# M.D. of Lesser Slave River No. 124

## Part of the Athabasca River Basin
## Tp 065 to 073, R 23 to 27, W4M & Tp 065 to 075, R 01 to 08, W5M
## 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
hydrogeological consultants ltd. (**HCL**)
1.800.661.7972
Our File No.: **02-225**

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**PERMIT TO PRACTICE**
HYDROGEOLOGICAL CONSULTANTS LTD.
Signature________________________
Date____________________________
**PERMIT NUMBER P 385**
The Association of Professional Engineers,
Geologists and Geophysicists of Alberta

# Table of Contents

# List of Figures

# List of Tables

# Appendices

# Acknowledgements

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Mr. Tony Cowen – AAFC-PFRA
Mr. Curtis Snell – AAFC-PFRA
Mr. Russell A. Jassman – M.D. of Lesser Slave River

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

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

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

# 1 PROJECT OVERVIEW

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

How a M.D. takes care of one of its most precious resources - groundwater - reflects the future wealth and health of its people. Good environmental practices are not an accident. They must include genuine foresight with knowledgeable planning. Implementation of strong practices not only commits to a better quality of life for future generations, but also creates a solid base for increased economic activity. **Though this report's scope is regional, it is a first step for the M.D. of Lesser Slave River No. 124 in managing their groundwater. It is also a guide for future groundwater-related projects.**

## 1.1 Purpose

This project is a regional groundwater assessment of the M.D. of Lesser Slave River No. 124 prepared by Hydrogeological Consultants Ltd. (HCL) with financial and technical assistance from the Prairie Farm Rehabilitation Administration branch of Agriculture and Agri-Food Canada (AAFC-PFRA) and the M.D. of Lesser Slave River. The project study area includes the parts of M.D. of Lesser Slave River bounded by townships 065 to 073, ranges 23 to 27, W4M and townships 065 to 075, ranges 01 to 08, W5M (herein referred to as the M.D.). The regional groundwater assessment provides the information to assist in the management of the groundwater resource within the M.D. Groundwater resource management involves determining the suitability of various areas in the M.D. for particular activities. These activities can vary from the development of groundwater for country residential, agricultural or industrial purposes, to the siting of waste storage. **Proper management ensures protection and utilization of the groundwater resource for the maximum benefit of the people of the M.D.**

The regional groundwater assessment will:

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

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

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[1] See glossary
[2] See glossary

## 1.2 The Project

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

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

Task 1 - Data Collection and Review
Task 2 - Hydrogeological Maps, Figures, Digital Data Files
Task 3 - Hydrogeological Evaluation and Preparation of Report
Task 4 - Groundwater Information Query Software
Task 5 - Review of Draft Report and GIS Data Files
Task 6 - Report Presentation and Familiarization Session
Task 7 - Provision of Report, Maps, Data Layers and Query
Task 8 - Provision of Compact Disk for Sale to General Public.

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

## 1.3 About This Report

This report provides an overview of (a) the groundwater resources of the M.D. of Lesser Slave River, (b) the processes used for the present project, and (c) the groundwater characteristics in the M.D.

Additional technical details are available from files on the CD-ROM provided with the final version of this report. The files include the geo-referenced electronic groundwater database, maps showing distribution of various hydrogeological parameters, the groundwater query, ArcView files and ArcExplorer files. Likewise, all of the illustrations and maps shown in this report, plus additional maps, figures and cross-sections, are available on the CD-ROM. In order to avoid map-edge effects, all maps are based on an analysis of hydrogeological data from townships 065 to 073, ranges 23 to 27, W4M and townships 065 to 075, ranges 01 to 08, W5M, plus a buffer area of 5,000 metres. For convenience, poster-size maps and cross-sections have been prepared as a visual summary of the results presented in this report. Copies of these poster-size drawings have been forwarded with this report, and are included as page-size drawings in Appendix D.

Appendix A features page-size copies of the figures within the report plus additional maps and cross-sections. An index of the page-size maps and figures is given at the beginning of Appendix A. A plastic M.D. map outline is provided to overlay the maps, and contains information such as towns, main rivers, etc.

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

Appendix C includes the following:

1) a procedure for conducting aquifer tests with water wells[3]
2) a table of contents for the Water (Ministerial) Regulation under the *Water Act*
3) interpretation of chemical analysis of drinking water
4) additional information.

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

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

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

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[3] See glossary

# 2 INTRODUCTION

## 2.1 Setting

The M.D. of Lesser Slave River is situated in north-central Alberta. The southwestern boundary is the Athabasca River. The other M.D. boundaries follow township or section lines, which include parts of the area bounded by townships 065 to 073, ranges 23 to 27, W4M and townships 065 to 075, ranges 01 to 08, W5M.

Regionally, the topographic surface varies between 540 and 1,000 metres above mean sea level (AMSL). The lowest elevations occur mainly in association with the Athabasca and Lesser Slave rivers and Lesser Slave Lake; the highest elevations are in the Lesser Slave Lake Lowlands, as shown on Figure 1 and page A-3.

The M.D. is within the Athabasca River basin. The area is well drained by the Athabasca River, the Lesser Slave River and Lesser Slave Lake.

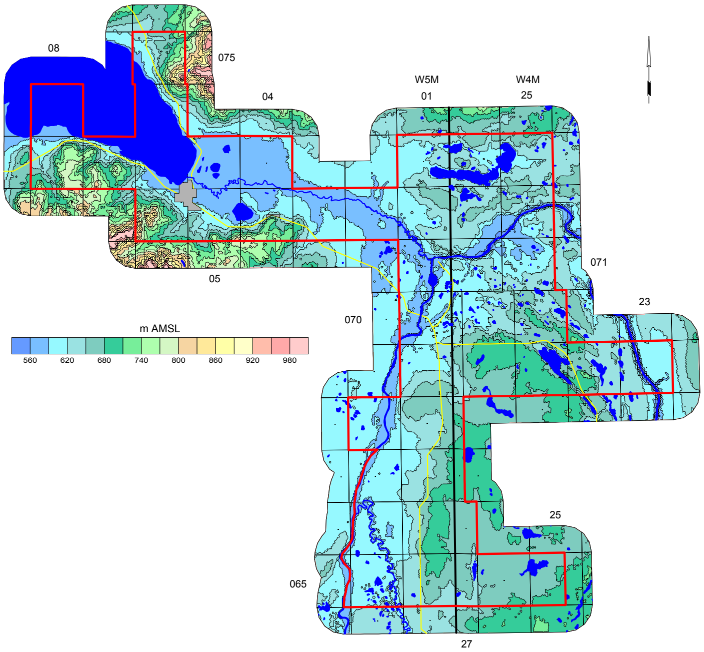

*Figure 1. Surface Topography*

## 2.2 Climate

The M.D. of Lesser Slave River 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 Leggat, 1981) shows that the M.D. is located mainly in the Mid Boreal Mixedwood Region; a small portion in the northwestern part of the M.D. is in the Low Boreal-Cordilleran Region. Increased precipitation and cooler temperatures, resulting in additional moisture availability, influence these vegetation changes.

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

The mean annual precipitation averaged from four meteorological stations within the M.D. measured 484.7 millimetres (mm), based on data from 1959 to 1993[5]. The mean annual temperature averaged 1.1° C, with the mean monthly temperature reaching a high of 15.4° C in July, and dropping to a low of -15.9° C in January. The calculated annual potential evapotranspiration is 470 millimetres.

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[4] See glossary

[5] Only two meteorological stations within the M.D. with data from 1971 to 2000 were available.

## 2.3 Background Information

### 2.3.1 Number, Type and Depth of Water Wells

There are currently 1,545 records in the groundwater database for the M.D., of which 1,110 are water wells. Of the 1,110 water wells, there are records for domestic (752), domestic/stock (104) or stock (126) purposes. The remaining 128 water wells were completed for a variety of uses, the main ones being industrial (31), municipal (26) and observation (10). Based on a rural population of 2,825, there are two domestic/stock water wells per family of four. There are 881 domestic, domestic/stock or stock water wells with a completed depth, of which 704 (80%) are completed at depths of less than 50 metres below ground surface. Details for lithology[6] are available for 975 water wells.

### 2.3.2 Number of Water Wells in Surficial and Bedrock Aquifers

There are 336 water wells with completion interval and lithologic information, such that the aquifer in which the water wells are completed can be identified. The water wells that were not drilled deep enough to encounter the bedrock plus water wells that have the bottom of their completion interval above the top of the bedrock are water wells completed in surficial aquifers. Of the 336 water wells for which aquifers could be defined, 189 are completed in surficial aquifers, with 272 (81%) having a completion depth of less than 50 metres below ground surface. The adjacent map shows that the water wells completed in the surficial deposits occur frequently in the vicinity of linear bedrock lows.

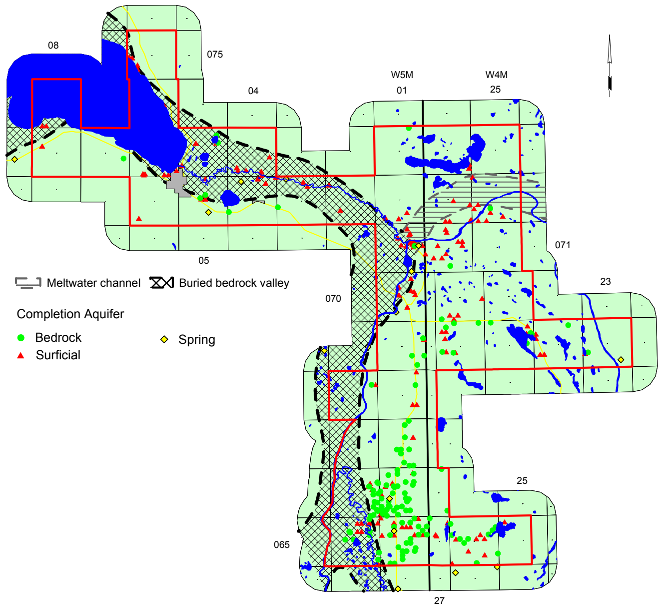

*Figure 2. Location of Water Wells and Springs*

The data for 147 water wells show that the top of the water well completion interval is below the bedrock surface, indicating that the water wells are completed in at least one bedrock aquifer. From Figure 2 (also see page A-5), it can be seen that water wells completed in bedrock aquifers occur mainly in the Flatbush area and north along Highway 44. There are only 34 water wells completed where the upper bedrock is the Lea Park Formation or the Milk River Formation (see Figure 17 or pate A-25 for bedrock geology map).

Within the M.D. of Lesser Slave River, there are currently records for 11 springs in the groundwater database, including two springs that were documented by Borneuf (1983). There are ten springs having at least one total dissolved solids (TDS) value, with nine springs having a TDS of less than 500 milligrams per litre (mg/L). There are three springs in the groundwater database with flow rates that range from 65 litres per minute (lpm) to 113 lpm. The dates the flow rates were measured are available for two springs; one spring was measured in October 1974 and one spring was measured in September 1979.

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[6] See glossary

### 2.3.3 Casing Diameter and Type

Data for casing diameters are available for 563 water wells, with 319 (57%) indicated as having a diameter of less than 275 mm and 244 (43%) having a diameter of more than 275 mm. The casing diameters of greater than 275 mm are mainly bored or dug water wells and those with a surface-casing diameter of less than 275 mm are mainly drilled water wells. The groundwater database suggests that 233 of the above-mentioned water wells in the M.D. were bored, hand dug, or dug by backhoe. The complete water well database for the M.D. suggests that 420 of the water wells in the M.D. were bored, hand dug or dug by backhoe.

For a water well with a small-diameter casing to be effective in surficial deposits and to provide sand-free groundwater, the water well must be completed with a water well screen. Some water wells completed in the surficial deposits are completed in low-permeability aquifers and have a large-diameter casing. The large-diameter water wells may have been hand dug or bored and because they are completed in very low permeability aquifers, most of these water wells would not benefit from water well screens. Within the M.D., casing-diameter information is available for 176 of the 189 water wells completed in the surficial deposits, of which 98 surficial water wells have a casing diameter of less than 275 millimetres and are assumed to be drilled water wells. Within the M.D., casing-diameter information is available for 144 of the 147 water wells completed below the top of bedrock, of which 143 have a surface-casing diameter of less than 275 mm and have been mainly completed with either a perforated liner or as open hole; there are 12 bedrock water wells completed with a water well screen.

Where the casing material is known, steel surface casing materials have been used in 65% of the drilled water wells over the last 40 years. For the remaining drilled water wells with known surface casing material, 22% were completed with plastic casing, and 12% were completed with galvanized steel casing. The main years where the type of surface casing was undocumented were between 1960 and 1965. Steel casing was in use in the 1960s and is still used in 70% of the water wells being drilled in the M.D. Galvanized steel surface casings were used from the mid-1960s to the mid 1980s, at which time plastic casing started to replace the use of galvanized steel casing.

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

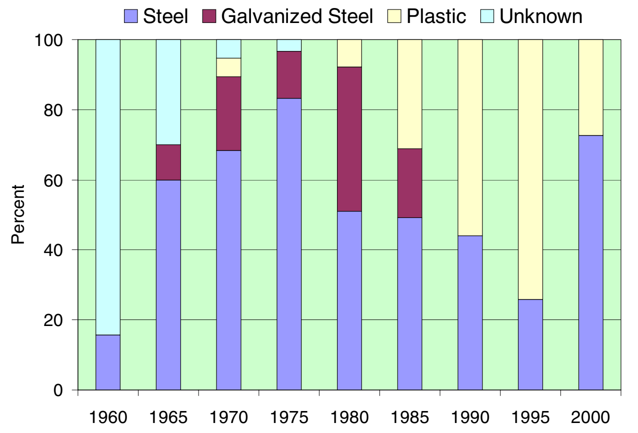

*Figure 3. Surface Casing Types Used in Drilled Water Wells*

### 2.3.4 Dry Water Test Holes

In the M.D., there are 1,545 records in the groundwater database. Of these 1,545 records, 62 (4%) are indicated as being dry or abandoned with "insufficient water"[7]. Of the 62 "dry" water test holes, 34 are completed in surficial deposits; the remaining 28 "dry" water test holes are completed in bedrock aquifers. Only about 15% of all water wells with apparent yield estimates were judged to yield less than 6.5 m$^3$/day (1 igpm).

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

### 2.3.5 Requirements for Licensing

With some exemptions, a diversion of groundwater starting after 01 Jan 1999 must have a licence. Exemptions include (1) the diversion for household use of up to 3.4 cubic metres per day (1,250 cubic metres per year [m$^3$/year] or 750 imperial gallons per day[8]), (2) the diversion of groundwaters with total dissolved solids in excess of 4,000 mg/L, (3) the diversion from a manually pumped water well, or (4) a diversion of groundwater that was eligible for registration as “Traditional Agriculture Use” but was not registered can continue to be used for Traditional Agriculture Use but without the protection of the *Water Act*.

