County of Vermilion River No. 24

Part of the North Saskatchewan and Battle River Basins
Parts of Tp 045 to 056, R 01 to 07, W4M
Regional Groundwater Assessment

Prepared for

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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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. **This report, even though it is regional in nature, is the first step in fulfilling a commitment by the County of Vermilion River No. 24 toward the management of the groundwater resource, which is a key component toward the well-being of the County, and is a guide for future groundwater-related projects.**

1.1 About This Report

This report provides an overview of (a) the groundwater resources of the County of Vermilion River No. 24, (b) the processes used for the present project and (c) the groundwater characteristics in the County.

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

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

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

Appendix C includes the following:

1) a procedure for conducting aquifer tests with water wells;
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; and
4) additional information.

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

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

1.2 The Project

It must be noted that the present project is a regional study and as such the results are to be used only as a guide. Detailed local studies are required to verify hydrogeological conditions at given locations.

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

Module 1 - Data Collection and Synthesis
Module 2 - Hydrogeological Maps
Module 3 - Covering Report
Module 4 - Groundwater Query
Module 5 - Familiarization Session

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

1.3 Purpose

This project is a regional groundwater assessment of the County of Vermilion River No. 24. 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 includes:

- identification of the aquifers[1] within the surficial deposits[2] and the upper bedrock;
- spatial definition of the main aquifers;
- quantity and quality of the groundwater associated with each aquifer;
- hydraulic relationship between aquifers; and
- identification of the first sand and gravel deposits below ground level.

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 the County.

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1 See glossary
2 See glossary

2 INTRODUCTION

2.1 Setting

The County of Vermilion River is situated in east-central Alberta. This area is part of the Alberta Plains region. The County is within the North Saskatchewan River (NSR) basin; a part of the County's southern boundary is the Battle River. The other County boundaries follow township or section lines. The area includes parts of the area bounded by township 056, range 07, W4M in the northwest and township 045, range 01, W4M in the southeast.

Regionally, the topographic surface varies between 480 and 760 metres above mean sea level (AMSL). The lowest elevations occur in the NSR and the Battle River valleys and the highest are in the southwestern part of the County as shown in Figure 1.

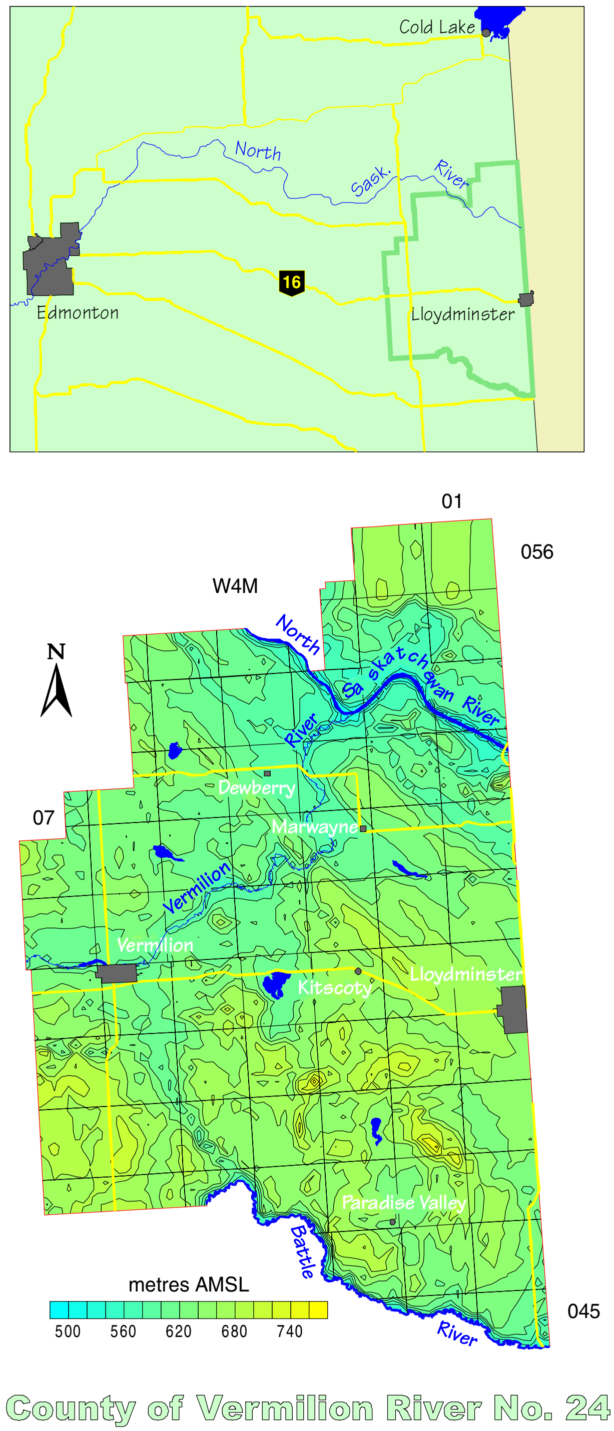

Figure 1. Index Map

2.2 Climate

The County of Vermilion River No. 24 lies within the transition zone between a humid, continental Dfb climate and a semiarid Bsk climate. This classification is based on potential evapotranspiration 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 the Aspen Parkland region, a transition between boreal forest and grassland environments.

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. A Bsk climate is characterized by its moisture deficiency, where mean annual potential evapotranspiration exceeds the mean annual precipitation.

The mean annual precipitation averaged from four meteorological stations within the County measured 419 millimetres (mm), based on data from 1952 to 1993. The annual temperature averaged 1.7 °C, with the mean monthly temperature reaching a high of 16.7 °C in July, and dropping to a low of -15.8 °C in January. The calculated annual potential evapotranspiration is 517 millimetres.

2.3 Background Information

There are currently records for 6,110 water wells in the groundwater database for the County. Of the 6,110 water wells, 5,081 are for domestic/stock purposes. The remaining 1,029 water wells were completed for a variety of uses, including municipal, industrial, irrigation and observation. Based on a rural population of 7,553, there are 3.2 domestic/stock water wells per family of four. The domestic or stock water wells vary in depth from 0.6 metres to 190 metres below ground level. Lithologic details are available for 3,491 water wells.

Data for casing diameters are available for 3,097 water wells, with 2,552 (82%) indicated as having a diameter of less than 275 mm and 545 having a diameter of more than 300 mm. The casing diameters of greater than 300 mm are mainly bored or dug water wells and those with a surface-casing diameter of less than 275 mm are drilled water wells. Large-diameter water wells are mainly in the areas where significant linear bedrock lows are present.

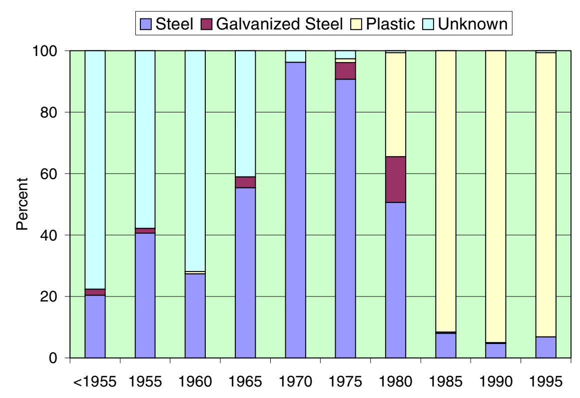

Figure 2. Surface Casing Types used in Drilled Water Wells

In the County, steel, galvanized steel and plastic represent 99% of the materials that have been used for surface casing in drilled water wells over the last 40 years. Until the 1960s, the type of surface casing used in drilled water wells was mainly undocumented. Steel casing was in use in the 1950s and is still used in 7% of the water wells being drilled in the County in the 1990s. Steel and galvanized steel were the main casing types until the start of the 1980s, at which time plastic casing started to replace the use of steel and galvanized steel casings.

Galvanized steel surface casing was used in a maximum of 15% of the new water wells from the 1950s to the early 1990s. Galvanized steel was last used in May 1990.

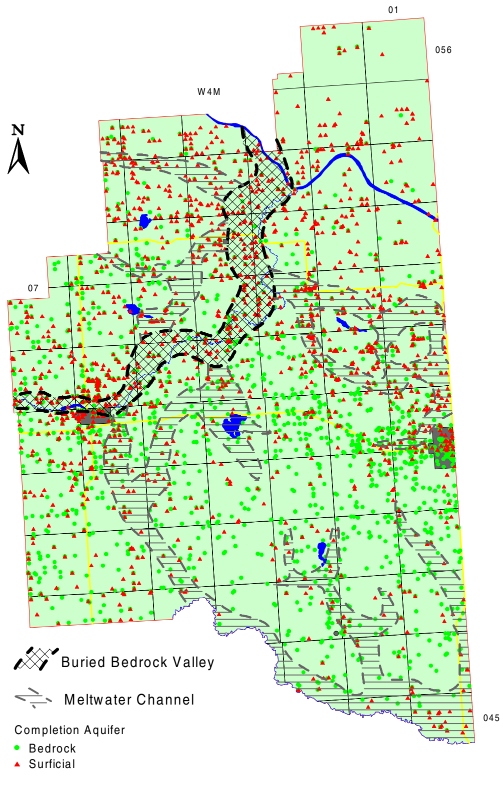

Figure 3. Location of Water Wells

There are 3,731 water well records with sufficient information to identify the aquifer in which the water wells are completed. The water wells that were not drilled deep enough to encounter the bedrock plus water wells that have the bottom of their completion interval above the bedrock surface are water wells completed in surficial aquifers. The number of water wells completed in aquifers in the surficial deposits is 1,790, with 60% having a completion depth of greater than 20 metres. The adjacent map shows that the majority of the water wells completed in the surficial deposits occur in the northern half of the County, frequently in the vicinity of linear bedrock lows.

The 1,941 water wells that have the top of their completion interval deeper than the top of the bedrock surface are referred to as bedrock water wells. From Figure 3, it can be seen that water wells completed in bedrock aquifers occur mainly in the southern two-thirds of the County.

Water wells not used for domestic needs and providing groundwater with total dissolved solids (TDS) of less than 4,000 milligrams per litre (mg/L) must be licensed. At the end of 1996, 164 groundwater diversions were licensed in the County. Of the 164 licensed groundwater users, 112 are for agricultural purposes, and the remaining 52 are for industrial, municipal, domestic and other purposes. The total maximum authorized diversion from the water wells associated with these licences is 8,503 cubic metres per day (m³/day); 43% percent of the authorized groundwater diversion is allotted for municipal use, 34% is allotted for industrial use, and 20% is allotted for agricultural use. The remaining 3% has been licensed for domestic and other uses. The largest potable groundwater diversion licensed within the County is for the Town of Vermilion, having a diversion of 929.7 m³/day. The largest licensed industrial groundwater diversion within the County is for a water source well completed in the Lower Sand and Gravel Aquifer in 16-10-052-04 W4M owned by Canadian Natural Resources Ltd.

The following table shows a breakdown of the 164 licensed groundwater diversions by the aquifer in which the water well is completed. The largest total licensed diversions are in the Lower Sand and Gravel and Ribstone Creek aquifers; the majority of the groundwater is used for municipal and industrial purposes.

	Licensed Groundwater Users (m³/day)						
Aquifer	Agricultural	Industrial	Municipal	Domestic	Other	Total	Percentage
Upper Sand and Gravel	369	652	91	20	3	1,135	13
Lower Sand and Gravel	432	1,366	2,191	14	0	4,003	47
Oldman	10	0	0	0	0	10	0
Birch Lake	71	0	0	0	27	98	1
Ribstone Creek	660	0	538	0	223	1,421	17
Victoria	148	0	805	0	0	953	11
Brosseau	0	0	0	0	0	0	0
Lea Park	10	0	0	0	0	10	0
Saline	0	849	0	0	0	849	10
Unknown	14	0	10	0	0	24	0
Total	1,714	2,867	3,635	34	253	8,503	100
Percentage	20	34	43	0	3	100	

Table 1. Licensed Groundwater Diversions

Based on the 1996 Agriculture Census, the water requirement for livestock for the County is in the order of 17,442 m³/day, which is more than ten times the amount of the groundwater diversion that is licensed for agricultural purposes; some of the difference would be related to the use of surface water.

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.

Groundwaters from the surficial deposits can be expected to be chemically hard with a high dissolved iron content. The total dissolved solids (TDS) concentrations in the groundwaters from the upper bedrock in the County are generally less than 1,100 milligrams per litre (mg/L). Groundwaters from the bedrock aquifers frequently are chemically soft with generally low concentrations of dissolved iron. The chemically soft groundwater is high in sodium concentration. Less than 1% of the chemical analyses indicate a fluoride concentration above 1.5 mg/L.

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, only average values of TDS and sodium concentrations exceed the guidelines.

Constituent	Range for County in mg/L Minimum	Maximum	Average	Recommended Maximum Concentration GCDWQ
Total Dissolved Solids	35.0	6006	1091	500
Sodium	4.0	1283	304	200
Sulfate	1.0	2886	318	500
Chloride	1.0	2340	65	250
Fluoride	0.02	2.65	0.31	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives

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

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

Alberta Environmental Protection (AEP) defines the Base of Groundwater Protection as the elevation below which the groundwater is expected to have more than 4,000 mg/L of total dissolved solids. By using the ground elevation, and the elevation of the Base of Groundwater Protection provided by the Alberta Energy and Utilities Board (EUB), a depth to the Base of Groundwater Protection can be determined. 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 is completed below the Base of Groundwater Protection with the total dissolved solids of the groundwater exceeding 4,000 mg/L, then the groundwater use does not require licensing by AEP.

Over approximately 60% of the County, the depth to the Base of Groundwater Protection is more than 100 metres. There are only a few areas where the depth to the Base of Groundwater Protection is less than 40 metres; these areas are mainly within a few kilometres of the North Saskatchewan and Vermilion rivers, as shown on the adjacent map.

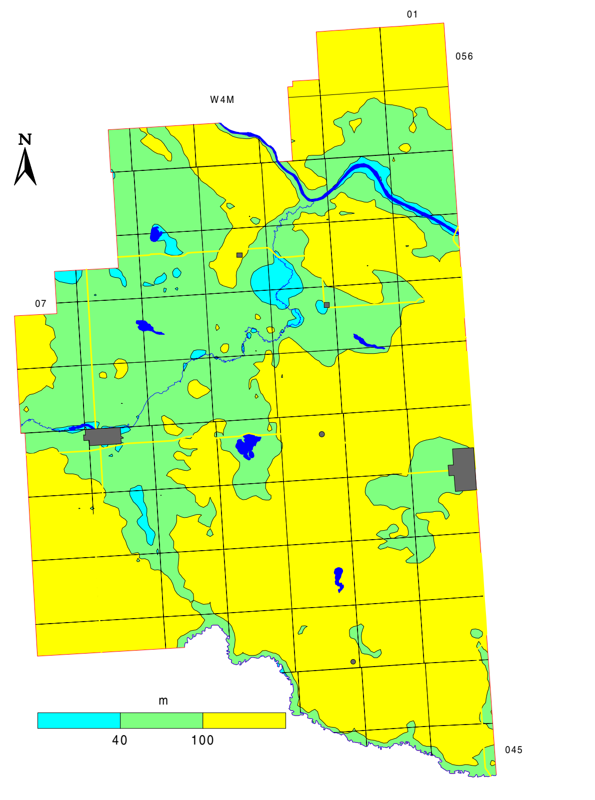

Figure 4. Depth to Base of Groundwater Protection (after EUB, 1995)

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 eight AEP-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 AEP, 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. 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.

3 TERMS

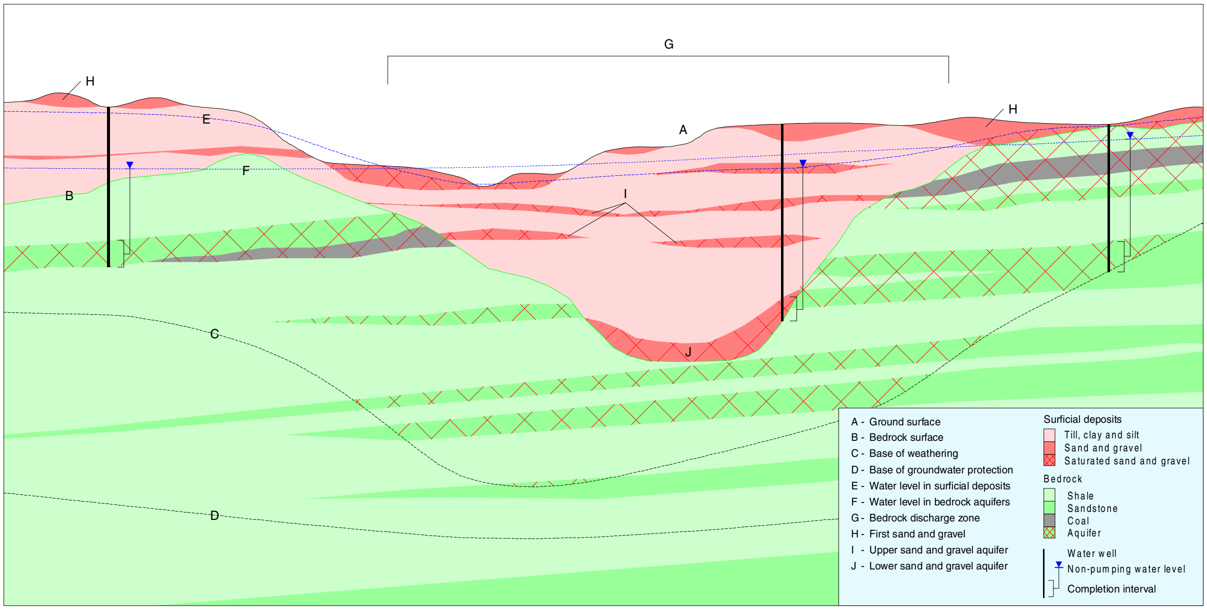

Figure 5. Generalized Cross-Section (for terminology only)

Lithology	Lithologic Description	Group and Formation: Thickness (m)	Group and Formation: Designation	Member: Thickness (m)	Member: Designation	Zone: Thickness (m)	Zone: Designation
	sand, gravel, till, clay, silt	<100	Surficial Deposits	<100	Upper	<50	First Sand and Gravel
				<80	Lower		
	sandstone, siltstone, shale, coal	<130	Belly River Group: Oldman Formation		Dinosaur Member	<0-25	Lethbridge Coal Zone
					Upper Siltstone Member		
					Comrey Member		
	sandstone, shale, coal	<180	Belly River Group: Foremost Formation	<70	Birch Lake Member		Taber Coal Zone
				<60	Ribstone Creek Member		
				<50	Victoria Member		
				<15	Brosseau Member		McKay Coal Zone
	shale, siltstone	40-80	Lea Park Formation				
	sandstone, siltstone, shale, coal	40-140	Milk River Formation				
	shale, siltstone		Colorado Group				

Figure 6. Geologic Column

4 METHODOLOGY

4.1 Data Collection and Synthesis

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

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

The main disadvantage to the database is the absence of quality control. Very little can be done to overcome this lack of quality control in the data collection, other than to assess the usefulness of control points relative to other data during the interpretation. Another disadvantage to the database is the lack of adequate spatial information. However, unlike other areas in the Province where there are numerous duplicate records, the present database for the County contains less than 20 duplicate water well IDs.

The AEP 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 NE ¼ of section 23, township 052, range 02, W4M, would have a horizontal coordinate with an Easting of 319,230 metres and a Northing of 5,936,986 metres, the centre of the quarter section. If the water well has been positioned by the Prairie Farm Rehabilitation Administration (PFRA) as a result of field verification, the location will be more accurate, possibly within several 10s 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) from the Resource Data Division of AEP.

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

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

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

Also, where sufficient information is available, values for apparent transmissivity[3] and apparent yield[4] 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.

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 geological units;
3) type and intervals for various down-hole geophysical logs; and
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 verify the geological interpretation of geophysical logs but cannot be distributed because of a licensing agreement.

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) wells drilled by the oil and gas industry; and
4) data from existing cross-sections.

The identification of aquifers becomes a two-step process: first, mapping the tops and bottoms of individual geological units; and second, identifying the porous and permeable parts of each geological unit in which the aquifer is present.

After obtaining values for the elevation of the top and bottom of individual geological units at specific locations, the spatial distribution of the individual surfaces can be determined. Digitally, establishment of the distribution of a surface requires the 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[5] 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.

The porous and permeable parts of the individual geological units have been mainly determined from geophysical logs.

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3 For definitions of Transmissivity, see glossary
4 For definitions of Yield, see glossary
5 See glossary

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), transmissivity and projected water well yield. The total dissolved solids, chloride and sulfate concentrations from the chemical analysis of the groundwater are also assigned to applicable aquifers.

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

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 two 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 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 map is categorized based on relative permeability. The information from these two sources is combined to form the risk assessment map. The criteria used in the classification of risk are given 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 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 geological 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 geological unit.

Grids must also be combined to allow the calculation of projected long-term yields for individual water wells. The grids related to the elevation of the NPWL and the elevation of the top of the aquifer are combined to determine the available drawdown[6]. The available drawdown data and the transmissivity values are used to calculate values for projected long-term yields for individual water wells, completed in a specific aquifer.

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6 See glossary

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

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

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

4.5 Software

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

- Acrobat 4.0
- ArcView 3.1
- AutoCAD 14.01
- CorelDRAW! 8.0
- Microsoft Professional Office 97
- Surfer 6.04

5 AQUIFERS

5.1 Background

An aquifer is a porous and permeable rock that is saturated. If the NPWL is above the top of the rock unit, this type of aquifer is an artesian aquifer. If the rock unit is not entirely saturated and the water level is below the top of the unit, this type of aquifer is a water-table aquifer. These types of aquifers occur in one of two general geological settings in the County. The first geological setting includes the sediments that overlie the bedrock surface. In this report, these are referred to as the surficial deposits. The second geological setting includes aquifers in the upper bedrock. The geological settings, the nature of the deposits making up the aquifers within each setting, the expected yield of water wells completed in aquifer(s) within different geological 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 100 metres. The Buried Vermilion Valley is the main linear bedrock low in the County. The Buried Vermilion Valley is present in townships 050 and 051, ranges 06 and 07, W4M and trends northeast to township 055, range 03, W4M. Cross-section A-A' passes through parts of the Buried Vermilion Valley, and shows the thickness of the surficial deposits varying from less than ten to more than 100 metres.

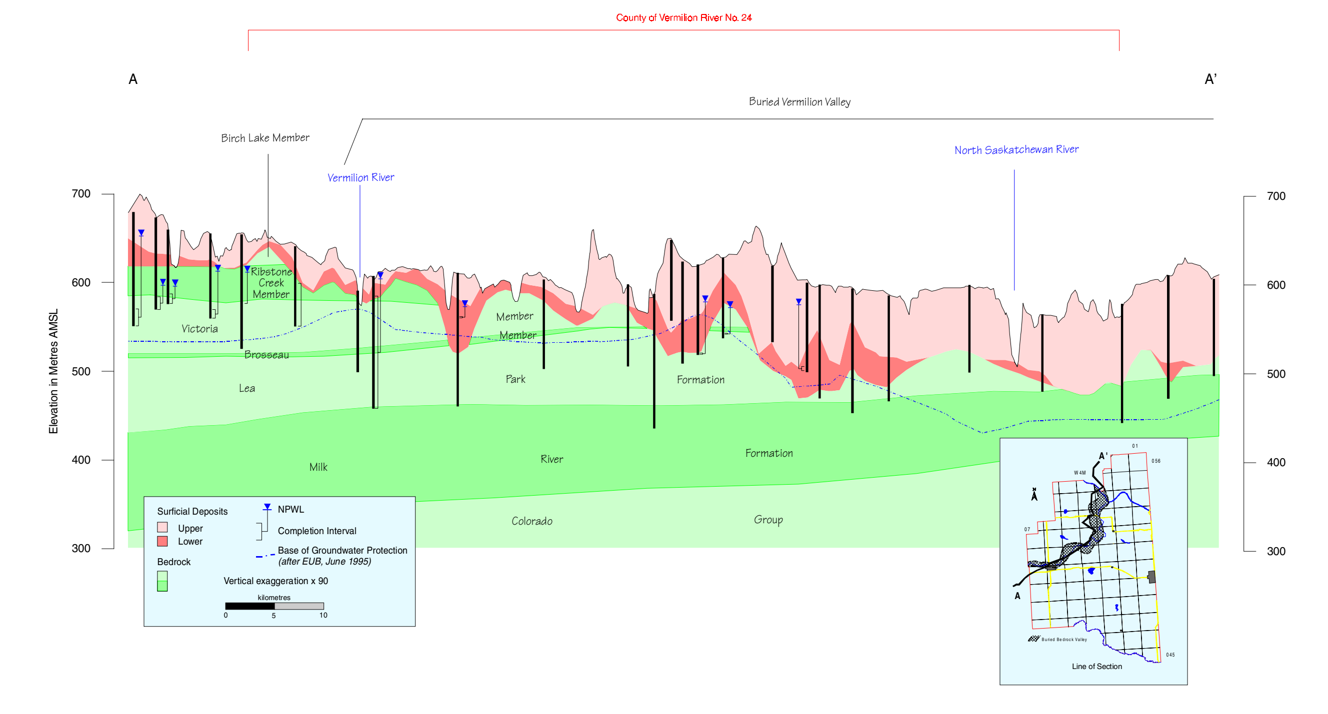

Figure 7. Cross-Section A - A'

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 NPWL in water wells that are less than 15 metres deep. The base of the surficial deposits is the bedrock surface.

For a water well with a small-diameter casing to be effective in surficial deposits and to provide sand-free groundwater, the water well must be completed with a water well screen. Some water wells completed in the surficial deposits are completed in low-permeability aquifers and have a large-diameter casing. The large-diameter water wells may have been hand dug or bored and because they are completed in very low permeability aquifers, most of these water wells would not benefit from water well screens. The groundwater from an aquifer in the surficial deposits usually has a chemical hardness of at least a few hundred mg/L and a dissolved iron concentration such that the groundwater must be treated before being used for domestic needs. Within the County, casing-diameter information is available for 1,241 of the 1,790 water wells completed in the surficial deposits; 243 of these have a casing diameter of more than 300 millimetres, and are assumed to be bored or dug water wells.

5.1.2 Bedrock Aquifers

The upper bedrock includes rocks that are less than 200 metres below the bedrock surface and above the Colorado Group. Some of this bedrock contains porous, permeable and 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 are friable[7] and water well screens are a necessity. The groundwater from the bedrock aquifers is usually chemically soft.

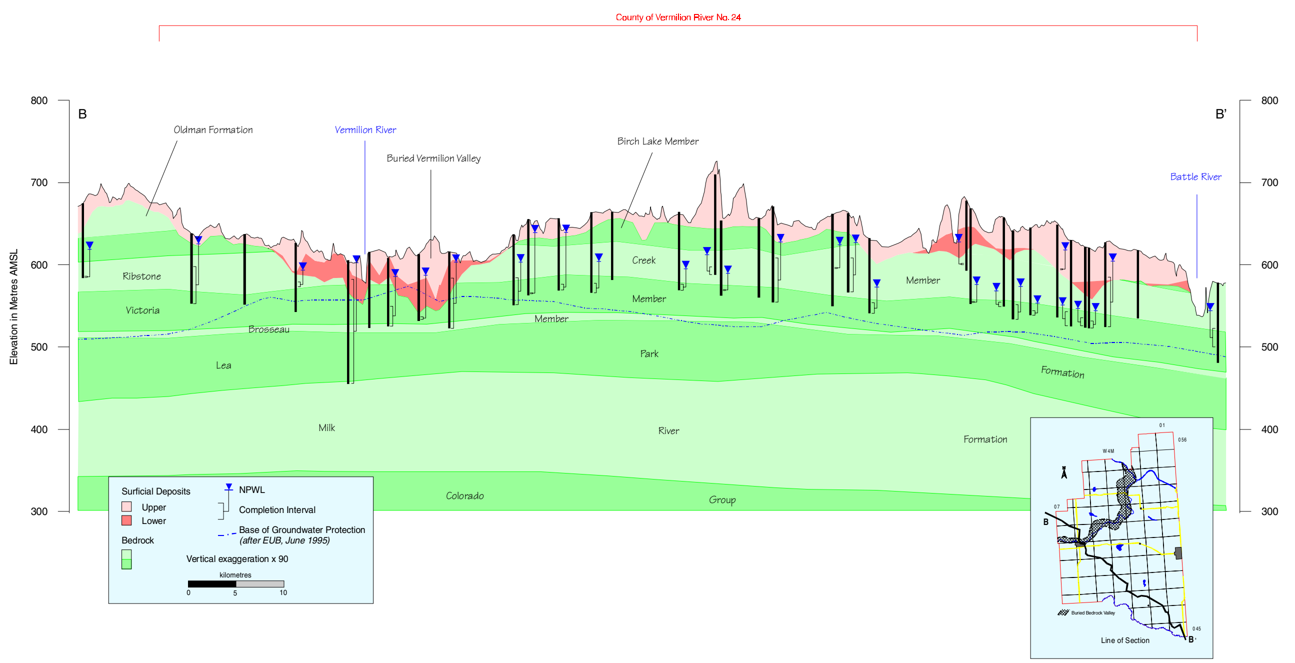

Figure 8. Cross-Section B - B'

The data for 1,941 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 1,830 of the 1,941 water wells completed in the bedrock aquifers. Of these 1,830 water wells, 98% have surface-casing diameters of less than 275 mm and these bedrock water wells have been mainly completed with either a screen or as open hole. There were 163 bedrock water wells that were completed with a slotted liner.

The upper bedrock includes a part of the Belly River Group, the Lea Park Formation and the Milk River Formation (Figure 8). The Lea Park Formation is a regional aquitard[8]. The Colorado Group underlies the Milk River Formation.

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[7] See glossary
[8] See glossary

5.2 Aquifers in Surficial Deposits

The surficial deposits are the sediments above the bedrock surface. This includes pre-glacial materials, which were deposited before glaciation, and materials deposited directly or indirectly by glaciation. The *lower surficial deposits* include pre-glacial fluvial[9] and lacustrine[10] deposits. The lacustrine deposits include clay, silt and fine-grained sand. The *upper surficial deposits* include the more traditional glacial deposits of till[11] and meltwater deposits.

5.2.1 Geological Characteristics of Surficial Deposits

While the surficial deposits are treated as one hydrogeological unit, they consist of three hydraulic units. The first unit is the sand and gravel deposits of the lower surficial deposits when present. These deposits are mainly saturated, where present. 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. See Figure 5 for a graphical depiction of the above description. 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. Because of the significance of the shallow sand and gravel deposits, they have been mapped where the tops of these deposits are present within one metre of the ground surface; these shallow deposits are referred to as the "first sand and gravel".

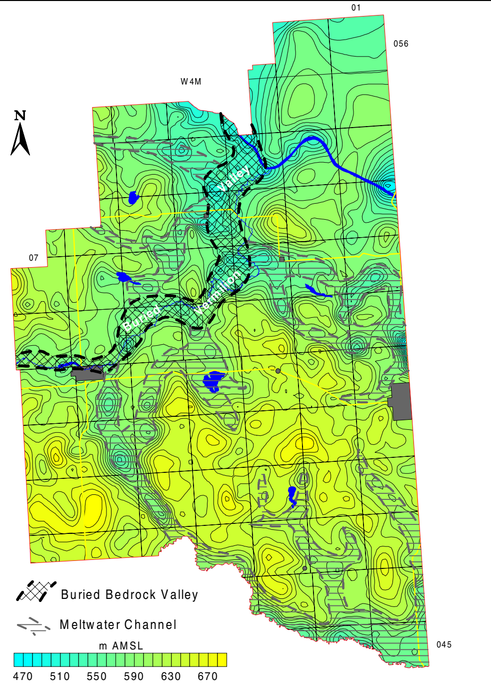

Figure 9. Bedrock Topography

The base of the surficial deposits is the bedrock surface, represented by the bedrock topography as shown on the adjacent map. There are numerous linear bedrock lows shown on the bedrock topography map. These lows trend mainly northwest to southeast in the County and are indicated as being of meltwater origin. However, because sediments associated with the lower surficial deposits are indicated as being present in these linear bedrock lows, it is possible that the bedrock lows were originally tributaries to the Buried Vermilion Valley drainage system present in the County.

Over the majority of the County, the upper surficial deposits are less than 30 metres thick. The exceptions are mainly in association with the linear bedrock lows where the deposits can have a thickness of more than 50 metres. The main linear bedrock low in the County has been designated as the Buried Vermilion Valley, as shown on Figure 9. This Valley trends east while occupying the present-day Vermilion River Valley, then turns northeast toward the North Saskatchewan River. The Buried Vermilion Valley is approximately eight to 15 kilometres wide, with local relief being up to 100 metres.

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 15 metres in the areas of the linear bedrock lows.

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9 See glossary
10 See glossary
11 See glossary

Cross-section C – C' passes three kilometres north of Lloydminster. At the east end of the cross-section, the surficial deposits are indicated as being close to 200 metres thick in an area where significant linear bedrock lows are not present. The thickness of the surficial deposits is believed to reflect the existence of a collapse structure that was at least partially formed during glaciation. The structure which is close to circular forms as a result of the removal of salt in the Prairie Evaporites at a depth of approximately 700 metres. Other examples of collapse structures formed as a result of the removal of salt have been documented in southern Saskatchewan (Christiansen, 1971).

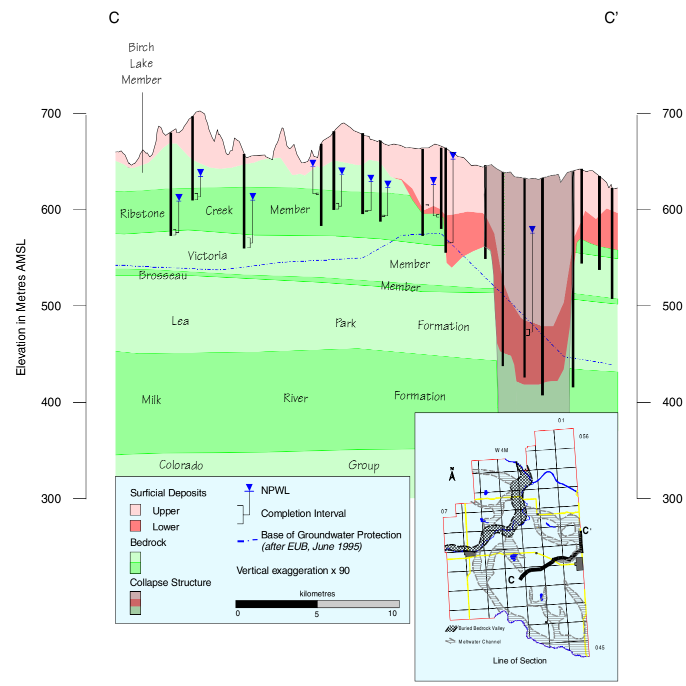

Figure 10. Cross-Section C – C'

The bedrock topography map suggests the existence of other collapse structures in the County. However, the one north of Lloydminster is the only one that can be delineated with the available data. The data show the presence of sand or gravel below a depth of 100 metres and apparent water well yields can be several hundred cubic metres per day.

The lower surficial deposits are composed mostly of fluvial and lacustrine deposits. Lower surficial deposits occur over more than 30% of the County, in association with linear bedrock lows. The total thickness of the lower surficial deposits is mainly less than 50 metres, but can be up to 100 metres in the areas of linear bedrock lows. 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 Vermilion Valley. The lower sand and gravel deposits are of fluvial origin, are usually less than five metres thick and may be discontinuous.

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 in association with the linear bedrock lows; there are several areas in the County where these deposits are not present.

Sand and gravel deposits can occur throughout the surficial deposits. The total thickness of sand and gravel deposits is generally less than five metres but can be more than 15 metres in the areas of the linear bedrock lows and meltwater channels.

The combined thickness of all sand and gravel deposits has been determined as a function of the total thickness of the surficial deposits. Over approximately 5% of the County, the sand and gravel deposits are more than 50% of the total thickness of the surficial deposits. One area where the sand and gravel percentages are higher is in association with the Buried Vermilion Valley. The other areas where sand and gravel deposits constitute more than 50% of the total thickness of the surficial deposits may be in areas of meltwater channels or areas where linear bedrock lows exist but have not been identified due to a shortage of accurate bedrock control points.

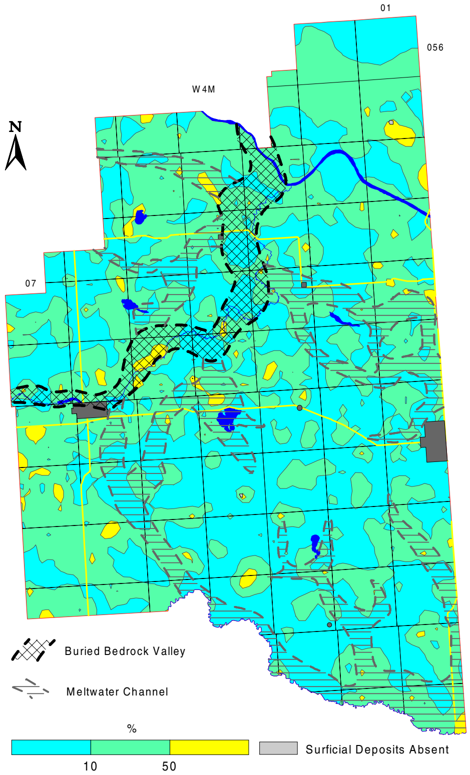

Figure 11. Amount of Sand and Gravel in Surficial Deposits

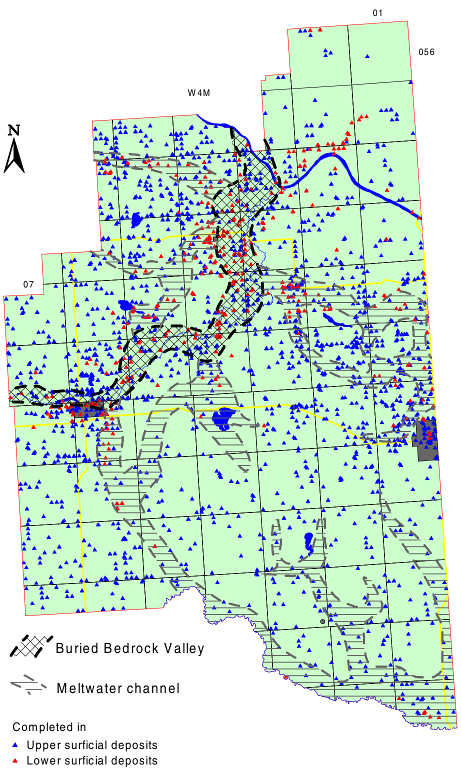

Figure 12. Water Wells Completed in Surficial Deposits

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. From the present hydrogeological analysis, 430 water wells are completed in aquifers in the lower surficial deposits and 2,403 are completed in the upper surficial deposits. This number of water wells is more than 1.5 times the number 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 expected elevation of the bedrock surface at the same location, then the water well is determined to be completed in an aquifer in the surficial deposits.

The water wells completed in the upper surficial deposits occur throughout the County, but are mainly concentrated in the northern half of the County, as shown in Figure 12. The majority of the water wells completed in the lower surficial deposits are located along the Buried Vermilion Valley and the meltwater channels north of the City of Lloydminster.

The adjacent map shows expected yields for water wells completed in aquifers in the sand and gravel aquifer(s), based on the aquifers that have been developed by existing water wells. These data show that water wells with yields of less than 100 m³/day from sand and gravel aquifer(s) can be expected in most areas of the County. The most notable areas where yields of more than 100 m³/day are expected are mainly in association with linear bedrock lows. In 50% of the County, the sand and gravel deposits are not present or, if present, are not saturated.

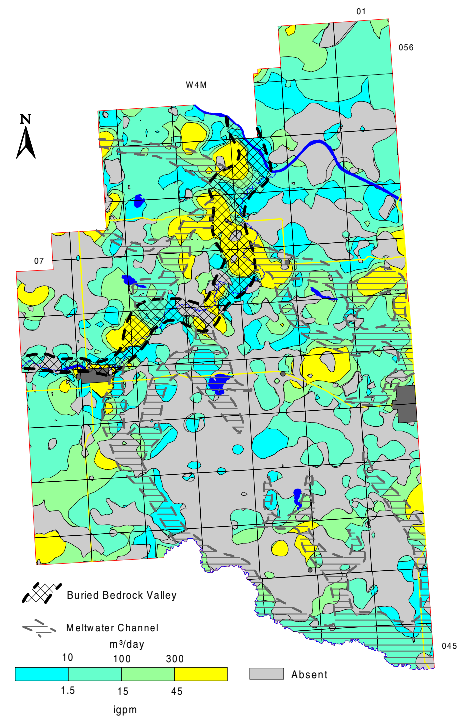

Figure 13. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)

5.2.2.1 Chemical Quality of Groundwater from Surficial Deposits

The chemical analysis results of groundwaters from the surficial deposits have not been differentiated based on aquifers in the upper or lower surficial deposits. The main reason for not separating the chemical analysis results into the different aquifers is the lack of data that can be attributed to the Lower Sand and Gravel Aquifer. This is in part related to the number of control points from this Aquifer, which is in part related to the limited areal extent of the lower surficial deposits.

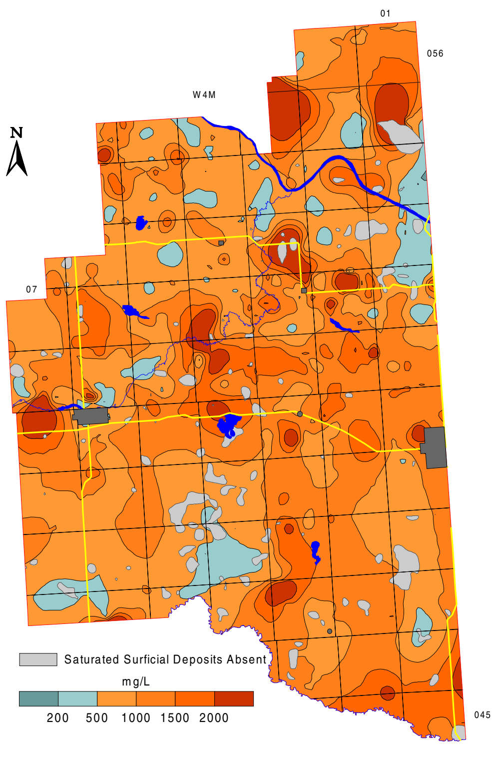

Figure 14. Total Dissolved Solids in Groundwater from Surficial Deposits

The other justification for not separating the analyses was that there appeared to be no major chemical difference between groundwaters from the upper and lower sand and gravel aquifers. The groundwaters from these aquifers are generally chemically hard and high in dissolved iron. In the County of Vermilion River, 70% of the groundwaters from the surficial aquifers have a chemical hardness of more than 400 mg/L.

The groundwaters from the surficial deposits are mainly calcium-magnesium-bicarbonate or sodium-bicarbonate-type waters, with approximately 60% of the groundwaters having a TDS of less than 1,000 mg/L. The groundwaters with TDS of more than 1,500 mg/L occur mainly in the central and southeastern parts of the County. Groundwaters from the surficial deposits are expected to have dissolved iron concentrations of less than 1 mg/L.

Although the majority of the groundwaters are bicarbonate-type waters, there are groundwaters from the surficial deposits with sulfate as the main anion. The groundwaters with elevated levels of sulfate generally occur in areas where there are elevated levels of total dissolved solids. There are very few groundwaters from the surficial deposits with appreciable concentrations of the chloride ion and in most of the County, the chloride ion concentration is less than 100 mg/L.

