296
Bokenfohr, Herman	11-02-054-26 W4M	Lower Horseshoe Canyon	19-Apr-85	43.6	143.0	6.7	22.0	M35377.049410
Bokenfohr, Herman	NW 11-054-26 W4M	Lower Horseshoe Canyon	04-Sep-85	43.6	143.0	18.3	60.0	M35377.049873
Bolle, C.	SE 25-057-26 W4M	Lower Horseshoe Canyon	12-Mar-77	22.9	75.0	12.2	40.0	M35377.058392
Borle, George	NW 30-054-26 W4M	Lower Surficial	12-Nov-82	19.8	65.0	12.1	39.7	M35377.055296
Bosch, Bill	NE 31-055-23 W4M	Lower Surficial	24-Aug-79	53.6	176.0	42.7	140.0	M35377.054933
Boulter, Ken	04-07-057-22 W4M	Upper Surficial	20-Jan-81	7.3	24.0	3.5	11.5	M35377.057619
Bova, Bernard	NW 24-057-23 W4M	Oldman	04-Mar-83	48.2	158.0	6.1	20.0	M35377.059536
Boyd, Glenn	NE 30-056-24 W4M	Lower Horseshoe Canyon	27-May-74	39.6	130.0	12.2	40.0	M35377.057332
Brenneis, Alex	SW 20-056-26 W4M	Lower Horseshoe Canyon	01-Dec-71	32.0	105.0	4.9	16.0	M35377.057154
Brochu, Dave	NE 24-055-27 W4M	Lower Horseshoe Canyon	17-May-78	42.4	139.0	16.8	55.0	M35377.055116
Brown, Al	SE 03-055-27 W4M	Lower Horseshoe Canyon	23-Jul-79	33.5	110.0	5.5	18.0	M35377.054482
Bushard	NW 13-055-27 W4M	Lower Horseshoe Canyon	02-Dec-71	42.7	140.0	2.4	8.0	M35377.054776
Byer, J.	NW 02-057-27 W4M	Lower Horseshoe Canyon	10-Apr-69	36.6	120.0	22.9	75.0	M35377.058644
Calahoo Fire Hall	NW 32-054-27 W4M	Lower Horseshoe Canyon	18-Oct-85	36.6	120.0	6.7	22.0	M35377.054047
Camarta, Ronald	NE 20-055-26 W4M	Lower Horseshoe Canyon	06-Jun-81	67.1	220.0	9.8	32.0	M35377.054979
Cantin, A.	09-13-054-25 W4M	Bearpaw	10-Sep-81	73.2	240.0	37.2	122.0	M35377.232053
Carruthers, D.	04-26-055-24 W4M	Lower Horseshoe Canyon	31-Jul-84	30.5	100.0	15.2	50.0	M35377.054365
Carruthers, Earl W.	SW 03-056-24 W4M	Bearpaw	02-May-78	33.5	110.0	16.5	54.0	M35377.063334
Case, Allan	NW 02-057-27 W4M	Lower Horseshoe Canyon	20-Oct-82	39.6	130.0	18.3	60.0	M35377.058648
Cassidy, Harold	SW 13-054-26 W4M	Bearpaw	01-May-74	93.3	306.0	21.6	71.0	M35377.049945
Chorney, S.	01-27-057-20 W4M	Birch Lake		51.8	170.0	44.2	145.0	M35377.057218
Cissell, Glen	NW 01-057-22 W4M	Oldman	04-Oct-73	45.7	150.0	13.3	43.6	M35377.057538
Clark, Brian	13-12-055-25 W4M	Bearpaw	18-Oct-82	43.3	142.0	3.1	10.0	M35377.054658
Con West Structures	08-13-054-01 W5M	Upper Horseshoe Canyon	11-Jun-84	36.3	119.0	10.7	35.0	M35379.043914
Control Land Survey	SE 23-055-24 W4M	Lower Surficial	21-Jun-78	51.8	170.0	34.4	112.8	M35377.053896

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
Courigan, D	12-19-057-25 W4M	Lower Horseshoe Canyon	12-Jun-78	31.1	102.0	14.9	49.0	M35377.058355
Cowen, Robert	SE 23-057-21 W4M	Oldman	17-Dec-80	21.9	72.0	1.8	6.0	M35377.057627
Craig, Robert & Nadia	02-26-057-24 W4M	Upper Surficial	24-Aug-82	28.0	92.0	16.2	53.0	M35377.067509
Crawford, W. G.	09-26-057-20 W4M	Upper Surficial	22-Apr-83	6.1	20.0	4.6	15.0	M35377.057211
Cuthbent, Sterling & Ebert	SE 10-057-21 W4M	Birch Lake	22-Aug-82	54.9	180.0	11.0	36.0	M35377.057331