In the last update from the Alberta Environment (AENV) groundwater database in October 2003, 97 groundwater licences and registrations were shown to be within the M.D., with the most recent groundwater user being registered in April 2003. Of the 97 licensed and registered groundwater users, 74 (76%) are registrations of Traditional Agriculture Use under the *Water Act*. These 74 registered users will continue to divert groundwater for stock watering and/or crop spraying. Typically, the groundwater diversion for crop spraying averages less than one m$^3$/day so most registered groundwater diversion is for stock watering. Of the 74 registrations, 36 (49%) could be linked to the AENV groundwater database. Of the remaining 23 from the 97 groundwater users, eight are for agricultural purposes (mainly stock watering), three are for commercial purposes (sand and gravel), nine are for industrial purposes (enhanced recovery or injection), one is for municipal purposes (mainly urban), and the remaining two are for recreation purposes. Of these 23 licensed groundwater diversions in the M.D., 16 (70%) could be linked to the AENV groundwater database. The maximum amount of groundwater that can be diverted each year from the water wells associated with these licences and registrations is 3,135 m$^3$/day, although actual use could be less. Of the 3,135 m$^3$/day, 180 m$^3$/day (5.7%) is registered for Traditional Agriculture Use, 26 m$^3$/day (0.8%) is licensed for agricultural purposes, 34 m$^3$/day (1.1%) is licensed for commercial purposes, 2,781 m$^3$/day (88.7%) is licensed for industrial purposes, 37 m$^3$/day (1.1%) is licensed for municipal purposes, and the remaining 77 m$^3$/day is licensed for recreation purposes (2.5%), as shown below in Table 1. A figure showing the locations of the groundwater users with either a licence or a registration is in Appendix A (page A-6) and on the CD-ROM. Table 1 also shows a breakdown of the 97 groundwater licences and/or registrations by the aquifer in which the water well is completed. Approximately 93% of the total quantity of licensed and registered groundwater use is in the Lower Sand and Gravel Aquifer. The water wells associated with the 97 licensed and registered use where a specific aquifer cannot be determined is because insufficient completion information is available.

| Aquifer ** | No. of Licences and Registrations | Registrations (m³/day) | Licensed Groundwater Users* (m³/day) | | | | | Total Quantity of Licensed and Registered Groundwater Diversion (m³/day) | Percentage |
|---|---|---|---|---|---|---|---|---|---|
| | | | Agricultural | Commercial | Industrial | Municipal | Recreation | | |
| Multiple Surficial Completions | 9 | 14 | 0 | 0 | 0 | 0 | 0 | 14.0 | 0.4 |
| Upper Sand and Gravel | 13 | 14 | 1 | 0 | 0 | 0 | 9 | 24 | 0.8 |
| Lower Sand and Gravel | 21 | 27 | 0 | 27 | 2,781 | 0 | 68 | 2,903 | 92.6 |
| Mulitple Bedrock Completion | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 6 | 0.2 |
| Oldman | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 5 | 0.2 |
| Foremost | 45 | 104 | 25 | 7 | 0 | 37 | 0 | 173 | 5.5 |
| Lea Park | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Milk River | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Unknown | 4 | 10 | 0 | 0 | 0 | 0 | 0 | 10 | 0.3 |
| Total | 97 | 180 | 26 | 34 | 2,781 | 37 | 77 | 3,135 | 100 |
| Percentage | | 5.7 | 0.8 | 1.1 | 88.7 | 1.2 | 2.5 | 100 | |

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

*Table 1. Licensed and Registered Groundwater Diversions*

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[8] see conversion table on page 60

| Livestock Type | Number | Estimated Water Requirement (m$^3$/day) |
|---|---|---|
| Total hens and chickens | 1,701 | 0 |
| Turkeys | 197 | 0 |
| Other poultry | 193 | 0 |
| Total cattle and calves | 15,282 | 834 |
| Bulls, 1 year and over | 320 | 22 |
| Total cows | 7,395 | 403 |
| Heifers, 1 year and over | 1,330 | 60 |
| Calves, under 1 year | 6,129 | 84 |
| Total pigs | 862 | 16 |
| Total sheep and lambs | 1,705 | 16 |
| Horses and ponies | 431 | 20 |
| Goats | 0 | 0 |
| Rabbits | 0 | 0 |
| Mink | 0 | 0 |
| Fox | 0 | 0 |
| Bison | 699 | 32 |
| Deer and elk | 0 | 0 |
| Llamas and alpacas | 0 | 0 |
| Totals | 36,244 | 1,486 |

***Table 2. Estimated Water Requirement for Livestock in the M.D. of Lesser Slave River***

Based on the 2001 Agriculture Census (Statistics Canada), the calculated water requirement for 36,244 livestock for the M.D. is in the order of 1,486 m$^3$/day. The number of livestock given in the adjacent table is for all of the M.D. of Lesser Slave River. This number includes intensive livestock use but not domestic animals and is based on an estimate of water use per livestock type. Of the 1,486 m$^3$/day calculated livestock use, AENV has authorized a groundwater diversion of 206 m$^3$/day (agricultural and registration) (14%) and licensed a surface-water diversion (stock and registration) based on consumptive use of 185 m$^3$/day (12%) for a total diversion of 391 m$^3$/day. Agriculture purpose includes water diverted and used for stockwatering and feedlot use. This assumes the majority of the groundwater and surface water authorized for diversion and use as traditional agriculture use is used for watering livestock. Using this assumption, 26% of the estimated total water requirements of 1,486 m$^3$/day is accounted for.

The remaining 1,095 m$^3$/day (74%) of the calculated water requirement for livestock use would have to be from other, including unlicensed, sources. The discrepancy may be partially accounted for in several ways. Based on some monitoring and reporting situations, the estimated water requirements for livestock, used by AENV, tend to be somewhat high. Some livestock water requirements would be made up from free-standing water following precipitation events, thus reducing the expected quantity needed. Also, it should be noted that 'household use', as defined in the *Water Act*, can provide sufficient water for about 75 head of cattle, with no need for a licence. It is possible that some such use may have been registered as traditional agriculture use and would therefore be included in the registration quantity. Also, diversions of groundwater and surface water that were eligible for registration as traditional agriculture use can continue to be used for traditional agricultural purposes without the need for authorization.

### 2.3.6 Base of Groundwater Protection

In general, Alberta Environment defines the Base of Groundwater Protection as the elevation below which the groundwater will have more than 4,000 mg/L of total dissolved solids. By using the ground elevation, formation elevations, and Alberta Energy and Utilities Board (EUB) information indicating the formations containing the deepest useable water for agricultural needs, a value for the depth to the Base of Groundwater Protection can be determined. These values are gridded using the Kriging[9] method to prepare a depth to the Base of Groundwater Protection surface. This depth, for the most part, would be the maximum drilling depth for a water well for agricultural purposes or for a potable water supply. If a water well has TDS concentrations that exceed 4,000 mg/L, the groundwater use does not require licensing by AENV. In the M.D., the depth to the Base of Groundwater Protection ranges from less than 50 metres in the northern and eastern parts of the M.D. to more than 1,000 metres in the southwestern parts of the M.D., as shown on Figure 4, on some cross-sections presented in Appendix A, and on the CD-ROM.

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[9] See glossary

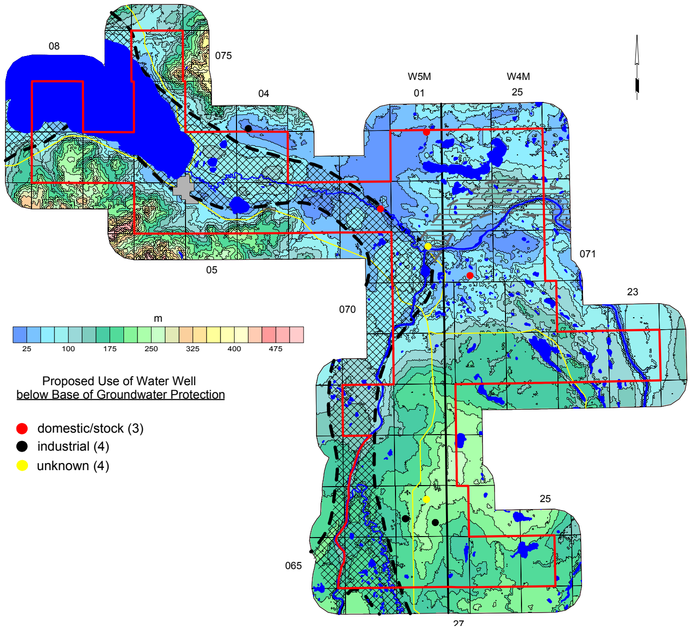


***Figure 4. Depth to Base of Groundwater Protection (after EUB, 1995)***

There are 1,109 water wells with completed depth data, of which 11 appear to be completed below the Base of Groundwater Protection. Most of these water wells are completed in the Milk River Formation. Of the 11 water wells completed below the Base of Groundwater Protection, three are/were used for domestic/stock purposes, four are/were used for industrial purposes and the proposed use for four water wells is unknown. Chemistry data are available for six of the 11 water wells, which provided groundwaters with TDS values ranging from 277 to 46,333 mg/L. In the M.D., the Base of Groundwater Protection passes below the top of the Foremost Formation (see pages A-11 to A-15).

Proper management of the groundwater resource requires water-level data. These data are often collected from observation water wells. At the present time, there is one AENV-operated observation water well within the M.D. (see page A-40 for the observation water well location). Additional data can be obtained from eight water source wells and observation water wells, including four licensed groundwater diversions. In the past, the data for authorized diversions have been difficult to obtain from AENV, in part because of the failure of the applicant to provide the data. Even with the available sources of data, the number of water-level data points relative to the size of the M.D. is too few to provide a reliable groundwater budget (see section 6.0 of this report). The most cost-efficient method to collect additional groundwater monitoring data would be to have the water well owners measuring the water level in their own water well on a regular basis, as has been the case in the Wildrose Country Ground Water Monitoring Association and Flagstaff County.

# 3 TERMS

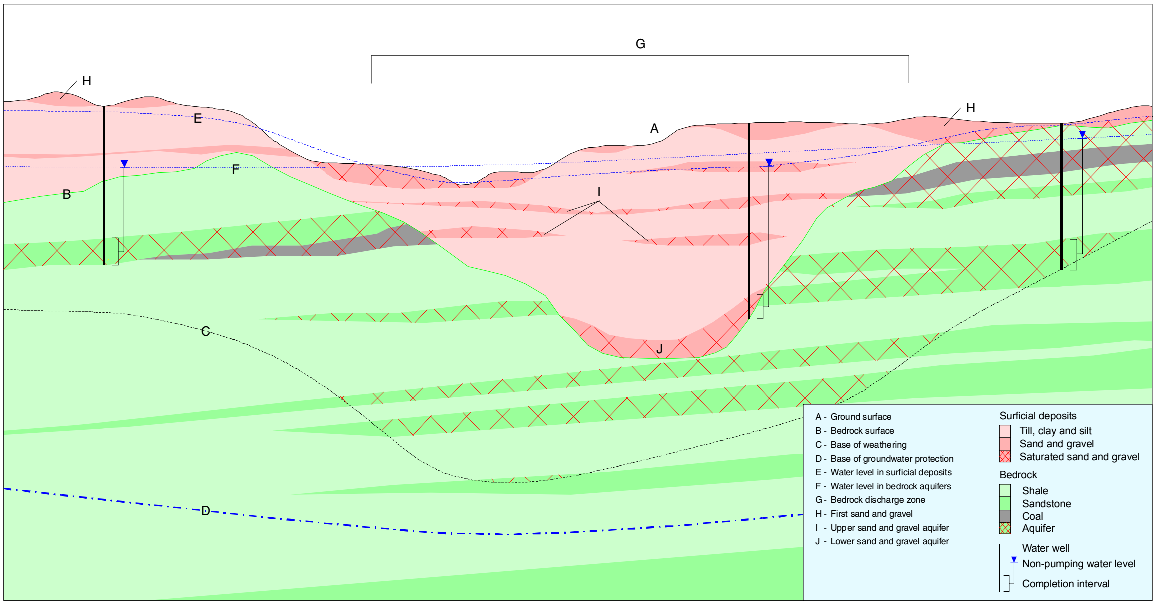
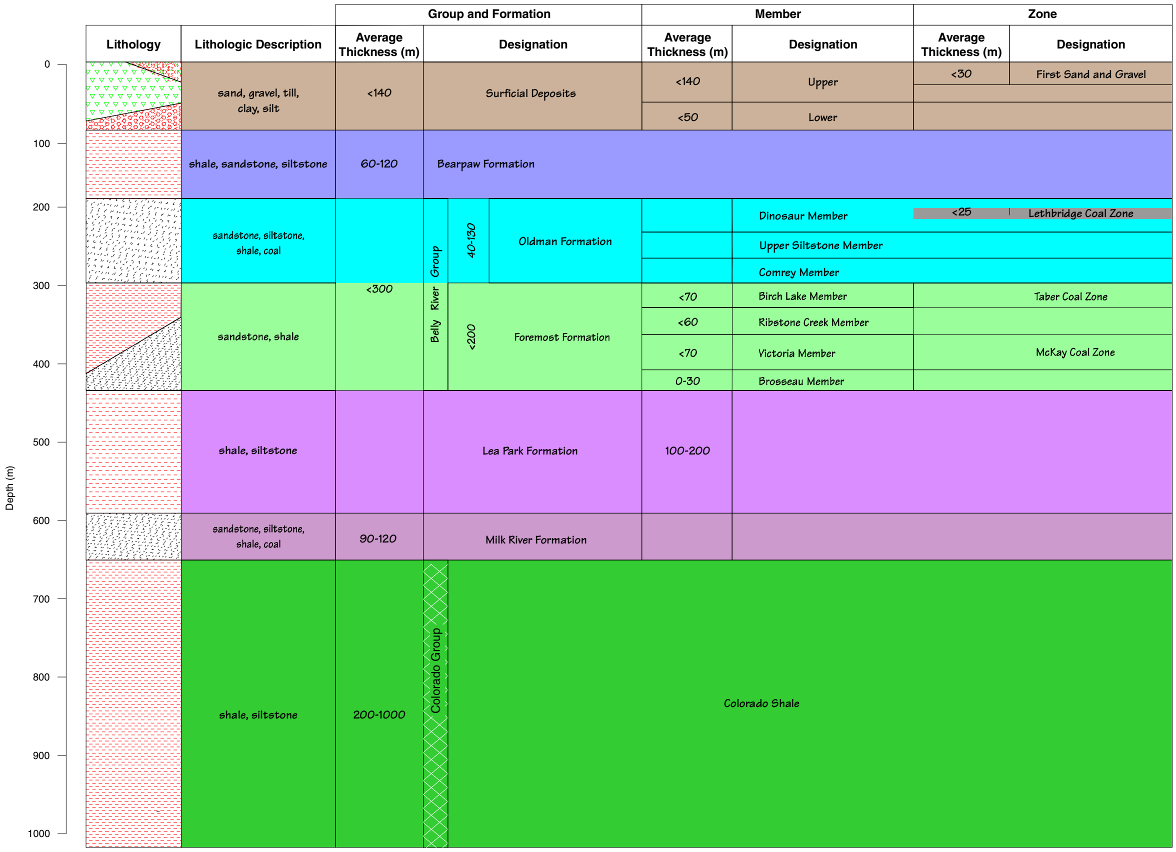


***Figure 5. Generalized Cross-Section (for terminology only)***

*(for larger version, see page A-8)*



| | | Group and Formation | | | | Member | | Zone | |
|---|---|---|---|---|---|---|---|---|---|
| Lithology | Lithologic Description | Average Thickness (m) | | | Designation | Average Thickness (m) | Designation | Average Thickness (m) | Designation |
| | sand, gravel, till, clay, silt | <140 | | | Surficial Deposits | <140 | Upper | <30 | First Sand and Gravel |
| | | | | | | <50 | Lower | | |
| | shale, sandstone, siltstone | 60-120 | | | Bearpaw Formation | | | | |
| | sandstone, siltstone, shale, coal | <300 | Belly River Group | 40-130 | Oldman Formation | | Dinosaur Member | <25 | Lethbridge Coal Zone |
| | | | | | | | Upper Siltstone Member | | |
| | | | | | | | Comrey Member | | |
| | sandstone, shale | | | <200 | Foremost Formation | <70 | Birch Lake Member | | Taber Coal Zone |
| | | | | | | <60 | Ribstone Creek Member | | |
| | | | | | | <70 | Victoria Member | | McKay Coal Zone |
| | | | | | | 0-30 | Brosseau Member | | |
| | shale, siltstone | | | | Lea Park Formation | 100-200 | | | |
| | sandstone, siltstone, shale, coal | 90-120 | | | Milk River Formation | | | | |
| | shale, siltstone | 200-1000 | Colorado Group | | Colorado Shale | | | | |

***Figure 6. Geologic Column***

*(for larger version, see page A-9)*

# 4 METHODOLOGY

## 4.1 Data Collection and Synthesis

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

1) water well drilling reports
2) aquifer test results from some water wells
3) locations of some springs
4) locations for some water wells determined during water well surveys
5) chemical analyses for some groundwaters[10]
6) locations of some flowing shot holes
7) locations of some structure test holes
8) a variety of data related to the groundwater resource.

