# County of Athabasca No. 12

Part of the Athabasca River Basin
Parts of Tp 062 to 074, R 16 to 25, 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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The Association of Professional Engineers,
Geologists and Geophysicists of Alberta



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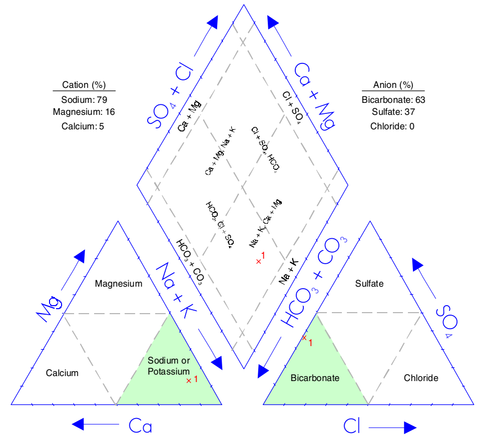
## Glossary

| | |
|---|---|
| Aquifer | a formation, group of formations, or part of a formation that contains saturated permeable rocks capable of transmitting groundwater to water wells or springs in economical quantities |
| Aquitard | a confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer |
| Available Drawdown | in a confined aquifer, the distance between the non-pumping water level and the top of the aquifer<br>in an unconfined aquifer (water table aquifer), two thirds of the saturated thickness of the aquifer |
| Borehole | includes all "work types" except springs |
| Deltaic | a depositional environment in standing water near the mouth of a river |
| Dewatering | the removal of groundwater from an aquifer for purposes other than use |
| Evapotranspiration | a combination of evaporation from open bodies of water, evaporation from soil surfaces, and transpiration from the soil by plants (Freeze and Cherry, 1979) |
| Facies | the aspect or character of the sediment within beds of one and the same age (Pettijohn, 1957) |
| Fluvial | produced by the action of a stream or river |
| Friable | poorly cemented |
| Hydraulic Conductivity | the rate of flow of water through a unit cross-section under a unit hydraulic gradient; units are length/time |
| km | kilometre |
| Kriging | a geo-statistical method for gridding irregularly-spaced data (Cressie, 1990) |
| Lacustrine | fine-grained sedimentary deposits associated with a lake environment and not including shore-line deposits |
| Lithology | description of rock material |
| Lsd | Legal Subdivision |
| m | metres |
| mm | millimetres |
| $m^2$/day | metres squared per day |
| $m^3$ | cubic metres |
| $m^3$/day | cubic metres per day |
| mg/L | milligrams per litre |
| Obs WW | Observation Water Well |

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




***Piper Tri-Linear Diagram***

**Rock** — earth material below the root zone

**Surficial Deposits** — includes all sediments above the bedrock

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

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

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

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

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

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

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

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

Apparent Yield: based mainly on apparent transmissivity

Long-Term Yield: based on effective transmissivity

**AE** — Alberta Environment

**AMSL** — above mean sea level

**DEM** — Digital Elevation Model

**DST** — drill stem test

| | |
|---|---|
| EUB | Alberta Energy and Utilities Board |
| GCDWQ | Guidelines for Canadian Drinking Water Quality |
| NPWL | non-pumping water level |
| NSR | North Saskatchewan River |
| PFRA | Prairie Farm Rehabilitation Administration |
| TDS | Total Dissolved Solids |
| WSW | Water Source Well or Water Supply Well |

# I. PROJECT OVERVIEW

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

How a County takes care of one of its most precious resources - groundwater - reflects the future wealth and health of its people. Good environmental practices are not an accident. They must include genuine foresight with knowledgeable planning. Implementation of strong practices not only commits to a better quality of life for future generations, but also creates a solid base for increased economic activity. **Though this report's scope is regional, it is a first step for the County of Athasbasca No. 12 in managing their groundwater. It is also a guide for future groundwater-related projects.**

## A. Purpose

This project is a regional groundwater assessment of the County of Athabasca No. 12 prepared by Hydrogeological Consultants Ltd. (HCL) with financial assistance from Prairie Farm Rehabilitation Administration (PFRA). The regional groundwater assessment provides the information to assist in the management of the groundwater resource within the County. Groundwater resource management involves determining the suitability of various areas in the County for particular activities. These activities can vary from the development of groundwater for agricultural or industrial purposes, to the siting of waste storage. **Proper management ensures protection and utilization of the groundwater resource for the maximum benefit of the people of the County.**

The regional groundwater assessment will:

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

## B. The Project

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

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

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

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1 See glossary
2 See glossary

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

## C. About This Report

This report provides an overview of (a) the groundwater resources of the County of Athasbasca No. 12, (b) the processes used for the present project, and (c) the groundwater characteristics in the County.

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

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

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

Appendix C includes the following:

1) a procedure for conducting aquifer tests with water wells[3]
2) a table of contents for the Water (Ministerial) Regulation under the new Water Act
3) a flow chart showing the licensing of a groundwater diversion under the new Water Act
4) 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.

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[3] See glossary

# II. INTRODUCTION

## A. Setting

The County of Athabasca is situated in central Alberta. This area is part of the Alberta Plains region. The County is within the Athabasca River basin; a part of the County's northwestern boundary is the Athabasca River. The other County boundaries follow township or section lines. The area includes parts of the area bounded by township 062, range 25, W4M in the southwest and township 074, range 16, W4M in the northeast. An overlay showing additional cultural details is in the pocket of this report.

Regionally, the topographic surface varies between 475 and 775 metres above mean sea level (AMSL). The lowest elevations occur in the Athabasca River Valley and the highest are in the southern part of the County as shown on Figure 1 and page A-3.

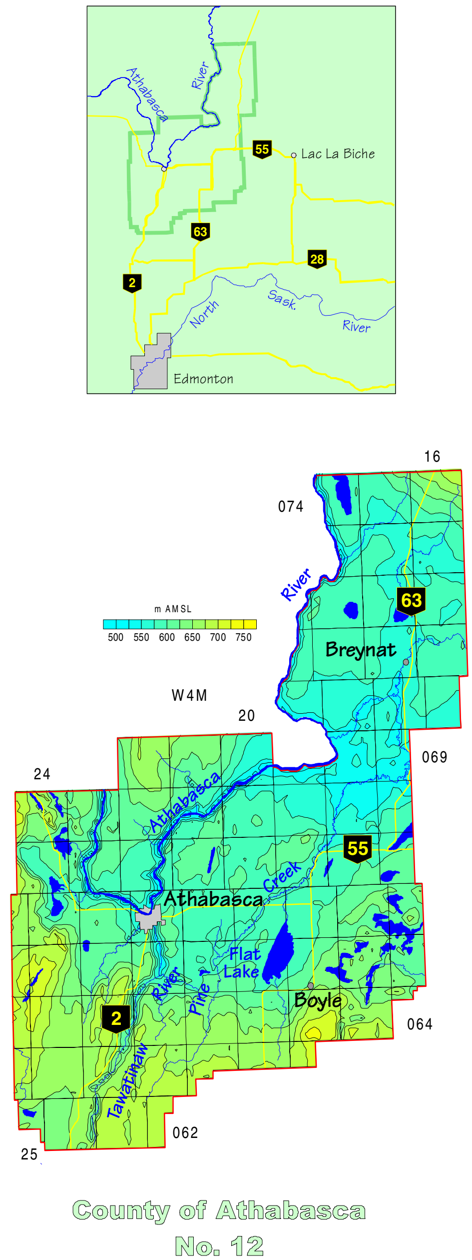


*Figure 1. Index Map*

## B. Climate

The County of Athabasca lies within the Dfb climate boundary. This classification is based on potential evapotranspiration[4] values determined using the Thornthwaite method (Thornthwaite and Mather, 1957), combined with the distribution of natural ecoregions in the area. The ecoregions map (Strong and Leggatt, 1981) shows that the County is located in the Low Boreal Mixedwood region. This vegetation change is influenced by increased precipitation and cooler temperatures, resulting in additional moisture availability.

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

The mean annual precipitation averaged from five meteorological stations within the County measured 484 millimetres (mm), based on data from 1936 to 1993. The annual temperature averaged 1.6° C, with the mean monthly temperature reaching a high of 16.2 °C in July, and dropping to a low of -16.2 °C in January. The calculated annual potential evapotranspiration is 507 millimetres.

[4] See glossary

# C. Background Information

### 1) Numbers, Types and Depths of Water Wells

There are currently records for 5,573 water wells in the groundwater database for the County. Of the 5,573 water wells, 5,077 are for domestic/stock purposes. The remaining 496 water wells were completed for a variety of uses, including municipal, industrial, irrigation and observation. Based on a rural population of 7,415 (Phinney, 1999), there are 2.7 domestic/stock water wells per family of four. The domestic or stock water wells vary in depth from 0.3 metres to 230 metres below ground level. Details for lithology[5] are available for 3,482 water wells.

### 2) Numbers of Water Wells in Surficial and Bedrock Aquifers

There are 2,825 water well records with sufficient information to identify the aquifer in which the water wells are completed. The water wells that were not drilled deep enough to encounter the bedrock plus water wells that have the bottom of their completion interval above the top of the bedrock are water wells completed in surficial aquifers. Of the 2,825 water wells for which aquifers could be defined, 2,226 are completed in surficial aquifers, with 75% having a completion depth of less than 30 metres. The adjacent map shows that the majority of the water wells completed in the surficial deposits occur throughout the County, frequently in the vicinity of linear bedrock lows.

The 599 water wells that have the top of their completion interval deeper than the top of the bedrock are referred to as bedrock water wells. From Figure 2, it can be seen that water wells completed in bedrock aquifers occur mainly in the southern half of the County.

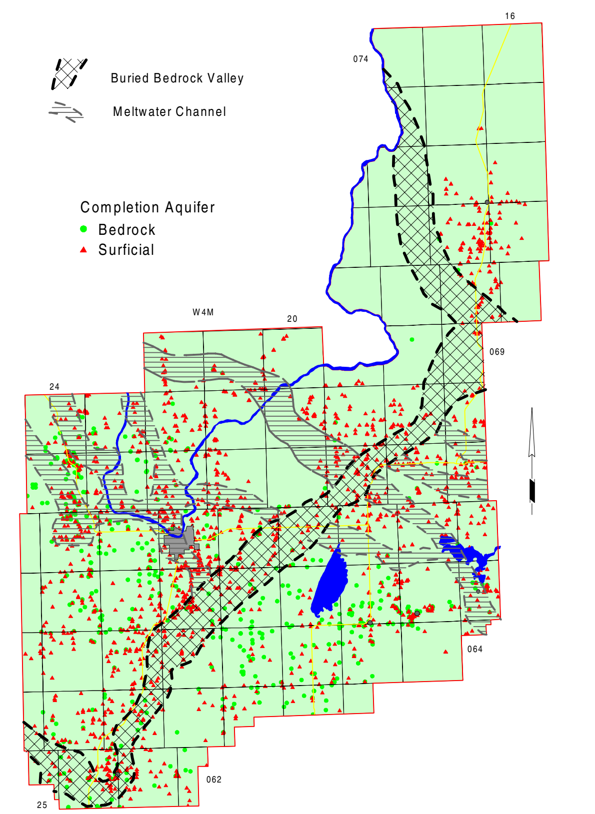


***Figure 2. Location of Water Wells***

5 See glossary

### 3) Casing Diameter and Types

Data for casing diameters are available for 2,260 water wells, with 1,365 (60%) indicated as having a diameter of less than 300 mm and 895 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 300 mm are drilled water wells. Large-diameter water wells are mainly in the areas where significant linear bedrock lows are present.

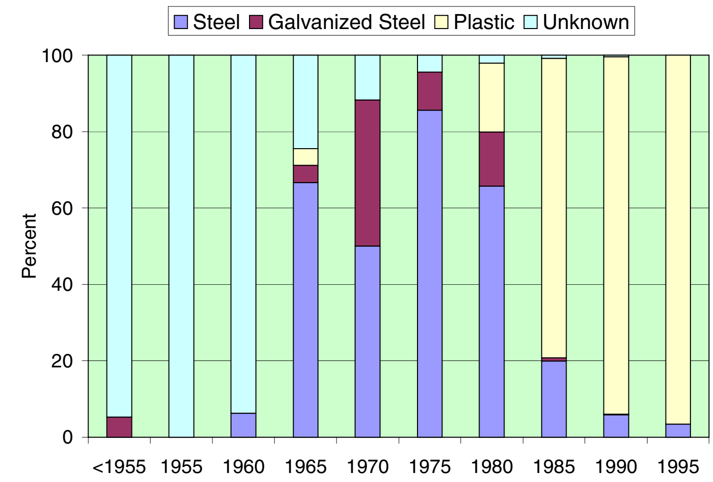


***Figure 3. Surface Casing Types used in Drilled Water Wells***

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 1960s and is still used in 3% 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 38% of the new water wells from the 1960s to the early 1990s. Galvanized steel was last used in May 1990.

### 4) Requirements for Licensing

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, 121 groundwater allocations were licensed in the County. Of the 121 licensed groundwater users, 103 are for agricultural purposes, and the remaining 18 are for industrial, municipal, diversion and domestic purposes. The total maximum authorized diversion from the water wells associated with these licences is 3,256 cubic metres per day ($m^3$/day), of which 68% is for “diversion” use, 26% is allotted for agricultural use, and 5% is allotted for municipal use. The remaining 3% has been licensed for domestic and industrial use as shown in Table 1 on the following page.

The largest licensed potable groundwater allocation within the County is for L & G Trucking Inc., having a “diversion” of 2,205 $m^3$/day. When a groundwater use is listed as “diversion”, the activity is usually related to dewatering[6] activities. The largest licensed potable groundwater allocation within the County is for a water supply well completed in the Upper Sand and Gravel Aquifer in 04-15-062-22 W4M owned by the County of Athabasca, having a diversion of 95 $m^3$/day.

6 See glossary

The following table shows a breakdown of the 121 licensed groundwater allocations by the aquifer in which the water well is completed. The largest total licensed allocations are in the Upper Sand and Gravel Aquifer; the majority of the groundwater is used for "diversion" and agricultural purposes.

| | Licensed Groundwater Users (m³/day) | | | | | | |
|---|---|---|---|---|---|---|---|
| Aquifer | Agricultural | Industrial | Municipal | Diversion | Domestic | Total | Percentage |
| Upper Sand and Gravel | 564 | 5 | 168 | 2,205 | 14 | 2,956 | 91 |
| Birch Lake | 45 | 0 | 0 | 0 | 9 | 54 | 2 |
| Ribstone Creek | 90 | 0 | 0 | 0 | 0 | 90 | 3 |
| Victoria | 82 | 0 | 0 | 0 | 5 | 87 | 3 |
| Brosseau | 14 | 0 | 0 | 0 | 0 | 14 | 0 |
| Lea Park | 9 | 5 | 0 | 0 | 0 | 14 | 0 |
| Unknown | 27 | 14 | 0 | 0 | 0 | 41 | 1 |
| Total | 831 | 24 | 168 | 2,205 | 28 | 3,256 | 100 |
| Percentage | 26 | 1 | 5 | 68 | 2 | 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 9,191 m³/day. Sixty-eight percent of the required water has been licensed by Alberta Environment (AE). Groundwater provides 831 m³/day and surface water provides 5,400 m³/day.

### 5) Groundwater Chemistry and Base of Groundwater Protection

Groundwaters from the surficial deposits can be expected to be chemically hard with a high dissolved iron content. The total dissolved solids (TDS) concentrations in the groundwaters from the upper bedrock in the County are generally less than 1,500 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 1.0 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 | 56.0 | 3284 | 923 | 500 |
| Sodium | 2.0 | 9554 | 381 | 200 |
| Sulfate | 4 | 650 | 180 | 500 |
| Chloride | 0.0 | 1325 | 50 | 250 |
| Fluoride | 0.00 | 1.57 | 0.30 | 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 Environment defines the Base of Groundwater Protection as the elevation below which the groundwater is expected to have more than 4,000 mg/L of total dissolved solids. By using the ground elevation, and the elevation of the Base of Groundwater Protection provided by the Alberta Energy and Utilities Board (EUB), a depth to the Base of Groundwater Protection can be determined. These values are gridded using the Kriging[7] method to prepared a Base of Groundwater Protection surface. This surface is then used throughout the project area. 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, the groundwater use does not require licensing by AE.

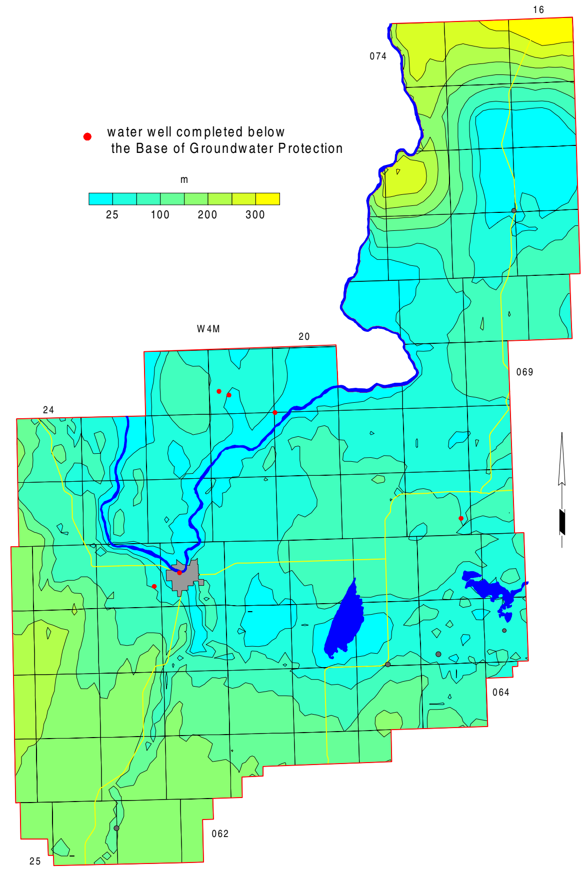


*Figure 4. Depth to Base of Groundwater Protection (modified after EUB, 1995)*

Of the 5,371 water wells with completed depth data, six are completed below the Base of Groundwater Protection in the Milk River Aquifer. Most of these water wells are located within a few kilometres of the Athabasca River. Chemistry data are not available for these six water wells. The proposed use of these six water wells is either domesitic or unknown.

Proper management of the groundwater resource requires water-level data. These data are often collected from observation water wells. At the present time, there is one AE-operated observation water well 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 AE, in part because of the failure of the licensee to provide the data.

However, even with the available sources of data, the number of water-level data points relative to the size of the County is too few to provide a reliable groundwater budget (see section 6.0). 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.

[7] See glossary

# III. TERMS

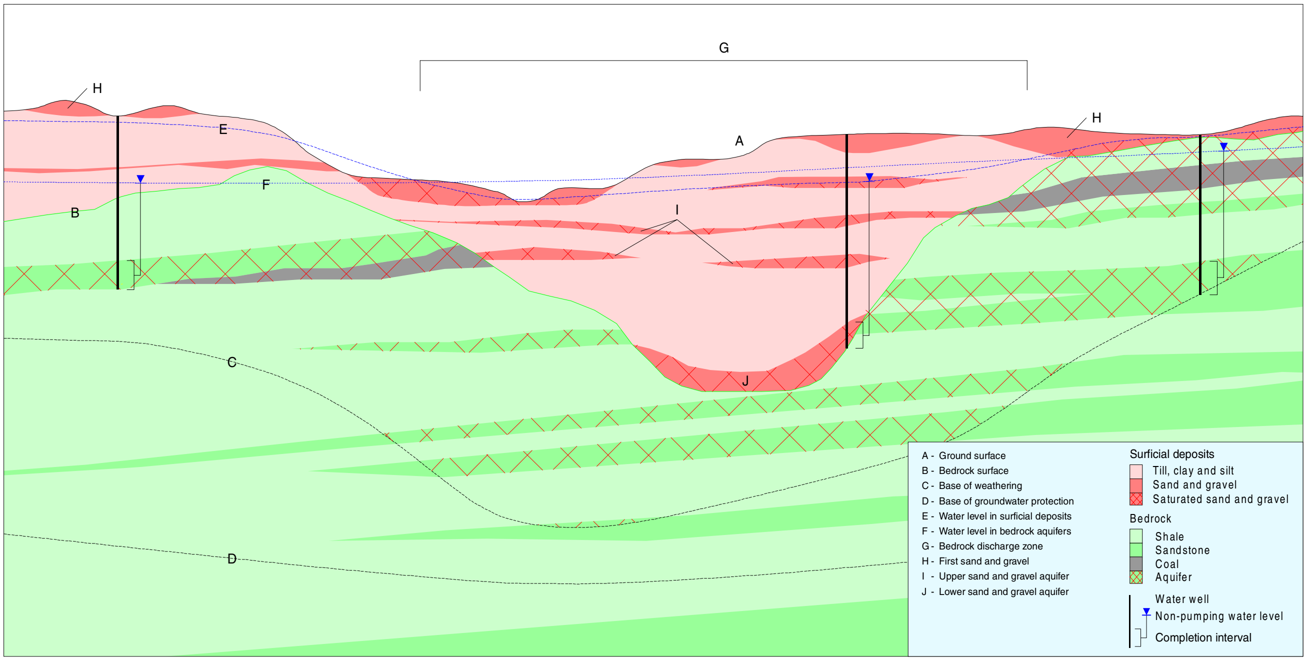


***Figure 5. Generalized Cross-Section (for terminology only)***

| Lithology | Lithologic Description | Group and Formation: Average Thickness (m) | Group | Group and Formation: Designation | Member: Average Thickness (m) | Member: Designation | Zone: Average Thickness (m) | Zone: Designation |
|---|---|---|---|---|---|---|---|---|
| | sand, gravel, till, clay, silt | <100 | | Surficial Deposits | <100 | Upper | <50 | First Sand and Gravel |
| | 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 | 100-200 | | Lea Park Formation | | | | |
| | sandstone, siltstone, shale, coal | 40-140 | Colorado Group | Milk River Formation | | | | |
| | shale, siltstone | 200-1000 | Colorado Group | *undivided* Colorado Group | | | | |
| | sandstone | 50 | Colorado Group | Viking Formation | | | | |

***Figure 6. Geologic Column***

# IV. METHODOLOGY

## A. Data Collection and Synthesis

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

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

The main disadvantage to the database is the absence of quality control. Very little can be done to overcome this lack of quality control in the data collection, other than to assess the usefulness of control points relative to other data during the interpretation. Another disadvantage to the database is the lack of adequate spatial information. However, unlike other areas in the Province where there are numerous duplicate records, the present database for the County contains approximately 175 duplicate water well IDs.

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

The present project uses the 10TM coordinate system. This means that a record for the SE ¼ of section 31, township 064, range 24, W4M, would have a horizontal coordinate with an Easting of 89,825 metres and a Northing of 6,045,858 metres, the centre of the quarter section. If the water well has been positioned by 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 AE.

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.

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

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

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

Also, where sufficient information is available, values for apparent transmissivity[8] and apparent yield[9] are calculated, based on the aquifer test summary data supplied on the water well drilling reports. Where valid detailed aquifer test results exist, the interpreted data provide values for aquifer transmissivity and effective transmissivity. Since the regional hydrogeology map was published in 1973 (Borneuf, 1973), 212 values for effective transmissivity have been added to the groundwater database.

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
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 (pages 35-36). 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.

## B. Spatial Distribution of Aquifers

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

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

The 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.

The values for the elevation of the top and bottom of individual geological units at specific locations help to determine the spatial distribution of the individual surfaces. Establishment of a surface distribution digitally requires preparating 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

8 For definitions of Transmissivity, see glossary
9 For definitions of Yield, see glossary

involves a more direct assessment of the quality of individual points. Because of the uneven distribution of the data, all data sets are gridded using the Kriging method.

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

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

## C. Hydrogeological Parameters

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

After the water wells are assigned to a specific aquifer, the parameters from the water well records are assigned to the individual aquifers. The parameters include non-pumping (static) water level (NPWL), 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.

### 1) Risk Criteria

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

***Table 3. Risk of Groundwater Contamination 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 above table.

## D. Maps and Cross-Sections

Once grids for geological surfaces have been prepared, various grids need to be combined to establish the extent and thickness of individual 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[10]. 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.

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.

The grids for the geological surfaces are used to prepare a three-dimensional stratigraphic model. The stratigraphic model has been prepared from the USGS 3-D MODFLOW model that was prepared for the County to estimate flow through various aquifers. Cross-sections are prepared by selecting specific rows or columns from the stratigraphic model grid and exporting the data to AutoCAD for finalizing for presentation. If a cross-section is required along a line that is at an angle to the model grid, the grid can be rotated. Once the cross-section has been selected, water wells that are within 400 metres of the line of section are added to the cross-section.

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

## E. Software

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

- Acrobat 4.0
- ArcView 3.1
- AutoCAD 14.01
- CorelDRAW! 8.0
- Environmental Systems
- Microsoft Professional Office 2000
- Surfer 6.04
- Tecplot 8.0
- USGS 3-D MODFLOW

[10] See glossary

# V. AQUIFERS

## A. Background

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

### 1) Surficial Aquifers

Surficial deposits in the County are mainly less than 50 metres thick, except in areas of linear bedrock lows where the thickness of the surficial deposits can exceed 100 metres. The Buried Amber Valley is the main linear bedrock low in the County. The Buried Amber Valley is present in the southwest corner of the County and trends northeast to township 069, range 17, W4M where it joins the Buried Helena Valley. The Buried Helena Valley, a major linear bedrock low east of the County, is not well defined within the County of Athabasca. Cross-section A-A' passes through parts of the Buried Amber Valley, and shows the thickness of the surficial deposits varying from less than ten to more than 100 metres.

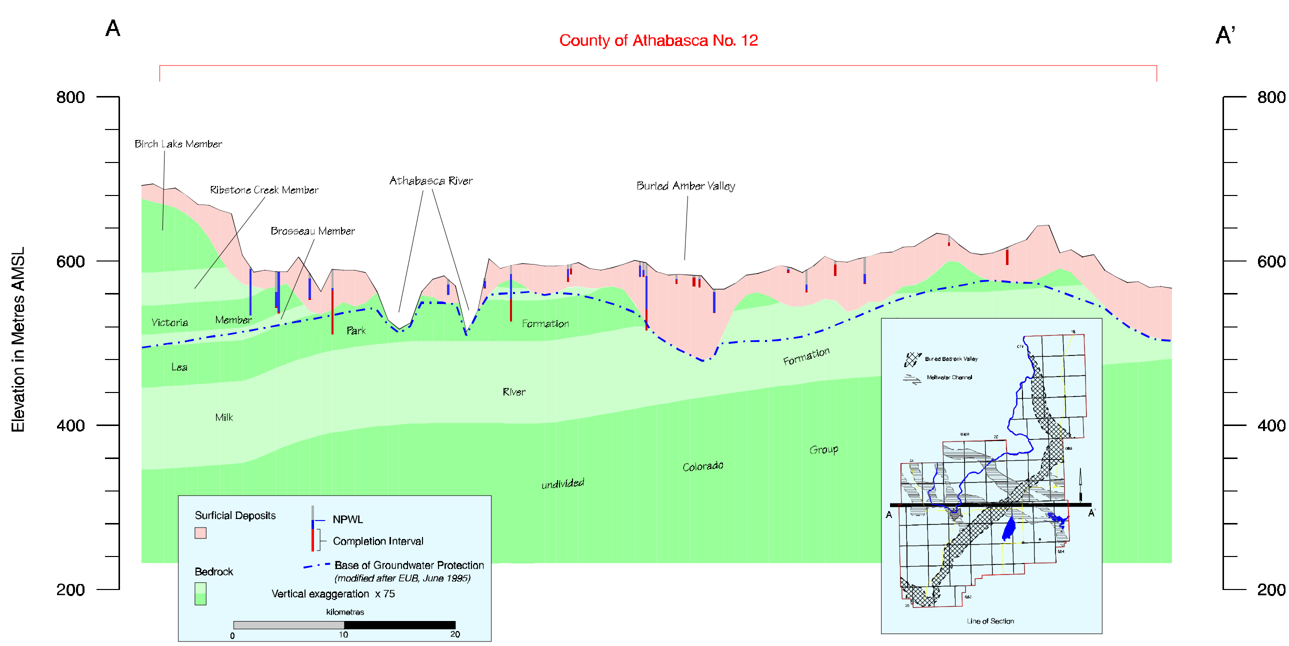


***Figure 7. Cross-Section A - A'***

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 1,553 of the 2,226 water wells completed in the surficial deposits; 45% of these have a casing diameter of more than 300 millimetres, and are assumed to be bored or dug water wells.

### 2) Bedrock Aquifers

The upper bedrock includes rocks that are less than 200 metres below the bedrock surface and above the Mannville 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[11] and water well screens are a necessity. The groundwater from the bedrock aquifers is usually chemically soft.

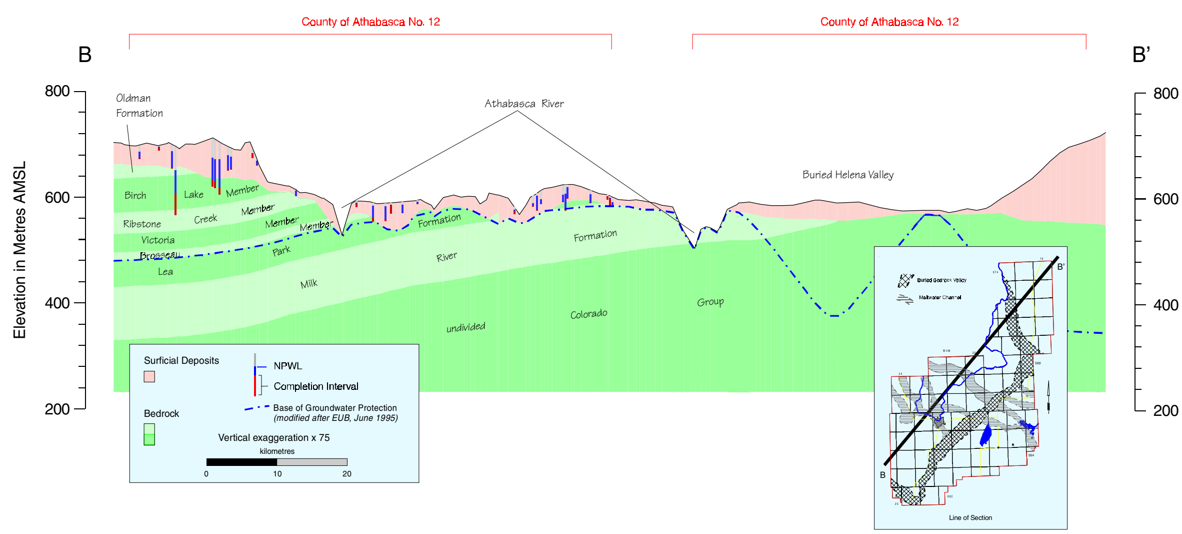


***Figure 8. Cross-Section B - B'***

The data for 599 water wells show that the top of the water well completion interval is below the top of bedrock, indicating that the water wells are completed in at least one bedrock aquifer. Within the County, casing-diameter information is available for 447 of the 599 water wells completed below the top of bedrock. Of these 447 water wells, 84% have surface-casing diameters of less than 300 mm and these bedrock water wells have been mainly completed nearly equally with either a screen, open hole, or with a perforated liner.

The upper bedrock includes a part of the Belly River Group, the Lea Park Formation, the Milk River Formation and the *undivided* Colorado Group (page A-7). In the County, the Lea Park and the Milk River formations and the *undivided* Colorado Group are regional aquitards[12]. The Mannville Group underlies the Colorado Group.

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11 See glossary
12 See glossary

## B. Aquifers in Surficial Deposits

The surficial deposits are the sediments above the bedrock surface. This includes pre-glacial materials, which were deposited before glaciation, and materials deposited directly or indirectly by glaciation. The *lower surficial deposits* include pre-glacial fluvial[13] and lacustrine[14] deposits. The lacustrine deposits include clay, silt and fine-grained sand. The *upper surficial deposits* include the more traditional glacial deposits of till[15] and meltwater deposits. In the County, no lower surficial deposits have been defined to date and the upper surficial deposits include mainly till.

### 1) Geological Characteristics of Surficial Deposits

While the surficial deposits are treated as one hydrogeological unit, they 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”.

The base of the surficial deposits is the bedrock surface, represented by the bedrock topography as shown on the adjacent map. Over the majority of the County, the upper surficial deposits are less than 50 metres thick (page A-11). The exceptions are mainly in association with areas where linear bedrock lows are present, where the deposits can have a thickness of up to 100 metres.

The main linear bedrock low in the County is designated as the Buried Amber Valley, as shown on Figure 9. This Valley trends north-northeast while occupying the present-day Tawatinaw River Valley, then turns northeast occupying the present-day Pine Creek and joins the Buried Helena Valley in township 069, range 17, W4M. The Buried Amber Valley is approximately four to ten kilometres wide, with local relief being up to 100 metres.

The Buried Helena Valley is present in the northeastern part of the County but is not well defined based on the bedrock topography contours; for purposes of illustration, the Buried Helena Valley was digitized from the Bedrock Topography of Alberta (Pawlowicz and Fenton, 1995). There are several connecting linear bedrock lows in the County. These lows trend mainly northwest to

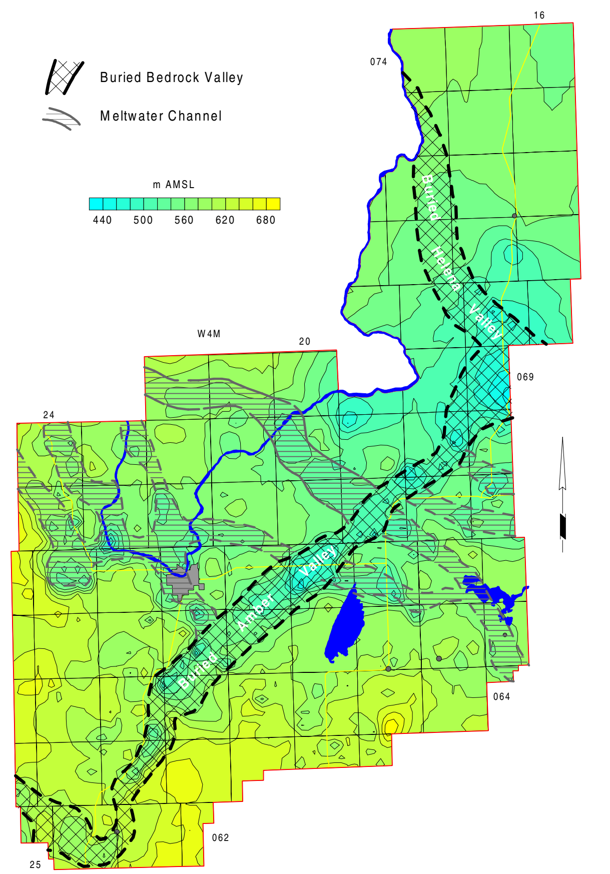


***Figure 9. Bedrock Topography***

13 See glossary
14 See glossary
15 See glossary

southeast in the County and are indicated as being of meltwater origin.

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.

The upper surficial deposits are either directly or indirectly a result of glacial activity. The deposits include till, with minor sand and gravel deposits, which are expected to occur mainly as isolated pockets. The greatest thickness of the upper surficial deposits is mainly in association with the linear bedrock lows; there are several areas where the upper surficial deposits are very thin or not present.

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 30% of the total thickness of the surficial deposits (page A-13). The areas where sand and gravel deposits constitute more than 30% of the total thickness of the surficial deposits may be in areas of buried bedrock valleys or meltwater channels or areas where linear bedrock lows exist but have not been identified due to a shortage of accurate bedrock control points.

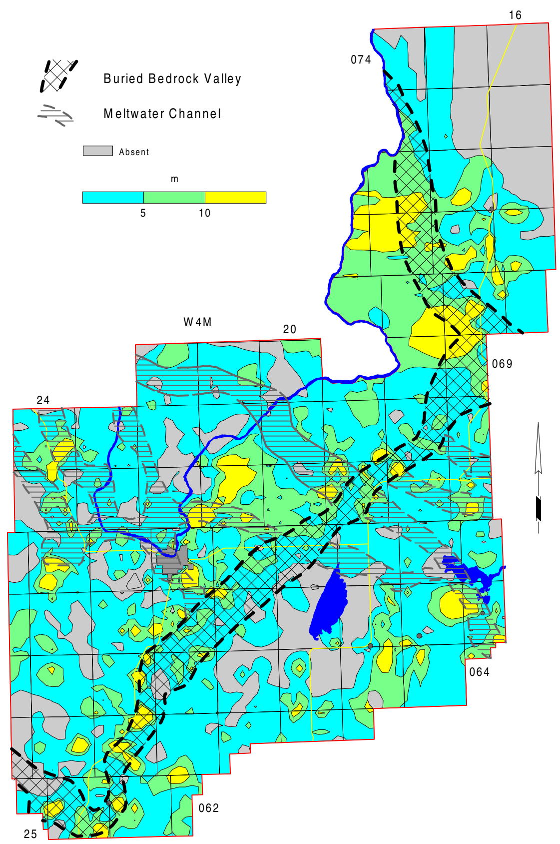

***Figure 10. Thickness of Sand and Gravel Deposits***

### 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. The thickness of saturated sand and gravel deposits (aquifer(s)) is mainly less than five metres, but can be more than ten metres.

From the present hydrogeological analysis, 4,938 water wells are completed in aquifers in the upper surficial deposits. This number of water wells is more than two 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.

Water wells completed in the upper surficial deposits occur throughout the project area. North of township 065 and east of range 23, W4M, there are no water wells completed in bedrock aquifers. This is the area where the upper bedrock is the Lea Park Formation or the Colorado Group.

### *a) Chemical Quality of Groundwater from Surficial Deposits*

The chemical analysis results of groundwaters from the sand and gravel aquifers in the surficial deposits indicate the groundwaters are generally chemically hard and high in dissolved iron. In the County of Athabasca, 50% of the groundwaters from the surficial aquifers have a chemical hardness of more than 400 mg/L.

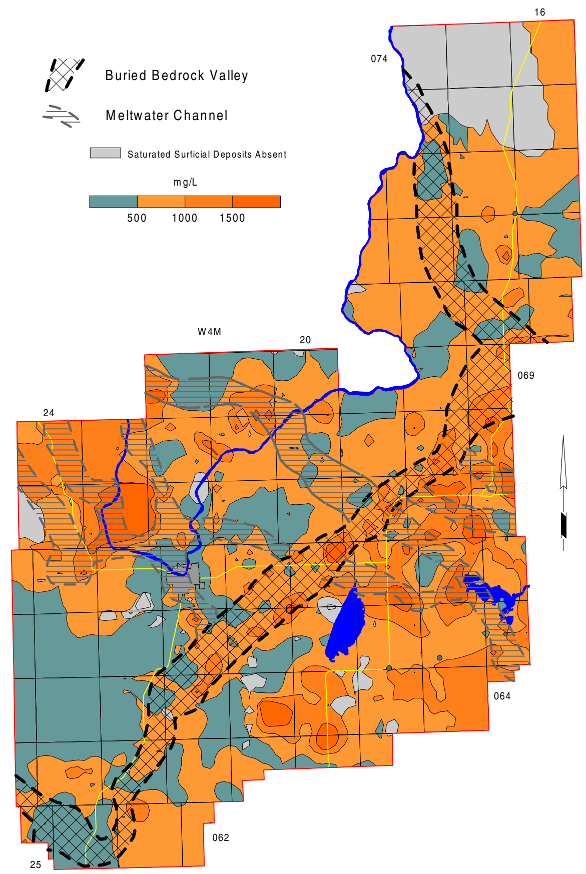


***Figure 11. Total Dissolved Solids in Groundwater from Surficial Deposits***

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 concentration of less than 1,000 mg/L. The groundwaters with a TDS concentration of more than 1,000 mg/L occur mainly in the Buried Amber Valley and in the vicinity of meltwater channels as shown on Figure 11. The large expanse showing saturated surficial deposits to be absent in the northeastern part of the County is a result of gridding a limited amount of data available for that area. 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 mainly less than 100 mg/L.

| Constituent | Range for County in mg/L Minimum | Maximum | Average | Recommended Maximum Concentration GCDWQ |
|---|---|---|---|---|
| Total Dissolved Solids | 105 | 7316 | 1444 | 500 |
| Sodium | 2 | 1762 | 235 | 200 |
| Sulfate | 0 | 4379 | 585 | 500 |
| Chloride | 0 | 2217 | 22 | 250 |
| Nitrate + Nitrite (as N) | 0 | 157 | 6.5 | 10 |

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 in Surficial Aquifers***

The nitrate + nitrite (as N) concentrations in the groundwaters from the surficial deposits exceed the maximum acceptable concentrations (MAC) of 10 mg/L mainly in the western part of the County.

The minimum, maximum and average concentrations of TDS, sodium, sulfate, chloride and nitrate + nitrite (as N) in the groundwaters from water wells completed in the surficial deposits in the County have been compared to the 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 chloride and nitrate + nitrite (as N) concentrations do not exceed the guidelines.