Constituent	Range for County in mg/L Minimum	Maximum	Average	Recommended Maximum Concentration GCDWQ
Total Dissolved Solids	156	8448	1116	500
Sodium	0.1	2800	176	200
Sulfate	1	5220	352	500
Chloride	1	1550	41	250
Fluoride	0.1	13.0	0.3	1.5

Concentration in milligrams per litre unless otherwise stated
Note: indicated concentrations are for Aesthetic Objectives

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

Table 4. Concentrations of Constituents in Groundwaters from Surficial Deposits

The minimum, maximum and average concentrations of TDS, sodium, sulfate, chloride and fluoride in the groundwaters from water wells completed in the surficial deposits in the County have been compared to the Guidelines for Canadian Drinking Water Quality (GCDWQ) in the adjacent table. Of the five constituents that have been compared to the GCDWQ, only the average values of TDS concentrations exceed the guidelines.

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. These aquifers can directly overlie or be close to the bedrock surface. Saturated sand and gravel deposits are not continuous but are expected over approximately 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 upper surficial deposits; and (2) the depth to the bedrock surface. Since the non-pumping water-level surface in the surficial deposits tends to be a subdued replica of the bedrock surface, the thickness of the Upper Sand and Gravel Aquifer tends to be directly proportional to the thickness of the surficial deposits.

While the sand and gravel deposits in the upper surficial deposits are not continuous, the Upper Sand and Gravel Aquifer includes all of the aquifers present in the upper surficial deposits. The Upper Sand and Gravel Aquifer is more than 15 metres thick in a few areas, but over the majority of the County where the Upper Sand and Gravel Aquifer is present, is less than 15 metres thick; in about 40% of the County, the Aquifer is absent. Most of the greater thickness in the Upper Sand and Gravel Aquifer occurs in the areas of linear bedrock lows.

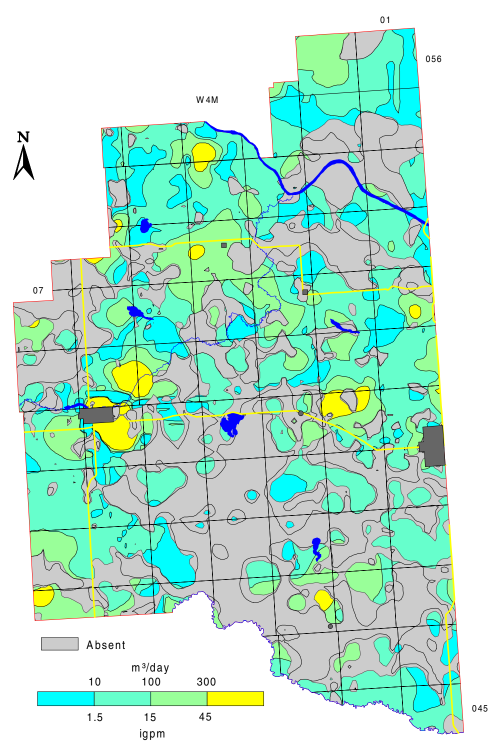

Figure 15. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

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 water wells with high yields; however, because the sand and gravel deposits occur mainly as hydraulically discontinuous pockets, the apparent yields of the water wells are limited. The apparent yields for water wells completed in this Aquifer are expected to be mainly between ten and 100 m³/day. 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.

Probe Exploration Inc. operates a water source well in 03-02-051-02 W4M that is completed in the Upper Sand and Gravel Aquifer. This water source well is currently licensed to divert 210 m³/day (Hydrogeological Consultants Ltd (HCL), March 1998).

Groundwater samples were collected eleven times from 1980 to 1998 from the water source well in 03-02 with no significant changes in water chemistry. There is no dominant cation or anion. Chemical data from the 1998 sampling indicate a TDS of 1,420 mg/L, a chloride concentration of 10.5 mg/l and a sulfate concentration of 578 mg/L (HCL, March 1998).

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 deepest part of the pre-glacial linear bedrock lows. The thickness of the sand and gravel deposits is mainly less than 5 metres. The Lower Sand and Gravel Aquifer is mostly restricted to the Buried Vermilion Valley and meltwater channels in the County.

5.2.4.1 Apparent Yield

Apparent yields for water wells completed in the Lower Sand and Gravel Aquifer range from less than ten m³/day to more than 300 m³/day. The highest yields are expected in the Buried Vermilion Valley and in the meltwater channels.

Water source wells completed for Husky Oil Operations Ltd. (Husky), Canadian Occidental Petroleum Ltd. (COPL) and Dome Petroleum Ltd. (Dome) in the Morgan area of townships 051 and 052, range 04, W4M have long-term yields of up to 1,300 m³/day (HCL, November 1984a; November 1984b; July 1992).

The Town of Vermilion has completed at least some of its water supply wells in the Lower Sand and Gravel Aquifer associated with the Buried Vermilion Valley. The projected long-term yield from one of the Town of Vermilion water supply wells is in excess of 4,000 m³/day (HCL, September 1979). In 1998, the Town diverted an average of 2,380 m³/day.

The Village of Marwayne has two of its four water supply wells in the Lower Sand and Gravel Aquifer associated with a meltwater channel. Water Supply Well No. 4 is currently licensed to divert 68 m³/day and WSW No. 5 is licensed to divert 150 m³/day.

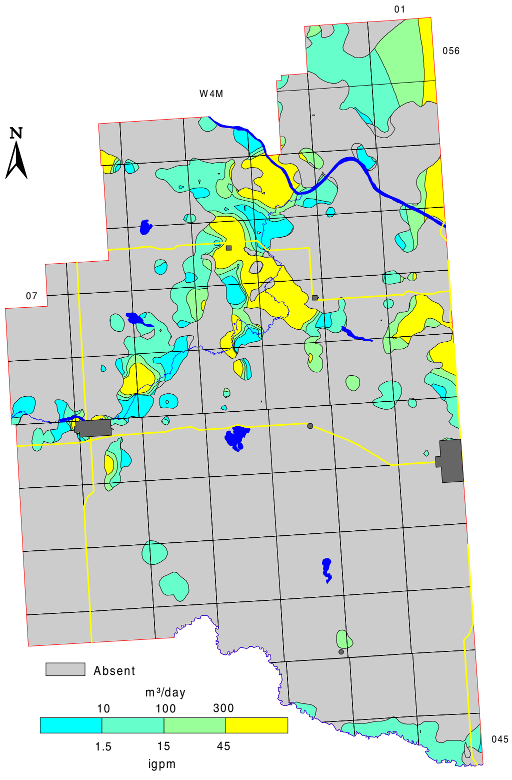

Figure 16. Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer

Groundwater samples were collected eight times from 1980 to 1991 from the Dome Morgan North Water Source Well in 16-10-052-04 W4M with considerable variation, particularly in the relative concentrations for the major cations. These variations may have been due to inconsistencies in the laboratories and analytical methods used. Chemical data from the 1991 sampling indicate a TDS of 746 mg/L, a chloride concentration of 10.9 mg/l and a sulfate concentration of 275 mg/L (HCL, July 1992).

5.3 Bedrock

5.3.1 Geological Characteristics

The upper bedrock in the County includes the Belly River Group and the Lea Park Formation. The Belly River Group includes the Oldman Formation and the Birch Lake, Ribstone Creek, Victoria and Brosseau members 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.

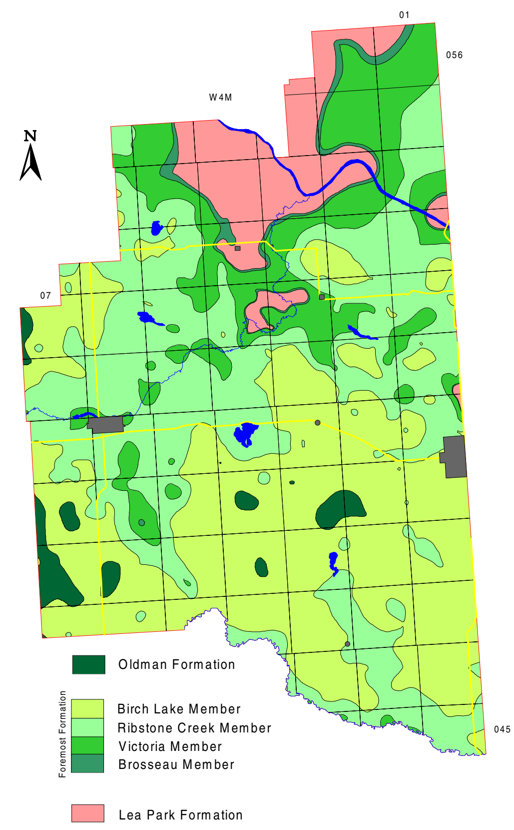

Figure 17. Bedrock Geology

The Belly River Group in the County has a maximum thickness of 200 metres. The Oldman Formation is present mainly in the extreme western part of the County and has a maximum thickness of 30 metres. The Foremost Formation includes marine facies[12] within the County.

The *marine* Foremost Formation is less than 170 metres thick and is between the overlying Oldman Formation and the underlying Lea Park Formation. In the *marine* Foremost Formation, individual members have been identified. The members include both sandstone and shale units. For the present project, the individual members are identified by the designation given to the sandstone members, with the underlying shale member being considered as the shale facies of the sandstone member. For example, in this report the Ribstone Creek Member includes the Ribstone Creek Member (a sandstone deposit) and the underlying shale deposit. Eastward, the sandstone layers of individual members grade into marine shale deposits.

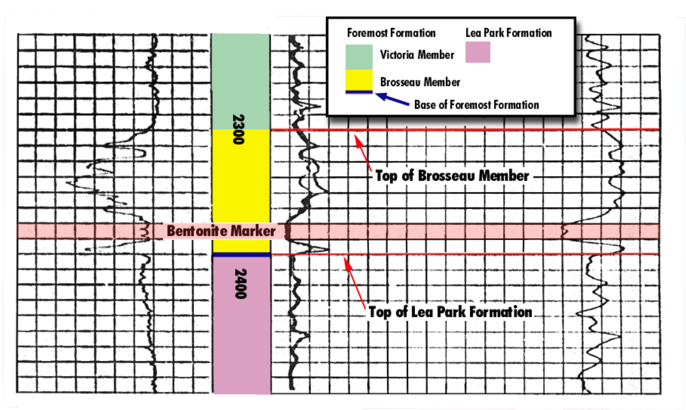

Figure 18. E-Log showing Base of Foremost Formation

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.

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The Lea Park Formation is mostly composed of shale, with only minor amounts of bentonitic siltstone present in some areas. Regionally, the Lea Park Formation is an aquitard. Because the Lea Park Formation is an aquitard, there will be no direct review of the Lea Park Aquitard in the body of this report. However, maps associated with the Lea Park Aquitard are included in Appendix A, and on the CD-ROM. In most of the area, the top of the Lea Park coincides with the Base of Groundwater Protection. In some areas, the Base of Groundwater Protection extends above the Brosseau Member. A map showing the depth to the Base of Groundwater Protection is given on page 6 of this report, in Appendix A, and on the CD-ROM.

The Milk River Formation is present under the entire County, has a thickness of approximately 100 metres, is composed mostly of shale, with minor amounts of coal, and underlies the Lea Park Formation. In the County of Vermilion River, the Milk River Aquifer has limited importance and there will be no direct review of the Milk River Aquifer in the body of this report. However, maps associated with the Milk River Aquifer are included in Appendix A, and on the CD-ROM.

5.3.2 Aquifers

Of the 6,110 water wells in the database, 1,941 were defined as being completed in bedrock aquifers. This designation is based on the top of the completion interval being below the bedrock surface. However, the completion depth is available for the majority of water wells and assigning the water wells 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 statistically determined that water wells typically have completion intervals equivalent to one quarter of their completed depth. With this knowledge and the use of geological surfaces that were determined from the interpretation of geophysical logs, it has been possible to increase the aquifer of completion for 1,338 additional water wells with 356 water wells identified as being completed in more than one bedrock aquifer.

The bedrock water wells are mainly completed in the Birch Lake, Ribstone Creek and Victoria aquifers, as shown in the adjacent table. Less than 10% of the bedrock water wells are likely to have multiple completions, of which 95% have the top of the first completion interval less than 100 metres below ground level.

Geological Unit	No. of Water Wells
Oldman	16
Birch Lake	575
Ribstone Creek	1,897
Victoria	417
Brosseau	18
Other	356
Total	3,279

Table 5. Completion Aquifer

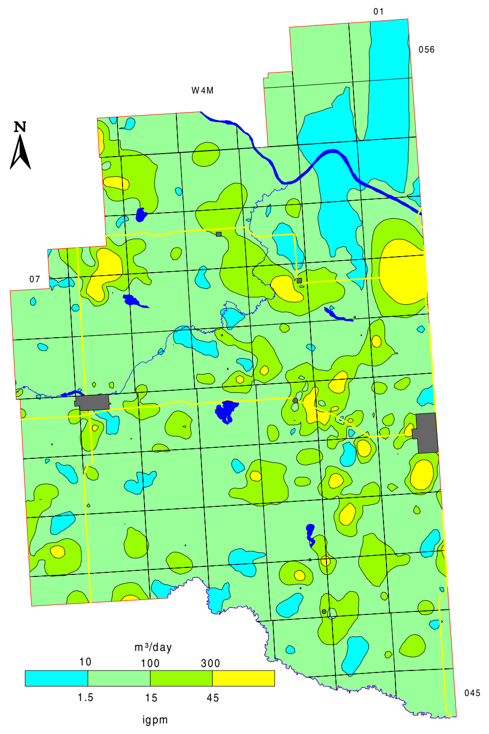


Figure 19. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)

There are 1,154 records for bedrock water wells that have apparent yield values, or 35% of the 3,279 bedrock water wells. In the County, yields for water well completed in the upper bedrock aquifer(s) are mainly between ten and 100 m³/day. In the County, there are scattered areas where yields are more than 300 m³/day. These higher yields may be a result of increased permeability from the weathering process.

Of the 1,154 water well records with apparent yield values, 1,118 have been assigned to aquifers associated with specific geologic units. Sixty-eight percent of the water wells completed in the bedrock aquifers have apparent yields that range from ten to 100 m³/day, and 24% have apparent yields that are more 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
Oldman	2	1	0	1
Birch Lake	116	8	84	24
Ribstone Creek	817	49	568	200
Victoria	175	23	109	43
Brosseau	8	2	5	1
Totals	1,118	83	766	269

Table 6. Apparent Yields of Bedrock Aquifers

5.3.3 Chemical Quality of Groundwater

The TDS concentrations in the groundwaters from the upper bedrock aquifer(s) range from less than 200 to more than 2,000 mg/L.

The relationship between TDS and sulfate concentrations shows that when TDS values in the groundwater 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 more than 90% of the County. The higher values can be expected mainly south of township 051, W4M, with 86% of the water wells having completion depths of greater than 70 metres.

In 90% of the County, the fluoride ion concentrations in the groundwaters from the upper bedrock aquifer(s) are less than 0.5 mg/L.

The Piper tri-linear diagrams [13] (see Appendix A) show that all chemical types of groundwater occur in the bedrock aquifers. However, the majority of the groundwaters are sodium-bicarbonate or sodium-sulfate types.

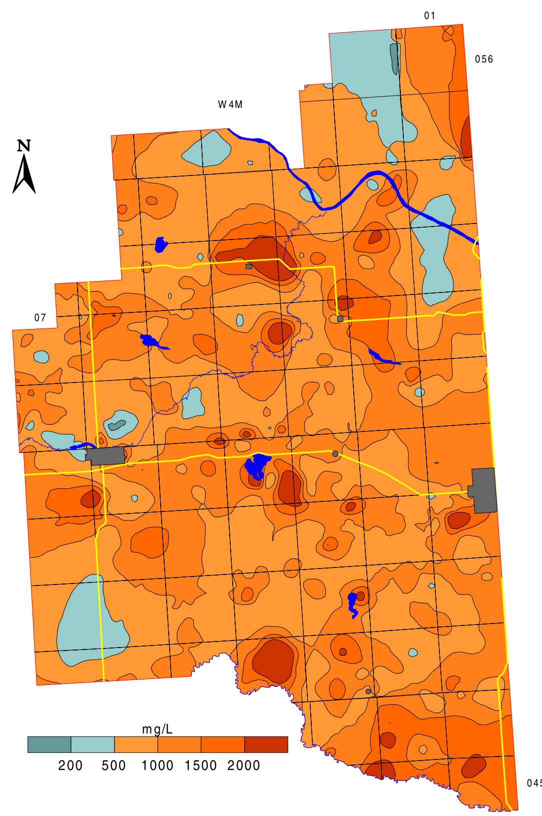


Figure 20. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)

13 See glossary

5.3.4 Oldman Aquifer

The Oldman Aquifer comprises the porous and permeable parts of the Oldman Formation. The Oldman Formation subcrops in the extreme western part of the County, mainly in townships 048 and 049, range 07, W4M. The Oldman Formation also subcrops in a small area of the south-central part of the County, mainly in townships 049 and 050, ranges 02 to 04, W4M. The thickness of the Oldman Formation is generally less than 30 metres, where present; in most of the County, the Oldman Formation has been eroded.

5.3.4.1 Depth to Top

The depth to the top of the Oldman Formation is mainly less than 40 metres below ground level and is a reflection of the thickness of the surficial deposits.

5.3.4.2 Apparent Yield

There are only two water well records in the database with sufficient information to determine the apparent yields for individual water wells completed through the Oldman Aquifer. The data from the adjacent municipality, the County of Minburn, indicate that the groundwaters from the Oldman can be expected to have apparent yields of less than 100 m³/day. The adjacent map shows the expected variation in apparent yields for water wells completed in the Oldman Aquifer.

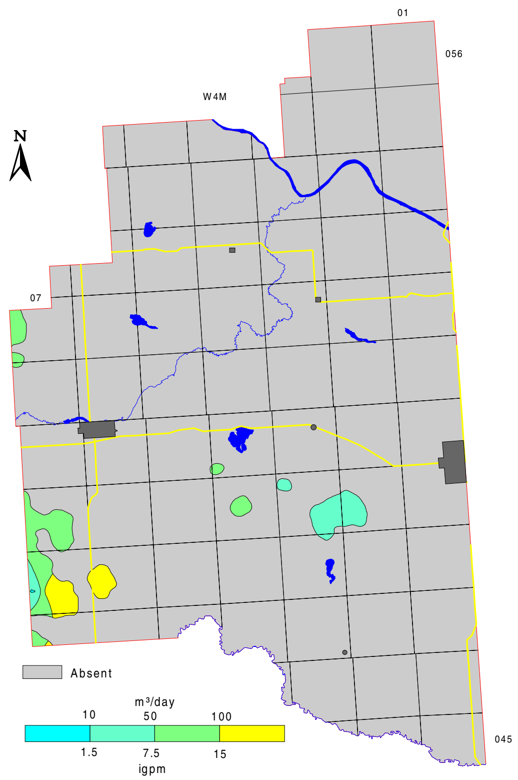


Figure 21. Apparent Yield for Water Wells Completed through Oldman Aquifer

5.3.4.3 Quality

There is only one water well record in the database with sufficient information to determine the chemical type of groundwater from the Oldman Aquifer. The groundwater is a sodium-bicarbonate type (see CD-ROM). The data from the County of Minburn indicate that the groundwaters from the Oldman Aquifer are mainly sodium-bicarbonate or soduim-sulfate-type waters. In the County of Vermilion River (using County of Minburn data), TDS concentrations in the groundwaters from the Oldman Aquifer are expected to be mainly less than 1,000 mg/L. The sulfate concentrations are expected to be mainly less than 250 mg/L and chloride concentrations from the Oldman Aquifer in the County are expected to be mainly less than 100 mg/L, based on data from the County of Minburn.

5.3.5 Birch Lake Aquifer

The Birch Lake Aquifer comprises the porous and permeable parts of the Birch Lake Member, as defined for the present program. Structure contours have been prepared for the top and bottom of the Member, which underlies most of the southern half of the County. The structure contours show the Member ranging from less than 20 metres thick at its edge to more than 60 metres thick in parts of townships 046 and 047, range 01, W4M.

5.3.5.1 Depth to Top

The depth to the top of the Birch Lake Member is mainly less than 40 metres below ground level and is a reflection of the thickness of the surficial deposits.

5.3.5.2 Apparent Yield

The apparent yields for individual water wells completed through the Birch Lake Aquifer are mainly in the range of 10 to 100 m³/day. The areas where water wells with higher yields are expected are mainly in the southeastern part of the County.

The Mount Joy Ski Club is licensed to divert an average of 27 m³/day at a maximum pumping rate of 130 m³/day from a water supply well completed in the Birch Lake Aquifer in NE 36-047-02 W4M (HCL, August 1998).

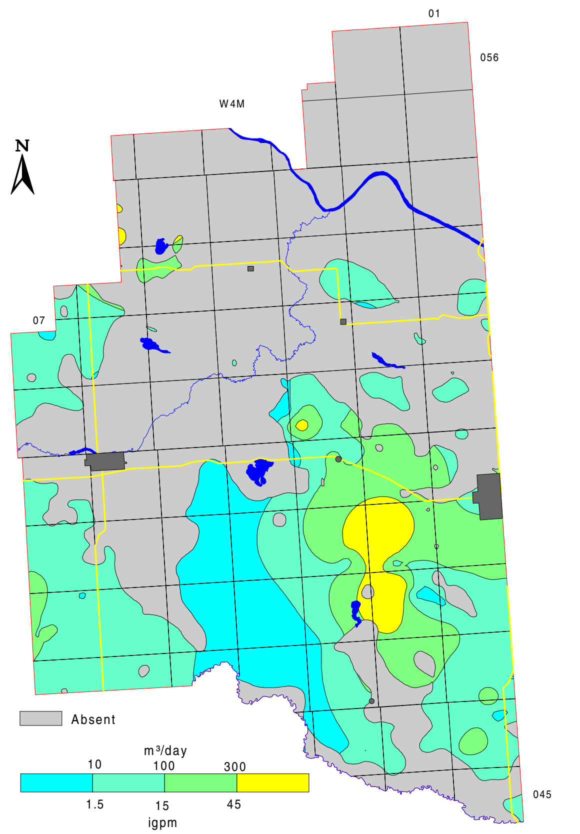


Figure 22. Apparent Yield for Water Wells Completed through Birch Lake Aquifer

5.3.5.3 Quality

The groundwaters from the Birch Lake Aquifer have no dominant chemical type; however, sodium and calcium are the main cations and bicarbonate and sulfate are the main anions (see CD-ROM). The TDS concentrations for groundwaters from the Birch Lake Aqiuifer range from less than 500 to more than 1,500 mg/L. The lower values of TDS occur mainly in townships 047 and 048, ranges 06 and 07, W4M. When TDS values in the groundwaters from the Birch Lake Aquifer exceed 1,200 mg/L, the sulfate concentrations exceed 400 mg/L.

The chloride concentrations of the groundwaters from the Birch Lake Aquifer can be expected to be mainly less than 50 mg/L.

5.3.6 Ribstone Creek Aquifer

The Ribstone Creek Aquifer comprises the porous and permeable parts of the Ribstone Creek Member. Structure contours have been prepared for the top and bottom of the Member, which underlies most of the southern two-thirds of the County. The structure contours show the Member being mostly less than 50 metres thick.

5.3.6.1 Depth to Top

The depth to the top of the Ribstone Creek Member is mainly less than 60 metres below ground level but can be more than 100 metres where the Oldman Formation is the upper bedrock.

5.3.6.2 Apparent Yield

The apparent yields for individual water wells completed through the Ribstone Creek Aquifer are mainly in the range of 10 to 100 m³/day, with 25% of the values being more than 100 m³/day. The areas where water wells with higher yields are expected are mainly in the northwestern part and eastern third of the County.

Examples of water wells in the eastern part of the County with apparent yields of between 100 and 300 m³/day are water supply wells drilled for the Village of Kitscoty (Epec, 1981), the Village of Paradise Valley (HCL, January 1971) and the Hamlet of Blackfoot (HCL, March 1976). An additional example of a high-yielding water well in the eastern part of the County is for a Husky Blackfoot-area water source well in 11d-30-050-01 W4M. This water source well is indicated as having a long-term yield of more than 200 m³/day. The Husky 11d-30 water source well was licensed to divert 224 m³/day (HCL, November 1977).

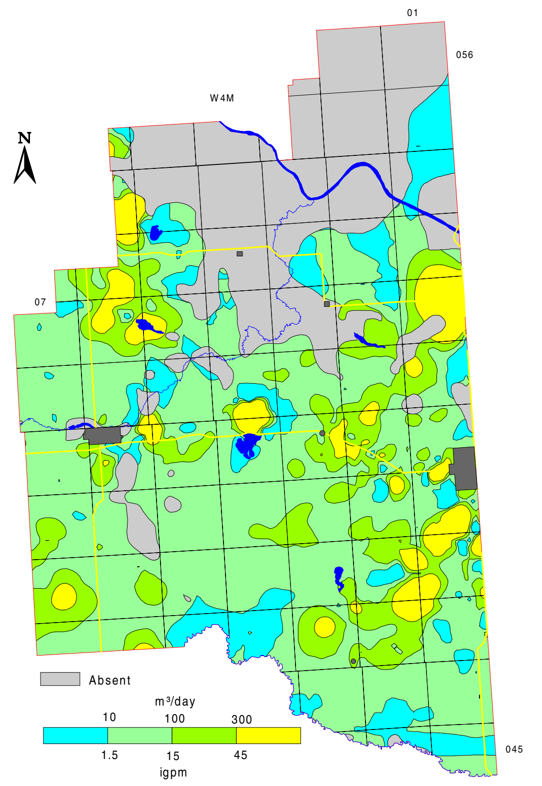


Figure 23. Apparent Yield for Water Wells Completed through Ribstone Creek Aquifer

5.3.6.3 Quality

The groundwaters from the Ribstone Creek Aquifer have no dominant chemical type; however, sodium and calcium are the main cations and bicarbonate and sulfate are the main anions (see Piper diagram on CD-ROM). The TDS concentrations range from less than 500 to more than 2,000 mg/L. The sulfate concentrations are mainly less than 500 mg/L. Chloride concentrations in the groundwaters from the Ribstone Creek Aquifer are mainly less than 100 mg/L.

The TDS concentrations were in the order of 800 to 1,000 mg/L in the groundwaters from the water wells completed for the Village of Paradise Valley, the Hamlet of Blackfoot and for Husky Blackfoot; the TDS concentration was 1,455 mg/L in the groundwater from Pumping Well (PW) 4 completed for the Village of Kitscoty. The sulfate concentrations were less than 250 mg/L in the water supply wells completed for the Village of Paradise Valley and the Hamlet of Blackfoot; the sulfate concentrations of the groundwaters from the water wells completed for Husky Blackfoot and for the Village of Kitscoty exceeded 500 mg/L. The chloride concentrations in the groundwaters from all four water wells were less than 30 mg/L.

5.3.7 Victoria Aquifer

The Victoria Aquifer comprises the porous and permeable parts of the Victoria Member. Structure contours have been prepared for the top of the Member, which underlies 85% of the County. The structure contours show the Member being mostly less than 50 metres thick.

5.3.7.1 Depth to Top

The depth to the top of the Victoria Member is mainly less than 100 metres below ground level but can be more than 140 metres in parts of the southern third of the County. In the western part of the County, the Base of Groundwater Protection extends into the Victoria Member. A map showing the depth to the Base of Groundwater Protection is given on page 6 of this report, in Appendix A, and on the CD-ROM.

5.3.7.2 Apparent Yield

The apparent yields for individual water wells completed through the Victoria Aquifer are mainly less than 150 m³/day. However, the lower yields presented in ranges 01 and 02, W4M may be a reflection of the limited amount of data rather than the hydraulic properties of the Aquifer. The adjacent map indicates that water wells with apparent yields of more than 150 m³/day are expected in the western two-thirds of the County. There are little or no data for the Aquifer in the eastern third of the County. In this area, the Victoria Aquifer would be at a depth of more than 100 metres.

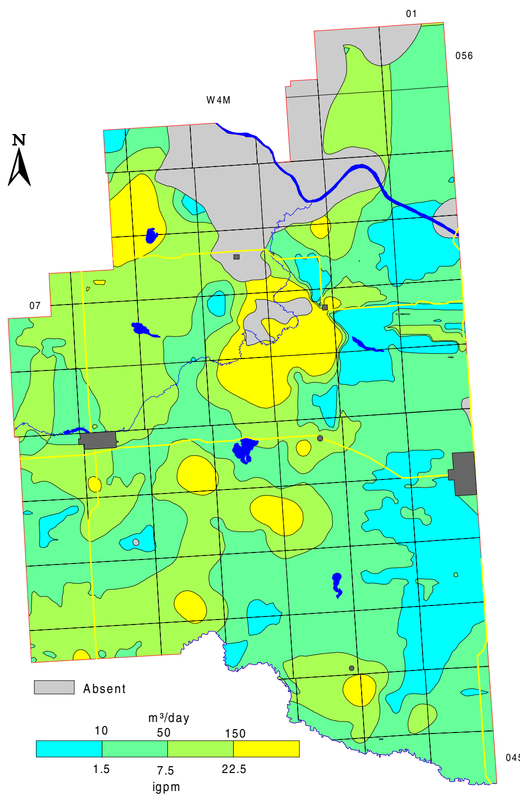


Figure 24. Apparent Yield for Water Wells Completed through Victoria Aquifer

Two of the four water supply wells used by the Village of Marwayne are completed in the Victoria Aquifer. Water Supply Well (WSW) No. 1 is licensed to divert 50 m³/day and WSW No. 3 is licensed to divert 78.5 m³/day (HCL, January 1999).

5.3.7.3 Quality

The groundwaters from the Victoria Aquifer have no dominant chemical type; however, sodium and calcium are the main cations and bicarbonate and sulfate are the main anions (see Piper diagram on CD-ROM). Total dissolved solids concentrations are expected to be mainly less than 1,000 to more than 2,500 mg/L, although there is a paucity of data in townships 047 to 050, ranges 01 and 02, W4M. However, since most of the Victoria Member is above the Base of Groundwater Protection in townships 047 to 050, ranges 01 and 02, W4M, the TDS would still be expected to be less than 4,000 mg/L.

Sulfate concentrations of more than 250 mg/L in the groundwaters from the Victoria Aquifer can be expected in the northern half of the County where the Victoria Aquifer is present, and sulfate concentrations of less then 250 mg/L can be expected in the southern half of the County. The indications are that in the northern two-thirds of the County, the chloride concentrations are expected to be less than 250 mg/L.

The groundwater from the Village of Marwayne WSW No. 3 has a TDS concentration of 1,107 mg/L, a sulfate concentration of 303 mgL and a chloride concentration of 28 mg/L (HCL, June 1992).

5.3.8 Brosseau Aquifer

The Brosseau Aquifer comprises the porous and permeable parts of the Brosseau Member. Structure contours have been prepared for the top of the Member, which underlies 90% of the County. The structure contours show the Member being mostly less than 10 metres thick. Because the amount of hydrogeological information from the groundwater database for the Brosseau Aquifer interval is limited in the County, a complete detailed map set has not been prepared.

5.3.8.1 Depth to Top

The depth to the top of the Brosseau Member is variable, ranging from less than 20 metres near the North Saskatchewan River to more than 180 metres in the southwestern corner of the County.

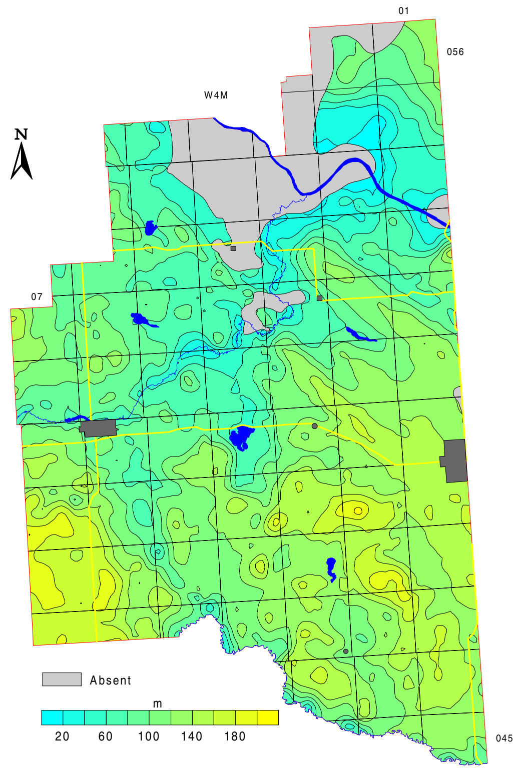


Figure 25. Depth to Top of Brosseau Member

5.3.8.2 Apparent Yield

There are eight water well records in the database with sufficient information to calculate apparent yields for individual water wells completed through the Brosseau Aquifer. Five of the apparent yields are between 10 and 100 m^3/day, two are less than 10 m^3/day, and one is greater than 100 m^3/day, with the largest being 198 m^3/day.

5.3.8.3 Quality

There are three water well records in the groundwater database with sufficient information to determine the chemical type of groundwaters from the Brosseau Aquifer in the County of Vermilion River. The groundwaters are bicarbonate-type waters with no dominant cation. There are four water well records in the database for the Municipal District (M.D.) of Wainwright. The groundwaters are either sodium-bicarbonate-chloride or sodium-chloride-type waters.

There are five water well records in the database for the County with TDS, sulfate and chloride concentrations; the TDS values are between 500 and 900 mg/L, the sulfate values are mainly less than 200 mg/L, and the chloride values are less than 50 mg/L.

6 GROUNDWATER BUDGET

6.1 Hydrographs

There are eight locations in the County where water levels are being measured and recorded with time. These sites are observation water wells (Obs WWs) that are part of the AEP regional groundwater-monitoring network. These eight Obs WWs are in three main areas of the County. Of the eight Obs WWs, three are in the southwestern part of the County in NW 20-048-07 W4M, three are in the vicinity of the Village of Dewberry (two in 06-21-053-04 W4M, one in SW 28-052-04 W4M) and the remaining two are in or near the City of Lloydminster (one in 01-36-050-01 W4M and one in 11-01-050-01 W4M). The hydrograph for AEP Obs WW No. 237 in SW 28-052-04 W4M is shown on the adjacent figure and in Appendix A; the hydrograph for AEP Obs No. 154 in 11-01-050-01 W4M is discussed and shown on Figure 29. Hydrographs for the other six AEP Obs WWs are of limited use but are included on the CD-ROM. Three additional water well sites that are being or have been monitored over time by Mow-Tech Ltd.[14] are also discussed in the text below.

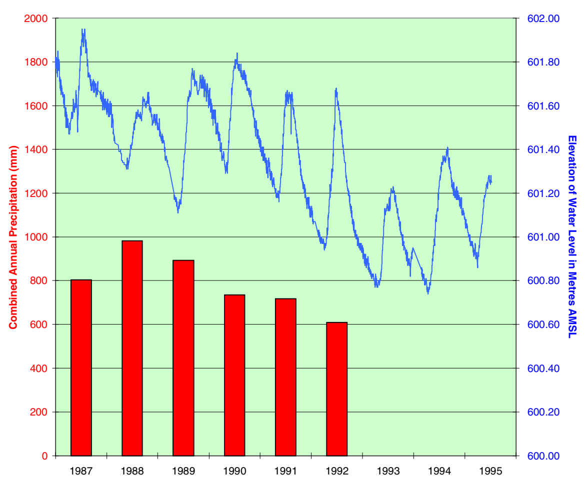


Figure 26. Annual Precipitation vs Water Levels in AEP Obs WW No. 237

AEP Obs WW No. 237 in SW 28-052-04 W4M is completed at a depth of 12.2 metres below ground level in the Ribstone Creek Aquifer. This hydrograph shows annual cycles of recharge in late spring/early summer and a decline throughout the remainder of the year. Overall annual fluctuations are approximately 0.40 to 0.80 metres. From 1986 to 1991, there has been a net decline in the water level of approximately 0.20 metres. From 1991 to 1993, the water level declined approximately 0.40 metres. From 1994 to 1996, the water level rose slightly. The Village of Islay water supply wells are licensed to divert 70 m³/day. These water supply wells are the closest licensed users to AEP Obs WW No. 237 and are also completed in the Ribstone Creek Aquifer. There has been no authorized increase in groundwater for the Village of Islay water supply wells since 1985. They were first put into use in 1980. The water-level decline in AEP Obs WW No. 237 has been compared to the combined precipitation data measured at the Lloydminster and Paradise Valley weather stations, the closest weather stations to the Obs WW with long-term data. The comparison in Figure 26 shows that the water-level decline from 1988 to 1992 reflects the decrease in total annual precipitation measured at the two weather stations.

From 1980 to 1997, Probe Exploration Inc. (Probe) has obtained groundwater from WSW No. 03C-02 completed in the Upper Sand and Gravel Aquifer in the upper surficial deposits in 03-02-051-02 W4M. Continuous water-level measurements in Obs WW No. 03C-02 and two domestic water wells show that diversion from WSW No. 03C-02 is having an impact on the water level in both the Upper Sand and Gravel Aquifer and the Ribstone Creek Aquifer.

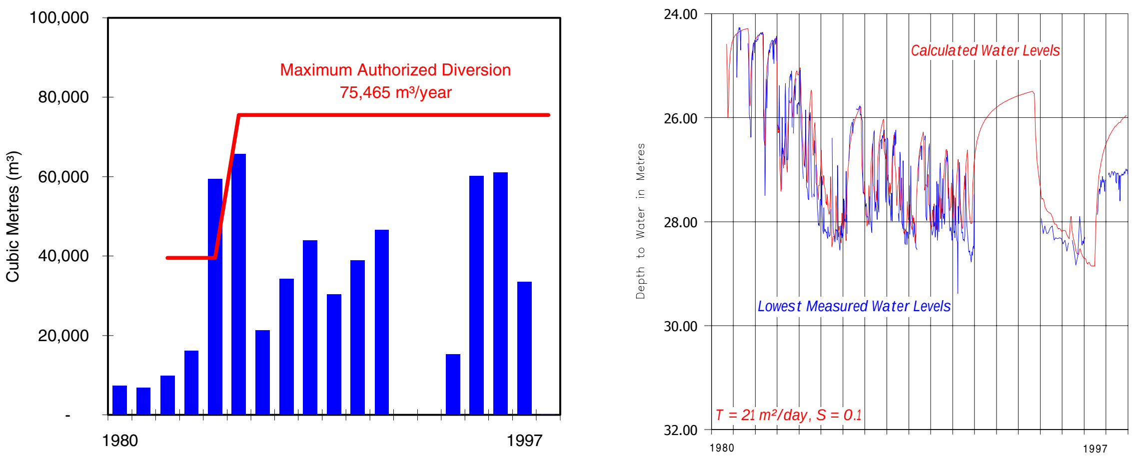
A mathematical model was used to calculate water levels at the location corresponding to Obs WW No. 03C-02, completed in the Upper Sand and Gravel Aquifer and one domestic water well completed in the Ribstone Creek Aquifer. The model is based on the annual groundwater production from WSW No. 03C-02, has an effective

[14] Mow-Tech Ltd. 1-800-GEO-WELL

transmissivity of 21 m²/day and a corresponding storativity of 0.1. The model assumes a homogeneous, isotropic aquifer of infinite areal extent and does not account for aquifer recharge.

There is a reasonable match between the calculated and measured water levels in Obs WW No. 03C-02 as shown below in Figure 27. The non-pumping water level in the domestic water well declined 3.5 metres between 1981 and 1998 suggesting that the diversion from WSW No. 03C-02 is responsible for the water-level decline. The mathematical model showed that there is a direct relationship between the production from the Upper Sand and Gravel Aquifer and the water level in the Ribstone Creek Aquifer, at the site of the domestic water well (HCL, March 1998).

Figure 27. Water-Level Comparison



WSW No. 03C-02 Groundwater Production ***Obs WW No. 03C-02***

From 1982 to 1991, Dome Petroleum Limited (Dome) diverted 734,461 cubic metres mainly from one water source well completed in the Lower Sand and Gravel Aquifer associated with the Buried Vermilion Valley in 16-10-052-04 W4M. The diverted groundwater had no adverse effect on the quantity of the groundwater available for the Lower Sand and Gravel Aquifer at the site of the Dome Auxiliary Water Well as shown in the adjacent figure (HCL, June 1992).

Canadian Occidental Petroleum Ltd. (COPL) and Husky Oil Operations Ltd. (Husky) also had water source wells completed in the Lower Sand and Gravel Aquifer in townships 051 and 052, range 04, W4M in the Morgan area. Although Husky cancelled their groundwater monitoring program in 1985 (HCL, January 1986), COPL diverted 77,885 cubic metres between 1987 and 1989 without having an adverse effect on the water level in the Lower Surficial Aquifer.

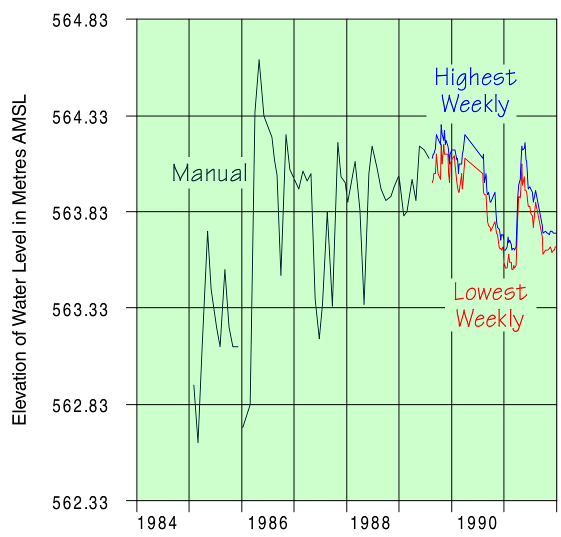


Figure 28. Hydrograph – Dome Auxiliary Water Well

There have been at least eight water source wells used to provide water at various times to a Husky refinery situated on the northern edge of the City of Lloydminster (HCL, January 1975). One of these water source wells has been used as an observation water well, first by the Alberta Research Council in 1957 and later in 1983 by AEP. This observation water well, Obs WW No. 154 in 11-01-050-01 W4M, is completed at a depth of 57.9 metres below ground level in the Lower Sand and Gravel Aquifer. Prior to 1960, when the City of Lloydminster was obtaining its water supply from the same aquifer as the Husky wells, the water level in the Lower Sand and Gravel Aquifer at the site of AEP Obs WW No. 154 declined to a depth of approximately 34 metres below ground level (610 metres AMSL). In 1960, the City of Lloydminster developed an alternate water supply well north of the City and stopped using the water wells completed in the Lower Sand and Gravel Aquifer (HCL, January 1975). Consequently, the water level in Obs WW No. 154 rose 4.5 metres in 1961, and has continued to be mainly between 620 and 625 metres AMSL. Since April 1993, Husky has been licensed to divert from two water source wells completed in the Lower Sand and Gravel Aquifer: 50.7 m³/day from a water source well in 11-01-050-01 W4M and 169 m³/day from a water source well in 12-01-050-01 W4M. There has been no apparent decline in the Lower Sand and Gravel Aquifer at the site of AEP Obs WW No. 154.