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

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

The present project uses the 10TM coordinate system based on the NAD27 datum. This means that a record for the NW ¼ of section 21, township 066, range 01, W5M would have a horizontal coordinate with an Easting of 58,217 metres and a Northing of 6,062,520 metres, the centre of the quarter section. If the water well has been repositioned by AAFC-PFRA using orthorectified aerial photographs, the location will be more accurate, possibly within several tens of metres of the actual location. Once the horizontal coordinates are determined for a record, a ground elevation for that record is obtained from the 1:20,000 Digital Elevation Model (DEM); AltaLIS Ltd. provides the DEM.

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

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

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[10] Since 1986, Alberta Health and Wellness has restricted access to chemical analysis data, and hence the database includes only limited amounts of chemical data after 1986.

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

1) depth to bedrock
2) total thickness of sand and gravel below 15 metres
3) total thickness of saturated sand and gravel
4) depth to the top and bottom of completion intervals[11].

Also, where sufficient information is available, values for apparent transmissivity[12] and apparent yield[13] are calculated, based on the aquifer test summary data supplied on the water well drilling reports. Where valid detailed aquifer test results exist, the interpreted data provide values for aquifer transmissivity and effective transmissivity. Since the last regional hydrogeological maps covering the M.D. were published in 1973 (Borneuf), in 1977 (Tokarsky), in 1978 (Vogwill), and in 1980 (Ozoray and Lytviak), more than 230 values for apparent transmissivity and apparent yield have been added to the groundwater database. The median apparent yield of the water wells with apparent yield values in the M.D. is 30 m³/day. Approximately 20 percent of the apparent yield values for these water wells are less than ten m³/day. With the addition of the apparent yield values, including a 0.1-m³/day value assigned to "dry" water wells and water test holes, a hydrogeological map has been prepared to help illustrate the general groundwater availability across the M.D. (Figure 7 and page A-10). The map is based on groundwater being obtained from all aquifers and has been prepared to allow direct comparison with the results provided on the Alberta Research Council (ARC) hydrogeological maps. In general, the ARC maps show lower estimated long-term yields. The differences between the two map renderings may be a result of fewer apparent yield values and the gridding method employed by the ARC.

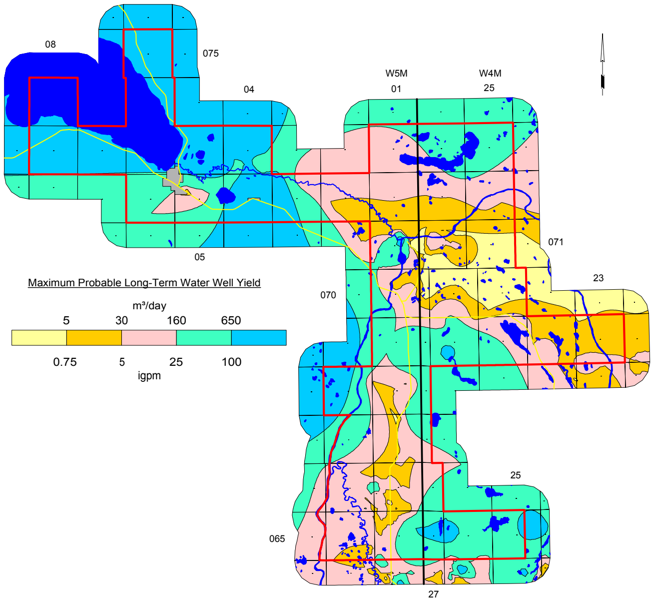

*Figure 7. Hydrogeological Map*

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

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

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

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

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

## 4.2 Spatial Distribution of Aquifers

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

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

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

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

## 4.3 Hydrogeological Parameters

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

After the water wells are assigned to a specific aquifer, the parameters from the water well records are assigned to the individual aquifers. The parameters include non-pumping (static) water level (NPWL), apparent transmissivity, and apparent water well yield. The NPWL given on the water well record is usually the water level recorded when the water well was drilled, measured prior to the initial aquifer test. In areas where groundwater levels have since fallen, the NPWL may now be lower and accordingly, the potential apparent yield would be reduced. The total dissolved solids, sulfate and chloride concentrations from the chemical analyses of the groundwaters are also assigned to applicable aquifers. In addition, chemical parameters of Nitrate + Nitrite (as N) are assigned to surficial aquifers and fluoride is assigned to upper bedrock aquifer(s). Nitrate + Nitrite (as N) concentrations are often related to water-well-specific data and may not indicate general aquifer conditions.

Once the values for the various parameters of the individual aquifers are established, the spatial distribution of these parameters must be determined. The distribution of individual parameters involves the same process as the distribution of geological surfaces. This means establishing a representative data set and then preparing a grid. The representative data set included using the available data from townships 065 to 073, ranges 23 to 27, W4M and townships 065 to 075, ranges 01 to 08, W5M, plus a buffer area of at least 5,000 metres. Even when only limited data are available, grids are prepared. However, the grids prepared from the limited data must be used with extreme caution because the gridding process can be unreliable; for the maps, the areas with little or no data are identified.

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

### 4.3.1 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 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) surficial geology and/or the soil maps The presence or absence of sand and gravel within one metre of the land surface is based on a geological surface prepared from the data supplied on the water well drilling reports. The information available on the surficial geology and/or the soil map is categorized based on relative permeability. The information from these sources is combined to form the risk assessment map. The criteria used in the classification of risk are given in the above table.

## 4.4 Maps and Cross-Sections

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

Once the appropriate grids are available, the maps are prepared by contouring the grids. Appendix A includes page-size maps from the text, plus additional page-size maps and figures that support the discussion in the text. A list of maps and figures that are included on the CD-ROM is given in Appendix B.

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

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

## 4.5 Software

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

- Acrobat 5.0
- ArcView 3.2
- AutoCAD 2002
- CorelDraw! 11.0
- Microsoft Office XP
- Surfer 8

# 5 AQUIFERS

## 5.1 Background

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

## 5.2 Aquifers in Surficial Deposits

The surficial deposits are the sediments above the bedrock surface. These include pre-glacial materials, which were deposited before glaciation, and materials deposited directly or indirectly as a result of glaciation. The *lower surficial deposits* include pre-glacial fluvial[14] deposits. The *upper surficial deposits* include the traditional glacial sediments of till[15] and ice-contact deposits. Pre-glacial materials are expected to be present in association with linear bedrock lows. Meltwater channels are associated with glaciation.

### 5.2.1 Geological Characteristics of Surficial Deposits

While the surficial deposits are treated as one hydrogeologic unit, they consist of three hydraulic units. The first unit is the preglacial sand and gravel deposits of the lower surficial deposits. These deposits are mainly saturated. The second and third hydraulic units are associated with the sand and gravel deposits in the upper surficial deposits. The sand and gravel deposits in the upper surficial deposits occur mainly as pockets. The second hydraulic unit is the saturated part of these sand and gravel deposits; the third hydraulic unit is the unsaturated part of these deposits that occur close to ground surface. For a graphical depiction of the above description, please refer to Figure 5, page 9 and to page A-8. While the unsaturated deposits are not technically an aquifer, they are significant as they provide a pathway for soluble contaminants to move downward into the groundwater. Because of the significance of the shallow sand and gravel deposits, they have been mapped where they are present within one metre of the ground surface and 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 in Figure 8 on the following page. Regionally, the bedrock surface varies between 460 and 820 metres AMSL. The lowest elevations occur along the present-day Lesser Slave River Valley, as shown on Figure 8 and page A-16. Over the majority of the M.D., the surficial deposits are less than 30 metres thick (see CD-ROM).

The main linear bedrock low in the M.D. is designated as the Buried High Prairie Valley. This Valley trends north-northeast, occupied by the present-day Athabasca River Valley, then turns northwest and is occupied by the present-day Lesser Slave River Valley. The Buried High Prairie Valley is approximately six to ten kilometres wide, with local relief being up to 80 metres. Sand and gravel deposits can be expected in association with the Buried High Prairie Valley, where the thickness of the sand and gravel deposits can be more than 30 metres.

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[14] See glossary
[15] See glossary

The lower sand and gravel deposits are composed of fluvial deposits. Lower sand and gravel deposits are identified mainly in association with linear bedrock lows. The total thickness of the lower sand and gravel deposits is mainly greater than ten metres (see CD-ROM).

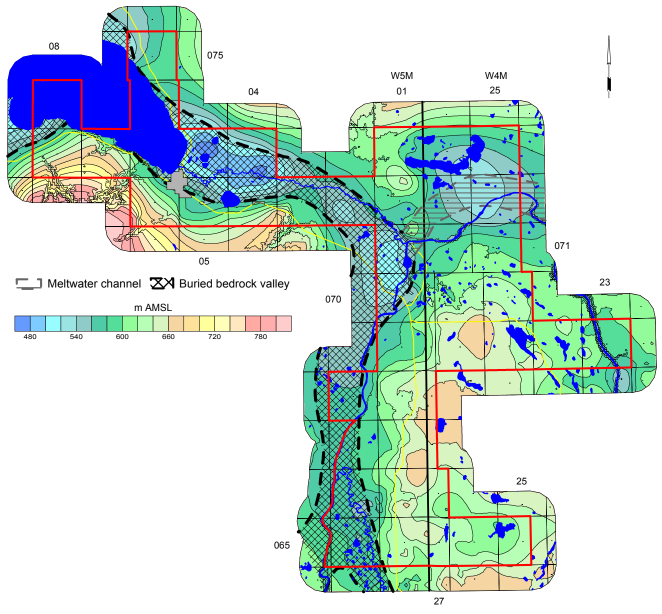

*Figure 8. Bedrock Topography*

In the M.D., there is a linear bedrock low that trends west to east and is indicated as being of meltwater origin. Because sediments associated with the lower sand and gravel deposits are indicated as being present in parts of the meltwater channel, it is possible that the meltwater channel was originally a tributary to the Buried High Prairie Valley (see CD-ROM). Because meltwater channels are mainly an erosional feature, the sand and gravel deposits associated with these features are considered not to be significant aquifers.

The upper surficial deposits are either directly or indirectly a result of glacial activity. The deposits include till, with minor sand and gravel deposits of meltwater origin, which are expected to occur mainly as isolated pockets. The thickness of the upper surficial deposits is mainly greater than 25 metres. Upper surficial deposits are present throughout the M.D. (see CD-ROM). The upper sand and gravel deposits are mainly greater than ten metres thick (see CD-ROM).

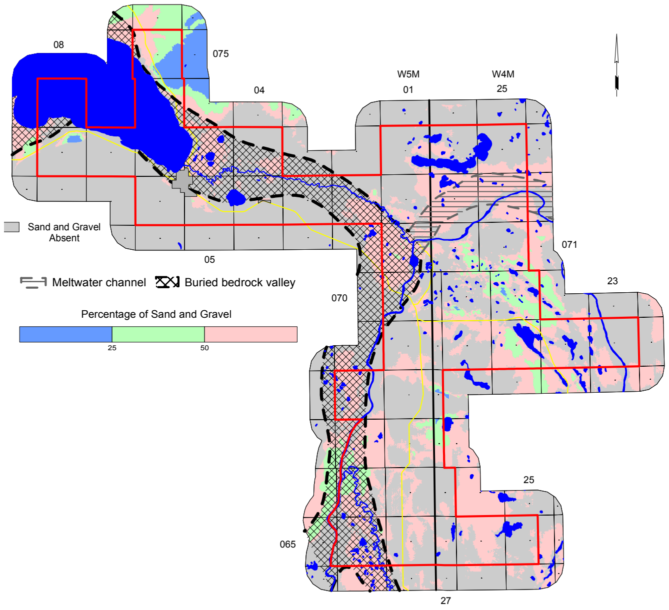

*Figure 9. Amount of Sand and Gravel in Surficial Deposits*

Sand and gravel deposits can occur throughout the surficial deposits. The total thickness of sand and gravel deposits is generally less than two metres but can be more than five metres in association with linear bedrock lows and river valleys.

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 80% of the M.D. where sand and gravel deposits are present, the sand and gravel deposits are more than 50% of the total thickness of the surficial deposits, as shown on the adjacent figure. The areas where sand and gravel deposits constitute more than 50% 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.

### 5.2.2 Sand and Gravel Aquifer(s)

The main aquifers in the surficial materials are sand and gravel deposits. In order for a sand and gravel deposit to be an aquifer, it must be saturated; if not saturated, a sand and gravel deposit is not an aquifer. The top of the surficial aquifers has been determined from the non-pumping water level in water wells that are less than 20 metres deep. The base of the surficial deposits is the bedrock surface.

Since the Sand and Gravel Aquifer(s) are not present everywhere, the actual aquifer that is developed at a given location is usually dictated by the aquifer that is present. Over more than 40% of the M.D., the sand and gravel deposits are not present, or if present, are not saturated; these areas are designated as grey on the adjacent map. In the M.D., the thickness of the Sand and Gravel Aquifer(s) is generally greater than 15 metres, but can be more than 50 metres in linear bedrock lows, as shown in Figure 10, in Appendix A and on the CD-ROM.