### 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 75% of the County.

#### *a) 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 ten metres thick; in about 25% 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. However, the area in the northeastern part of the County that is indicated on Figure 12 as being unsaturated or absent may be a reflection of the limited amount of data.

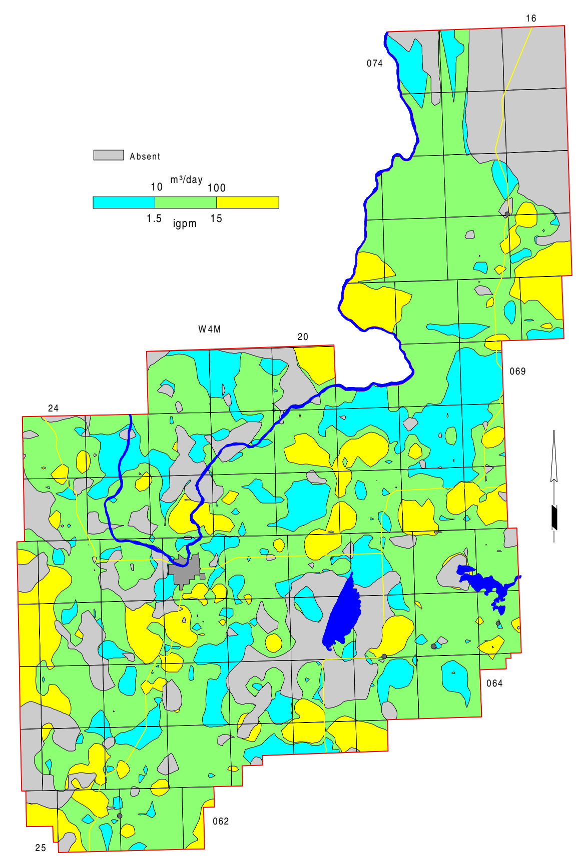


***Figure 12. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer***

#### *b) 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 from this Aquifer, and construction of a water supply well into the underlying bedrock may be the only alternative in the southwestern part of the County.

A groundwater study conducted for CN Rail (Hydrogeological Consultants Ltd. (HCL), November 1991) determined a long-term yield of 60 m³/day for a water supply well at the Bondiss Station Grounds in NW 05-065-18 W4M that is completed in the Upper Sand and Gravel Aquifer. The chemical data from a groundwater sample collected from the CN Rail water supply well in October 1991 indicated a TDS concentration of 542 mg/L, a chloride concentration of 3 mg/L and a sulfate concentration of 31 mg/L. The groundwater from this water supply well is a bicarbonate-type water with no dominant cation.

# C. Bedrock

### 1) Geological Characteristics

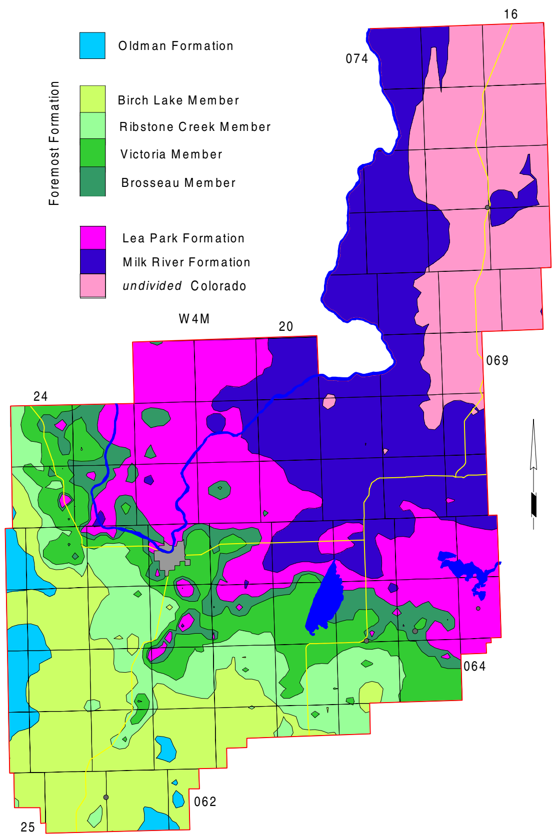


***Figure 13. Bedrock Geology***

The upper bedrock in the County includes the Belly River Group, the Lea Park Formation and the Colorado Group. 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.

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 80 metres. The Foremost Formation includes the continental facies[16] within the County.

The *continental* Foremost Formation is less than 180 metres thick and is between the overlying Oldman Formation and the underlying Lea Park Formation. In the *continental* Foremost Formation, individual members have been identified. The members include both sandstone and shale units. 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 deposits.

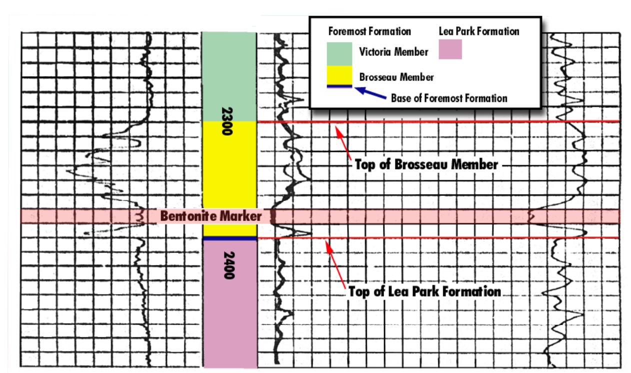


***Figure 14. E-Log showing Base of Foremost Formation***

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 50 metres above the Milk

16 See glossary

River Shoulder.

The Lea Park Formation is approximately 50 metres thick and subcrops in the central part of the County. 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 only a brief summary of the Lea Park Aquitard in the following paragraph of this report.

The apparent yields for water wells completed through the Lea Park Aquitard are less than 15 $m^3$/day. The groundwaters from the Lea Park Aquitard are mainly a sodium-bicarbonate type with TDS mainly between 1,000 and 1,500 mg/L. The sulfate concentrations are expected to be less than 500 mg/L and chloride concentrations are expected to be mainly less than 250 mg/L. Structure-contour maps associated with the Lea Park Formation 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 below the Colorado Group. 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 Colorado Group includes the Milk River Formation, the *undivided* Colorado Group and the Viking Formation. The Milk River Formation is present under most of the County but subcrops in the northeastern part of the 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 Athabasca, the Colorado Group has limited importance and there will be only a brief summary in the following paragraph of this report.

The apparent yields for water wells completed through the Milk River Aquitard are less than 15 $m^3$/day. The groundwaters from the Milk River Aquitard are mainly a sodium-bicarbonate type with TDS mainly less than 1,000 mg/L. The sulfate concentrations are expected to be less than 500 mg/L, with concentrations decreasing with depth of burial. The chloride concentrations are less than 250 mg/L, with concentrations increasing with depth of burial. Structure-contour maps of the Milk River Formation are included in Appendix A and on the CD-ROM. The *undivided* Colorado Group, composed mostly of shale, underlies the Milk River Formation, has a thickness of 250 metres, is present under all of the project area, but subcrops in the extreme northeastern part of the County. The Viking Formation, a 50-metre-thick sandstone unit that sometimes can be distinguished near the base of the Colorado Group, is the only geological unit within the Colorado Group with any significant permeability. However, even the Viking Formation would not be expected to have yields of greater than 20 $m^3$/day.

### 2) Aquifers

Of the 5,671 water wells in the database, 599 were defined as being completed below the top of bedrock. However, at least a reported completion depth is available for the majority of boreholes[17] and assigning the boreholes to specific geologic units is possible only if the completion interval is identified. In order to make use of additional information within the groundwater database, it was assumed that if the total drilled depth of a borehole was more than ten metres below the top of a particular geological unit, the borehole was assigned to the particular geological unit. With this assumption, it has been possible to designate the aquifer of completion for 902 additional boreholes. There are 779 boreholes that have been identified as being completed in bedrock aquitards/aquifers below the Brosseau Member, or in more than one bedrock aquifer.

| Geological Unit | No. of Boreholes |
|---|---|
| Oldman | 5 |
| Birch Lake | 121 |
| Ribstone | 168 |
| Victoria | 264 |
| Brosseau | 164 |
| Other | 386 |
| Multiple Completions | 393 |
| Total | 1,501 |

***Table 5. Completion Aquifer***

The bedrock boreholes are mainly completed in the Victoria and Ribstone Creek aquifers, as shown in the above table. More than 25% of the bedrock boreholes are likely to have multiple completions, of which 96% have the top of the first completion interval less than 100 metres below ground level.

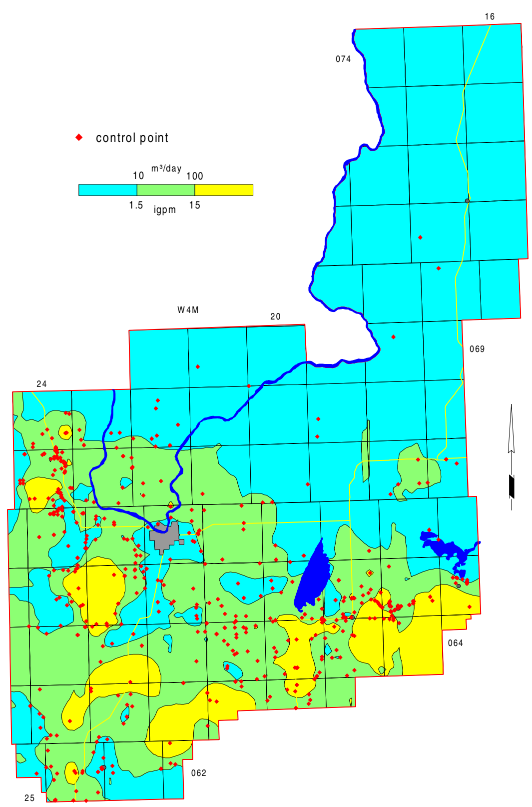


***Figure 15. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)***

There are 527 records for bedrock water wells that have apparent yield values, 35% of all bedrock water wells. In the County, yields for water wells completed in the upper bedrock aquifer(s) are mainly between ten and 100 m³/day. The few areas with yields of more than 100 m³/day indicated on the adjacent figure are in the southern part of the County. These higher yield areas may identify areas of increased permeability resulting from the weathering process.

| 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 |
|---|---|---|---|---|
| Birch Lake | 58 | 26 | 22 | 10 |
| Ribstone Creek | 98 | 36 | 51 | 11 |
| Victoria | 160 | 42 | 96 | 22 |
| Brosseau | 116 | 12 | 62 | 42 |
| Totals | 432 | 116 | 231 | 85 |

***Table 6. Apparent Yield of Bedrock Aquifers***

Of the 527 water well records with apparent yield values, 432 have been assigned to aquifers associated with specific geologic units that are being discussed. Fifty-three percent or 231 of the water wells completed in the bedrock aquifers have apparent yields that range from ten to 100 m³/day, and 27% or 116 have apparent yields that are less than ten m³/day, as shown in the table above.

17 See glossary

### 3) Chemical Quality of Groundwater

The TDS concentrations in the groundwaters from the upper bedrock aquifer(s) range from less than 500 to more than 2,500 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 75% of the County. The higher chloride values can be expected in the southeastern part of the County, with 65% of the bedrock water wells having completion depths of less than 70 metres.

In 95% of the County, the fluoride ion concentrations in the groundwaters from the upper bedrock aquifer(s) are less than 1 mg/L.

The Piper tri-linear diagrams[18] (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.

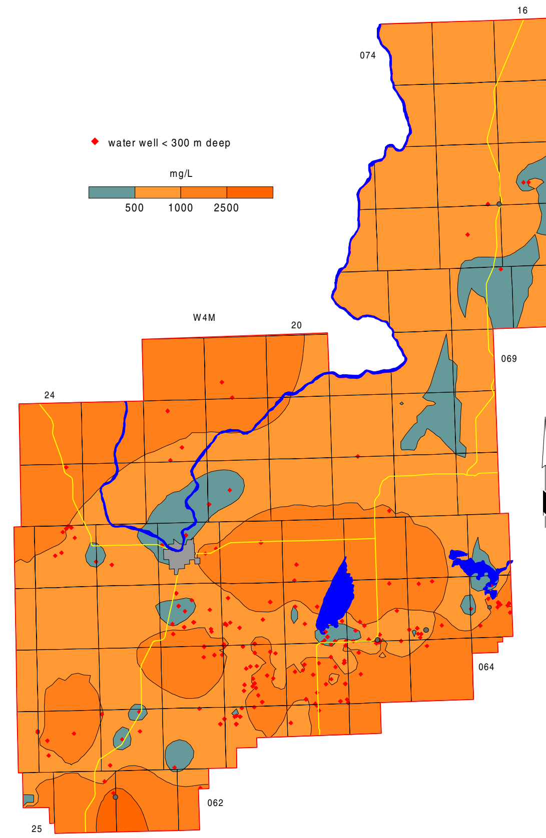


***Figure 16. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)***

[18] See glossary

### 4) 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 the southwestern part of the County. The structure contours show the Member has a maximum thickness of 65 metres.

#### *a) Depth to Top*

The depth to the top of the Birch Lake Member is mainly less than 30 metres below ground level and is a reflection of the thickness of the surficial deposits.

#### *b) Apparent Yield*

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

#### *c) Quality*

The groundwaters from the Birch Lake Aquifer are mainly a sodium-bicarbonate type (see CD-ROM), with the TDS concentrations ranging mainly from 500 to 750 mg/L. The lower values of TDS occur mainly in townships 063 and 064, ranges 19, 20 and 21, 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.

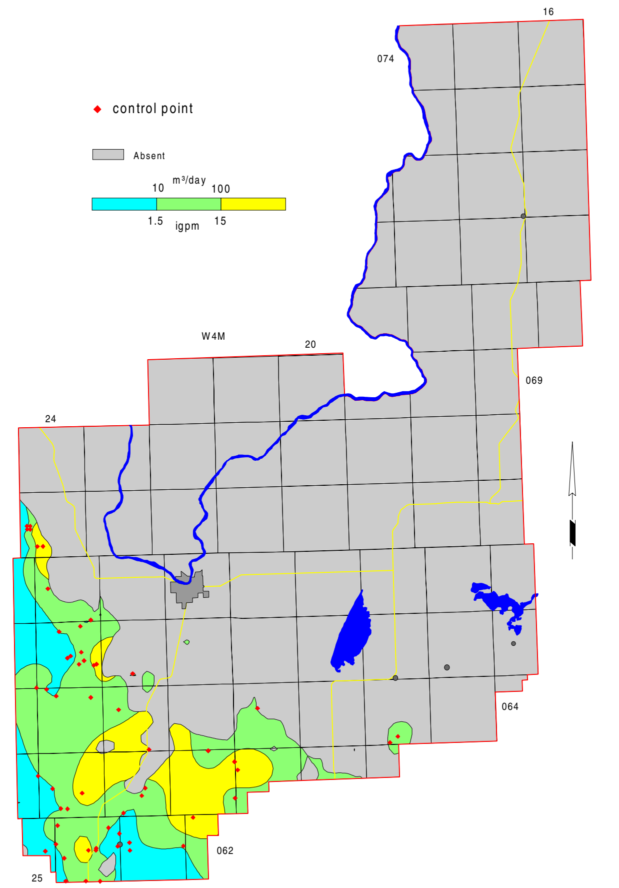


***Figure 17. Apparent Yield for Water Wells Completed through Birch Lake Aquifer***

### 5) 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 southwestern one-third of the County. The structure contours show the Member having a maximum thickness of 50 metres.

#### *a) Depth to Top*

The depth to the top of the Ribstone Creek Member is mainly less than 80 metres below ground level but can be more than 120 metres where the Oldman Formation is the upper bedrock.

#### *b) Apparent Yield*

The apparent yields for individual water wells completed through the Ribstone Creek Aquifer are mainly in the range of ten to 50 m³/day, with 25% of the values being more than 50 m³/day. The areas where water wells with higher yields are expected are mainly in the western and eastern parts of the County where the Aquifer is present.

#### *c) Quality*

The groundwaters from the Ribstone Creek Aquifer are mainly calcium-bicarbonate or sodium-bicarbonate types (see Piper diagram on CD-ROM). The TDS concentrations range from less than 1,000 to more than 1,500 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, with concentrations increasing with depth of burial of the Aquifer.

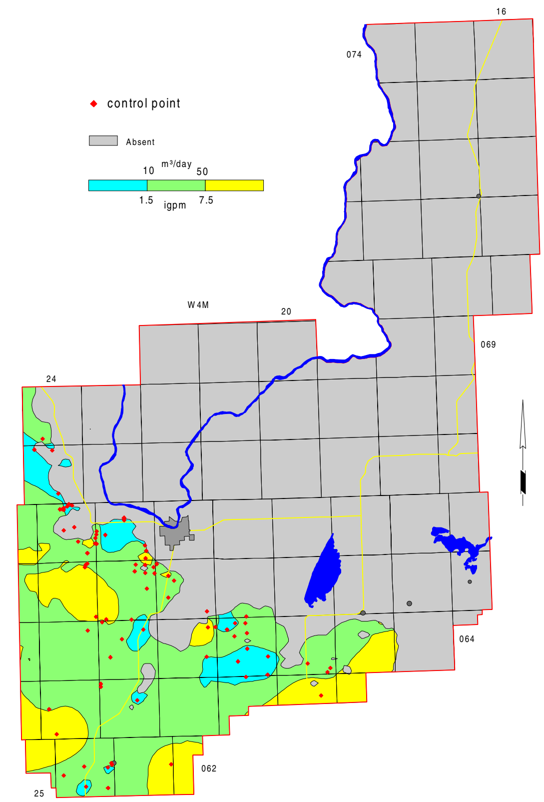


***Figure 18. Apparent Yield for Water Wells Completed through Ribstone Creek Aquifer***

### 6) 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 the southwestern third of the County. The structure contours show the Member having a maximum thickness of 35 metres.

#### *a) Depth to Top*

The depth to the top of the Victoria Member is mainly less than 120 metres below ground level but can be more than 160 metres in parts of the southwestern part of the County, where the Oldman Formation is the upper bedrock.

#### *b) Apparent Yield*

The apparent yields for individual water wells completed through the Victoria Aquifer range mainly from ten to 100 m³/day. However, the control points are mainly limited to where the Member is the upper bedrock. The adjacent map indicates that water wells with apparent yields of more than 100 m³/day are expected mainly in townships 063 and 064, ranges 19 and 20, W4M. There are little or no data for the Aquifer in the southwestern part of the County. In this area, the Victoria Aquifer would be at a depth of more than 120 metres.

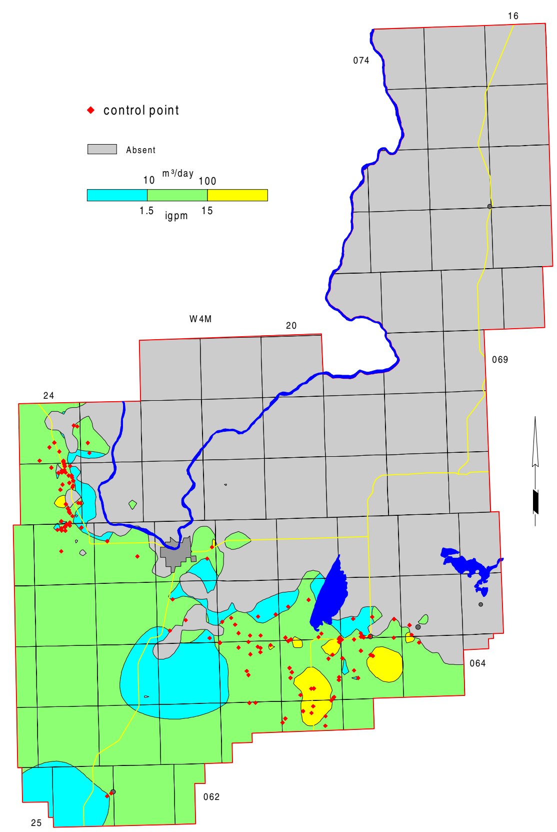


***Figure 19. Apparent Yield for Water Wells through Victoria Aquifer***

#### *c) Quality*

The groundwaters from the Victoria Aquifer are mainly calcium-bicarbonate or sodium-bicarbonate types (see Piper diagram on CD-ROM). Total dissolved solids concentrations are expected to range mainly from 750 to 1,500 mg/L, although there is a paucity of data where the depth of burial is greater than 100 metres. However, since most of the Victoria Member is above the Base of Groundwater Protection, the TDS would still be expected to be less than 4,000 mg/L.

Sulfate concentrations of less than 100 mg/L in the groundwaters from the Victoria Aquifer can be expected where the Victoria Member is the upper bedrock, and sulfate concentrations ranging mainly from 100 to 500 mg/L can be expected in the rest of the County where the Member is present. The indications are that chloride concentrations are expected to be less than 50 mg/L.

### 7) 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 the southwestern third of the County. The structure contours show the Member having an average thickness of 15 metres.

*a) Depth to Top*

The depth to the top of the Brosseau Member is variable, ranging from less than 20 metres near the Athabasca River to more than 220 metres in the southwestern part of the County.

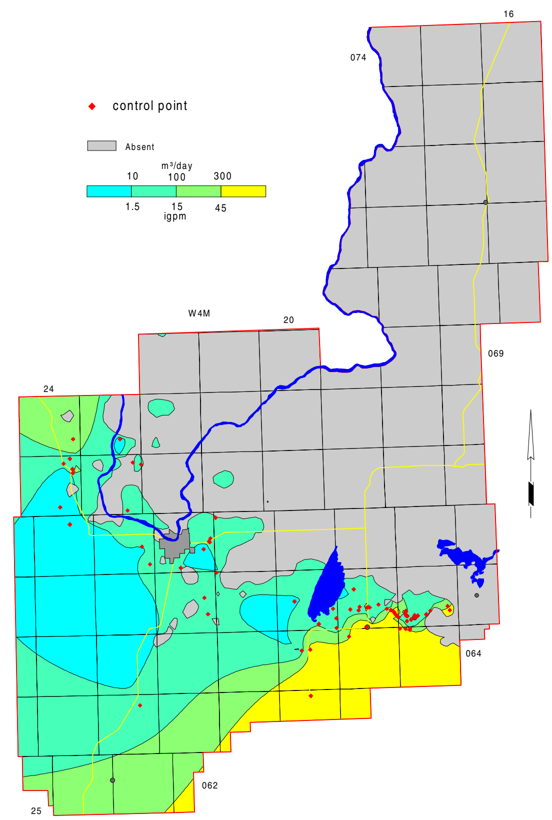


***Figure 20. Apparent Yield for Water Wells Completed through Brosseau Member***

*b) Apparent Yield*

The apparent yields for individual water wells completed through the Brosseau Aquifer range mainly from ten to 100 m³/day. However, the control points are mainly limited to where the Member is the upper bedrock. The adjacent map indicates that water wells with apparent yields of more than 300 m³/day are expected mainly in townships 063 and 064, ranges 18 to 20, W4M. There are little or no data for the Aquifer in the southwestern part of the County. In this area, the Brosseau Aquifer would be at a depth of more than 140 metres.

*c) Quality*

There are nine 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 Athabasca. The groundwaters are bicarbonate-type waters with no dominant cation.

There are eight water well records in the database for the County with TDS, sulfate and chloride concentrations; the TDS values are mainly between 500 and 1,000 mg/L, the sulfate values are mainly less than 250 mg/L, and the chloride values are less than 100 mg/L.

# VI. GROUNDWATER BUDGET

## A. Hydrographs

There is one location in the County where water levels are being measured and recorded with time. This site is an observation water well (Obs WW) that is part of the AE regional groundwater-monitoring network. The hydrograph for AE Obs WW No. 252 in 13-06-065-24 W4M is shown on the adjacent figure, in Appendix A, and included on the CD-ROM.

The water-level fluctuations in AE Obs WW No. 252 in 13-06-065-24 W4M have been compared to the summer precipitation measured at the Cross Lake weather station from 1986 to 1998; the comparison is shown in the adjacent figure. The observation water well is completed at a depth of 26.8 metres below ground level in the Upper Surficial Deposits. The summer precipitation includes the total precipitation measured in May, June, July and August of each year. The comparison shows that, in general, the water-level fluctuation does not reflect the changes in summer precipitation.

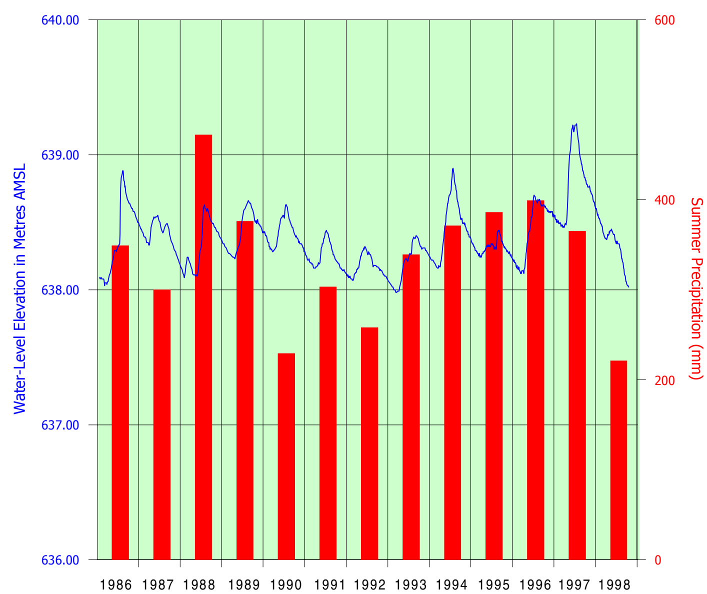


***Figure 21. Annual Precipitation vs Water Levels in AE Obs WW No. 252***

The water-level graph does show a “typical” yearly fluctuation in the water levels in aquifers in Alberta. The water level rises in late spring/early summer and declines until late spring/early summer of the next year. In 1995, there is no pronounced late spring/early summer water-level rise but a slight rise late in the summer. This would suggest that there was insufficient moisture available for recharge as the frost was leaving the ground but sufficient precipitation later in the year to overcome any soil moisture deficiency to allow for some groundwater recharge.

## B. 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.

### 1) Quantity of Groundwater

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 the surficial deposits. In areas where the elevation of the water-level surface is below the bedrock surface, the surficial deposits are not saturated. The water-level map for the surficial deposits shows a general flow direction toward the Athabasca River.

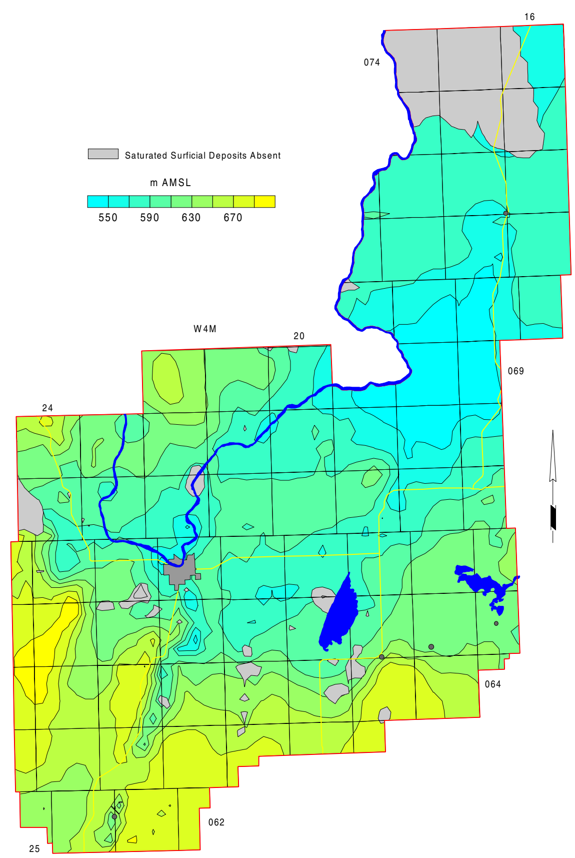


***Figure 22. Non-Pumping Water-Level Surface in Surficial Deposits***

### 2) Recharge/Discharge

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

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

#### *a) 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 (i.e. recharge) 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.

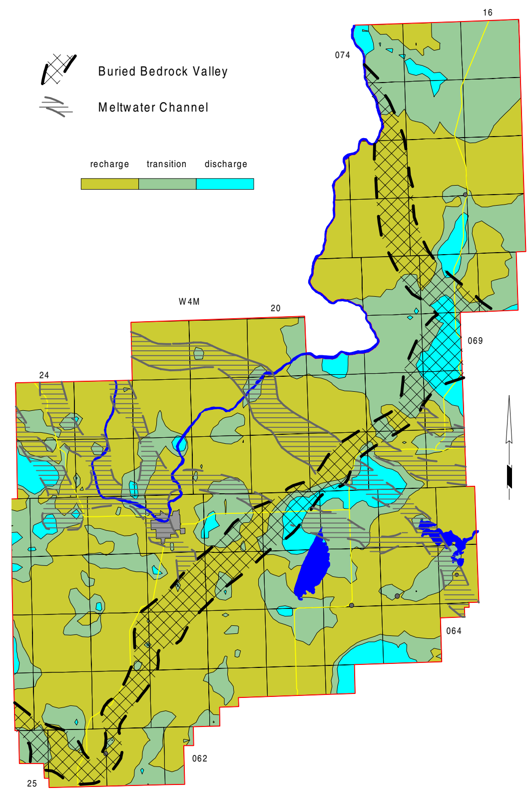


**Figure 23. Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)**

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

*b) 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.

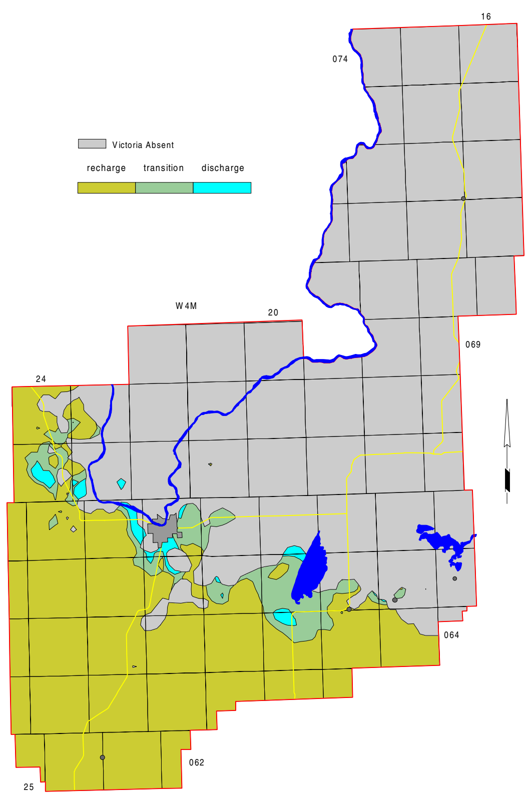


**Figure 24. Recharge/Discharge Areas between Surficial Deposits and Victoria Aquifer**

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

## C. Groundwater Flow Model

A USGS 3-D Modflow groundwater model was prepared for the County. A simulation was completed using the model. The model has five layers, one layer for each geological unit. The values for the transmissivity distribution for each geological unit were determined using an automated calibration method. The main criterion for the calibration is the water level in the surficial deposits. The initial values for transmissivity distribution were the values determined from the present study. The model results are considered very approximate and are meant to support the regional study. The model needs considerably more data before it could be used for management of the groundwater resource in the County.

The adjacent figure shows the water-level surface for the surficial deposits for the model. There are five main groundwater recharge areas; the main discharge points are the Athabasca River and Tawatinaw River.

The results of the model were used to prepare the following table:

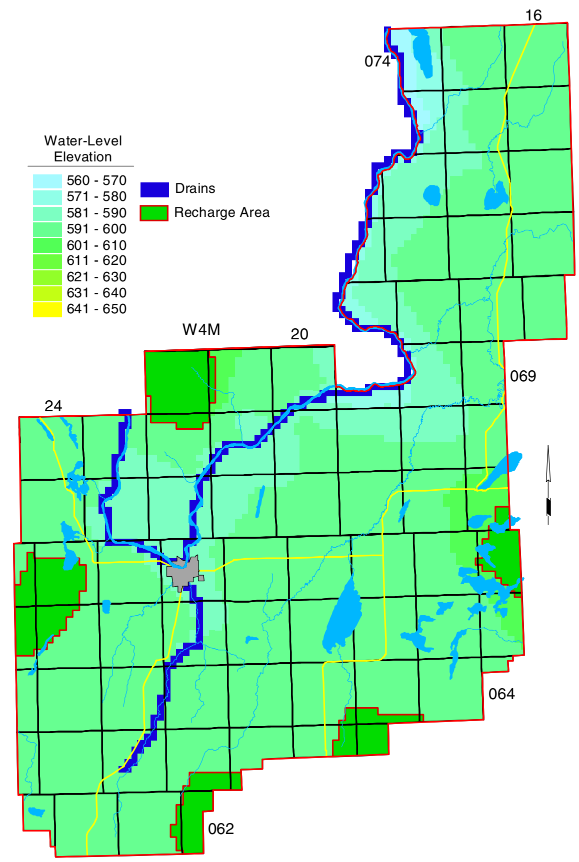


***Figure 25. Modelled Non-Pumping Water-Level Surface in Surficial Deposits***

| Aquifer/Area | Horizontal Volume (m³/day) | Vertical Volume (m³/day) | General Horizontal Direction of Flow | Volume (m³/day) | Aquifer Volume (m³/day) | Authorized Diversion (m³/day) |
|---|---|---|---|---|---|---|
| Upper Surficial | | | | | 10,700 | 2,956 |
| Southeastern area | 5160 | 2300 | northwest | 7460 | | |
| Southwestern area | 975 | 1785 | northeast | 2760 | | |
| Northern area | 511 | 0 | south | 511 | | |
| Birch Lake | | | | | 4,500 | 54 |
| Southeastern area | 1340 | 1000 | northwest | 2340 | | |
| Southwestern area | 1450 | 700 | northeast | 2150 | | |
| Ribstone Creek | | | | | 3,300 | 90 |
| Southeastern area | 850 | 900 | northwest | 1750 | | |
| Southwestern area | 980 | 600 | northeast | 1580 | | |
| Victoria | | | | | 2,900 | 87 |
| Southeastern area | 480 | 500 | northwest | 980 | | |
| Southwestern area | 1480 | 400 | northeast | 1880 | | |
| Brosseau | | | | | 1,600 | 14 |
| Southeastern area | 565 | 565 | northwest | 1130 | | |
| Southwestern area | 250 | 250 | northeast | 500 | | |

***Table 7. Groundwater Budget***

The data provided in the adjacent 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.

## VII. POTENTIAL FOR GROUNDWATER CONTAMINATION

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

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

The potential for groundwater contamination is based on the concept that the easier it is for a liquid contaminant to move downward, the easier it is for the groundwater to become contaminated. In areas where there is groundwater discharge, liquid contaminants cannot enter the groundwater flow systems to be distributed throughout the area. In 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 Agricultural Region of Alberta Soil Inventory Database (AGRASID) (CAESA, 1998) has been reclassified based on the relative permeability. The classification of materials is as follows:

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

To identify the areas where sand and gravel can be expected within one metre of the ground surface, all groundwater database records with lithologies were reviewed. From a total of 4,529 records with lithological descriptions in the area of the County, 936 have the top of a sand and gravel deposit present within one metre of ground level. In the remaining 3,593 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.

### 1) Risk of Groundwater Contamination Map

The information from the reclassification of AGRASID 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 8. Risk of Groundwater Contamination Criteria***

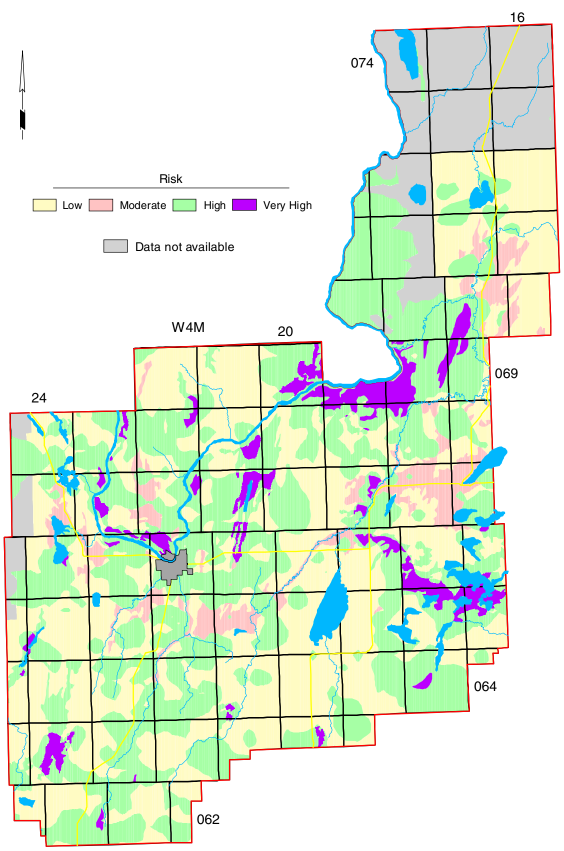


***Figure 26. Risk of Groundwater Contamination***

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.

## VIII. RECOMMENDATIONS

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

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

The quality of the data in the groundwater database is affected by two factors: a) the technical training of the persons collecting the data, and b) the quality control of the data. The possible options to upgrade the database include the creation of a "super" database, which includes only verified data. The first step would be to field-verify the 306 existing water wells listed in Appendix E. These water well records indicate that a complete water well drilling report is available along with at least a partial chemical analysis. The level of verification would have to include identifying the water well in the field, obtaining meaningful horizontal coordinates for the water well and the verification of certain parameters such as water level and completed depth. Even though the water wells for which the County has responsibility do not satisfy the above criteria, it is recommended that they be field-verified, water levels be measured, a water sample be collected for analysis, and a short aquifer test be conducted. There is one County-operated water well that is also included in Appendix E. An attempt to update the quality of the entire database is not recommended.

In general, the elevation of the Base of Groundwater Protection may be too shallow along stretches of the Athabasca River. It is recommended that the elevation of the Base of Groundwater Protection be reviewed by EUB and AE in the study area, specifically along the Athabasca River and the other areas indicated on Figure 4 where the water wells are completed below the Base of Groundwater Protection.

While there are a few areas where water-level data are available, on the overall, there are an insufficient number of water levels to set up a groundwater budget. One method to obtain additional water-level data is to solicit the assistance of the water well owners who are stakeholders in the groundwater resource. In the M.D. of Rocky View and in Flagstaff County, water well owners are being provided with a tax credit if they accurately measure the water level in their water well once per week for a year. A pilot project indicated that approximately five years of records are required to obtain a reasonable data set. The cost of a five-year project involving 50 water wells would be less than the cost of one drilling program that may provide two or three observation water wells.

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 ten metres. The coordinates must be in 10TM NAD 27 or some other system that will allow conversion to 10TM NAD 27 coordinates.
2) A four-hour aquifer test (two hours of pumping and two hours of recovery) should be performed with the water well to obtain a realistic estimate for the transmissivity of the aquifer in which the water well is completed.

3) Water samples should be collected for chemical analysis after five and 115 minutes of pumping, and analyzed for major and minor ions.