Cyr, G.	SE 36-057-25 W4M	Bearpaw	8-Jun-85	18.3	60.0	5.8	19.0	M35377.059384
Dalziel, J.	06-23-055-24 W4M	Lower Surficial	11-Jun-80	82.9	272.0	2.4	8.0	M35377.054124
Danake, Stan	NE 03-057-24 W4M	Bearpaw	21-Jul-77	29.3	96.0	7.0	23.0	M35377.058164
Davidson, Don	01-24-056-01 W5M	Lower Horseshoe Canyon	24-Jun-79	42.7	140.0	3.0	9.9	M35379.086842
Davis, Marshall	01-04-056-24 W4M	Bearpaw	2-Aug-79	33.5	110.0	10.1	33.0	M35377.063340
Deharn, John	NW 31-055-23 W4M	Bearpaw	11-Sep-81	57.6	189.0	47.2	155.0	M35377.054832
Derouin	NE 22-056-22 W4M	Oldman	16-Aug-85	45.7	150.0	6.7	22.0	M35377.055924
Derrien, Al	SE 06-058-24 W4M	Upper Surficial	21-Sep-82	14.6	48.0	5.5	18.0	M35377.166190
Detonnancour, Leonard	NE 25-055-26 W4M	Lower Horseshoe Canyon	21-Oct-82	48.8	160.0	7.6	25.0	M35377.055243
Detonnancour, Leonard	NE 25-055-26 W4M	Lower Horseshoe Canyon	16-May-87	48.8	160.0	3.7	12.0	M35377.055248
Dixon, William	SE 29-054-27 W4M	Middle Horseshoe Canyon	6-Feb-81	24.1	79.0	0.9	3.0	M35377.055715
Don Perry Real Estate	SE 24-054-25 W4M	Bearpaw	14-Jun-73	68.6	225.0	35.1	115.0	M35377.049612
Dowhaniuk, Bill	SE 18-058-23 W4M	Oldman	13-Aug-71	9.1	30.0	1.8	6.0	M35377.166053
Dowhaniuk, Don	NW 20-057-24 W4M	Bearpaw	22-Jan-81	33.5	110.0	6.1	20.0	M35377.058903
Du Perron, Floyd	04-01-054-26 W4M	Lower Horseshoe Canyon	17-Jun-83	64.0	210.0	9.8	32.0	M35377.231878
Dubois, Paul	SW 09-056-23 W4M	Lower Surficial	10-Mar-76	41.8	137.0	24.4	80.0	M35377.056595
Durrant, Star	04-35-057-20 W4M	Upper Surficial	7-May-77	10.4	34.0	0.9	3.0	M35377.077125
Dwernychuk, R.	NW 08-056-25 W4M	Lower Horseshoe Canyon	24-May-79	50.3	165.0	12.2	40.0	M35377.056565
Erickson, W.	05-28-057-22 W4M	Oldman	30-Oct-79	13.4	44.0	1.8	6.0	M35377.058902
Esso Resources Canada Ltd.	SE 29-057-21 W4M	Oldman	31-Aug-84	29.9	98.0	5.5	18.0	M35377.055998
Etty, Roy	SW 32-057-22 W4M	Oldman	26-Jul-82	30.5	100.0	3.7	12.0	M35377.059019
Evoy, Glen	NW 25-057-21 W4M	Upper Surficial	30-Sep-84	13.4	44.0	11.3	37.0	M35377.057651
Ewasiw	NE 24-056-23 W4M	Oldman	16-Jul-75	82.3	270.0	22.9	75.0	M35377.058844
Fassbender, C.	04-34-057-23 W4M	Oldman	19-Aug-63	53.6	176.0	6.1	20.0	M35377.060067
Fedoriw, L.	05-23-055-24 W4M	Lower Surficial	28-Apr-79	40.8	134.0	25.6	84.0	M35377.054111
Ferchoff, Walter	SW 09-056-23 W4M	Lower Surficial	15-Jul-72	21.0	69.0	11.0	36.0	M35377.056611
Ference, Bill	SW 10-055-26 W4M	Lower Horseshoe Canyon	6-Sep-83	45.7	150.0	7.6	25.0	M35377.054217
Fernhout, John	13-10-054-26 W4M	Lower Surficial	9-Jun-70	12.8	42.0	5.6	18.5	M35377.049841
Fewchuk, Bob	NE 07-055-23 W4M	Bearpaw	25-Sep-71	36.6	120.0	18.3	60.0	M35377.050502
Fink, A.	NW 07-056-26 W4M	Lower Horseshoe Canyon	23-Jul-75	35.1	115.0	-0.6	-2.0	M35377.065173
Forman, D.	SW 19-056-22 W4M	Oldman	28-Feb-74	85.6	281.0	38.1	125.0	M35377.055829
Fraser, John C.	SE 03-056-23 W4M	Upper Surficial	1-Apr-65	14.0	46.0	6.1	20.0	M35377.055596