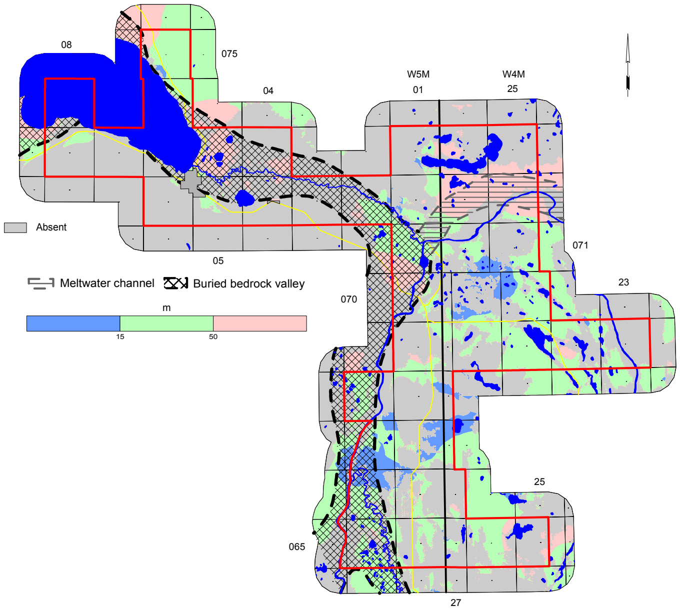

*Figure 10. Thickness of Sand and Gravel Aquifer(s)*

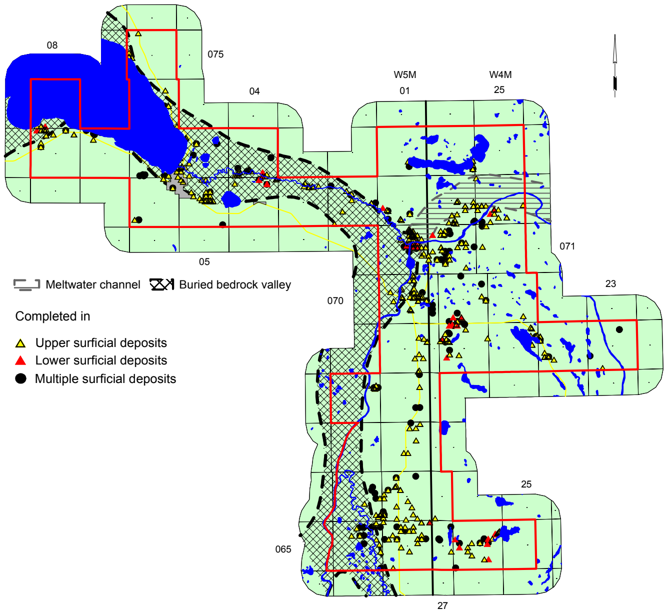

*Figure 11. Water Wells Completed in Surficial Deposits*

Of the 1,110 water wells in the database, 189 were defined as being completed in surficial aquifers, based on lithologic information and water well completion details. From the present hydrogeological analysis, 654 water wells are completed in aquifers in the surficial deposits. Of the 654 water wells, 469 are completed in aquifers in the upper surficial deposits, 33 are completed in aquifers in the lower surficial deposits, and 152 water wells are completed in multiple surficial aquifers. This number of water wells (654) is nearly three and a half times the number (189) determined to be completed in aquifers in the surficial deposits, based on lithologies given on the water well drilling reports. The larger number is obtained by comparing the elevation of the reported depth of a water well to the elevation of the bedrock surface at the same location. For example, if only the depth of a water well is known, the elevation of the completed depth can be calculated. If the elevation of the completed depth is above the elevation of the bedrock surface determined from the gridded bedrock topographic surface at the same location, then the water well is considered to be completed in an aquifer in the surficial deposits.

Water wells completed in the lower surficial deposits are mainly in the linear bedrock lows, and water wells completed in the upper surficial deposits are often in the linear bedrock lows but are also located throughout the M.D., as shown on the previous page in Figure 11.

In the M.D., there are 129 records for surficial water wells with apparent yield data, which is 20% of the 654 surficial water wells. Twenty-six percent (34) of the 129 water wells completed in the Sand and Gravel Aquifer(s) have apparent yields that are less than ten m³/day, 39% (50) have apparent yield values that range from 10 to 100 m³/day, and 35% (45) have apparent yields that are greater than 100 m³/day. In addition to the 129 records for surficial water wells, there are 31 records that indicate that the water well is dry. In order to depict a more accurate yield map, an apparent yield of 0.1 m³/day was assigned to each of the 31 dry test holes prior to gridding.

| Aquifer | No. of Water Wells with Values for Apparent Yield (*) | Number of Water Wells with Apparent Yields <10 m³/day | 10 to 100 m³/day | >100 m³/day |
|---|---|---|---|---|
| Upper Surficial | 54 | 24 | 20 | 10 |
| Lower Surficial | 24 | 2 | 4 | 18 |
| Multiple Completions | 51 | 8 | 26 | 17 |
| Totals | 129 | 34 | 50 | 45 |

* - does not include dry test holes

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

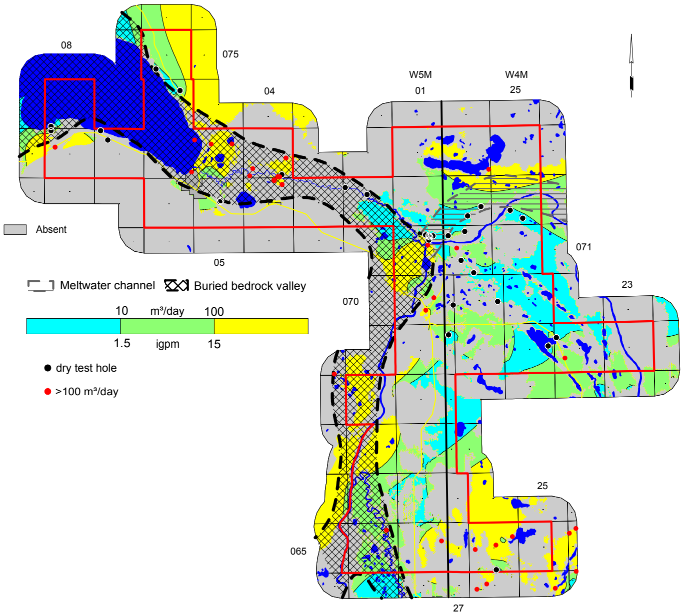

***Figure 12. Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)***

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

Based on the aquifers that have been developed by existing water wells, these data show that water wells with yields of more than 100 m³/day from the Sand and Gravel Aquifer(s) can be expected in 50% of the M.D. where the Sand and Gravel Aquifer(s) are present. The most notable areas where yields of more than 100 m³/day are expected are near the Town of Slave Lake, near the junction of the meltwater channel and the Buried High Prairie Valley, townships 064 and 065, ranges 24 to 27, W4M, and in association with linear bedrock lows.

### *5.2.2.1 Chemical Quality of Groundwater from Surficial Deposits*

Groundwaters from an aquifer in the surficial deposits can be expected to be chemically hard, having a total 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.

In the M.D. of Lesser Slave River, groundwaters from the surficial aquifers mainly have a chemical hardness of greater than 200 mg/L (see CD-ROM).

The Piper tri-linear diagram[16] for the surficial deposits (page A-27) shows that the groundwaters from the surficial deposits are mainly calcium-magnesium-bicarbonate waters. Sixty percent of the groundwaters from the surficial deposits have a TDS concentration of less than 500 mg/L. Thirty-two percent of the groundwaters from the surficial deposits are reported to have dissolved iron concentrations of less than or equal to the aesthetic objective (AO) of 0.3 mg/L. However, many iron analyses results are questionable due to varying sampling and analytical methodologies.

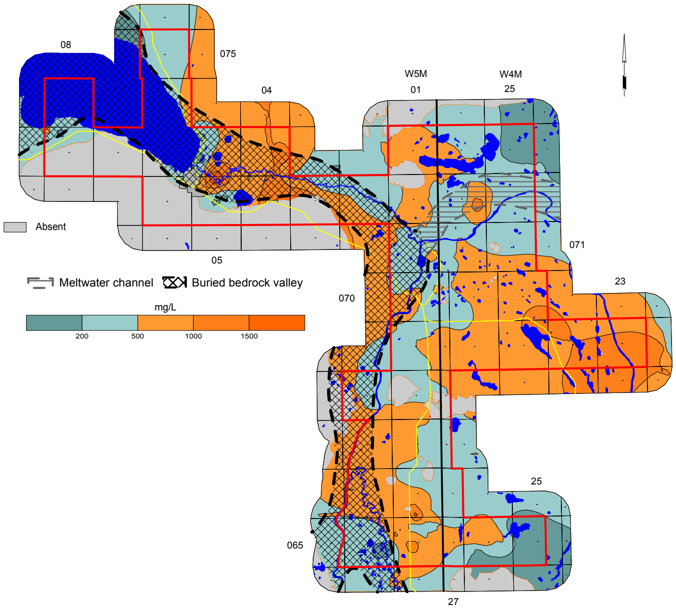

***Figure 13. Total Dissolved Solids in Groundwater from Surficial Deposits***

In some areas, the groundwater chemistry of the surficial aquifers is such that sulfate is the major anion[17]. The groundwaters with elevated levels of sulfate generally occur in areas where there are elevated levels of total dissolved solids. There are very few groundwaters from the surficial deposits with appreciable concentrations of the chloride ion; in more than 80% of the samples analyzed for surficial deposits in the M.D., the chloride ion concentration is less than 50 mg/L (see CD-ROM).

In the M.D., the Nitrate + Nitrite (as N) concentrations in the groundwaters from the surficial deposits exceed the maximum acceptable concentrations (MAC) of ten mg/L for the surficial aquifers in seven of the 230 groundwater samples analyzed (up to about 1986). A plot of Nitrate + Nitrite (as N) in surficial aquifers is on the accompanying CD-ROM.

The minimum, maximum and median concentrations of TDS, sodium, sulfate, chloride and Nitrate + Nitrite (as N) in the groundwaters from water wells completed in the surficial deposits in the M.D. have been compared to the Summary of Guidelines for Canadian Drinking Water Quality (SGCDWQ) in the adjacent table. The range of concentrations shown in Table 5 are values in the groundwater database; however, the extreme minimum and maximum concentrations generally represent less than 0.2% of the total number of analyses and should have little effect on the median values. These extreme values are not used in the preparation of the figures.

| Constituent | No. of Analyses | Range for County in mg/L Minimum | Maximum | Median | Recommended Maximum Concentration SGCDWQ |
|---|---|---|---|---|---|
| Total Dissolved Solids | 358 | 0 | 2,476 | 450 | 500 |
| Sodium | 295 | 0 | 570 | 20 | 200 |
| Sulfate | 368 | 0 | 1,030 | 20 | 500 |
| Chloride | 367 | 0 | 1,409 | 7 | 250 |
| Nitrate + Nitrite (as N) | 230 | 0 | 43 | 0.0 | 10 |

Concentration in milligrams per litre unless otherwise stated
**Note:** indicated concentrations are for Aesthetic Objectives except for Nitrate + Nitrite (as N), which is for Maximum Acceptable Concentration (MAC)
**SGCDWQ** - Summary of Guidelines for Canadian Drinking Water Quality Federal-Provincial-Territorial Committee on Drinking Water, April 2003

***Table 5. Concentrations of Constituents in Groundwaters from Surficial Deposits***

Of the five constituents that have been compared to the SGCDWQ, none of the median values exceeds the guidelines.

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[16] See glossary

[17] See glossary

## 5.2.3 Upper Sand and Gravel Aquifer

The Upper Sand and Gravel Aquifer includes saturated sand and gravel deposits in the upper surficial deposits. Typically, these aquifers are present within the surficial deposits at no particular depth. Saturated sand and gravel deposits in the upper surficial deposits are not usually continuous over large areas but are expected over approximately 50% of the M.D.

### *5.2.3.1 Aquifer Thickness*

The thickness of the Upper Sand and Gravel Aquifer is a function of two parameters: (1) the elevation of the non-pumping water-level surface associated with the surficial deposits; and (2) the depth to the bedrock surface or the depth to the top of the lower surficial deposits when present. In the M.D., the thickness of the Upper Sand and Gravel Aquifer is mainly greater than 15 metres but less than 50 metres.

### *5.2.3.2 Apparent Yield*

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

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

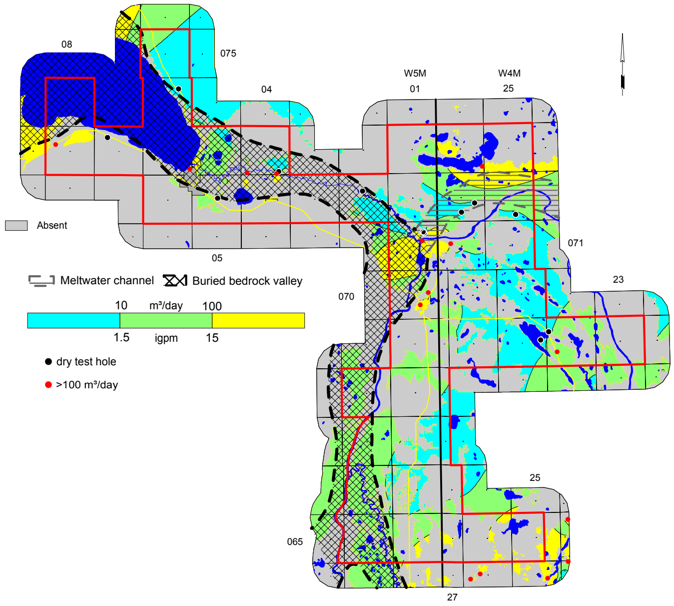


***Figure 14. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer***

Apparent yields for water wells completed through the Upper Sand and Gravel Aquifer range from less than ten m³/day to more than 100 m³/day. The most notable areas where yields of more than 100 m³/day may be possible are near the junction of the meltwater channel and the Buried High Prairie Valley, townships 064 and 065, ranges 24 to 26, W4M, and in association with linear bedrock lows, where the saturated thickness of the upper sand and gravel deposits is more than 15 metres.

In the M.D., there are 13 licensed and registered water wells that are completed through the Upper Sand and Gravel Aquifer, for a total authorized diversion of 24 $m^3$/day (Table 1, page 6). The highest authorized amount is 9.3 m³/day for a water supply well in SE 08-075-06 W5M for recreation purposes. Three of the 20 licensed and registered water wells completed through the Upper Sand and Gravel Aquifer could be linked to a water well in the AENV groundwater database.

### 5.2.4 Lower Sand and Gravel Aquifer

The Lower Sand and Gravel Aquifer is a saturated sand and gravel deposit that occurs at or near the base of the surficial deposits in the deeper part of the linear bedrock lows. The top of the lower surficial deposits based on more than 1,000 control points across Alberta, is limited to areas where the base of the sand and gravel directly overlies the bedrock.

#### *5.2.4.1 Aquifer Thickness*

The thickness of the Lower Sand and Gravel Aquifer is mainly less than 30 metres (see CD-ROM).

#### *5.2.4.2 Apparent Yield*

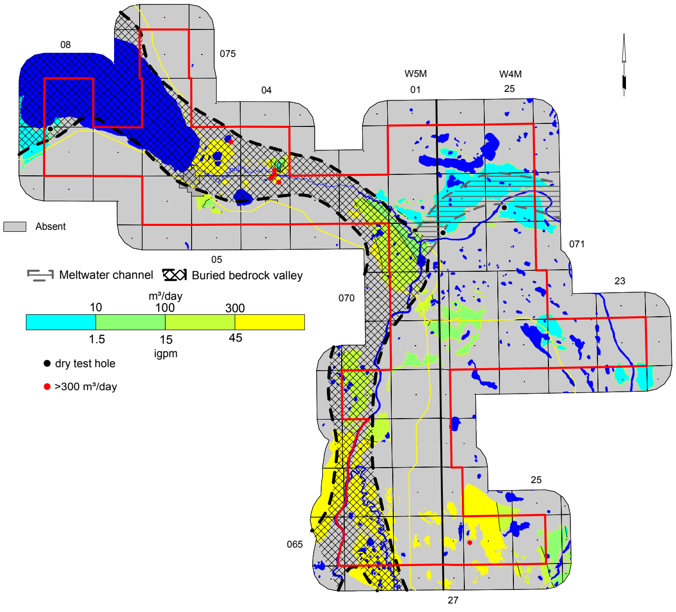


***Figure 15. Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer***

Apparent yields for water wells completed through the Lower Sand and Gravel Aquifer range from less than ten m³/day to more than 300 m³/day. The most notable areas where yields of more than 300 m³/day are expected are mainly in areas where the thickness of the Lower Sand and Gravel Aquifer is greater than ten metres.

For most of the M.D., the Lower Sand and Gravel Aquifer, where present, can be of significant groundwater importance. The lower sand and gravel deposits associated with the Buried High Prairie Valley are an important source of groundwater for industrial purposes (enhanced recovery or injection).