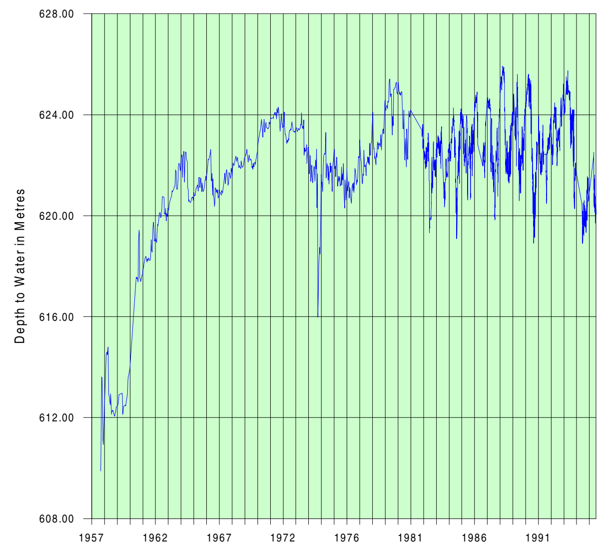


Figure 29. AEP Obs WW No. 154

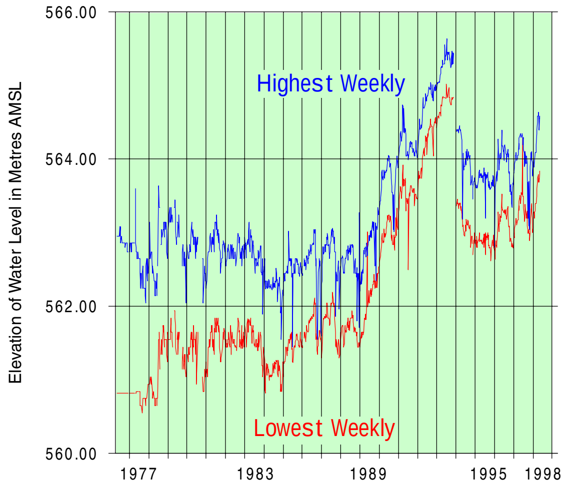


Figure 30. Hydrograph – Village of Marwayne WSW No. 3

The Village of Marwayne diverts groundwater from four water supply wells. Water Supply Well No. 3 is completed open-hole from 37.0 to 40.5 metres below ground level in the Victoria Aquifer and is licensed to divert 78.4 m³/day. As a result of the Village maintaining an excellent groundwater monitoring program, HCL has been able to advise the Village to divert no more than 63 m³/day from WSW No. 3, if the water levels are to remain above the top of the completion interval of 561.34 metres AMSL (HCL, January 1999).

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. Based on these assumptions, the estimated lateral groundwater flow through the individual bedrock aquifers can be summarized as follows:

Aquifer Designation	Transmissivity (m^2/day)	Gradient (m/m)	Width (km)	Main Direction of Flow	Quantity (m^3/day)	Authorized Diversion (m^3/day)
Surficial Deposits						**5,138**
Upper Sand and Gravel						1,135
Upper Sand and Gravel (Buried Vermilion Valley)	20	0.0025	10	Northeast	500	
Upper Sand and Gravel (NW from Lloydminster)	15	0.003	15	Northwest, southeast	675	
Lower Sand and Gravel						4,003
Lower Sand and Gravel (Buried Vermilion Valley)	1800	0.0003	1	Northeast	540	
Lower Sand and Gravel (NW from Lloydminster)	1800	0.002	1	Northwest	3600	
Birch Lake						**98**
Birch Lake-Northeast of Grizzly Bear Creek	8	0.004	50	Northeast	1600	
Birch Lake-Southwest of Grizzly Bear Creek	8	0.003	15	Northeast	360	
Ribstone Creek						**1,421**
Ribstone Creek	8	0.002	60	Northwest, Southeast	960	
Ribstone Creek	8	0.002	45	Southwest	720	
Victoria						**953**
Victoria, Eastern part	5	0.002	100	West	1000	
Victoria, Western part	5	0.002	50	East	500	

The data provided in the above table indicate there is more groundwater flowing through the individual bedrock aquifers than has been authorized to be diverted from each aquifer. The calculations of flow through individual aquifers as presented in the above table are very approximate and are intended as a guide for future investigations.

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 1 to 5.3 cubic kilometres. This volume is based on an areal extent of 3,500 square kilometres and a saturated sand and gravel thickness of five metres. The variation in the total volume is based on the value of porosity that is used for the sand and gravel. One estimate of porosity is 5%, which gives the low value of the total volume. The high estimate is based on a porosity of 30% (Ozoray, Dubord and Cowen, 1990).

The adjacent water-level map has been prepared from water levels associated with water wells completed in aquifers in the surficial deposits. These water levels were used for the calculation of the saturated thickness of 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 North Saskatchewan River, the Battle River, and the Vermilion River, with the lowest water-level elevations occurring along the North Saskatchewan River.

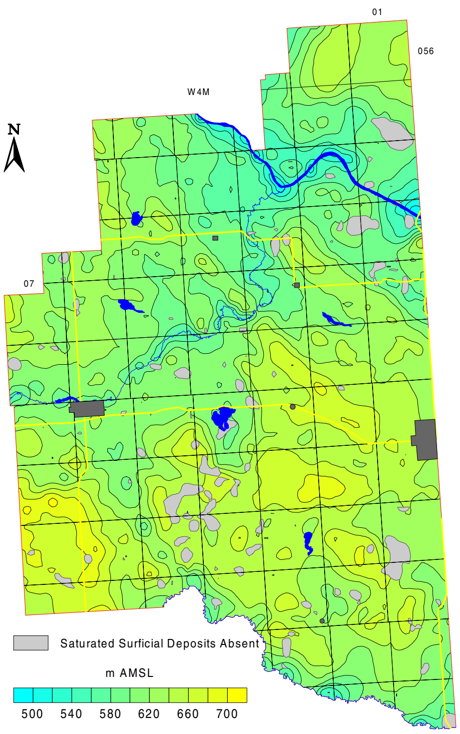


Figure 31. Non-Pumping Water-Level Surface in Surficial Deposits

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 non-pumping water-level surface associated with all water wells completed in the upper bedrock aquifer(s) from the non-pumping water-level surface determined for all water wells in the surficial deposits. The recharge classification is used where the water level in the surficial deposits is more than five metres above the water level 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, that is, no recharge and no discharge.

The adjacent map shows that, in more than 75% of the County, there is a downward hydraulic gradient from the surficial deposits toward the upper bedrock aquifer(s). Areas where there is an upward hydraulic gradient 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.

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.

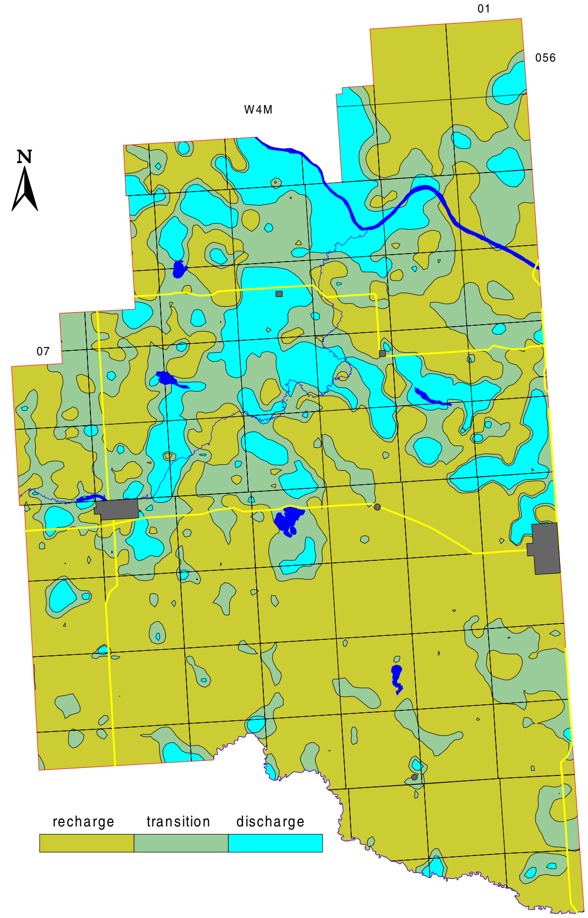


Figure 32. Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)

The hydraulic relationship between the surficial deposits and the Ribstone Creek Aquifer indicates that in more than 95% of the County where the Ribstone Creek Aquifer is present, there is a downward hydraulic gradient (i.e. recharge). Discharge areas for the Ribstone Creek Aquifer are mainly associated with the edge of the Aquifer and with the Battle River. The hydraulic relationship between the surficial deposits and the remainder of the bedrock aquifers indicates there is also mainly a downward hydraulic gradient.

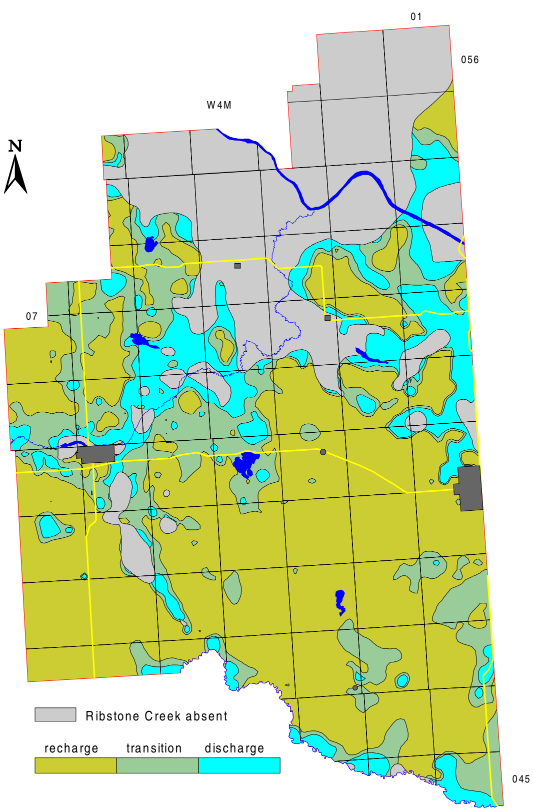


Figure 33. Recharge/Discharge Areas between Surficial Deposits and Ribstone Creek Aquifer

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. The 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 which 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 groundwater recharge areas, 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 surficial geology map prepared by the Alberta Research Council (Shetsen, 1990) 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; and
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 4,354 records in the area of the County with lithological descriptions, 769 have the top of a sand and gravel deposit present within one metre of ground level. In the remaining 3,585 records, the first sand and gravel is deeper 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 surficial geology 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 7. Risk of Groundwater Contamination Criteria

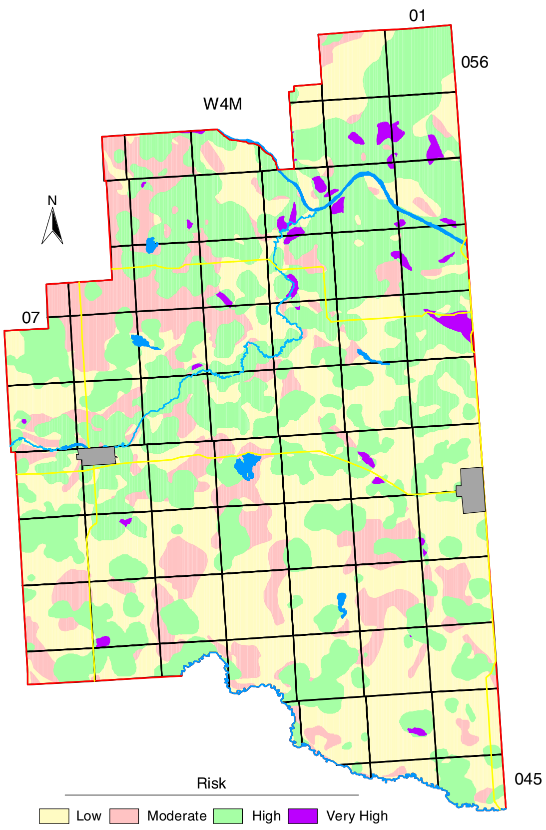


Figure 34. Risk of Groundwater Contamination

The Risk of Groundwater Contamination map shows that, in 45% 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; and
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 363 existing water wells listed in Appendix E. These water well records indicate that a complete water well drilling report is available along with at least a partial chemical analysis. The level of verification would have to include identifying the water well in the field, obtaining meaningful horizontal coordinates for the water well and the verification of certain parameters such as water level and completed depth. Even though the water wells for which the County has responsibility do not satisfy the above criteria, it is recommended that they be field-verified, water levels be measured, a water sample collected for analysis and a short aquifer test be conducted. A list of at least some of the County-operated water wells are also included in Appendix E. An attempt to update the quality of the entire database is not recommended.

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, 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. Another municipality, Flagstaff County, is currently in the process of setting up a regional groundwater-monitoring program.

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 network. The water levels in the water wells could be measured regularly by County personnel and/or local residents.

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

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

1. The horizontal location of the water well should be determined within 10 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 5 and 115 minutes of pumping, and analyzed for major and minor ions.

A list of 363 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 AEP Resource Data Division in an electronic form. The money presently being spent by AEP and PFRA to transpose the paper form to the electronic form should be used to allow for a technical review of the data and follow-up discussions with the drillers.

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

Groundwater is a renewable resource and it must be managed.

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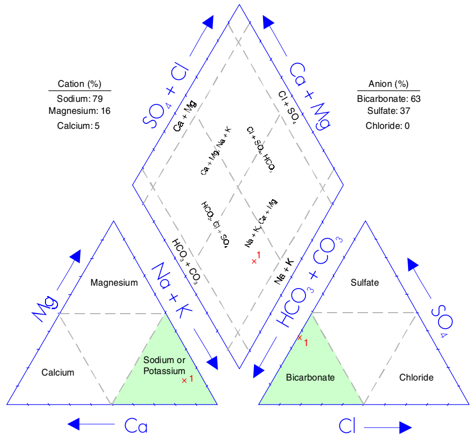
10 GLOSSARY

AEP	Alberta Environmental Protection
AMSL	above mean sea level
Aquifer	a formation, group of formations, or part of a formation that contains saturated permeable rocks capable of transmitting groundwater to water wells or springs in economical quantities
Aquitard	a confining bed that retards but does not prevent the flow of water too or from an adjacent aquifer
Available Drawdown	in a confined aquifer, the distance between the non-pumping water level and the top of the aquifer
	in an unconfined aquifer (water table aquifer), two thirds of the saturated thickness of the aquifer
DEM	Digital Elevation Model
DST	drill stem test
EUB	Alberta Energy and Utilities Board
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
GCDWQ	Guidelines for Canadian Drinking Water Quality
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
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
NPWL	non-pumping water level
NSR	North Saskatchewan River

Obs WW	Observation Water Well
PFRA	Prairie Farm Rehabilitation Administration
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

Surficial Deposits	includes all sediments above the bedrock
TDS	Total Dissolved Solids
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
WSW	Water Source Well or Water Supply Well
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

11 CONVERSIONS

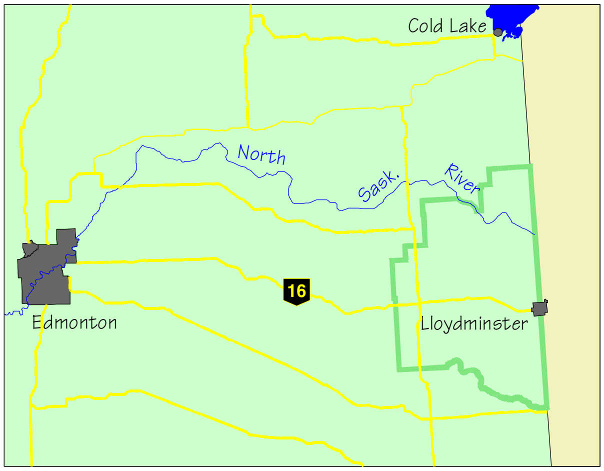
Mulitiply	by	To Obtain
Length/Area		
feet	0.304 785	metres
metres	3.281 000	feet
hectares	2.471 054	acres
centimetre	0.032 808	feet
centimetre	0.393 701	inches
acres	0.404 686	hectares
inchs	25.400 000	millimetres
miles	1.609 344	kilometres
kilometer	0.621 370	miles (statute)
square feet (ft^2)	0.092 903	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

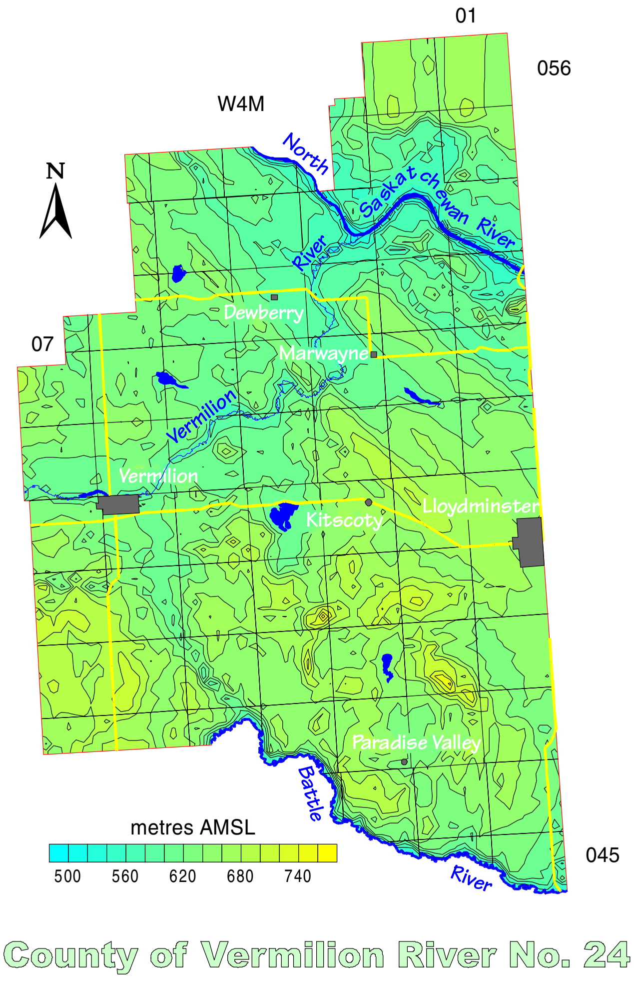
COUNTY OF VERMILION RIVER NO. 24

Appendix A

HYDROGEOLOGICAL MAPS AND FIGURES

Index Map





County of Vermilion River No. 24

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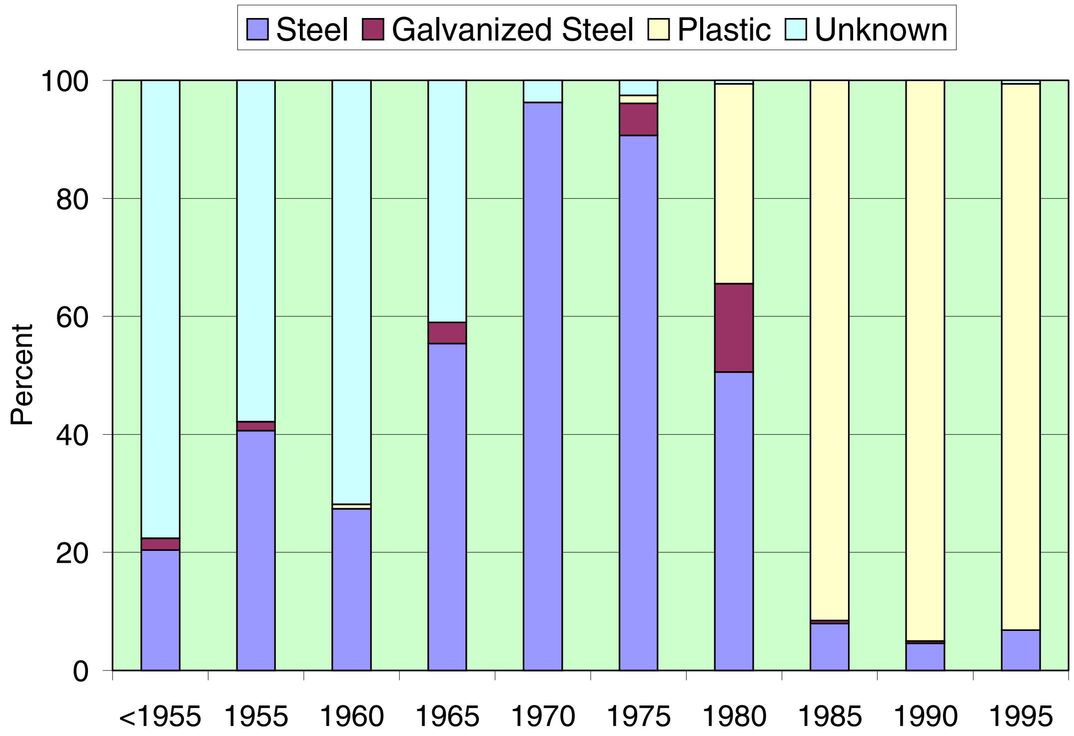
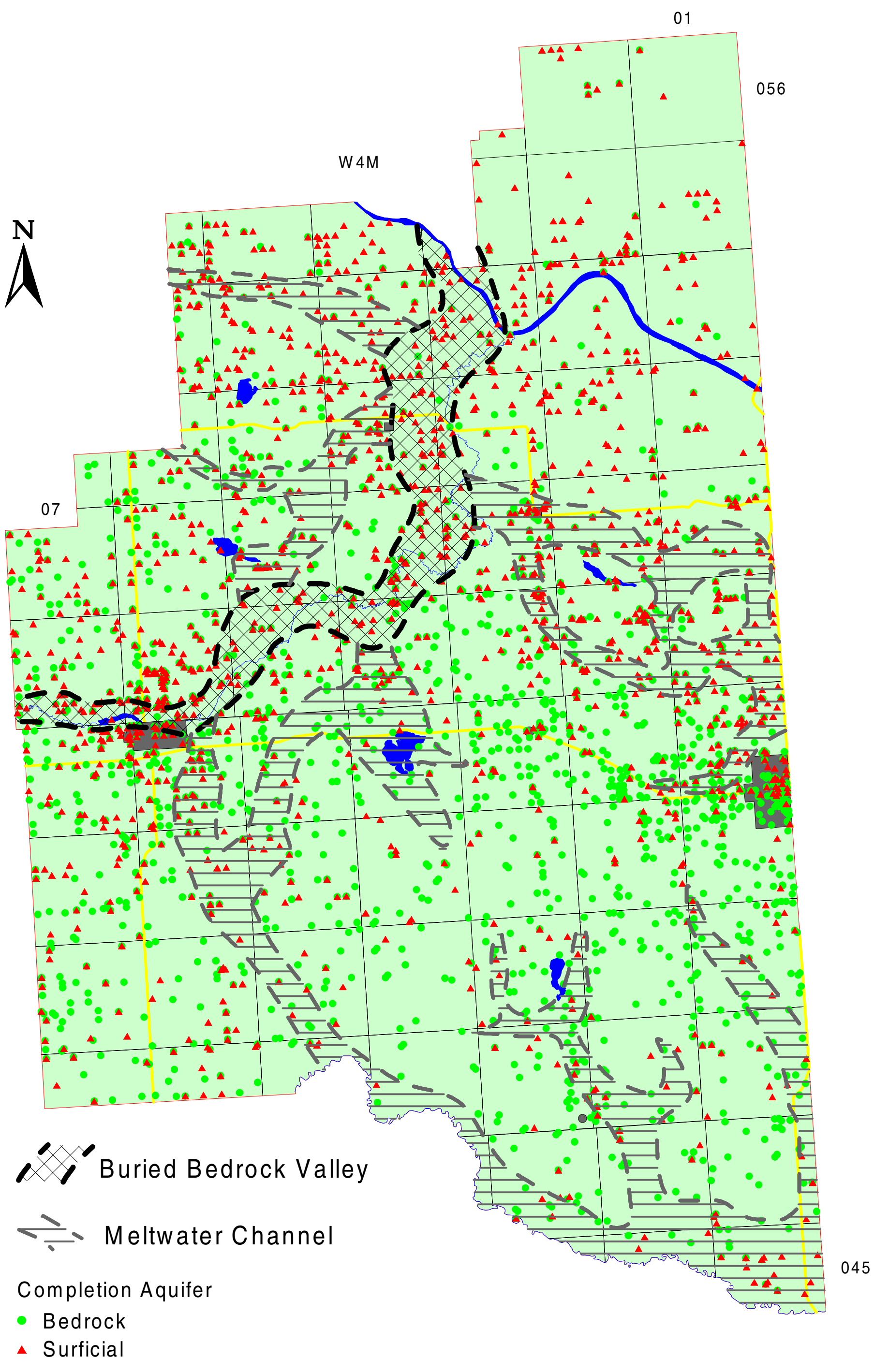
Surface Casing Types used in Drilled Water Wells

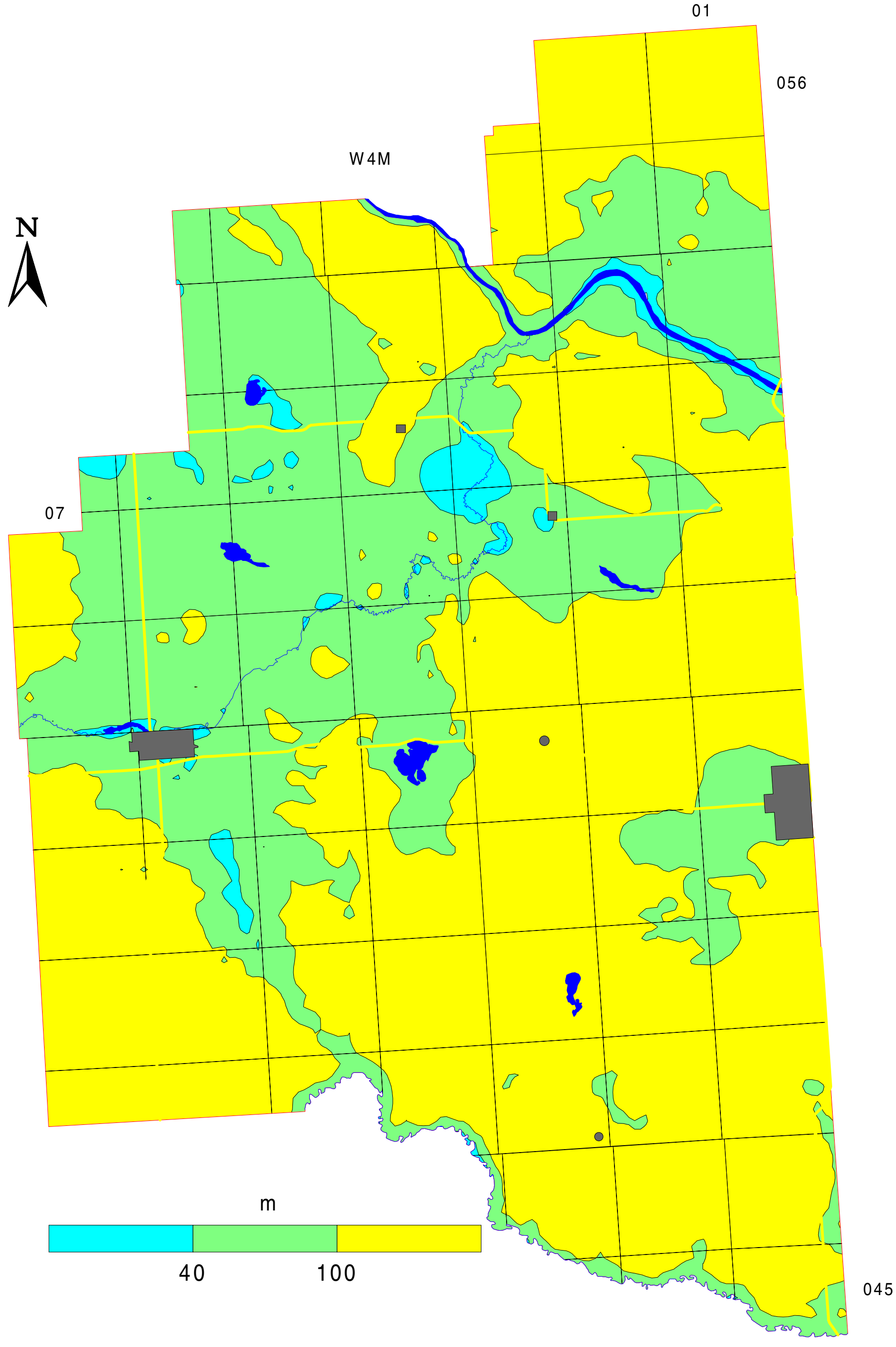


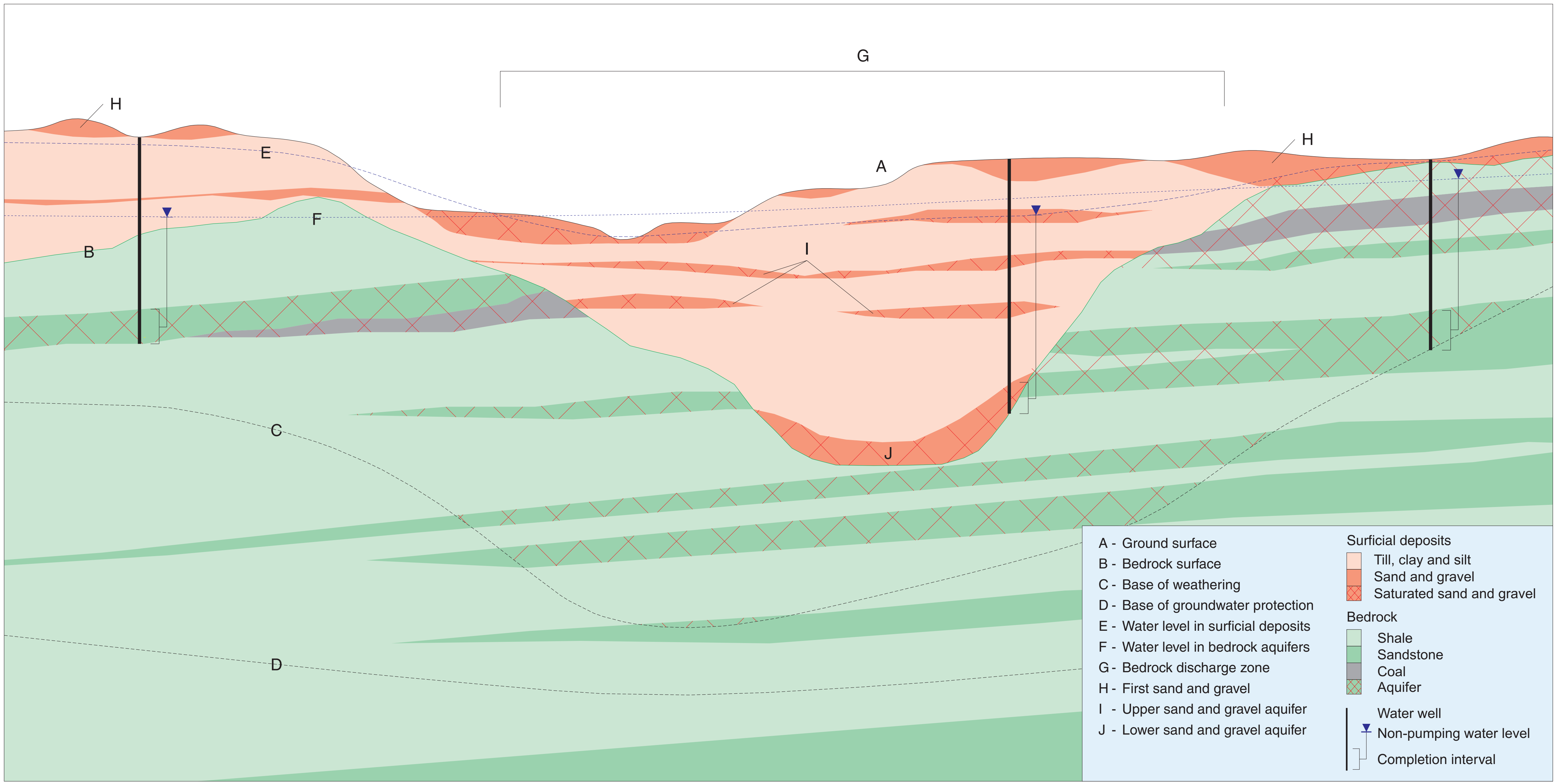
Location of Water Wells



Depth to Base of Groundwater Protection

(after EUB, 1995)

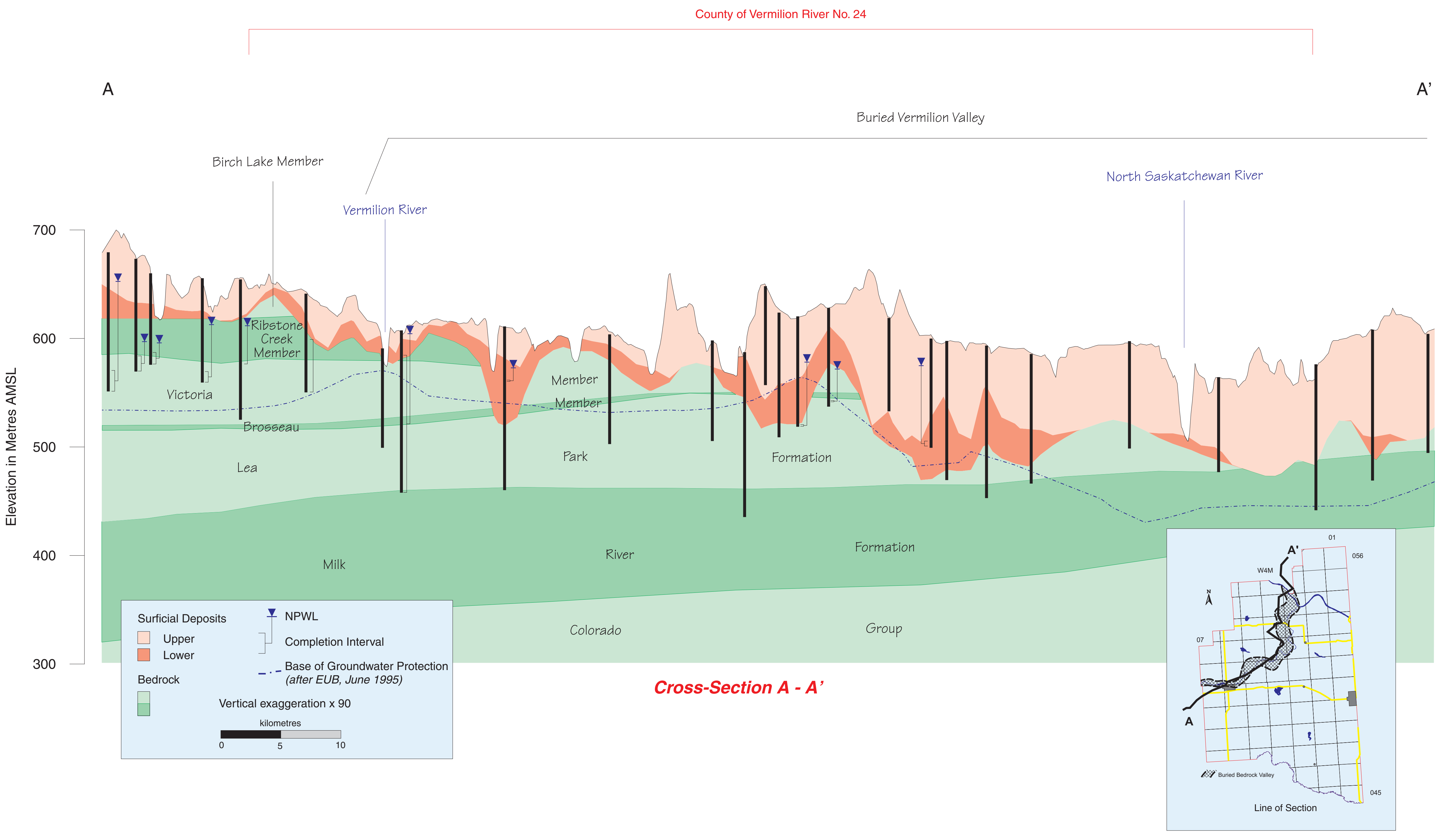




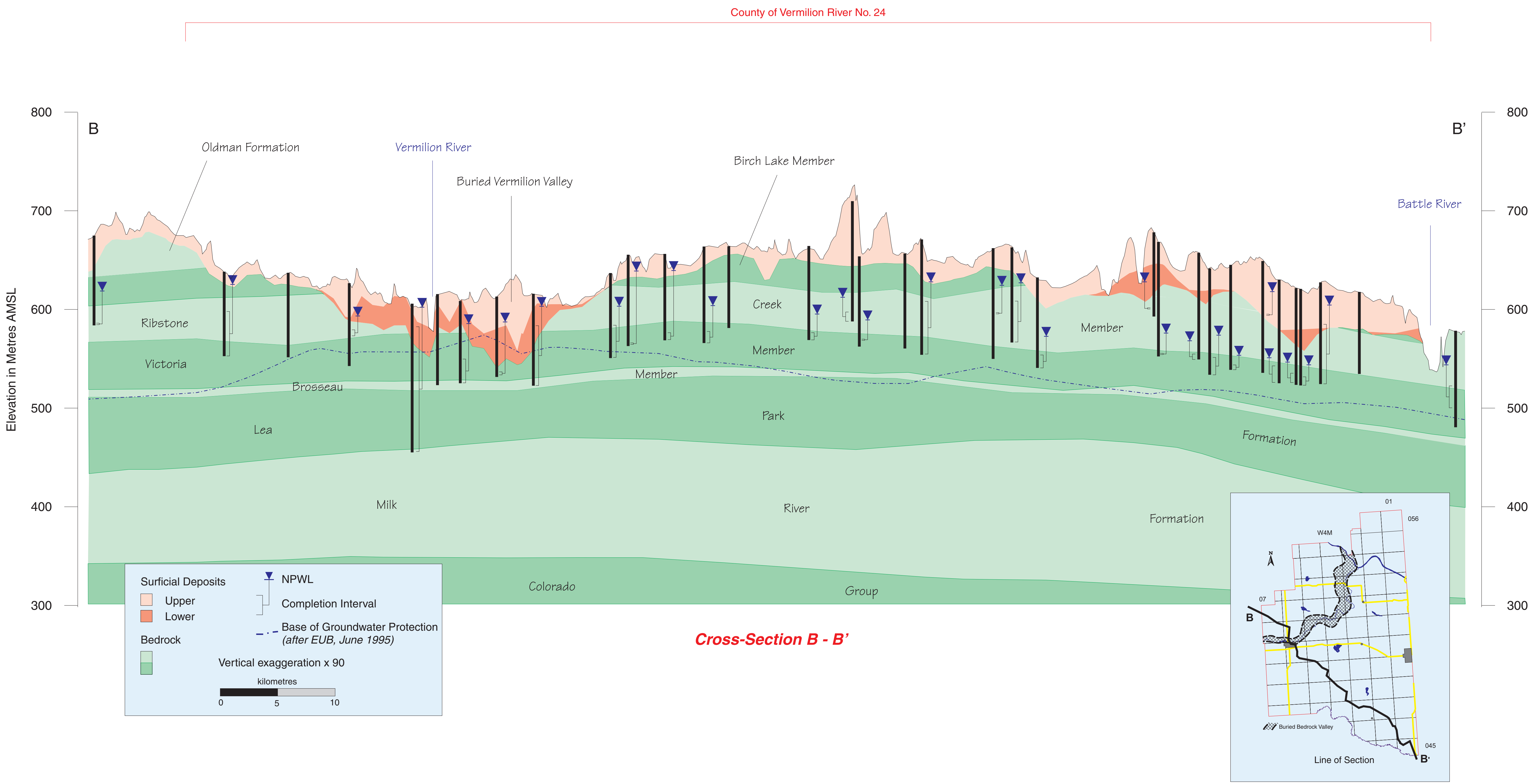
Generalized Cross-Section
(for terminology only)

		Group and Formation		Member		Zone	
Lithology	Lithologic Description	Thickness (m)	Designation	Thickness (m)	Designation	Thickness (m)	Designation
	sand, gravel, till, clay, silt	<100	Surficial Deposits	<100	Upper	<50	First Sand and Gravel
				<80	Lower		
	sandstone, siltstone, shale, coal	<130	Belly River Group – Oldman Formation		Dinosaur Member	<0-25	Lethbridge Coal Zone
					Upper Siltstone Member		
					Comrey Member		
	sandstone, shale, coal	<180	Belly River Group – Foremost Formation	<70	Birch Lake Member		Taber Coal Zone
				<60	Ribstone Creek Member		
				<50	Victoria Member		
				<15	Brosseau Member		McKay Coal Zone
	shale, siltstone	40-80	Lea Park Formation				
	sandstone, siltstone, shale, coal	40-140	Milk River Formation				
	shale, siltstone		Colorado Group				

Geologic Column

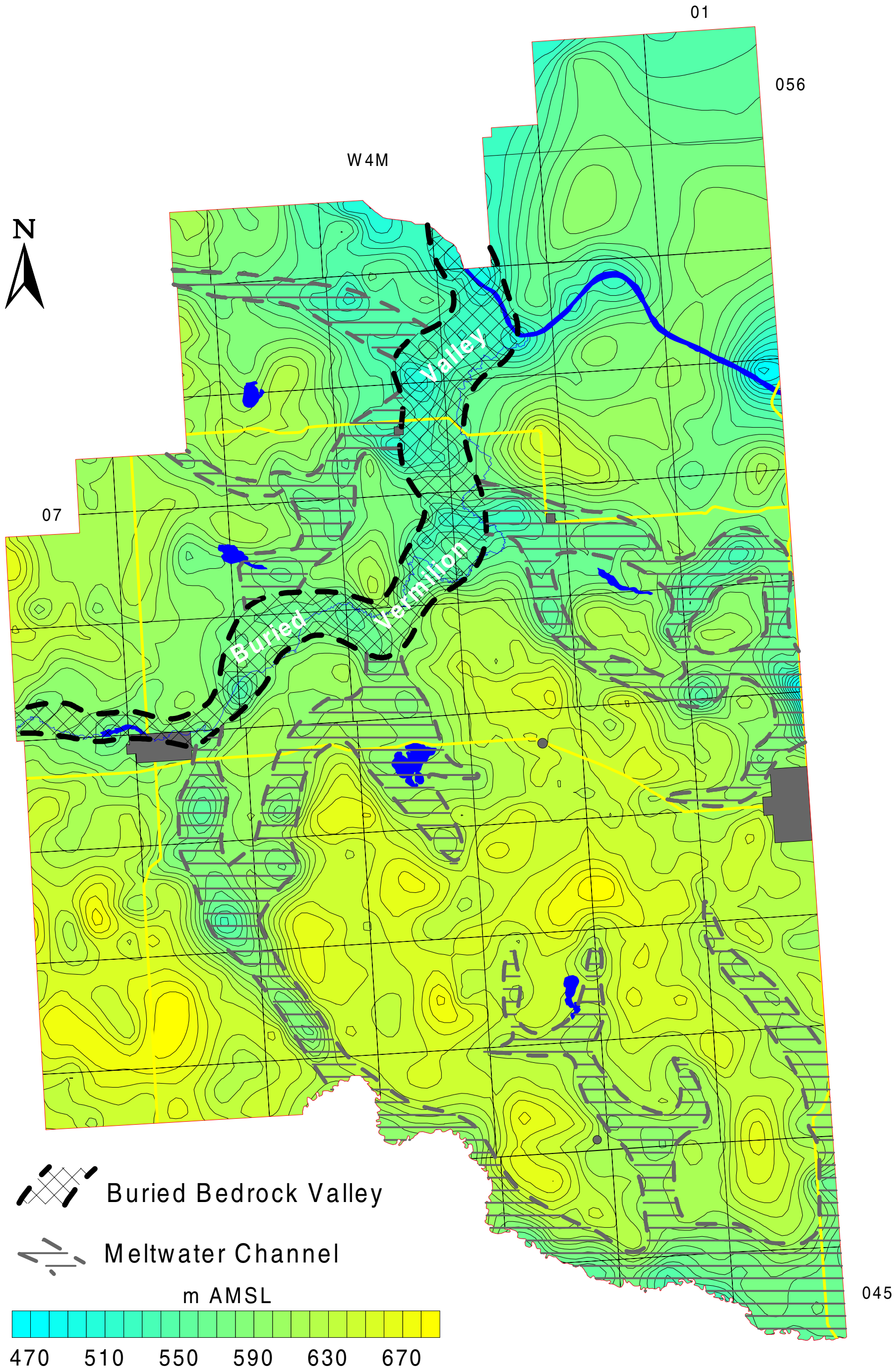


Cross-Section A - A'