Friedrick, O.	SE 30-054-27 W4M	Lower Horseshoe Canyon	19-May-76	25.9	85.0	6.1	20.0	M35377.050852
From, Earl	SE 15-057-22 W4M	Oldman	13-Oct-76	61.0	200.0	10.7	35.0	M35377.057939
Fulton, Ryan	SE 28-056-27 W4M	Lower Horseshoe Canyon	22-Apr-81	31.1	102.0	3.1	10.0	M35377.055938
Gabbey, H.	NE 23-055-24 W4M	Lower Surficial	18-Aug-86	48.8	160.0	31.0	101.7	M35377.054343
Gagnon, Clifford	SE 13-055-25 W4M	Bearpaw	28-Feb-86	41.2	135.0	5.5	18.0	M35377.054696
General Land Holdings	NE 26-054-27 W4M	Lower Surficial	6-May-80	19.2	63.0	12.2	40.0	M35377.050771
Geracitano, A.	SE 30-055-24 W4M	Bearpaw	26-Sep-84	45.7	150.0	2.4	8.0	M35377.054416
Glenday, J.	NW 18-054-24 W4M	Lower Horseshoe Canyon	1-Jun-73	61.0	200.0	28.7	94.0	M35377.231993
Gogal, Dennis M.	NW 19-055-23 W4M	Bearpaw	10-May-86	41.2	135.0	10.7	35.0	M35377.054318

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
Goulet, Jim	NW 36-054-28 W4M	Lower Horseshoe Canyon	7-Oct-87	38.1	125.0	15.2	50.0	M35377.054412
Granger, Dwayne	SE 20-056-26 W4M	Lower Horseshoe Canyon	4-Apr-84	45.7	150.0	6.1	20.0	M35377.065197
Gravelle, Bob	SE 24-054-25 W4M	Bearpaw	1-Jul-70	62.5	205.0	27.4	90.0	M35377.049738
Gravelle, Robert	SW 11-057-26 W4M	Lower Horseshoe Canyon	16-May-80	70.1	230.0	22.9	75.0	M35377.058104
Hackman, J.	06-23-055-24 W4M	Lower Surficial	20-May-76	81.1	266.0	58.5	192.0	M35377.054059
Hall, Marshall	NE 17-056-22 W4M	Oldman	15-Jun-88	42.7	140.0	9.8	32.0	M35377.055795
Halun, M.	SE 34-057-21 W4M	Upper Surficial	23-Aug-78	26.8	88.0	4.3	14.0	M35377.057833
Hartmetz, Oliver	16-21-054-26 W4M	Lower Horseshoe Canyon	18-Apr-80	39.3	129.0	11.6	38.0	M35377.055009
Hawrelko, Josephine	10-32-057-22 W4M	Upper Surficial	30-Mar-78	4.9	16.0	2.4	8.0	M35377.059041
Heitel, Herman	SE 25-057-23 W4M	Oldman	2-Nov-83	30.5	100.0	9.1	30.0	M35377.059638
Hengen, Lee	NE 34-056-27 W4M	Lower Horseshoe Canyon	9-Mar-99	42.7	140.0	16.9	55.5	M36270.576622
Hewitt Estates	SE 06-056-23 W4M	Upper Surficial	25-Feb-76	47.6	156.0	23.5	77.0	M35377.065083
Hewitt, M. R.	04-06-056-23 W4M	Upper Surficial	3-Apr-64	39.6	130.0	25.6	84.0	M35377.055995
Hicks, Terry	SE 21-057-21 W4M	Birch Lake	6-Mar-79	61.0	200.0	4.3	14.0	M35377.067253
Hodgins, Buford	01-34-056-24 W4M	Bearpaw	22-Feb-83	67.1	220.0	12.8	42.0	M35377.057457
Hofs, Henry	SE 18-056-22 W4M	Oldman	27-Nov-73	61.0	200.0	3.1	10.0	M35377.055798
Holden, Ed	SW 18-054-25 W4M	Lower Horseshoe Canyon	11-Oct-78	42.7	140.0	21.3	70.0	M35377.049401
Huillery, Randy	SW 24-057-21 W4M	Birch Lake	13-May-81	48.8	160.0	15.2	50.0	M35377.057638
Hume, B.	SW 09-056-23 W4M	Lower Surficial	28-Jun-71	44.5	146.0	25.8	84.5	M35377.056663
Jeffery, J.	13-12-055-24 W4M	Bearpaw	16-Sep-82	51.8	170.0	10.7	35.0	M35377.054733
Jodoin, Albert	NE 13-057-24 W4M	Bearpaw	5-Aug-81	24.4	80.0	8.2	27.0	M35377.058683
Kapach, L	03-23-055-24 W4M	Bearpaw	22-Jan-76	77.4	254.0	51.8	170.0	M35377.054073