A list of 306 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 AE Resource Data Division in an electronic form. The money presently being spent by AE 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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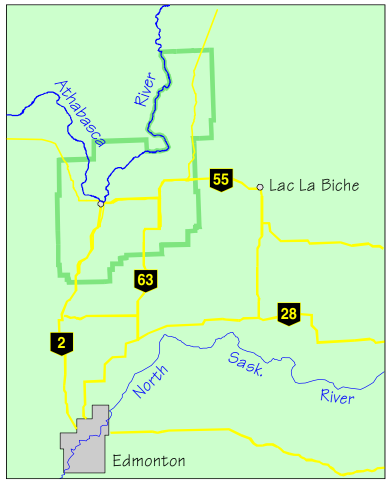
# X. Conversions

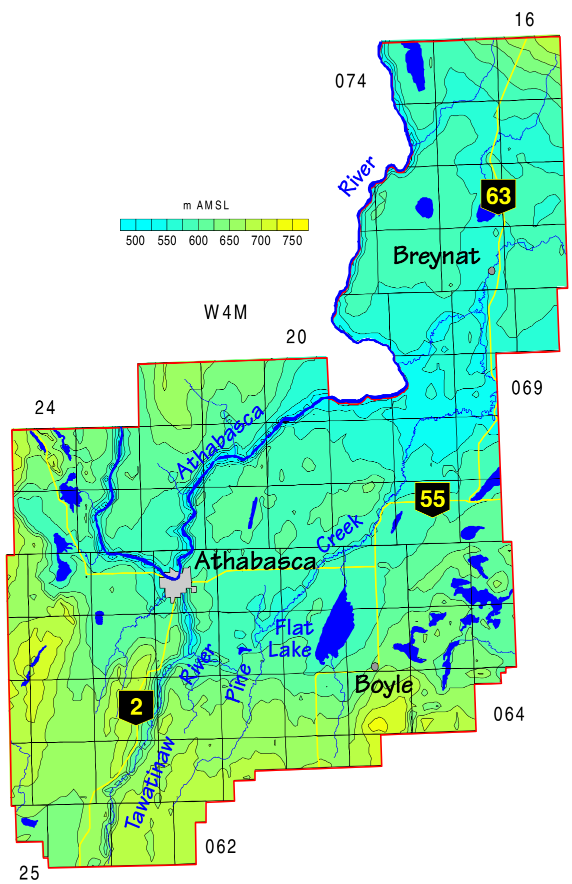
| Multiply | by | To Obtain |
|---|---|---|
| **Length/Area** | | |
| feet | 0.304 785 | metres |
| metres | 3.281 000 | feet |
| hectares | 2.471 054 | acres |
| centimetre | 0.032 808 | feet |
| centimetre | 0.393 701 | inches |
| acres | 0.404 686 | hectares |
| inchs | 25.400 000 | millimetres |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

## COUNTY OF ATHABASCA NO. 12
## Appendix A

### Hydrogeological Maps and figures

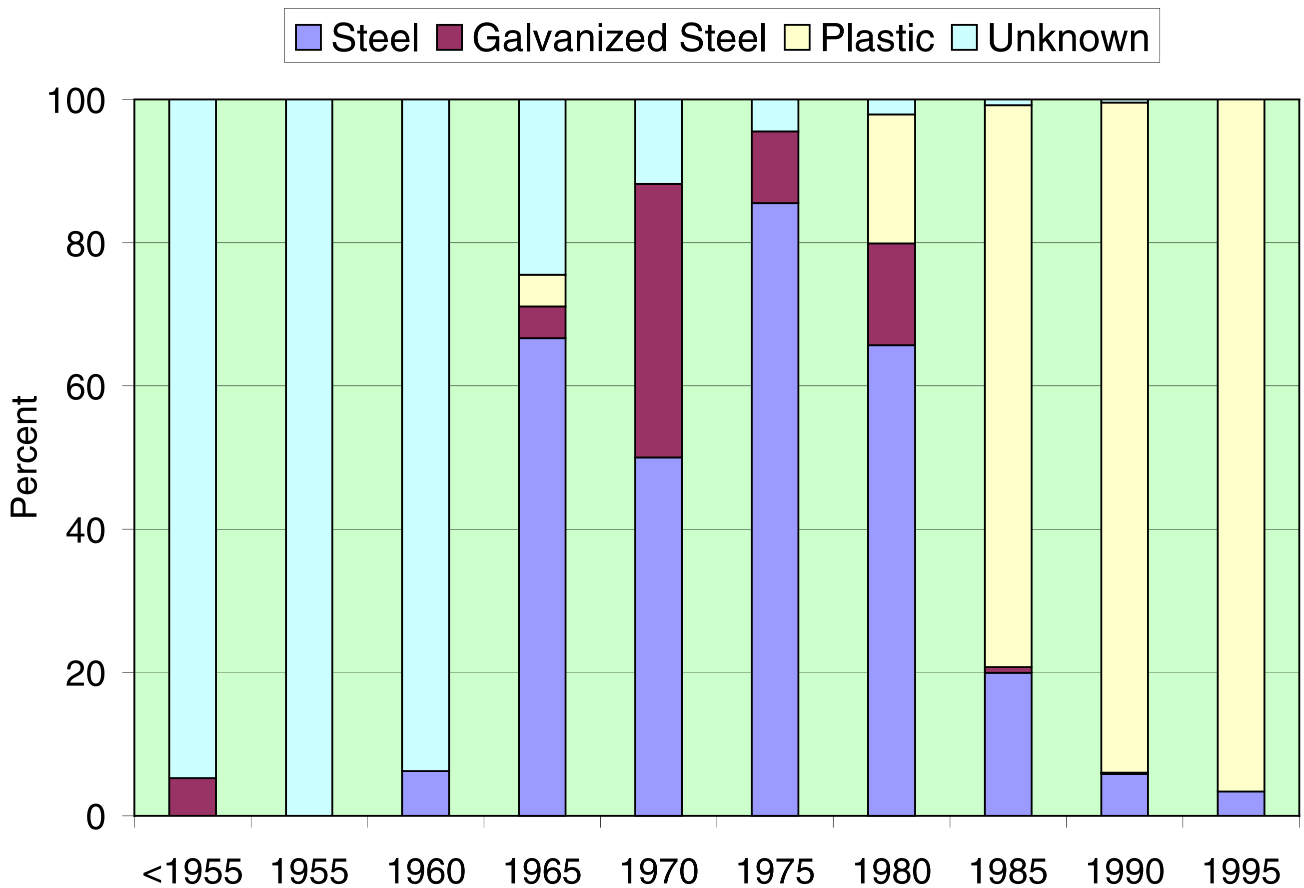
## Index Map



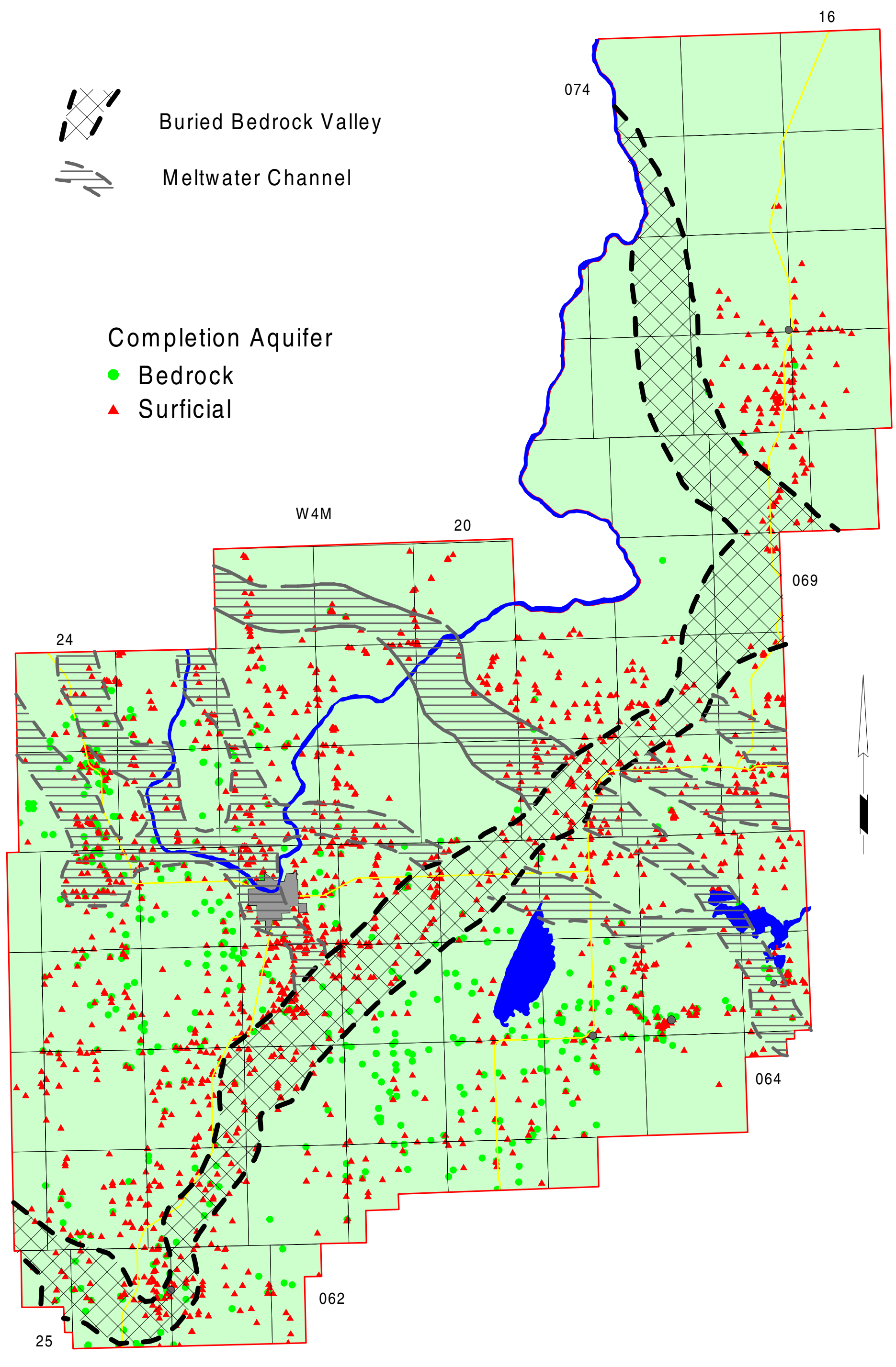




**County of Athabasca No. 12**

## Surface Casing Types used in Drilled Water Wells

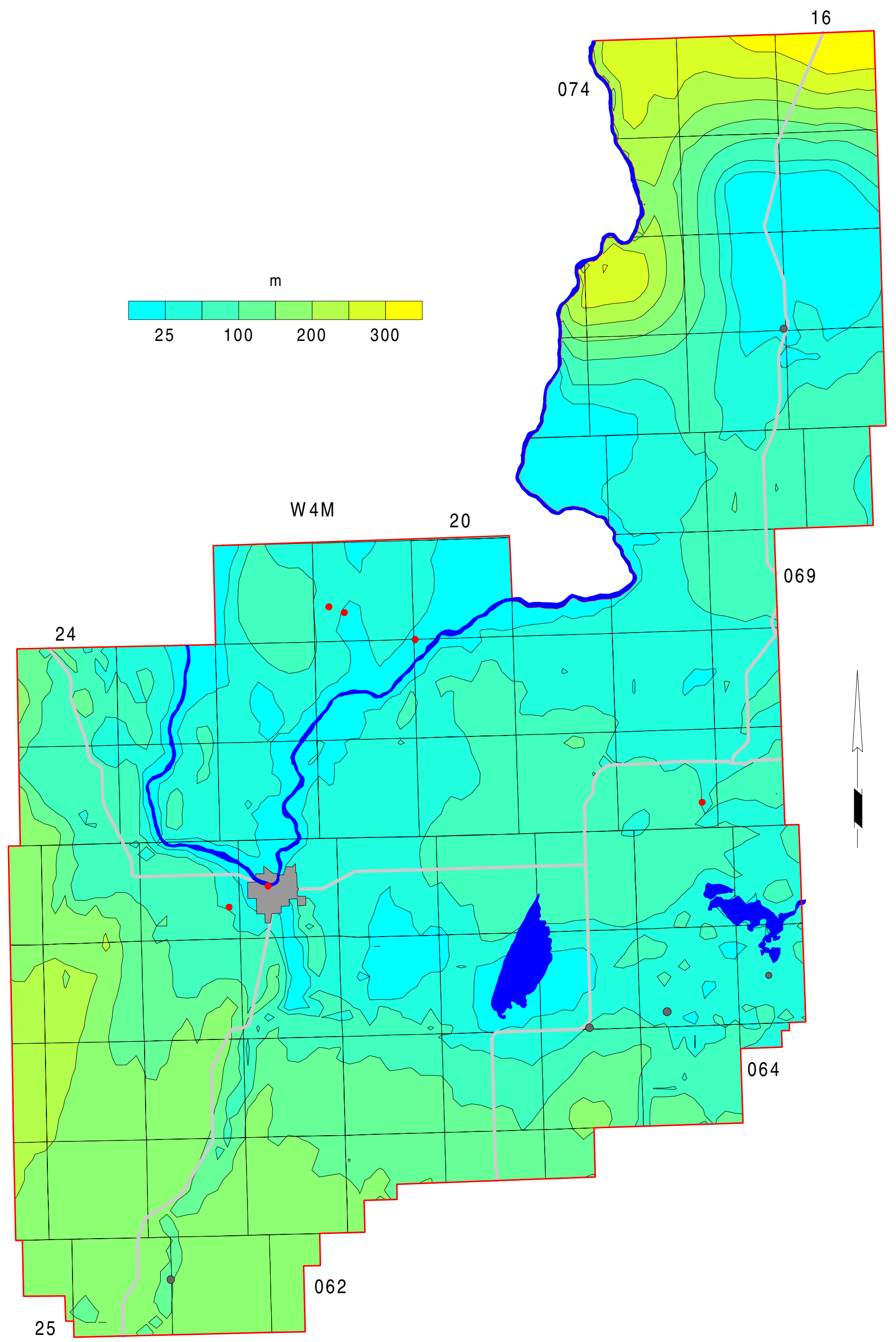


## Location of Water Wells



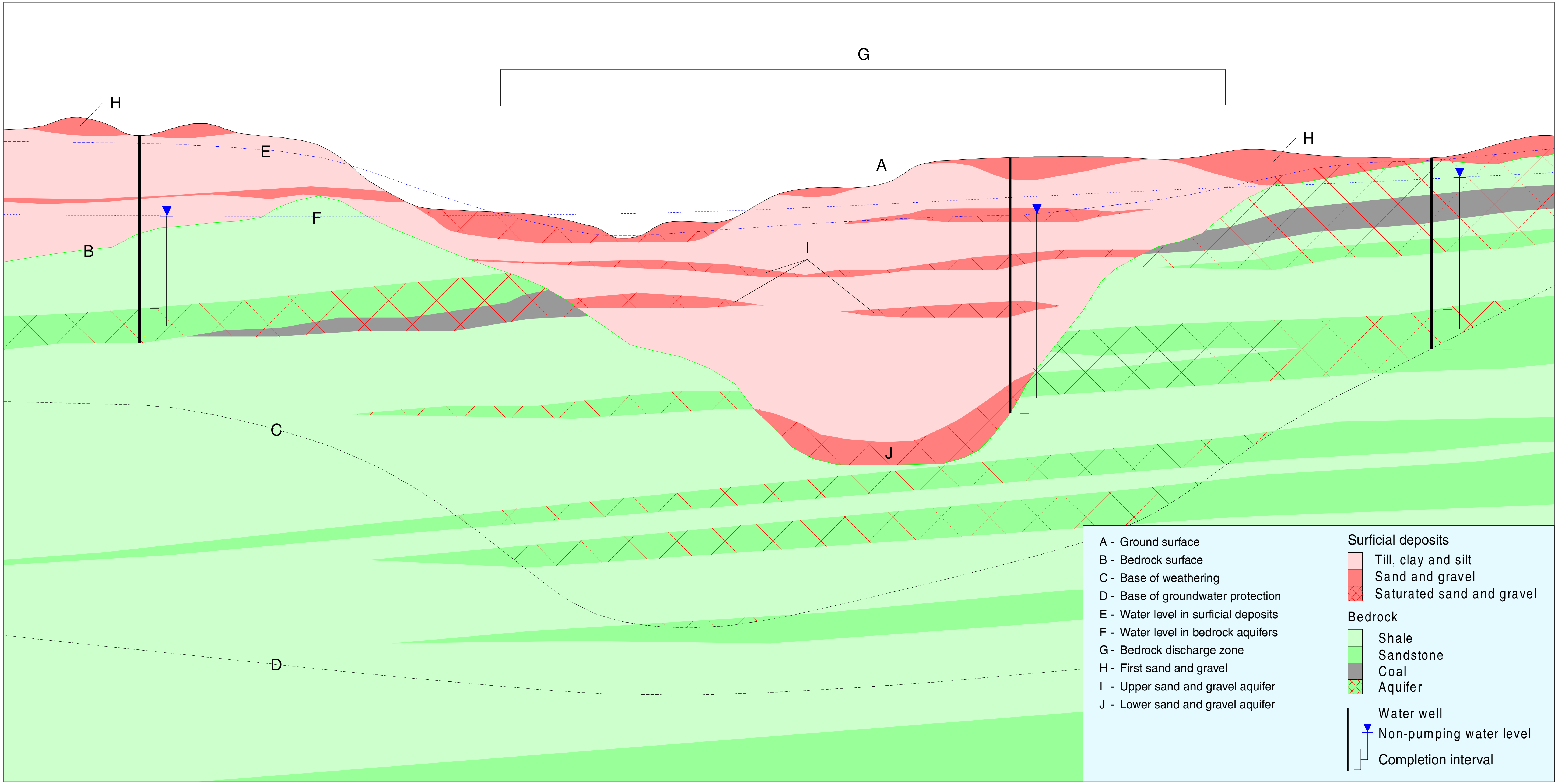
# Depth to Base of Groundwater Protection

*(modified after EUB, 1995)*



## Generalized Cross-Section

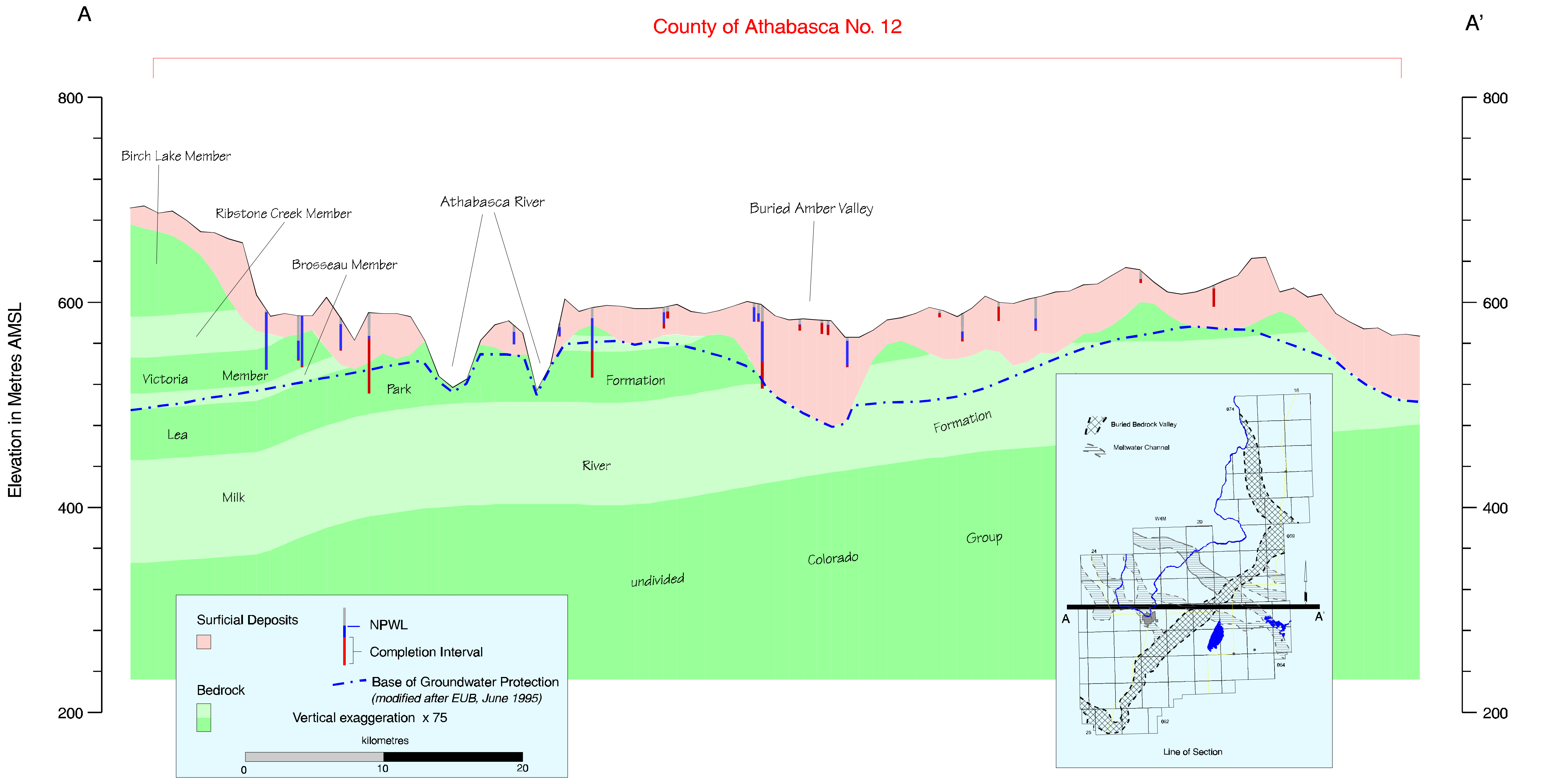
*(for terminology only)*



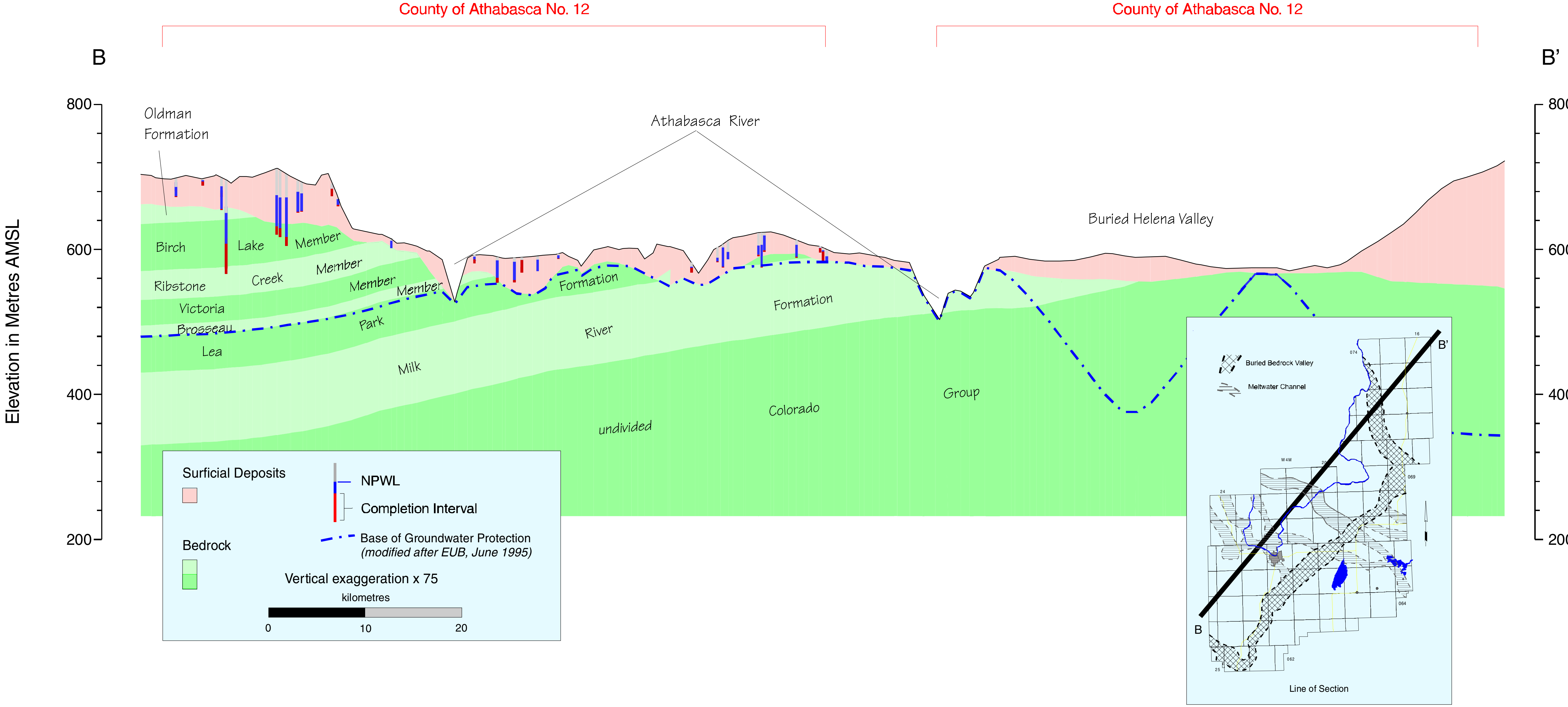
## Geologic Column

| Lithology | Lithologic Description | Group and Formation: Average Thickness (m) | Group | Group and Formation: Designation | Member: Average Thickness (m) | Member: Designation | Zone: Average Thickness (m) | Zone: Designation |
|---|---|---|---|---|---|---|---|---|
| | sand, gravel, till, clay, silt | <100 | | Surficial Deposits | <100 | Upper | <50 | First Sand and Gravel |
| | 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 | 100-200 | | Lea Park Formation | | | | |
| | sandstone, siltstone, shale, coal | 40-140 | Colorado Group | Milk River Formation | | | | |
| | shale, siltstone | 200-1000 | Colorado Group | *undivided* Colorado Group | | | | |
| | sandstone | 50 | Colorado Group | Viking Formation | | | | |

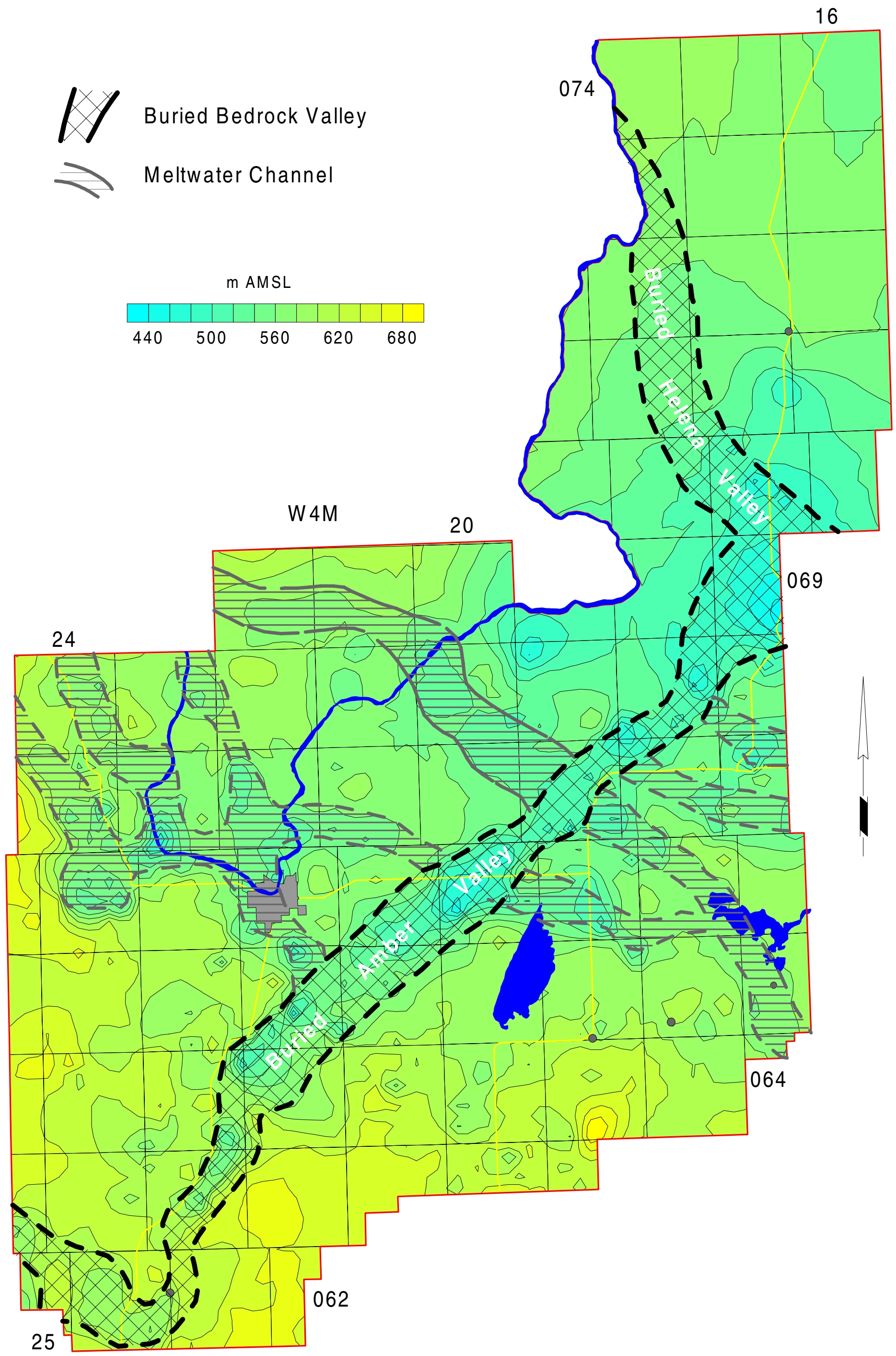
# Cross-Section A - A'



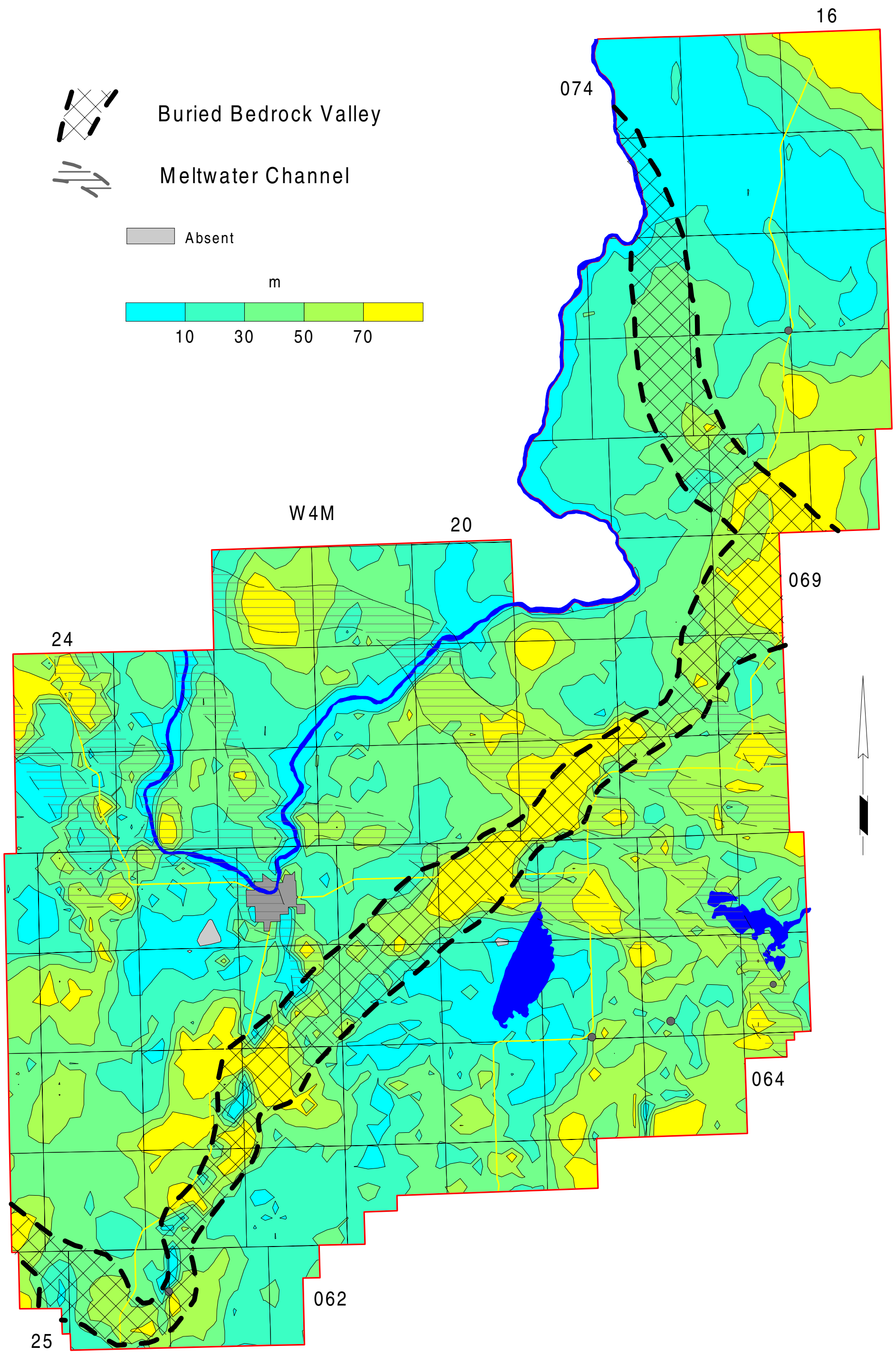
## Cross-Section B - B'



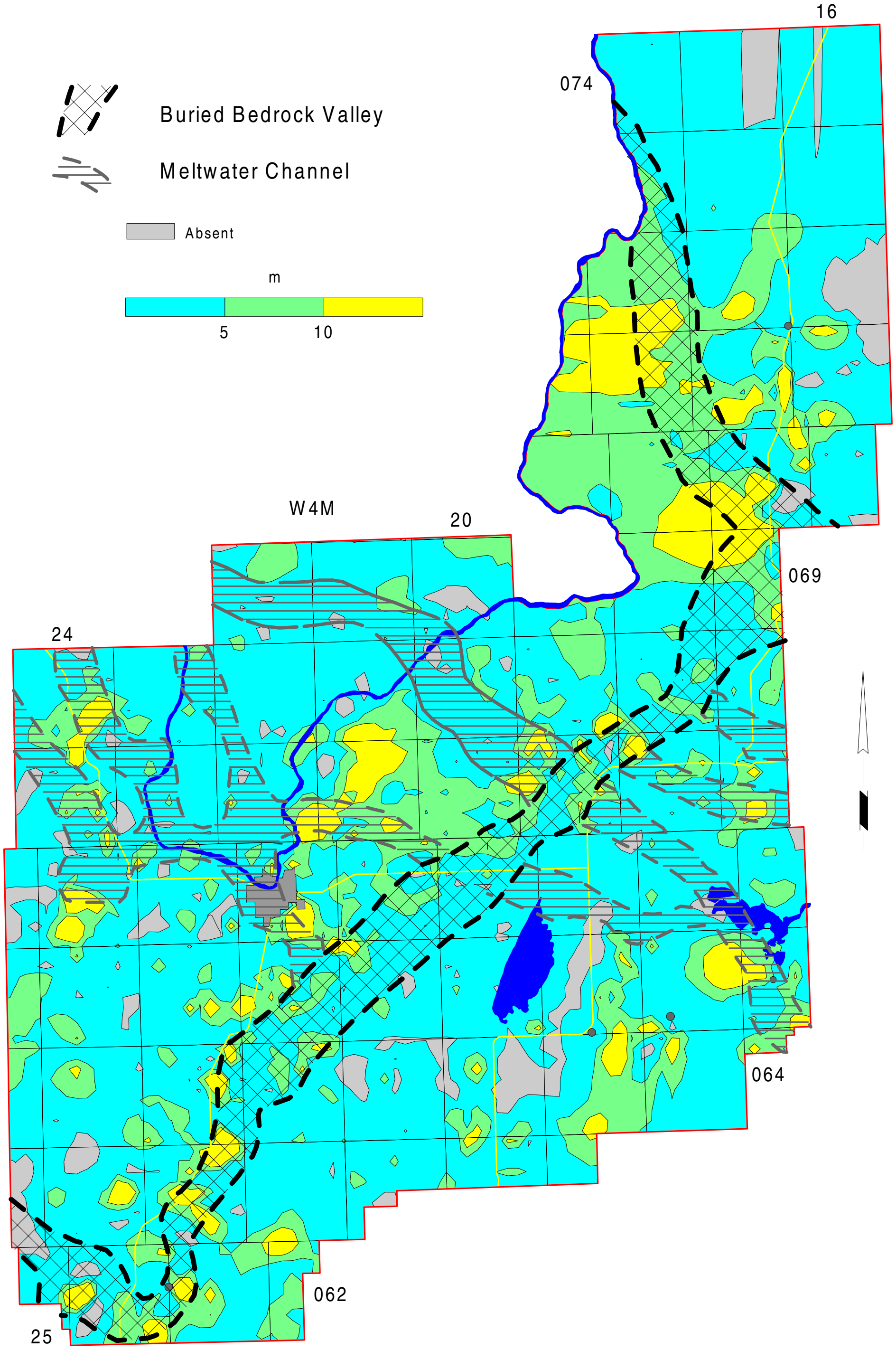
# Bedrock Topography



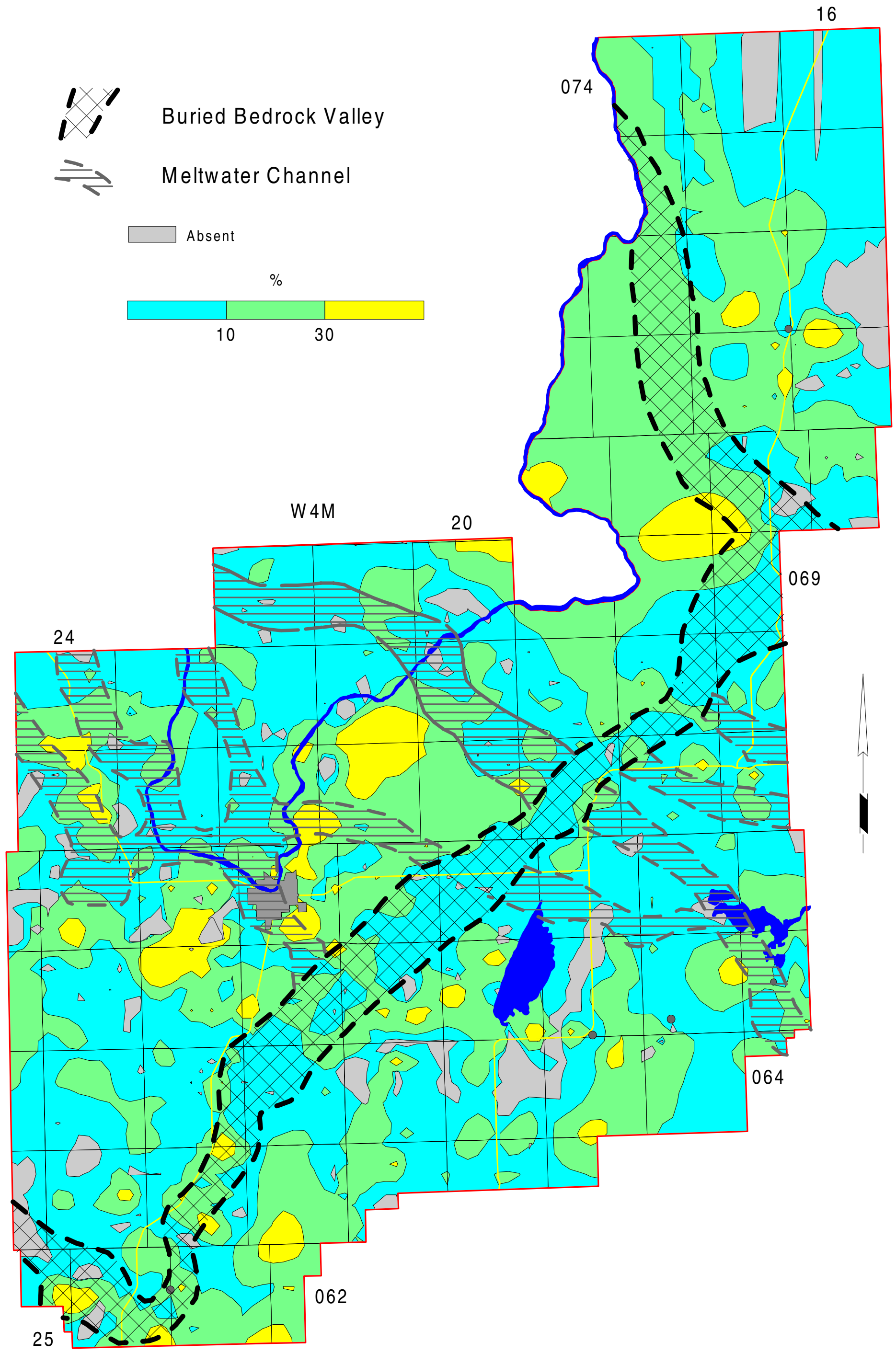
# Thickness of Surficial Deposits



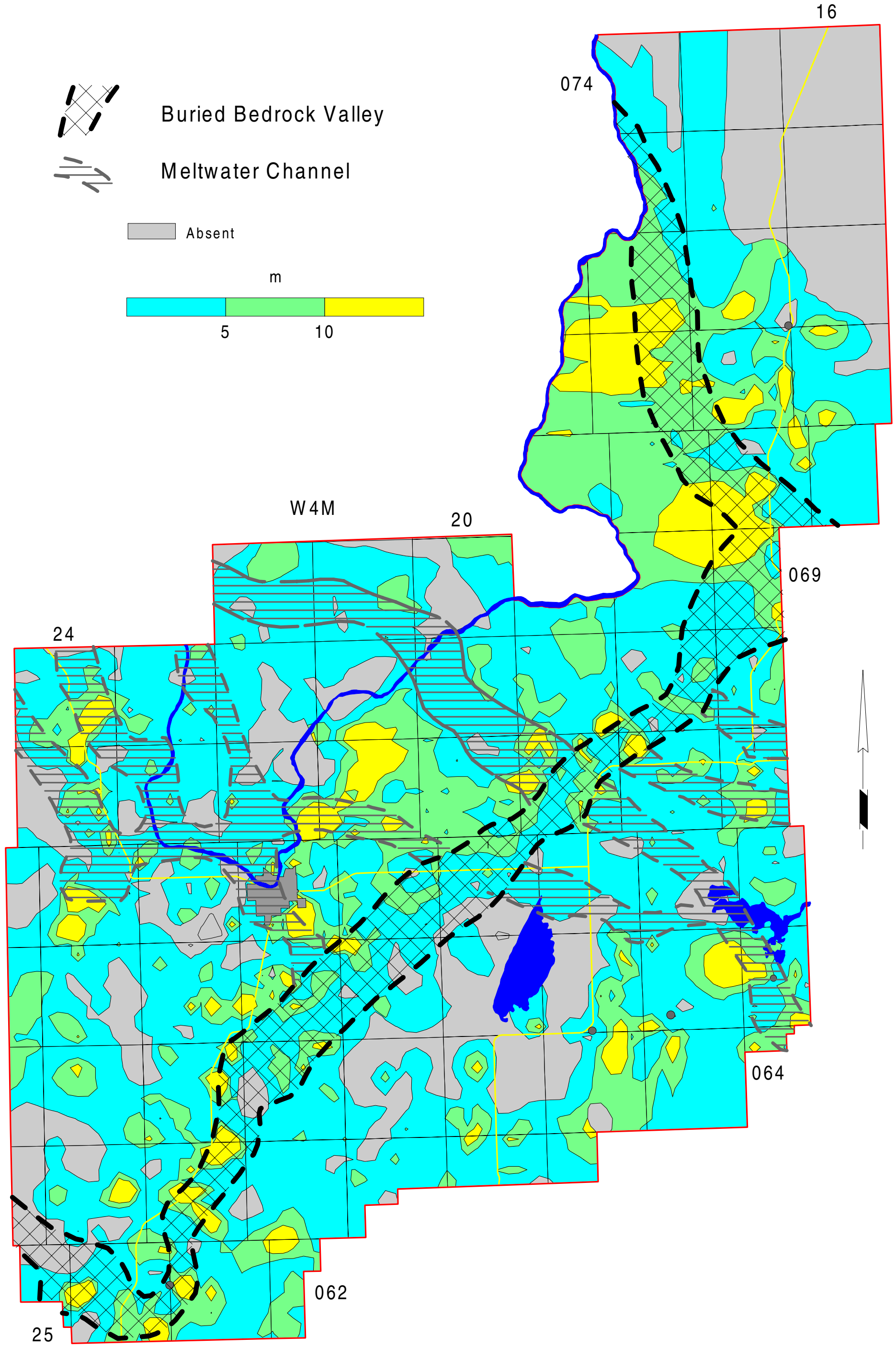
## Thickness of Sand and Gravel Deposits