In the M.D., there are three dry water test holes completed in the Lower Sand and Gravel Aquifer.

In the M.D., there are 21 licensed or registered authorizations for water wells that are completed through the Lower Sand and Gravel Aquifer, for a total authorized diversion of 2,903 $m^3$/day. Of the 2,903 m³/day, the oil industry is authorized to divert 2,781 (96%) for injection purposes. Seventeen of the 21 authorizations could be linked to a water well in the AENV groundwater database.

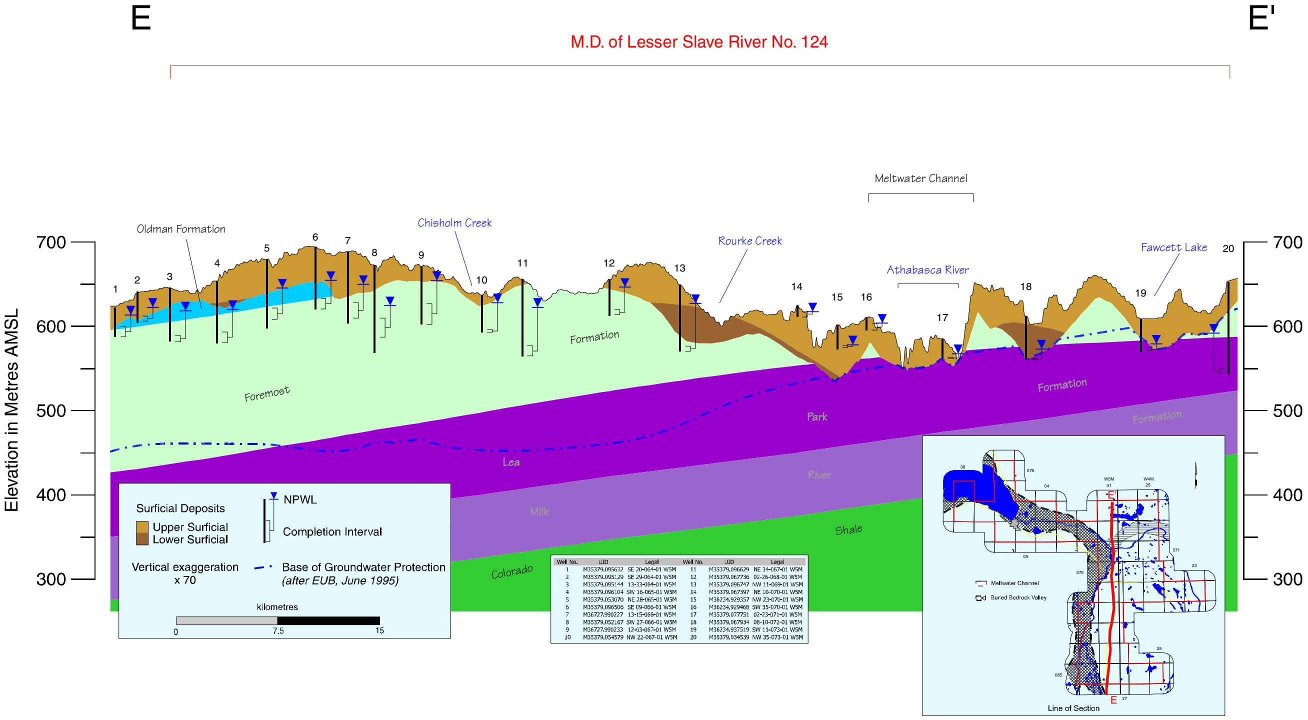
Trans World Oil and Gas Ltd. (Trans World) diverts groundwater from Water Source Well (WSW) No. 2-91 for injection purposes in 10-34-072-04 W5M. The water source well is completed in the Lower Sand and Gravel Aquifer in the depth interval between 95.1 and 99.7 metres below ground level and is licensed to divert up to 200 m³/day. Extended aquifer tests with WSW No. 2-91 indicated that the water source well has a long-term yield of 1,330 m³/day based on an effective transmissivity of 35 metres squared per day (m²/day) and a corresponding storativity of 0.0003 (HCL, Sept-1991).

A chemical analysis of a groundwater sample collected in May 1991 from WSW No. 2-91 indicates the groundwater is a sodium-chloride-type, with a TDS of 1,269 mg/L, a sulfate concentration of 1 mg/L, a chloride concentration of 522 mg/L, a fluoride concentration of 0.44 mg/L, and a total hardness of 194 mg/L (HCL, Sept-1991).

## 5.3 Bedrock

### 5.3.1 Bedrock Aquifers

The upper bedrock includes formations that are generally less than 200 metres below the bedrock surface. In the M.D., the upper bedrock includes the Oldman, Foremost, Lea Park and Milk River formations, as shown below on cross-section E-E' (see page A-15). Also shown on cross-section E-E' is the Colorado Shale. Some of this bedrock contains saturated rocks that are permeable enough to transmit groundwater for a specific need. Water wells completed in bedrock aquifers usually do not require water well screens, although some of the sandstones may be friable[18] and water well screens are a necessity.



| Well No. | UID | Legal | Well No. | UID | Legal |
|---|---|---|---|---|---|
| 1 | M35379.095632 | SE 20-064-01 W5M | 11 | M35379.096629 | NE 34-067-01 W5M |
| 2 | M35379.095129 | SE 29-064-01 W5M | 12 | M35379.067736 | 02-26-068-01 W5M |
| 3 | M35379.095144 | 13-33-064-01 W5M | 13 | M35379.096747 | NW 11-069-01 W5M |
| 4 | M35379.096104 | SW 16-065-01 W5M | 14 | M35379.067397 | NE 10-070-01 W5M |
| 5 | M35379.053070 | NE 28-065-01 W5M | 15 | M36234.929357 | NW 23-070-01 W5M |
| 6 | M35379.096506 | SE 09-066-01 W5M | 16 | M36234.929468 | SW 35-070-01 W5M |
| 7 | M36727.990227 | 13-15-066-01 W5M | 17 | M35379.077751 | 02-23-071-01 W5M |
| 8 | M35379.052167 | SW 27-066-01 W5M | 18 | M35379.067934 | 08-10-072-01 W5M |
| 9 | M36727.990233 | 12-03-067-01 W5M | 19 | M36234.937519 | SW 11-073-01 W5M |
| 10 | M35379.054579 | NW 22-067-01 W5M | 20 | M35379.034539 | NW 35-073-01 W5M |

***Figure 16. Cross-Section E - E'***

In the study area, the Base of Groundwater Protection is variable, extending from a depth as little as 25 metres to a depth of over 500 metres below ground surface. In the M.D., the Base of Groundwater Protection is mainly below the Foremost Formation. A map showing the depth to the Base of Groundwater Protection is given in Figure 4 on page 8 of this report, in Appendix A (Page A-7), and on the CD-ROM.

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[18] See glossary

### 5.3.2 Geological Characteristics

The upper bedrock in the M.D. study area includes the Bearpaw Formation, the Belly River Group, the Lea Park Formation, and the Milk River Formation. The Belly River Group includes the Oldman and Foremost formations. The adjacent bedrock geology map, showing the subcrop of different geological units, has been prepared in part from the interpretation of geophysical logs related to oil and gas activity.

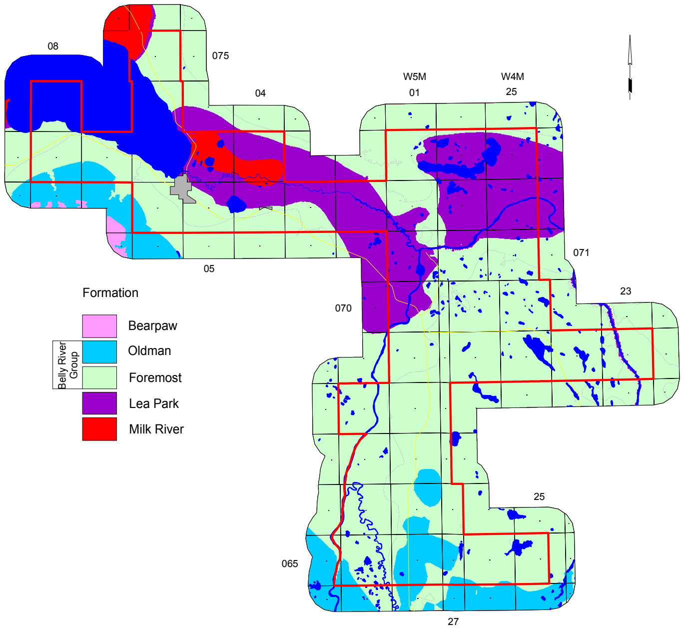

*Figure 17. Bedrock Geology*

The Bearpaw Formation is in the order of 80 metres thick and is the upper bedrock in the extreme western part of the study area. The Bearpaw Formation includes transgressive, shallow marine (shoreface) and open marine facies [19] deposits. The Bearpaw Formation consists of marine shale, siltstone and minor sandstone layers except in some areas where the thickness of the sandstone layers can be significant. The Bearpaw Formation "represents the final widespread marine unit in the Western Canada Foreland Basin" (Catuneanu et al, 1997).

The Belly River Group in the County has a maximum thickness of 200 metres. The Oldman Formation is present in the extreme western and southern parts of the County and has a maximum thickness of 110 metres.

The Foremost Formation, composed of sandstone and shale units, is less than 180 metres thick and is between the overlying Oldman Formation and the underlying Lea Park Formation. The Foremost Formation includes both sandstone and shale units. Coal zones occur within the Foremost Formation along with minor amounts of ironstone, a chemical deposit. 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 Lea Park Formation is approximately 50 metres thick and subcrops in the central part of the M.D. 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 ten $m^3$/day. The groundwaters from the Lea Park Aquitard are mainly a calcium-magnesium-bicarbonate type with TDS mainly less than 500 mg/L. The sulfate concentrations are expected to be less than 50 mg/L and chloride concentrations are expected to be mainly less than ten 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.

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[19] See glossary

The Milk River Formation underlies the entire M.D. but subcrops in the northwestern part of the M.D., has a thickness of approximately 50 metres, is composed mostly of shale, with minor amounts of coal, and underlies the Lea Park Formation. In the M.D., the Milk River Formation has limited importance and there will be no direct review in the text of this report; there are insufficient or no hydrogeological data within the study area to prepare meaningful maps. Structure-contour maps of the Milk River Formation are included in Appendix A and on the CD-ROM.

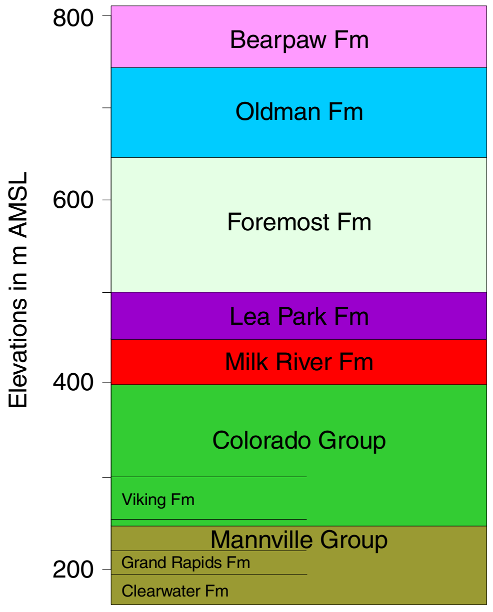

***Figure 18. Stratigraphic Section***

The Colorado Group, present under the entire M.D., includes mainly shale units between the Milk River Formation and the Mannville Group. The Viking Formation, a 50-metre-thick sandstone unit that sometimes can be distinguished near the base of the Colorado Group, is composed of well-washed and variable shaly, fine- to coarse-grained sandstone, with subordinate conglomerate and pebbly sandstone. In the southern part of the province, the Viking Formation is developed as a source of groundwater, and in many central and northern parts of the province as a source of gas. However, even the Viking Formation would not be expected to have yields of greater than 20 m³/day (HCL, Revised May 15, 1991).

The Mannville Group underlies the Colorado Group and contains several porous and permeable zones toward its base, which include the Grand Rapids and Clearwater formations.

### 5.3.3 Upper Bedrock Completion Aquifer(s)

Of the 1,110 water wells in the database, 147 were defined as being completed below the top of bedrock, based on lithologic information and water well completion details. However, at least a reported completion depth is available for 402 water wells completed below the bedrock surface. Assigning a water well to a specific geologic unit is possible only if the completion interval is identified. In order to make use of additional information within the groundwater database, it was assumed that the top of the completion interval was 80% of the total completed depth of a water well. With this assumption, it has been possible to designate the specific bedrock aquifer of completion for an additional 234 bedrock water wells, giving a total of 381 water wells. The remaining 21 of the total 402 upper bedrock water wells are identified as being completed in more than one bedrock aquifer, as shown in Table 7. The bedrock water wells are mainly completed in the Foremost Aquifer.

| Geologic Unit | No. of Bedrock Water Wells |
|---|---|
| Bearpaw | 0 |
| Oldman | 7 |
| Foremost | 340 |
| Lea Park | 25 |
| Milk River | 9 |
| Multiple Completions | 21 |
| Total | 402 |

***Table 6. Completion Aquifer for Upper Bedrock Water Wells***

The water wells shown to be completed in the Lea Park and Milk River formations have been determined mainly based on completed depth only and without the benefit of lithologic description or any other supporting documentation, and therefore the completion formations are suspect.

There are 125 records for bedrock water wells that have apparent yield values, which is 31% of the 402 bedrock water wells in the M.D.

The main areas where bedrock water wells are largely absent are where the Lea Park and Milk River formations are the upper bedrock. In these areas, water wells are mainly completed in surficial deposits. Yields for water wells completed in the upper bedrock aquifer(s) are mainly between 10 and 100 m$^3$/day and have a median apparent yield of 25 m$^3$/day. The areas in the northwestern part of the M.D. where apparent yields of more than 100 m$^3$/day are shown and the areas in the northeastern part of the M.D. where apparent yields are between ten and 100 m$^3$/day are a result of the gridding process using limited data control. The bedrock water wells in the southern part of the County having apparent yields of less than ten m$^3$/day are mainly where the upper bedrock is the Oldman Formation.

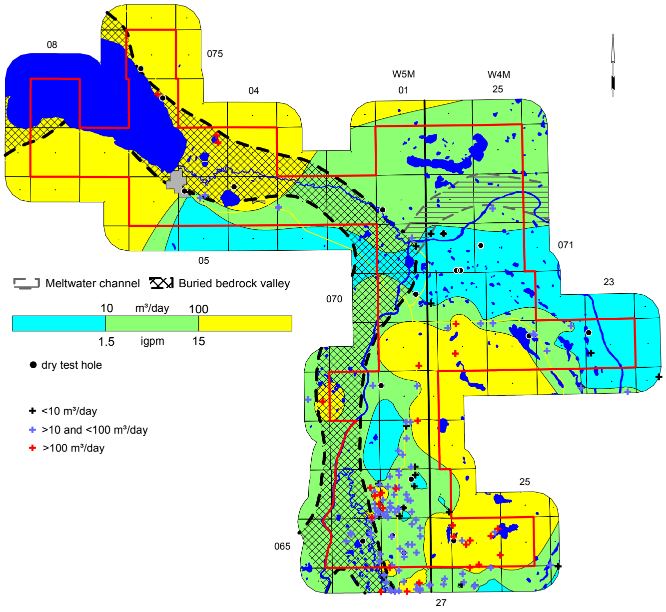

*Figure 19. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)*

In addition to the 125 records for bedrock water wells with apparent yield values, there are 28 records that indicate that the water well/water test hole is dry, or abandoned with "insufficient water". In order to depict a more accurate yield map, an apparent yield of 0.1 m$^3$/day was assigned to the 28 dry water test holes prior to gridding.

| Aquifer | No. of Water Wells with Values for Apparent Yield (*) | Number of Water Wells with Apparent Yields <10 m³/day | 10 to 100 m³/day | >100 m³/day |
|---|---|---|---|---|
| Bearpaw | 0 | 0 | 0 | 0 |
| Oldman | 3 | 0 | 3 | 0 |
| Foremost | 108 | 17 | 71 | 20 |
| Lea Park | 2 | 2 | 0 | 0 |
| Milk River | 0 | 0 | 0 | 0 |
| Multiple Completions | 12 | 2 | 5 | 5 |
| Totals | 125 | 21 | 79 | 25 |

* - does not include dry test holes

*Table 7. Apparent Yields of Bedrock Aquifers*

Of the 125 water well records with apparent yield values, 108 have been assigned to the Foremost Aquifer. Seventeen percent (21) of the 125 water wells completed in bedrock aquifers have apparent yields that are less than ten m$^3$/day, 63% (79) have apparent yield values that range from 10 to 100 m$^3$/day, and 20% (25) have apparent yield values that are greater than 100 m$^3$/day, as shown in Table 7. In the Foremost Aquifer, nearly 45% of the apparent yield values are greater than 100 m$^3$/day.