Kaup, Henry	SW 36-055-27 W4M	Lower Horseshoe Canyon	18-Mar-82	44.2	145.0	12.2	40.0	M35377.055264
Kelly, Don	01-28-054-26 W4M	Lower Horseshoe Canyon	22-Jul-75	54.9	180.0	24.1	79.0	M35377.055191
Kemper, T.	12-02-057-25 W4M	Lower Horseshoe Canyon	10-Sep-75	33.5	110.0	8.2	27.0	M35377.057896
Ken Payne Homes	SE 02-054-26 W4M	Lower Surficial	16-Jan-86	25.9	85.0	6.1	20.0	M35377.231948
Kennedy, R.	SE 23-055-24 W4M	Lower Surficial	11-Mar-86	59.4	195.0	33.5	110.0	M35377.053926
Kennett, Norman	NW 28-056-27 W4M	Lower Horseshoe Canyon	8-Jun-76	48.8	160.0	12.5	41.0	M35377.057153
Keylor, J.	01-13-056-25 W4M	Lower Horseshoe Canyon	15-Jun-76	44.2	145.0	8.5	28.0	M35377.056920
Kieftenheld, Perry & Harvey	SE 29-055-26 W4M	Lower Horseshoe Canyon	22-Apr-67	61.0	200.0	6.1	20.0	M35377.193803
Kieser, Kevin	NE 14-055-25 W4M	Lower Horseshoe Canyon	29-Sep-83	21.0	69.0	4.0	13.0	M35377.054775
Kieser, Robert	NE 26-056-26 W4M	Lower Horseshoe Canyon	29-Jun-76	18.3	60.0	3.1	10.0	M35377.057355
King, R.	NW 14-054-26 W4M	Bearpaw	22-Feb-74	88.4	290.0	21.9	72.0	M35377.049994
Klassen, A. & Frank	08-36-057-24 W4M	Oldman	8-Jun-81	25.0	82.0	6.4	21.0	M35377.183235
Klassen, Jim	NW 25-056-22 W4M	Oldman	22-Aug-75	45.7	150.0	6.1	20.0	M35377.055994
Klein, F	SW 23-056-25 W4M	Lower Horseshoe Canyon	30-May-74	54.9	180.0	7.6	25.0	M35377.057242
Kluthe, H.	05-30-055-24 W4M	Bearpaw	26-May-83	57.9	190.0	1.8	6.0	M35377.054414
Kluthe, Norman	13-34-054-26 W4M	Lower Horseshoe Canyon	1-Jun-83	45.7	150.0	15.2	50.0	M35377.055424
Koch, Otto	NW 34-054-27 W4M	Lower Horseshoe Canyon	12-Nov-87	29.3	96.0	3.7	12.0	M35377.054139
Kooznetsaff, Bill	SW 22-057-23 W4M	Upper Surficial	12-Jul-85	12.2	40.0	2.3	7.5	M35377.059321
Krajacid, George	SW 09-056-23 W4M	Lower Surficial	15-May-78	43.0	141.0	18.3	60.0	M35377.056668
Kremer, Ray	04-15-054-26 W4M	Lower Horseshoe Canyon	7-May-80	36.6	120.0	7.0	23.0	M35377.050030
Kreway, John	16-18-056-24 W4M	Lower Horseshoe Canyon	3-Oct-82	51.8	170.0	6.1	20.0	M35377.056830
Krupa, Eugene	NE 28-057-24 W4M	Bearpaw	7-Dec-81	80.8	265.0	14.6	48.0	M35377.067524
Krupa, John	SE 31-054-27 W4M	Lower Horseshoe Canyon	4-Apr-77	36.6	120.0	8.5	28.0	M35377.053912

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
Kuiper, A. & D.	01-33-056-21 W4M	Upper Surficial	1-May-77	18.9	180.0	8.2	55.0	M35377.055931
Kuzyk, B.	NW 24-056-24 W4M	Upper Surficial	1-Apr-77	24.4	75.0	15.2	13.4	M35377.063437
Lakeside Dairy Ltd.	NW 14-057-24 W4M	Bearpaw	19-May-81	30.5	170.0	10.7	65.0	M35377.067485
Lakeside Dairy Ltd.	NW 14-057-24 W4M	Bearpaw	19-Nov-81	38.1	63.0	7.6	20.0	M35377.067486
Lamoureux, J.	SE 05-055-22 W4M	Lower Surficial	14-Sep-82	11.3	117.0	6.4	31.0	M35377.049635
Larsen, Peter	SE 04-056-22 W4M	Oldman	12-Aug-85	45.7	110.0	14.9	85.0	M35377.055338
Leclair, Douglas	SW 25-054-01 W5M	Lower Horseshoe Canyon	6-Oct-82	67.1	88.0	16.8	58.0	M35379.044373