Cross-Section B - B'

Bedrock Topography



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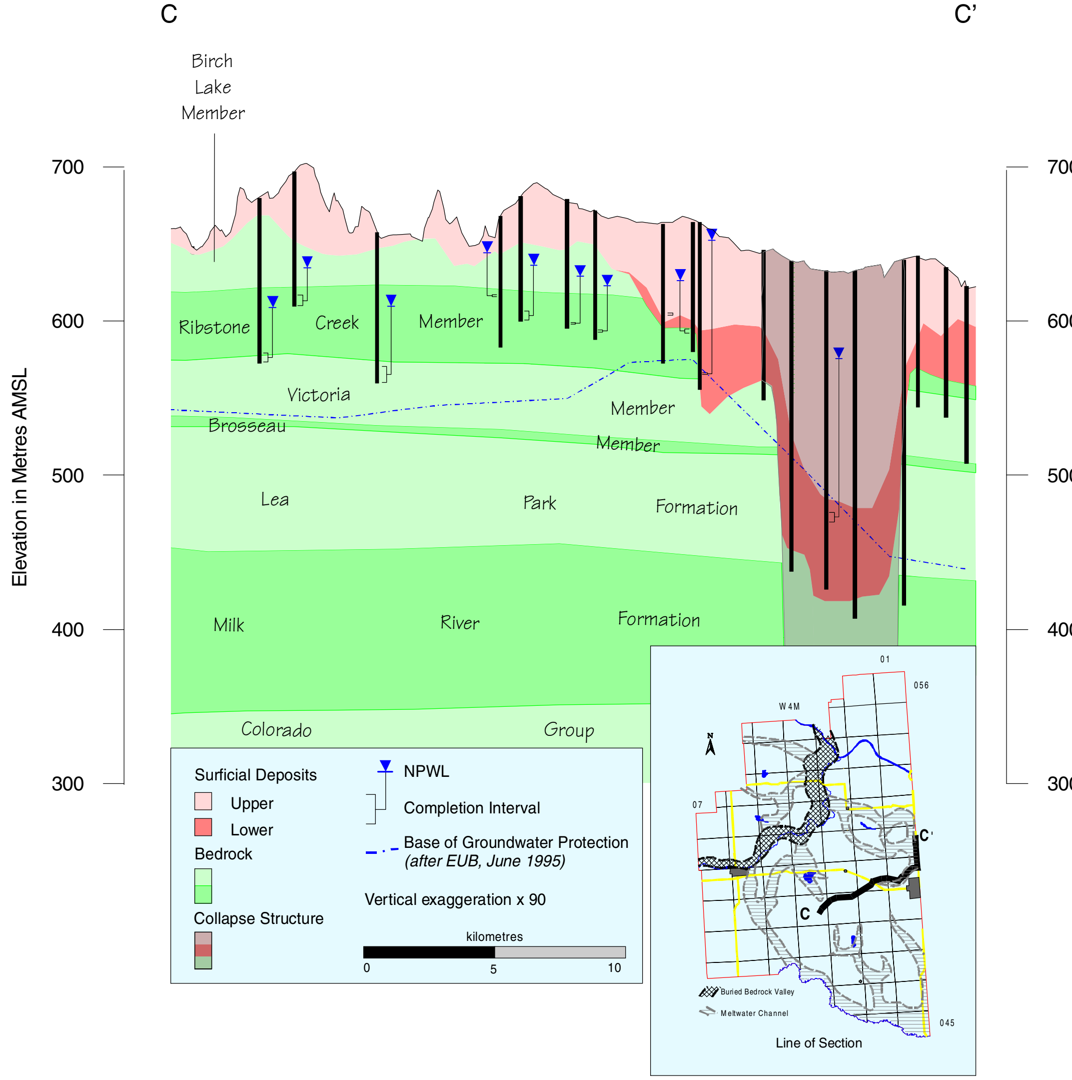
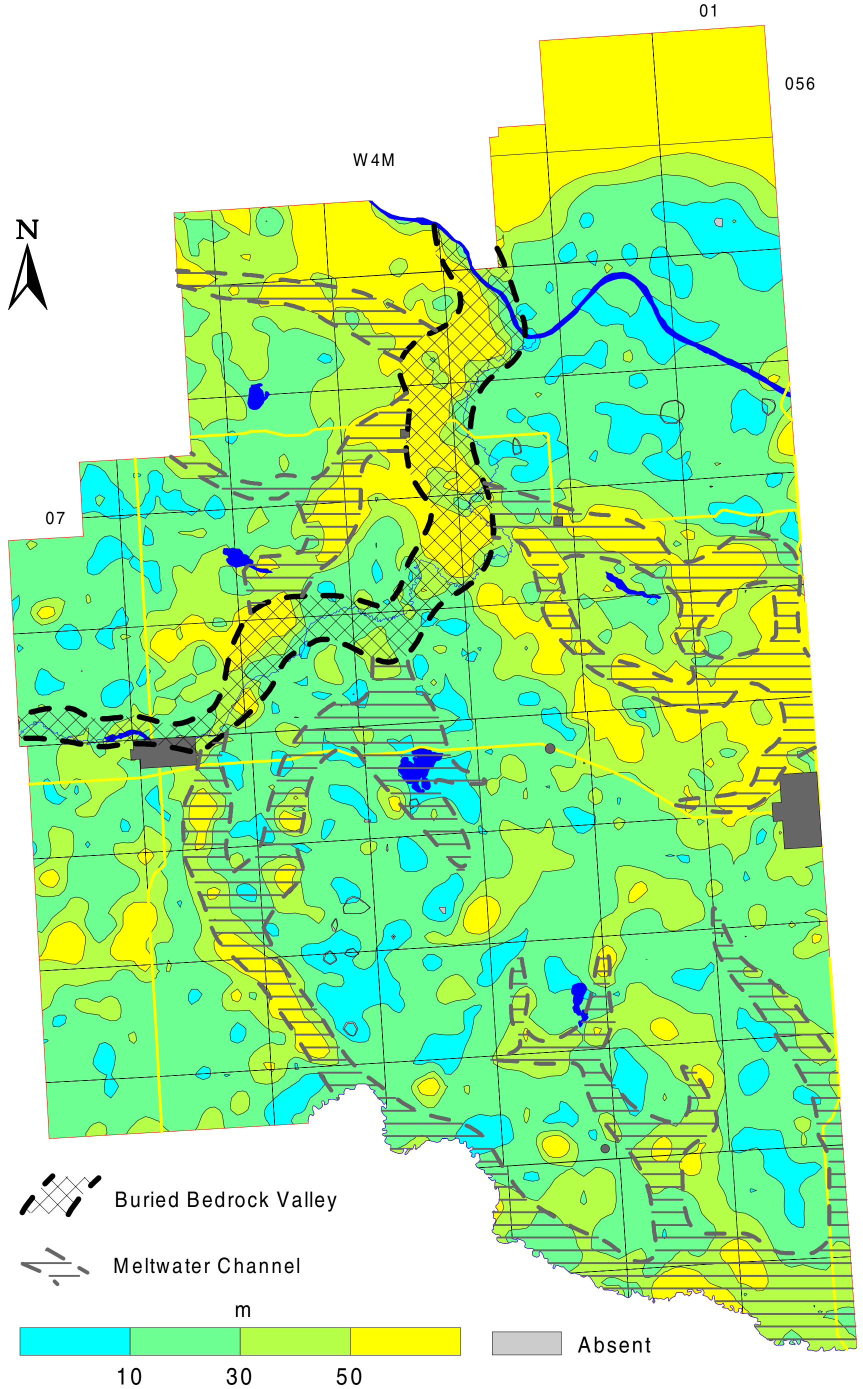
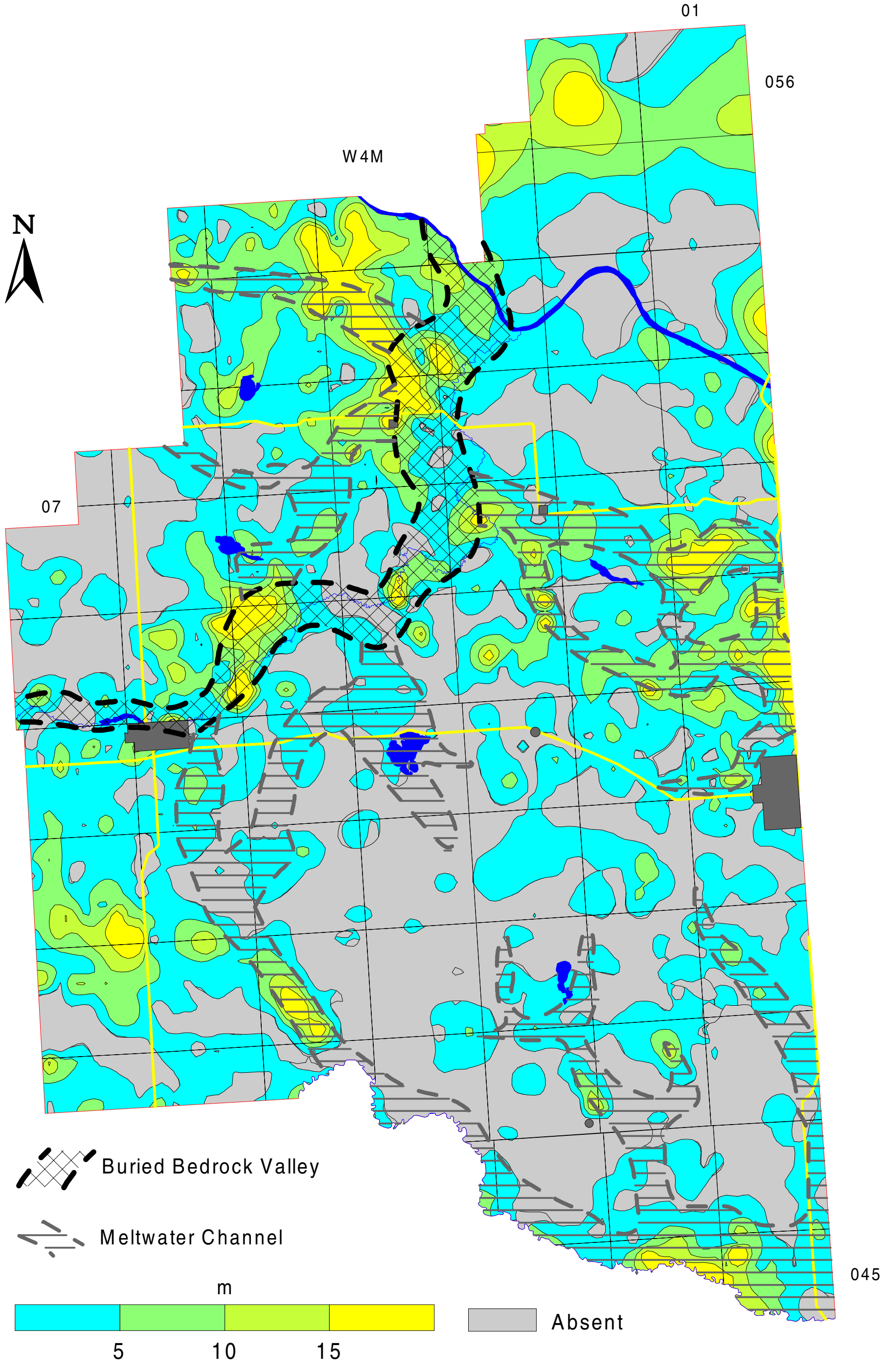
Cross-Section C - C'



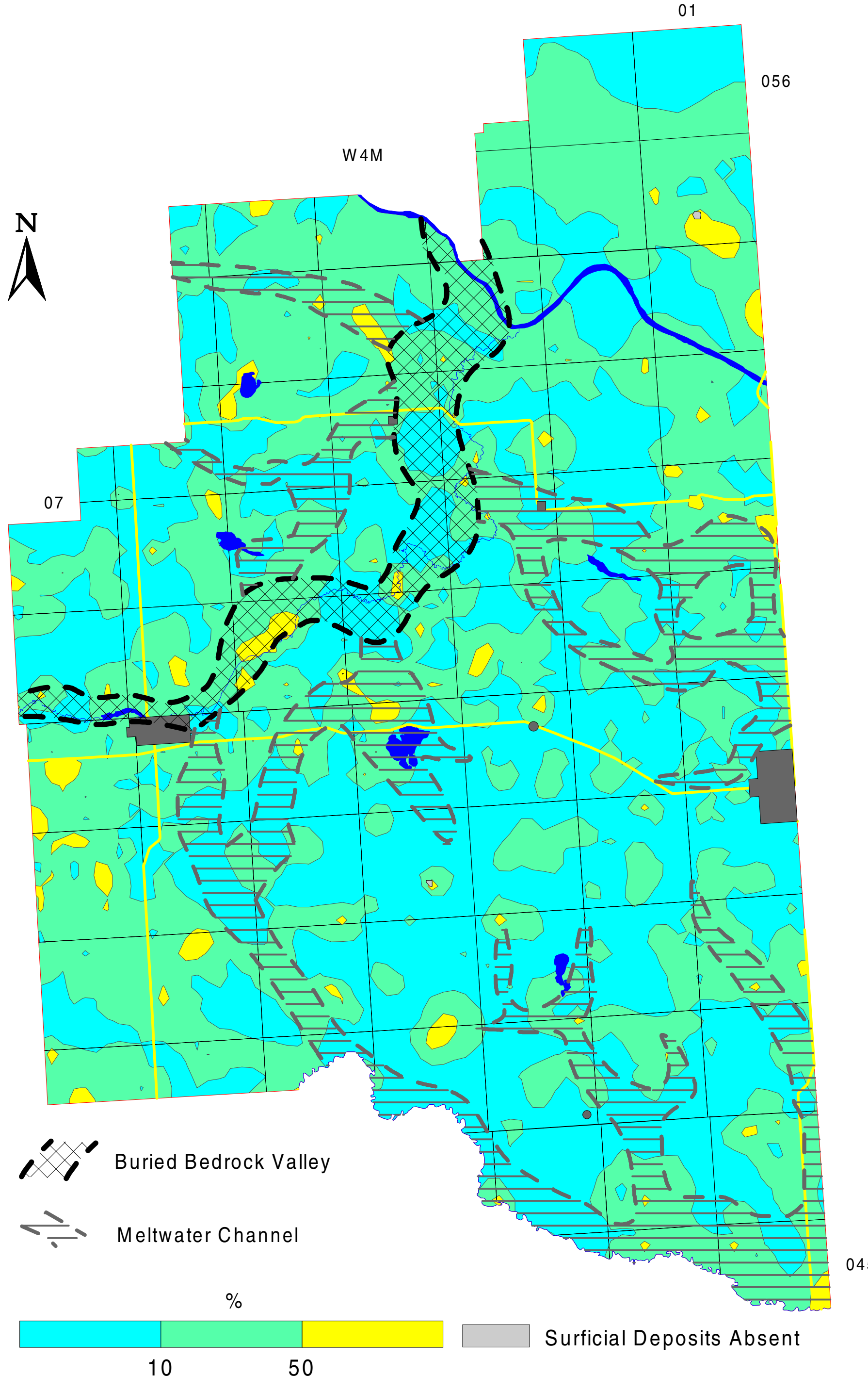
Thickness of Surficial Deposits



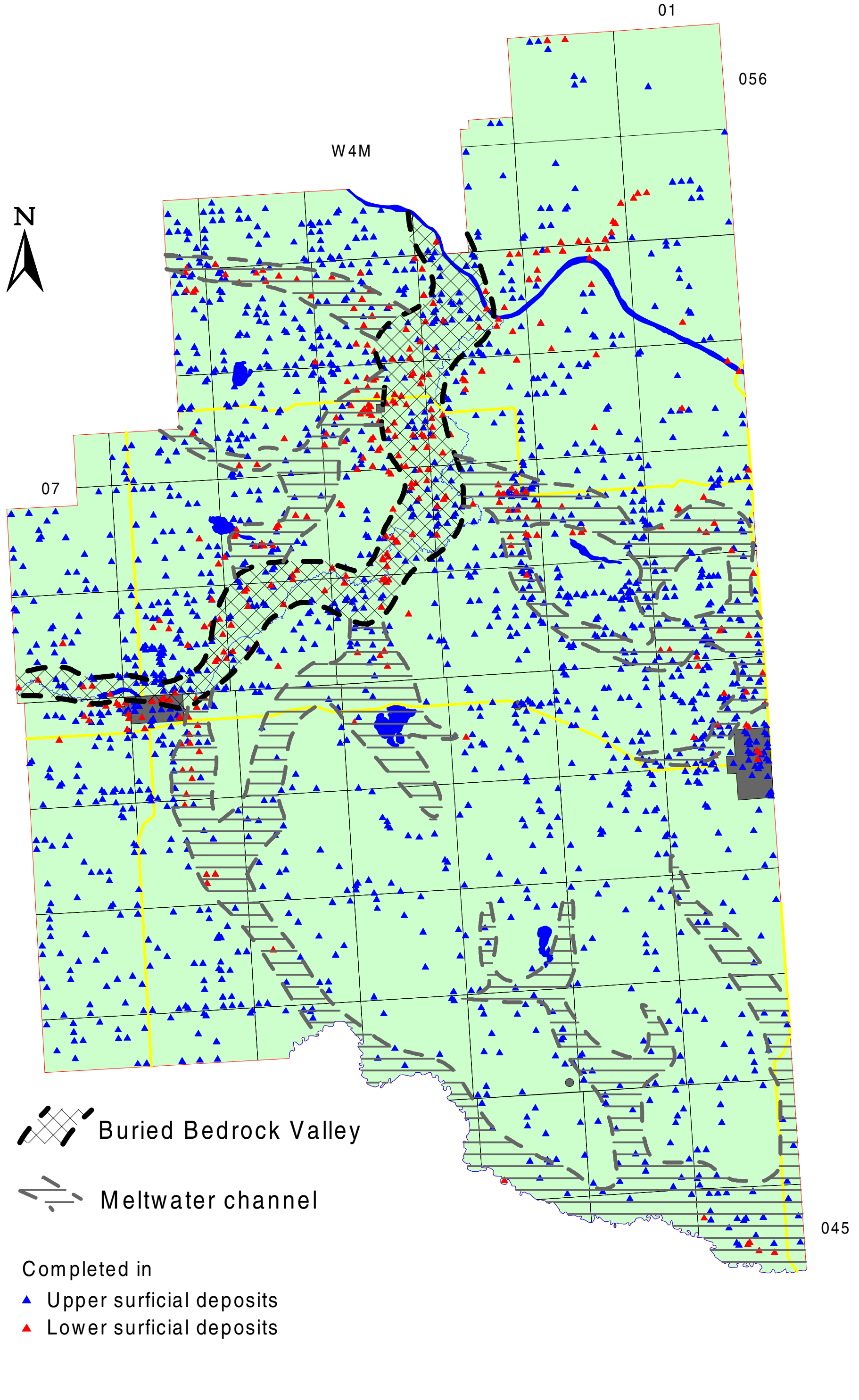
Thickness of Sand and Gravel Aquifer(s)



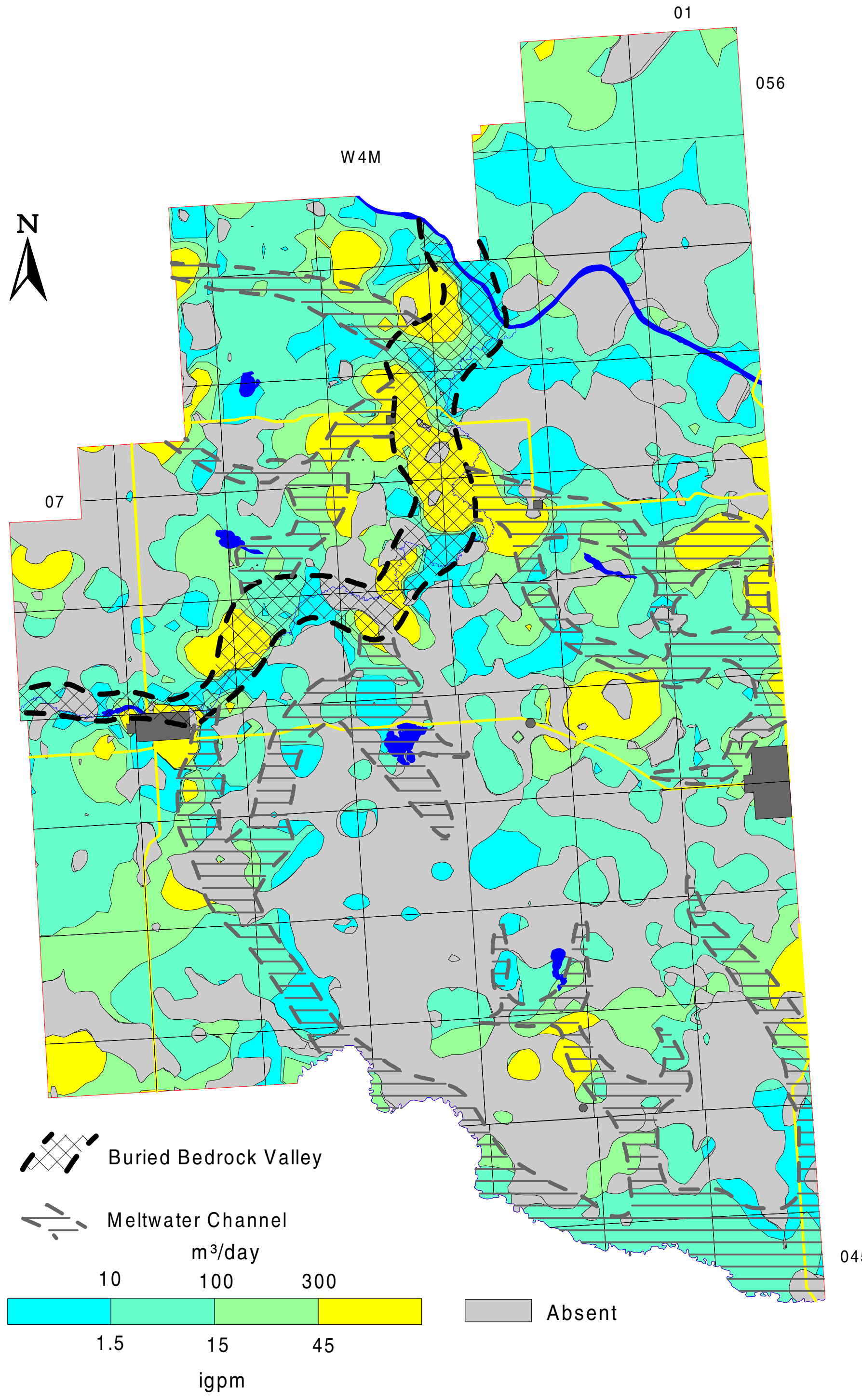
Amount of Sand and Gravel in Surficial Deposits



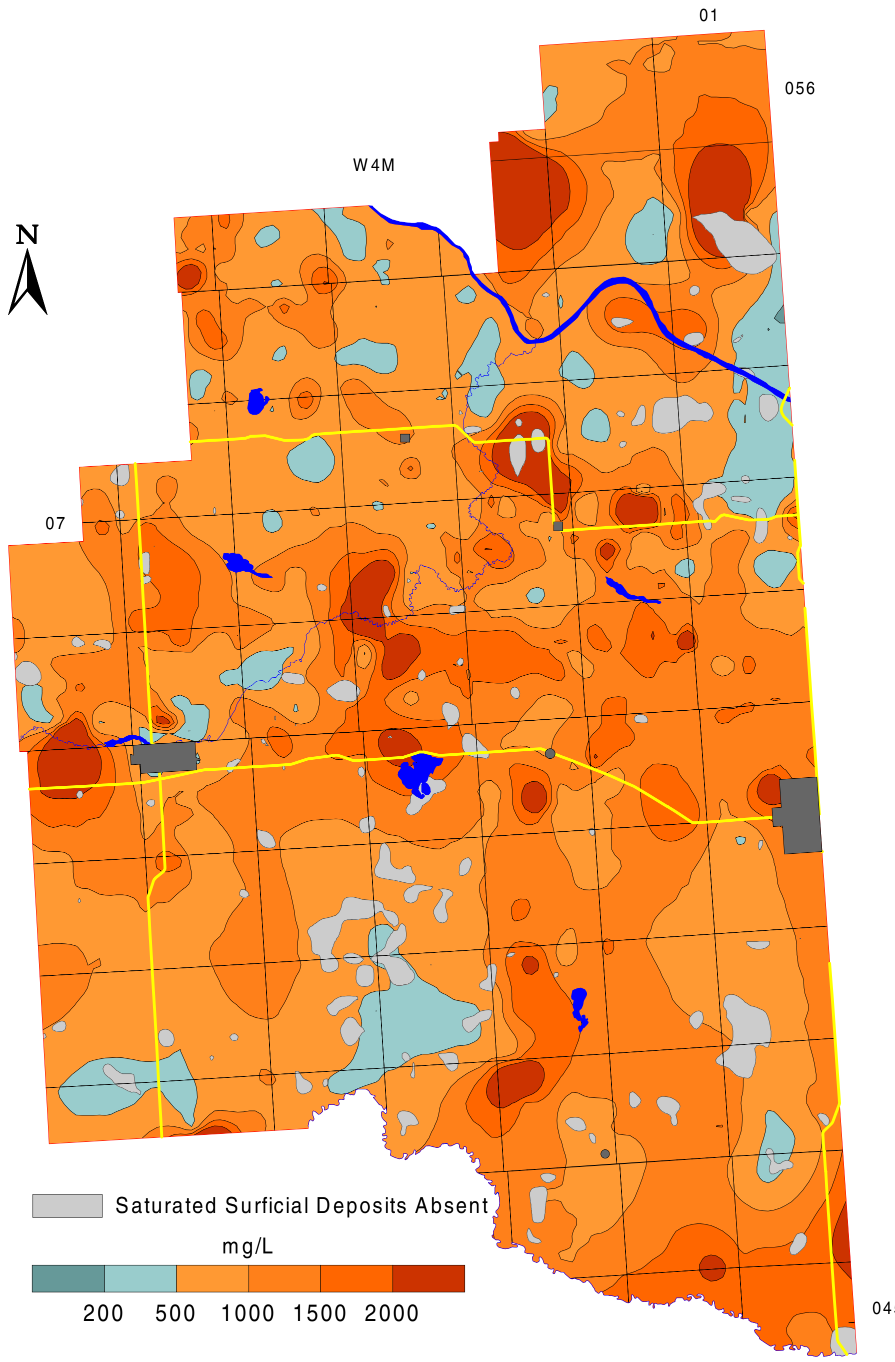
Water Wells Completed in Surficial Deposits



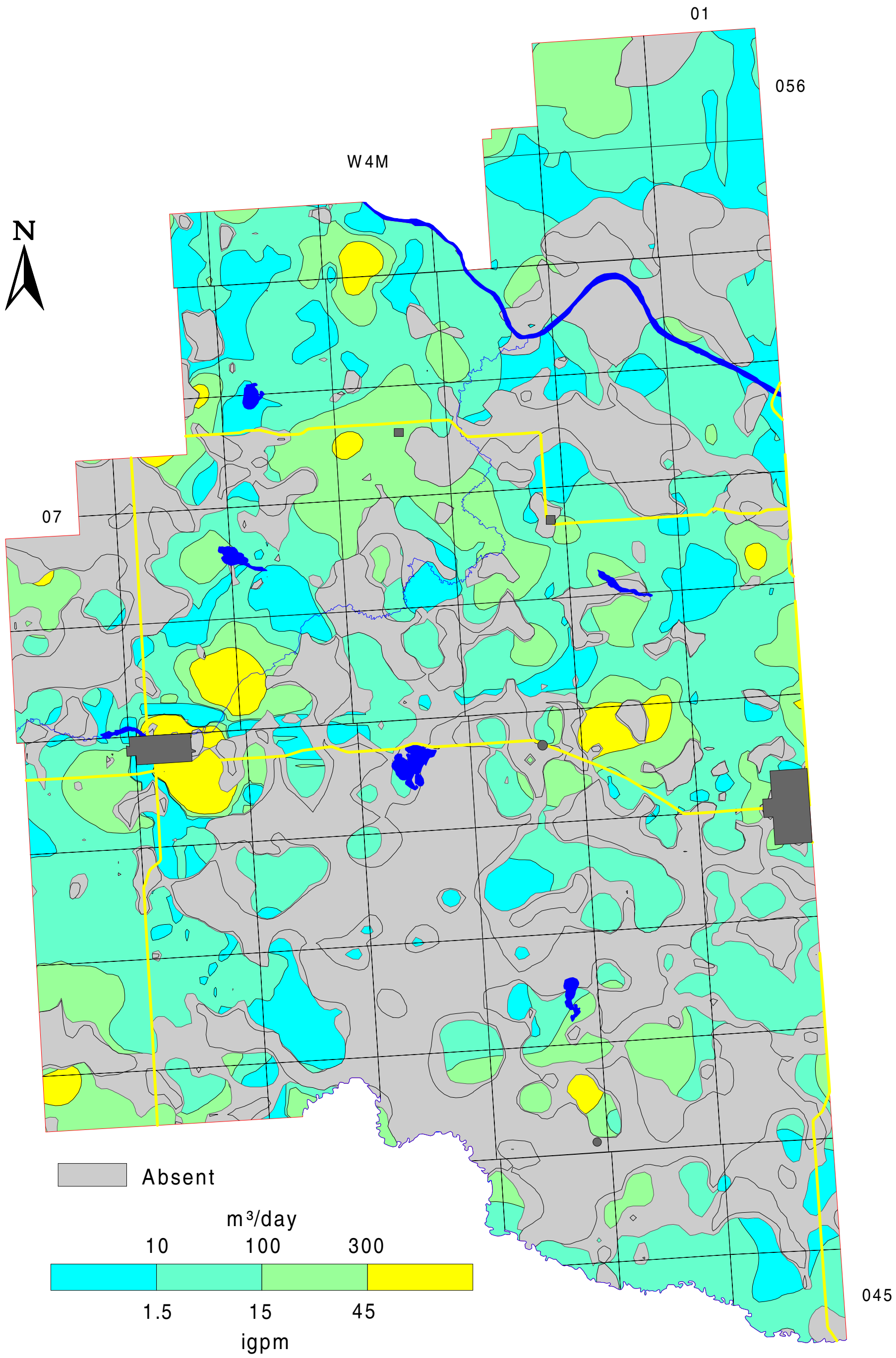
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)



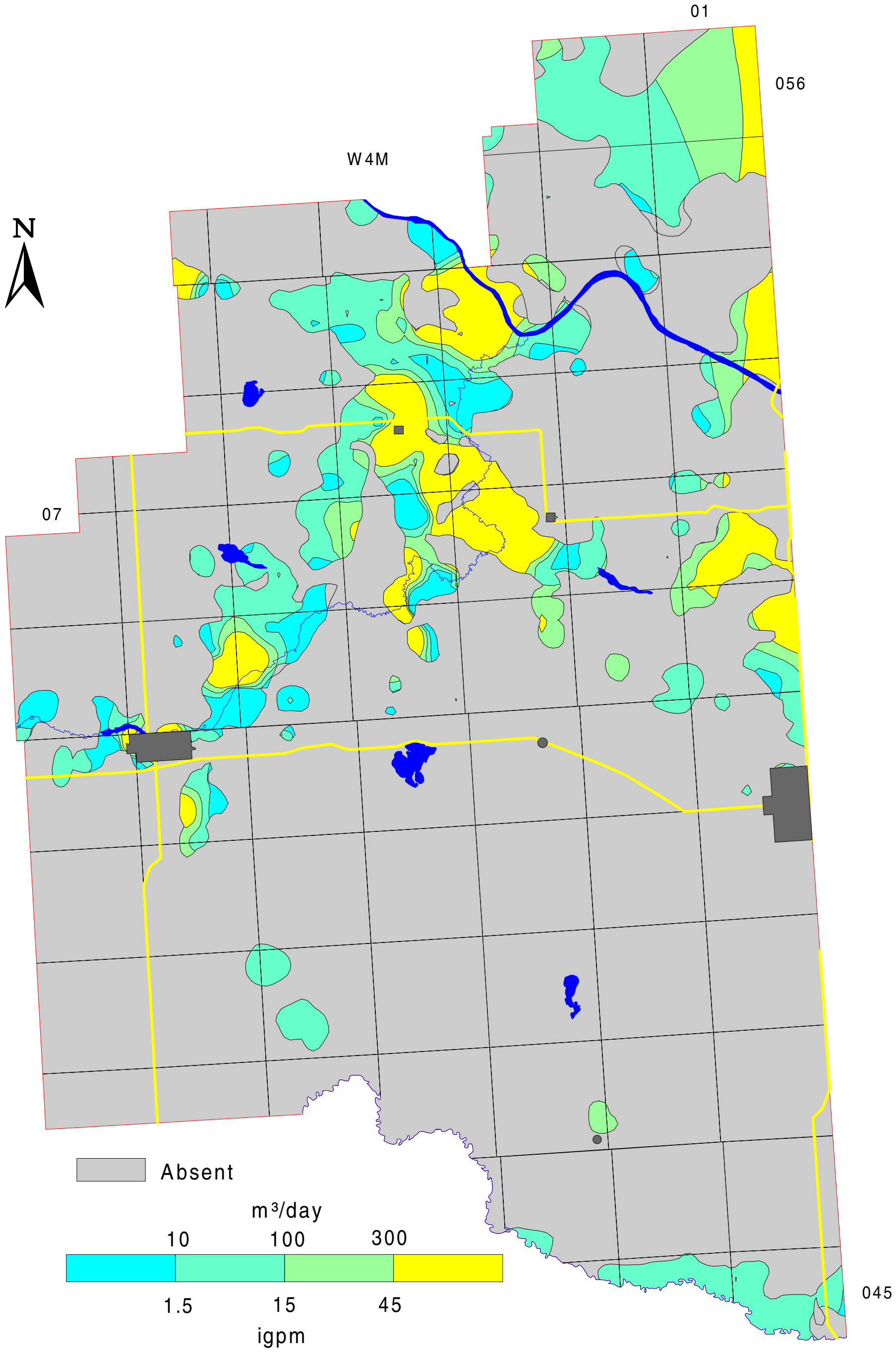
Total Dissolved Solids in Groundwater from Surficial Deposits



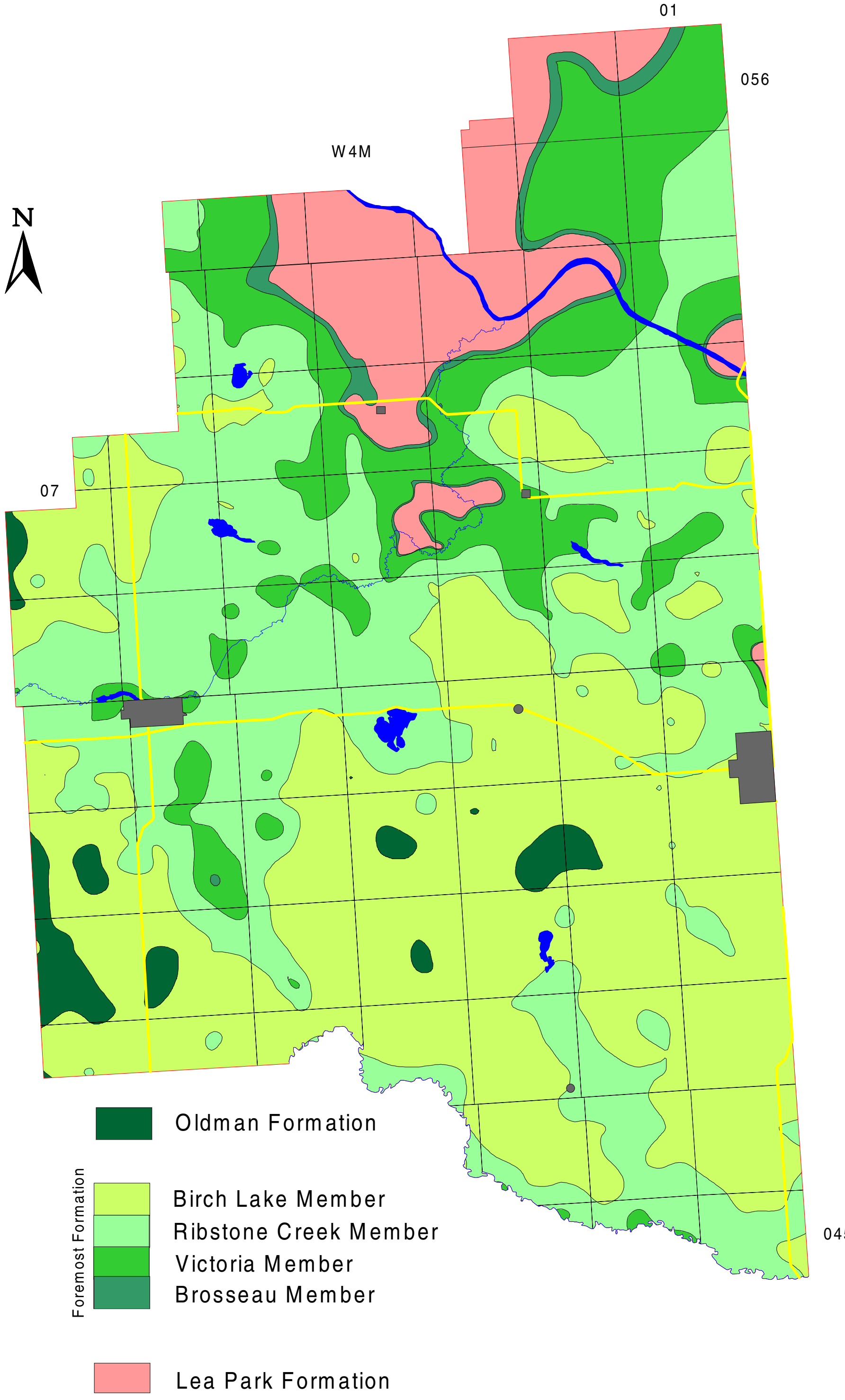
Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer



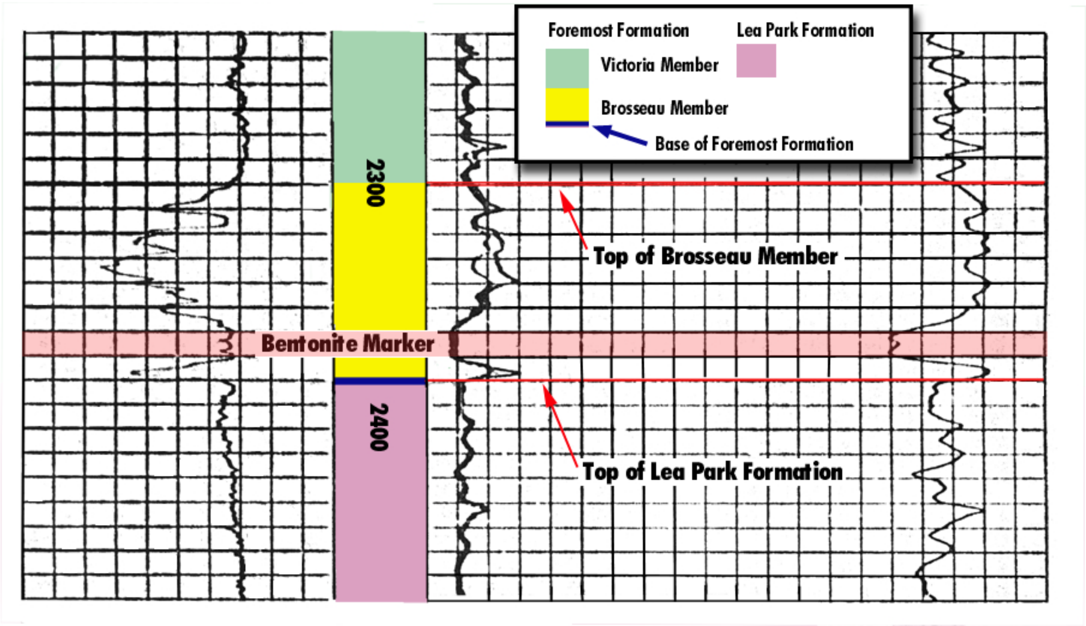
Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer



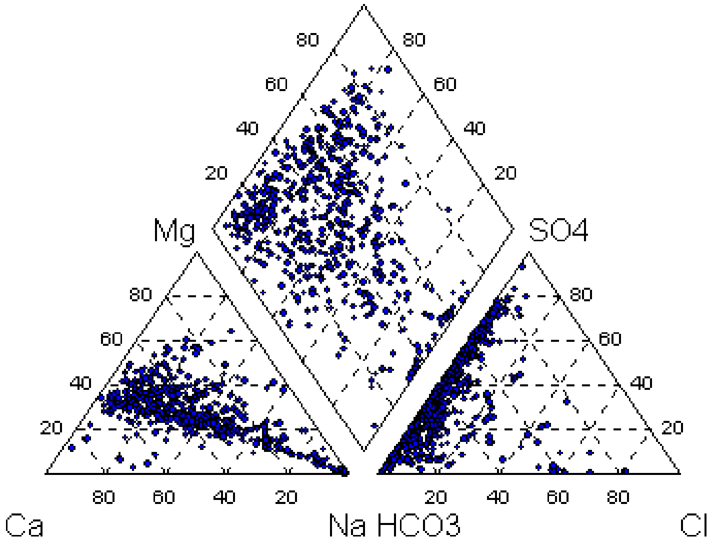
Bedrock Geology



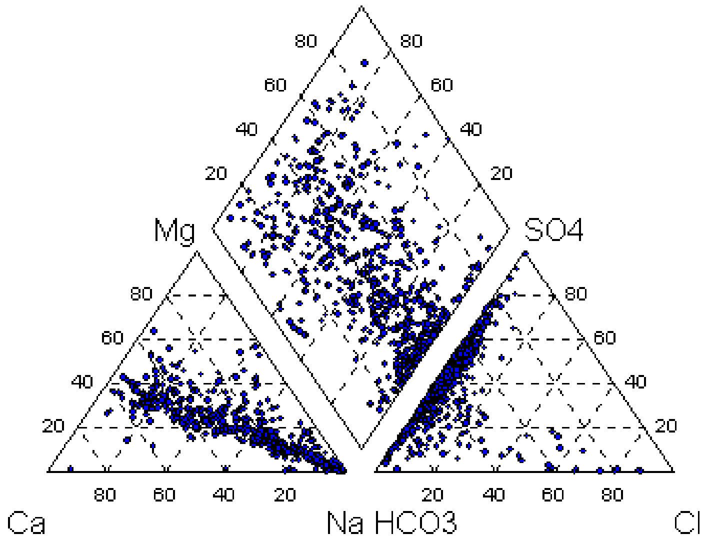
E-Log showing Base of Foremost Formation