### 5.3.4 Chemical Quality of Groundwater

The Piper tri-linear diagram for bedrock aquifers (page A-27) shows that groundwaters from bedrock aquifers are mainly sodium-bicarbonate or calcium-magnesium-type waters.

The TDS concentrations in the groundwaters from the upper bedrock aquifer(s) range from less than 500 mg/L to more than 1,500 mg/L, with most of the groundwaters with higher TDS concentrations occurring where the Oldman Formation is the upper bedrock in the southern part of the M.D.

The relationship between TDS and sulfate concentrations shows that when TDS values in the groundwaters from the upper bedrock aquifer(s) exceed 1,200 mg/L, the sulfate concentrations exceed 400 mg/L.

In the M.D., more than 85% of the chloride concentrations in the groundwaters from the upper bedrock aquifer(s) are less than 50 mg/L.

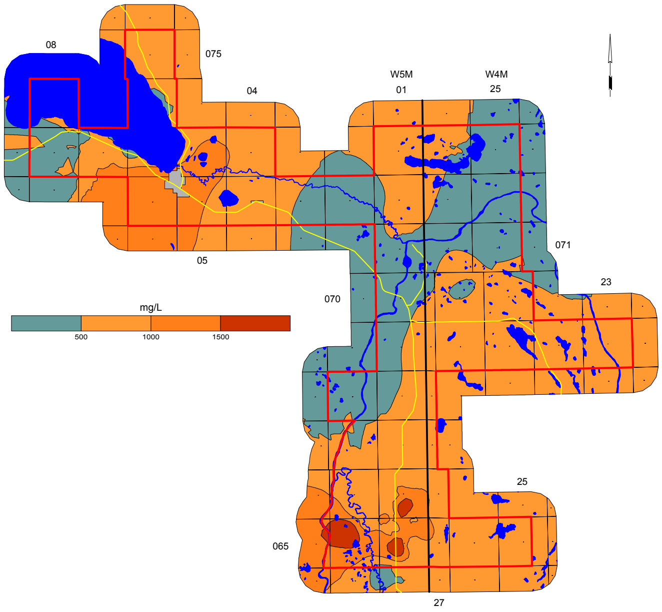

*Figure 20. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)*

In the M.D., there were 11 groundwater samples that had Nitrate + Nitrite (as N) concentrations that were greater than the SGCDWQ for the upper bedrock aquifer(s). Approximately 55% of the total hardness values in the groundwaters from the upper bedrock aquifer(s) are less than 200 mg/L.

In the M.D., approximately 75% of the groundwater samples from upper bedrock aquifer(s) have fluoride concentrations that are too low (less than 0.5 mg/L) to meet the recommended daily needs of people. Approximately 23% of the groundwater samples from the entire M.D. are between 0.5 and 1.5 mg/L and approximately 2% exceed the MAC for fluoride of 1.5 mg/L. with most of the exceedances occurring in the southern part of the M.D. (see CD-ROM).

The minimum, maximum and median[20] concentrations of TDS, sodium, sulfate, chloride and fluoride in the groundwaters from water wells completed in the upper bedrock in the M.D. have been compared to the SGCDWQ in Table 8. Of the five constituents compared to the SGCDWQ, median concentrations of TDS exceed the guidelines.

| Constituent | No. of Analyses | Range for County in mg/L Minimum | Maximum | Median | Recommended Maximum Concentration SGCDWQ |
|---|---|---|---|---|---|
| Total Dissolved Solids | 250 | 0 | 8,559 | 679 | 500 |
| Sodium | 213 | 0 | 1,091 | 80 | 200 |
| Sulfate | 250 | 0 | 1,345 | 48 | 500 |
| Chloride | 250 | 0 | 1,450 | 7 | 250 |
| Fluoride | 220 | 0 | 2.2 | 0.3 | 1.5 |

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

**SGCDWQ** - Summary of Guidelines for Canadian Drinking Water Quality Federal-Provincial-Territorial Committee on Drinking Water, April 2003

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

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[20] see glossary

### 5.3.5 Oldman Aquifer

The Oldman Aquifer comprises the permeable parts of the Oldman Formation, as defined for the present program. The structure contours show that the Oldman Formation ranges in elevation from less than 590 to more than 790 metres AMSL and has a maximum thickness of 110 metres. The regional groundwater flow direction in the Oldman Aquifer is downgradient to the west toward the Pembina River (see CD-ROM).

#### *5.3.5.1 Depth to Top*

The depth to the top of the Oldman Formation is mainly less than 50 metres and is a reflection of the thickness of the surficial deposits (page A-30).

#### *5.3.5.2 Apparent Yield*

The apparent yield values for individual water wells completed through the Oldman Aquifer range from less than five to more than 30 m³/day, and have a median apparent yield of 25 m³/day. The areas where data control points are present show that water wells with yields of greater than 30 m³/day are expected to be in the southwestern part of the M.D., as shown on Figure 21.

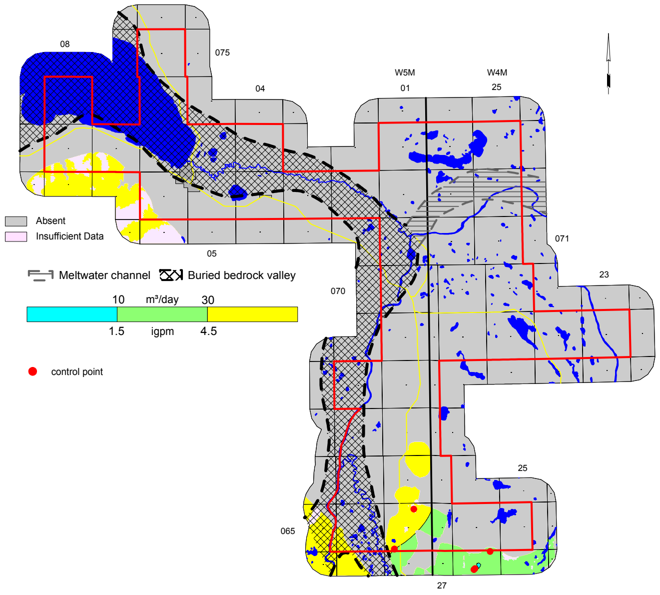


***Figure 21. Apparent Yield for Water Wells Completed through Oldman Aquifer***

There are three registered groundwater users that have water wells completed through the Oldman Aquifer, for a total groundwater diversion of five m³/day. Of the three registered groundwater users, one could be linked to a water well in the AENV groundwater database.

#### *5.3.5.3 Quality*

There were insufficient chemistry data to determine the groundwater type in the Oldman Aquifer. The TDS concentrations range from less than 500 to more than 1,000 mg/L, with the highest TDS concentration being 1,346 mg/L (page A-32). More than 70% of the sulfate concentrations in groundwaters from the Oldman Aquifer are less than 500 mg/L. All of the chloride concentrations from the Oldman Aquifer are less than or equal to two mg/L and all of the fluoride concentrations are less than 2.5 mg/L.

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

| Constituent | No. of Analyses | Range for County in mg/L Minimum | Maximum | Median | All Bedrock Median | Recommended Maximum Concentration SGCDWQ |
|---|---|---|---|---|---|---|
| Total Dissolved Solids | 7 | 430 | 1,346 | 982 | 679 | 500 |
| Sodium | 5 | 33 | 228 | 202 | 80 | 200 |
| Sulfate | 7 | 16 | 623 | 316 | 48 | 500 |
| Chloride | 7 | 0 | 2 | 1 | 7 | 250 |
| Fluoride | 5 | 0 | 0 | 0.2 | 0.3 | 1.5 |

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

**SGCDWQ** - Summary of Guidelines for Canadian Drinking Water Quality
Federal-Provincial Subcommittee on Drinking Water, April 2002

***Table 9. Apparent Concentrations of Constituents in Groundwaters from Oldman Aquifer***

### 5.3.6 Foremost Aquifer

The Foremost Aquifer comprises the permeable parts of the Foremost Formation, as defined for the present program. The Foremost Formation subcrops under the surficial deposits in most of the M.D. The structure contours show that the Foremost Formation ranges in elevation from less than 520 to more than 680 metres AMSL and has a maximum thickness of 180 metres. The regional groundwater flow direction in the Foremost Aquifer is downgradient to the northeast toward the Lesser Slave River and west toward the Pembina River (see CD-ROM).

#### *5.3.6.1 Depth to Top*

The depth to the top of the Foremost Formation ranges from less than 25 metres to more than 350 metres in the areas north and south of Lesser Slave Lake (page A-33).

#### *5.3.6.2 Apparent Yield*

The apparent yields for individual water wells completed through the Foremost Aquifer range from less than ten to more than 100 m³/day, as shown on Figure 22. The areas showing water wells with yields of greater than 100 m³/day are expected to be in the southern parts of the M.D.

Shown on the adjacent map are the locations of 14 dry water test holes.

There are 45 licensed and registered groundwater users that have water wells completed through the Foremost Aquifer, for a total authorized groundwater diversion of 173 m³/day.

Of the 45 licensed and registered groundwater users, 28 could be linked to water wells in the AENV groundwater database.

The highest authorized groundwater use is for a water well in 13-16-066-01 W5M completed for the Town of Flatbush in July 1991, licensed to Alberta Municipal Affairs to divert 37.2 m³/day for municipal purposes.

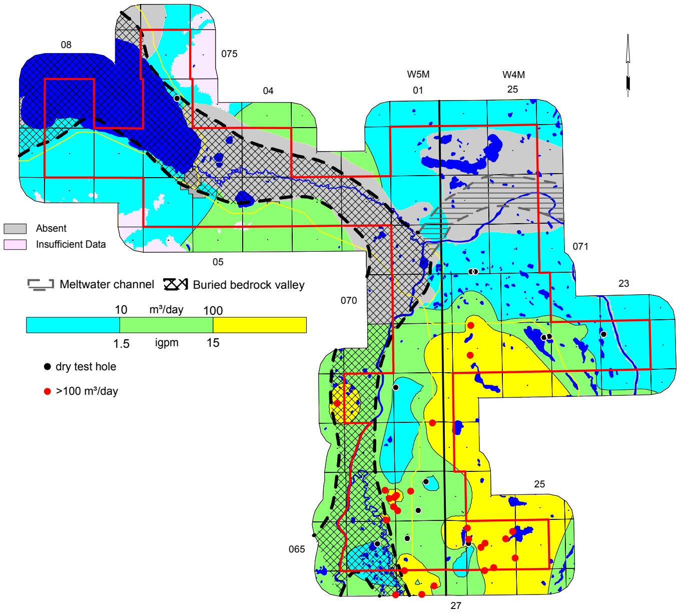


*Figure 22. Apparent Yield for Water Wells Completed through Foremost Aquifer*

An extended aquifer test conducted with a Town of Flatbush Highway Maintenance Yard water supply well in 04-09-066-01 W5M completed in the Foremost Aquifer in October 1973 indicated a long-term yield of 14.4 m³/day (HCL, Nov-1973).

#### *5.3.6.3 Quality*

The groundwaters from the Foremost Aquifer are mainly a calcium-magnesium-bicarbonate type (see Piper diagram on CD-ROM), with 85% of the groundwater samples having TDS concentrations of less than 1,000 mg/L (page A-35). Seventy percent of the sulfate concentrations in groundwaters from the Foremost Aquifer are less than 100 mg/L. Eighty-five percent of the chloride concentrations from the Foremost Aquifer are less than 50 mg/L, and 75% of the fluoride concentrations from the Foremost Aquifer are less than 0.5 mg/L.

A chemical analysis of a groundwater sample collected in October 1973 from the Town of Flatbush Highway Maintenance Yard water supply well in 04-09-066-01 W5M indicates the groundwater is a sodium-bicarbonate type, with a TDS concentration of 1,706 mg/L, a sulfate concentration of 570 mg/L, a chloride concentration of 4 mg/L, and a fluoride concentration of 0.46 mg/L (HCL, Nov-1973).

Of the five constituents that have been compared to the SGCDWQ, the median value of TDS exceeds the guidelines. The median concentrations of TDS, sulfate and chloride from water wells completed in the Foremost Aquifer are greater than the median concentrations from water wells completed in all upper bedrock aquifer(s).

| Constituent | No. of Analyses | Range for County in mg/L Minimum | Maximum | Median | All Bedrock Median | Recommended Maximum Concentration SGCDWQ |
|---|---|---|---|---|---|---|
| Total Dissolved Solids | 216 | 0 | 2,820 | 702 | 679 | 500 |
| Sodium | 192 | 0 | 1,091 | 80 | 80 | 200 |
| Sulfate | 217 | 0 | 1345 | 50 | 48 | 500 |
| Chloride | 217 | 0 | 1450 | 9 | 7 | 250 |
| Fluoride | 199 | 0 | 2 | 0.3 | 0.3 | 1.5 |

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

**SGCDWQ** - Summary of Guidelines for Canadian Drinking Water Quality
Federal-Provincial Subcommittee on Drinking Water, April 2002

***Table 10. Apparent Concentrations of Constituents in Groundwaters from Foremost Aquifer***

## 5.3.7 Mannville Group

### *5.3.7.1 Grand Rapids Formation*

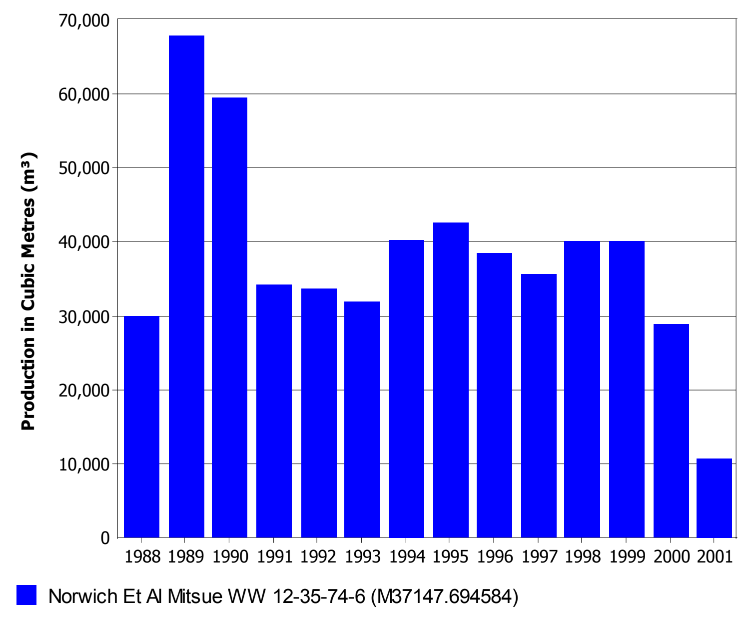


***Figure 23. Norwich Resources Water Source Well - Annual Groundwater Production***

A Norwich Resources water source well in 12-35-074-06 W5M is completed from 530 to 534 metres below ground surface in the Grand Rapids Formation of the Mannville Group (see Figure 18 on Page 23 showing a graphical stratigraphic section of the Mannville Group). Water Source Well 12-35 was completed in August 1987 and was licensed to divert 340 $m^3$/day for oil industrial (injection) purposes.