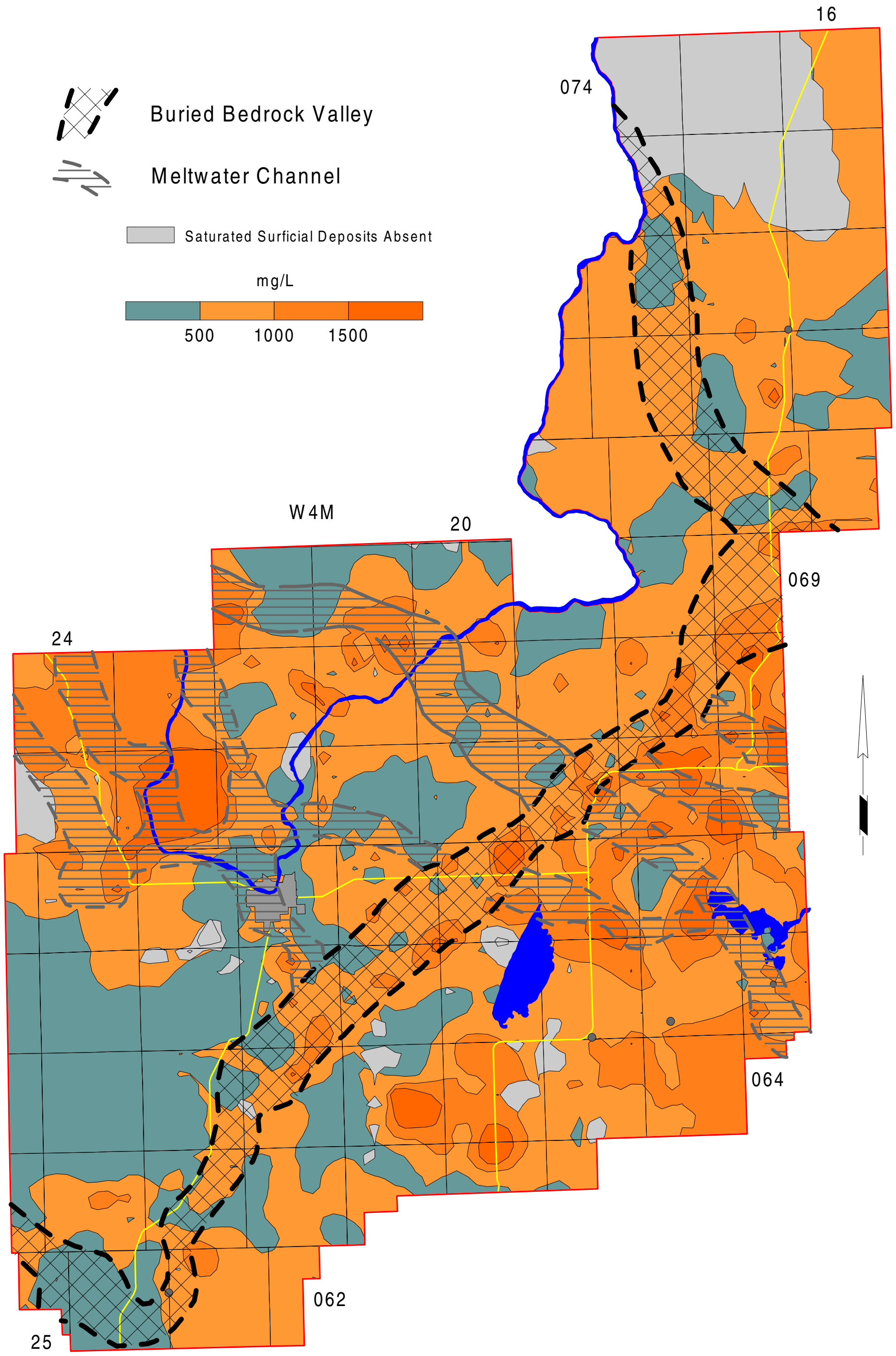
## Amount of Sand and Gravel in Surficial Deposits



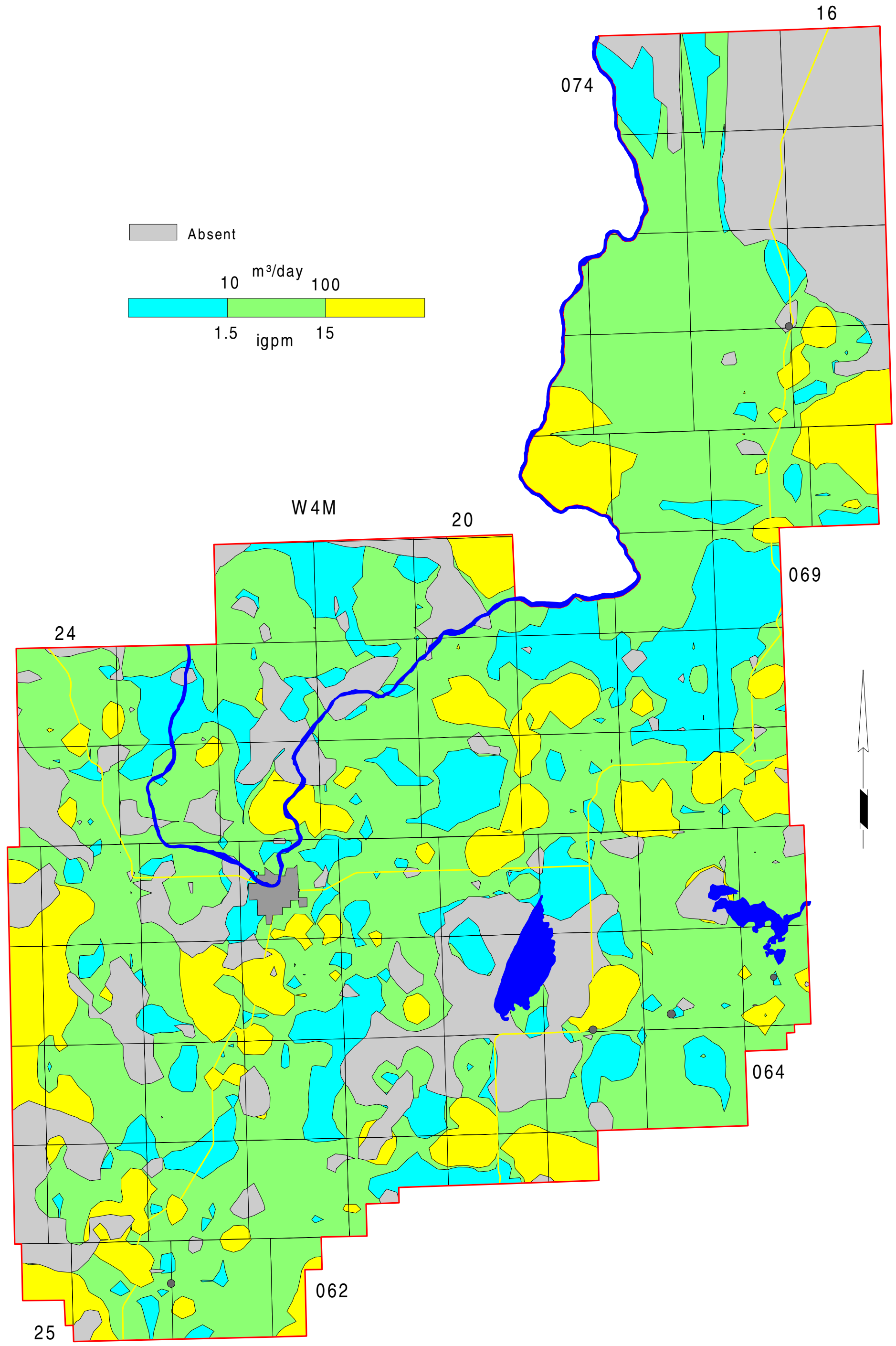
## Thickness of Sand and Gravel Aquifer(s)



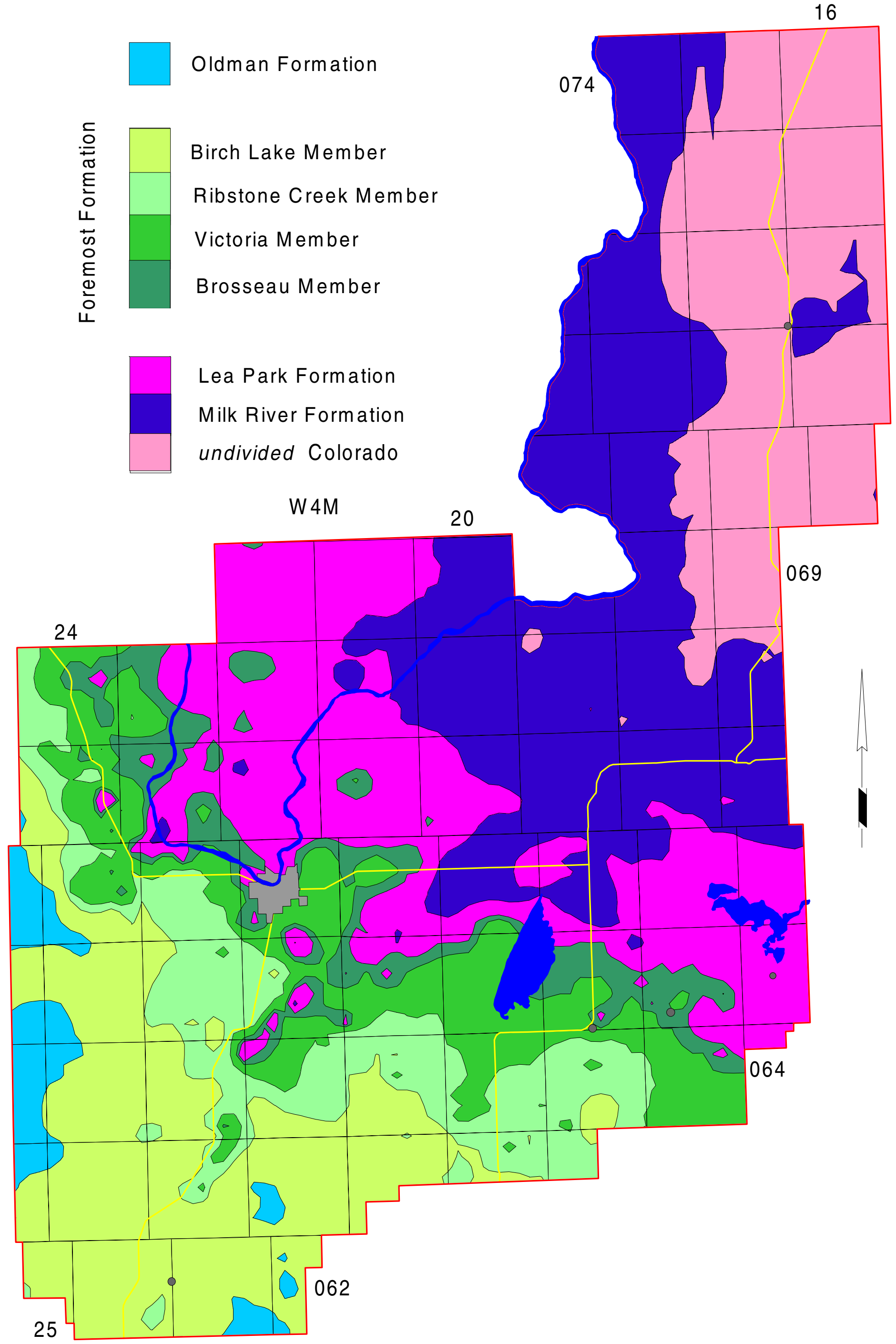
## Total Dissolved Solids in Groundwater from Surficial Deposits



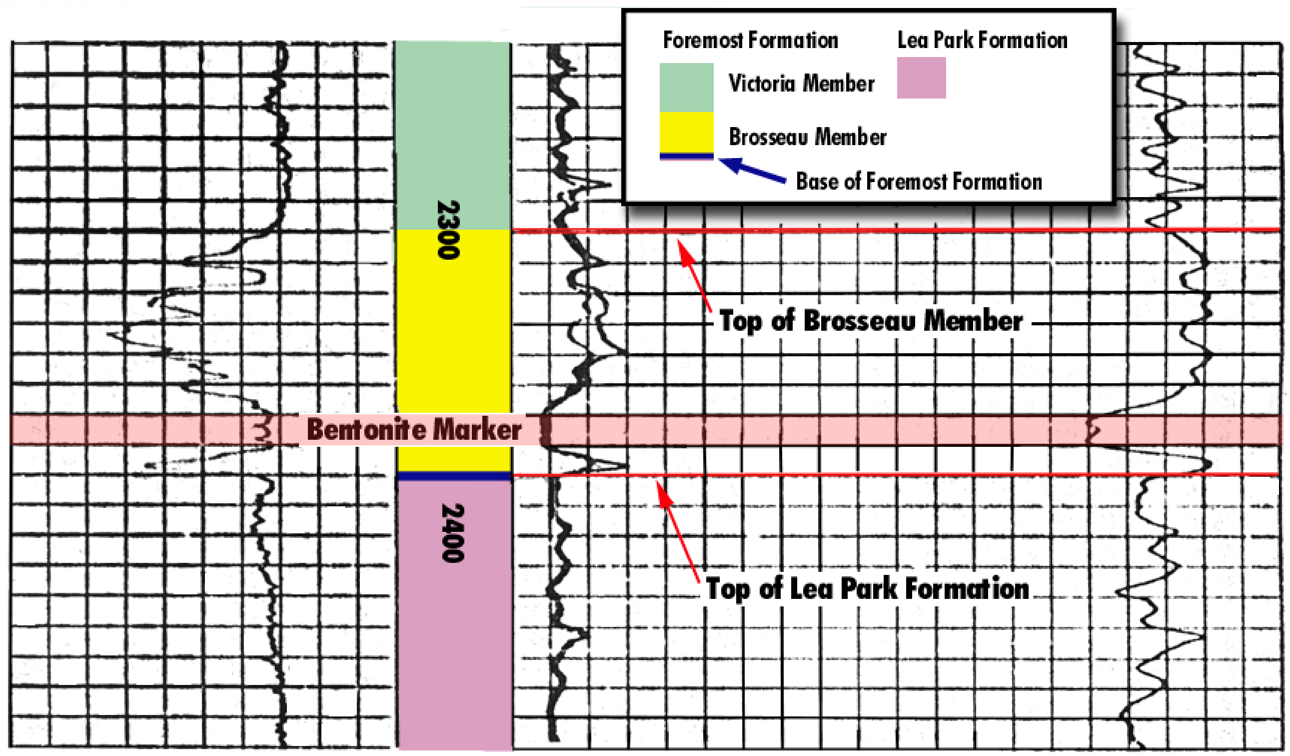
# Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer(s)



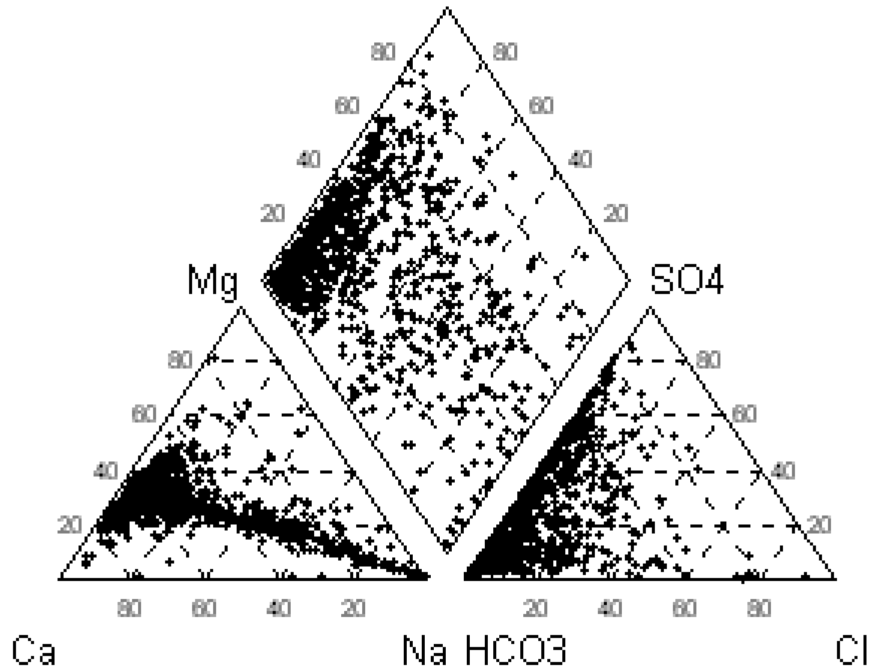
# Bedrock Geology



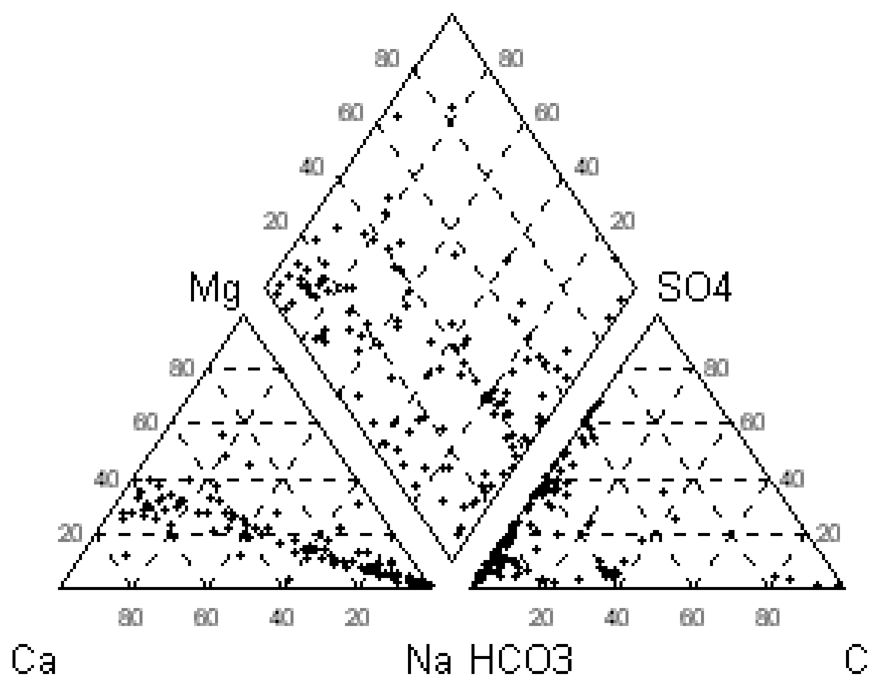
## E-Log Showing Base of Foremost Formation



# *Piper Diagrams*

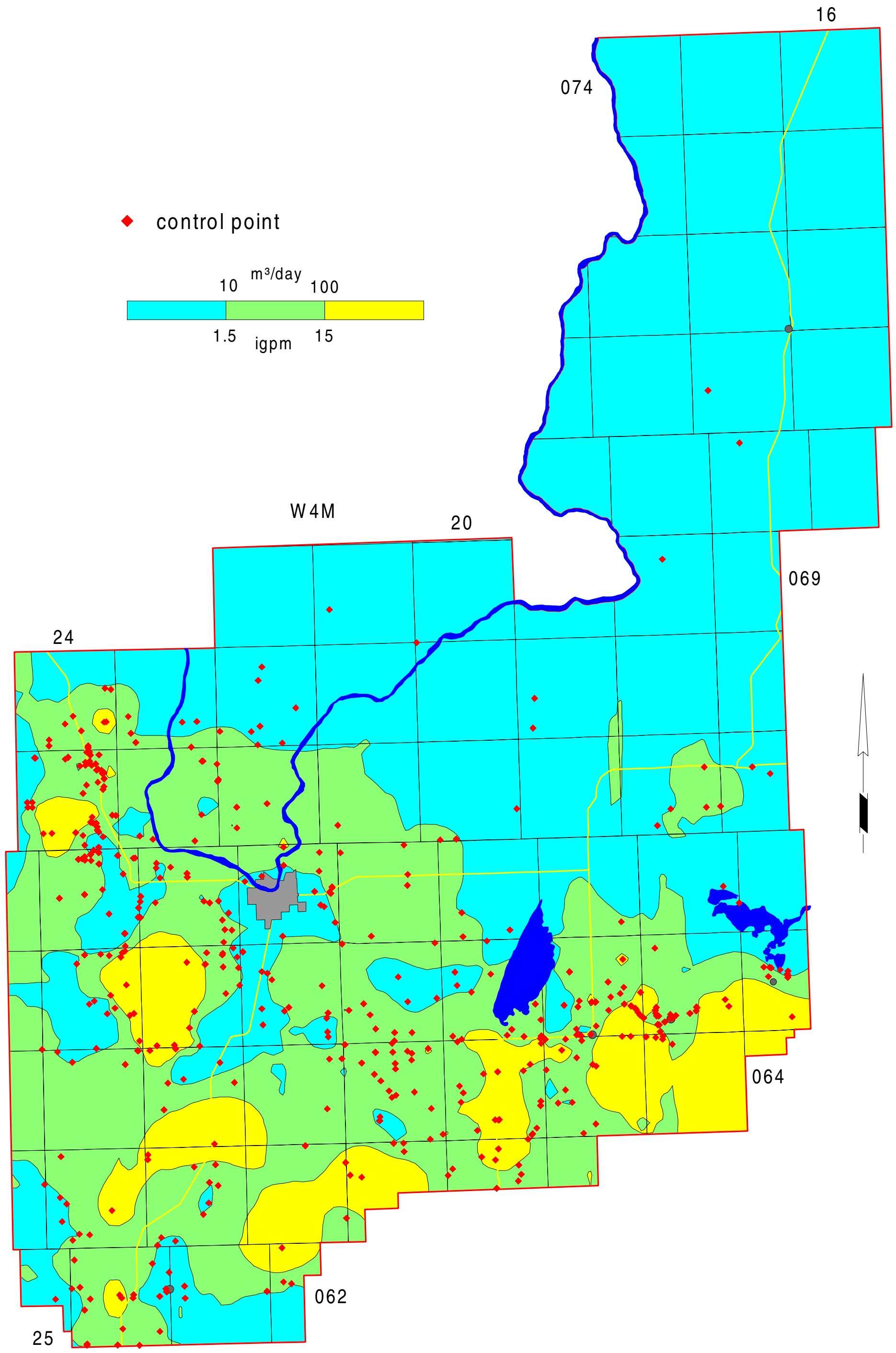



**Surficial Deposits**

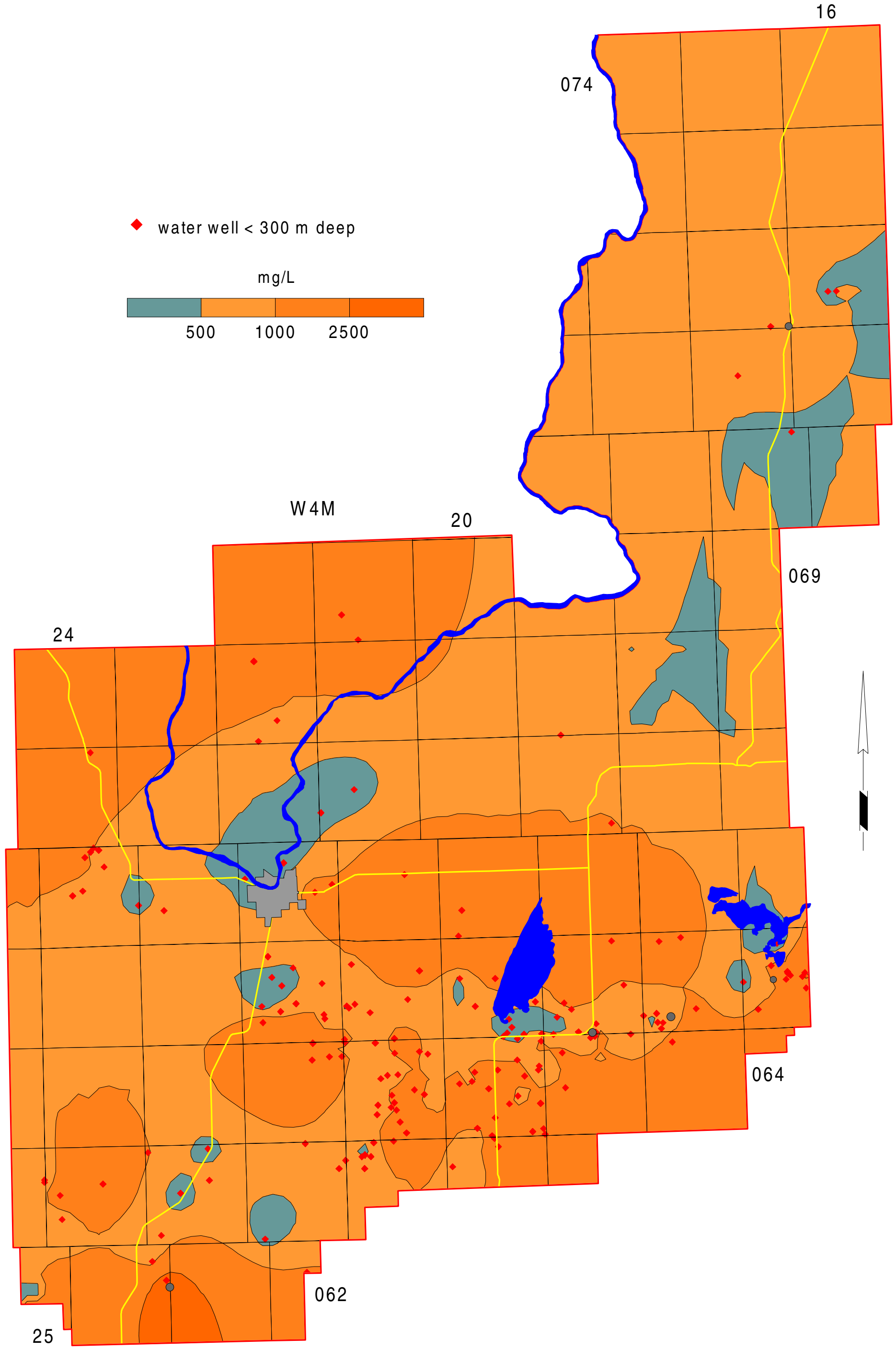



**Bedrock Aquifers**

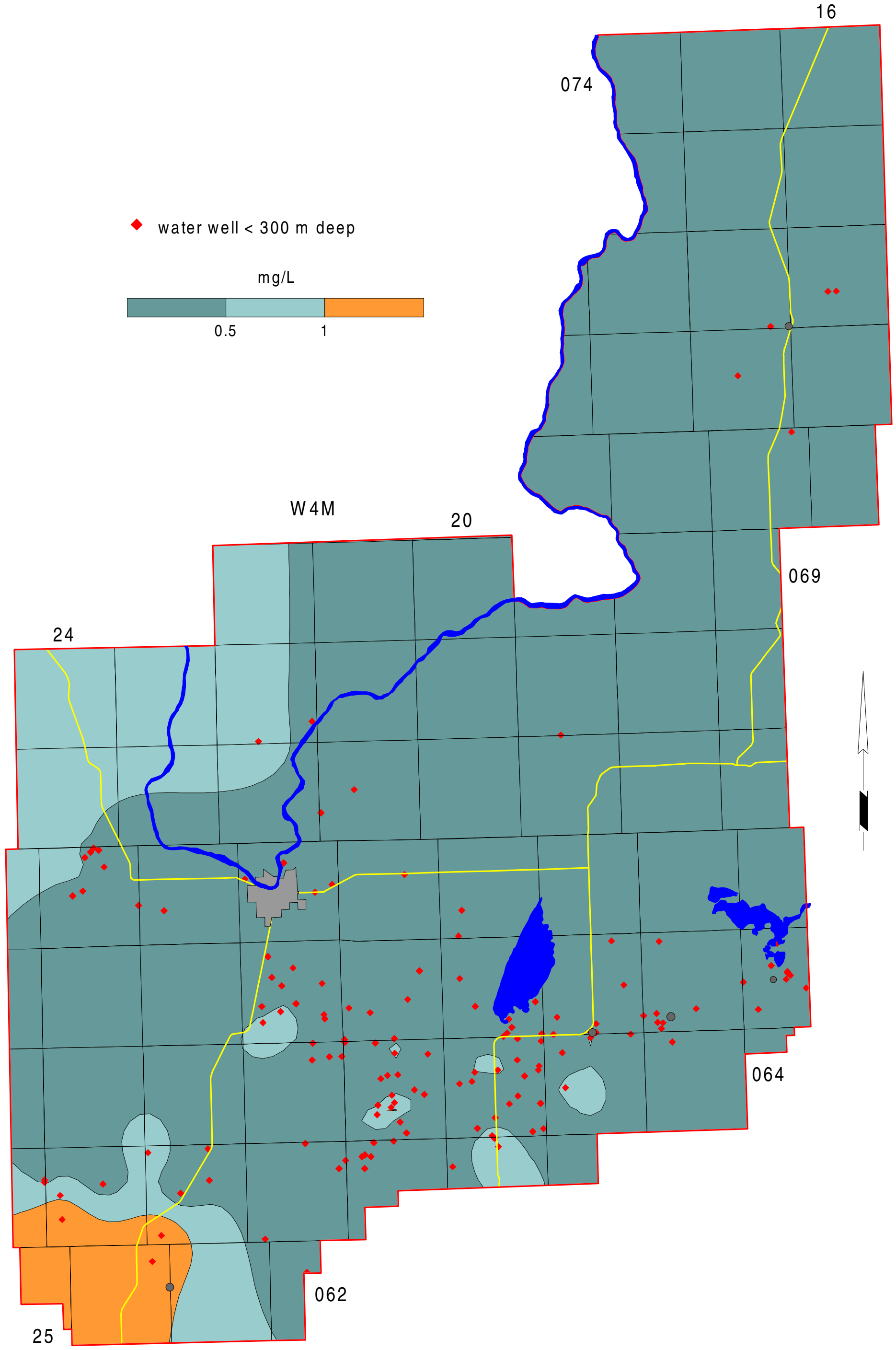
# Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)



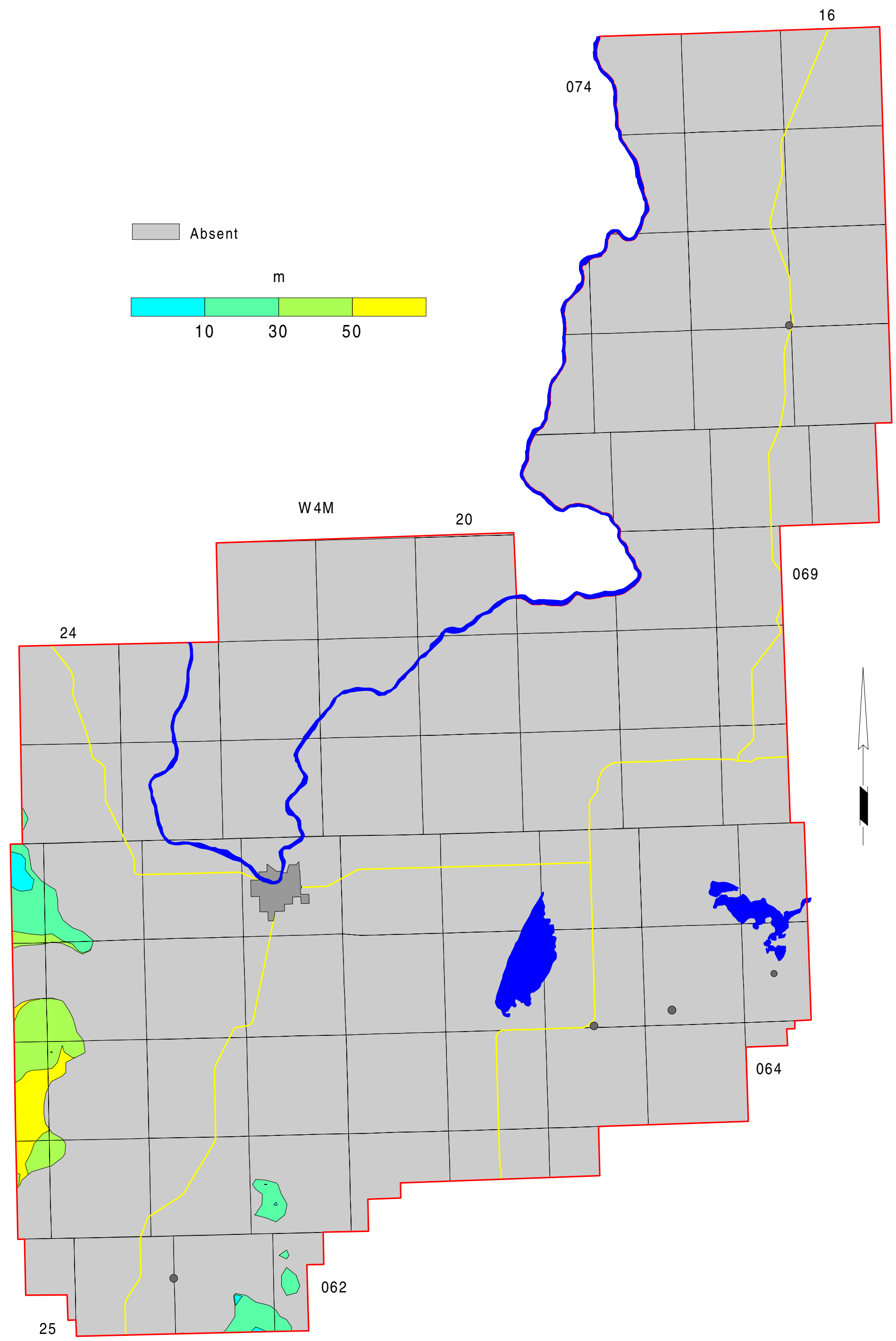
## Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)



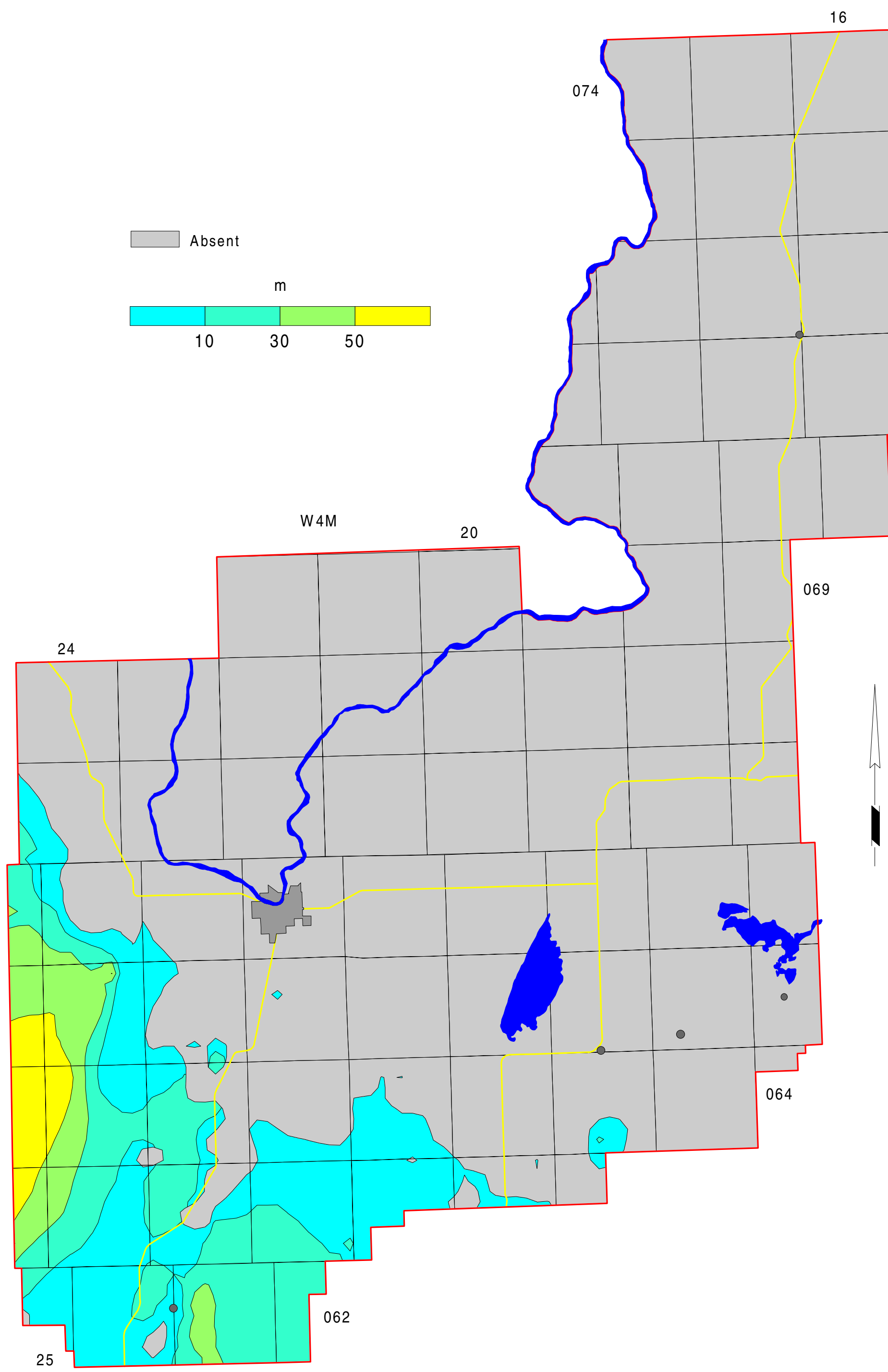
# Fluoride in Groundwater from Upper Bedrock Aquifer(s)