Leitz, B.	SE 04-057-26 W4M	Lower Horseshoe Canyon	16-May-78	38.1	65.0	6.1	12.0	M35377.058011
Lema, Don	12-22-054-26 W4M	Lower Horseshoe Canyon	13-Aug-79	44.2	225.0	14.9	60.0	M35377.055038
Lemmens, Bud	NW 25-057-21 W4M	Oldman	7-Sep-83	23.8	155.0	7.3	15.0	M35377.057645
Litwin, Terry	NE 26-056-23 W4M	Oldman	30-Nov-78	70.1	39.0	21.3	10.0	M35377.058957
Lorenson, L.	13-18-054-24 W4M	Bearpaw	17-May-73	79.2	170.0	29.9	50.0	M35377.232009
Lozniack, W.	SW 23-055-24 W4M	Lower Surficial	22-Jul-77	75.0	180.0	55.5	65.0	M35377.053957
Mack, H.	SW 23-055-24 W4M	Lower Surficial	11-May-75	69.5	75.0	45.7	40.0	M35377.053996
Mahe, Alex	01-29-056-24 W4M	Lower Horseshoe Canyon	28-Sep-81	33.5	160.0	6.1	70.0	M35377.057274
Mahe, Pat	SW 13-057-26 W4M	Lower Horseshoe Canyon	13-Aug-76	53.3	115.0	10.7	40.0	M35377.058157
Majeau, Edmond	07-07-054-26 W4M	Lower Horseshoe Canyon	1-May-76	52.4	113.0	17.1	15.0	M35377.049689
Marshall, Marina	NE 19-055-26 W4M	Lower Horseshoe Canyon	16-Jul-74	54.9	110.0	12.2	7.0	M35377.054846
Mason, Jim	SE 13-058-24 W4M	Oldman	1-Aug-76	67.1	190.0	12.8	68.0	M35377.166231
Matiuk, John	SE 15-057-23 W4M	Upper Surficial	27-Jun-81	6.7	100.0	4.9	6.0	M35377.067284
Mcavay, G.	NW 14-056-23 W4M	Oldman	12-Oct-73	57.9	115.0	9.1	53.0	M35377.057366
Mcconnell, B.	SE 33-057-25 W4M	Bearpaw	13-Feb-80	30.5	255.0	13.7	67.0	M35377.059139
McGee, Debra	02-21-057-23 W4M	Oldman	11-Nov-81	61.0	160.0	48.8	35.0	M35377.059207
McKirdy, T.	NE 35-056-25 W4M	Lower Horseshoe Canyon	9-Mar-73	32.6	157.0	7.3	70.0	M35377.057546
McLaughlan, Wayne	SW 17-054-26 W4M	Lower Horseshoe Canyon	23-Jan-79	55.2	120.0	21.9	23.0	M35377.050162
McNally, Peter	SW 02-054-26 W4M	Lower Surficial	1-May-71	16.2	145.0	8.2	37.0	M35377.049163
McVay, Bill#Shil Shol Estates	NW 34-054-27 W4M	Lower Horseshoe Canyon	10-Dec-86	29.0	48.0	3.7	14.0	M35377.054136
Medwed, Ronald & Elizabeth	NE 28-055-26 W4M	Lower Horseshoe Canyon	10-Nov-80	19.8	60.0	1.8	44.0	M35377.055477
Medwid, Peter	SW 09-056-23 W4M	Lower Surficial	21-May-74	40.2	175.0	25.9	23.0	M35377.056589
Menzies, Neil & Laurie	01-13-054-01 W5M	Upper Surficial	19-May-81	34.8	210.0	21.3	70.0	M35379.043921
Mercier, Ray J.	08-15-054-26 W4M	Lower Surficial	18-Apr-80	46.9	137.0	13.7	50.0	M35377.050013
Michaluk, E.	SE 10-057-22 W4M	Oldman	14-Apr-80	61.0	120.0	16.8	16.0	M35377.057740
Miller	SW 13-056-23 W4M	Upper Surficial	15-Jul-65	6.7	180.0	2.4	70.0	M35377.057015
Mitchell, Richard	NW 31-054-27 W4M	Lower Horseshoe Canyon	3-Oct-79	36.9	130.0	8.2	40.0	M35377.053930
Montpetit, Jim	NE 08-058-24 W4M	Upper Surficial	28-Sep-79	21.3	184.0	14.3	30.0	M35377.166202
Montpetit, Martin	SW 17-058-24 W4M	Oldman	28-Jul-86	67.1	220.0	24.4	72.0	M35377.166244
Moore, L. W.	NE 19-054-25 W4M	Lower Horseshoe Canyon	1-Feb-70	28.0	110.0	11.6	54.0	M35377.049420
Morris, Robin	01-25-056-24 W4M	Upper Surficial	5-Nov-76	51.5	215.0	27.7	85.0	M35377.063466
Mulligan, Henry	NE 15-056-24 W4M	Bearpaw	14-Feb-83	54.9	120.0	11.6	26.0	M35377.056768