Piper Diagrams

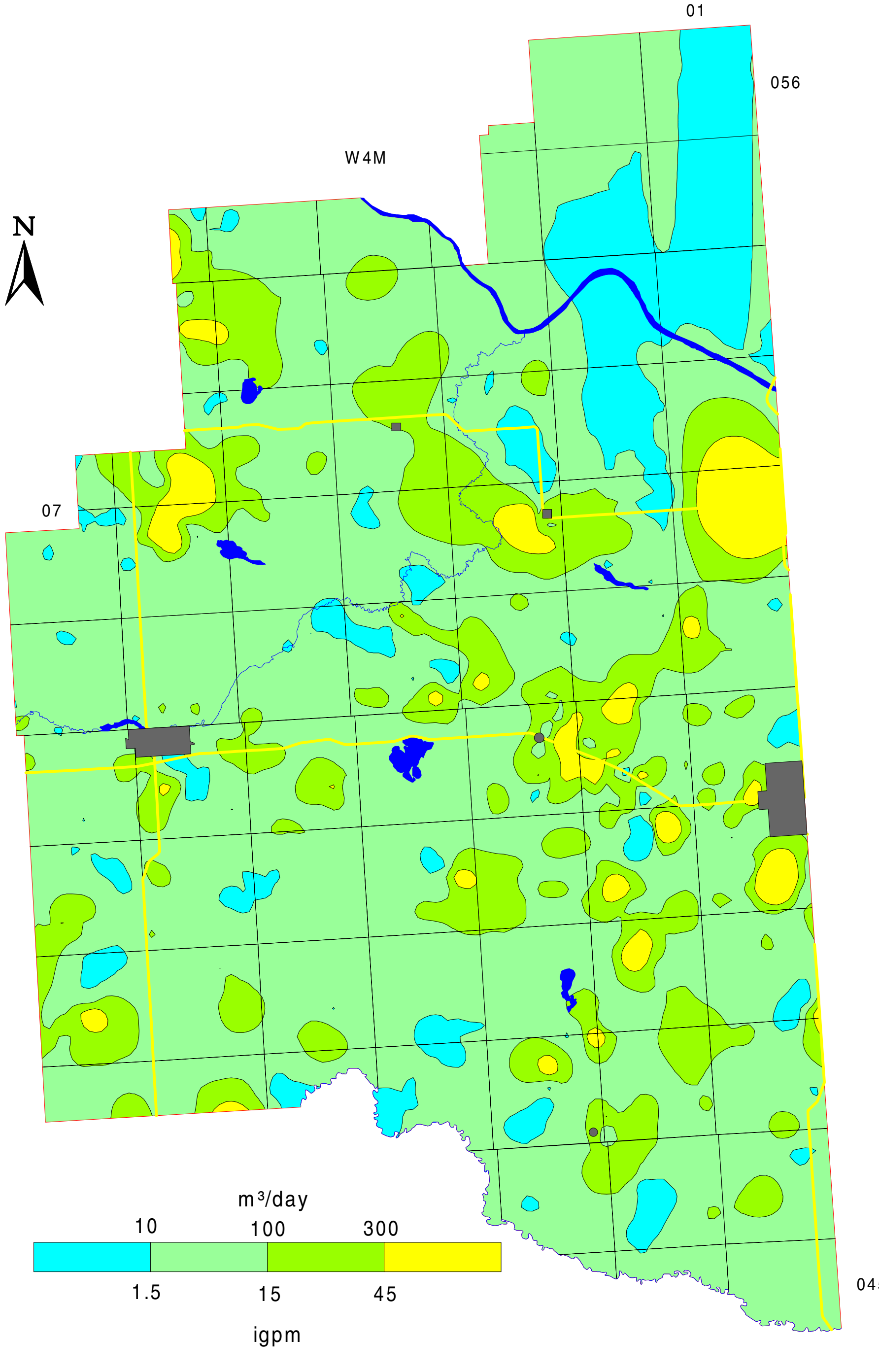


Surficial Deposits

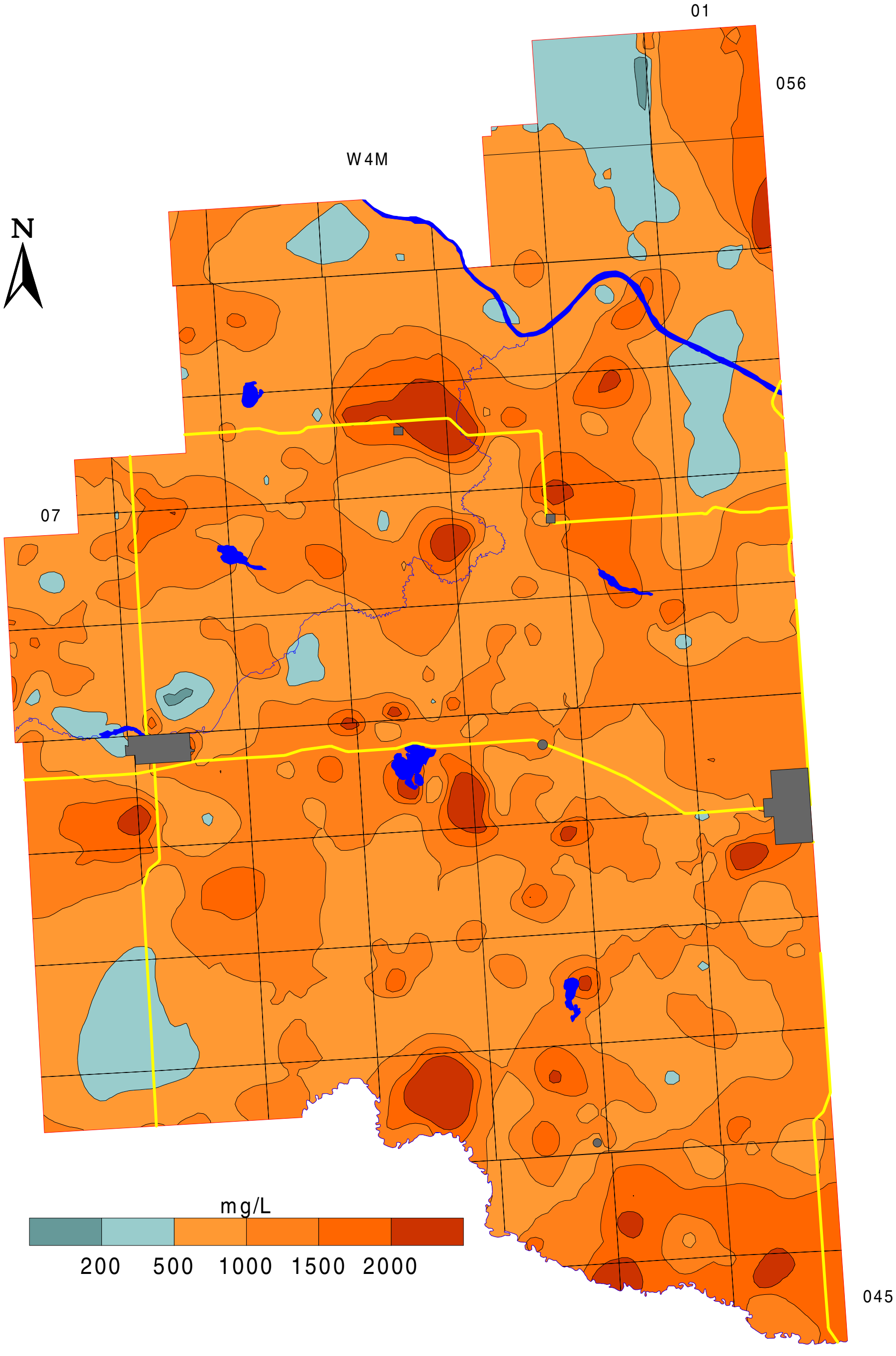


Bedrock Aquifers

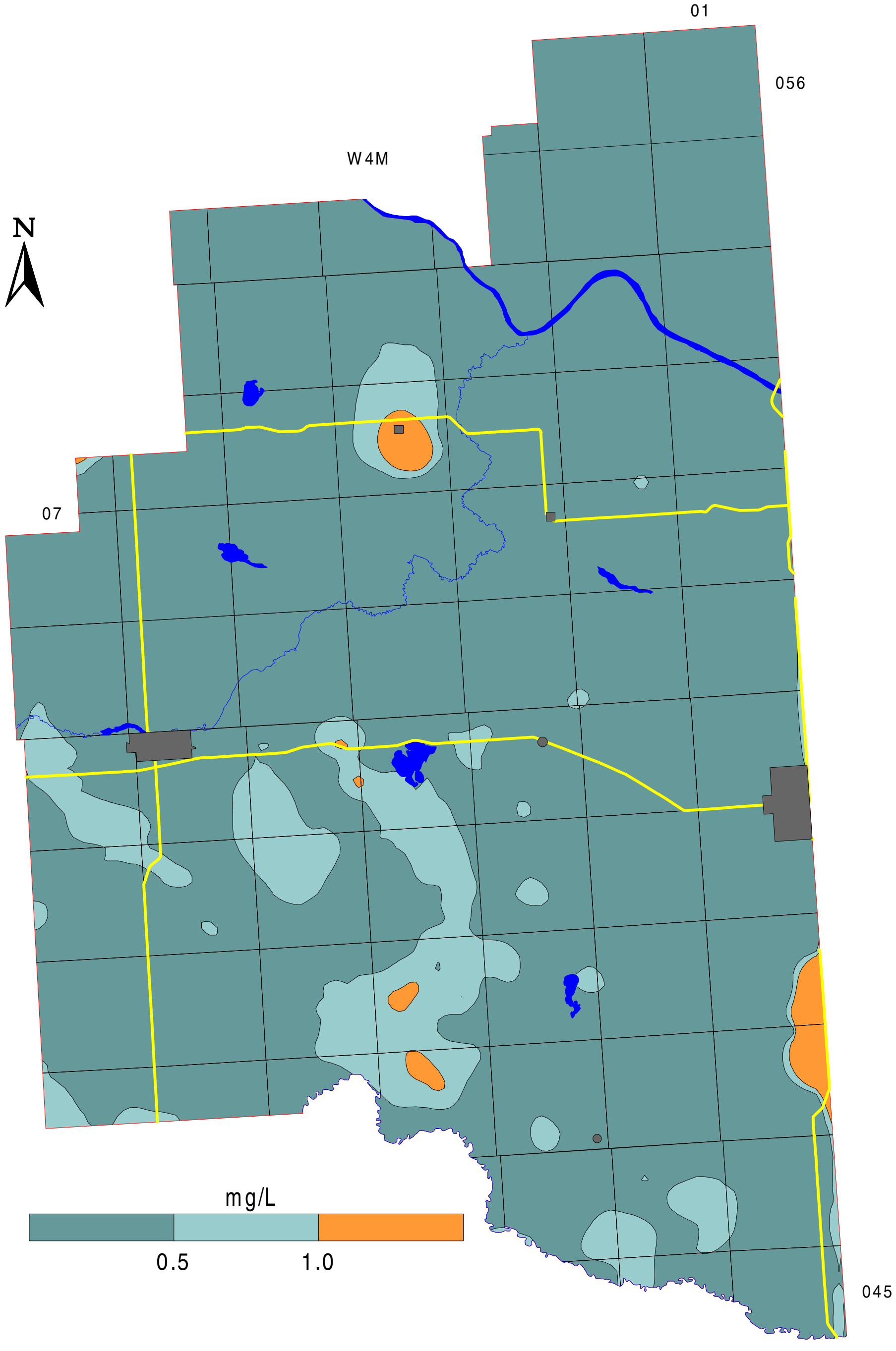
Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)



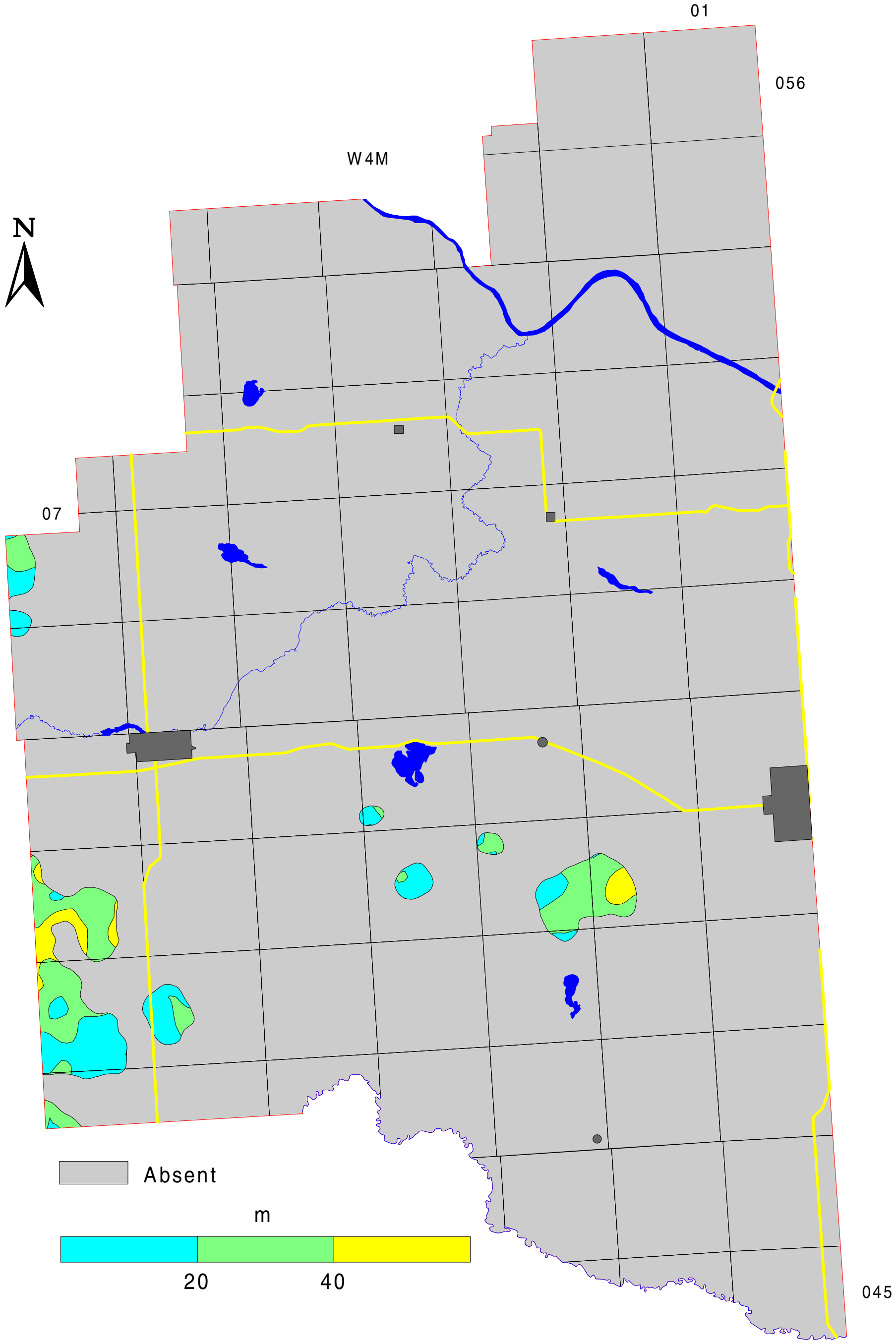
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)



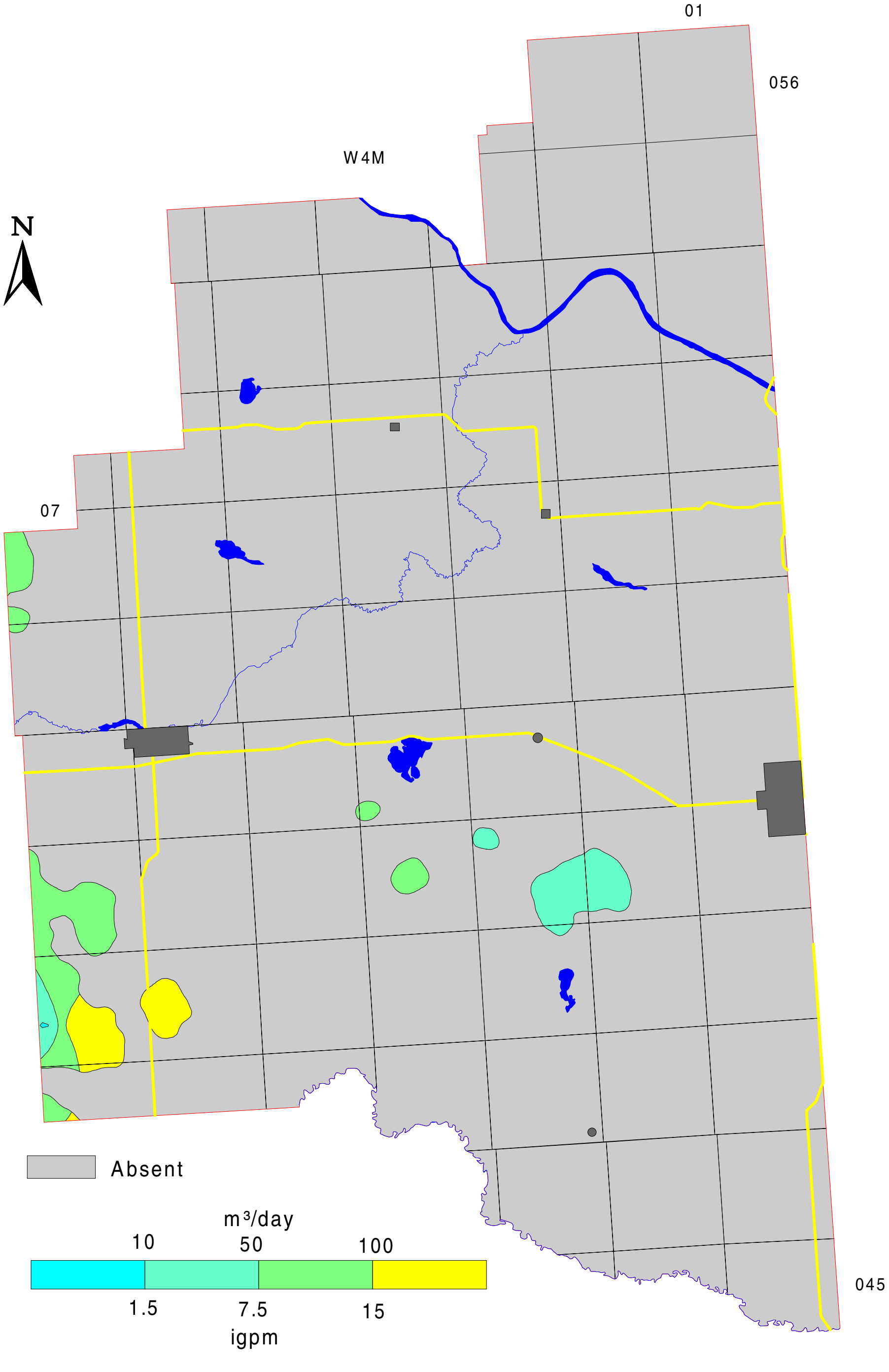
Fluoride in Groundwater from Upper Bedrock Aquifer(s)



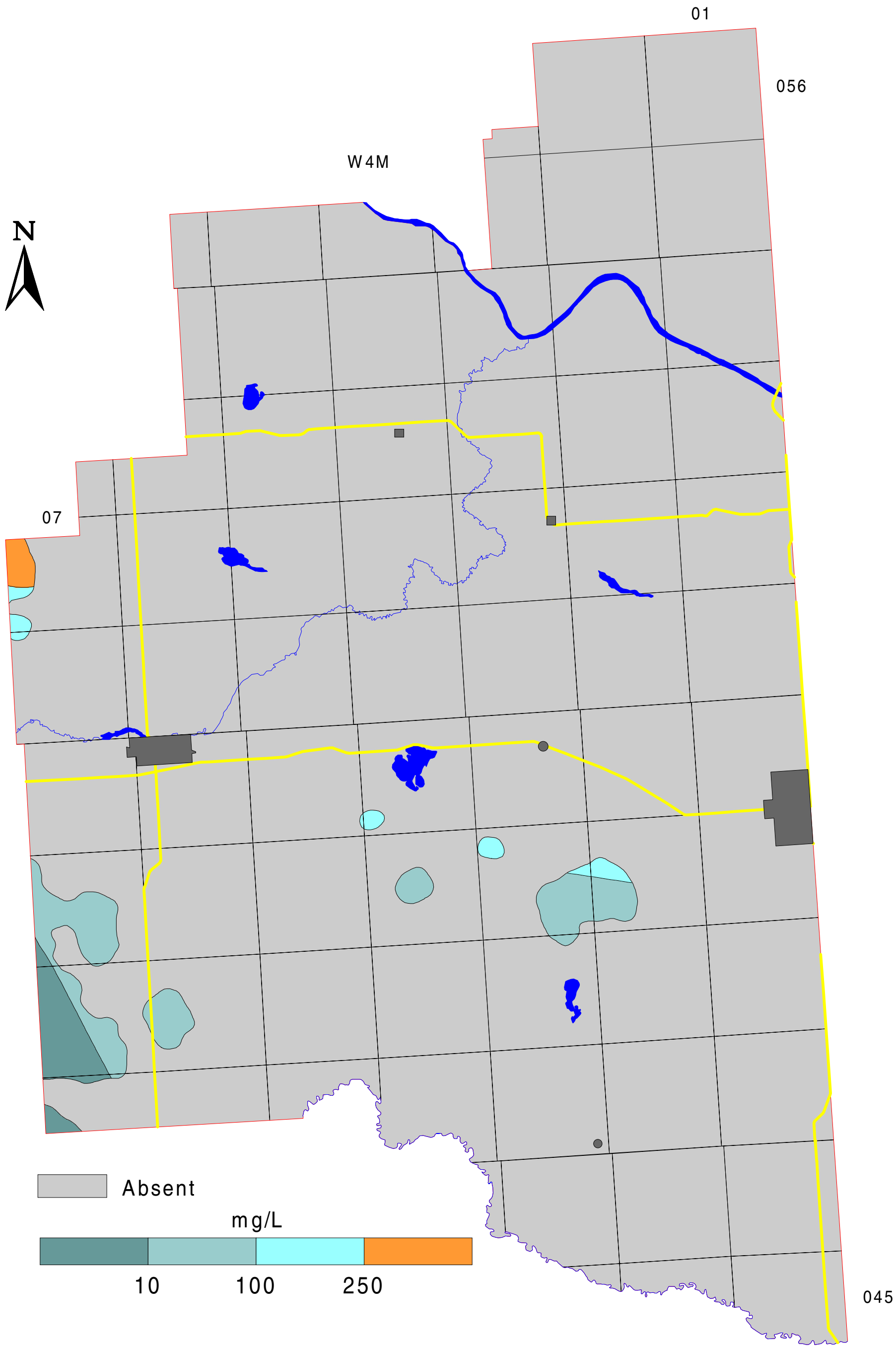
Depth to Top of Oldman Formation



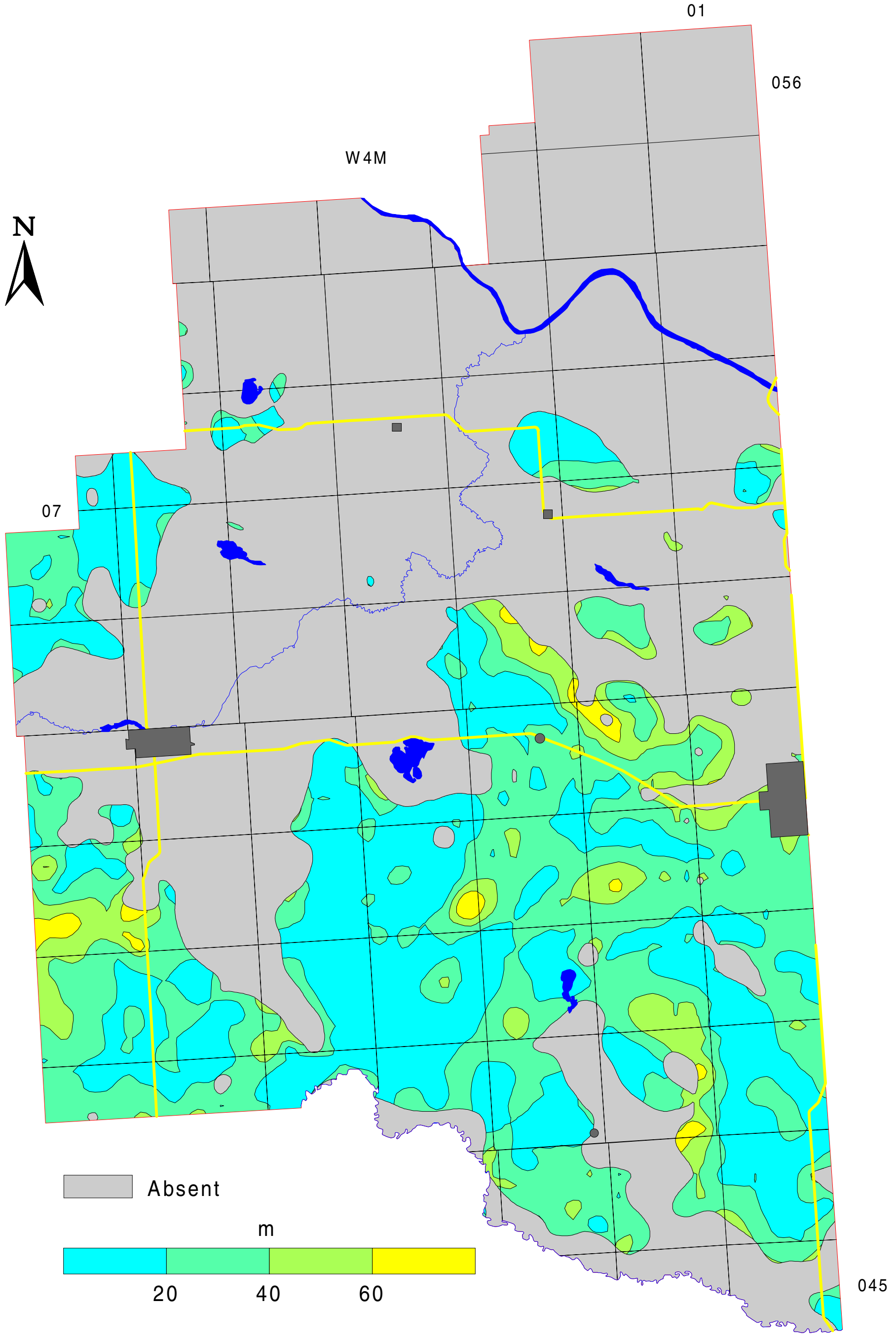
Apparent Yield for Water Wells Completed through Oldman Aquifer



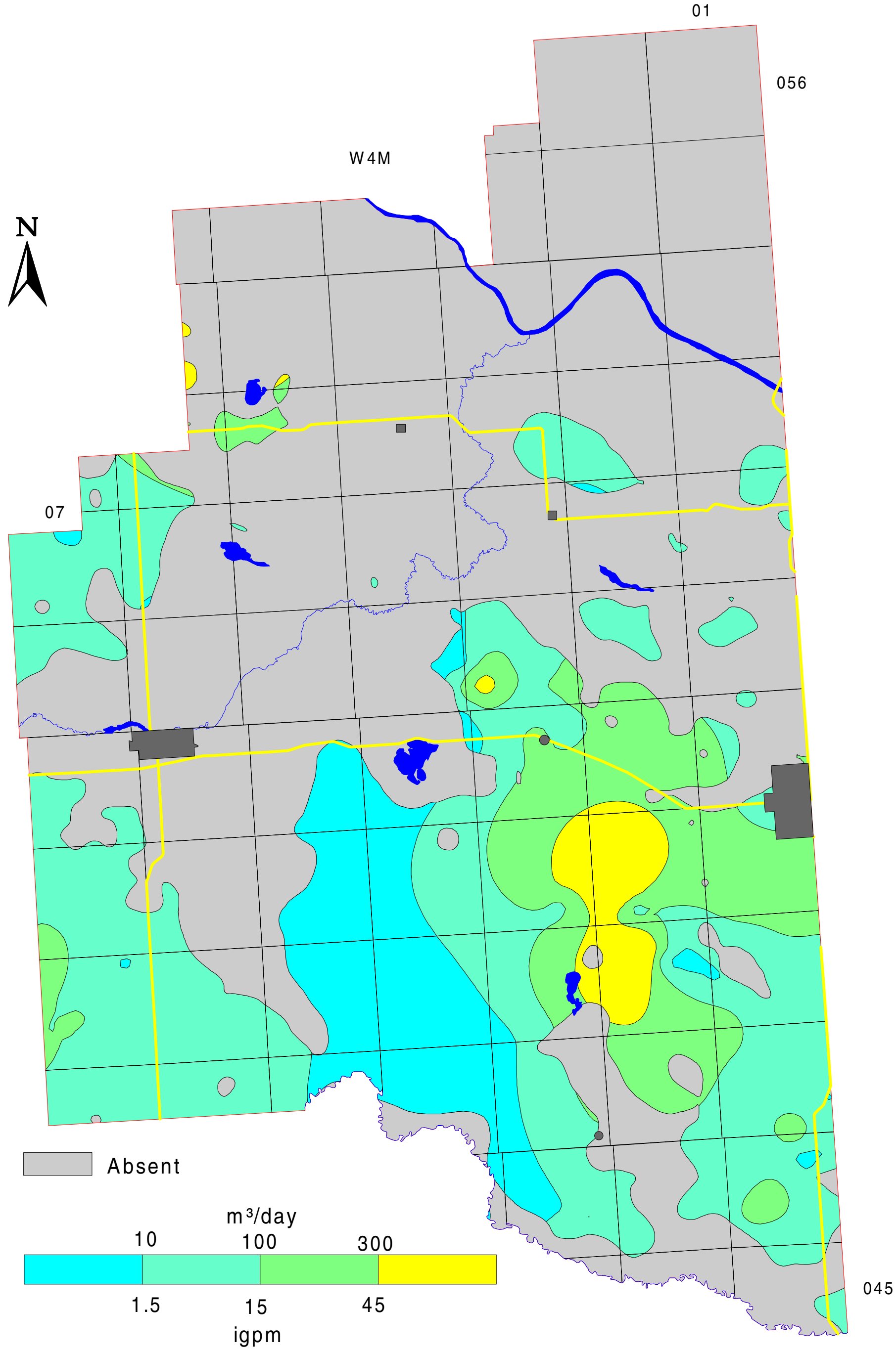
Chloride in Groundwater from Oldman Aquifer



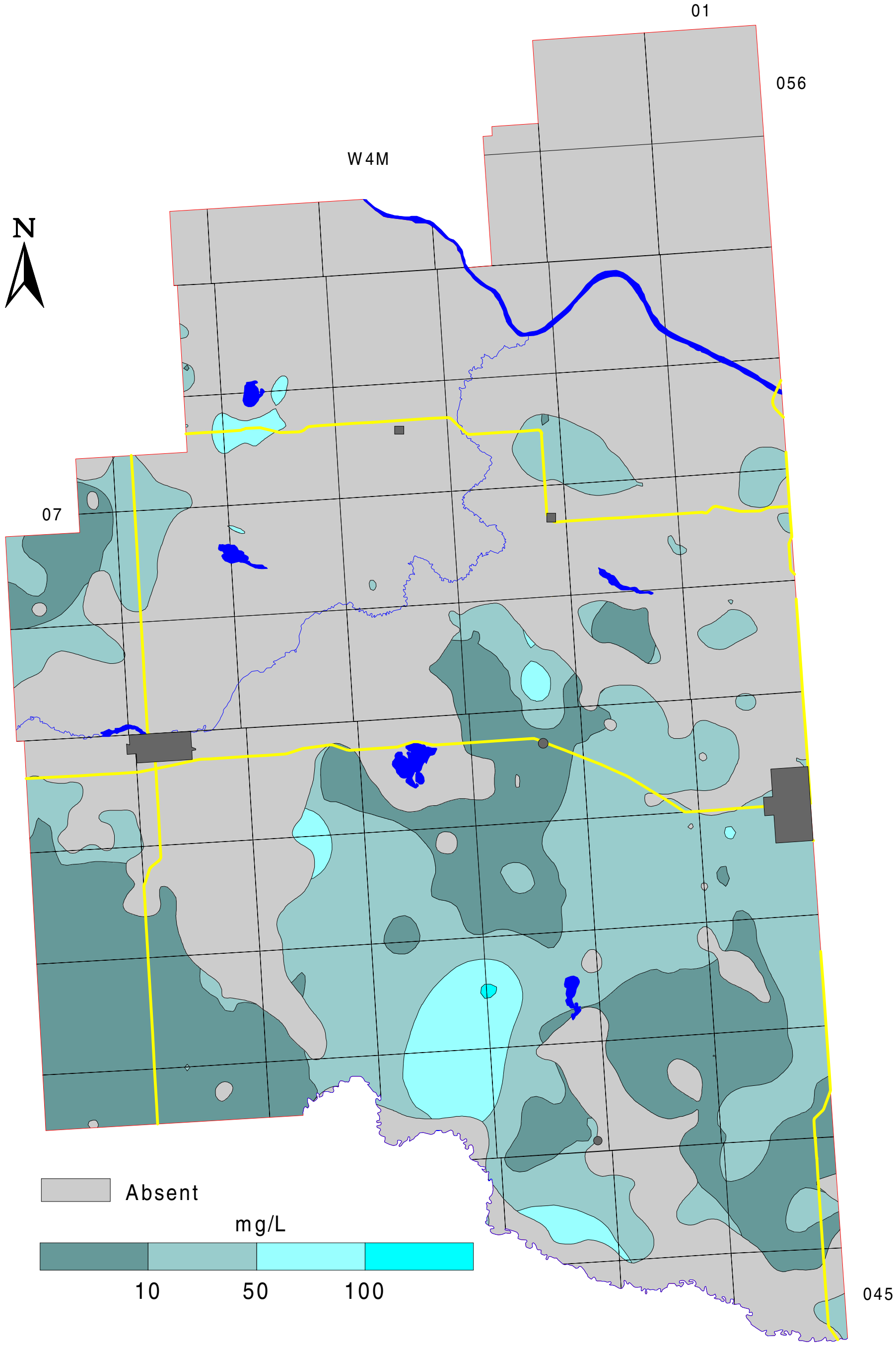
Depth to Top of Birch Lake Member



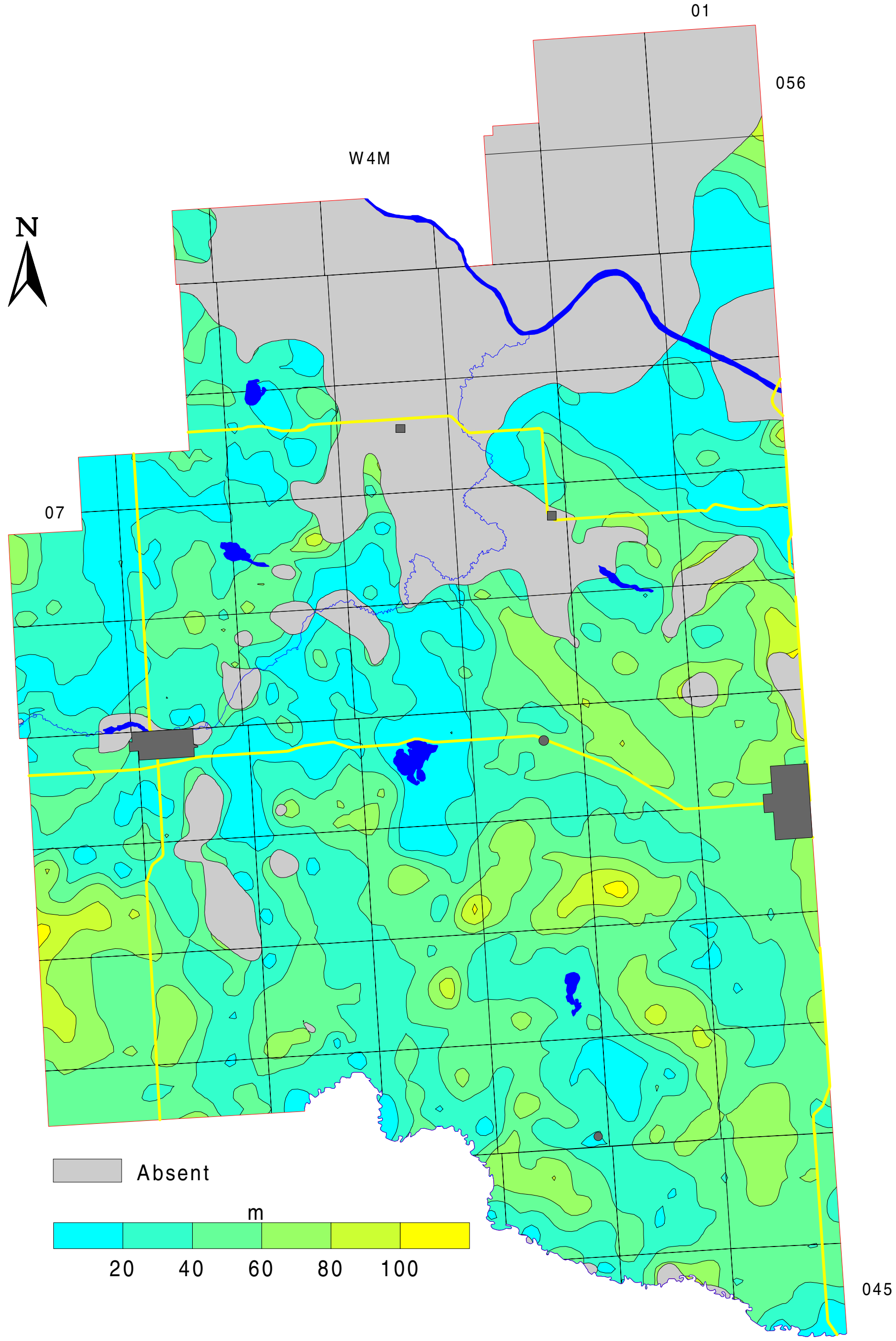
Apparent Yield for Water Wells Completed through Birch Lake Aquifer



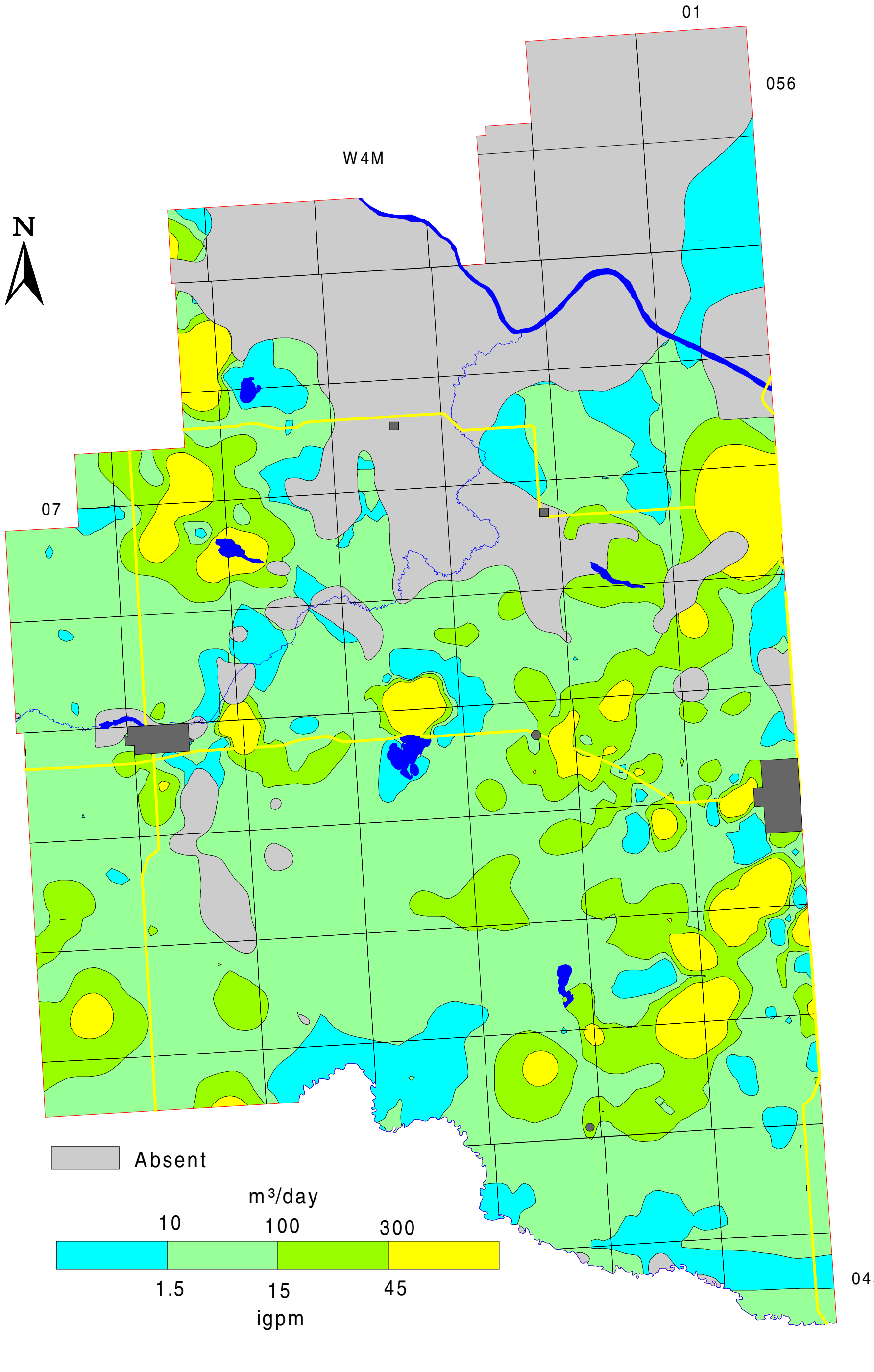
Chloride in Groundwater from Birch Lake Aquifer