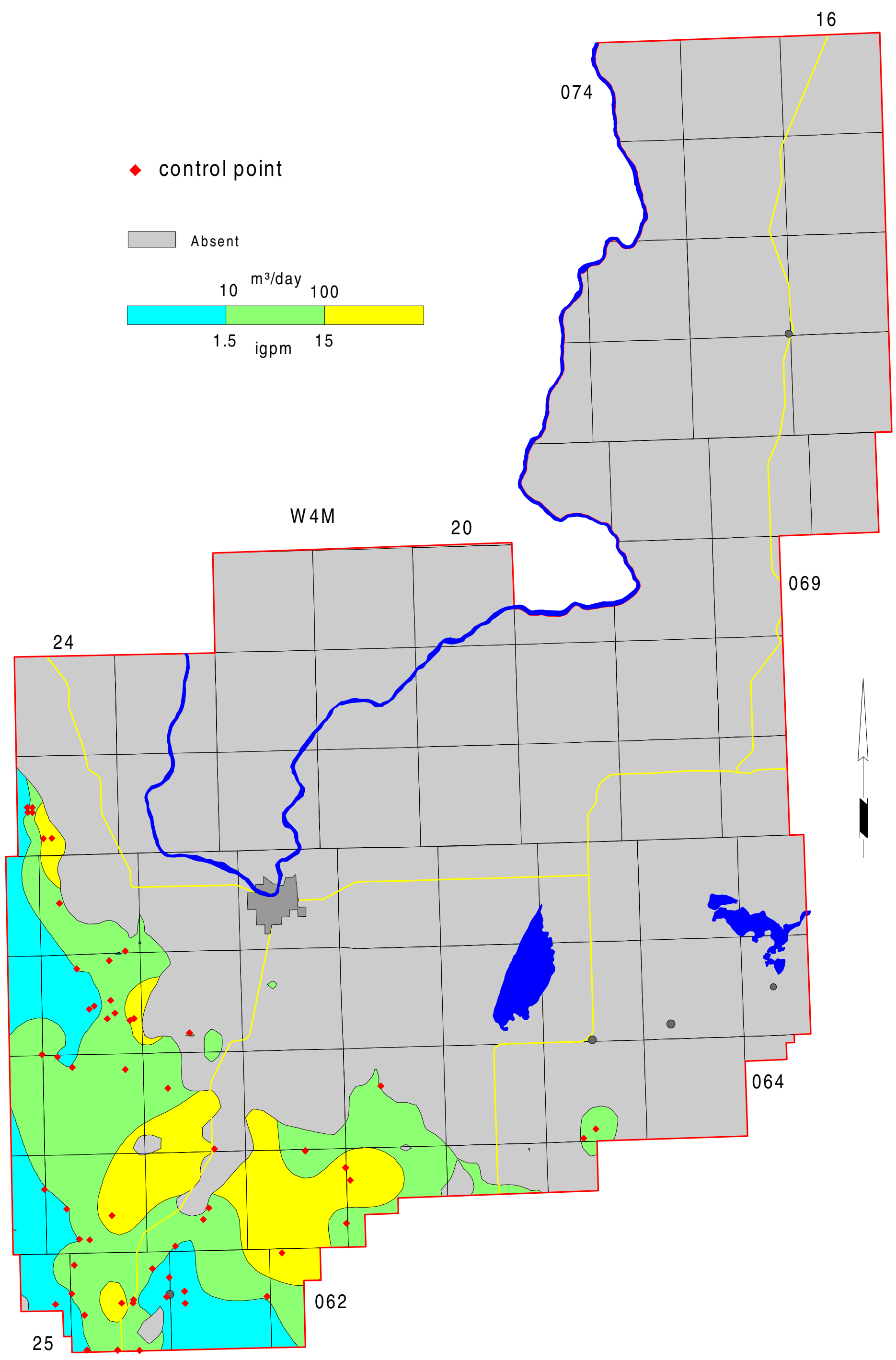
## Depth to Top of Oldman Formation



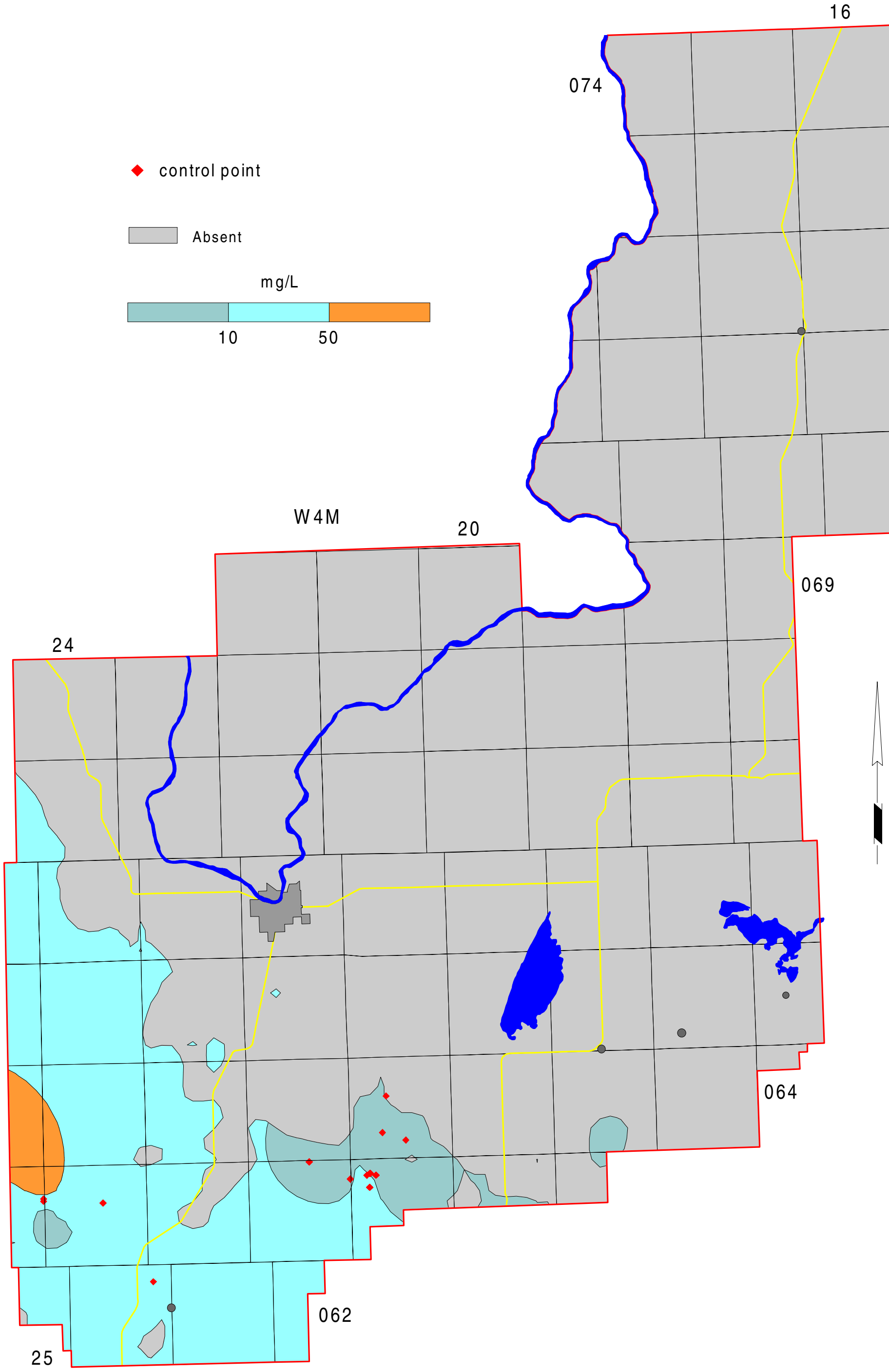
## Depth to Top of Birch Lake Member



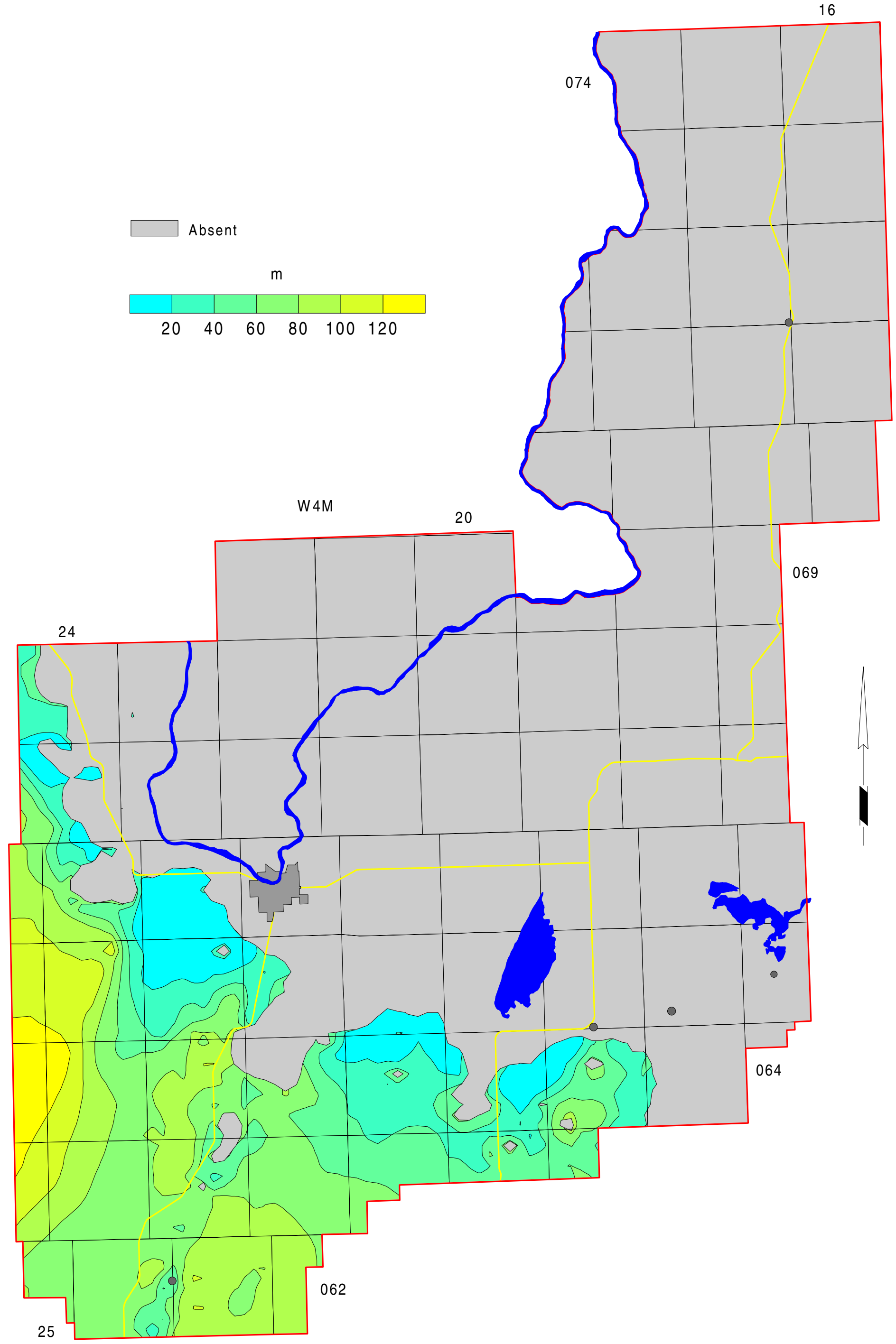
## Apparent Yield for Water Wells Completed through Birch Lake Aquifer



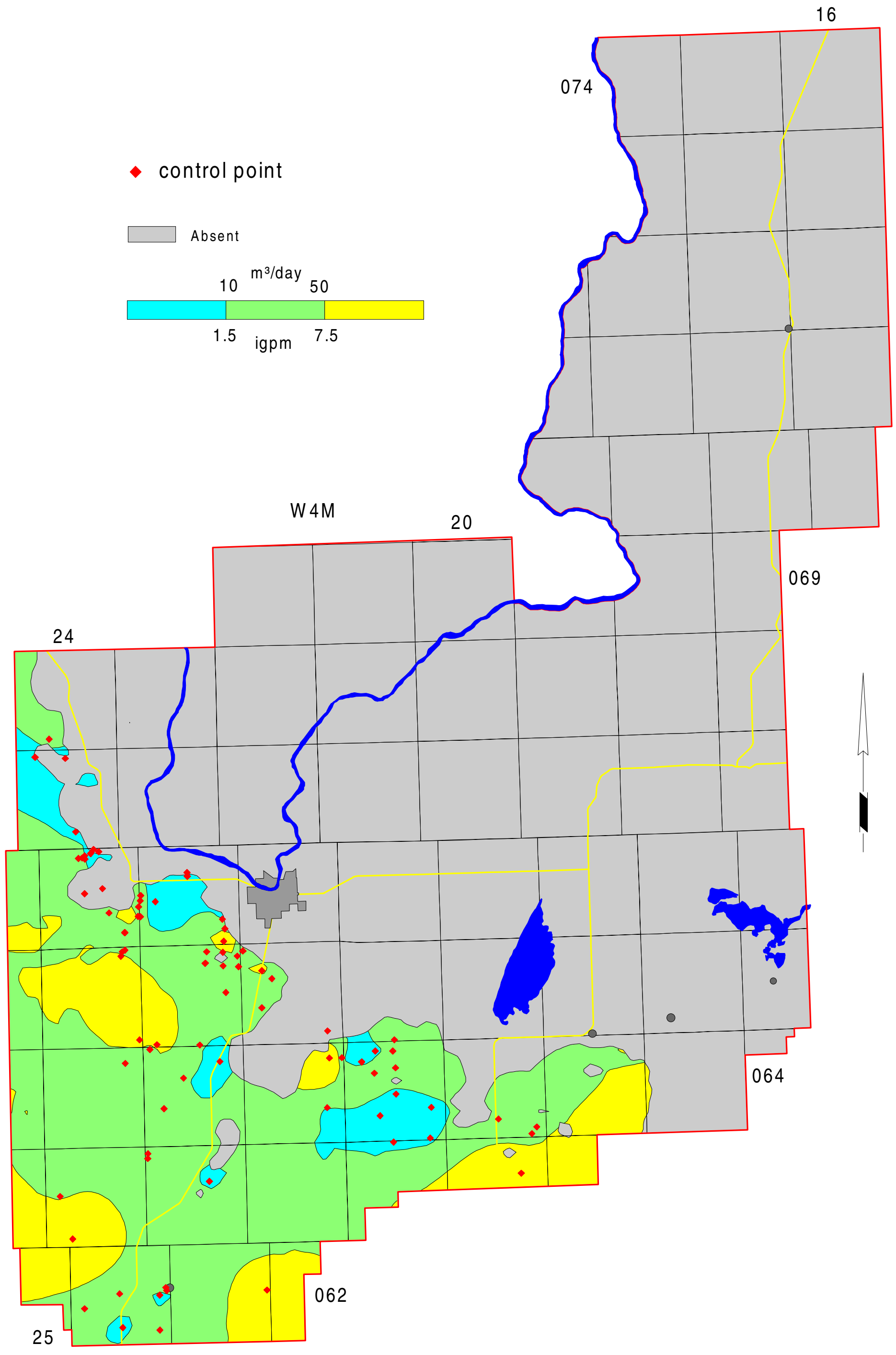
# Chloride in Groundwater from Birch Lake Aquifer



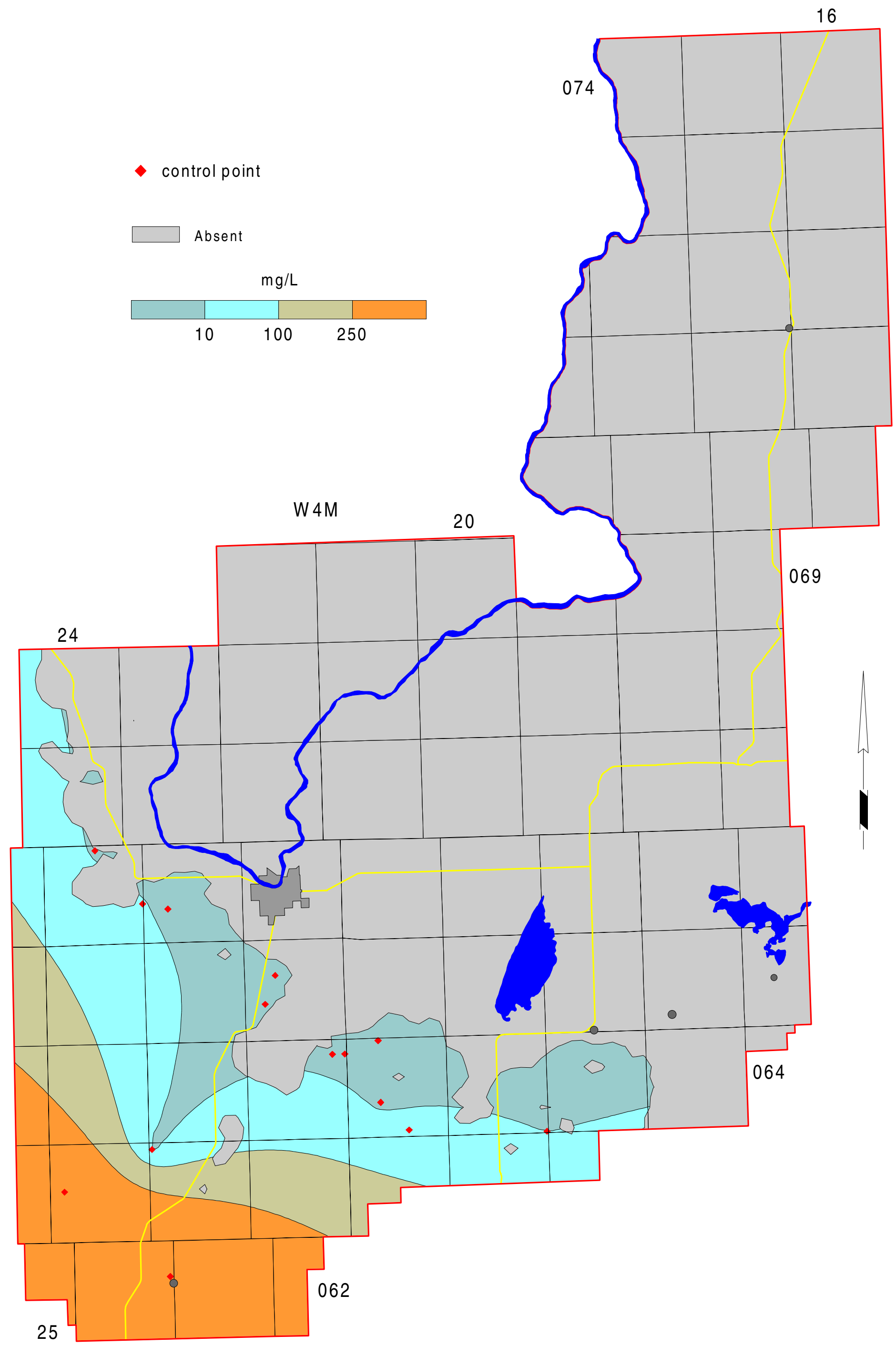
## Depth to Top of Ribstone Creek Member



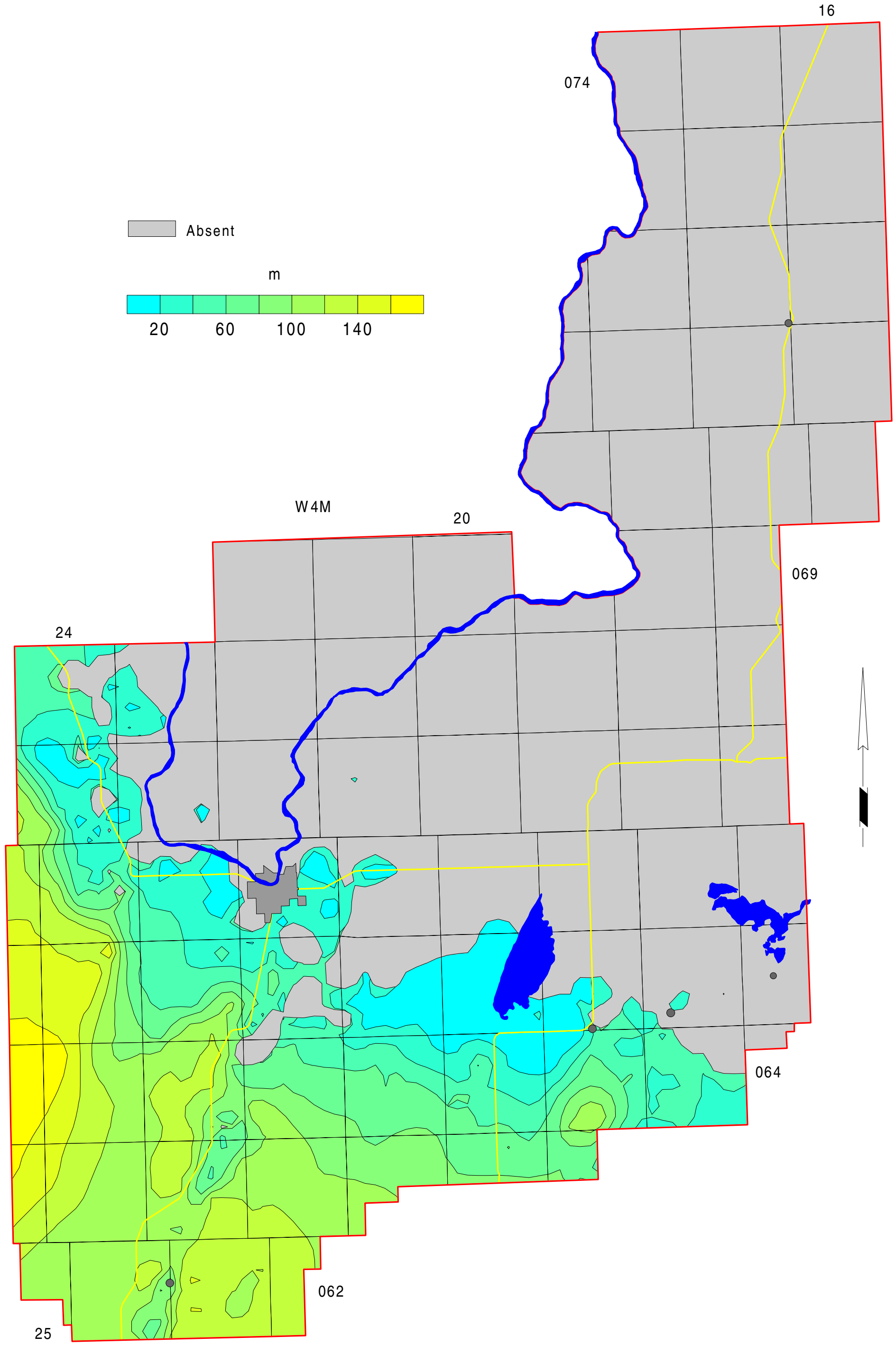
# Apparent Yield for Water Wells Completed through Ribstone Creek Aquifer



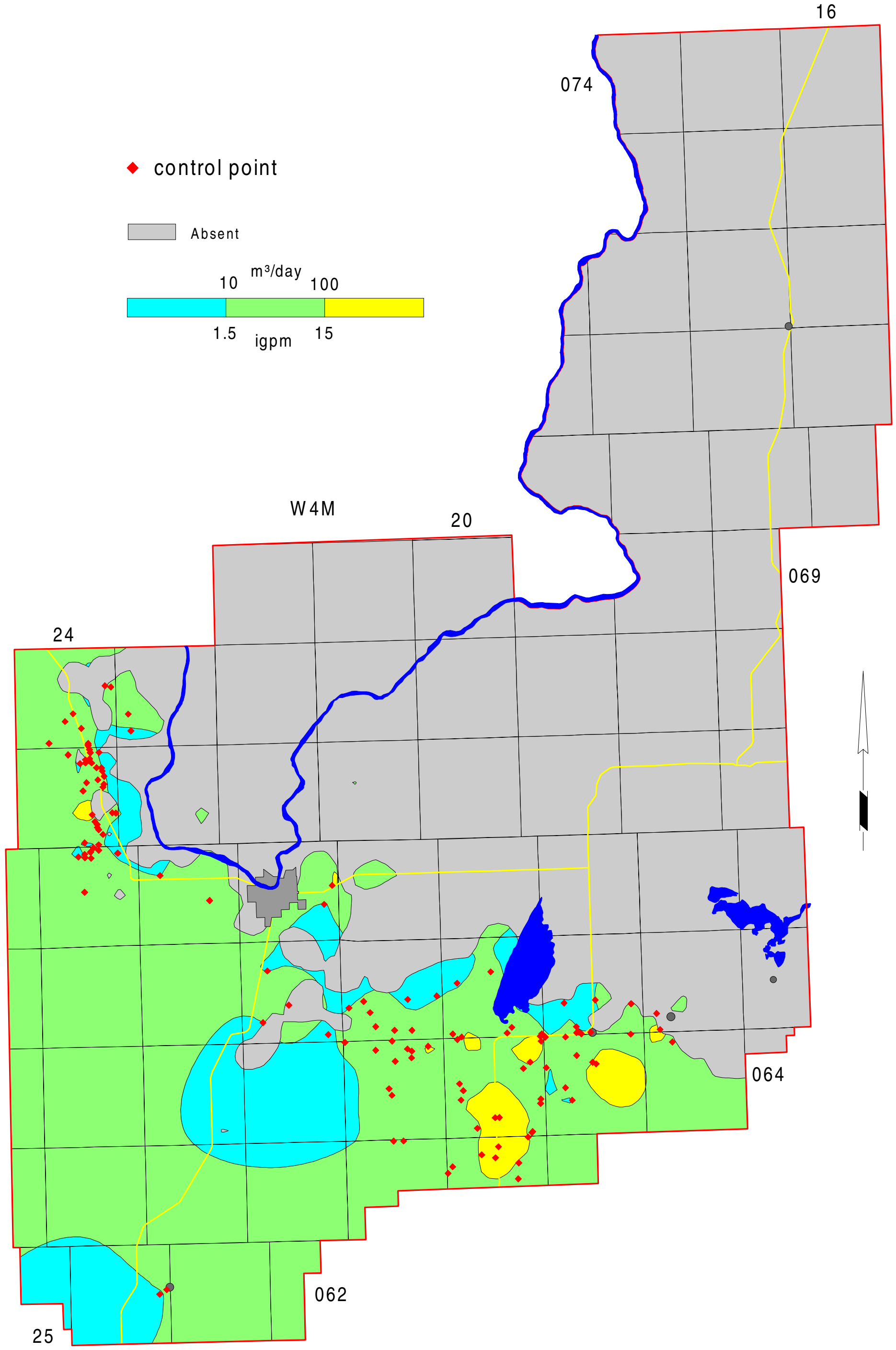
## Chloride in Groundwater from Ribstone Creek Aquifer



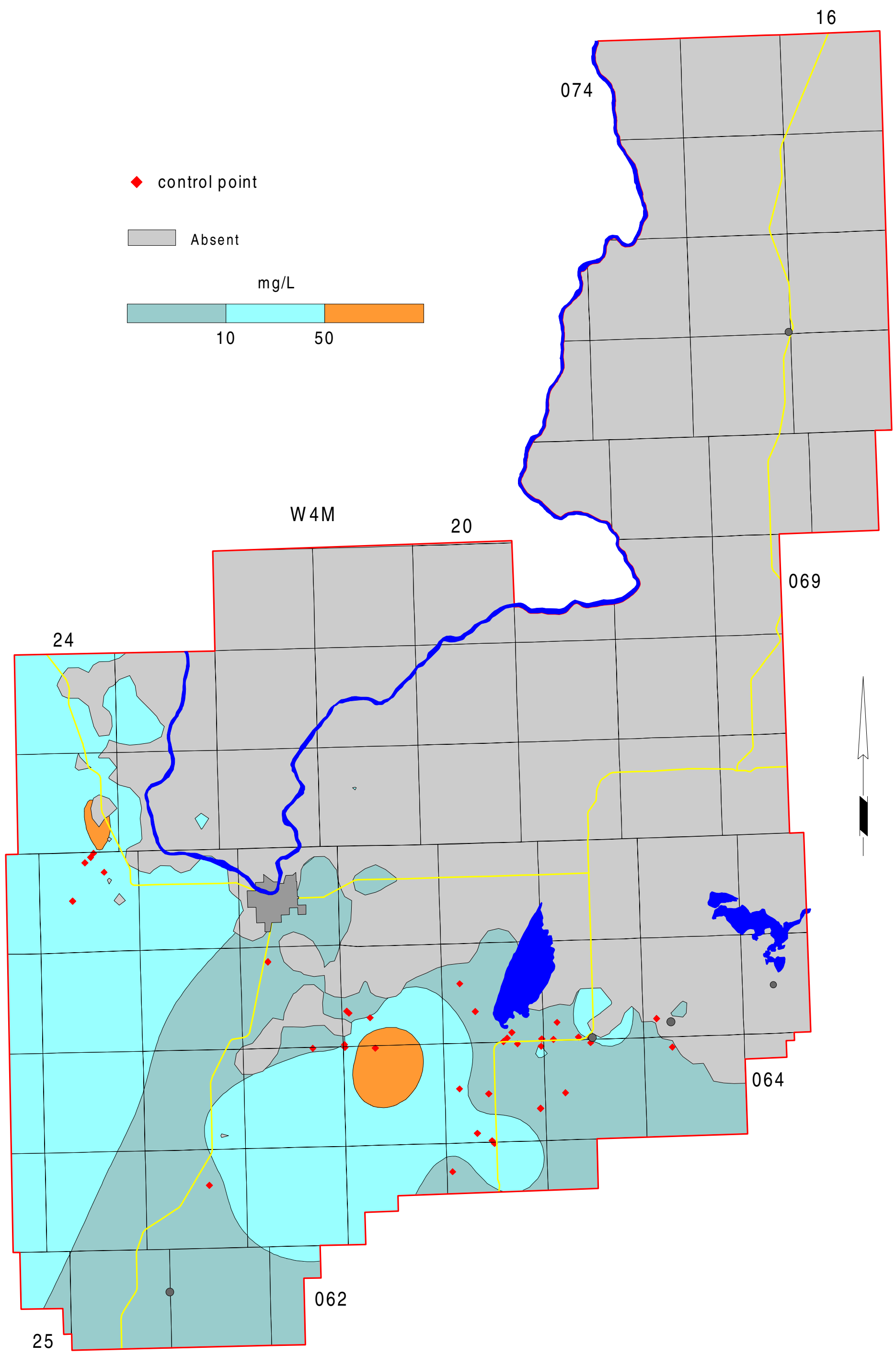
# Depth to Top of Victoria Member



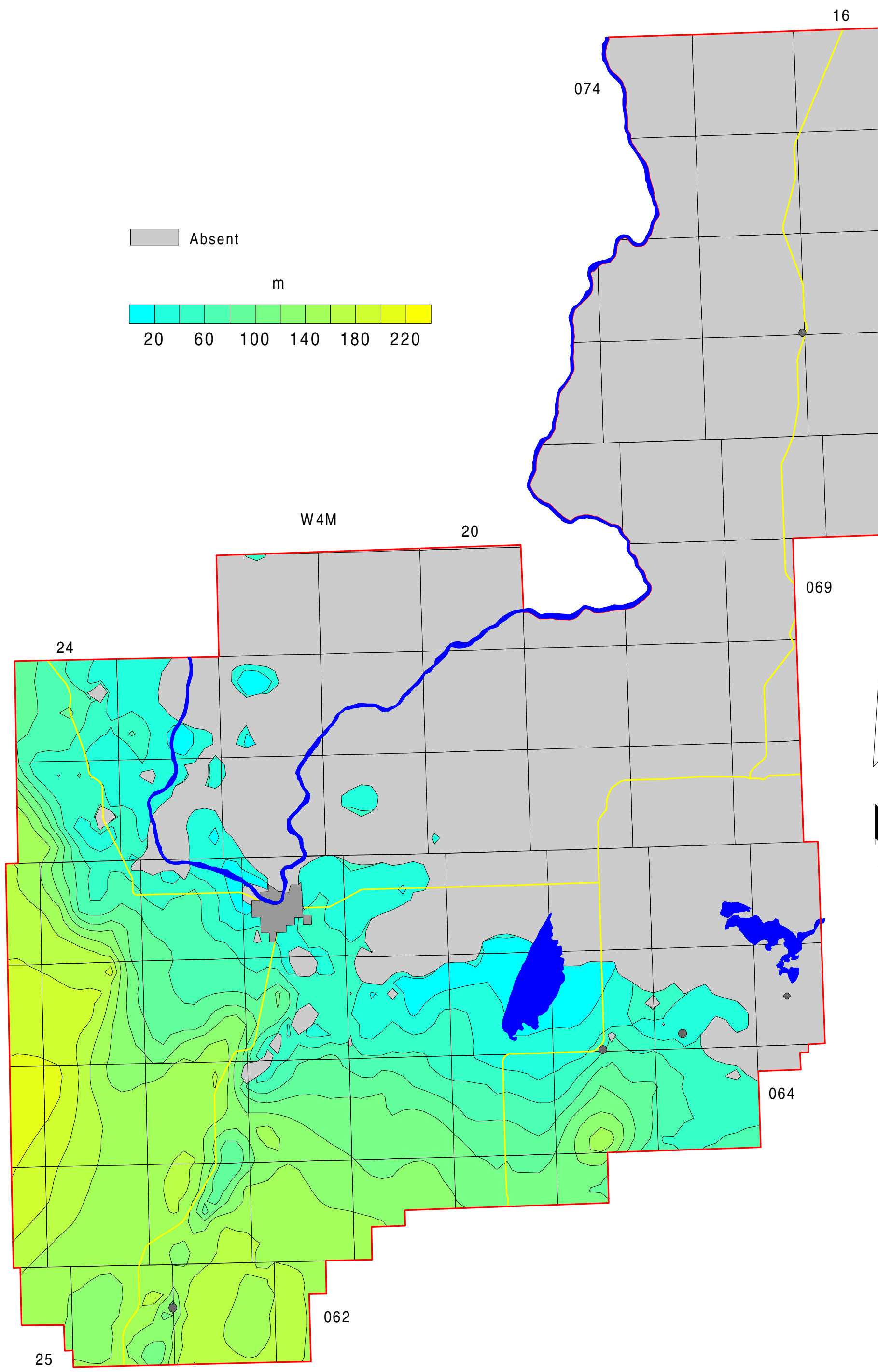
## Apparent Yield for Water Wells Completed through Victoria Aquifer



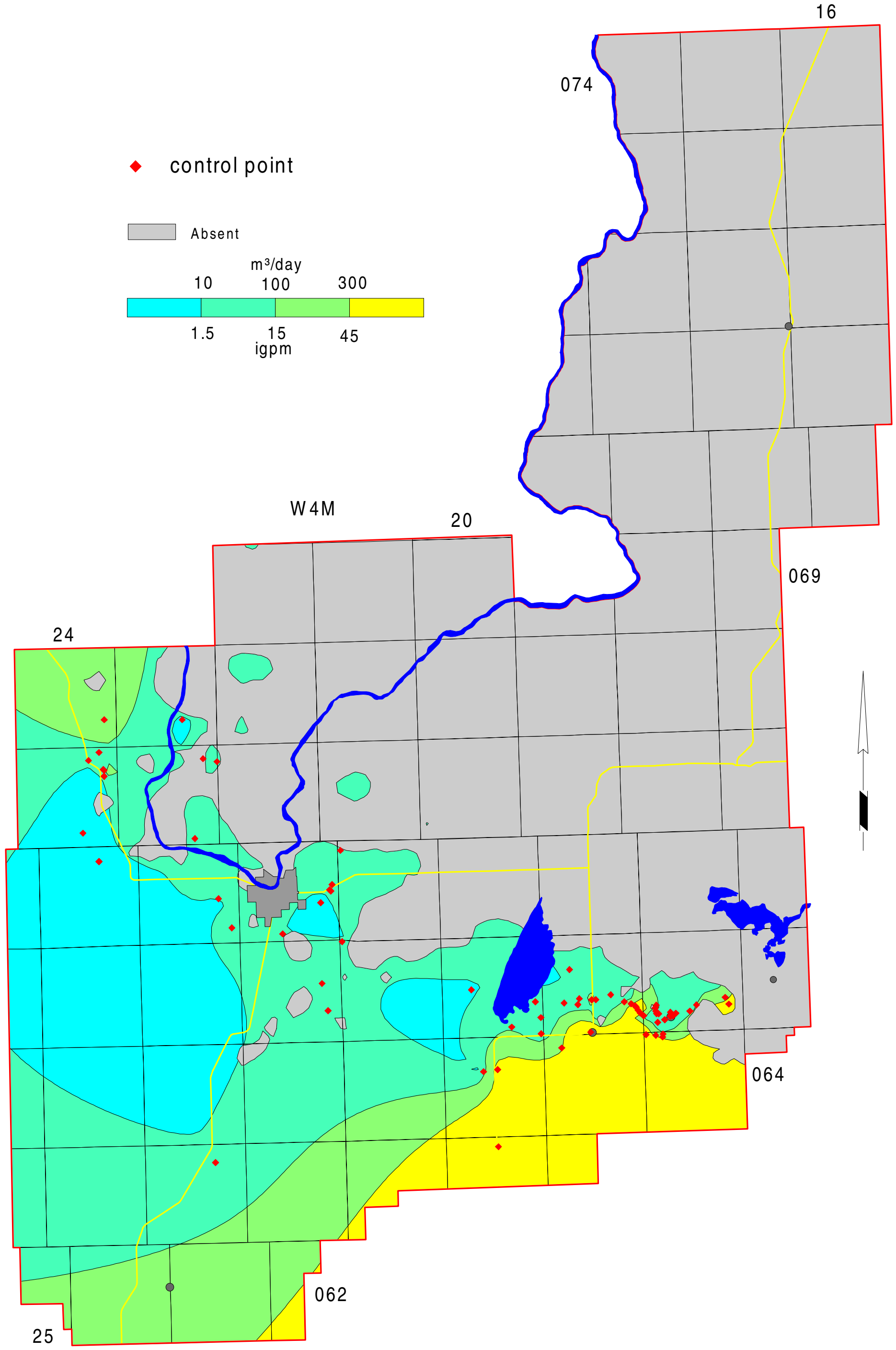
# Chloride in Groundwater from Victoria Aquifer



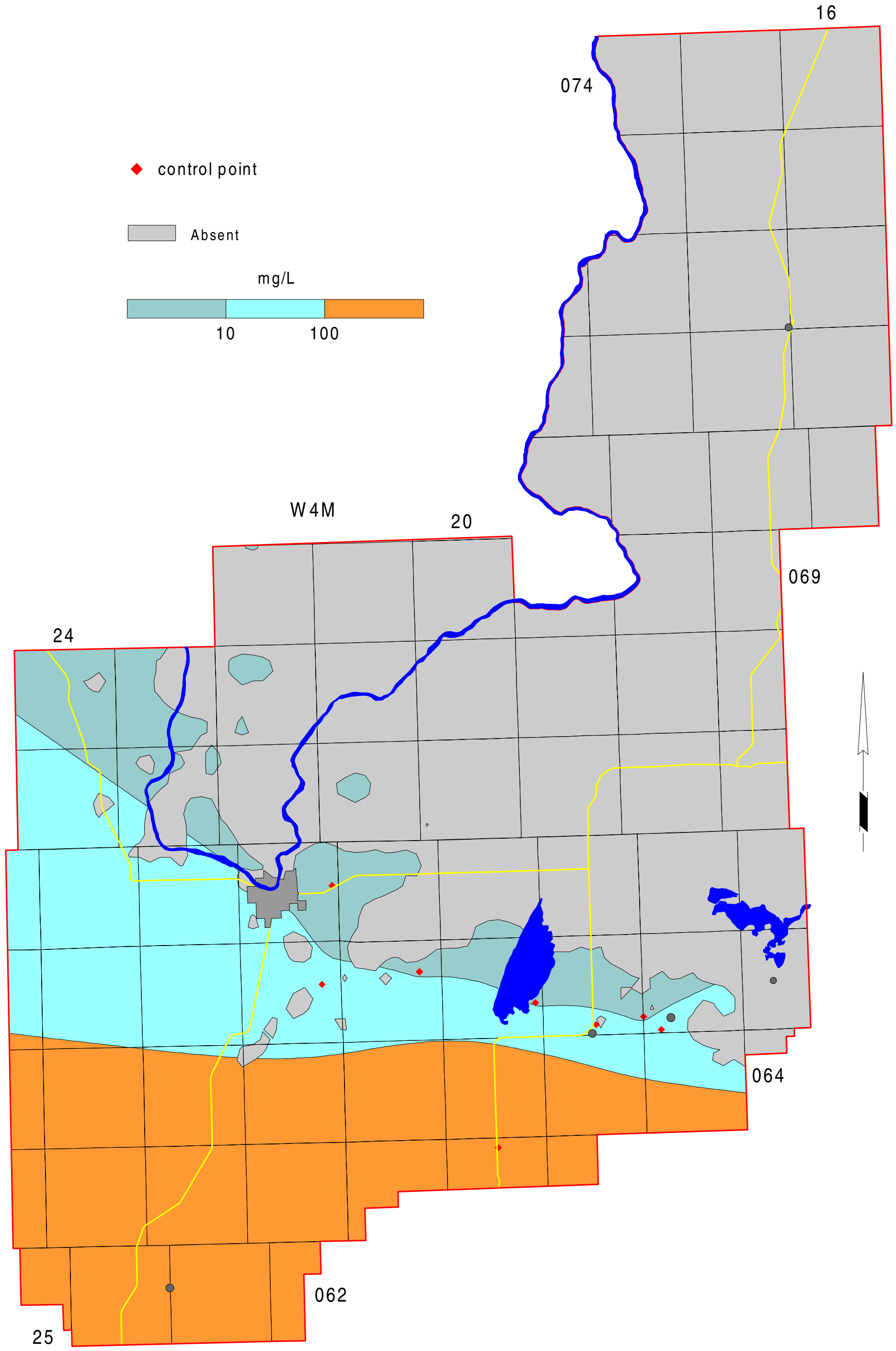
## Depth to Top of Brosseau Member



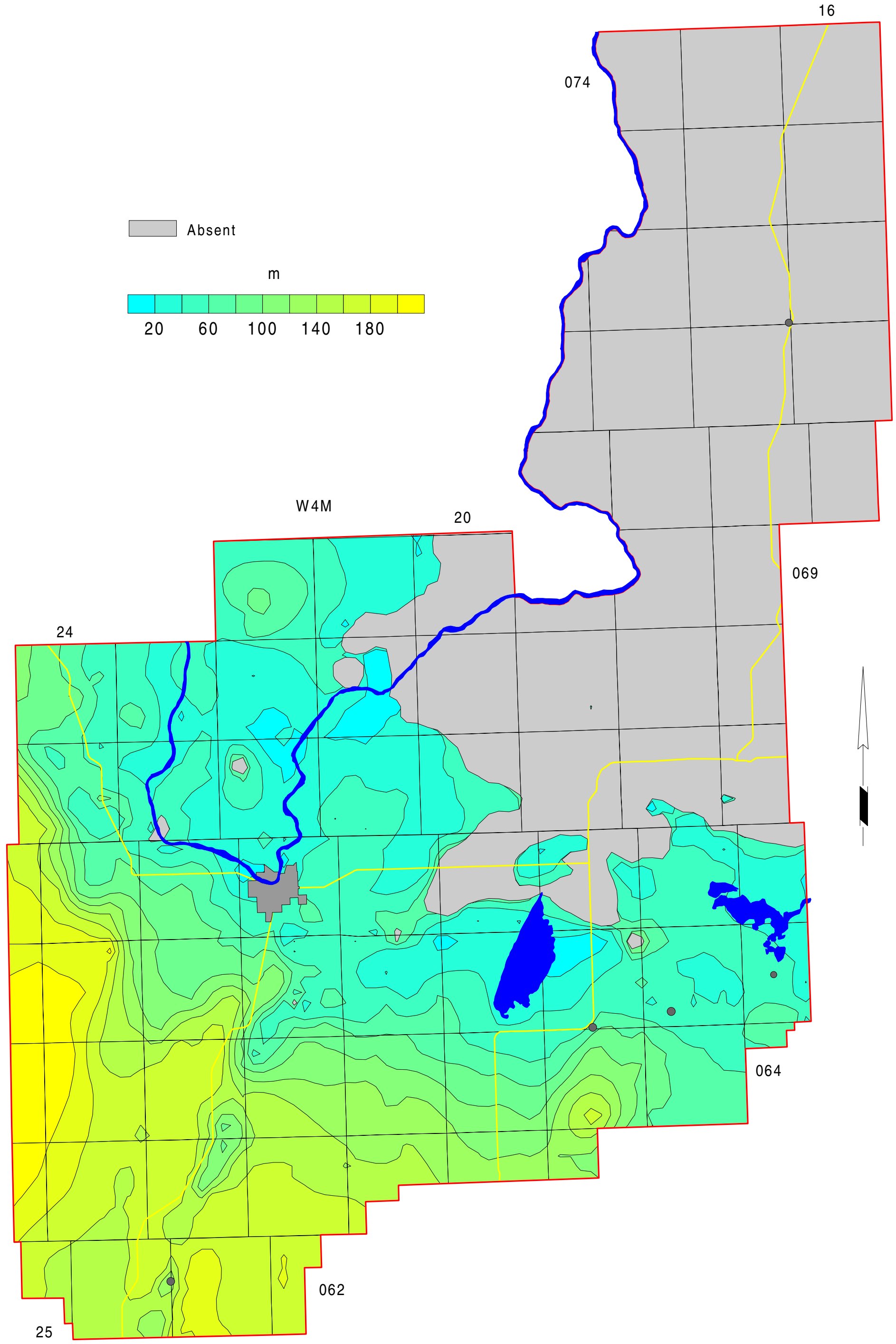
# Apparent Yield for Water Wells Completed through Brosseau Aquifer