Murray, Norman A.	05-23-054-26 W4M	Lower Surficial	1-Oct-72	36.9	115.0	19.2	30.0	M35377.055050
Namao Ridge Estates	NE 22-055-24 W4M	Bearpaw	24-Mar-75	41.2	105.0	12.2	24.0	M35377.050886
Nicoll, George	05-24-057-22 W4M	Upper Surficial	31-Jul-77	15.9	260.0	4.0	110.0	M35377.058394
Ogilvie, R.	04-08-056-24 W4M	Lower Horseshoe Canyon	11-Aug-77	32.3	90.0	5.5	9.0	M35377.063359
Ogle, M.	SE 30-055-26 W4M	Lower Horseshoe Canyon	7-Apr-77	44.8	49.0	12.8	10.0	M35377.055672
Ozipko, Nester	16-10-056-24 W4M	Upper Surficial	25-May-81	10.4	73.0	10.7	35.0	M35377.063410

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

Owner	Location	Aquifer Name	Date Water Well Drilled	Completed Depth		NPWL		UID
				Metres	Feet	Metres	Feet	
P & P Finishing & Carpentry	SW 24-054-25 W4M	Upper Surficial	11-Jul-75	24.1	105.0	15.2	78.0	M35377.064333
Paquette, E. & A.	SW 17-055-27 W4M	Lower Horseshoe Canyon	5-Nov-82	35.1	135.0	19.8	45.0	M35377.069170
Park, Bob	NW 12-057-24 W4M	Bearpaw	1-Apr-74	36.6	85.0	26.2	57.0	M35377.067436
Pasay, Dan	SW 14-055-25 W4M	Lower Horseshoe Canyon	14-Jun-77	33.5	162.0	5.5	75.0	M35377.054743
Patrick, Ed	12-30-054-27 W4M	Lower Surficial	22-Dec-84	27.4	160.0	10.7	98.0	M35377.050887
Pauline, R F	NE 33-056-25 W4M	Lower Horseshoe Canyon	8-May-80	46.0	230.0	11.0	96.0	M35377.063477
Pelletier, Omer	NW 01-058-25 W4M	Oldman		71.6	185.0	13.7	18.0	M35377.169443
Pelletier, Paul	NW 12-058-25 W4M	Oldman	29-May-84	73.2	120.0	18.9	45.0	M35377.169500
Perdue, Pat	04-30-057-23 W4M	Oldman	25-Apr-77	100.6	104.0	38.1	30.0	M35377.059948
Perrault, Marcel	13-23-057-26 W4M	Lower Horseshoe Canyon	19-Jun-57	37.8	160.0	10.7	46.0	M35377.056041
Pestera, Brent & Ingrid	SW 22-057-23 W4M	Upper Surficial	28-Jul-89	8.5	180.0	3.1	40.0	M35377.067289
Petsula, Mr. J.	SW 23-055-24 W4M	Bearpaw	26-Apr-75	69.8	160.0	45.8	50.0	M35377.055778
Phair, R	05-23-055-24 W4M	Bearpaw	27-Jul-78	68.3	120.0	43.0	53.0	M35377.054088
Poliwchuck, Paul	SW 11-057-21 W4M	Birch Lake	26-Jan-76	25.9	30.0	7.6	6.0	M35377.067249
Pollard, Russ	NW 23-054-26 W4M	Lower Horseshoe Canyon	18-May-79	44.8	102.0	23.2	81.0	M35377.055078
Potter, R.	SE 30-055-23 W4M	Bearpaw	29-Mar-71	39.6	105.0	9.8	30.0	M35377.054713
Prefontaine, Frank	NE 26-057-24 W4M	Bearpaw	30-Apr-79	91.4	122.0	38.7	20.0	M35377.067515
Ranson, Jack	SW 09-056-23 W4M	Bearpaw	22-Apr-72	36.6	172.0	27.8	35.0	M35377.056645
Reid, Beverly	SW 18-057-21 W4M	Oldman	21-May-81	45.7	70.0	3.7	25.0	M35377.067251
Rigney, R. L.	14-23-056-24 W4M	Upper Surficial	8-Jul-64	42.4	230.0	15.2	55.0	M35377.057045
Rockwell	NW 30-056-23 W4M	Bearpaw	4-Dec-67	39.3	150.0	25.9	94.0	M35377.059322
Romaniuk, C.	NW 30-057-21 W4M	Oldman	16-Jun-78	29.6	220.0	9.1	28.0	M35377.057710
Rosychuk, Curt	01-02-057-21 W4M	Birch Lake	5-Oct-87	47.2	87.0	13.3	30.0	M35377.057253
Rusnell, Carl	SW 24-054-25 W4M	Lower Horseshoe Canyon	17-Jun-80	53.3	97.0	22.9	60.0	M35377.055508