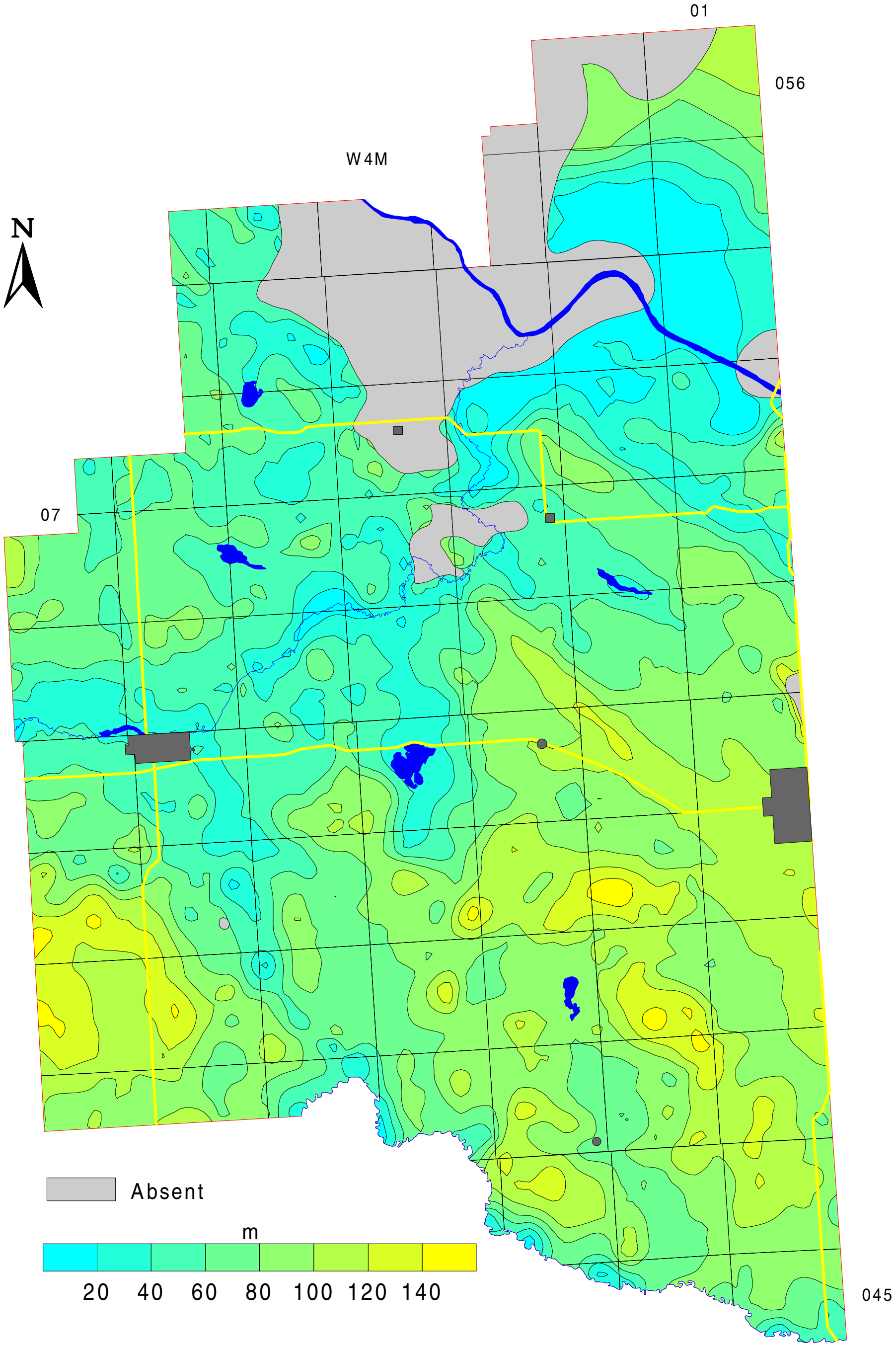
Depth to Top of Ribstone Creek Member



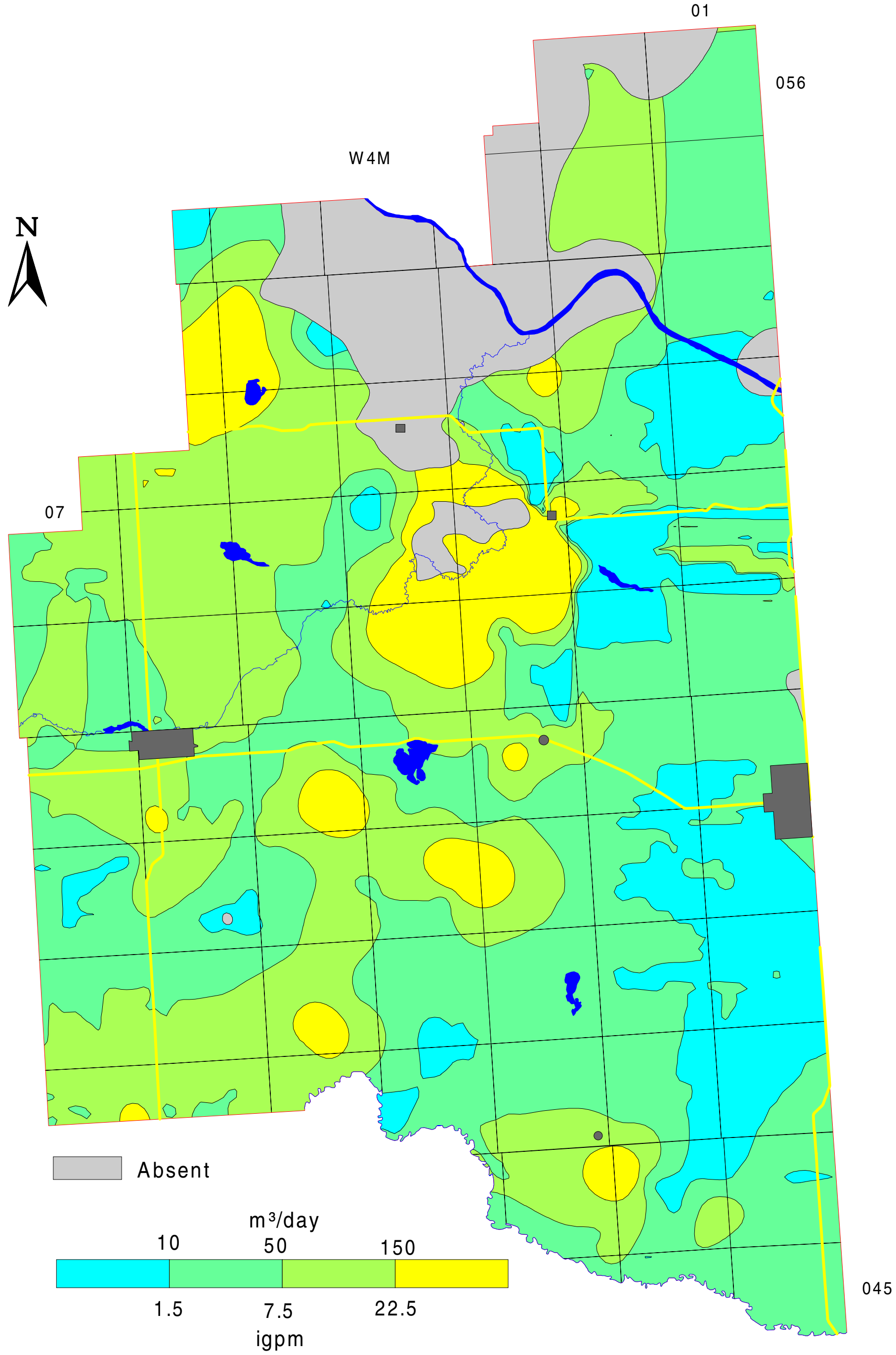
Apparent Yield for Water Wells Completed through Ribstone Creek Aquifer



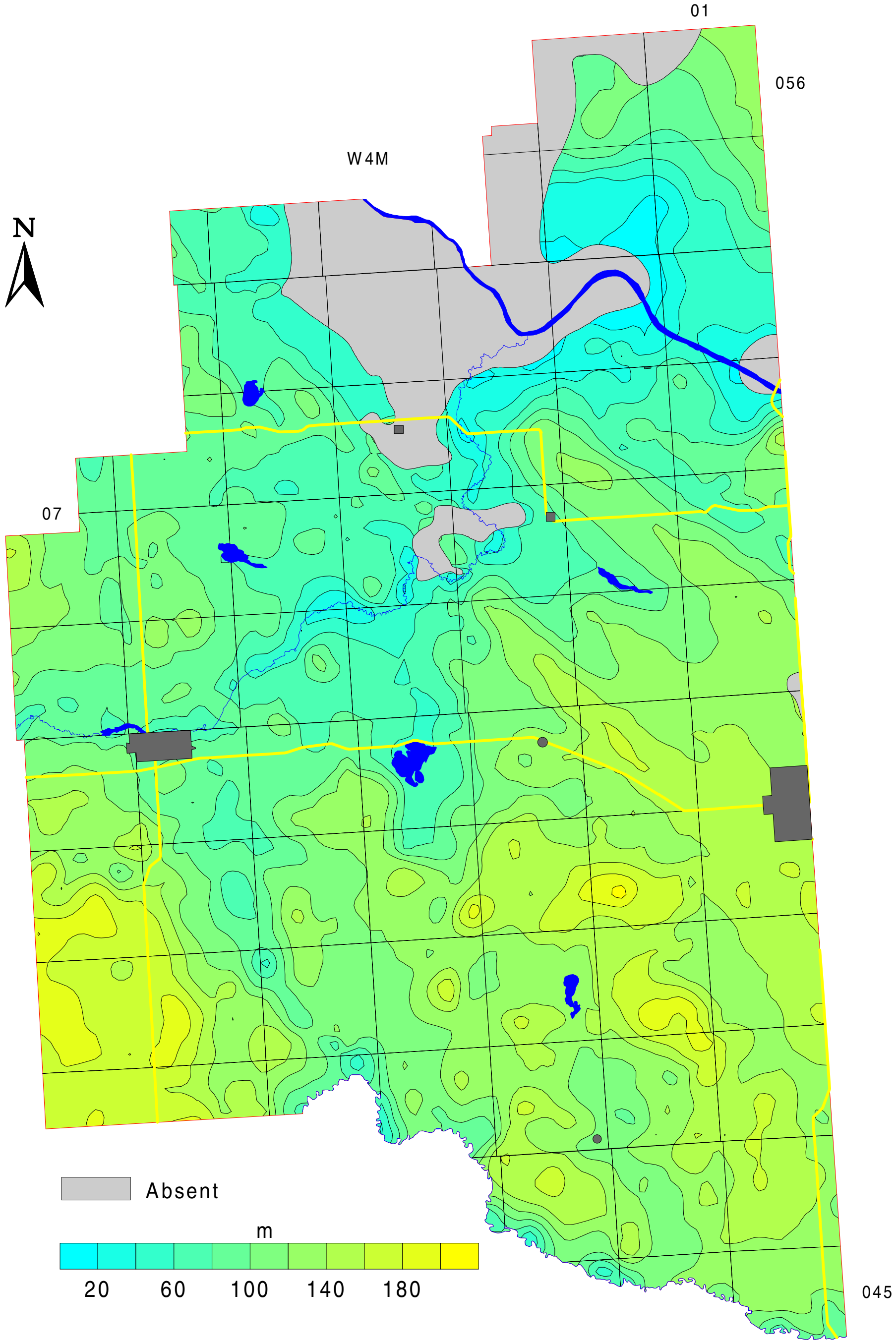
Depth to Top of Victoria Member



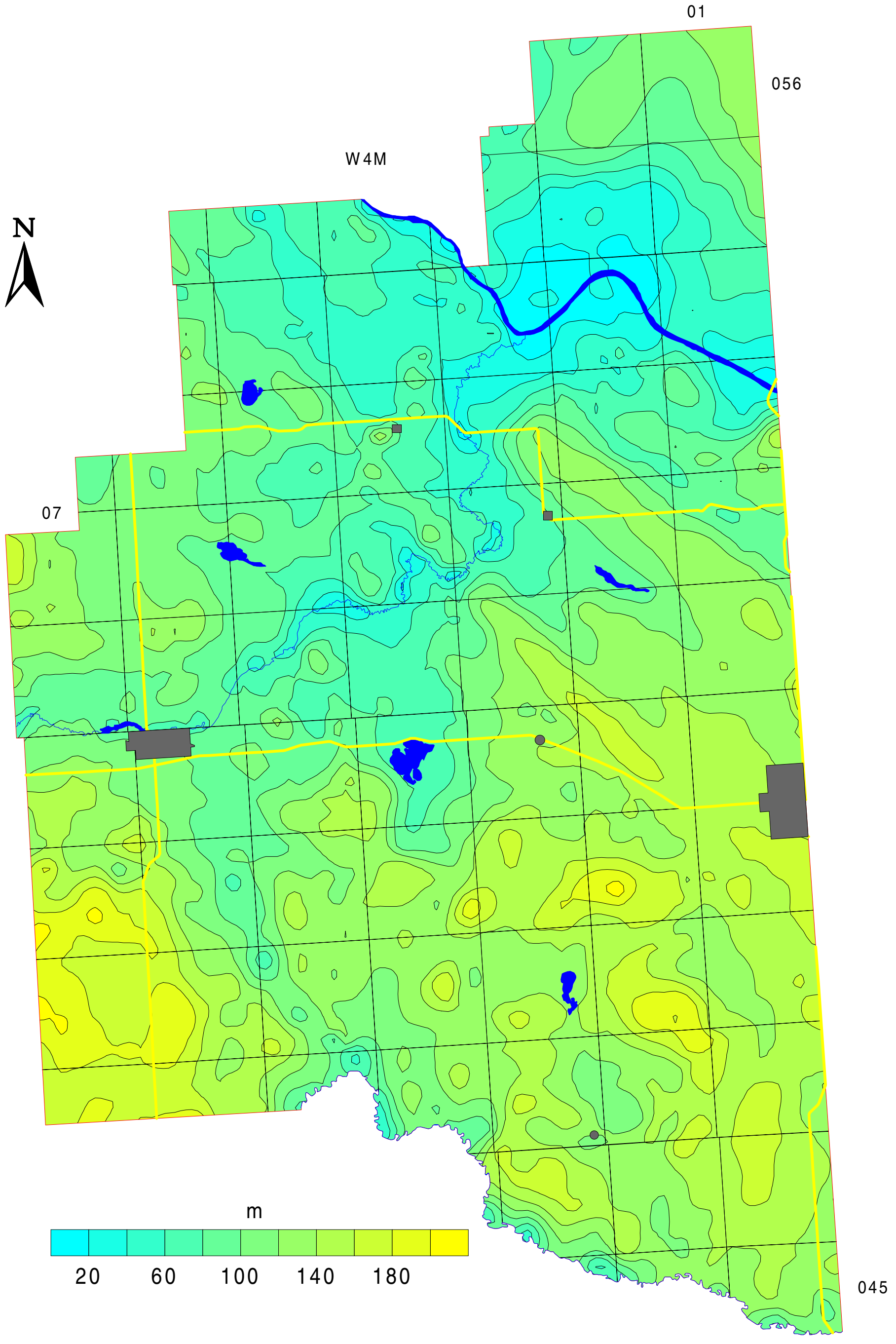
Apparent Yield for Water Wells Completed through Victoria Aquifer



Depth to Top of Brosseau Member



Depth to Top of Lea Park Formation



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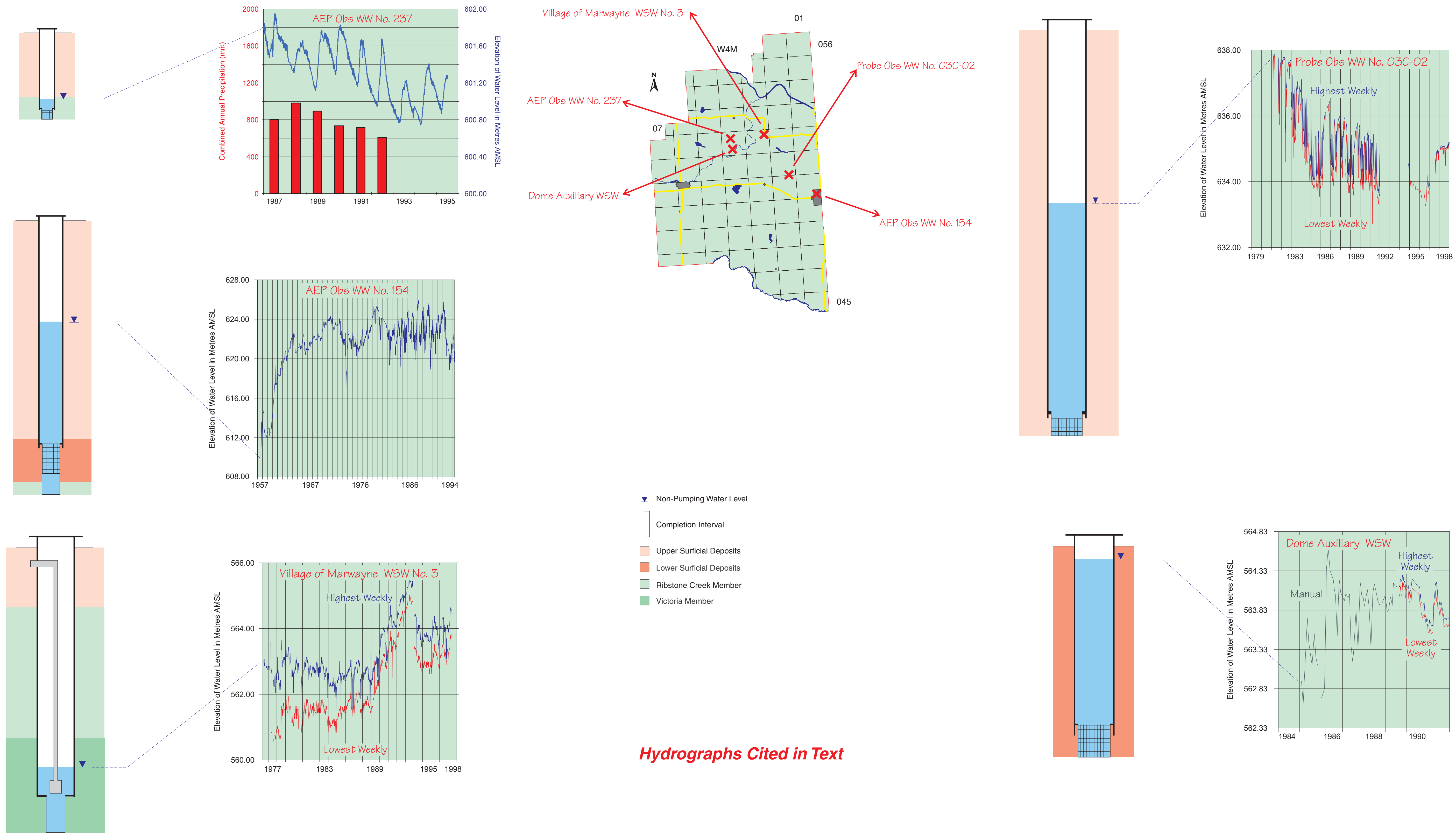
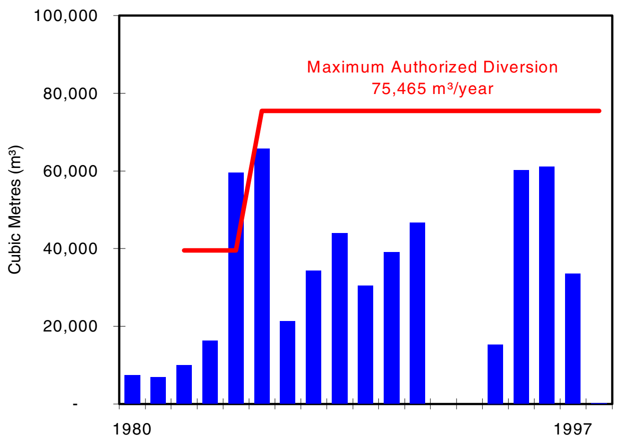
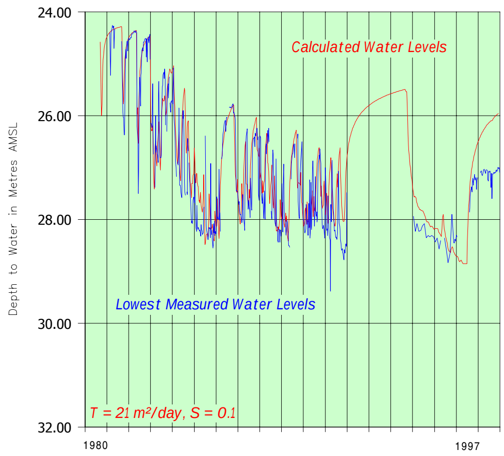


Hydrographs Cited in Text

Water-Level Comparison

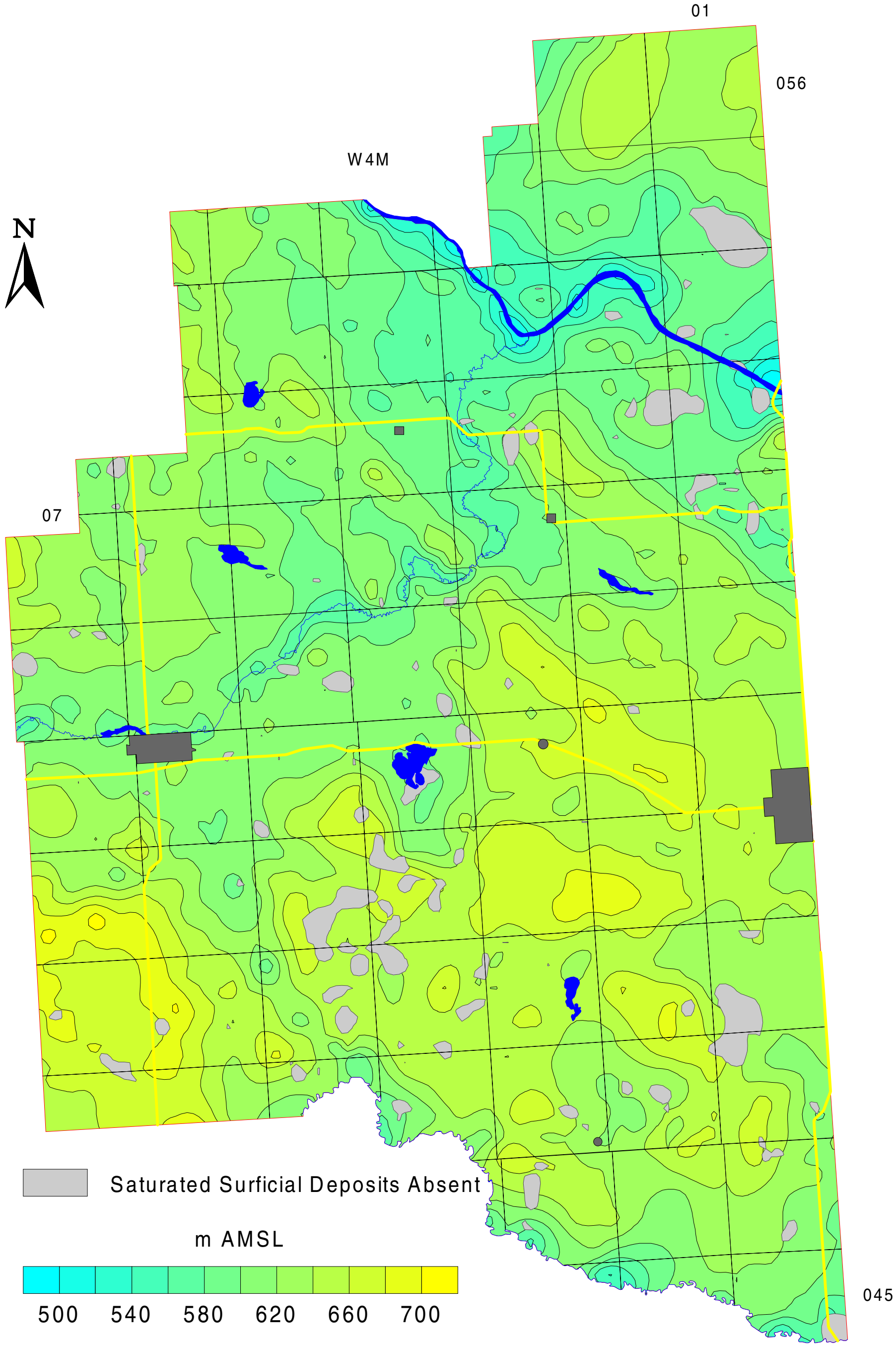


WSW No. 03C-02 Groundwater Production

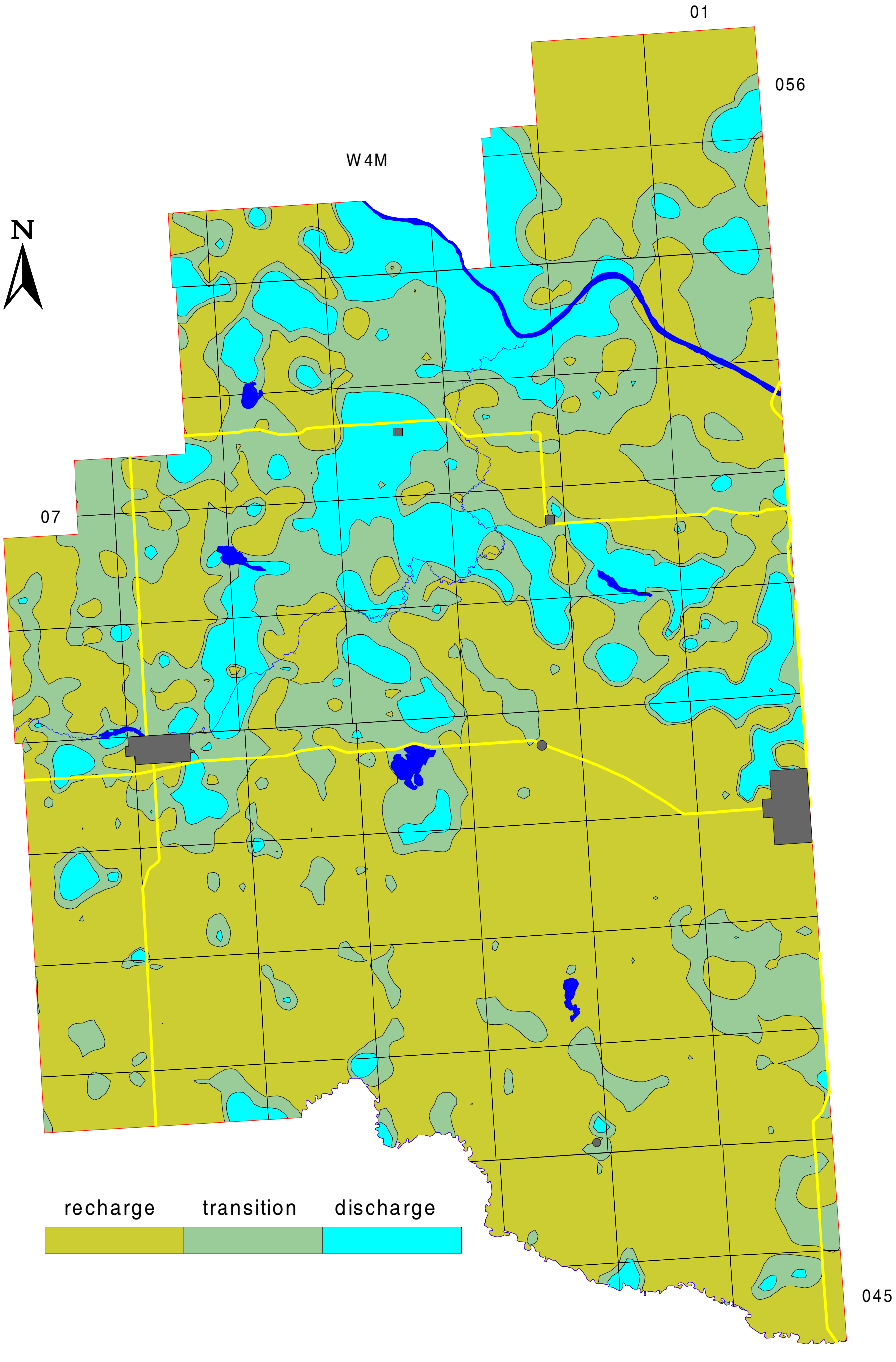


Obs WW No. 03C-02

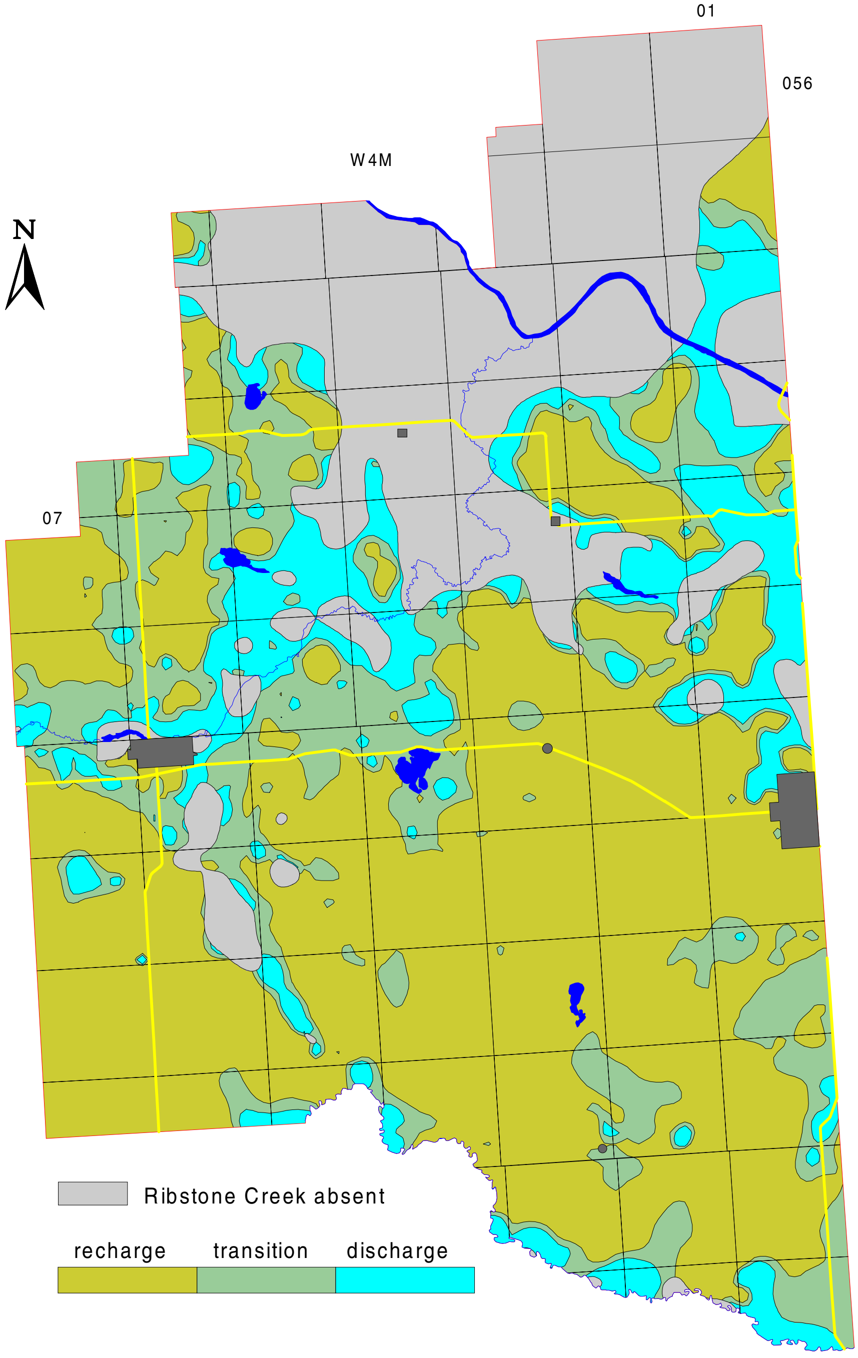
Non-Pumping Water-Level Surface in Surficial Deposits



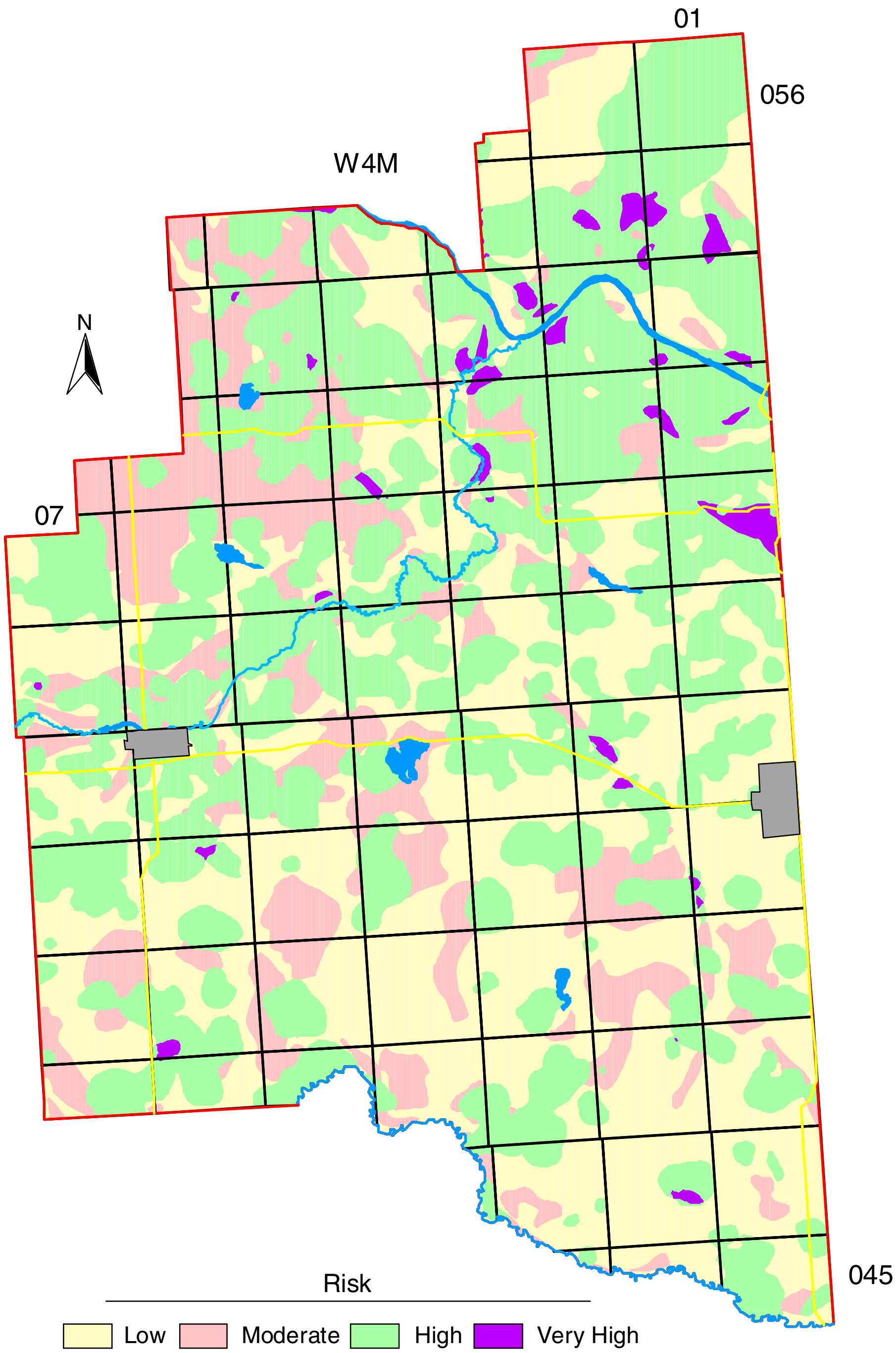
Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)



Recharge/Discharge Areas between Surficial Deposits and Ribstone Creek Aquifer



Risk of Groundwater Contamination



COUNTY OF VERMILION RIVER NO. 24

Appendix B

MAPS AND FIGURES ON CD-ROM

A) Database
B) ArcView Files
C) Query
D) Maps and Figures

1) General

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- Depth of Existing Water Wells
- Depth to Base of Groundwater Protection
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- Geologic Column
- Cross-Section A - A'
- Cross-Section B - B'
- Bedrock Topography
- Cross-Section C - C'
- Bedrock Geology
- E-Log showing Base of Foremost Formation
- Hydrographs Cited in Text
- Water-Level Comparison
- Hydrographs - All in Study Area
- Risk of Groundwater Contamination
- Relative Permeability
- Water Wells Recommended for Field Verification

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

b) First Sand and Gravel

- Thickness of First Sand and Gravel
- First Sand and Gravel - Saturation

c) Upper Sand and Gravel

- Thickness of Upper Surficial Deposits
- Thickness of Upper Sand and Gravel (not all drill holes fully penetrate surficial deposits)
- Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

d) Lower Sand and Gravel

- Structure-Contour Map - Top of Lower Surficial Deposits
- Depth to Top of Lower Surficial Deposits
- Thickness of Lower Surficial Deposits
- Thickness of Lower Sand and Gravel (not all drill holes fully penetrate surficial deposits)
- Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer
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3) Bedrock Aquifers

a) General

- Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)
- Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)
- Sulfate in Groundwater from Upper Bedrock Aquifer(s)
- Chloride in Groundwater from Upper Bedrock Aquifer(s)
- Fluoride in Groundwater from Upper Bedrock Aquifer(s)
- Total Hardness of Groundwater from Upper Bedrock Aquifer(s)
- Piper Diagram - Bedrock Aquifers
- Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)
- Non-Pumping Water-Level Surface in Upper Bedrock Aquifer(s)

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- Depth to Top of Oldman Formation
- Structure-Contour Map - Oldman Formation
- Non-Pumping Water-Level Surface - Oldman Aquifer
- Apparent Yield for Water Wells Completed through Oldman Aquifer
- Total Dissolved Solids in Groundwater from Oldman Aquifer
- Sulfate in Groundwater from Oldman Aquifer
- Chloride in Groundwater from Oldman Aquifer
- Piper Diagram - Oldman Aquifer
- Recharge/Discharge Areas between Surficial Deposits and Oldman Aquifer

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- Depth to Top of Birch Lake Member
- Structure-Contour Map - Birch Lake Member
- Non-Pumping Water-Level Surface - Birch Lake Aquifer
- Apparent Yield for Water Wells Completed through Birch Lake Aquifer
- Total Dissolved Solids in Groundwater from Birch Lake Aquifer
- Sulfate in Groundwater from Birch Lake Aquifer
- Chloride in Groundwater from Birch Lake Aquifer
- Piper Diagram - Birch Lake Aquifer
- Recharge/Discharge Areas between Surficial Deposits and Birch Lake Aquifer

b) Ribstone Creek Aquifer

- Depth to Top of Ribstone Creek Member
- Structure-Contour Map - Top of Ribstone Creek Member
- Non-Pumping Water-Level Surface - Ribstone Creek Aquifer
- Apparent Yield for Water Wells Completed through Ribstone Creek Aquifer
- Total Dissolved Solids in Groundwater from Ribstone Creek Aquifer
- Sulfate in Groundwater from Ribstone Creek Aquifer
- Chloride in Groundwater from Ribstone Creek Aquifer
- Piper Diagram - Ribstone Creek Aquifer
- Recharge/Discharge Areas between Surficial Deposits and Ribstone Creek Aquifer

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- Depth to Top of Victoria Member
- Structure-Contour Map - Top of Victoria Member
- Non-Pumping Water-Level Surface - Victoria Aquifer
- Apparent Yield for Water Wells Completed through Victoria Aquifer
- Total Dissolved Solids in Groundwater from Victoria Aquifer
- Sulfate in Groundwater from Victoria Aquifer
- Chloride in Groundwater from Victoria Aquifer
- Piper Diagram - Victoria Aquifer
- Recharge/Discharge Areas between Surficial Deposits and Victoria Aquifer

c) Brosseau Aquifer

- Depth to Top of Brosseau Member
- Structure-Contour Map - Top of Brosseau Member

d) Lea Park Aquifer

- Depth to Top of Lea Park Formation
- Structure-Contour Map - Top of Lea Park Formation

d) Milk River Formation

- Depth to Top of Milk River Formation
- Structure-Contour Map - Top of Milk River Formation

COUNTY OF VERMILION RIVER NO. 24

Appendix C

GENERAL WATER WELL INFORMATION

Domestic Water Well Testing

Purpose and Requirements

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

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

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

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

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

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

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

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

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

Procedure

Site Diagrams

These diagrams are a map showing the distance to nearby significant features. This would include things like a corner of a building (house, barn, garage etc.) or the distance to the half-mile or mile fence. The description should allow anyone not familiar with the site to be able to unequivocally identify the water well that was tested.

In lieu of a map, UTM coordinates accurate to within five metres would be acceptable. If a hand-held GPS is used, the post-processing correction details must be provided.