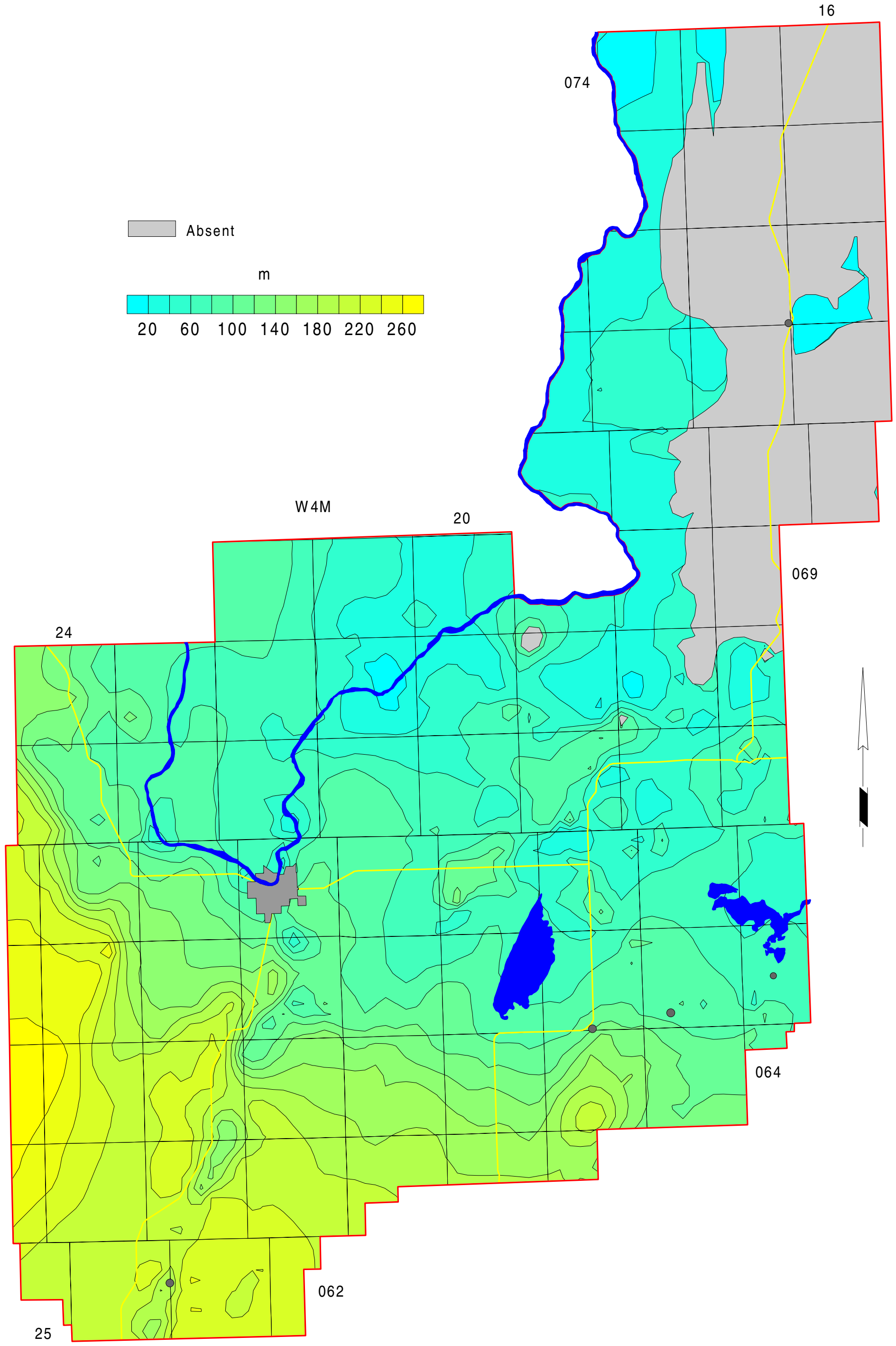
## Chloride in Groundwater from Brosseau Aquifer



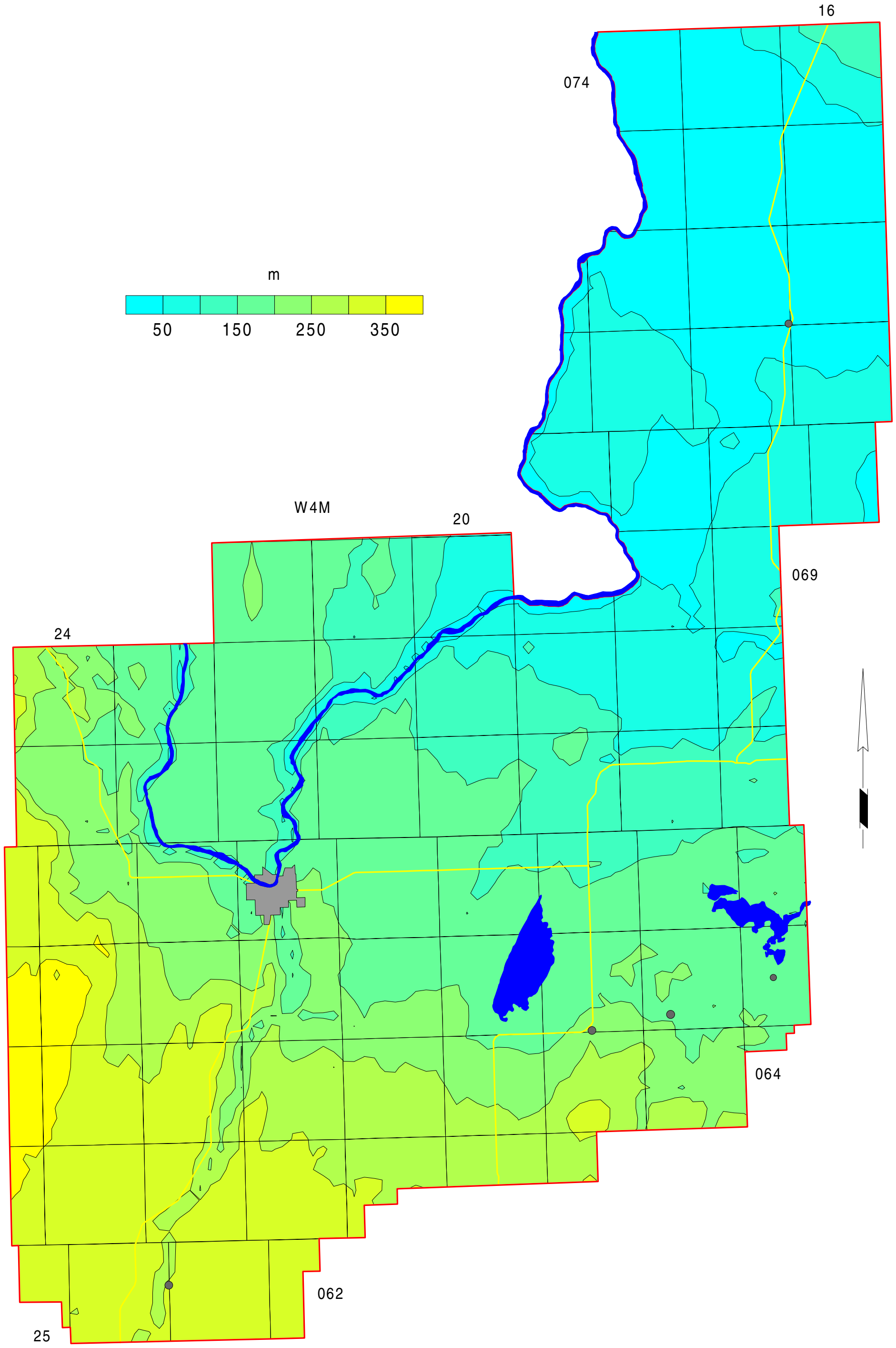
# Depth to Top of Lea Park Formation



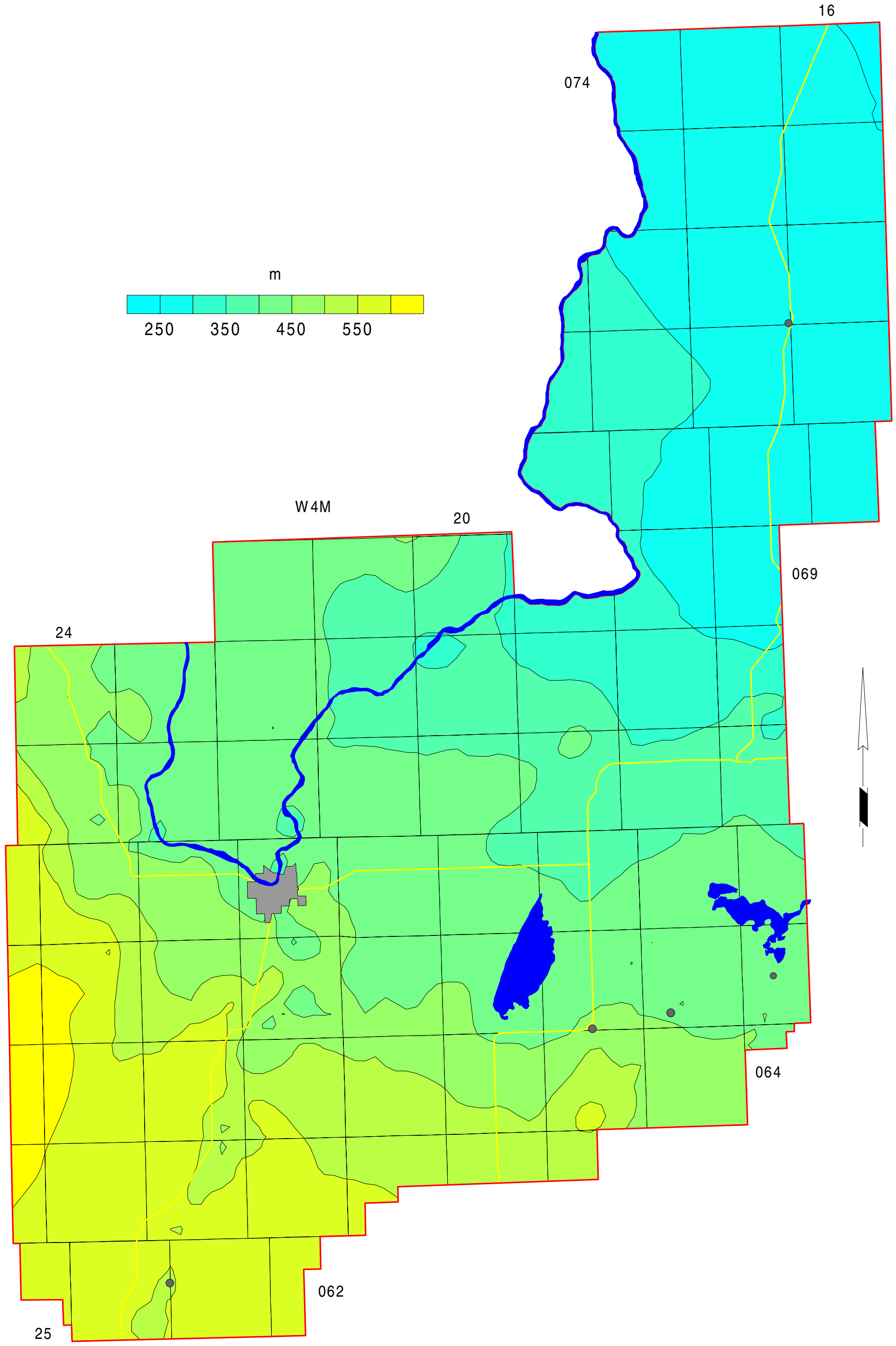
# Depth to Top of Milk River Formation



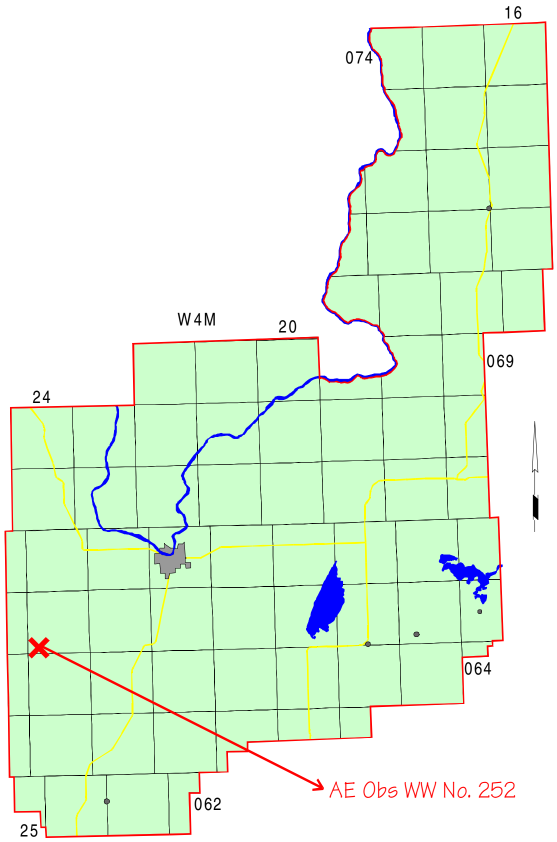
# Depth to Top of undivided Colorado Group



# Depth to Top of Mannville Group

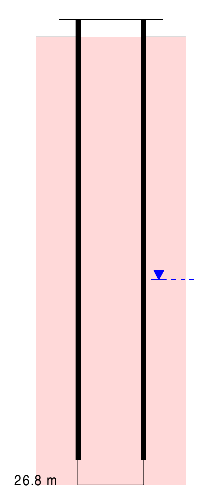


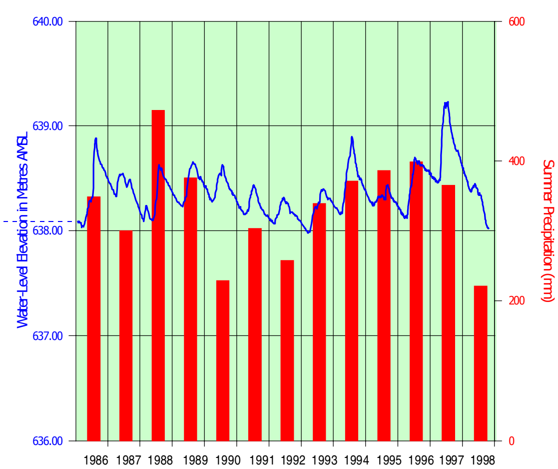
# AE Observation Water Well No. 252



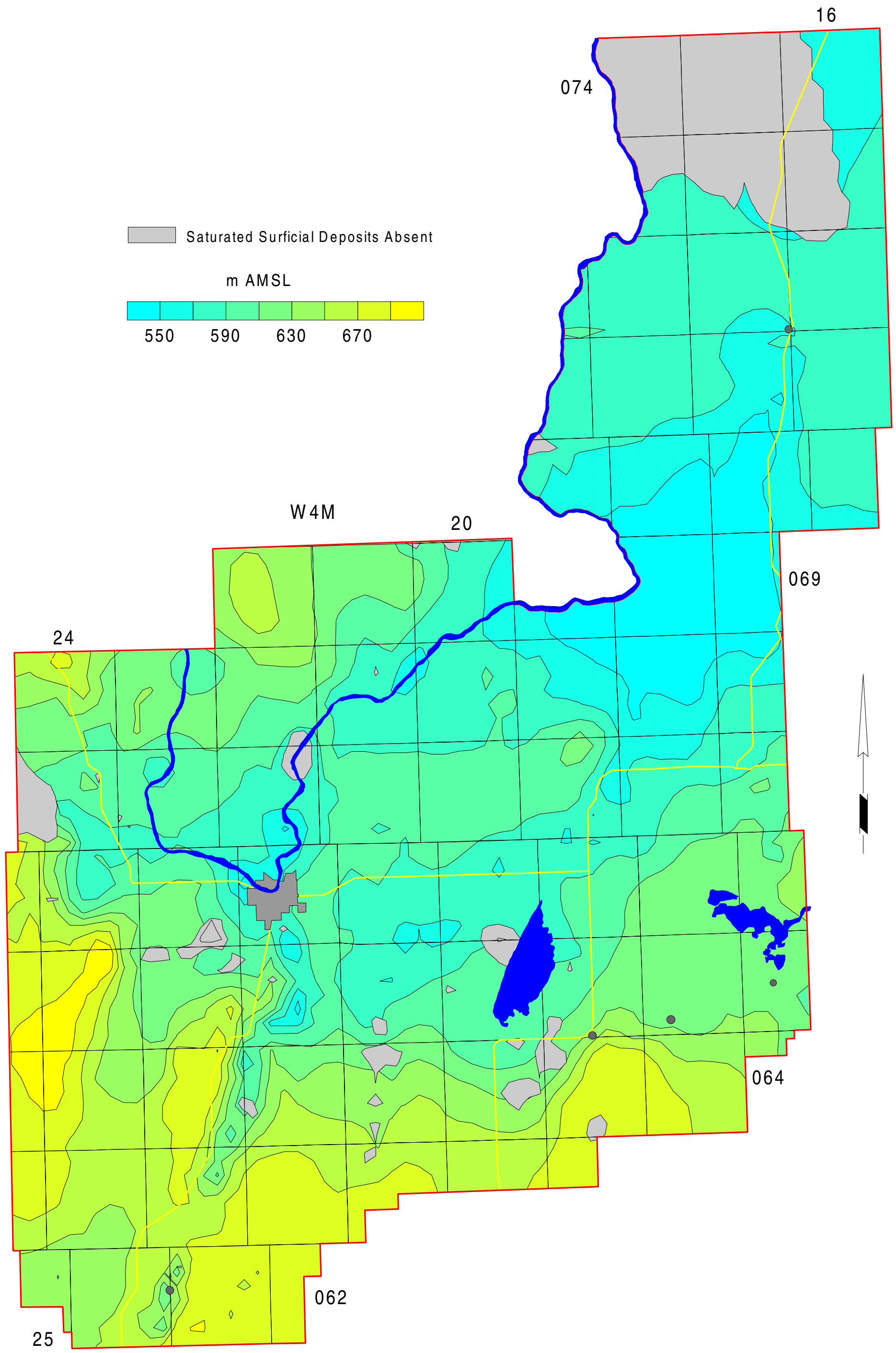

Non-Pumping Water Level

Upper Surficial Deposits

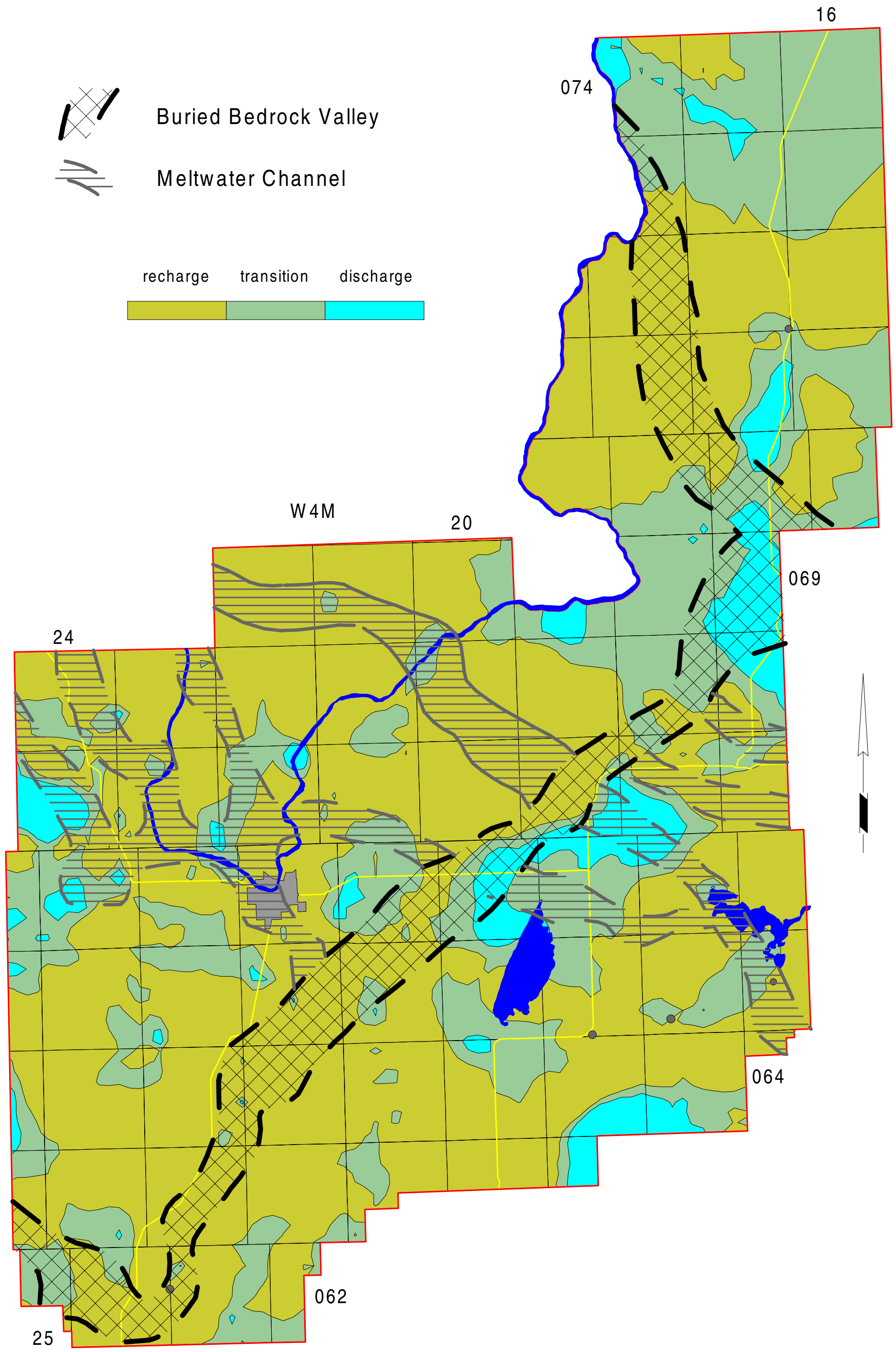


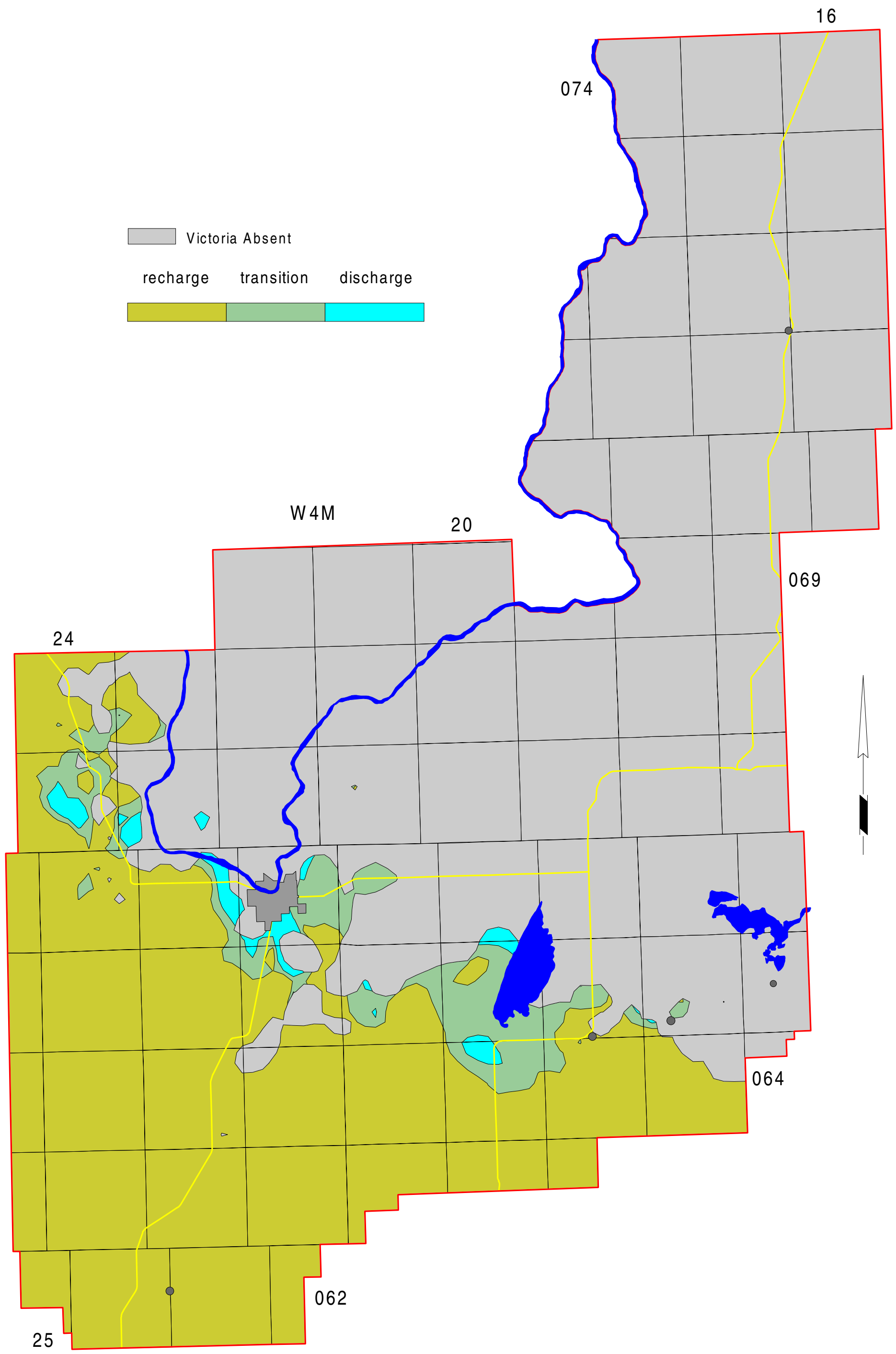
## Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep



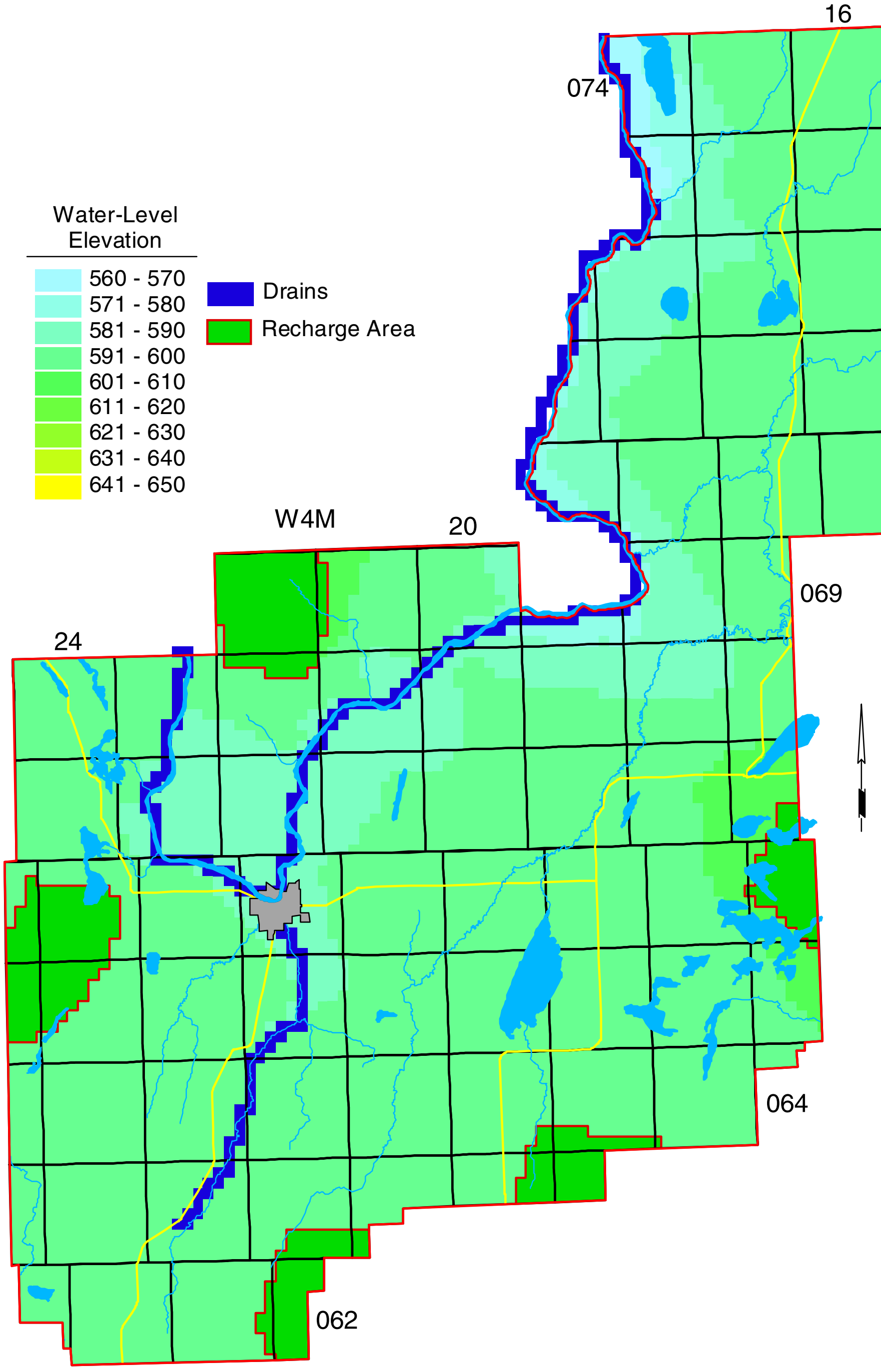
# Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)



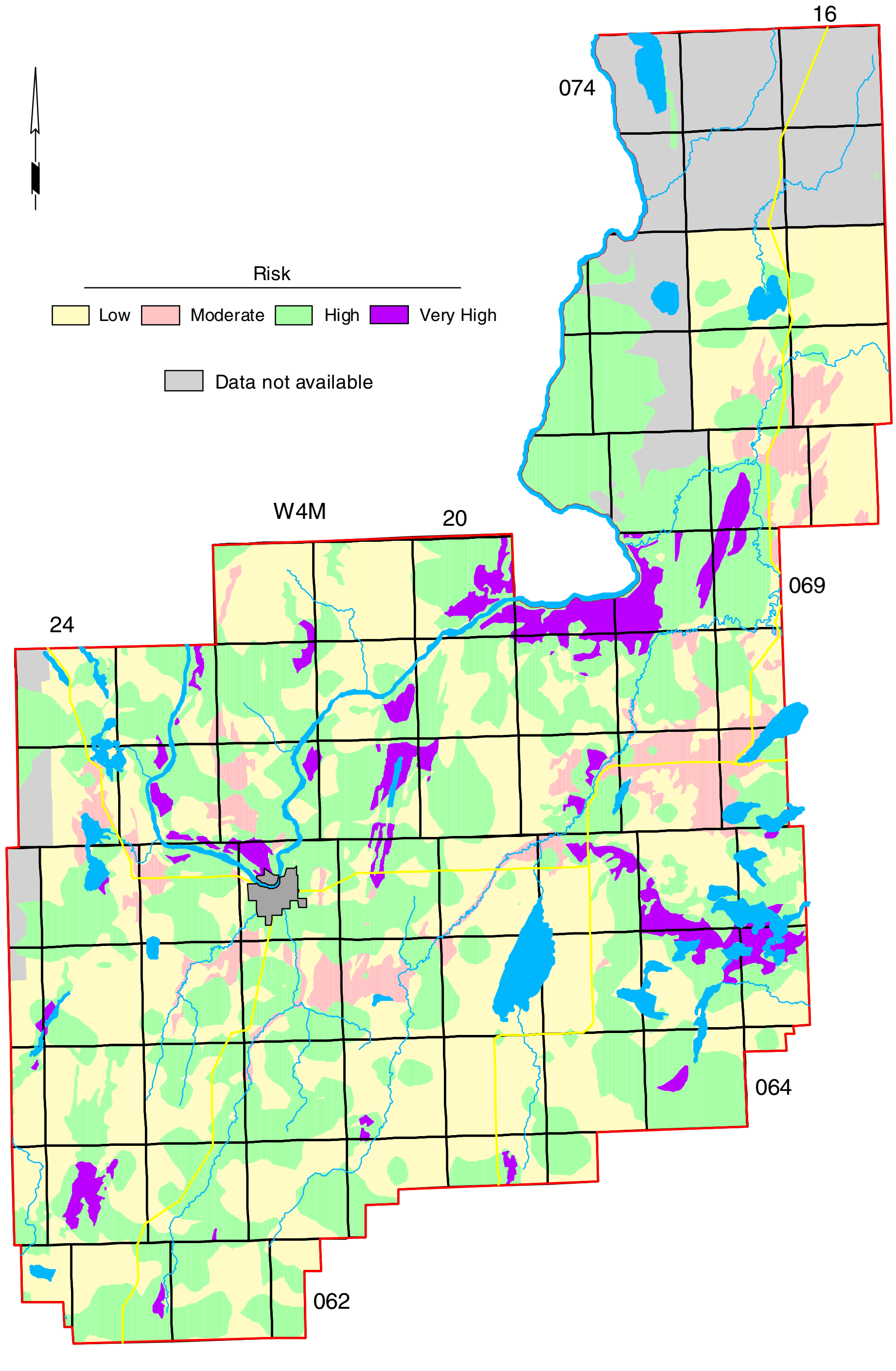
## Recharge/Discharge Areas between Surficial Deposits and Victoria Aquifer



## Modelled Non-Pumping Water-Level Surface in Surficial Deposits



# Risk of Groundwater Contamination




hydrogeological consultants ltd.