Saligo's Service Ltd.	12-33-054-24 W4M	Bearpaw	22-Jul-66	42.7	70.0	18.3	39.0	M35377.064233
Salisbury, Vern	NE 30-056-22 W4M	Upper Surficial	21-Feb-78	13.7	43.0	7.9	15.0	M35377.057512
Saunders, Gecil	SE 27-056-22 W4M	Oldman	27-Aug-84	35.7	80.0	6.1	27.0	M35377.056131
Sawka, Walter	SE 04-057-21 W4M	Oldman	2-Dec-76	30.5	105.0	4.6	15.0	M35377.057263
Schafers, Shane	09-12-054-27 W4M	Lower Surficial	9-Jun-93	8.2	110.0	3.1	57.0	M35377.178669
Schayes, E.	13-11-056-25 W4M	Lower Horseshoe Canyon		30.5	140.0	0.6	42.0	M35377.056887
Schmermund, Don	SE 01-055-01 W5M	Lower Horseshoe Canyon	23-Apr-76	33.5	180.0	7.6	38.0	M35379.043424
Schmrmund, Ray	SE 07-055-27 W4M	Lower Horseshoe Canyon	1-Jul-69	20.1	55.0	1.8	25.0	M35377.054557
Schneider, E.	05-13-056-25 W4M	Lower Horseshoe Canyon	1-Aug-76	48.8	180.0	7.1	45.0	M35377.056944
Schofield, Gerald	SW 24-054-25 W4M	Lower Horseshoe Canyon	7-Apr-70	57.9	210.0	39.0	40.0	M35377.064335
Schwing, Roman	SE 04-057-21 W4M	Oldman	3-Aug-79	27.4	160.0	5.2	65.0	M35377.057267
Sharma, R. & G.	SW 14-057-23 W4M	Upper Surficial	18-Sep-82	2.4	130.0	1.2	22.0	M35377.067283
Sharrun, Ken	SW 26-056-22 W4M	Oldman	1-Apr-73	38.1	97.0	4.6	25.0	M35377.056054
Sitek, Larry	NW 35-057-20 W4M	Birch Lake	1-Jun-76	22.9	54.0	9.8	20.0	M35377.057449
Skidmore, L.	SW 23-055-24 W4M	Bearpaw	18-Aug-74	76.2	185.0	54.7	45.0	M35377.054077
Sobolewski, S.	SE 04-055-27 W4M	Lower Horseshoe Canyon	17-May-73	64.0	180.0	12.2	90.0	M35377.054496
Soderstrom, Ed	NE 31-056-22 W4M	Oldman	20-Sep-74	41.2	76.0	13.7	24.0	M35377.056221
Soetaert, Rene	16-29-054-26 W4M	Lower Horseshoe Canyon	6-Oct-82	33.5	120.0	8.5	20.0	M35377.055242
Southwood, Thomas	NW 01-057-24 W4M	Bearpaw	30-Mar-83	36.6	80.0	5.8	9.7	M35377.057848
Spaeth, Werner	SE 34-057-26 W4M	Lower Horseshoe Canyon	16-Aug-80	32.0	230.0	6.1	68.0	M35377.058548
Spilak, E.	SW 11-056-25 W4M	Lower Horseshoe Canyon	27-Nov-73	38.1	106.0	4.6	18.0	M35377.063439

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
St. Llery, Bill	NE 24-054-27 W4M	Lower Surficial	6-Jun-83	17.7	148.0	10.4	32.0	M35377.050734
St. Pierre, M.	SW 23-055-24 W4M	Lower Surficial	23-Jul-73	34.8	40.0	22.9	37.0	M35377.054013
Stamper, Fred	SE 17-056-26 W4M	Lower Horseshoe Canyon	12-Jun-84	32.0	62.0	0.0	25.0	M35377.057005
Stevenson, Mike	14-26-053-26 W4M	Lower Surficial	8-Sep-77	20.7	100.0	5.5	21.0	M36234.944685
Strawson, Irwin	03-13-056-24 W4M	Upper Surficial	20-Jun-78	29.3	85.0	18.9	31.0	M35377.056660
Street, N.	SW 23-055-24 W4M	Bearpaw	19-Apr-78	78.3	120.0	48.2	59.0	M35377.054099
Tailleur, Richard	NE 31-055-23 W4M	Bearpaw	15-Dec-77	54.3	20.0	41.8	-2.0	M35377.054907
Therres, Lenard	NE 20-056-26 W4M	Lower Horseshoe Canyon	2-Jun-86	46.3	210.0	7.6	50.0	M35377.057208
Thomas, R.	13-33-057-22 W4M	Upper Surficial	19-Sep-78	2.4	100.0	3.1	10.0	M35377.059082