An extended aquifer test conducted with WSW 12-35 in September 1988 indicated a long-term yield of in excess of 305 $m^3$/day, based on an effective transmissivity of 34 $m^2$/day and a corresponding storativity of $8.7 \times 10^{-5}$ (HCL, April-1989).

Groundwater production data are available from 1988 to 2001. Water Source Well No. 12-35 diverted an annual maximum of 67,840 cubic metres (185 $m^3$/day) in 1994 (HCL, Dec-1995). The groundwaters from WSW No. 12-35 are a sodium-chloride-type with TDS concentrations in excess of 10,000 mg/L.

### *5.3.7.2 Clearwater Formation*

A Glen Isle Exploration Ltd. hydrocarbon well in 03-05-074-04 W5M was recompleted as a water source well by perforating the depth interval from 500 to 505 metres below Kelly Bushing (KB) in a sandstone layer within the Clearwater Formation, approximately 75 metres below the Grand Rapids Formation of the Mannville Group; KB elevation is 601.5 metres AMSL. The 03-05-074-04 W5M was the target location for the hydrocarbon well; the surface location is 06-05-074-04 W5M. Water Source Well No. 06-05, completed from 101.5 to 96.5 metres AMSL, is completed approximately 95 metres below the Norwich Resources water source well in 12-35-074-06 W5M. An extended aquifer test conducted with WSW No. 06-05 in March 1991 indicated a long-term yield of 165 $m^3$/day, based on an effective transmissivity of 3.8 $m^2$/day and a corresponding storativity of $8.7 \times 10^{-5}$ (HCL, Revised May 15, 1991).

The chemical quality of the groundwater from the Norwich Resources water source well and the Glen Isle Exploration Ltd. water source well is similar, with TDS concentrations ranging from 8,000 to 12,000 mg/L.

# 6 GROUNDWATER BUDGET

## 6.1 Hydrographs

In the M.D., there is one observation water well that is part of the AENV regional groundwater monitoring network where water levels are being measured and recorded as a function of time: AENV Obs Water Well: Smith 2420E (No. 86-1) in 08-10-072-01 W5M. The water level in AENV Obs WW No. 86-1 has been measured since 1988. The hydrograph for AENV Obs Water Well No. 86-1 is below on Figure 25, on page A-40 and on the CD-ROM.

AENV Obs WW No. 86-1 is located near the Hamlet of Smith, was reconditioned in May 1987, and is completed from 50.3 to 51.8 metres below ground surface in the Lower Sand and Gravel Aquifer in association with the Buried High Prairie Valley. The obs water well diagram shown on Figure 24 shows a NPWL of 39.65 metres below ground level. This water level was measured prior to an aquifer test conducted on July 16, 1989.

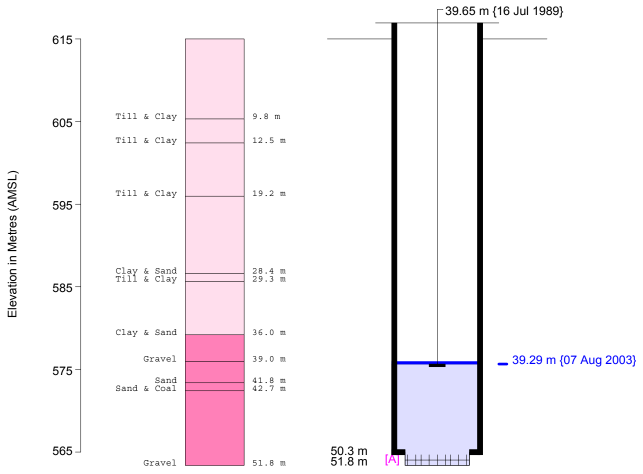


*Figure 24. AENV Obs Water Well No. 86-1 Well Diagram*

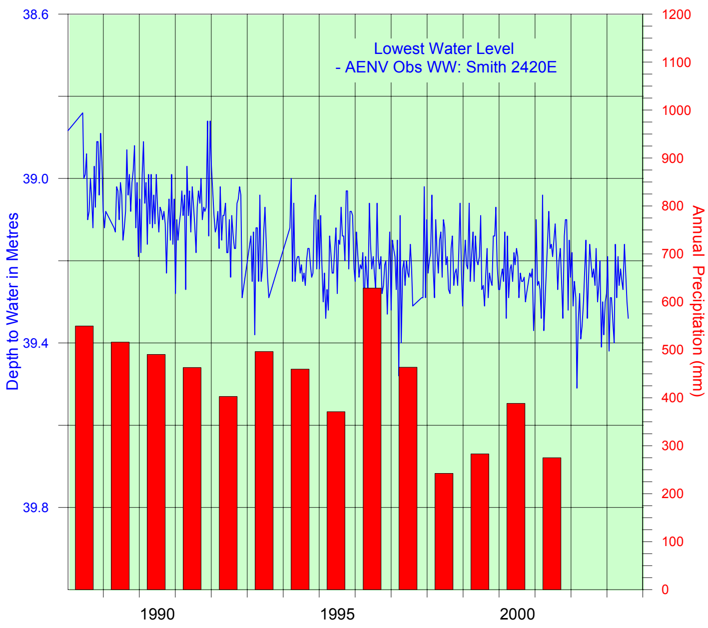


*Figure 25. Annual Precipitation vs Water Levels in AENV Obs WW No. 86-1*

The water level in AENV Obs WW No. 86-1 has declined from 38.8 metres below ground surface in July 1988 to 39.3 metres below ground surface in August 2003, a net decline in the water level of 0.5 metres. In an area where there are no pronounced seasonal uses of groundwater, the highest water level will usually occur in late spring/early summer and the lowest water level will be in late winter/early spring.

The water-level fluctuations in AENV Obs WW No. 86-1 in 08-10-072-01 W5M have been compared to the annual precipitation measured at the Slave Lake weather station from 1988 to 2002; the comparison is shown in the adjacent figure. The comparison shows that, in general, the water-level fluctuation does not reflect the changes in annual precipitation or a seasonal use of groundwater.

## 6.2 Estimated Groundwater Use in M.D. of Lesser Slave River

An estimate of the quantity of groundwater removed from each geologic unit in the M.D. of Lesser Slave River must include both the groundwater diversions with licences and/or registrations and the groundwater diversions without licences and/or registrations. As stated previously on page 7 of this report, the daily water requirement for livestock for the M.D. based on the 2001 census is estimated to be 1,486 cubic metres. As of January 2003, AENV has licensed the use of 391 m$^3$/day for livestock, which includes both surface water and groundwater. To obtain an estimate of the quantity of groundwater being diverted from the individual geologic units, it has been assumed that the remaining 1,095 m$^3$/day of water required for livestock watering is obtained from unauthorized groundwater use.

There are 230 water wells that are used for domestic/stock or stock purposes. There are 82 licensed and registered groundwater users for agricultural (stock) and registration (stock) purposes, giving 148 unlicensed and not registered groundwater stock water wells. (Please refer to Table 1 on page 6 for the breakdown of aquifer of the 82 licensed and registered stock groundwater users). By dividing the number of stock and domestic/stock water wells (148) into the quantity required for stock purposes that is not licensed and registered (1,095 m$^3$/day), the average water well with a licence and registration diverts 7.4 m$^3$/day per stock water well.

Groundwater for household use does not require a licence if the use is less than 1,250 m$^3$/year. Under the *Water Act*, a residence is protected for up to 3.4 m$^3$/day. However, the standard groundwater use for household purposes (a family of four) is 1.1 m$^3$/day. Since there are 104 domestic or domestic/stock water wells in the M.D. of Lesser Slave River serving a population of 2,825, the domestic use per water well is 0.8 m$^3$/day. It is assumed that these 104 water wells are active; however, many are very old and may no longer be in use or have been abandoned.

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

| | |
|---|---|
| Domestic | 0.8 m$^3$/day |
| Stock | 7.4 m$^3$/day |
| Domestic/stock | 8.2 m$^3$/day |

Because of the limitations of the data, no attempt has been made to compensate for dugouts, springs or inactive water wells.

Based on using all available domestic, domestic/stock, and stock water wells and corresponding calculations, the following table was prepared. Table 11 shows a breakdown of the 980 (750+126+104) water wells for which there is no licence and registration used for domestic, stock, or domestic/stock purposes by the geologic unit in which each water well is completed. The final column in the table equals the total amount of groundwater that is being used for both domestic and stock purposes from water wells for which there is no licence and registration. The data provided in Table 11 indicate that most of the 2,201 m$^3$/day, estimated to be diverted from domestic, stock, or domestic/stock water wells for which there is no licence and registration, is from the Upper Sand and Gravel Aquifer.

| | *Groundwater Diversions from Water Wells With or Without Licences and/or Registrations* | | | | | | | *Groundwater Diversions With Licences and/or Registrations* | *Groundwater Diversions Without Licences and/or Registrations* |
|---|---|---|---|---|---|---|---|---|---|
| Aquifer Designation | Number of Domestic | Daily Use (0.8 m$^3$/day) | Number of Stock | Daily Use (7.4 m$^3$/day) | Number of Domestic and Stock | Daily Use (8.2 m$^3$/day) | Totals m$^3$/day | Totals (m$^3$/day) | Totals m$^3$/day |
| Multiple Surficial Completions | 81 | 67 | 21 | 155 | 24 | 197 | 420 | 14 | 406 |
| Upper Sand and Gravel | 349 | 288 | 42 | 311 | 39 | 321 | 919 | 15 | 904 |
| Lower Sand and Gravel | 22 | 18 | 5 | 37 | 2 | 16 | 72 | 27 | 45 |
| Mulitple Bedrock Completion | 14 | 12 | 3 | 22 | 1 | 8 | 42 | 6 | 36 |
| Oldman | 4 | 3 | 2 | 15 | 0 | 0 | 18 | 5 | 13 |
| Foremost | 220 | 182 | 51 | 377 | 36 | 296 | 855 | 129 | 726 |
| Lea Park | 20 | 17 | 2 | 15 | 1 | 8 | 40 | 0 | 40 |
| Milk River | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Unknown | 39 | 32 | 0 | 0 | 1 | 8 | 40 | 10 | 30 |
| Totals (1) | 750 | 620 | 126 | 932 | 104 | 854 | 2,407 | 206 | 2,201 |

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

*Table 11. Total Groundwater Diversions by Aquifer*

By assigning 0.8 m³/day for domestic use, 7.4 m³/day for stock use and 8.2 m³/day for domestic/stock use, and using the total maximum authorized diversion associated with any licensed and/or registered water well, a map has been prepared that shows the estimated groundwater use in terms of volume per section per day for the M.D. (not including springs).

There are 1,568 sections in the M.D. In 81% (1271) of the sections in the M.D., there is no domestic, stock or licensed and registered groundwater user. The range in groundwater use for the remaining 297 sections is from one m³/day to 1,274 m³/day (injection), with an average use per section of 18 m³/day (2.7 igpm). The estimated water well use per section can be more than 30 m³/day in 18 of the 297 sections. There are 18 of the total 97 licensed and/or registered groundwater users in areas of greater than 30 m³/day.

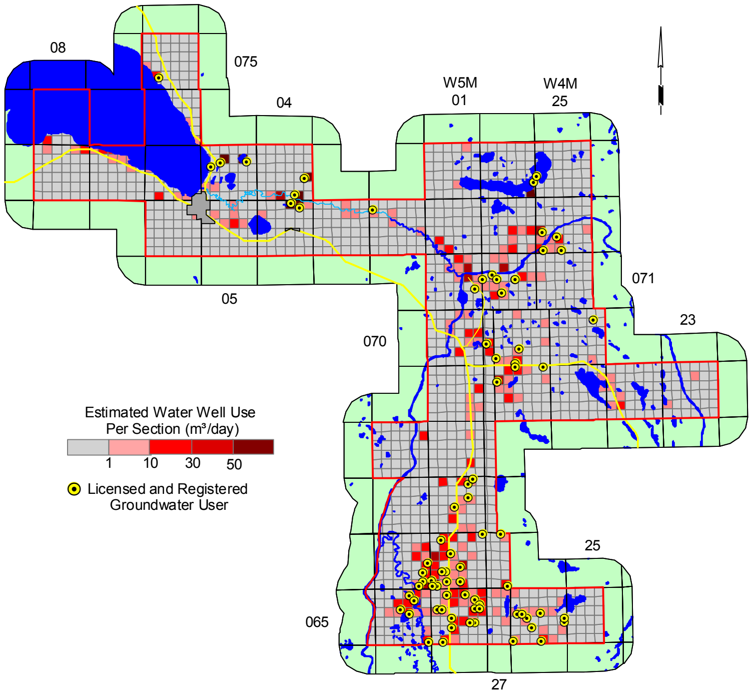


***Figure 26. Estimated Water Well Use Per Section***
**(for larger version, see page A-39)**

| Groundwater Use within the M.D. of Lesser Slave River (m³/day) | | % |
|---|---|---|
| Domestic/Stock (including agriculture and registrations) | 2,407 | 45 |
| Municipal (licensed) | 1 | 0 |
| Commercial/Industrial/Recreation (licensed) | 2,892 | 55 |
| Total | 5,300 | 100 |

***Table 12. Total Groundwater Diversions***

In summary, the estimated total groundwater use within the M.D. of Lesser Slave River is 5,300 m³/day, with the breakdown as shown in the adjacent table. An estimated 5,260 m³/day is being withdrawn from a specific aquifer. The remaining 40 m³/day (1%) is being withdrawn from unknown aquifer units. Of the 5,260 m³/day, 20% is being diverted from bedrock aquifers and 80% from surficial aquifers. Approximately 65% of the total estimated groundwater use is from licensed and registered water wells.