# COUNTY OF ATHABASCA NO. 12

## 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
Bedrock Geology
E-Log showing Base of Foremost Formation
Risk of Groundwater Contamination
Relative Permeability
Water Wells Recommended for Field Verification

### 2) Surficial Aquifers

#### a) Surficial Deposits

Thickness of Surficial Deposits
Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep
Modelled Non-Pumping Water-Level Surface in Surficial Deposits
Total Dissolved Solids in Groundwater from Surficial Deposits
Sulfate in Groundwater from Surficial Deposits
Fluoride in Groundwater from Surficial Deposits
Nitrate + Nitrite (as N) in Groundwater from Surficial Deposits
Chloride in Groundwater from Surficial Deposits
Total Hardness in Groundwater from Surficial Deposits
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Amount of Sand and Gravel in Surficial Deposits
Thickness of Sand and Gravel Aquifer(s)

#### b) Upper Sand and Gravel

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

#### b) First Sand and Gravel

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

## 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 Aquifer(s)
Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)
Non-Pumping Water-Level Surface in Upper Bedrock Aquifer(s)

### b) Oldman Formation

Depth to Top of Oldman Formation
Structure-Contour Map - Oldman Formation

### c) Birch Lake Member

Depth to Top of Birch Lake Member
Structure-Contour Map - Birch Lake Member
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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

### d) Ribstone Creek Member

Depth to Top of Ribstone Creek Member
Structure-Contour Map - Ribstone Creek Member
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Total Dissolved Solids in Groundwater from Ribstone Aquifer
Sulfate in Groundwater from Ribstone Aquifer
Chloride in Groundwater from Ribstone Aquifer
Piper Diagram - Ribstone Aquifer
Recharge/Discharge Areas between Surficial Deposits and Ribstone Aquifer

### e) Victoria Member

Depth to Top of Victoria Member
Structure-Contour Map - 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

**f) Brosseau Member**

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

**g) Lea Park Formation**

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

**h) Milk River Formation**

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

**I) *undivided* Colorado Group**

Depth to Top of *undivided* Colorado Group
Structure-Contour Map - *undivided* Colorado Group

**j) Mannvile Group (Grand Rapids)**

Depth to Top of Mannville Group
Structure-Contour Map - Mannville Group

**4) Hydrographs and Observation Water Wells**

Hydrograph - AE Observation Water Well No. 252

# COUNTY OF ATHABASCA NO. 12

# APPENDIX C

## General Water Well Information

# Domestic Water Well Testing

## Purpose and Requirements

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

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

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

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

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

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

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

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

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

# Procedure

**Site Diagrams**

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

**Surface Details**

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

**Groundwater Discharge Point**

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

**Water-Level Measurements**

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

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

**Discharge Measurements**

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

**Water Samples**

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

# Water Act - Water (Ministerial) Regulation

PROVINCE OF ALBERTA

## WATER ACT

## WATER (MINISTERIAL) REGULATION

**Alberta Regulation 205/98**

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**ALBERTA REGULATION 205/98**

**Water Act**

**WATER (MINISTERIAL) REGULATION**

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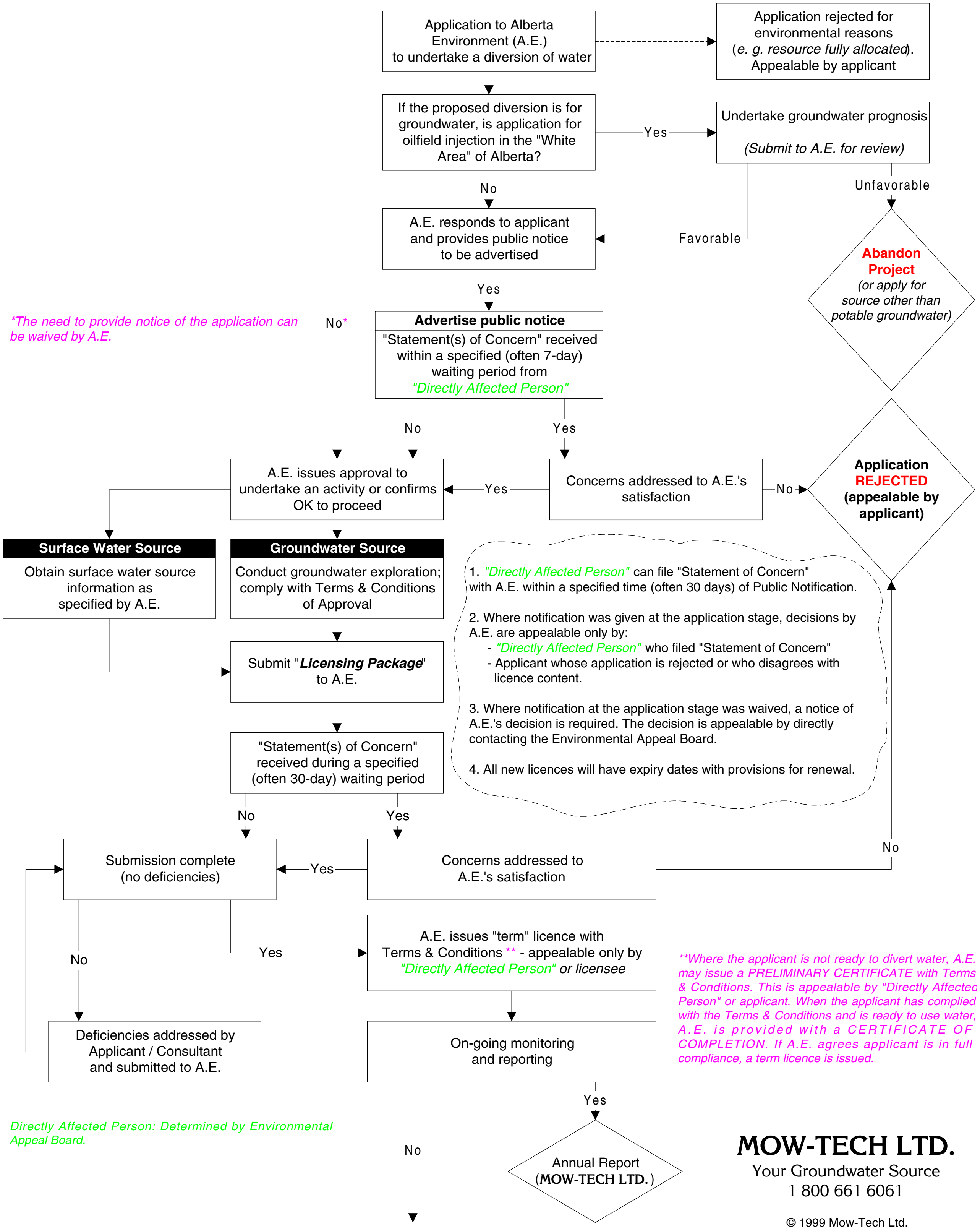
# Water Act - Flowchart




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



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

# 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

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Paul Vasseur (Edmonton: 780-427-2433)

PRAIRIE FARM REHABILITATION ADMINISTRATION

Curtis Snell (Westlock: 780-349-3963)

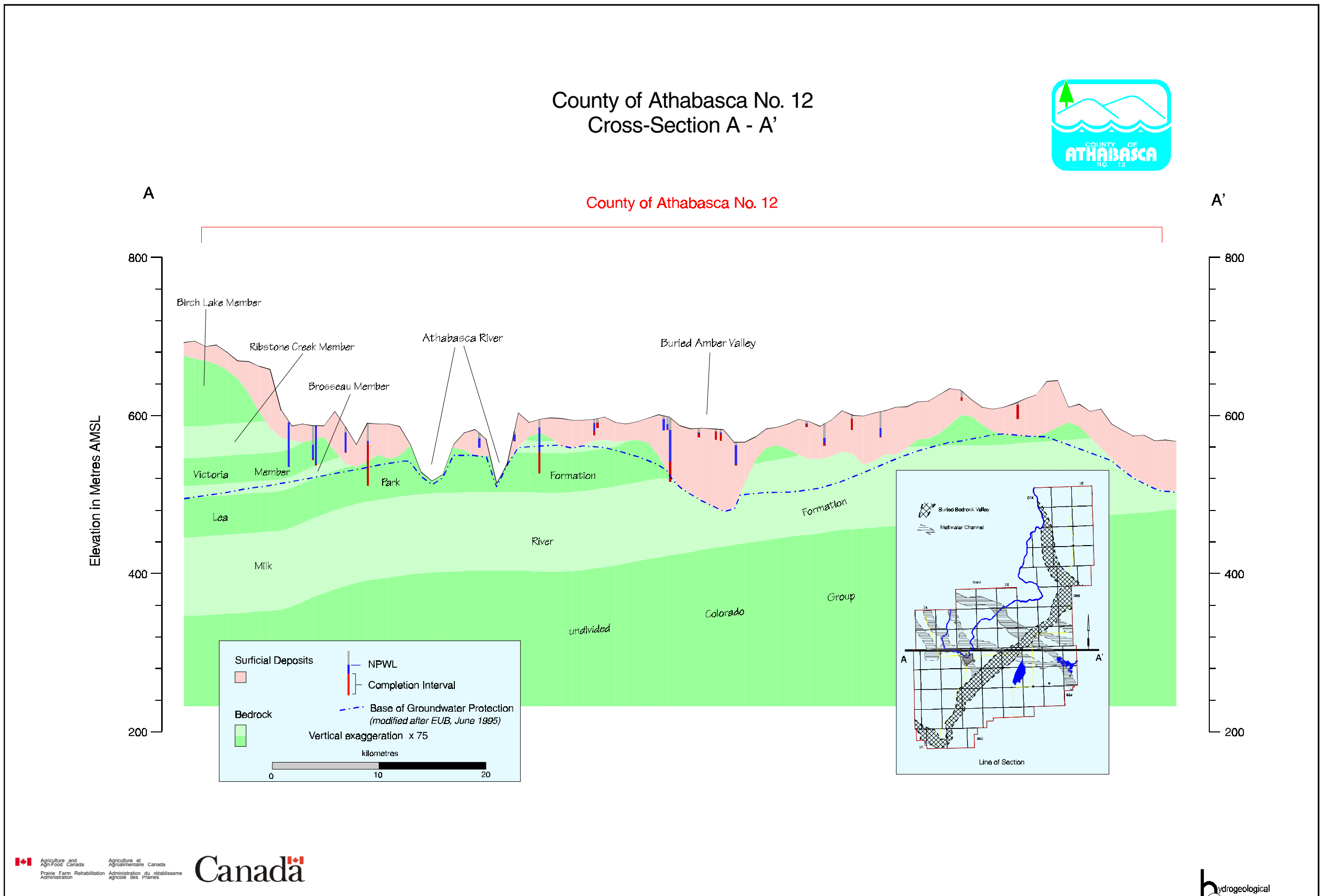
LOCAL HEALTH DEPARTMENTS

# COUNTY OF ATHABASCA NO. 12

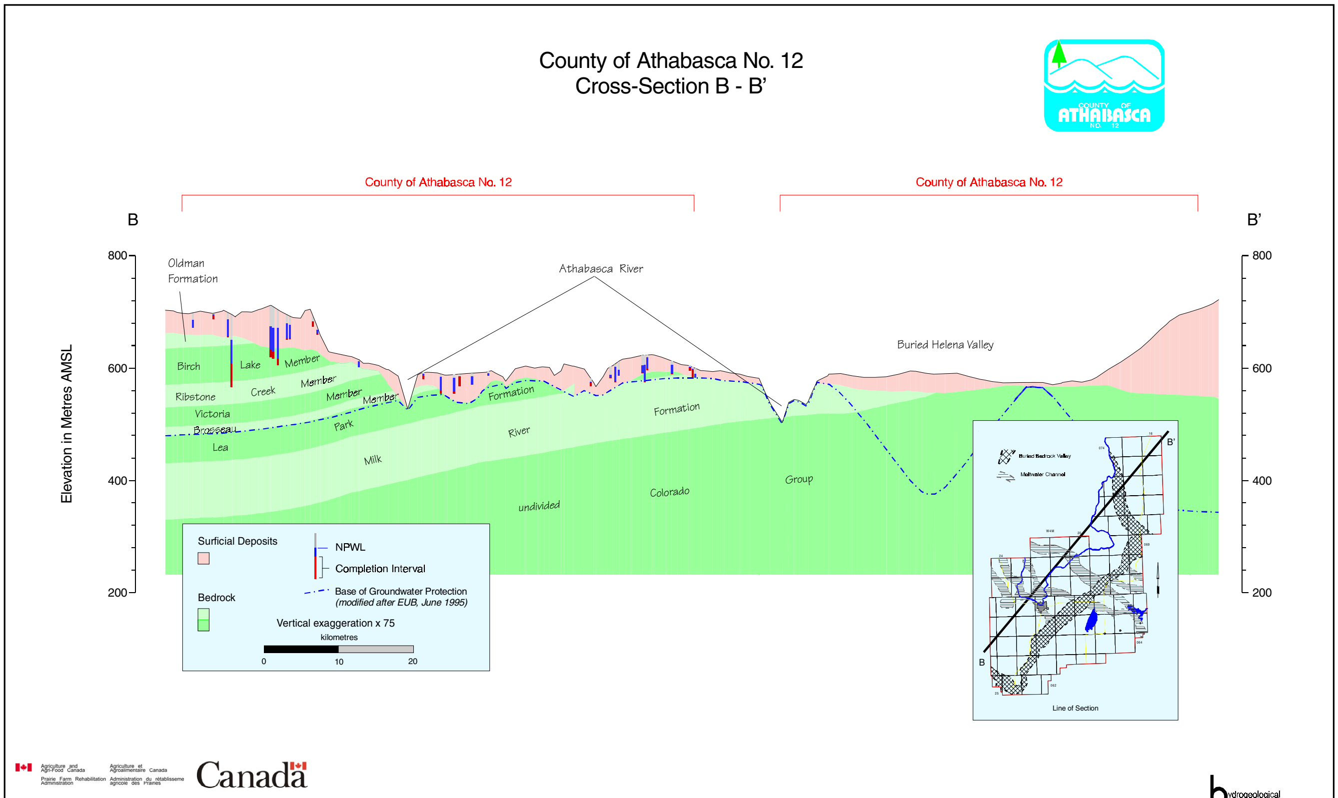
## Appendix D

### Maps and Figures Included as Large Plots

## *Cross-Section A - A’*

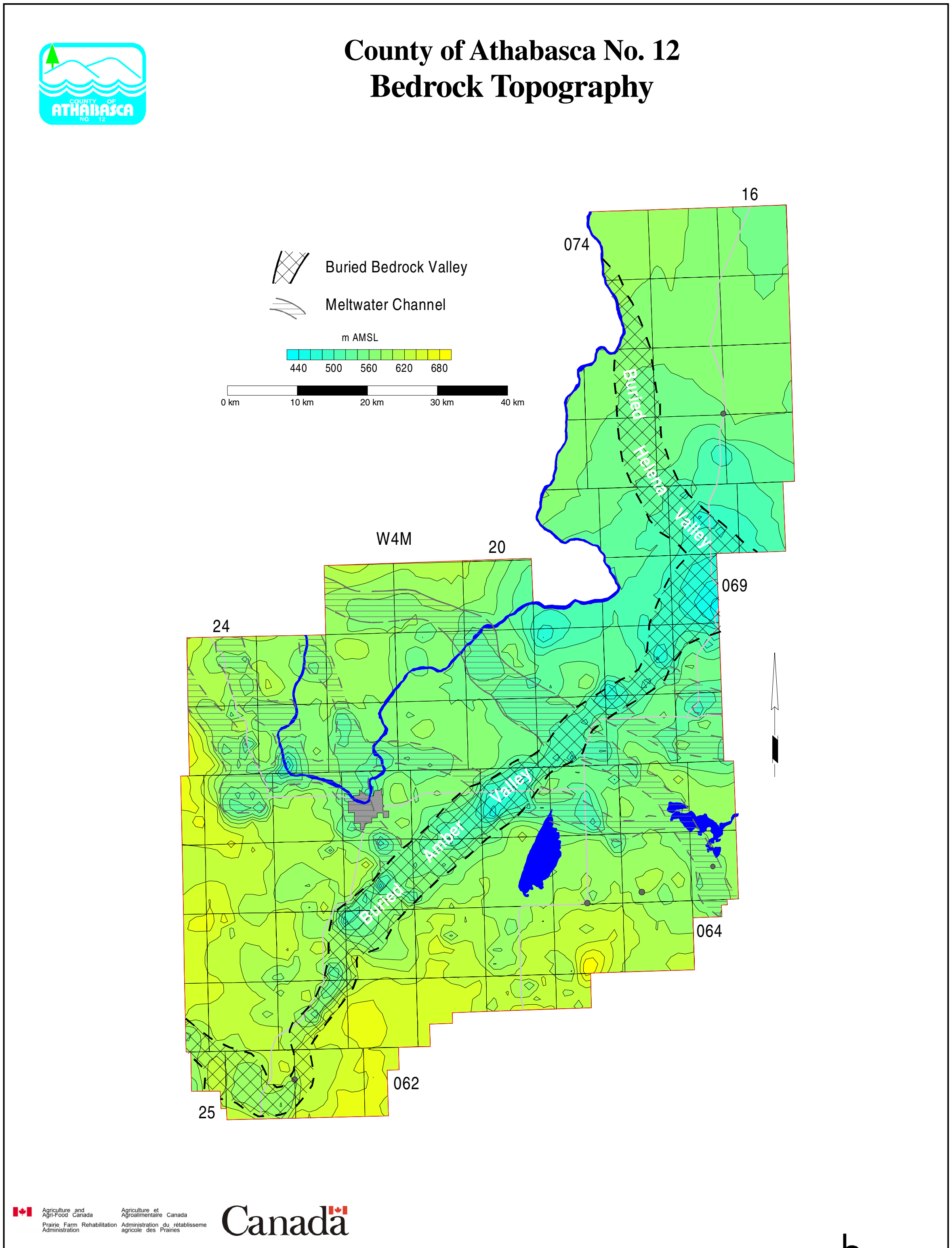


## *Cross-Section B - B'*




hydrogeological consultants ltd, edmonton, alberta - 1-800-661-7972 - project no. 99-135 - csBB.cdr

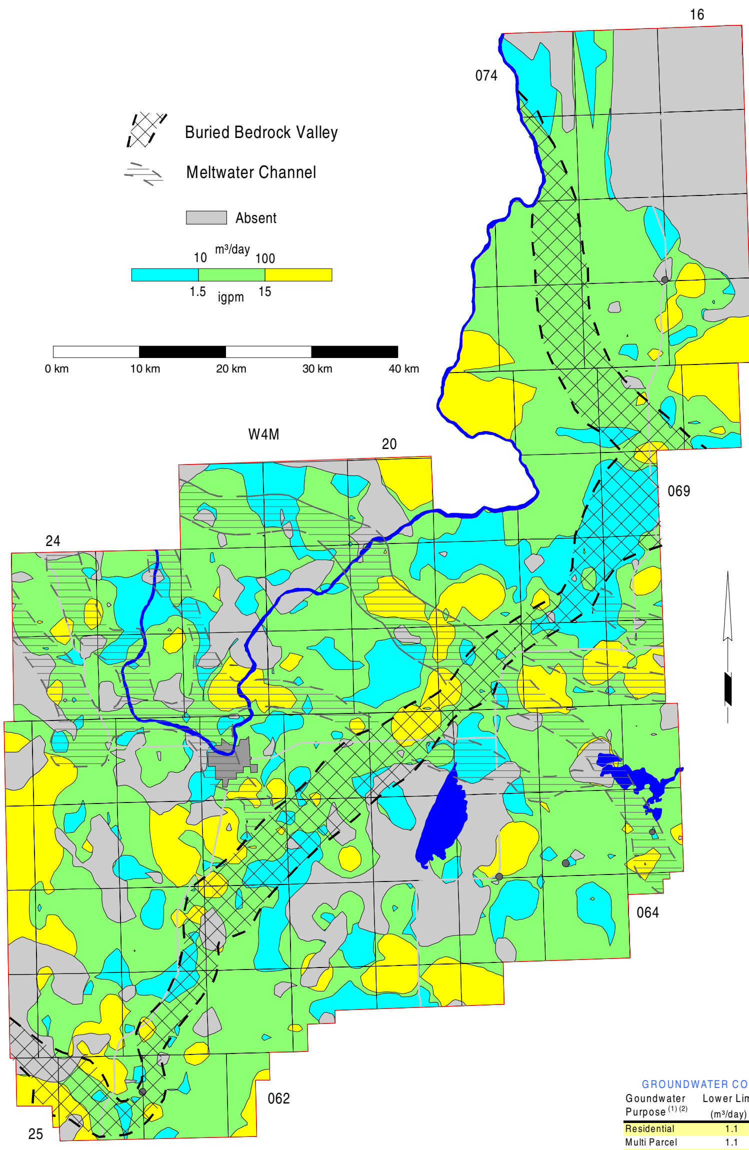
***Bedrock Topography***




hydrogeological consultants ltd, edmonton, alberta - 1-800-661-7972 - project no. 99-135 - bgp.cdr

## *Apparent Yield for Water Wells Completed in Surficial Aquifer(s)*

# County of Athabasca No. 12
# Apparent Yield for Water Wells Completed in Upper Sand and Gravel Aquifer(s)




GROUNDWATER CONSUMPTION

| Goundwater Purpose (1) (2) | Lower Limit (m³/day) | Upper Limit (m³/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



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

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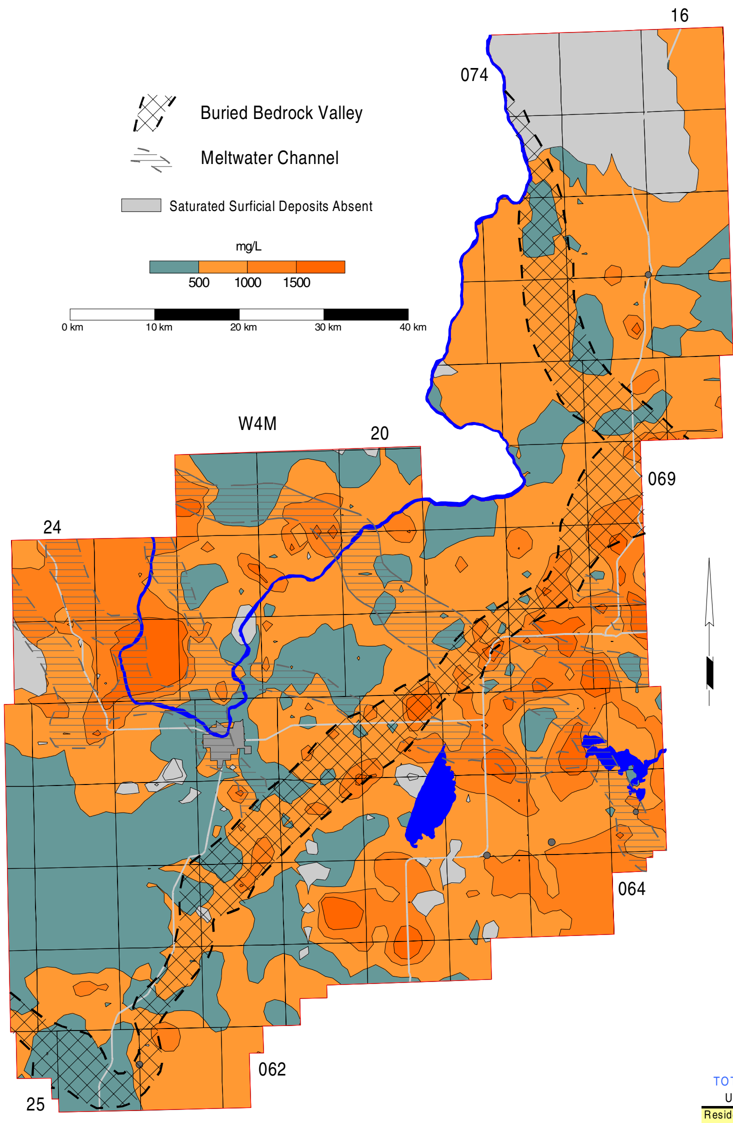
hydrogeological consultants ltd.

## *Total Dissolved Solids in Groundwater from Surficial Aquifer(s)*

# County of Athabasca No. 12
## Total Dissolved Solids in Groundwater from Surficial Aquifer(s)




MAXIMUM LIMIT
TOTAL DISSOLVED SOLIDS

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

from: Canadian Water Quality Guidelines, 1992

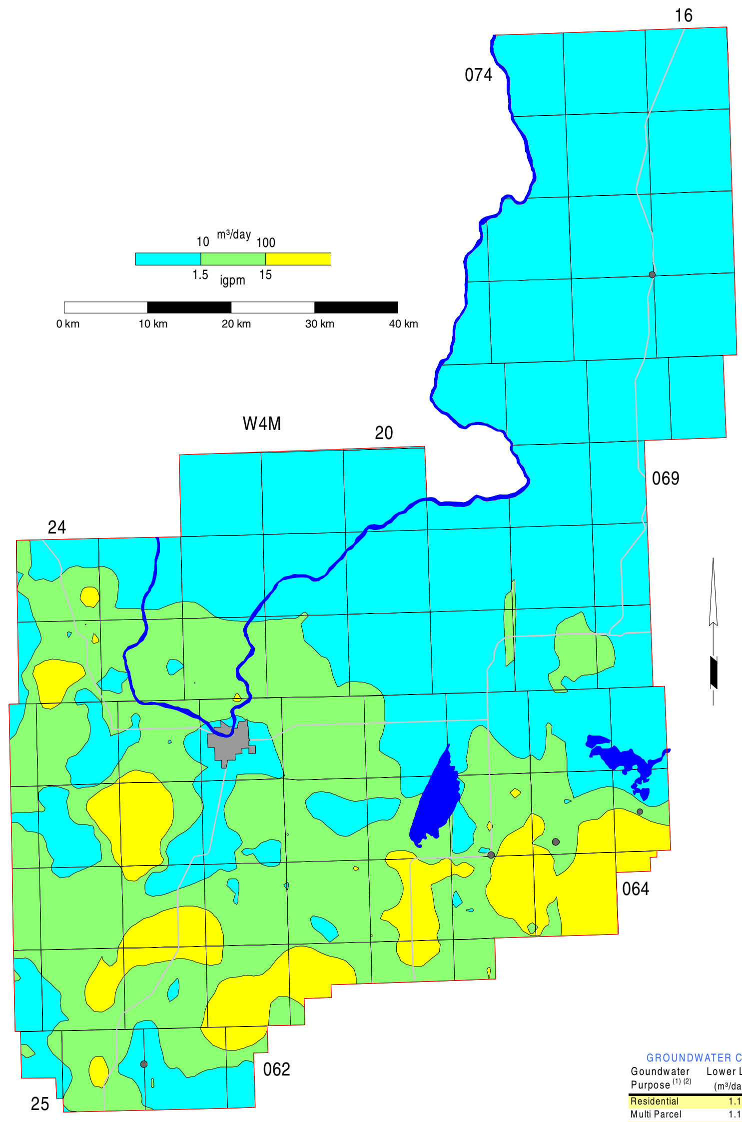


Agriculture and Agri-Food Canada
Prairie Farm Rehabilitation Administration
Agriculture et Agroalimentaire Canada
Administration du rétablisseme agricole des Prairies
Canada

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

# County of Athabasca No. 12

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



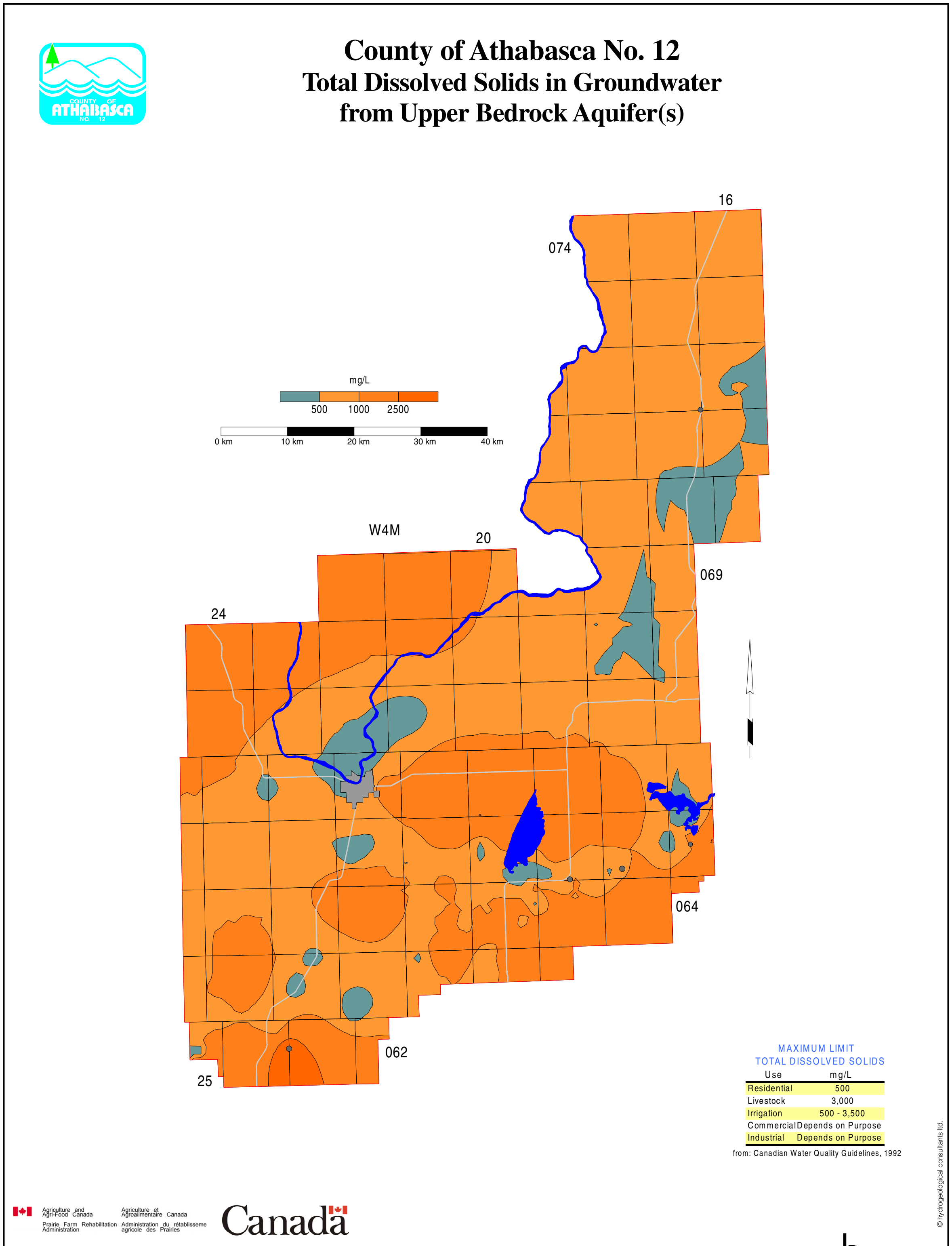

GROUNDWATER CONSUMPTION

| Goundwater Purpose (1) (2) | Lower Limit (m³/day) | Upper Limit (m³/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

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

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

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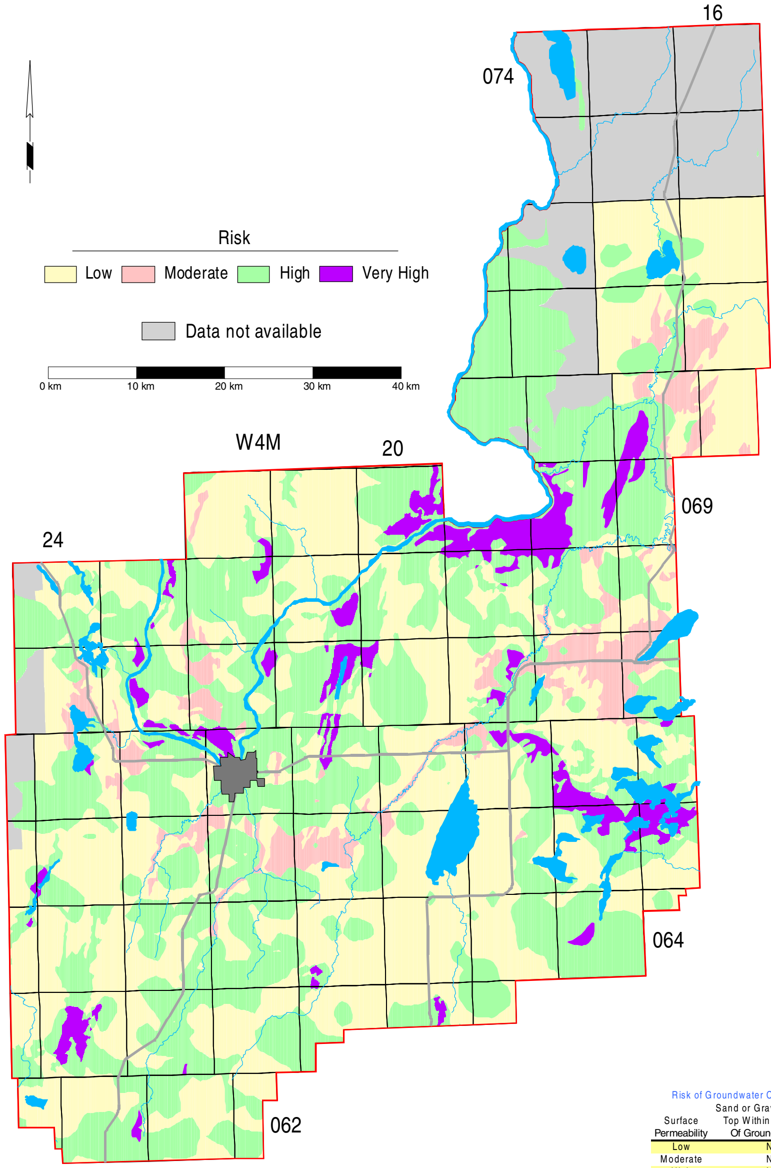
## *Risk of Groundwater Contamination*

# County of Athabasca No. 12
## Risk of Groundwater Contamination




Risk of Groundwater Contamination Criteria

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



Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada
Prairie Farm Rehabilitation Administration / Administration du rétablissement agricole des Prairies
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# COUNTY OF ATHABASCA NO. 12

## Appendix E

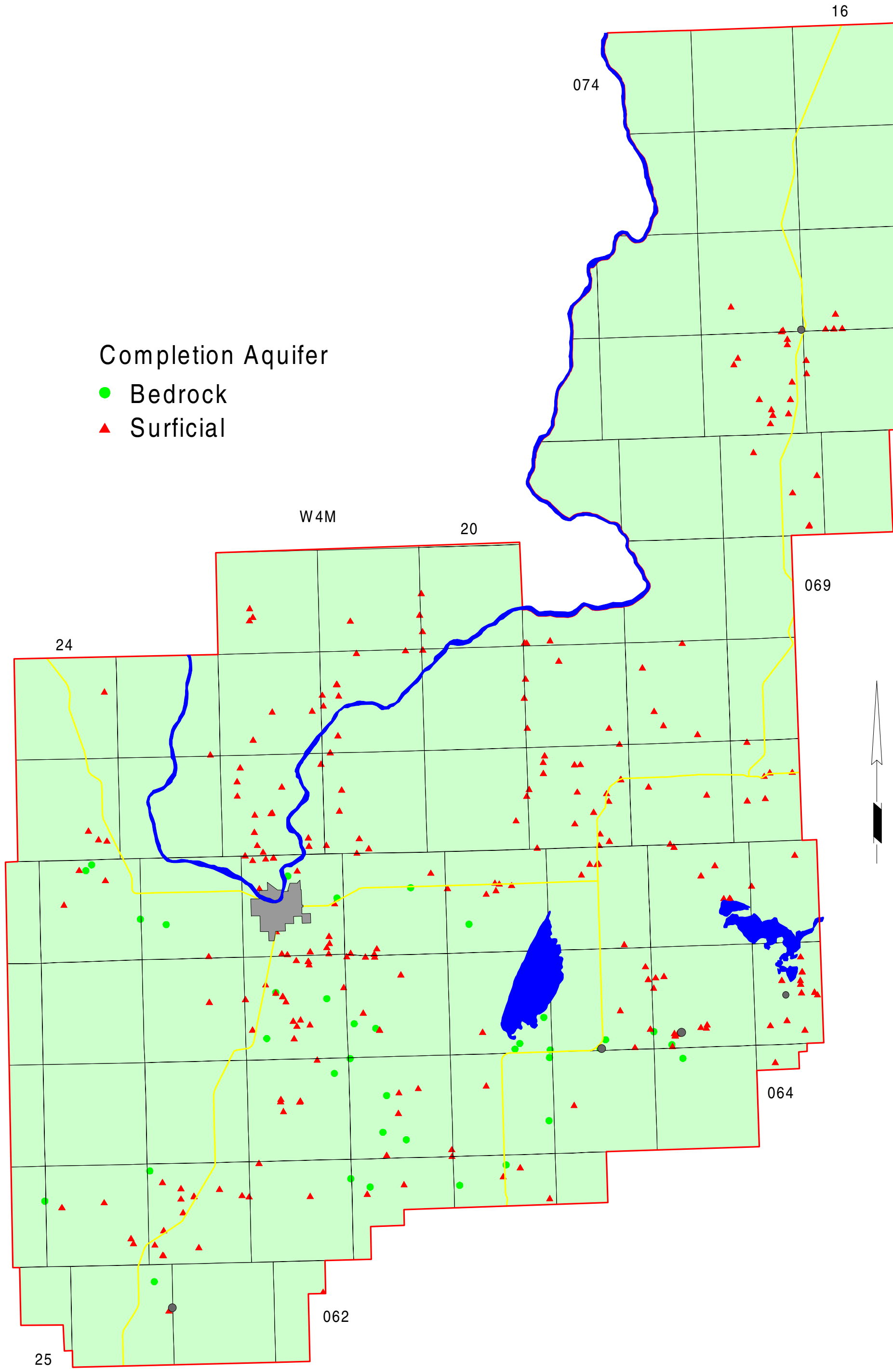
### WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

### AND

### COUNTY - OPERATED WATER WELL

## Water Wells Recommended for Field Verification

*(details on following pages)*



**WATER WELLS RECOMMENDED FOR FIELD VERIFICATION**

| Owner | Location | Aquifer Name | Date Water Well Drilled | Completed Depth Metres | Completed Depth Feet | NPWL Metres | NPWL Feet |
|---|---|---|---|---|---|---|---|
| Adock, E. | 15-12-064-20 W4M | Victoria | May-78 | 57.9 | 190.0 | 24.4 | 80.0 |
| Alberta Municipal Affairs | 01-21-065-17 W4M | Upper Surficial | Oct-84 | 33.8 | 111.0 | 13.1 | 43.0 |
| Aleksiuk, Brent | SW-02-068-18 W4M | Upper Surficial | Oct-88 | 3.7 | 12.0 | 2.4 | 8.0 |
| Amisk Lake Trailer Park | SW-10-065-18 W4M | Upper Surficial | Apr-81 | 9.8 | 32.0 | 2.4 | 8.0 |
| Anderson, Lloyd | SE-08-065-17 W4M | Upper Surficial | Sep-80 | 42.7 | 140.0 | 14.6 | 48.0 |
| Armfelt, Gerald | SW-20-066-24 W4M | Upper Surficial | Sep-81 | 13.7 | 45.0 | 6.1 | 20.0 |
| Ashbey, Allen | 13-27-065-21 W4M | Upper Surficial | Sep-84 | 6.7 | 22.0 | 2.1 | 7.0 |
| Balay, Tony | 08-26-062-24 W4M | Birch Lake | Aug-76 | 53.3 | 175.0 | 21.9 | 72.0 |
| Bambrack/Alberta Forestry | 02-02-072-17 W4M | Upper Surficial | Oct-79 | 14.6 | 48.0 | 7.0 | 23.0 |
| Bandola, Nick | 16-20-063-23 W4M | Upper Surficial | May-77 | 7.6 | 25.0 | 3.1 | 10.0 |
| Battrick, Robert | 16-25-063-22 W4M | Birch Lake | Jan-79 | 12.2 | 40.0 | 1.8 | 6.0 |
| Baxandall, Dan | 09-19-063-24 W4M | Upper Surficial | May-76 | 53.3 | 175.0 | 7.0 | 23.0 |
| Baxandall, Don | 09-19-063-24 W4M | Upper Surficial | Oct-70 | 54.3 | 178.0 | 10.7 | 35.0 |
| Begalow, Geo | 04-24-071-17 W4M | Upper Surficial | Jun-78 | 14.0 | 46.0 | 9.1 | 30.0 |
| Bencharsky, David | SW-14-065-19 W4M | Upper Surficial | Sep-75 | 13.1 | 43.0 | 2.3 | 7.5 |
| Benham, Derril | 12-31-063-23 W4M | Ribstone Creek | Aug-81 | 108.2 | 355.0 | 18.3 | 60.0 |
| Benn Water Wells Ltd | NE-20-065-22 W4M | Ribstone Creek | Mar-93 | 42.7 | 140.1 | 18.3 | 60.0 |
| Benn, W. | 09-16-064-21 W4M | Upper Surficial | Apr-81 | 40.5 | 133.0 | 18.3 | 60.0 |
| Berezowski, Dean | NW-08-066-20 W4M | Lea Park | Sep-84 | 42.1 | 138.0 | 3.7 | 12.0 |
| Besler, Ron | ---21-065-22 W4M | Upper Surficial | May-84 | 15.5 | 51.0 | 15.9 | 52.0 |
| Beye, Grant | 09-29-063-23 W4M | Upper Surficial | Jan-79 | 19.5 | 64.0 | 4.6 | 15.0 |
| Bibaud, William | NE-24-063-23 W4M | Upper Surficial | Aug-85 | 11.3 | 37.0 | 0.9 | 3.0 |
| Bicherstaff, Dale | NE-21-066-20 W4M | Upper Surficial | Sep-78 | 11.3 | 37.0 | 3.7 | 12.0 |
| Birkigt, A. | 15-28-066-22 W4M | Lea Park | Jun-82 | 13.7 | 45.0 | 4.6 | 15.0 |
| Bittorf, Brian | NE-20-064-22 W4M | Upper Surficial | Jul-79 | 29.0 | 95.0 | 6.7 | 22.0 |
| Bizon, C. | SW-33-068-19 W4M | Upper Surficial | Jul-87 | 10.1 | 33.0 | 4.0 | 13.0 |
| Bizon, Roman | 08-08-065-20 W4M | Upper Surficial | Jun-78 | 12.5 | 41.0 | 3.7 | 12.0 |
| Bobocel, Dan | 03-24-066-22 W4M | Upper Surficial | Sep-79 | 10.4 | 34.0 | 3.1 | 10.0 |
| Bouque, Joe | 13-15-064-17 W4M | Upper Surficial | Jan-84 | 64.0 | 210.0 | 30.6 | 100.3 |
| Boven, Tom | SE-30-067-22 W4M | Upper Surficial | Jun-80 | 14.0 | 46.0 | 6.1 | 20.0 |
| Bow Valley Inn | SE-05-072-16 W4M | Upper Surficial | Aug-84 | 44.8 | 147.0 | 32.3 | 106.0 |
| Bowzaylo, Jim | 07-03-066-23 W4M | Upper Surficial | Sep-69 | 10.7 | 35.0 | 4.0 | 13.0 |
| Bradfield, C. | SE-13-066-24 W4M | Ribstone Creek | Jul-86 | 20.7 | 68.0 | 6.4 | 21.0 |
| Breckenridge, Morley | SE-23-065-22 W4M | Brosseau | Sep-85 | 48.8 | 160.0 | 14.3 | 47.0 |
| Bryan, Robert | SW-17-066-23 W4M | Ribstone Creek | Jun-78 | 13.7 | 45.0 | 3.7 | 12.0 |
| Buch, Marvin | SE-17-067-22 W4M | Upper Surficial | Oct-79 | 11.0 | 36.0 | 2.4 | 8.0 |
| Buerfeind, Manfred | SW-34-063-20 W4M | Brosseau | Aug-85 | 109.7 | 360.0 | 43.3 | 142.0 |
| Bychyk, Doug | SW-07-065-18 W4M | Brosseau | Dec-79 | 41.2 | 135.0 | 4.3 | 14.0 |
| Byer, Carl | 14-22-063-24 W4M | Upper Surficial | Sep-81 | 15.2 | 50.0 | 2.4 | 8.0 |
| Byrtus, Stan | NE-16-067-22 W4M | Upper Surficial | Nov-78 | 9.1 | 30.0 | 4.3 | 14.0 |
| Byrtus, Stan | NE-16-067-22 W4M | Upper Surficial | May-88 | 36.0 | 118.0 | 10.5 | 34.5 |
| Campbell, Norman | SE-27-067-17 W4M | Upper Surficial | Apr-86 | 64.0 | 210.0 | 28.0 | 92.0 |
| Cardinal, Ray | NW-29-064-17 W4M | Upper Surficial | Oct-73 | 33.2 | 109.0 | 22.0 | 72.3 |
| Casavant, Lucien | NE-18-065-21 W4M | Upper Surficial | Nov-72 | 7.3 | 24.0 | 3.1 | 10.0 |
| Chamzuk, Jerry | SE-25-065-19 W4M | Upper Surficial | Jul-81 | 15.2 | 50.0 | 12.2 | 40.0 |
| Chamzuk, Leonard | NE-32-066-18 W4M | Upper Surficial | Aug-68 | 13.7 | 45.0 | 7.3 | 24.0 |
| Chamzuk, Stanley | 15-32-066-18 W4M | Upper Surficial | Dec-77 | 19.5 | 64.0 | 6.7 | 22.0 |
| Chamzuk, Stanley | NE-32-066-18 W4M | Upper Surficial | Apr-76 | 11.0 | 36.0 | 4.9 | 16.0 |
| Cholak, E.J. | NW-27-067-19 W4M | Upper Surficial | Jun-82 | 88.1 | 289.0 | 56.4 | 185.0 |
| Chrusch, Mike | SW-20-068-21 W4M | Upper Surficial | Aug-85 | 11.6 | 38.0 | 4.6 | 15.0 |
| Clarke, Gordon | 12-21-064-21 W4M | Birch Lake | Oct-83 | 18.3 | 60.0 | 6.4 | 21.0 |
| Clarke, M. | SW-21-066-20 W4M | Upper Surficial | May-81 | 13.7 | 45.0 | 5.5 | 18.0 |
| Claussen, F. | SE-05-066-21 W4M | Upper Surficial | Nov-73 | 4.3 | 14.0 | 2.1 | 7.0 |
| Claussen, Frank | 02-05-066-21 W4M | Upper Surficial | May-76 | 73.2 | 240.0 | 15.2 | 50.0 |
| Colli, H./Whetstone, Arthur | NW-21-065-22 W4M | Upper Surficial | Jun-85 | 16.5 | 54.0 | 3.4 | 11.0 |