Town of Bon Accord	01-13-056-24 W4M	Upper Surficial	15-Oct-64	30.2	180.0	16.8	25.0	M35377.063412
Turgeon, E.	04-19-055-25 W4M	Lower Horseshoe Canyon	15-Apr-77	41.2	131.0	6.1	4.0	M35377.055053
Underschultz, Bill	08-12-054-26 W4M	Lower Surficial	23-Oct-79	47.2	90.0	13.4	11.0	M35377.049914
Van Tighem, John	NE 14-055-27 W4M	Lower Horseshoe Canyon	20-Mar-74	51.8	58.0	7.6	26.0	M35377.054871
Vandam, Will	SW 21-055-26 W4M	Lower Horseshoe Canyon	16-Nov-83	14.9	110.0	6.1	28.0	M35377.055037
Verbeek, J. J. & Sons	NW 33-054-27 W4M	Lower Surficial	16-Oct-82	23.2	185.0	7.3	26.0	M35377.054069
Verbeek, L.	SW 22-055-27 W4M	Lower Horseshoe Canyon	4-Dec-67	32.0	120.0	8.5	10.0	M35377.055863
Verbeek, L. & Kockling, A.	NE 21-055-27 W4M	Lower Horseshoe Canyon	30-Nov-67	30.5	105.0	12.2	8.0	M35377.055859
Veroba, B.	SW 24-054-25 W4M	Bearpaw	30-May-73	70.1	160.0	25.9	42.0	M35377.049825
Victor, Charles	SE 30-053-26 W4M	Lower Horseshoe Canyon	23-Oct-75	19.8	315.0	9.1	50.0	M36234.944737
Vranas, Harvey	01-21-055-25 W4M	Lower Horseshoe Canyon	10-Jun-85	30.5	175.0	3.1	25.0	M35377.055132
W. J. Francl And Assoc	09-23-054-25 W4M	Bearpaw	27-Feb-75	68.0	64.0	6.4	35.0	M36239.965114
Walker	NW 06-055-24 W4M	Lower Horseshoe Canyon	28-Jul-75	38.1	55.0	9.1	26.0	M35377.050376
Watson, Jerry	NW 14-056-26 W4M	Lower Horseshoe Canyon	29-May-86	49.4	165.0	19.5	14.9	M35377.056929
Watt, Allan	NW 32-056-22 W4M	Oldman	20-Jul-80	42.1	135.0	15.2	78.0	M35377.056289
Wattie, Rick	SW 29-054-27 W4M	Lower Surficial	26-Sep-84	23.8	140.0	5.5	69.5	M35377.050846
Weiss, Donald	16-22-055-25 W4M	Lower Horseshoe Canyon	7-Oct-83	9.8	155.0	2.4	75.0	M35377.055332
Williams, Martin	SW 20-054-27 W4M	Lower Surficial	30-Oct-87	30.5	165.0	24.4	38.0	M35377.050661
Willis Realty	11-23-055-24 W4M	Lower Surficial	26-Jun-75	74.7	160.0	46.0	79.0	M35377.054264
Wilson, Garth	NE 20-054-27 W4M	Lower Surficial	26-Apr-77	15.9	105.0	0.9	18.0	M35377.055704
Wolanski, W.	SW 34-056-21 W4M	Oldman	30-Mar-74	28.0	50.0	2.1	30.0	M35377.055991
Wolansky, W.	04-34-056-21 W4M	Upper Surficial	12-Jun-85	15.2	60.0	3.1	40.0	M35377.055970
Workun, Rocky	08-19-057-22 W4M	Upper Surficial	21-May-81	3.7	84.0	2.4	28.0	M35377.058043
Wozniak, J	01-24-056-25 W4M	Lower Horseshoe Canyon	3-Oct-72	45.7	104.0	9.1	71.0	M35377.057270
Yaremko, Bob	NE 36-054-27 W4M	Lower Surficial	24-May-88	12.2	130.0	3.7	38.0	M35377.054192
Zemlak, Clarence	NE 31-055-23 W4M	Lower Surficial	12-Jun-79	58.8	180.0	31.4	130.0	M35377.054911
Ziegler, Robert	NW 13-055-01 W5M	Lower Horseshoe Canyon	22-Aug-84	21.3	205.0	4.3	60.0	M35379.044146

STURGEON COUNTY-OPERATED WATER WELLS

		Aquifer	Date Water	Completed Depth		NPWL		
Owner	Location	Name	Well Drilled	Metres	Feet	Metres	Feet	UID
County of Sturgeon	NW 23-055-24 W4M	Lower Surficial	14-Jun-91	76.8	252.0	49.1	161.0	M35377.090176
County of Sturgeon	14-24-055-25 W4M	Lower Horseshoe Canyon	08-Mar-78	12.2	40.0	6.1	20.0	M35377.055440