Surface Details

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

Groundwater Discharge Point

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

Water-Level Measurements

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

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

Discharge Measurements

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

Water Samples

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

Water Act –

Water (Ministerial) Regulation

PROVINCE OF ALBERTA

WATER ACT

WATER (MINISTERIAL) REGULATION

Alberta Regulation 205/98

EXTRACT FROM THE
ALBERTA GAZETTE

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Water Act

WATER (MINISTERIAL) REGULATION

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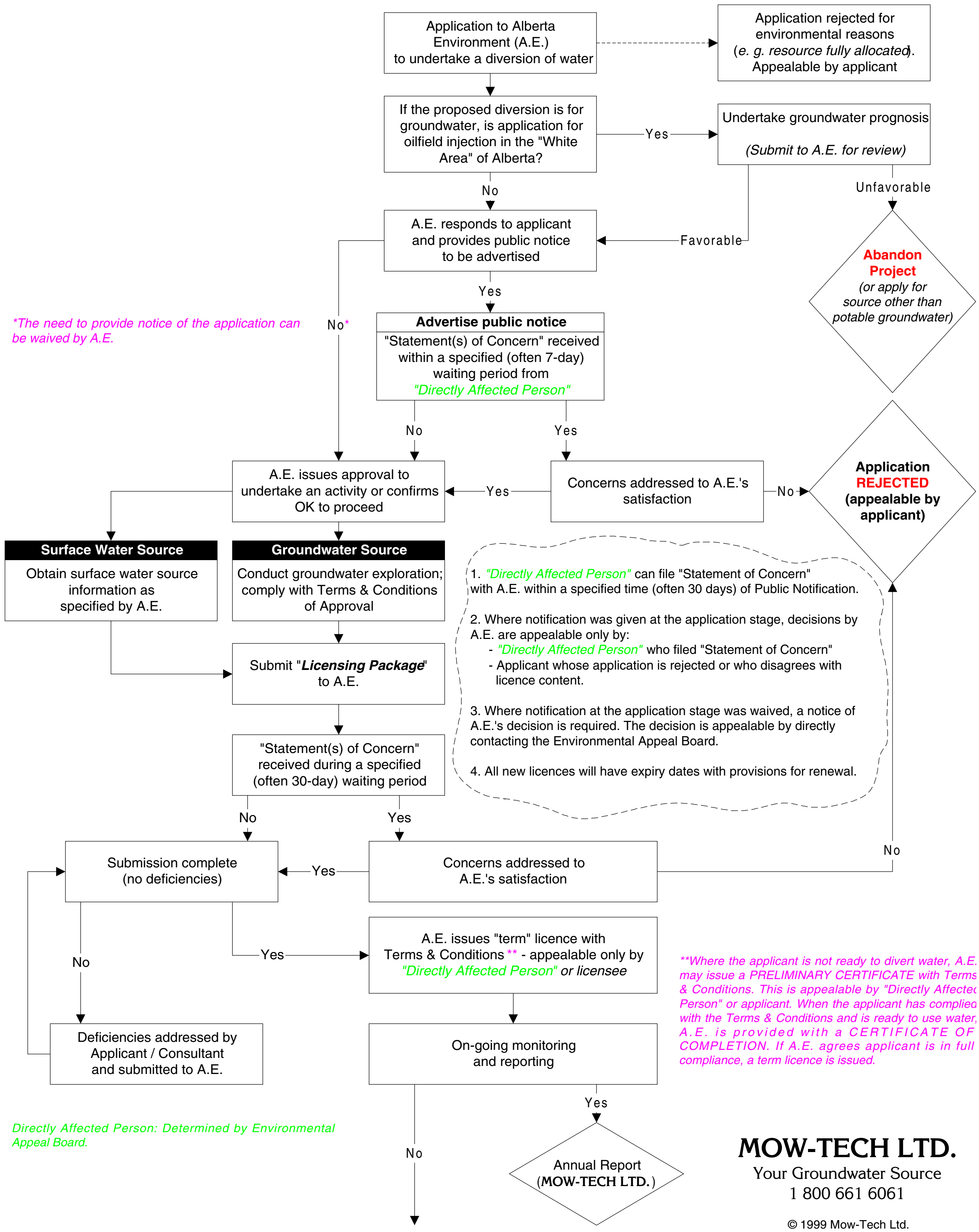
Water Act – Flow Chart



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.*

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)

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GEOPHYSICAL INSPECTION SERVICE

Edmonton: 780-427-3932

COMPLAINT INVESTIGATIONS

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Carl Mendosa (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

Keith Shick (Vegreville: (780)-632-2919)

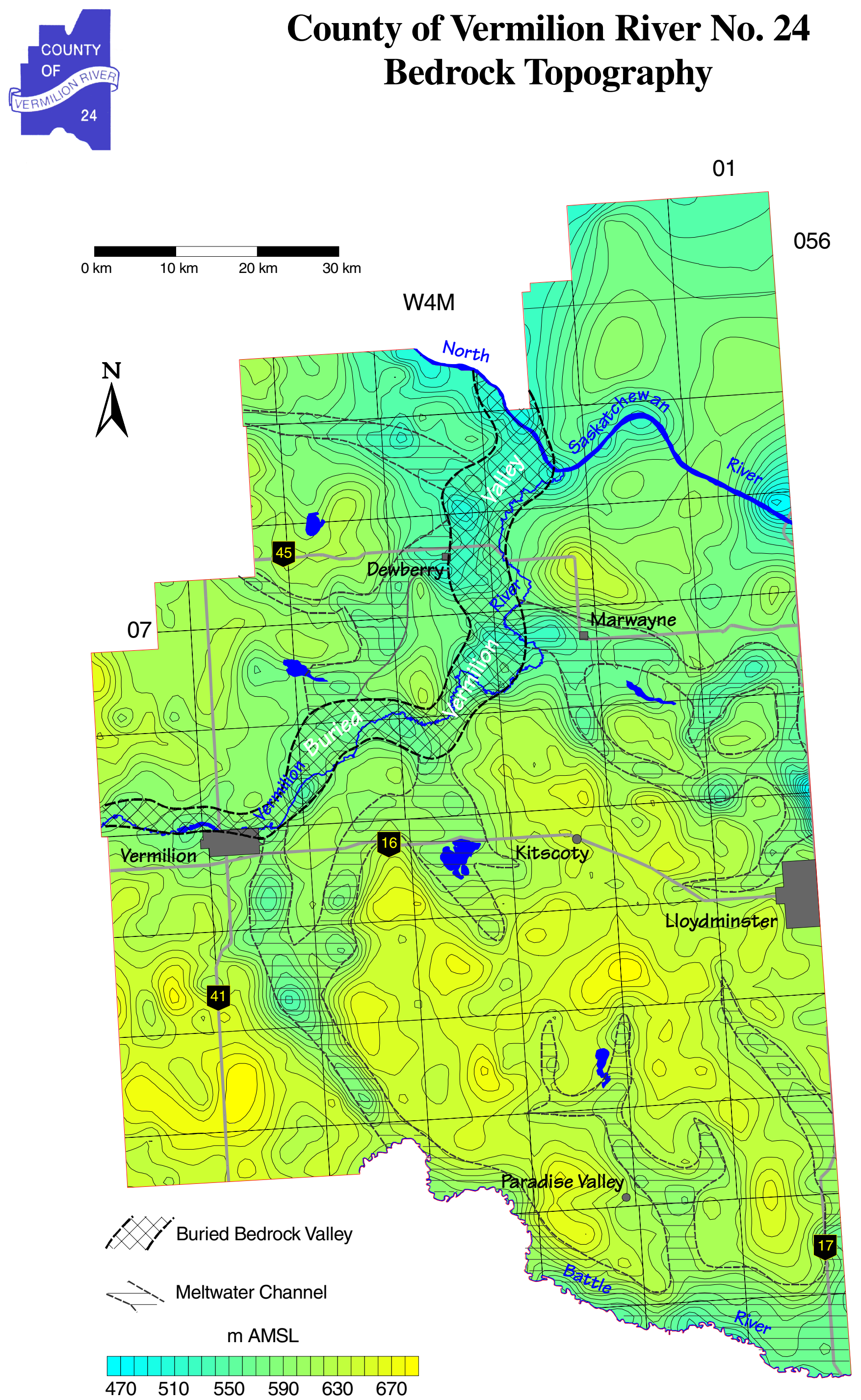
LOCAL HEALTH DEPARTMENTS

COUNTY OF VERMILION RIVER NO. 24

Appendix D

MAPS AND FIGURES INCLUDED AS LARGE PLOTS

County of Vermilion River No. 24
Bedrock Topography



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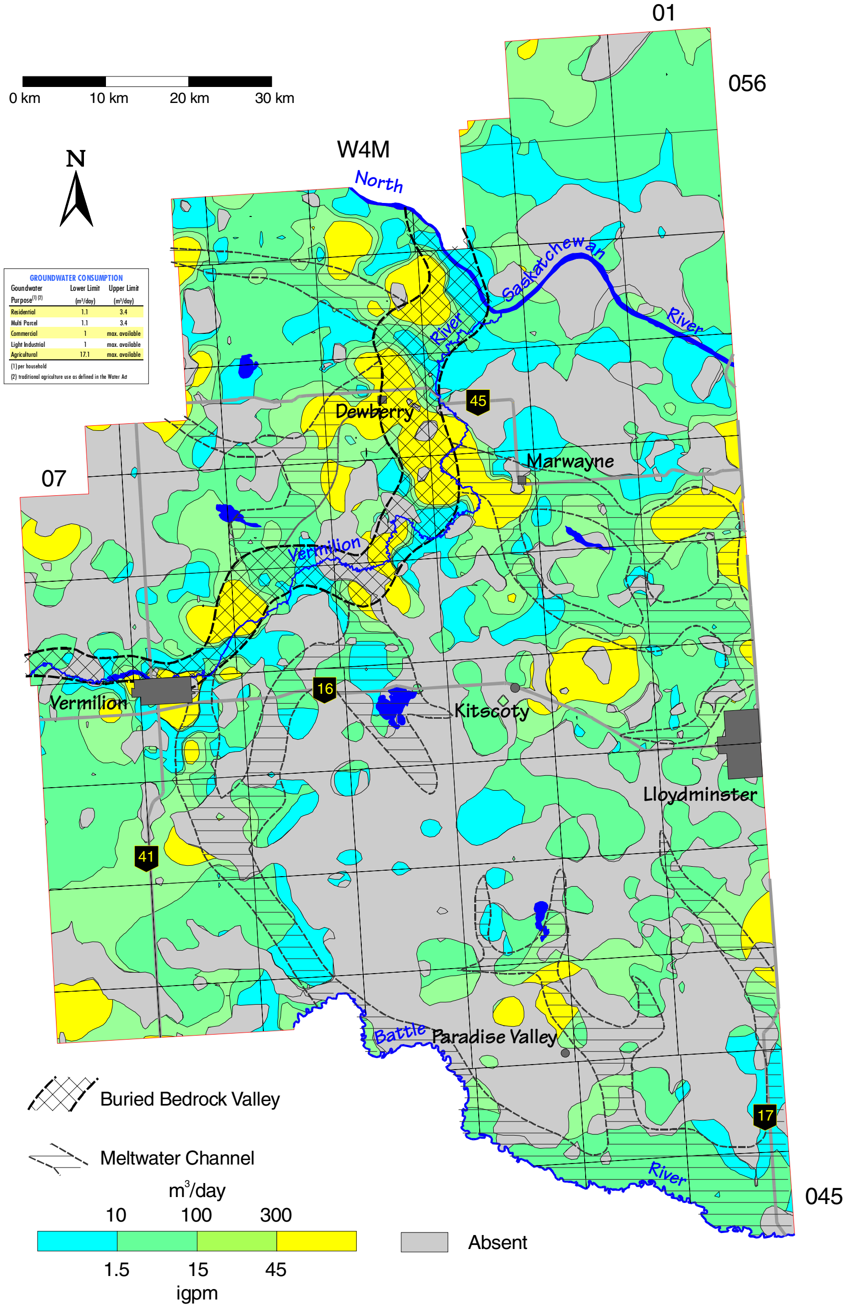
Agriculture et Agroalimentaire Canada
PFRA
Prairie Farm Rehabilitation Administration
hydrogeological consultants ltd, edmonton, alberta - 1-800-661-7972 - project no. 98-169 - Bdrv.cdr - 30 July 99
hydrogeological consultants ltd.

County of Vermilion River No. 24
Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)



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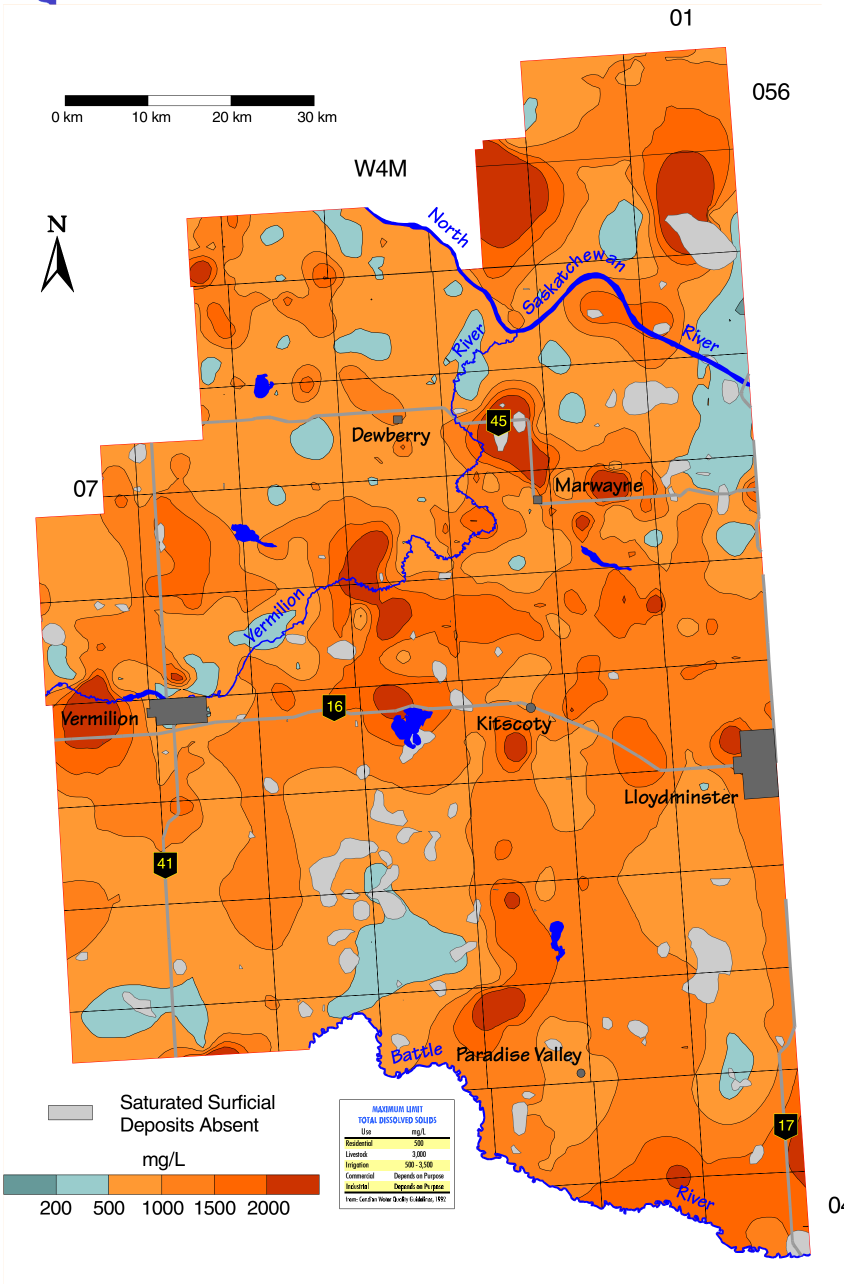
County of Vermilion River No. 24 Total Dissolved Solids in Groundwater from Surficial Deposits



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: Candian Water Quality Guidelines, 1992

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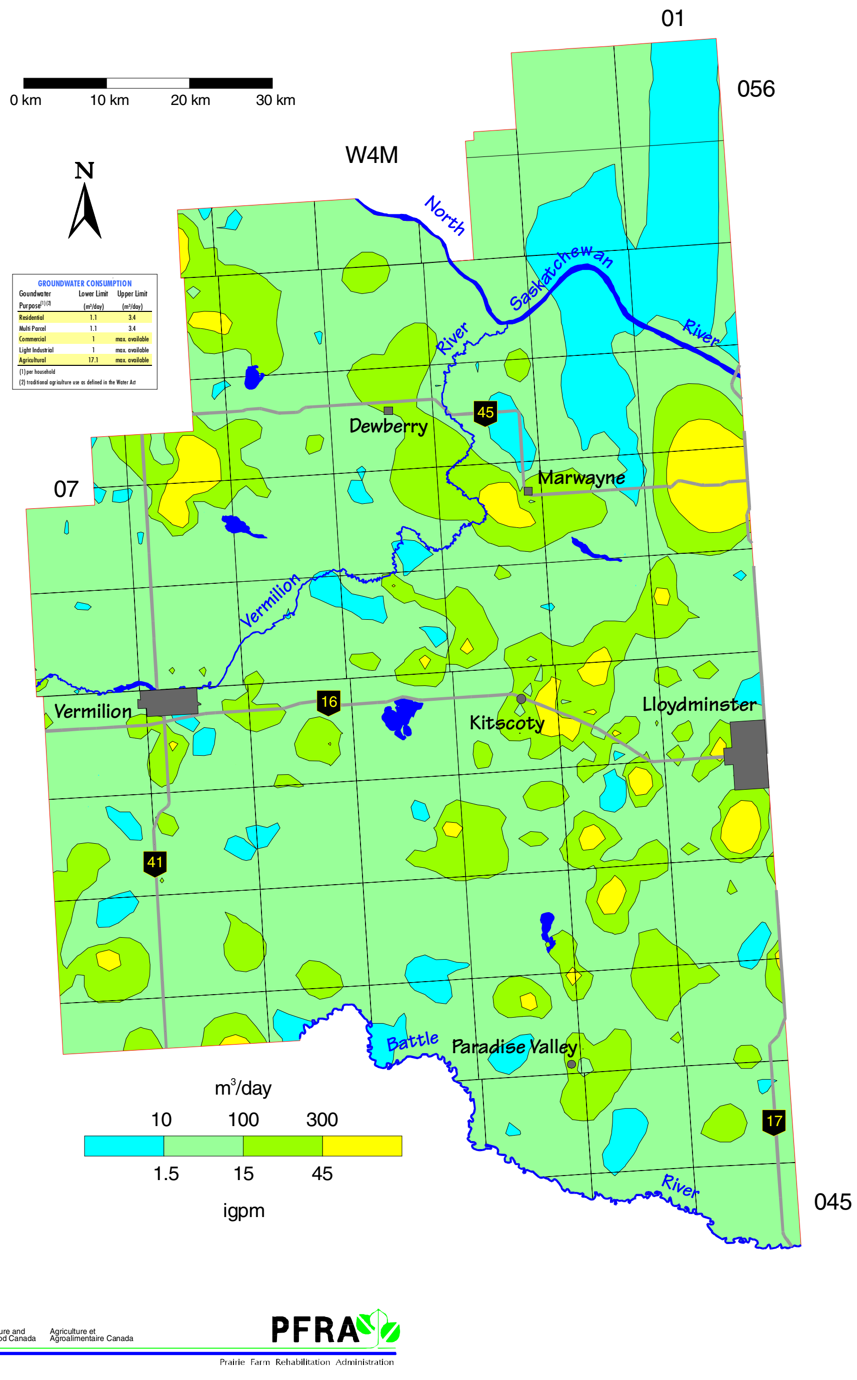
County of Vermilion River No. 24 Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)



GROUNDWATER CONSUMPTION

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

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

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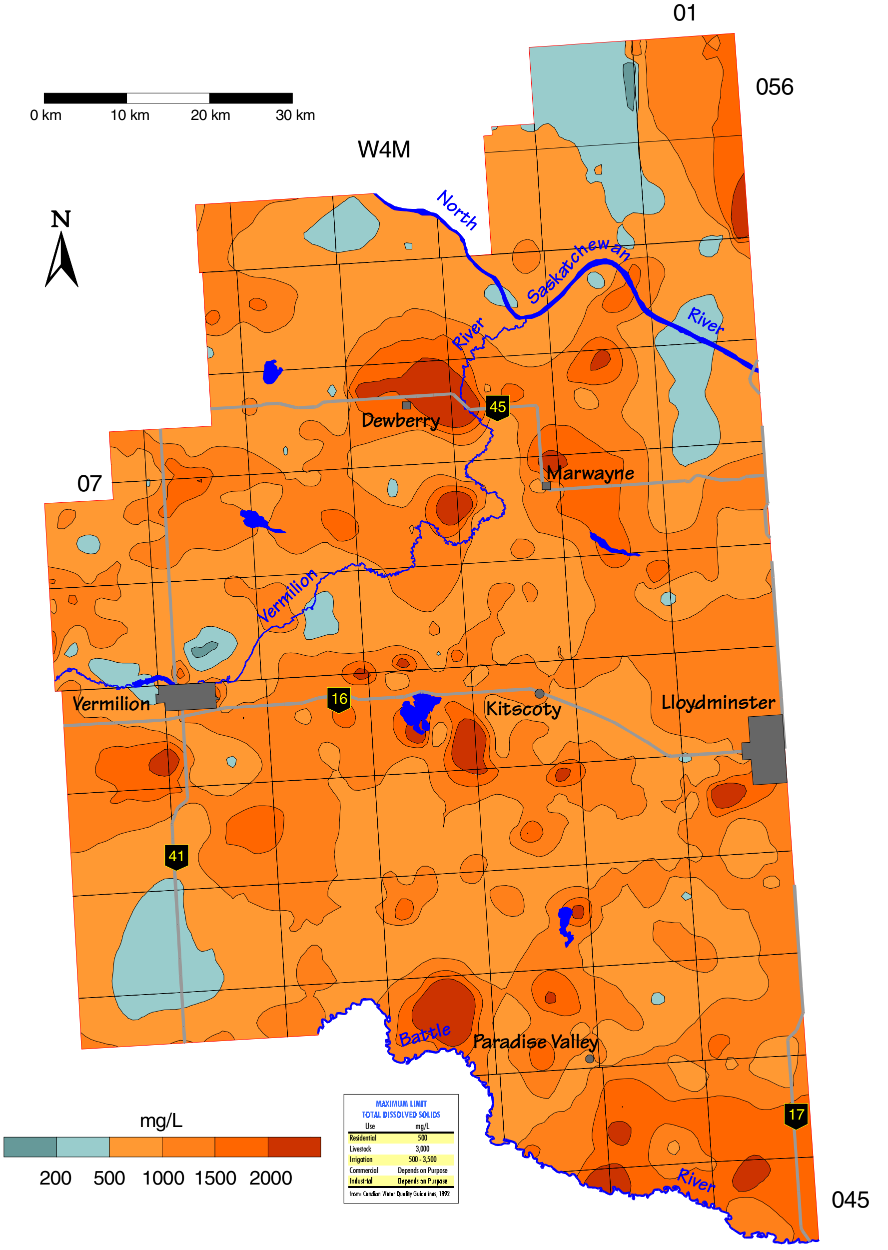
COUNTY OF VERMILION RIVER 24

County of Vermilion River No. 24
Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)



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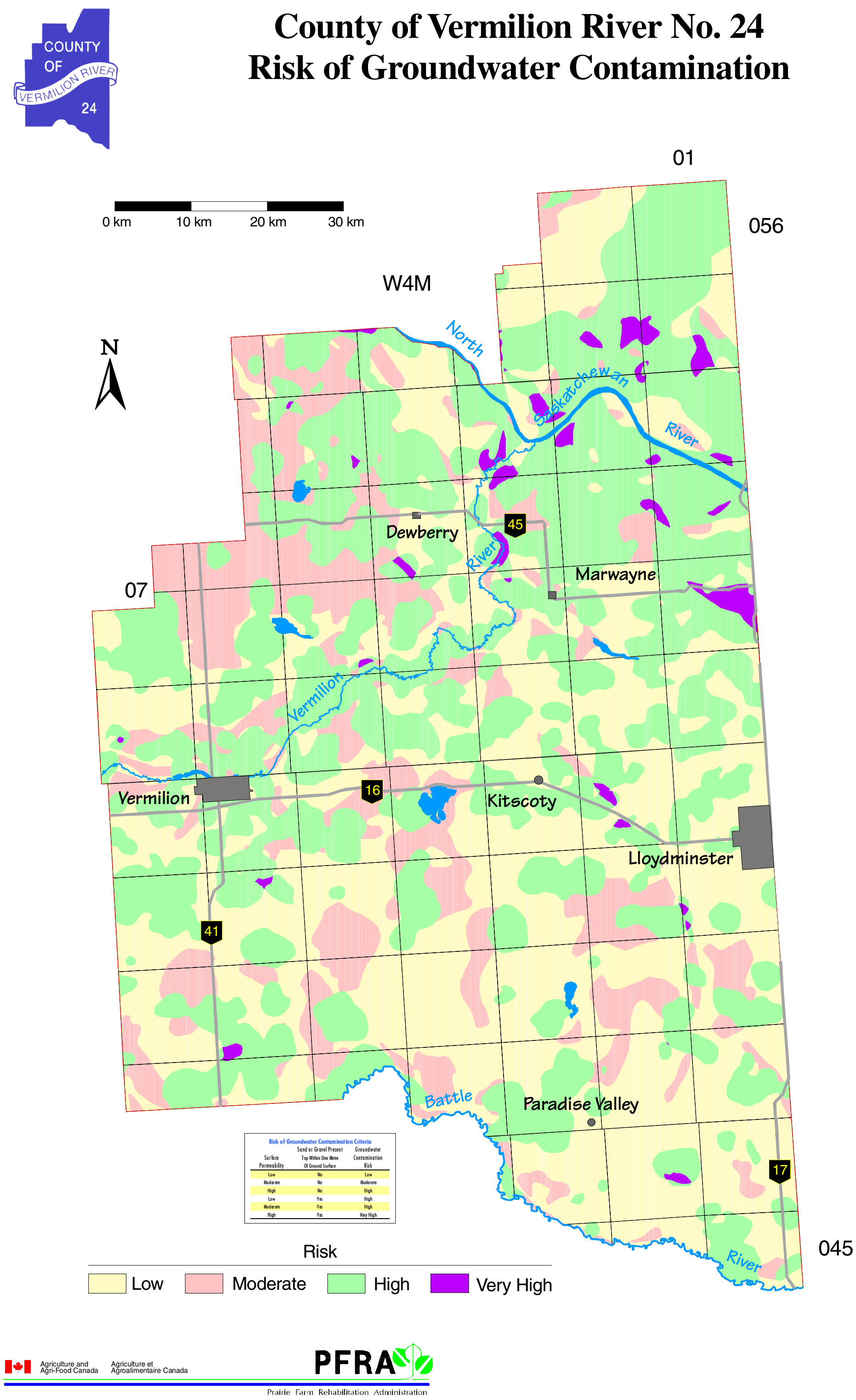
County of Vermilion River No. 24
Risk of Groundwater Contamination



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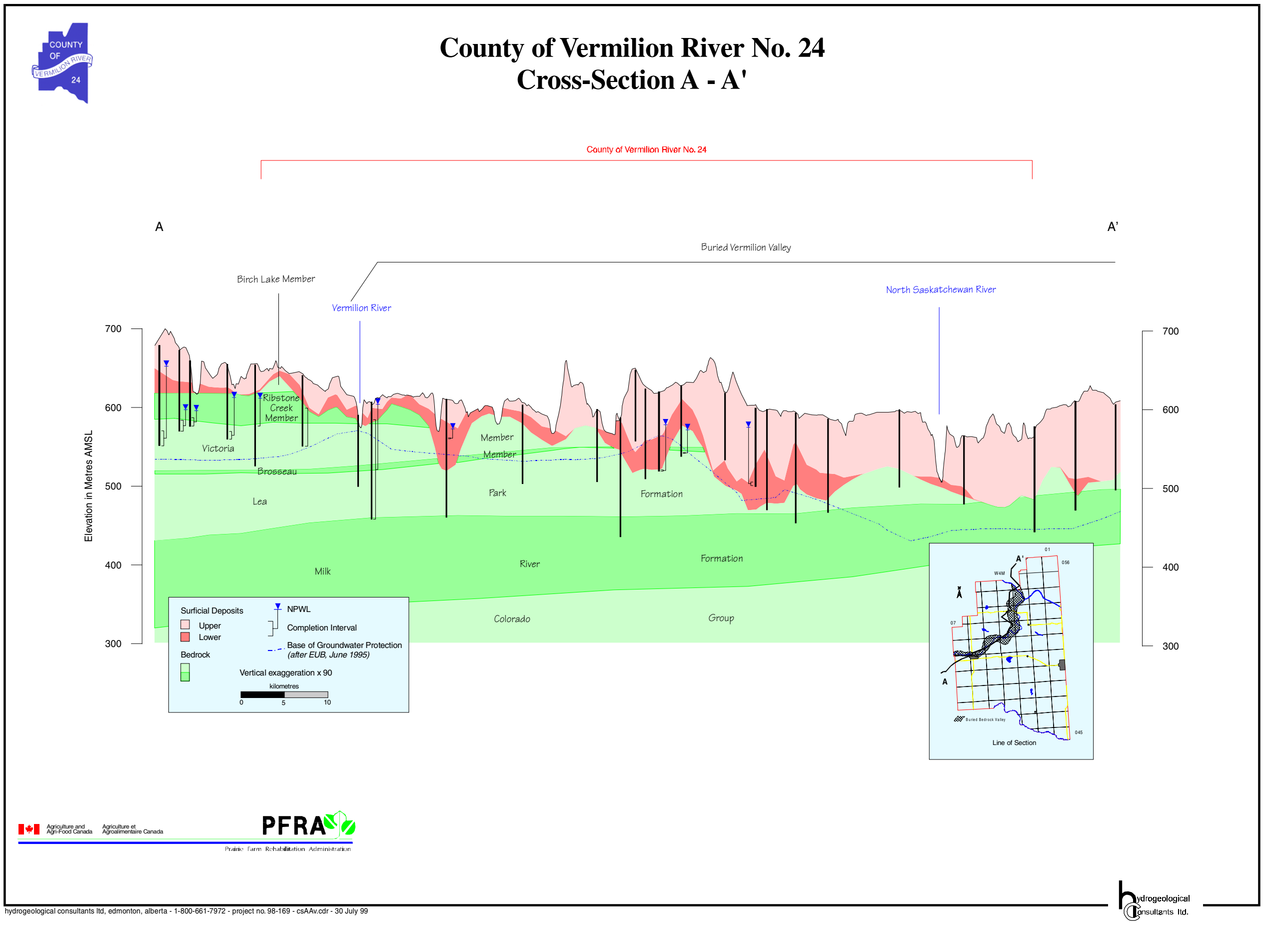
County of Vermilion River No. 24
Cross-Section A - A'
County of Vermilion River No. 24
A
A'
Buried Vermilion Valley
Birch Lake Member
Vermilion River
North Saskatchewan River
Ribstone Creek Member
Victoria
Brosseau
Lea
Member
Member
Park
Formation
Milk
River
Formation
Colorado
Group
Elevation in Metres AMSL
700
600
500
400
300
Surficial Deposits
Upper
Lower
Bedrock
NPWL
Completion Interval
Base of Groundwater Protection (after EUB, June 1995)
Vertical exaggeration x 90
kilometres
0
5
10
Line of Section
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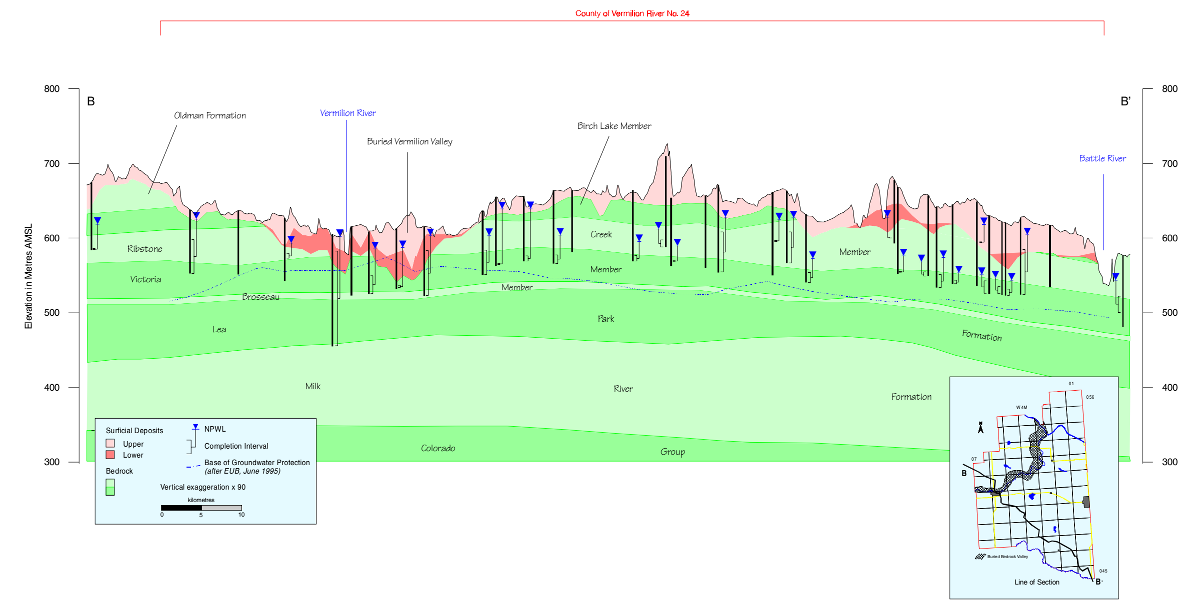
County of Vermilion River No. 24
Cross-Section B - B'



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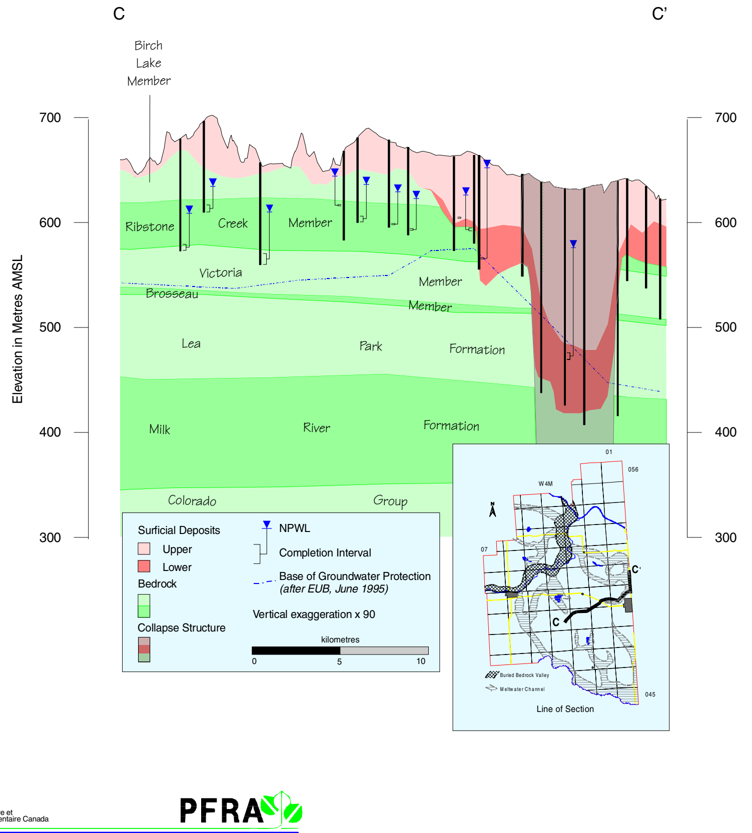
County of Vermilion River No. 24
Cross-Section C - C'



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COUNTY OF VERMILION RIVER NO. 24

Appendix E

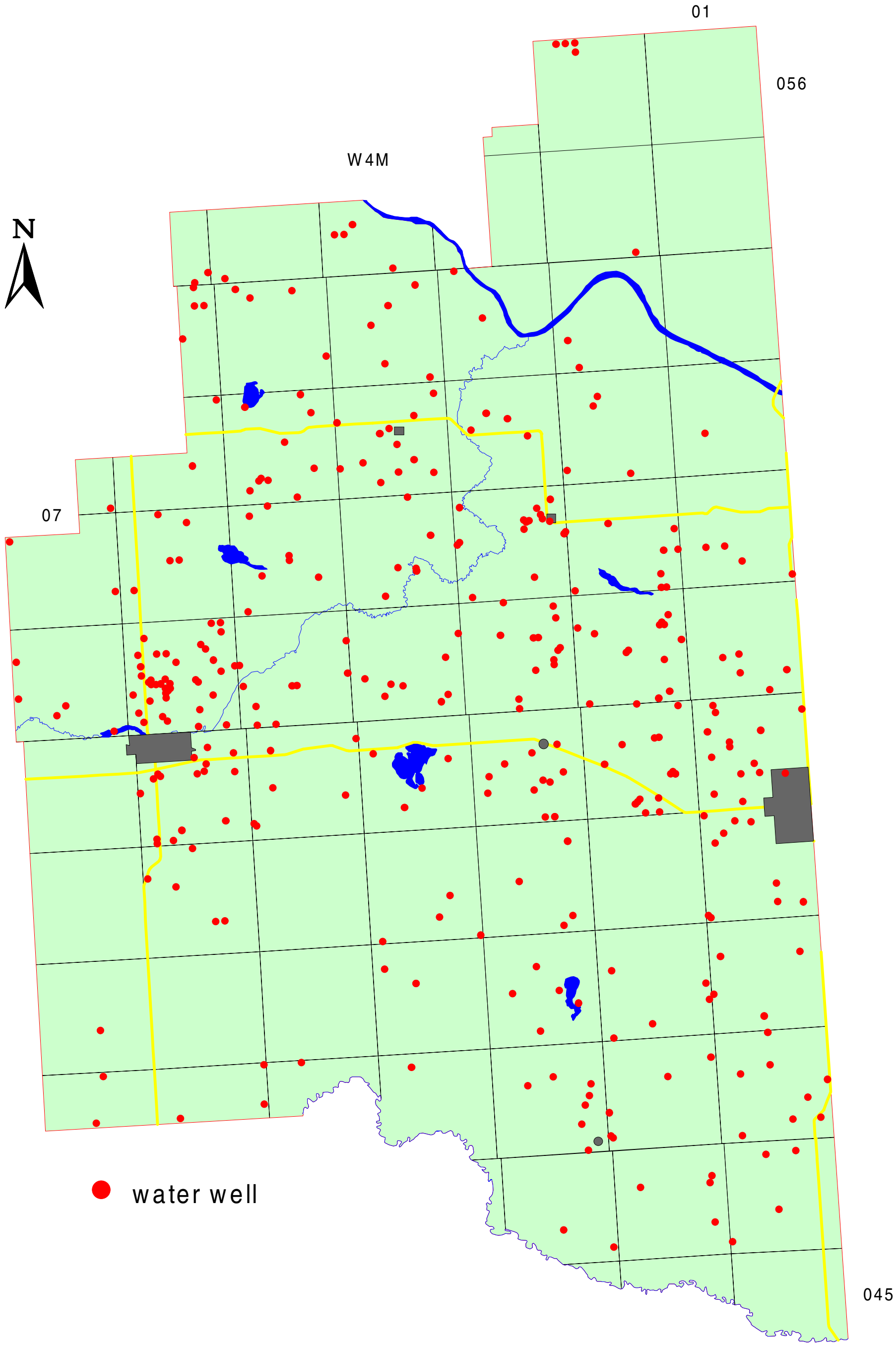
WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

AND

COUNTY-OPERATED WATER WELLS

Water Wells Recommended for Field Verification

(details on following pages)



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WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

Owner	Location	Water Well Contractor	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet
Adams Bros	09-14-047-03 W4M	Stan Byrt & Sons Ltd.	Jun-79	21.3	70.0	9.9	32.5
Adams, Don	SW 27-047-03 W4M	Stan Byrt & Sons Ltd.	Jun-76	57.9	190.0	34.8	114.3
Adams, Herman	10-11-047-03 W4M	Stan Byrt & Sons Ltd.	Jun-76	48.5	159.0	29.0	95.2
Alberta Environment	NE 22-052-03 W4M	Hi-Rate Drilling 1985 Ltd.	Nov-74	47.6	156.0	23.2	76.2
Alberta Environment	06-21-053-04 W4M	lberta Environment/Earth Sciences Divisio	Oct-85	68.6	225.0	26.7	87.5
Alberta Environment	06-21-053-04 W4M	lberta Environment/Earth Sciences Divisio	Oct-85	102.4	336.0	9.1	29.7
Alberta Government	NW 25-050-06 W4M	Morton's Water Well Drilling Ltd.	Oct-82	47.9	157.0	25.3	83.0
Alberta Transporation	05-15-050-01 W4M	Stan Byrt & Sons Ltd.	Aug-80	67.1	220.0	33.5	110.0
Allen, Dennis	SW 09-050-04 W4M	Martin, J. Water Wells	Jul-85	56.4	185.0	25.0	82.0
Alliance Church	SW 25-052-03 W4M	Frederickson, J.E.		50.6	166.0	24.4	80.1
Anderson, Stan	14-17-048-03 W4M	McAllister Holdings Ltd.	May-83	35.4	116.0	11.0	36.0
Anson, L.	SW 15-050-04 W4M	McAllister Drilling Ltd.	Dec-62	48.8	160.0	19.8	65.0
Aplin, John	01-17-051-01 W4M	Stan Byrt & Sons Ltd.	May-83	16.2	53.0	5.1	16.6
Argne, Jim	SE 26-051-02 W4M	Tindall, W. Water Wells	Jun-79	24.7	81.0	1.7	5.5
Arthur, Bill	SW 20-047-06 W4M	Fred's Water Well Drilling Ltd.	Oct-83	106.7	350.0	83.2	273.0
Ashmead, Robert	08-14-051-03 W4M	Tindall, W. Water Wells	Mar-79	68.3	224.0	16.2	53.0
Ashmead, Robert	09-14-051-03 W4M	Tindall, W. Water Wells	Oct-84	20.7	68.0	10.4	34.0
Audenait, Monty J.	13-23-051-03 W4M	Morton's Water Well Drilling Ltd.	Oct-80	76.5	251.0	44.5	146.0
Bardoel, Bernie	SW 14-053-06 W4M	Morton's Water Well Drilling Ltd.	Sep-77	23.2	76.0	7.3	24.0
Beck, Howard	14-33-051-03 W4M	Laws & Byrt	Apr-62	83.8	275.0	61.0	200.0
Beck, M.	08-25-051-04 W4M	McAllister Drilling Ltd.	Oct-68	48.8	160.0	20.9	68.5
Beckman, Ralph	NE 23-051-06 W4M	Morton's Water Well Drilling Ltd.	Sep-80	33.5	110.0	8.8	29.0
Behnke, Bernard	01-02-052-02 W4M	Stan Byrt & Sons Ltd.	Jun-84	81.7	268.0	20.7	68.0
Belsheim, Terry	SE 02-055-02 W4M	Martin, J. Water Wells	Oct-88	10.7	35.0	4.6	15.0
Benoit, Ed.	16-03-049-01 W4M	Stan Byrt & Sons Ltd.	Jul-75	73.2	240.0	28.5	93.4
Benoit, Ray	16-10-049-01 W4M	Stan Byrt & Sons Ltd.	May-76	72.2	237.0	28.8	94.4
Berezanski, Russell	NW 30-052-07 W4M	McAllister Drilling Ltd.	Sep-74	64.6	212.0	56.7	186.0
Bierman, J.C.	04-12-053-04 W4M	McAllister Drilling Ltd.	Mar-78	42.7	140.0	8.5	28.0
Blair, Jesse	NE 07-050-03 W4M	McAllister Drilling Ltd.	Mar-75	20.1	66.0	7.3	24.0
Blake, Gordon	13-34-050-02 W4M	Laws & Byrt	Apr-64	47.2	155.0	20.4	67.0
Bossert, Ken	03-18-051-06 W4M	Morton's Water Well Drilling Ltd.	Aug-82	32.6	107.0	15.2	50.0
Bowman, Alvin	14-08-053-04 W4M	Stan Byrt & Sons Ltd.	Dec-77	21.9	72.0	15.0	49.2
Brady, Brian	04-24-051-06 W4M	Morton's Water Well Drilling Ltd.	Jun-80	25.9	85.0	13.4	44.0
Braithewaite, Bobby	13-11-053-04 W4M	Morton's Water Well Drilling Ltd.	Apr-84	18.3	60.0	7.0	23.0
Braithwaite, Don	SW 10-053-04 W4M	Stan Byrt & Sons Ltd.	Oct-75	37.5	123.0	22.7	74.3
Braithwaite, Roger	SW 01-054-04 W4M	Morton's Water Well Drilling Ltd.	May-79	20.7	68.0	6.1	20.0
Brass, Robert	09-19-051-06 W4M	Morton's Water Well Drilling Ltd.	May-81	26.5	87.0	9.1	30.0
Brassington, Frank	NE 04-048-02 W4M	McAllister Waterwells Ltd.	Jun-83	98.1	322.0	69.5	228.0
Brassington, Frank #Well 2	02-06-048-02 W4M	McAllister Holdings Ltd.	Apr-83	54.9	180.0	29.6	97.0
Brindle, Larry	11-16-051-06 W4M	Morton's Water Well Drilling Ltd.	Jun-77	31.1	102.0	5.2	17.0
Brittian, Art	01-15-051-03 W4M	Fred's Water Well Drilling Ltd.	May-79	57.3	188.0	40.2	132.0
Brown, Newman	SE 20-050-03 W4M	McAllister Drilling Ltd.	Jun-76	49.1	161.0	18.0	59.0
Buchanan, Warner	04-24-051-04 W4M	McAllister Holdings Ltd.	Sep-79	54.9	180.0	34.0	111.4
Buffalo Coulee School	SW 15-048-07 W4M	Morton's Water Well Drilling Ltd.	Dec-81	48.8	160.0	12.2	40.0
Burrows, Bob	04-14-050-03 W4M	McAllister Drilling Ltd.	May-84	62.8	206.0	34.4	113.0
Butz, Adolph	NE 26-053-05 W4M	Ashmont Water Well Drilling Ltd.	Jun-84	22.9	75.0	14.3	47.0
Butz, Geogre	SE 06-055-05 W4M	Morton's Water Well Drilling Ltd.	May-78	45.4	149.0	33.2	109.0
Byrne, Gordon O.	16-04-050-02 W4M	McAllister Drilling Ltd.	Feb-81	67.1	220.0	30.9	101.4
Campell, Don	16-06-050-01 W4M	McAllister Holdings Ltd.	Mar-79	64.3	211.0	39.6	130.0
Carey, Duncan	02-11-050-06 W4M	Stan Byrt & Sons Ltd.	Jun-74	43.6	143.0	8.4	27.7
Cheley, Grant	02-27-050-01 W4M	Morton's Water Well Drilling Ltd.	Nov-83	64.0	210.0	48.8	160.0
Chisholm, James H.	SE 26-051-02 W4M	Tindall, W. Water Wells		31.7	104.0	4.6	15.0
Chrisp, Brian	NW 06-050-05 W4M	Stan Byrt & Sons Ltd.	Jul-75	41.8	137.0	10.9	35.8
Chrisp, Richard	13-06-050-05 W4M	Stan Byrt & Sons Ltd.	Jul-75	39.6	130.0	10.1	33.2
Christie Corrosion Control Ltd	06-04-050-01 W4M	McAllister Holdings Ltd.	Aug-86	70.7	232.0	3.6	11.8
Christie, Daryle	SE 14-050-02 W4M	McAllister Holdings Ltd.	Oct-84	81.1	266.0	50.0	164.0
Clark, Trevor	NE 20-049-06 W4M	Stan Byrt & Sons Ltd.	May-78	78.3	257.0	56.7	186.2
Clarke, R.	08-24-051-06 W4M	Morton's Water Well Drilling Ltd.	Sep-79	53.3	175.0	32.6	107.0
Cleland, Harold	SE 21-047-07 W4M	Fred's Water Well Drilling Ltd.	Jul-83	81.4	267.0	61.3	201.0
Cloppert, Jack	SE 14-051-02 W4M	McAllister Drilling Ltd.	Aug-75	53.0	174.0	20.4	67.0
Cole, T.	02-30-048-01 W4M	McAllister Drilling Ltd.	Oct-80	26.5	87.0	4.0	13.0
Convey, George	NW 05-053-05 W4M	Stan Byrt & Sons Ltd.		29.6	97.0	7.6	25.0
Corey, Bill	16-32-047-05 W4M	Morton's Water Well Drilling Ltd.	Nov-81	90.2	296.0	79.2	260.0
Cowan, Bill	NW 04-053-04 W4M	Stan Byrt & Sons Ltd.	Dec-76	59.4	195.0	51.2	168.0
Cox, Kelly	SE 24-052-03 W4M	Stan Byrt & Sons Ltd.		60.0	196.9	31.9	104.7
Curtis, Leslie	SW 30-051-02 W4M	Anderson Drilling Co. Ltd.	May-80	32.3	106.0	7.3	24.0