**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 |
|---|---|---|---|---|---|---|---|
| Combs, L. | SW-15-071-17 W4M | Upper Surficial | Jun-82 | 22.6 | 74.0 | 13.1 | 43.0 |
| Connochie, Robert W. | SW-26-064-21 W4M | Upper Surficial | Oct-74 | 9.5 | 31.0 | 1.5 | 5.0 |
| Coonan, Jack | NW-19-071-16 W4M | Upper Surficial | Jul-82 | 63.1 | 207.0 | 36.6 | 120.0 |
| County of Ahtabasca | SE-30-065-18 W4M | Upper Surficial | Sep-86 | 55.5 | 182.0 | 22.9 | 75.0 |
| Croteau, Vic | SE-29-071-17 W4M | Upper Surficial | Jul-85 | 17.7 | 58.0 | 6.1 | 20.0 |
| Cumbleton, Steve | 16-24-063-25 W4M | Birch Lake | Jun-86 | 79.2 | 260.0 | 27.4 | 90.0 |
| Currat, Henry | SE-32-064-18 W4M | Victoria | Jul-82 | 51.8 | 170.0 | 21.3 | 70.0 |
| Dagley, Paul | 13-16-064-22 W4M | Upper Surficial | Aug-81 | 13.7 | 45.0 | 0.9 | 3.0 |
| Danylchuk, Steve | 13-36-068-21 W4M | Upper Surficial | Jul-83 | 13.4 | 44.0 | 4.0 | 13.0 |
| Davidson, Bill | 16-19-063-21 W4M | Upper Surficial | Oct-76 | 16.8 | 55.0 | 7.6 | 25.0 |
| Desjarlais, Claude III | 16-20-064-17 W4M | Upper Surficial | Jan-84 | 61.0 | 200.0 | 11.1 | 36.5 |
| Dew All Truss Ltd | SE-02-066-22 W4M | Upper Surficial | Jun-86 | 18.9 | 62.0 | 16.2 | 53.0 |
| Donatville Gas And Groceries | SE-33-066-19 W4M | Upper Surficial | Sep-87 | 11.3 | 37.0 | 4.9 | 16.0 |
| Doole, Allan | SE-34-065-22 W4M | Upper Surficial | Oct-74 | 22.6 | 74.0 | 18.0 | 59.0 |
| Droziak, P/ Norgard, Brenda | NW-21-065-22 W4M | Upper Surficial | Apr-85 | 25.6 | 84.0 | 11.4 | 37.3 |
| Duigou, Gilbert | SW-28-067-17 W4M | Upper Surficial | Sep-73 | 11.6 | 38.0 | 7.6 | 25.0 |
| Duigou, Gilbert | SW-28-067-17 W4M | Upper Surficial | Feb-86 | 35.4 | 116.0 | 7.6 | 25.0 |
| Duma, Alex | NW-12-067-20 W4M | Upper Surficial | Jun-89 | 42.7 | 140.0 | 20.7 | 68.0 |
| Duma, Stan | SW-27-066-20 W4M | Upper Surficial | Nov-88 | 13.1 | 43.0 | 5.8 | 19.0 |
| Duniece, Dale | 16-13-068-20 W4M | Upper Surficial | Sep-83 | 57.9 | 190.0 | 18.3 | 60.0 |
| Dunkley, Delbert | SW-12-063-24 W4M | Upper Surficial | Jun-84 | 13.1 | 43.0 | 9.1 | 30.0 |
| Durell, Gerald | SW-09-068-18 W4M | Upper Surficial | Aug-82 | 20.7 | 68.0 | 5.5 | 18.0 |
| Edwards, Ken | NE-22-066-20 W4M | Upper Surficial | Dec-88 | 20.7 | 68.0 | 15.5 | 51.0 |
| Elsenheimer, Lawrence J. | NW-32-065-21 W4M | Upper Surficial | | 14.6 | 48.0 | 3.1 | 10.0 |
| Emmond, Don | SE-09-065-18 W4M | Upper Surficial | Oct-83 | 20.7 | 68.0 | 10.7 | 35.0 |
| Energy & Natural Res | SE-02-072-17 W4M | Upper Surficial | Sep-83 | 40.2 | 132.0 | 22.3 | 73.0 |
| Faragini, Ruth | SE-08-066-22 W4M | Upper Surficial | | 15.9 | 52.0 | 9.8 | 32.0 |
| Farrell, Garth C. | 03-06-066-21 W4M | Upper Surficial | Oct-80 | 6.1 | 20.0 | 3.1 | 10.0 |
| Faulkner, Richard | 04-36-064-22 W4M | Ribstone Creek | Jul-82 | 32.6 | 107.0 | 22.9 | 75.0 |
| Fesuk, J. | 16-05-068-22 W4M | Upper Surficial | May-81 | 13.7 | 45.0 | 4.6 | 15.0 |
| Flasha, John | NW-19-067-19 W4M | Upper Surficial | Jun-76 | 86.0 | 282.0 | 39.0 | 128.0 |
| Fleming, Garry | SW-04-067-22 W4M | Upper Surficial | Aug-81 | 12.2 | 40.0 | 3.1 | 10.0 |
| Fleming, George | SE-23-067-19 W4M | Upper Surficial | Jun-87 | 24.4 | 80.0 | 18.6 | 61.0 |
| Fleming, Gordon | NE-14-067-19 W4M | Upper Surficial | May-88 | 55.5 | 182.0 | 21.9 | 72.0 |
| Forcier, Leo | 14-05-065-18 W4M | Upper Surficial | Jun-78 | 11.9 | 39.0 | 1.2 | 4.0 |
| Foss/Johnson (Roy, T.) | SE-02-067-19 W4M | Upper Surficial | May-86 | 12.5 | 41.0 | 2.7 | 9.0 |
| Fugger, Walter | 01-09-063-23 W4M | Upper Surficial | Nov-79 | 9.1 | 30.0 | 6.7 | 22.0 |
| Georgijevic, B. | 02-13-065-20 W4M | Brosseau | Nov-77 | 9.5 | 31.0 | 4.9 | 16.0 |
| Germain, Real | SW-13-071-17 W4M | Upper Surficial | Jun-81 | 16.8 | 55.0 | 14.0 | 46.0 |
| Gervais, Paul | SE-33-066-17 W4M | Upper Surficial | Aug-77 | 18.3 | 60.0 | 1.2 | 4.0 |
| Gill, Ralph | SE-25-065-22 W4M | Upper Surficial | Sep-89 | 33.2 | 109.0 | 12.2 | 40.0 |
| Goodwin, Clifford F. | SE-24-063-20 W4M | Upper Surficial | Jun-77 | 26.5 | 87.0 | 4.3 | 14.0 |
| Goossen, Walter/Tara Const | SW-04-066-22 W4M | Upper Surficial | Aug-93 | 19.2 | 63.0 | 7.3 | 24.0 |
| Gorden, Bruce | SW-19-066-17 W4M | Upper Surficial | Apr-89 | 59.1 | 194.0 | 22.3 | 73.0 |
| Gordey, Garry | 12-15-068-22 W4M | Upper Surficial | Jun-79 | 11.3 | 37.0 | 3.1 | 10.0 |
| Gorski, Adolph | 04-07-069-20 W4M | Upper Surficial | Feb-74 | 7.9 | 26.0 | 6.1 | 20.0 |
| Gorski, S. | NW-31-068-20 W4M | Upper Surficial | Aug-79 | 9.8 | 32.0 | 3.1 | 10.0 |
| Gosling Holdings Ltd. | NE-20-065-17 W4M | Upper Surficial | Oct-78 | 45.7 | 150.0 | 13.4 | 43.9 |
| Guay, John | SE-28-063-23 W4M | Upper Surficial | Sep-86 | 10.1 | 33.0 | 3.1 | 10.0 |
| Guay, John W. | SE-28-063-23 W4M | Upper Surficial | Jun-79 | 5.5 | 18.0 | 2.4 | 8.0 |
| Gunderson, Albert | SW-10-064-21 W4M | Birch Lake | Aug-78 | 21.9 | 72.0 | 3.1 | 10.0 |
| Hanna, George #1 Well | 15-31-063-22 W4M | Upper Surficial | Sep-78 | 28.4 | 93.0 | 14.3 | 47.0 |
| Hatch, Ron | NW-28-071-17 W4M | Upper Surficial | Sep-85 | 8.5 | 28.0 | 5.5 | 18.0 |
| Haub, Robert | SW-01-068-23 W4M | Upper Surficial | Jul-86 | 20.7 | 68.0 | 11.0 | 36.0 |
| Hay, D.D. | 13-10-065-22 W4M | Upper Surficial | Nov-76 | 83.8 | 275.0 | 2.4 | 8.0 |

**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 |
|---|---|---|---|---|---|---|---|
| Hayes, Jack | SE-24-062-24 W4M | Upper Surficial | Aug-72 | 9.1 | 30.0 | 8.3 | 27.1 |
| Hendy, Rick | 16-08-069-22 W4M | Upper Surficial | Aug-82 | 27.7 | 91.0 | 14.9 | 49.0 |
| Henson, Don | NE-21-065-17 W4M | Upper Surficial | Feb-85 | 30.5 | 100.0 | 7.3 | 24.0 |
| Henson, Donald | NE-21-065-17 W4M | Upper Surficial | Nov-75 | 10.7 | 35.0 | 5.5 | 18.0 |
| Henson, Donald | NE-21-065-17 W4M | Upper Surficial | Feb-85 | 34.1 | 112.0 | 7.3 | 24.0 |
| Henson, Rock | 02-22-065-17 W4M | Upper Surficial | Dec-85 | 22.9 | 75.0 | 9.1 | 30.0 |
| Herrmann, Egon | NE-28-063-20 W4M | Upper Surficial | Nov-78 | 10.4 | 34.0 | 7.9 | 26.0 |
| Hewko, Tony | SW-27-066-18 W4M | Upper Surficial | Sep-79 | 9.8 | 32.0 | 4.3 | 14.0 |
| Hillson Nursery | SE-18-063-23 W4M | Upper Surficial | Jul-85 | 18.6 | 61.0 | 18.6 | 61.0 |
| Hofner, D. | NW-02-067-19 W4M | Upper Surficial | Mar-78 | 11.9 | 39.0 | 7.6 | 25.0 |
| Holdis, Romeo | NW-24-067-19 W4M | Upper Surficial | Oct-81 | 25.9 | 85.0 | 14.6 | 48.0 |
| Holdis, Romeo | NW-24-067-19 W4M | Upper Surficial | Aug-66 | 19.5 | 64.0 | 14.0 | 46.0 |
| Holst, E. | 13-17-064-19 W4M | Upper Surficial | May-82 | 12.5 | 41.0 | 4.6 | 15.0 |
| Holt Construction | NE-34-065-22 W4M | Upper Surficial | Aug-86 | 24.1 | 79.0 | 4.0 | 13.0 |
| Holt, H. | SE-28-066-20 W4M | Upper Surficial | Oct-77 | 9.8 | 32.0 | 3.1 | 10.0 |
| Homa, Mike | SE-24-067-20 W4M | Upper Surficial | Sep-83 | 82.3 | 270.0 | 34.8 | 114.0 |
| Hrycun, Casey | NE-28-067-19 W4M | Upper Surficial | Nov-73 | 13.7 | 45.0 | 0.6 | 2.0 |
| Hrycun, Nick | SE-09-067-19 W4M | Upper Surficial | Nov-85 | 24.4 | 80.0 | 9.8 | 32.0 |
| Hrynyk, Howard/Allan | NE-17-067-17 W4M | Upper Surficial | Apr-83 | 47.2 | 155.0 | 27.4 | 90.0 |
| Hume, Gordon | 16-22-066-21 W4M | Lea Park | May-76 | 28.7 | 94.0 | 2.4 | 8.0 |
| Hunter, Bruce | SW-05-072-16 W4M | Upper Surficial | Jun-82 | 16.8 | 55.0 | 3.7 | 12.0 |
| Hussynec, Harry | SE-18-067-17 W4M | Upper Surficial | Apr-84 | 62.5 | 205.0 | 36.6 | 120.0 |
| Ireland, Jim | SW-06-067-19 W4M | Upper Surficial | Aug-82 | 12.8 | 42.0 | 9.1 | 30.0 |
| Jauch, Ralph | NW-14-066-18 W4M | Upper Surficial | Jan-81 | 43.3 | 142.0 | 11.9 | 39.0 |
| Jenkins, Bob | 16-21-064-21 W4M | Upper Surficial | Oct-84 | 12.5 | 41.0 | 5.5 | 18.0 |
| Jenkins, Charles | SW-20-067-18 W4M | Upper Surficial | Feb-86 | 59.7 | 196.0 | 38.1 | 125.0 |
| Jenkins, Lloyd | NW-34-068-18 W4M | Upper Surficial | Aug-85 | 11.6 | 38.0 | 3.4 | 11.0 |
| Jensen, T. | 01-30-068-21 W4M | Upper Surficial | Aug-81 | 13.7 | 45.0 | 3.4 | 11.0 |
| Jensen, Terry | 01-30-068-21 W4M | Upper Surficial | Apr-82 | 10.7 | 35.0 | 3.1 | 10.0 |
| Jewell, T. | NW-01-066-22 W4M | Upper Surficial | Nov-80 | 33.5 | 110.0 | 19.8 | 65.0 |
| Jodry, Ray | NE-31-066-22 W4M | Upper Surficial | May-74 | 11.0 | 36.0 | 8.5 | 28.0 |
| Johansen, Fred | 09-06-063-23 W4M | Upper Surficial | Sep-80 | 11.3 | 37.0 | 6.1 | 20.0 |
| Johansen, Fred | NE-06-063-23 W4M | Upper Surficial | Nov-80 | 14.6 | 48.0 | 10.1 | 33.0 |
| Johnson, W.C. | SE-16-065-22 W4M | Upper Surficial | May-85 | 25.0 | 82.0 | 1.2 | 4.0 |
| Jolly, Del | 01-02-065-19 W4M | Upper Surficial | Jul-82 | 51.8 | 170.0 | 21.3 | 70.0 |
| Kachur, W. | NW-14-067-18 W4M | Upper Surficial | Jan-78 | 18.3 | 60.0 | 6.1 | 20.0 |
| Kastyk, Don | NW-08-066-22 W4M | Upper Surficial | Jun-84 | 10.7 | 35.0 | 3.1 | 10.0 |
| Kavulok, Alex | SE-27-067-22 W4M | Upper Surficial | May-76 | 7.6 | 25.0 | 2.4 | 8.0 |
| Keddie, Eric | NE-34-065-22 W4M | Upper Surficial | Oct-73 | 7.6 | 25.0 | 3.8 | 12.5 |
| Khakoo, Firoz | SW-07-063-23 W4M | Upper Surficial | Nov-81 | 12.2 | 40.0 | 2.4 | 8.0 |
| Kincaid, Nore | NW-20-067-21 W4M | Upper Surficial | May-81 | 18.0 | 59.0 | 13.7 | 45.0 |
| Klack, A. | NE-08-069-21 W4M | Upper Surficial | Jul-73 | 9.8 | 32.0 | 4.3 | 14.0 |
| Kochan, Stanley | SE-33-066-19 W4M | Upper Surficial | Jul-76 | 14.0 | 46.0 | 3.7 | 12.0 |
| Komick, Louis | 05-27-063-21 W4M | Upper Surficial | Aug-83 | 10.7 | 35.0 | 4.6 | 15.0 |
| Kononchuk, Alex | NE-08-068-18 W4M | Upper Surficial | Oct-85 | 70.4 | 231.0 | 18.3 | 60.0 |
| Korolak, Dave | 01-13-069-21 W4M | Upper Surficial | May-78 | 23.2 | 76.0 | 13.7 | 45.0 |
| Kosowan, Blayne | 01-08-072-16 W4M | Upper Surficial | Aug-82 | 49.4 | 162.0 | 21.9 | 72.0 |
| Kostiuk, John | NW-36-071-17 W4M | Upper Surficial | Aug-75 | 12.2 | 40.0 | 1.8 | 6.0 |
| Kostiuk, John | 12-36-071-17 W4M | Upper Surficial | Feb-83 | 48.8 | 160.0 | 35.1 | 115.0 |
| Kowalchuk, Frank | NE-17-069-22 W4M | Upper Surficial | Jun-86 | 27.4 | 90.0 | 6.1 | 20.0 |
| Kowalchuk, G. | SW-16-069-22 W4M | Upper Surficial | Jul-79 | 6.7 | 22.0 | 2.4 | 8.0 |
| Krawec, John | SW-05-067-22 W4M | Upper Surficial | Sep-81 | 13.4 | 44.0 | 7.6 | 25.0 |
| Kryway, Gordon | NW-07-065-22 W4M | Upper Surficial | May-73 | 9.1 | 30.0 | 5.5 | 18.0 |
| Kwasney, Peter E. | NW-32-066-22 W4M | Upper Surficial | Jul-75 | 7.0 | 23.0 | 3.2 | 10.5 |
| Labonte, Roy | 13-05-065-18 W4M | Upper Surficial | May-83 | 7.6 | 25.0 | 0.9 | 3.0 |

**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 |
|---|---|---|---|---|---|---|---|
| Laine, Violet | SE-05-067-21 W4M | Upper Surficial | May-78 | 9.5 | 31.0 | 5.5 | 18.0 |
| Larose, Blain | 08-34-064-17 W4M | Upper Surficial | Jan-84 | 19.8 | 65.0 | 6.0 | 19.6 |
| Larose, Grace | 08-34-064-17 W4M | Upper Surficial | Jan-84 | 28.7 | 94.0 | 11.9 | 39.1 |
| Laschuk, Wm | SE-24-066-22 W4M | Brosseau | Apr-76 | 33.5 | 110.0 | 2.7 | 9.0 |
| Lodewijk, Bert | SE-28-063-23 W4M | Upper Surficial | Jul-80 | 17.7 | 58.0 | 7.6 | 25.0 |
| Loeuw, Kerry | SE-12-065-19 W4M | Upper Surficial | Dec-78 | 23.5 | 77.0 | 2.4 | 8.0 |
| Lowe, Jeff | 01-30-068-21 W4M | Upper Surficial | May-78 | 15.2 | 50.0 | 3.1 | 10.0 |
| Lucas, Robert | SW-21-063-23 W4M | Upper Surficial | Jun-78 | 24.4 | 80.0 | 4.3 | 14.0 |
| Luchka, Terry | SW-01-068-19 W4M | Upper Surficial | Jun-89 | 39.6 | 130.0 | 25.9 | 85.0 |
| Lyall, Gorden | NE-34-065-22 W4M | Upper Surficial | Jun-78 | 34.8 | 114.0 | 17.7 | 58.0 |
| Madson, Gary | NE-20-065-22 W4M | Upper Surficial | Jul-86 | 62.5 | 205.0 | 28.4 | 93.0 |
| Maguire, David | 09-20-064-22 W4M | Upper Surficial | Jul-79 | 20.7 | 68.0 | 15.2 | 50.0 |
| Martha, Joe | 10-24-064-17 W4M | Upper Surficial | Mar-94 | 62.8 | 206.0 | 25.0 | 81.9 |
| Matoga, John | SE-11-068-19 W4M | Upper Surficial | Oct-87 | 10.4 | 34.0 | 6.1 | 20.0 |
| Matthews, R.J. | NE-22-063-22 W4M | Upper Surficial | Jun-78 | 11.6 | 38.0 | 4.9 | 16.0 |
| Mauling, Rudy | SW-30-063-20 W4M | Victoria | Nov-83 | 97.5 | 320.0 | 17.7 | 58.0 |
| Mcintyre, Jim | SE-28-063-23 W4M | Upper Surficial | Jun-74 | 7.9 | 26.0 | 5.8 | 19.0 |
| Melsness, A.L. | SE-36-067-22 W4M | Upper Surficial | Oct-78 | 9.5 | 31.0 | 3.1 | 10.0 |
| Milot, Armond | 08-34-063-20 W4M | Upper Surficial | Jul-76 | 93.9 | 308.0 | 45.1 | 148.0 |
| Mochid, Walter | 14-33-068-21 W4M | Upper Surficial | Jun-79 | 22.9 | 75.0 | 20.4 | 67.0 |
| Moe, Charlie | NE-27-066-24 W4M | Upper Surficial | Jul-82 | 44.2 | 145.0 | 23.8 | 78.0 |
| Mohawk Oil Co. Ltd. | 09-36-064-20 W4M | Victoria | Dec-82 | 24.4 | 80.0 | 2.1 | 7.0 |
| Morrill, Dianne F. | SW-08-065-22 W4M | Lea Park | Jul-81 | 61.0 | 200.0 | 27.4 | 90.0 |
| Murray, Don | NE-14-066-18 W4M | Upper Surficial | Jul-89 | 12.8 | 42.0 | 4.6 | 15.0 |
| Mynio, Peter | 16-30-063-23 W4M | Upper Surficial | Apr-75 | 13.7 | 45.0 | 5.5 | 18.0 |
| Nabula Developments | 10-14-066-18 W4M | Upper Surficial | Oct-77 | | #VALUE! | 27.1 | 88.9 |
| Nahorney, Grant | SW-04-067-18 W4M | Upper Surficial | Mar-86 | 43.9 | 144.0 | 11.9 | 39.0 |
| Nalesnik, Bill | SW-29-063-21 W4M | Birch Lake | Mar-78 | 18.3 | 60.0 | 6.1 | 20.0 |
| Nedza, Paul | NW-34-066-24 W4M | Ribstone Creek | Sep-84 | 18.3 | 60.0 | 9.8 | 32.0 |
| Neil, L.M. | 08-01-064-21 W4M | Upper Surficial | Jan-79 | 12.5 | 41.0 | 10.7 | 35.0 |
| Neil, William F. | 01-01-064-21 W4M | Upper Surficial | Mar-85 | 21.0 | 69.0 | 6.7 | 22.0 |
| Nelson, Allyn | NE-10-065-22 W4M | Upper Surficial | Oct-80 | 33.8 | 111.0 | 13.7 | 45.0 |
| Nelson, Carl | 09-19-067-22 W4M | Upper Surficial | May-78 | 13.4 | 44.0 | 3.1 | 10.0 |
| Netterville, Reg | 13-25-066-21 W4M | Upper Surficial | Jul-83 | 11.0 | 36.0 | 1.5 | 5.0 |
| Nykpilo, James P. | SE-03-065-20 W4M | Victoria | Sep-86 | 24.4 | 80.0 | 4.3 | 14.0 |
| Olsen, H.J. | SE-04-067-21 W4M | Upper Surficial | Aug-79 | 6.7 | 22.0 | 1.8 | 6.0 |
| Olson, Kelly | 08-22-065-23 W4M | Upper Surficial | Oct-80 | 14.3 | 47.0 | 2.4 | 8.0 |
| Omelchuk, Victor | NE-30-068-18 W4M | Upper Surficial | Jun-88 | 23.5 | 77.0 | 3.1 | 10.0 |
| Opper, James | NE-34-065-22 W4M | Upper Surficial | Sep-85 | 23.8 | 78.0 | 2.7 | 9.0 |
| Ostronder, Dean | 04-10-065-18 W4M | Upper Surficial | Aug-79 | 6.7 | 22.0 | 3.7 | 12.0 |
| Palfenier, W. | NW-03-065-19 W4M | Brosseau | Mar-83 | 84.4 | 277.0 | 51.8 | 170.0 |
| Palset, Peter | 13-34-065-22 W4M | Upper Surficial | Sep-78 | 21.6 | 71.0 | 6.1 | 20.0 |
| Parent, Gerald | NE-03-071-17 W4M | Upper Surficial | Sep-84 | 19.5 | 64.0 | 7.6 | 25.0 |
| Patenaude, Laurie | 16-30-064-16 W4M | Upper Surficial | Jan-84 | 32.6 | 107.0 | 22.4 | 73.5 |
| Patenaude, Susan | 05-32-064-16 W4M | Upper Surficial | Jan-84 | 34.7 | 114.0 | 17.6 | 57.7 |
| Patry, Bernard | SW-33-066-24 W4M | Upper Surficial | Aug-74 | 38.4 | 126.0 | 6.1 | 20.0 |
| Patry, Dorothy | SE-33-066-24 W4M | Victoria | Oct-84 | 36.6 | 120.0 | 2.7 | 9.0 |
| Patterson, Dave | SW-04-072-16 W4M | Upper Surficial | Aug-83 | 58.5 | 192.0 | 29.3 | 96.0 |
| Perch Core Estates | NW-19-065-18 W4M | Upper Surficial | Mar-82 | 30.2 | 99.0 | 4.4 | 14.5 |
| Peruniak, Geoff | NW-19-066-20 W4M | Upper Surficial | Jul-85 | 12.5 | 41.0 | 4.6 | 15.0 |
| Peters, Walter | NW-04-067-22 W4M | Upper Surficial | May-67 | 7.3 | 24.0 | 2.7 | 9.0 |
| Petrson, Jim | 02-22-065-17 W4M | Upper Surficial | Jul-80 | 24.4 | 80.0 | 6.7 | 22.0 |
| Pfannmuller, Ken | NE-08-065-21 W4M | Victoria | May-81 | 25.9 | 85.0 | 3.7 | 12.0 |
| Pitman, C. | NW-07-065-21 W4M | Victoria | Aug-79 | 17.1 | 56.0 | 9.1 | 30.0 |

**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 |
|---|---|---|---|---|---|---|---|
| Plamondon, John | SE-07-065-17 W4M | Upper Surficial | May-81 | 27.4 | 90.0 | 7.9 | 26.0 |
| Plamondon, Ray | SE-11-071-17 W4M | Upper Surficial | Jun-86 | 42.1 | 138.0 | 15.5 | 51.0 |
| Plante, George | NW-09-066-22 W4M | Upper Surficial | Dec-76 | 19.8 | 65.0 | 5.8 | 19.0 |
| Polak, Louis | 01-28-062-22 W4M | Upper Surficial | Mar-66 | 33.5 | 110.0 | 7.9 | 26.0 |
| Polok, Larry | 11-13-068-22 W4M | Upper Surficial | Jul-80 | 11.6 | 38.0 | 3.7 | 12.0 |
| Proskow, W. | 13-14-070-17 W4M | Upper Surficial | Sep-80 | 13.7 | 45.0 | 8.5 | 28.0 |
| Proulx, Philip | SW-11-071-17 W4M | Upper Surficial | Sep-75 | 12.2 | 40.0 | 5.5 | 18.0 |
| Pruden, Ken | 16-16-064-17 W4M | Upper Surficial | Jan-84 | 47.5 | 156.0 | 13.8 | 45.3 |
| Pusiarski, Edward | NE-27-066-18 W4M | Upper Surficial | Oct-85 | 11.6 | 38.0 | 1.8 | 6.0 |
| Quint Oil Field Contractors | 12-01-067-22 W4M | Upper Surficial | Mar-82 | 27.4 | 90.0 | 17.1 | 56.0 |
| Quint Oil Field Contractors | 04-12-067-22 W4M | Upper Surficial | Mar-82 | 37.5 | 123.0 | 21.8 | 71.5 |
| Ramey, B. | 16-32-066-22 W4M | Upper Surficial | Oct-79 | 17.1 | 56.0 | 5.2 | 17.0 |
| Reders, K. | NE-32-065-21 W4M | Upper Surficial | Jul-80 | 6.4 | 21.0 | 3.1 | 10.0 |
| Richard Langevin | SW-05-065-18 W4M | Brosseau | Sep-83 | 54.9 | 180.1 | 11.6 | 38.1 |
| Rodel, G. | NW-04-067-21 W4M | Upper Surficial | May-78 | 27.7 | 91.0 | 18.3 | 60.0 |
| Rogers, G.D. | SE-08-067-22 W4M | Upper Surficial | Mar-88 | 6.7 | 22.0 | 4.3 | 14.0 |
| Rogers, Jim | 04-29-066-22 W4M | Upper Surficial | Aug-84 | 13.7 | 45.0 | 5.5 | 18.0 |
| Rogers, Marvin | NW-19-065-22 W4M | Upper Surficial | Apr-80 | 59.4 | 195.0 | 25.9 | 85.0 |
| Rosa, Metro | 16-04-065-17 W4M | Upper Surficial | Feb-84 | 29.9 | 98.0 | 12.8 | 42.0 |
| Rouncuelle, S. | 02-04-066-22 W4M | Upper Surficial | Sep-82 | 13.7 | 45.0 | 7.0 | 23.0 |
| Ryan, Gerald | SW-34-066-22 W4M | Upper Surficial | Jul-80 | 12.2 | 40.0 | 1.8 | 6.0 |
| Ryder, Alex | 08-05-066-21 W4M | Upper Surficial | Aug-85 | 41.8 | 137.0 | 9.1 | 30.0 |
| Sale, Normand | NE-18-067-21 W4M | Upper Surficial | Jul-88 | 23.8 | 78.0 | 15.2 | 50.0 |
| Saley, Alex | 13-31-065-21 W4M | Upper Surficial | Jul-81 | 11.0 | 36.0 | 7.0 | 23.0 |
| Saunders, Charlie | 02-25-063-23 W4M | Upper Surficial | May-78 | 12.8 | 42.0 | 2.4 | 8.0 |
| Sawchuk, Tony | SE-30-067-19 W4M | Upper Surficial | Dec-77 | 9.8 | 32.0 | 3.1 | 10.0 |
| Scheller, E. | SW-06-068-21 W4M | Upper Surficial | Apr-78 | 9.1 | 30.0 | 3.1 | 10.0 |
| Schmid, Frank | 01-07-068-21 W4M | Upper Surficial | Feb-84 | 9.1 | 30.0 | 2.7 | 9.0 |
| Schmittroth, Louis | NW-31-064-21 W4M | Victoria | May-78 | 48.8 | 160.0 | 27.4 | 90.0 |
| Schmold, Siegfried | 08-03-066-22 W4M | Upper Surficial | Mar-81 | 15.2 | 50.0 | 12.8 | 42.0 |
| Sewall, Ian | 06-06-069-19 W4M | Upper Surficial | Aug-79 | 8.2 | 27.0 | 3.1 | 10.0 |
| Sewall, Ian | 05-06-069-19 W4M | Upper Surficial | Oct-80 | 11.9 | 39.0 | 3.1 | 10.0 |
| Sheppard, E. | NE-20-067-17 W4M | Upper Surficial | Jun-83 | 6.7 | 22.0 | 3.1 | 10.0 |
| Sherenata, Bill | SE-15-067-19 W4M | Upper Surficial | Jul-88 | 24.4 | 80.0 | 14.6 | 48.0 |
| Sherman, Walter | NW-05-065-18 W4M | Upper Surficial | Nov-85 | 13.7 | 45.0 | 0.3 | 1.0 |
| Shewchuk, Mike | SE-21-067-19 W4M | Upper Surficial | Oct-88 | 44.2 | 145.0 | 29.0 | 95.0 |
| Shmyrko, Joe | SW-30-065-18 W4M | Upper Surficial | Jul-85 | 20.7 | 68.0 | 11.6 | 38.0 |
| Silkie, Walter | SW-29-065-22 W4M | Upper Surficial | Jun-72 | 6.1 | 20.0 | 3.7 | 12.0 |
| Skeleton Lake Resort | NW-05-065-18 W4M | Upper Surficial | May-83 | 8.2 | 26.9 | 1.1 | 3.6 |
| Smith, S. | SE-04-065-19 W4M | Victoria | Nov-80 | 13.7 | 45.0 | 6.1 | 20.0 |
| Smith, Taes | 01-32-070-17 W4M | Upper Surficial | Jul-80 | 13.7 | 45.0 | 4.6 | 15.0 |
| Snydmiller, S. | 12-01-070-17 W4M | Upper Surficial | Oct-80 | 11.6 | 38.0 | 2.4 | 8.0 |
| Snydmiller, Steve | NW-01-070-17 W4M | Upper Surficial | Sep-80 | 21.0 | 69.0 | 3.1 | 10.0 |
| Souch, Sam | SE-28-065-17 W4M | Upper Surficial | Oct-83 | 36.6 | 120.0 | 6.1 | 20.0 |
| Souch, Sam | SE-28-065-17 W4M | Upper Surficial | May-87 | 36.6 | 120.0 | 6.7 | 22.0 |
| Souch, Sam | SE-33-065-17 W4M | Upper Surficial | Oct-83 | 33.5 | 110.0 | 1.8 | 6.0 |
| Sparkling Eyes, Jim | 09-35-064-17 W4M | Upper Surficial | Jan-84 | 34.4 | 113.0 | 10.7 | 35.1 |
| St Jean, R.M.J. | 10-24-070-17 W4M | Upper Surficial | Oct-81 | 11.6 | 38.0 | 7.6 | 25.0 |
| Stady, Dennis | 13-35-064-22 W4M | Upper Surficial | May-79 | 49.7 | 163.0 | 33.5 | 110.0 |
| Stanton, Daniel O. | SW-05-065-18 W4M | Upper Surficial | Jul-73 | 6.1 | 20.0 | 3.1 | 10.0 |
| Stapley, Don | SE-11-067-24 W4M | Upper Surficial | Feb-83 | 16.2 | 53.0 | 4.0 | 13.0 |
| Stephenson, Edward | SW-28-066-19 W4M | Upper Surficial | May-80 | 91.1 | 299.0 | 25.9 | 85.0 |
| Stewart, L. | SW-30-068-19 W4M | Upper Surficial | Jun-82 | 9.1 | 30.0 | 2.4 | 8.0 |
| Stobee, Ernie | 01-09-065-22 W4M | Upper Surficial | Jan-85 | 26.8 | 88.0 | 15.2 | 50.0 |
| Storoschuk, A. | NE-08-072-17 W4M | Upper Surficial | Jan-81 | 24.4 | 80.0 | 20.1 | 66.0 |

## 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 |
|---|---|---|---|---|---|---|---|
| Sutherland, Larry | SW-32-067-22 W4M | Upper Surficial | May-76 | 18.3 | 60.0 | 5.2 | 17.0 |
| Swink, Dale | SW-15-065-22 W4M | Upper Surficial | Sep-75 | 9.5 | 31.0 | 3.7 | 12.0 |
| Szmyrko, Dwayne | NE-25-065-19 W4M | Upper Surficial | Mar-82 | 32.9 | 108.0 | 25.6 | 84.0 |
| Szmyrko, Gary | SW-02-066-19 W4M | Upper Surficial | Mar-83 | 15.2 | 50.0 | 9.8 | 32.0 |
| Talmey, Walt | 16-32-066-22 W4M | Upper Surficial | Aug-80 | 21.0 | 69.0 | 3.1 | 10.0 |
| Thomson, G. | 01-01-065-20 W4M | Victoria | Jul-82 | 13.7 | 45.0 | 4.3 | 14.0 |
| Thorburn, Ron | NW-11-067-24 W4M | Upper Surficial | May-80 | 11.6 | 38.0 | 3.7 | 12.0 |
| Tonack, Bob | 09-08-065-21 W4M | Upper Surficial | Sep-76 | 20.4 | 67.0 | 14.6 | 48.0 |
| Tonack, Bob | 09-08-065-21 W4M | Upper Surficial | Sep-76 | 15.2 | 50.0 | 5.8 | 19.0 |
| Trela, Frank J. | SW-07-068-19 W4M | Upper Surficial | May-79 | 11.9 | 39.0 | 9.1 | 30.0 |
| Turner, Duncan | 12-02-065-20 W4M | Victoria | Jul-81 | 12.2 | 40.0 | 4.6 | 15.0 |
| Turton, Bill | 09-11-063-24 W4M | Upper Surficial | Aug-80 | 19.2 | 63.0 | 7.0 | 23.0 |
| Verstrasto, Emilion | 09-08-064-21 W4M | Birch Lake | Jun-81 | 22.6 | 74.0 | 18.3 | 60.0 |
| Wabaco Property Svc | 14-24-068-24 W4M | Upper Surficial | Jul-79 | 25.3 | 83.0 | 5.8 | 19.0 |
| Wandering River Valley Estates | SW-30-071-16 W4M | Upper Surficial | Nov-78 | 29.9 | 98.0 | 18.2 | 59.6 |
| Ward, Glen | SW-26-063-23 W4M | Upper Surficial | Jul-85 | 29.6 | 97.0 | 24.7 | 81.0 |
| Williams, John M. | NW-06-067-21 W4M | Upper Surficial | Aug-82 | 21.0 | 69.0 | 9.8 | 32.0 |
| Willsie, Gordon | 12-22-064-22 W4M | Upper Surficial | | 20.7 | 68.0 | 11.6 | 38.0 |
| Willsie, Larry | 05-22-064-22 W4M | Upper Surficial | Mar-79 | 12.2 | 40.0 | 2.7 | 9.0 |
| Witney, Hugh | SW-02-067-19 W4M | Upper Surficial | Nov-79 | 10.4 | 34.0 | 2.4 | 8.0 |
| Witney, John | 04-34-066-19 W4M | Upper Surficial | Jun-81 | 9.8 | 32.0 | 4.9 | 16.0 |
| Wolansky, Willard | NE-15-065-17 W4M | Upper Surficial | Feb-75 | 18.3 | 60.0 | 9.1 | 30.0 |
| Wolanuk, Victor | NW-18-068-21 W4M | Upper Surficial | May-74 | 19.5 | 64.0 | 12.2 | 40.0 |
| Wolnuk, John | SW-19-068-21 W4M | Upper Surficial | Aug-85 | 7.6 | 25.0 | 2.4 | 8.0 |
| Woloncewich, Lanny | 04-12-066-22 W4M | Upper Surficial | Jun-83 | 17.4 | 57.0 | 6.1 | 20.0 |
| Woods, Bob | 04-01-066-22 W4M | Upper Surficial | Sep-74 | 32.3 | 106.0 | 12.2 | 40.0 |
| Yaremchuck, Richard | 04-28-064-20 W4M | Upper Surficial | May-82 | 59.4 | 195.0 | 20.4 | 67.0 |
| Zachkewich, S. | SE-05-069-19 W4M | Upper Surficial | May-78 | 9.8 | 32.0 | 3.7 | 12.0 |
| Zak, Ed | NE-31-067-17 W4M | Upper Surficial | Apr-86 | 44.5 | 146.0 | 12.8 | 42.0 |
| Zayonc, M. | SE-10-071-17 W4M | Upper Surficial | Jul-80 | 9.1 | 30.0 | 5.2 | 17.0 |
| Zembal, Dwayne | NW-32-067-19 W4M | Upper Surficial | Aug-83 | 8.5 | 28.0 | 3.7 | 12.0 |
| Zembal, Stanley | SE-31-067-19 W4M | Upper Surficial | Jun-82 | 62.5 | 205.0 | 22.9 | 75.0 |
| Ziegler, G. | SW-04-064-21 W4M | Upper Surficial | Nov-78 | 22.6 | 74.0 | 4.9 | 16.0 |
| Zolkawski, Wes | 12-19-069-20 W4M | Upper Surficial | Jul-81 | 12.2 | 40.0 | 2.4 | 8.0 |

## COUNTY OF ATHABASCA-OPERATED WATER WELLS

| Owner | Location | Date Water Well Drilled | Completed Depth Metres | Completed Depth Feet | NPWL Metres | NPWL Feet |
|---|---|---|---|---|---|---|
| County of Athabasca #12 | SE-30-065-18 W4M | Sep-86 | 55.5 | 182.0 | 22.9 | 75.0 |