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

Owner	Location	Water Well Contractor	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet
Cusack, Pat J.	NE 11-053-05 W4M	Big Iron Drilling Ltd.	Aug-86	54.9	180.0	18.9	62.0
Cusack, Sid	SW 22-053-05 W4M	Morton's Water Well Drilling Ltd.	May-86	26.2	86.0	9.8	32.0
Davidson, D.	SE 28-048-03 W4M	McAllister Drilling Ltd.	May-73	54.9	180.0	27.4	90.0
Davidson, Gladys	NE 19-048-02 W4M	Fred's Water Well Drilling Ltd.	Mar-80	75.0	246.0	47.9	157.0
Davidson, Greg	04-24-047-03 W4M	Stan Byrt & Sons Ltd.	Nov-82	31.1	102.0	5.4	17.8
Davies, Emerson	13-25-051-03 W4M	Tindall, W. Water Wells	Apr-84	21.3	70.0	4.9	16.0
Davis, Eunice	15-11-051-06 W4M	Morton's Water Well Drilling Ltd.	Apr-82	21.3	70.0	14.0	46.0
Dayna, Mike	NW 04-050-06 W4M	Morton's Water Well Drilling Ltd.	Nov-82	39.0	128.0	24.4	80.0
Deaville, Don	16-20-047-03 W4M	McAllister Drilling Ltd.	May-70	66.4	218.0	37.5	123.0
Dickson, D.H.	16-05-051-06 W4M	Morton's Water Well Drilling Ltd.	Apr-83	18.3	60.0	6.1	20.0
Dome Petro Ltd	16-10-052-04 W4M	McAllister Holdings Ltd.	May-80	34.1	112.0	1.9	6.2
Dome Petro Ltd	16-10-052-04 W4M	McAllister Holdings Ltd.	Jun-80	37.5	123.0	2.0	6.4
Dome Petroleum Limited	NE 10-052-04 W4M	<unknown contractor>		34.3	112.5	1.9	6.2
Dome Petroleum Limited	NE 10-052-04 W4M		May-80	34.3	112.5	1.9	6.2
Double Rn Ranch	SE 17-053-01 W4M	Stan Byrt & Sons Ltd.	Aug-85	11.0	36.0	3.2	10.3
Doull, George	04-11-052-03 W4M	Morton's Water Well Drilling Ltd.	May-80	50.0	164.0	9.1	30.0
Dutchak, Paul	01-19-051-06 W4M	Morton's Water Well Drilling Ltd.	Apr-77	27.7	91.0	15.2	50.0
Dyck, George	13-09-051-06 W4M	Morton's Water Well Drilling Ltd.	Sep-83	26.2	86.0	9.8	32.0
Earle, Austin	SE 08-051-04 W4M	McAllister Drilling Ltd.	Aug-77	42.7	140.0	17.7	58.0
Elliott, Eric E.	12-04-052-04 W4M	McAllister Drilling Ltd.	Jun-82	30.5	100.0	22.6	74.0
Erickson, Roger	SW 30-049-06 W4M	Stan Byrt & Sons Ltd.	Nov-76	66.1	217.0	43.9	144.0
Evans, J.	SE 16-051-01 W4M	McAllister Drilling Ltd.	Jul-70	51.8	170.0	25.8	84.6
Eyben, Carl	16-22-051-03 W4M	Stan Byrt & Sons Ltd.	Jul-78	41.5	136.0	24.1	79.0
Fadden, Linden	16-36-047-06 W4M	Morton's Water Well Drilling Ltd.	Sep-77	59.4	195.0	45.7	150.0
Farkash, Wayne	04-13-050-05 W4M	Morton's Water Well Drilling Ltd.	Nov-77	56.4	185.0	14.3	47.0
Ferguson, W.T.	04-32-051-06 W4M	Morton's Water Well Drilling Ltd.	Aug-81	50.6	166.0	36.6	120.0
Filgate, Bill	09-19-050-06 W4M	McAllister Drilling Ltd.	Mar-78	42.7	140.0	14.6	48.0
Finlay, Roy	04-30-053-04 W4M	Laws & Byrt	Sep-64	47.2	155.0	35.1	115.0
Finley, Evan	04-30-053-04 W4M	Stan Byrt & Sons Ltd.	Jul-84	47.9	157.0	35.4	116.0
Fisher	SW 20-053-03 W4M	McAllister Holdings Ltd.	Oct-78	18.3	60.0	6.0	19.8
Flint Dale	16-15-048-03 W4M	Stan Byrt & Sons Ltd.	Jun-84	55.2	181.0	31.1	102.0
Frost, W.	SW 32-053-05 W4M	McAllister Drilling Ltd.	May-64	25.3	83.0	3.4	11.0
Gale, B.F.	13-16-049-03 W4M	McAllister Drilling Ltd.	Feb-73	82.3	270.0	54.0	177.0
Gardiner, Barry	03-31-052-03 W4M	Stan Byrt & Sons Ltd.	Jul-80	25.3	83.0	10.7	35.0
Garnier, Russel	09-21-053-04 W4M	Morton's Water Well Drilling Ltd.	Nov-79	43.9	144.0	11.7	38.3
Gayna, Mike	08-06-050-06 W4M	Morton's Water Well Drilling Ltd.	Aug-78	25.3	83.0	12.7	41.6
George, Marvin	01-29-053-02 W4M	Pete's Waterwell Contracting Ltd.	Feb-81	11.6	38.0	13.7	44.9
Gibbs, Barry	SE 30-049-01 W4M	McAllister Drilling Ltd.	Jun-78	73.8	242.0	14.7	48.1
Gies, Fred	01-14-048-03 W4M	McAllister Holdings Ltd.	May-83	53.3	175.0	15.7	51.4
Goerge, Albert	12-28-053-02 W4M	Stan Byrt & Sons Ltd.	Oct-65	10.4	34.0	16.7	54.7
Golinowski, F.	04-28-051-03 W4M	McAllister Drilling Ltd.	Apr-67	98.1	322.0	17.7	58.0
Goodard, Fred	05-32-052-05 W4M	Morton's Water Well Drilling Ltd.	Sep-82	32.0	105.0	18.7	61.3
Gordey, Barry	02-17-052-05 W4M	Morton's Water Well Drilling Ltd.	Aug-83	51.2	168.0	19.7	64.5
Gould, Wayne	08-25-051-05 W4M	McAllister Drilling Ltd.	May-75	23.2	76.0	20.7	67.8
Graham, Allan	SE 15-050-03 W4M	Stan Byrt & Sons Ltd.	May-74	51.8	170.0	21.7	71.1
Graham, Roy	03-17-052-01 W4M	Stan Byrt & Sons Ltd.	Apr-84	70.7	232.0	22.7	74.4
Gray, Ralph	01-05-051-05 W4M	McAllister Drilling Ltd.	Jul-75	67.1	220.0	23.7	77.7
Green, Pete	06-02-049-03 W4M	Stan Byrt & Sons Ltd.	Oct-79	96.6	317.0	24.7	80.9
Green, Robert	09-17-051-06 W4M	Morton's Water Well Drilling Ltd.	Aug-78	23.8	78.0	25.7	84.2
Grout, S.H.	04-12-051-04 W4M	Morton's Water Well Drilling Ltd.	Oct-76	19.8	65.0	26.7	87.5
Haerslew, H.	NW 34-047-07 W4M	Stan Byrt & Sons Ltd.	Aug-75	29.6	97.0	27.7	90.8
Hamernyk, Wm	NW 21-052-02 W4M	Stan Byrt & Sons Ltd.	Sep-74	49.7	163.0	28.7	94.1
Hames, Ed	NE 07-054-02 W4M	R & D WW Boring	Jun-77	18.0	59.0	29.7	97.3
Hancock	NW 15-053-04 W4M	McAllister Drilling Ltd.	Nov-75	27.7	91.0	30.7	100.6
Hansen, Leif	01-34-050-06 W4M	McAllister Drilling Ltd.	Jul-76	24.7	81.0	31.7	103.9
Harbin, Walter	NE 25-047-02 W4M	Stan Byrt & Sons Ltd.	Jun-84	63.4	208.0	32.7	107.2
Hartwell, Jerry	SW 16-051-06 W4M	McAllister Drilling Ltd.	Jul-85	25.9	85.0	33.7	110.5
Hartwell, Stan	06-16-051-06 W4M	McAllister Holdings Ltd.	Jun-79	26.8	88.0	34.7	113.8
Harvie, Don	01-13-052-02 W4M	McAllister Drilling Ltd.	Jun-83	22.6	74.0	35.7	117.0
Headon, Murray	SE 27-052-03 W4M	Stan Byrt & Sons Ltd.		36.6	120.1	36.7	120.3
Headon, Murray	SE 27-052-03 W4M	Stan Byrt & Sons Ltd.		36.6	120.1	37.7	123.6
Heath, Doug	14-22-047-02 W4M	McAllister Holdings Ltd.	May-84	19.8	65.0	38.7	126.9
Henry, Don	NW 17-050-05 W4M	Morton's Water Well Drilling Ltd.	Sep-80	57.0	187.0	39.7	130.2
Herzog, D.	NE 04-050-02 W4M	Stan Byrt & Sons Ltd.	Sep-81	50.9	167.0	40.7	133.4
Hines, Dallas	SE 03-051-06 W4M	Morton's Water Well Drilling Ltd.	Jun-81	9.1	30.0	41.7	136.7

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

Owner	Location	Water Well Contractor	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet
Hines, Jim	04-28-053-03 W4M	K & W Water Boring	Oct-79	11.0	36.0	42.7	140.0
Hines, Lyle	SW 36-052-03 W4M	Tindall, W. Water Wells		10.1	33.1	43.7	143.3
Hines, Marty	04-28-053-03 W4M	K & W Water Boring	Jun-79	11.9	39.0	44.7	146.6
Hlatt, Ben D.	02-07-051-06 W4M	Morton's Water Well Drilling Ltd.	Apr-79	61.6	202.0	45.7	149.8
Hnatow, John	SE 06-052-03 W4M	Lakeland Drilling Ltd.	Jul-80	42.7	140.0	46.7	153.1
Hodgson, Victor	15-34-052-04 W4M	McAllister Drilling Ltd.	Nov-85	86.6	284.0	47.7	156.4
Holt, Fred	04-18-048-01 W4M	McAllister Holdings Ltd.	May-81	23.8	78.0	48.7	159.7
Home Oil Co Ltd	03-02-051-02 W4M	McAllister Holdings Ltd.	Sep-80	63.3	207.7	49.7	163.0
Hondl, Lavern	04-19-052-03 W4M	Tindall, W. Water Wells	Jun-80	28.4	93.0	50.7	166.2
Horpestad, Arvida	10-17-051-06 W4M	Tizzard Drilling Ltd.	May-83	25.0	82.0	51.7	169.5
Hozack Bros	NE 16-051-02 W4M	Laws & Byrt	Sep-62	48.8	160.0	52.7	172.8
Huebepohl, Barry	06-26-051-06 W4M	Morton's Water Well Drilling Ltd.	Jul-77	32.0	105.0	53.7	176.1
Hutchison, Gene	08-32-049-01 W4M	McAllister Drilling Ltd.	Sep-77	67.4	221.0	54.7	179.4
Imrie, Calvin	NE 21-051-06 W4M	Morton's Water Well Drilling Ltd.	Oct-78	39.6	130.0	55.7	182.7
Inge, Stuart	SW 32-050-01 W4M	Stan Byrt & Sons Ltd.	May-72	51.5	169.0	56.7	185.9
Inge, Stuart	12-32-050-01 W4M	Morton's Water Well Drilling Ltd.	Aug-83	53.0	174.0	57.7	189.2
Isert, Darren	01-16-052-04 W4M	Martin, J. Water Wells	May-85	17.7	58.0	58.7	192.5
Isert, Otto	SW 26-053-04 W4M	Stan Byrt & Sons Ltd.	May-76	40.8	134.0	59.7	195.8
Islay, Hamlet Of	13-09-051-04 W4M	Stan Byrt & Sons Ltd.	Aug-81	25.9	85.0	60.7	199.1
James, Norman	13-17-050-02 W4M	Stan Byrt & Sons Ltd.		22.6	74.0	61.7	202.3
Jensen, Ed	SE 33-049-01 W4M	McAllister Drilling Ltd.	Aug-75	71.3	234.0	62.7	205.6
Johnson, Alan	SW 24-051-03 W4M	Stan Byrt & Sons Ltd.	May-76	36.3	119.0	63.7	208.9
Johnson, Allan	04-24-051-03 W4M	Stan Byrt & Sons Ltd.	Nov-79	40.5	133.0	64.7	212.2
Jones, Ray	12-04-051-06 W4M	Morton's Water Well Drilling Ltd.	May-81	11.6	38.0	65.7	215.5
Just, Bob	01-03-050-02 W4M	McAllister Holdings Ltd.	Apr-86	59.7	196.0	66.7	218.7
Kashuba, Nick	12-26-051-06 W4M	Morton's Water Well Drilling Ltd.	Sep-85	45.7	150.0	67.7	222.0
Kengan, Fred	SW 06-049-01 W4M	McAllister Drilling Ltd.	Nov-73	32.0	105.0	68.7	225.3
Kenyon, Wilf	05-06-049-01 W4M	Stan Byrt & Sons Ltd.	May-75	36.6	120.0	69.7	228.6
Kibblewhite, W.A.	15-22-050-06 W4M	Morton's Water Well Drilling Ltd.	Sep-82	27.4	90.0	70.7	231.9
Kitscoty, Village Of	02-26-050-03 W4M	Stan Byrt & Sons Ltd.	Sep-77	54.0	177.0	71.7	235.1
Kneen, Bill	NE 23-052-04 W4M	Stan Byrt & Sons Ltd.	Oct-85	60.0	197.0	72.7	238.4
Kohn, A.	NE 09-051-04 W4M	Downey Drilling	Jul-59	12.5	41.0	73.7	241.7
Kokotaila, Ken	SW 21-054-03 W4M	K & W Water Boring	Oct-79	12.2	40.0	74.7	245.0
Kreitz, Carl	NE 07-052-06 W4M	McAllister Drilling Ltd.	Jun-73	38.4	126.0	75.7	248.3
Kung, Bert	NE 09-051-07 W4M	McAllister Drilling Ltd.	Jun-81	17.1	56.0	76.7	251.6
Kutzak, R.	01-14-050-02 W4M	McAllister Drilling Ltd.	Sep-80	76.8	252.0	77.7	254.8
Labiuk, Jim	02-06-051-02 W4M	Pete's Waterwell Contracting Ltd.	Jun-81	11.6	38.0	78.7	258.1
Lamont, G.	10-04-050-02 W4M	McAllister Waterwells Ltd.	Aug-84	57.9	190.0	79.7	261.4
Lamport, R.	10-30-048-04 W4M	McAllister Drilling Ltd.	Sep-63	49.7	163.0	80.7	264.7
Lawrence, Anthony	08-08-053-05 W4M	Morton's Water Well Drilling Ltd.	Jul-83	17.4	57.0	81.7	268.0
Lawrence, Ewan	SW 09-053-05 W4M	Morton's Water Well Drilling Ltd.	Apr-79	20.7	68.0	82.7	271.2
Lawrence, Ewen	SE 08-053-05 W4M	McAllister Drilling Ltd.	Aug-74	16.8	55.0	83.7	274.5
Leighton, W.J.	02-26-051-02 W4M	Laws & Byrt	Jan-64	25.6	84.0	84.7	277.8
Leudtke, Art	14-10-050-01 W4M	Tindall, W. Water Wells	May-83	17.4	57.0	85.7	281.1
Little, Sam	09-06-051-06 W4M	Morton's Water Well Drilling Ltd.	Apr-86	42.7	140.0	86.7	284.4
Maccre, Ken	01-10-051-06 W4M	Morton's Water Well Drilling Ltd.	May-78	14.6	48.0	87.7	287.6
Macdonald, Ronald	09-20-050-01 W4M	Morton's Water Well Drilling Ltd.	Jul-82	55.8	183.0	88.7	290.9
Mackay, Doug	16-26-049-03 W4M	McAllister Holdings Ltd.	Sep-79	54.9	180.0	89.7	294.2
Macmillan, Ken	NW 33-052-06 W4M	Morton's Water Well Drilling Ltd.	Mar-81	18.3	60.0	90.7	297.5
Maggs, Edward	05-19-051-05 W4M	Morton's Water Well Drilling Ltd.	Aug-82	54.9	180.0	91.7	300.8
Manley, George	SW 02-051-01 W4M	Stan Byrt & Sons Ltd.	Apr-78	39.6	130.0	92.7	304.1
Marshal, Morley	13-18-050-06 W4M	McAllister Drilling Ltd.	Jul-74	28.0	92.0	93.7	307.3
Martin, James	04-22-052-05 W4M	Morton's Water Well Drilling Ltd.	Jul-78	54.6	179.0	94.7	310.6
Marwayne	SE 26-052-03 W4M	Frederickson, J.E.		62.5	205.1	95.7	313.9
Marwayne	SW 26-052-03 W4M	<unknown contractor>	Sep-88	51.8	170.0	96.7	317.2
Matheson, Harold	16-31-054-03 W4M	Laws & Byrt	Aug-64	22.9	75.0	97.7	320.5
Mccambridge, Edith	SW 36-051-06 W4M	McAllister Drilling Ltd.	Dec-75	59.4	195.0	98.7	323.7
Mcdonald, A.	08-20-050-01 W4M	Stan Byrt & Sons Ltd.	Jul-82	55.5	182.0	99.7	327.0
Mcintyre, Keith	NW 36-051-06 W4M	Mannville Drilling	May-68	35.7	117.0	100.7	330.3
Mckenzie, S.	SW 16-051-06 W4M	Morton's Water Well Drilling Ltd.	May-82	31.4	103.0	101.7	333.6
Mckerihan, T.M.	09-18-050-03 W4M	McAllister Drilling Ltd.	Oct-63	61.6	202.0	102.7	336.9
Mclaughlin, George	SE 24-051-02 W4M	Stan Byrt & Sons Ltd.	Oct-85	33.2	109.0	103.7	340.1
Mclennan, Bruce	NE 02-051-04 W4M	McAllister Drilling Ltd.	Mar-74	26.8	88.0	104.7	343.4
Mcphee, Bill	SE 34-052-06 W4M	Morton's Water Well Drilling Ltd.	Sep-80	22.3	73.0	105.7	346.7
Mcphee, George	SW 22-052-06 W4M	Morton's Water Well Drilling Ltd.	Aug-81	16.5	54.0	106.7	350.0

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

Owner	Location	Water Well Contractor	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet
Mcphee, Tom	SE 21-052-06 W4M	Morton's Water Well Drilling Ltd.	Sep-77	21.9	72.0	107.7	353.3
Miller, Gary	01-01-049-04 W4M	McAllister Drilling Ltd.	Oct-77	73.2	240.0	108.7	356.5
Minish, Calvin	13-33-052-05 W4M	Morton's Water Well Drilling Ltd.	Apr-77	50.3	165.0	109.7	359.8
Minke, Elmer	NW 22-050-06 W4M	McAllister Drilling Ltd.	Apr-78	42.7	140.0	110.7	363.1
Mitchell Farms	SW 02-050-03 W4M	McAllister Drilling Ltd.	Dec-72	54.6	179.0	111.7	366.4
Mitchell Farms	SW 02-050-03 W4M	Stan Byrt & Sons Ltd.	Apr-79	48.2	158.0	112.7	369.7
Moan, Kevin	04-03-050-02 W4M	McAllister Waterwells Ltd.	May-82	56.4	185.0	113.7	373.0
Monteith, Robert	09-14-050-03 W4M	Morton's Water Well Drilling Ltd.	Jun-82	57.9	190.0	114.7	376.2
Moran, Jim	01-36-050-05 W4M	McAllister Drilling Ltd.	Jan-76	57.9	190.0	115.7	379.5
Morrison, Ken	NW 24-050-06 W4M	McAllister Drilling Ltd.	Nov-76	48.8	160.0	116.7	382.8
Mutch, Kevin	SW 19-052-03 W4M	Stan Byrt & Sons Ltd.	Jun-86	71.6	235.0	117.7	386.1
Newlin Farms Ltd	08-01-052-01 W4M	McAllister Drilling Ltd.	Jul-85	19.8	65.0	118.7	389.4
Nickless, Grace	03-16-052-01 W4M	McAllister Holdings Ltd.	Mar-86	69.5	228.0	119.7	392.6
Nillson, Russel	SW 10-052-01 W4M	McAllister Drilling Ltd.	Apr-73	101.2	332.0	120.7	395.9
Nohnychuk, E.	04-13-052-02 W4M	McAllister Drilling Ltd.	Jun-67	74.1	243.0	121.7	399.2
Nohnychuk, Jim	NW 06-053-02 W4M	McAllister Drilling Ltd.	Oct-74	12.8	42.0	122.7	402.5
O'Hare, Hugh	NW 22-050-03 W4M	Stan Byrt & Sons Ltd.	Jun-86	78.3	257.0	123.7	405.8
Oldenburg, Roy	NW 21-048-04 W4M	Downey, Gordon B.	Jul-58	45.4	149.0	124.7	409.0
Oldenburg, Roy	NW 21-048-04 W4M	McAllister Drilling Ltd.	Sep-75	50.0	164.0	125.7	412.3
Oliver, Glenn	NE 13-048-02 W4M	Fred's Water Well Drilling Ltd.	May-81	44.2	145.0	126.7	415.6
Omness, O.A.	13-15-052-05 W4M	Laws & Byrt	May-61	37.2	122.0	127.7	418.9
Ottenbreit, George	NE 26-052-03 W4M	<unknown contractor>		54.9	180.1	128.7	422.2
Otto, Kieth	12-25-051-02 W4M	McAllister Waterwells Ltd.	Nov-85	20.7	68.0	129.7	425.4
Parke, Bill	NW 22-053-03 W4M	Tindall, W. Water Wells	Sep-85	20.1	66.0	130.7	428.7
Parker, H.	SW 05-054-02 W4M	Stan Byrt & Sons Ltd.	Sep-85	14.0	46.0	131.7	432.0
Parkin, Anna	SE 03-050-03 W4M	Stan Byrt & Sons Ltd.	Apr-79	59.7	196.0	132.7	435.3
Parkin, Gerald	NW 10-050-03 W4M	McAllister Drilling Ltd.	Aug-74	35.1	115.0	133.7	438.6
Parr, Frank	SW 01-054-04 W4M	Morton's Water Well Drilling Ltd.	May-79	56.7	186.0	134.7	441.9
Pashniak, Glenn	07-03-053-02 W4M	Martin, J. Water Wells	Aug-84	17.4	57.0	135.7	445.1
Payne, Joe#1	SW 18-051-05 W4M	McAllister Drilling Ltd.	Jul-71	50.9	167.0	136.7	448.4
Pearman, Charlie	01-06-051-05 W4M	McAllister Waterwells Ltd.	Sep-83	39.0	128.0	137.7	451.7
Pearman, Dave C.	01-07-051-05 W4M	McAllister Drilling Ltd.	Mar-81	36.6	120.0	138.7	455.0
Pederson, Calvin	11-17-051-06 W4M	McAllister Drilling Ltd.	May-77	18.3	60.0	139.7	458.3
Peregrym Farms Ltd	13-21-050-02 W4M	McAllister Drilling Ltd.	Jun-71	95.7	314.0	140.7	461.5
Person, Walter	SE 24-052-02 W4M	Morton's Water Well Drilling Ltd.	Aug-84	45.7	150.0	141.7	464.8
Popowich, Gerald	NW 36-050-02 W4M	Stan Byrt & Sons Ltd.	Apr-86	44.2	145.0	142.7	468.1
Presley, P.E.	SE 10-049-04 W4M	Downey, Gordon B.	Aug-61	46.6	153.0	143.7	471.4
Pyper, Gerald	04-16-051-06 W4M	McAllister Holdings Ltd.	Oct-79	28.0	92.0	144.7	474.7
Quinn, Bill	NE 04-048-03 W4M	McAllister Drilling Ltd.	Apr-77	39.3	129.0	145.7	477.9
Rainey, Gordon	SW 21-054-04 W4M	McAllister Drilling Ltd.	Jun-76	51.8	170.0	146.7	481.2
Brodbin, Brian	09-01-055-06 W4M	Morton's Water Well Drilling Ltd.	Oct-85	24.4	80.0	147.7	484.5
Toews, Verne	NE 12-054-05 W4M	Martin, J. Water Wells	Sep-81	27.1	89.0	148.7	487.8
Pfefferle, M	04-23-054-06 W4M	Morton's Water Well Drilling Ltd.	Mar-84	39.6	130.0	149.7	491.1
Quickstad, F	14-25-054-06 W4M	Morton's Water Well Drilling Ltd.	Jul-82	49.4	162.0	150.7	494.3
Andedrson, F	16-26-054-06 W4M	Morton's Water Well Drilling Ltd.	Oct-82	35.7	117.0	151.7	497.6
Quickstad, C	16-35-054-06 W4M	Morton's Water Well Drilling Ltd.	Jul-82	86.6	284.0	152.7	500.9
Goad, Clifford	01-32-054-05 W4M	Stan Byrt & Sons Ltd.	Jul-74	61.6	202.0	153.7	504.2
Brodbin, George	12-32-054-05 W4M	Stan Byrt & Sons Ltd.	Aug-82	51.8	170.0	154.7	507.5
Campbell, Dave	05-35-054-05 W4M	Morton's Water Well Drilling Ltd.	Jul-81	47.9	157.0	155.7	510.8
Kurucz, Jim	SW 17-055-04 W4M	McAllister Holdings Ltd.	Feb-80	44.2	145.0	156.7	514.0
Clack, Lorne	NE 17-055-04 W4M	Morton's Water Well Drilling Ltd.	Jul-80	43.0	141.0	157.7	517.3
Rainey, Rick	SE 18-055-04 W4M	Stan Byrt & Sons Ltd.	Aug-76	51.5	169.0	158.7	520.6
Unrah, Lyle	SE 03-055-04 W4M	McAllister Drilling Ltd.	Jul-85	27.1	89.0	159.7	523.9
Strome, O.A.	NE 35-051-06 W4M	Stan Byrt & Sons Ltd.	Nov-65	67.1	220.0	160.7	527.2
ept. Of Env.(Streamstown Sc	01-26-051-02 W4M	Hi-Rate Drilling 1985 Ltd.	Sep-76	17.4	57.0	161.7	530.4
Martin, Thomas	SE 03-053-05 W4M	Morton's Water Well Drilling Ltd.	Apr-80	39.0	128.0	162.7	533.7
Bardoel, Robert	SE 01-053-07 W4M	Morton's Water Well Drilling Ltd.	Apr-83	18.3	60.0	163.7	537.0
Chisholm, James H.	SE 26-051-02 W4M	Tindall WW Drilling	Jul-80	29.9	98.0	164.7	540.3
Vermilion Provincial Park	SW 01-051-07 W4M	McAllister Holdings Ltd.	Nov-87	41.5	136.0	165.7	543.6
Deschamps, David	NW 32-056-02 W4M	Satellite Drilling Ltd.	Nov-75	26.8	88.0	166.7	546.8
Deschamps, Joe #74-4	NE 32-056-02 W4M	Hi-Rate Drilling 1985 Ltd.	Jun-74	48.5	159.0	167.7	550.1
Deschamps, Ernest	SW 33-056-02 W4M	Hi-Rate Drilling 1985 Ltd.	Jun-74	39.0	128.0	168.7	553.4
Powder, Robert	NW 33-056-02 W4M	Satellite Drilling Ltd.	Nov-75	65.5	215.0	169.7	556.7
Lakusta, Anna	16-33-047-01 W4M	McAllister Holdings Ltd.	Nov-83	26.8	88.0	170.7	560.0
Hobbs, Tom	NW 31-049-01 W4M	McAllister Drilling Ltd.	Jul-76	75.0	246.0	171.7	563.2

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

Owner	Location	Water Well Contractor	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet
Haines, Andy	02-06-049-04 W4M	Morton's Water Well Drilling Ltd.	Jun-79	50.3	165.0	172.7	566.5
Langenfurth, John	16-03-050-02 W4M	McAllister Holdings Ltd.	Aug-78	73.2	240.0	173.7	569.8
Christie, Bob	01-14-050-02 W4M	Stan Byrt & Sons Ltd.	Jan-84	78.3	257.0	174.7	573.1
Hiltz, Bob	01-04-051-03 W4M	Stan Byrt & Sons Ltd.	Apr-74	48.8	160.0	175.7	576.4
Booth, Russell A.	04-01-052-02 W4M	McAllister Waterwells Ltd.	Jul-83	82.6	271.0	176.7	579.7
Alberta Environment	01-36-050-01 W4M	lberta Environment/Earth Sciences Divisic	Jun-77	163.4	536.0	177.7	582.9
Velikold, Kermit	12-06-046-01 W4M	McAllister Drilling Ltd.	Jun-79	57.3	188.0	178.7	586.2
Reid, Cecil	SE 16-046-01 W4M	McAllister Drilling Ltd.	Aug-74	48.8	160.0	179.7	589.5
Harbin, Cliff	SW 33-046-01 W4M	McAllister Drilling Ltd.	Oct-71	52.4	172.0	180.7	592.8
Berg, Audrey	08-34-046-01 W4M	McAllister Holdings Ltd.	May-81	48.2	158.0	181.7	596.1
Adams, Ken	NE 01-046-03 W4M	Stan Byrt & Sons Ltd.	Aug-78	109.7	360.0	182.7	599.3
Anderson, Harry	NW 12-046-02 W4M	McAllister Drilling Ltd.	Oct-70	103.6	340.0	183.7	602.6
Gordon, J.W.	14-20-046-02 W4M	McAllister Drilling Ltd.	Sep-66	100.6	330.0	184.7	605.9
Parsons, Don	13-24-046-02 W4M	McAllister Drilling Ltd.	Oct-67	108.2	355.0	185.7	609.2
Mckinnon, M.H.	SW 25-046-02 W4M	McAllister Drilling Ltd.		42.4	139.0	186.7	612.5
Brown, John D.	13-10-046-03 W4M	McAllister Holdings Ltd.	Dec-81	69.8	229.0	187.7	615.7
Nysetvold, Clair	05-05-047-01 W4M	McAllister Drilling Ltd.	Nov-85	65.2	214.0	188.7	619.0
Malka, Walter	01-10-047-01 W4M	Tindall, W. Water Wells	Jul-82	35.4	116.0	189.7	622.3
Mccuaig, Neil	03-12-047-01 W4M	McAllister Drilling Ltd.	Jul-85	35.4	116.0	190.7	625.6
Kuzyk, Mike	SE 14-047-01 W4M	McAllister Drilling Ltd.	Aug-75	38.1	125.0	191.7	628.9
Johnson, Wayne	NW 20-047-01 W4M	Stan Byrt & Sons Ltd.	Oct-85	29.3	96.0	192.7	632.2
Baker Bros	01-24-047-01 W4M	Stan Byrt & Sons Ltd.	Dec-80	27.1	89.0	193.7	635.4
Baker, Lyle	01-28-047-01 W4M	McAllister Drilling Ltd.	Jul-76	39.0	128.0	194.7	638.7
Paradise Valley, Village Of	NW 06-047-02 W4M	McAllister Drilling Ltd.	Nov-77	47.2	155.0	195.7	642.0
Paradise Valley	13-06-047-02 W4M	McAllister Holdings Ltd.	May-82	48.8	160.0	196.7	645.3
Redman, Charlie	01-02-047-03 W4M	McAllister Drilling Ltd.	Aug-76	40.5	133.0	197.7	648.6
Rayson, Butch	04-18-047-02 W4M	McAllister Holdings Ltd.	Jun-81	20.7	68.0	198.7	651.8
Rayson, T.R.	SE 30-050-04 W4M	McAllister Drilling Ltd.	May-77	61.0	200.0	199.7	655.1
Reimer, Brian	NW 35-053-05 W4M	Stan Byrt & Sons Ltd.	Nov-86	32.0	105.0	200.7	658.4
Reinhart, Jim	14-09-050-01 W4M	Stan Byrt & Sons Ltd.	Jul-78	65.8	216.0	201.7	661.7
Rewuski, Rick	12-07-053-04 W4M	Morton's Water Well Drilling Ltd.	Jul-80	46.6	153.0	202.7	665.0
Ruhl, Alex	NE 04-048-01 W4M	McAllister Drilling Ltd.	Sep-85	27.1	89.0	203.7	668.2
Ruud, Arnold	NE 24-047-06 W4M	Stan Byrt & Sons Ltd.	Sep-76	54.0	177.0	204.7	671.5
Rybchinski, Orest	04-01-055-06 W4M	McAllister Drilling Ltd.	Mar-76	102.7	337.0	205.7	674.8
Sampson, Carl	NW 29-049-01 W4M	McAllister Drilling Ltd.	Aug-74	62.5	205.0	206.7	678.1
Schaefer, Ron	01-27-050-02 W4M	McAllister Holdings Ltd.	Oct-86	64.0	210.0	207.7	681.4
Selte Farms Ltd	SE 32-047-04 W4M	McAllister Drilling Ltd.	Jun-74	93.6	307.0	208.7	684.6
Seward, Wayne	05-16-051-06 W4M	Morton's Water Well Drilling Ltd.	Jun-79	30.5	100.0	209.7	687.9
Shantz, Gilbert	SW 06-052-02 W4M	Big Iron Drilling Ltd.	May-85	51.8	170.0	210.7	691.2
Share All Farms Ltd	13-20-051-02 W4M	McAllister Holdings Ltd.	Nov-82	23.8	78.0	211.7	694.5
Sheppard, Glen	01-26-048-01 W4M	Morton's Water Well Drilling Ltd.	Sep-83	48.8	160.0	212.7	697.8
Sherwood, L. & R.	01-16-051-05 W4M	McAllister Waterwells Ltd.	Sep-83	19.5	64.0	213.7	701.1
Sikora, Harvey	SE 35-054-04 W4M	McAllister Waterwells Ltd.	Jun-81	30.5	100.0	214.7	704.3
Silver Birch Farms	16-16-051-02 W4M	Stan Byrt & Sons Ltd.	Oct-79	38.4	126.0	215.7	707.6
Skimmer Oil Separators Ltd	12-36-051-03 W4M	McAllister Holdings Ltd.	Mar-88	90.2	296.0	216.7	710.9
Smith, B.G.	06-14-049-04 W4M	McAllister Drilling Ltd.	Aug-72	67.1	220.0	217.7	714.2
Smith, Ron	16-12-048-02 W4M	McAllister Waterwells Ltd.	Jul-83	35.7	117.0	218.7	717.5
Spca	NE 11-050-01 W4M	Stan Byrt & Sons Ltd.	Oct-76	67.1	220.0	219.7	720.7
Stachwiak, Terry	NE 36-053-06 W4M	McAllister Waterwells Ltd.	Oct-82	16.5	54.0	220.7	724.0
Starko, John	SE 06-052-05 W4M	Stan Byrt & Sons Ltd.		58.2	191.0	221.7	727.3
Stewart, Dave	NW 29-050-05 W4M	McAllister Holdings Ltd.	Sep-79	51.8	170.0	222.7	730.6
Stroud, Fred	NE 33-049-06 W4M	McAllister Drilling Ltd.	Oct-79	45.1	148.0	223.7	733.9
Sunderland, Myron	NW 24-047-03 W4M	McAllister Drilling Ltd.	Nov-73	30.5	100.0	224.7	737.1
Swasiuk, Mike	SW 28-051-06 W4M	McAllister Drilling Ltd.	Sep-74	55.5	182.0	225.7	740.4
Sweeney Bros	NW 11-049-06 W4M	McAllister Drilling Ltd.	Dec-74	56.1	184.0	226.7	743.7
Termoster, Emerson	SE 18-051-04 W4M	McAllister Drilling Ltd.	Nov-71	18.9	62.0	227.7	747.0
Tetz, Henry	16-18-050-01 W4M	McAllister Holdings Ltd.	Feb-83	64.3	211.0	228.7	750.3
Thompson, Reg	SE 05-050-06 W4M	McAllister Drilling Ltd.	Jul-74	37.2	122.0	229.7	753.5
Tremblay, J.	01-14-050-02 W4M	McAllister Drilling Ltd.	Mar-81	67.1	220.0	230.7	756.8
Tullson, Oliver	NW 08-051-06 W4M	Morton's Water Well Drilling Ltd.	Sep-80	29.6	97.0	231.7	760.1
Tupper, Joe	08-24-052-03 W4M	Stan Byrt & Sons Ltd.	Nov-84	56.1	184.0	232.7	763.4
Tupper, Joe	SE 24-052-03 W4M	Stan Byrt & Sons Ltd.		60.0	196.9	233.7	766.7
Tyner, A.J.	16-02-052-02 W4M	Tindall, W. Water Wells	Sep-83	12.2	40.0	234.7	770.0
Ulan, J.	09-02-051-02 W4M	McAllister Drilling Ltd.	Apr-65	71.0	233.0	235.7	773.2
Vandendolder, Doug	04-15-051-05 W4M	McAllister Drilling Ltd.	Apr-77	30.5	100.0	236.7	776.5

WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

Owner	Location	Water Well Contractor	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet
Vee Tee Feeders	SW 12-051-01 W4M	Stan Byrt & Sons Ltd.	Mar-78	163.4	536.0	237.7	779.8
Vee Tee Ranching #8	SE 09-051-01 W4M	Stan Byrt & Sons Ltd.	Aug-73	46.0	151.0	238.7	783.1
Vermilion Golf Club	NW 20-050-06 W4M	Stan Byrt & Sons Ltd.		35.1	115.0	239.7	786.4
Vertex Industries	12-27-050-06 W4M	Morton's Water Well Drilling Ltd.	Sep-79	41.5	136.0	240.7	789.6
Village Of Marwayne	SE 26-052-03 W4M	McAllister Drilling Ltd.	Jul-78	30.8	101.0	241.7	792.9
Village of Marwayne	SE 27-052-03 W4M	McAllister Drilling Ltd.	Jul-78	32.9	108.0	242.7	796.2
Vivian, Ken	NW 14-053-03 W4M	Martin, J. Water Wells	Mar-83	17.7	58.0	243.7	799.5
Walker, E.C.	SW 27-054-04 W4M	McAllister Drilling Ltd.	Jun-77	56.7	186.0	244.7	802.8
Walker, Wiliam	SW 01-051-06 W4M	Downey Drilling	Sep-66	14.6	48.0	245.7	806.0
Walton, Howard	09-04-051-03 W4M	Stan Byrt & Sons Ltd.	Apr-81	47.9	157.0	246.7	809.3
Ward, Al	09-15-051-06 W4M	McAllister Holdings Ltd.	Aug-78	28.7	94.0	247.7	812.6
Warewa, Tom	04-16-051-06 W4M	Morton's Water Well Drilling Ltd.	Sep-79	28.0	92.0	248.7	815.9
Warman, Peter	04-26-050-02 W4M	McAllister Waterwells Ltd.	Oct-82	61.6	202.0	249.7	819.2
Waterfield, Art	NE 23-050-04 W4M	McAllister Drilling Ltd.	Apr-73	25.6	84.0	250.7	822.4
Websdale, Herb	06-36-053-04 W4M	Morton's Water Well Drilling Ltd.	Sep-80	34.4	113.0	251.7	825.7
West, F.	NE 15-051-06 W4M	McAllister Drilling Ltd.	Oct-67	33.8	111.0	252.7	829.0
West, Kenneth	09-13-051-05 W4M	McAllister Drilling Ltd.	Feb-74	42.7	140.0	253.7	832.3
Whitfield, Morris	SE 30-050-01 W4M	McAllister Drilling Ltd.	Sep-85	62.8	206.0	254.7	835.6
Wick, S.	NW 01-049-01 W4M	McAllister Drilling Ltd.	Sep-67	57.0	187.0	255.7	838.9
Wilhelm, M	NE 10-049-06 W4M	Morton's Water Well Drilling Ltd.	May-78	57.0	187.0	256.7	842.1
Williams, Robert	02-14-050-02 W4M	McAllister Holdings Ltd.	Nov-81	73.5	241.0	257.7	845.4
Willoughby, Robert	16-02-049-03 W4M	McAllister Holdings Ltd.	Nov-84	84.7	278.0	258.7	848.7
Wilson, Curt	15-11-052-05 W4M	Morton's Water Well Drilling Ltd.	Jul-80	50.3	165.0	259.7	852.0
Wilson, Doug	SE 29-051-06 W4M	McAllister Drilling Ltd.	Jul-72	53.0	174.0	260.7	855.3
Wilson, Glenn	SW 16-051-06 W4M	Morton's Water Well Drilling Ltd.	Jul-84	31.1	102.0	261.7	858.5
Wilson, Ralph	SE 30-051-06 W4M	Downey, Gordon B.	May-58	27.4	90.0	262.7	861.8
Wilson, Robert	13-16-051-06 W4M	McAllister Drilling Ltd.	Jul-74	27.1	89.0	263.7	865.1
Windermere Farms Ltd	01-06-050-06 W4M	McAllister Holdings Ltd.	Sep-83	24.7	81.0	264.7	868.4
Winnyk, Ray	NE 12-052-07 W4M	Fred's Water Well Drilling Ltd.	May-79	17.1	56.0	265.7	871.7
Wowk, George	01-09-054-04 W4M	Morton's Water Well Drilling Ltd.	Apr-83	61.0	200.0	266.7	874.9
Woywitka, Ken	SW 30-051-07 W4M	McAllister Drilling Ltd.	Oct-71	42.7	140.0	267.7	878.2
Woywitka, Lorne	SW 18-051-07 W4M	Morton's Water Well Drilling Ltd.	Jul-80	22.9	75.0	268.7	881.5
Wynnychuk, Peter	SW 09-051-07 W4M	Ashmont Water Well Drilling Ltd.	Jun-83	19.5	64.0	269.7	884.8
Yaceyko, Paul	NW 17-051-06 W4M	McAllister Drilling Ltd.	May-77	24.7	81.0	270.7	888.1
Yaceyko, Paul	14-17-051-06 W4M	McAllister Holdings Ltd.	Nov-79	37.2	122.0	271.7	891.3
Zaharko, Pete	SE 27-050-06 W4M	Morton's Water Well Drilling Ltd.	Aug-81	21.9	72.0	272.7	894.6
Zayac, Emil	13-20-050-06 W4M	Morton's Water Well Drilling Ltd.	Oct-82	40.8	134.0	273.7	897.9

COUNTY-OPERATED WATER WELLS

Owner	Location	Date Water Well Drilled	Completed Depth Metres	Completed Depth Feet	NPWL Metres	NPWL Feet
County Of Vermilion River #24	35-050-03 W4M	Oct-89	50.3	165.0	25.5	83.7
Vermilion Park #Wolf Point Kit	31-050-06 W4M	May-58	30.5	100.0	14.0	46.0
Vermilion Prov Park	31-050-06 W4M	Mar-58	15.2	50.0	9.1	30.0
Vermilion Prov Park Well#1	31-050-06 W4M	Jun-65	12.2	40.0	3.2	10.3
Vermilion Provincial Park	01-051-07 W4M	Nov-87	41.5	136.0	28.0	91.7
Vermilion River, County Of	17-053-05 W4M	Oct-84	16.8	55.0	9.7	31.9
Vermilion, County Of	35-050-03 W4M	Sep-82	45.1	148.0	22.3	73.0