## 6.3 Groundwater Flow

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

The flow through each aquifer assumes that by taking a large enough area, an aquifer can be considered as homogeneous, the average gradient can be estimated from the non-pumping water-level surface, and flow takes place through the entire width of the aquifer; flow through the aquifers takes into consideration hydrogeological conditions outside the M.D. border. Based on these assumptions, the estimated lateral groundwater flow through the individual aquifers has been summarized in Table 13.

| Aquifer/Area | Trans ($m^2$/day) | Gradient (m/m) | Width (m) | Flow ($m^3$/day) | Aquifer Flow ($m^3$/day) | Licensed and Registered Diversion ($m^3$/day) | Not Licensed and Registered Diversion ($m^3$/day) | Total ($m^3$/day) |
|---|---|---|---|---|---|---|---|---|
| Surficial | | | | | 13,259 | 14 | 406 | 420 |
| Athabasca Basin | | | | | | | | |
| Southeast part of area | | | | | | | | |
| West | 29 | 0.00625 | 25.6 | 4,640 | | | | |
| East-central part of area | | | | | | | | |
| Northwest | 29 | 0.00625 | 12.8 | 2,320 | | | | |
| Northeast | 29 | 0.00139 | 16 | 644 | | | | |
| Fawcett Lake | | | | | | | | |
| Northwest | 29 | 0.00417 | 14.4 | 1,740 | | | | |
| Southeast | 29 | 0.00938 | 14.4 | 3,915 | | | | |
| Lower Surficial | | | | | 2,100 | 2,903 | 45 | 2,948 |
| Lesser Slave River Basin | | | | | | | | |
| Southeast | 35 | 0.006 | 10 | 2,100 | | | | |
| Foremost Formation | | | | | 4,268 | 173 | 726 | 899 |
| Lesser Slave River Basin | | | | | | | | |
| Northwest part of area | | | | | 1,900 | | | |
| North | 7.5 | 0.004 | 19 | 600 | | | | |
| Northeast | 7.5 | 0.008 | 21 | 1,300 | | | | |
| Athabasca Basin | | | | | | | | |
| Southeast part of area | | | | | 2,368 | | | |
| Southeast | | | | | | | | |
| Northwest | 7.5 | 0.004 | 19 | 514 | | | | |
| West 1 | 7.5 | 0.005 | 27 | 1,020 | | | | |
| West 2 | 7.5 | 0.006 | 13 | 533 | | | | |
| East | 7.5 | 0.003 | 13 | 300 | | | | |

***Table 13. Groundwater Budget***

Table 13 indicates that there is more groundwater flowing through the aquifers than has been authorized to be diverted from the individual aquifers, except for the Lower Sand and Gravel Aquifer. However, even where use is less than the calculated aquifer flow, there can still be local impacts on water levels. The calculations of flow through individual aquifers as presented in Table 13 are very approximate and are intended only as a guide; more detailed investigations are needed to better understand the groundwater flow.

### 6.3.1 Quantity of Groundwater

An estimate of the volume of groundwater stored in the sand and gravel aquifers is 2.0 to 12.1 cubic kilometres. This volume is based on an areal extent of 1,347 square kilometres and a saturated thickness of 30 metres. The variation in the total volume is based on the value of porosity that is used for the surficial deposits. One estimate of porosity is 5%, which gives the low value of the total volume. The high estimate is based on a porosity of 30% (Ozoray, Dubord and Cowen, 1990).

The adjacent non-pumping water-level map has been prepared from water levels associated with water wells completed to depths of less than 20 metres in aquifers in the surficial deposits. The water levels from these water wells were used for the calculation of the saturated thickness of the surficial deposits and for calculations of recharge/discharge areas. In areas where the elevation of the water-level surface is below the bedrock surface, the surficial deposits are not saturated (indicated by grey areas on the map). The water-level map for the surficial deposits shows a flow direction toward the Athabasca River and the Lesser Slave River.

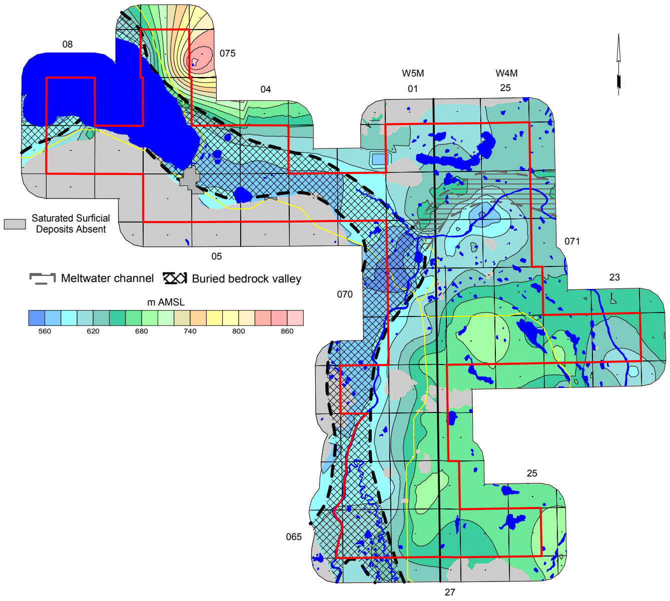


***Figure 27. Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep***

### 6.3.2 Recharge/Discharge

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

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

### *6.3.2.1 Surficial Deposits/Bedrock Aquifers*

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

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.

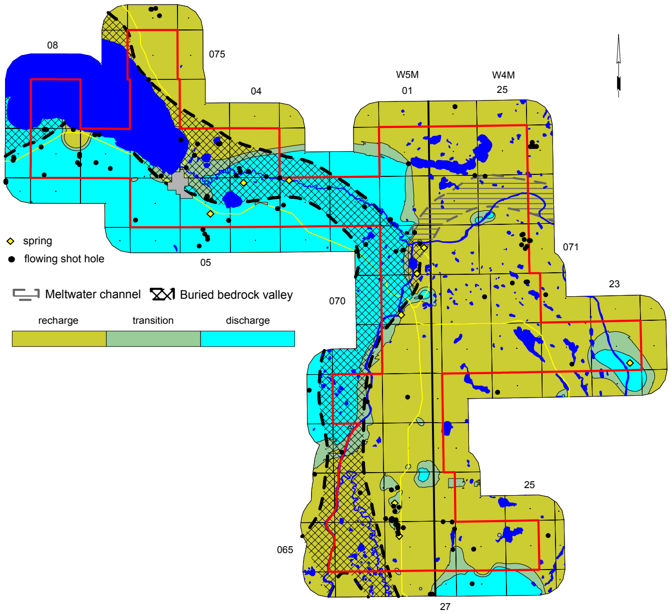


***Figure 28. Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)***

The location of springs, flowing shot holes and any water wells that had a water level measurement depth of less than 0.1 metres are shown on Figure 28. These locations would reflect where there is an upward hydraulic gradient from the bedrock to the surficial deposits (i. e. discharge).

Figure 28 shows that, in 65% of the M.D., 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 (i .e. discharge) from the bedrock to the surficial deposits are mainly in the vicinity of linear bedrock lows. The remaining parts of the M.D. are areas where there is a transition condition.

Because of the paucity of data, recharge/discharge maps for the individual bedrock aquifers have not been attempted.

With 65% of the M.D. land area being one of recharge to the bedrock, and the average precipitation being 485 mm per year, 0.1 percent of the annual precipitation is sufficient to provide the total calculated quantity of groundwater flowing through the upper bedrock aquifer(s).

## 6.4 Areas of Groundwater Decline

In order to determine the areas of possible water-level decline in the Sand and Gravel Aquifer(s) and in the Upper Bedrock Aquifer(s), the following approach was attempted. The available non-pumping water-level elevation for each water well was first sorted by location, and then by date of water-level measurement. The dates of measurements were required to differ by at least 365 days. Only the earliest and latest control points at a given location were used. The method of calculating changes in water levels is at best an estimate. Additional data would be needed to verify water-level change.

Of the 284 surficial water wells with a non-pumping water level and date in the M.D. and buffer area, there are 40 water wells with sufficient control to prepare the adjacent map.

Where the earliest water level is at a higher elevation than the latest water level, there is the possibility that some groundwater decline has occurred. The interpretation of the adjacent map should be limited to areas where control points are present. Most of the areas in which the map suggests that there has been a decline in NPWL may reflect the nature of gridding a limited number of control points. The adjacent map, where sufficient control exists, indicates that there may have been a decline in the NPWL in most areas.

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

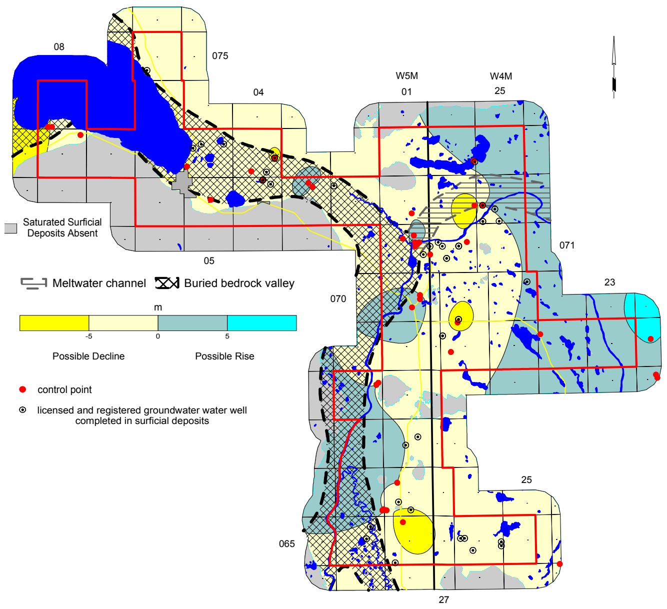


*Figure 29. Changes in Water Levels in Surficial Deposits*

Of the 43 licensed and registered groundwater users completed in surficial aquifers, most occur in areas where a decline in the NPWL may have occurred.

Figure 29 indicates that in 70% of the M.D. where surficial deposits are present, it is possible that the non-pumping water level has declined. The areas of groundwater decline in the Sand and Gravel Aquifer(s) where there is no estimated water well use suggest that groundwater diversion is not having an impact and that the decline may be due to variations in recharge to the Aquifer(s) or because the water wells are not on file with Alberta Environment.

In areas where a water-level decline of more than five metres may exist, 42% of the areas has no estimated water well use; 28% is less than 10 m³/day, 27% of the use is between 10 and 30 m³/day; and the remaining 3% of the declines occurred where the estimated groundwater use per section is greater than 30 m³/day, as shown in Table 14.

| Estimated Water Well Use Per Section (m³/day) | *% of Area with More than a 5-Metre Projected Decline* |
|---|---|
| <10 | *28* |
| 10 to 30 | *27* |
| >30 | *3* |
| no use | *42* |

***Table 14. Water-Level Decline in Sand and Gravel Aquifer(s)***

Of the 301 bedrock water wells with a non-pumping water level and date in the M.D. and buffer area, there are 54 water wells with sufficient control to prepare the adjacent map. The adjacent map indicates that in 75% of the M.D., it is possible that the non-pumping water level has declined. Of the 50 licensed and registered groundwater users completed in Upper Bedrock Aquifer(s), most occur in areas where a water-level decline may have occurred. The areas north of township 067 where the map suggests that there has been a decline in NPWL may be a result of gridding a limited number of control points.

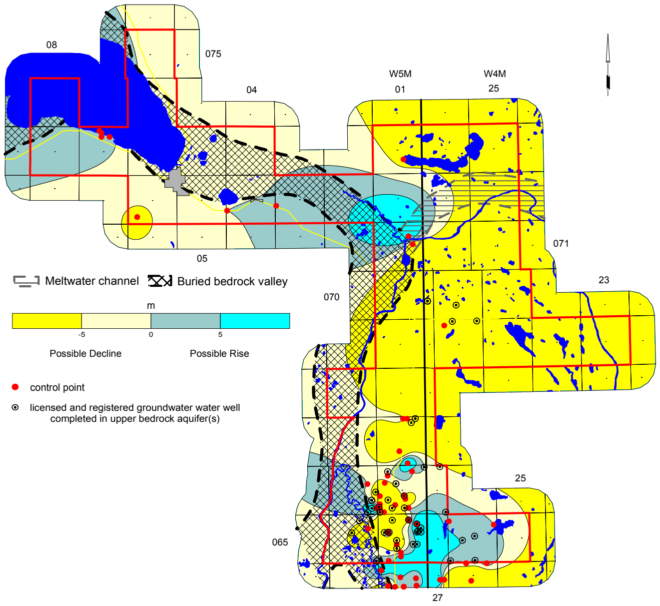


*Figure 30. Areas of Potential Groundwater Depletion - Upper Bedrock Aquifer(s)*

In areas where a water-level decline exists, 79% of the areas has no estimated water well use; 14% is less than 10 $m^3$/day, 6% of the use is between 10 and 30 $m^3$/day; and the remaining 1% of the declines occurred where the estimated groundwater use per section is greater than 30 $m^3$/day, as shown below in Table 15.

| Estimated Water Well Use Per Section ($m^3$/day) | *% of Area with More than a 5-Metre Projected Decline* |
|---|---|
| <10 | *14* |
| 10 to 30 | *6* |
| >30 | *1* |
| no use | *79* |

***Table 15. Water-Level Decline of More than 5 Metres in Upper Bedrock Aquifer(s)***

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

# 7 POTENTIAL FOR GROUNDWATER CONTAMINATION

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

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

The potential for groundwater contamination is based on the concept that the easier it is for a liquid contaminant to move downward, the easier it is for the groundwater to become contaminated. In areas where there is groundwater discharge, liquid contaminants cannot enter the groundwater flow systems to be distributed throughout the area. In areas of groundwater recharge, low-permeability materials impede the downward movement of liquid contaminants. 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), (Geological Survey of Canada, 1986), (Geological Survey of Canada, 1975), and (Research Council of Alberta, 1963) have 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 967 records with lithological descriptions in the area of the M.D., 370 have the top of a sand and gravel deposit present within one metre of ground level. In the remaining 597 records, the first sand and gravel deposit is deeper than one metre or not present. This information was gridded to prepare a distribution of where the first sand and gravel deposit could be expected within one metre of ground level.

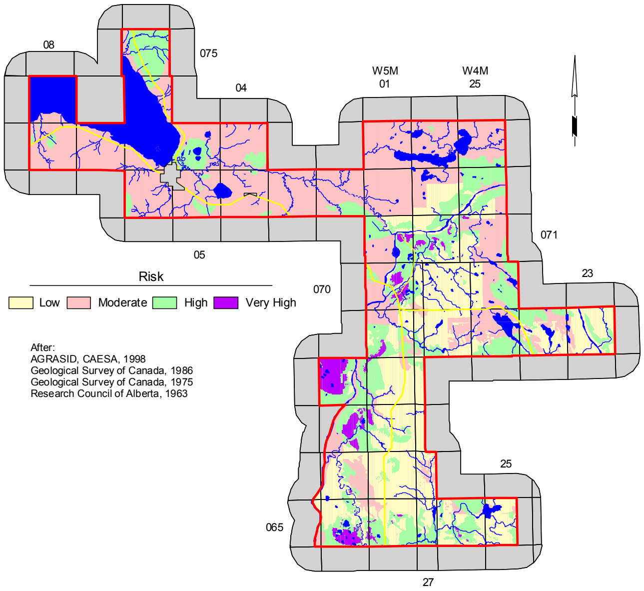
### 7.1.1 Risk of Groundwater Contamination Map

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

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

*Table 16. Risk of Groundwater Contamination Criteria*

The Risk of Groundwater Contamination map shows that, in 20% of the M.D., 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.



After:
AGRASID, CAESA, 1998
Geological Survey of Canada, 1986
Geological Survey of Canada, 1975
Research Council of Alberta, 1963

*Figure 31. Risk of Groundwater Contamination*

# 8 RECOMMENDATIONS

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

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

The quality of the data in the groundwater database is affected by two factors: a) the technical training of the persons collecting the data, and b) the quality control of the data. The possible options to upgrade the database include the creation of a "super" database, which includes only verified data. The first step would be to field-verify the 30 existing water wells listed in Appendix E. These water well records indicate that a complete water well drilling report is available along with at least a partial chemical analysis. The level of verification would have to include identifying the water well in the field, obtaining meaningful horizontal coordinates for the water well and the verification of certain parameters such as water level and completed depth. There are nine water wells for which the M.D. has responsibility; the M.D.-operated water well is included in Appendix E. It is recommended that the nine M.D.-operated water wells plus the 30 water wells be field-verified, water levels be measured, a water sample be collected for analysis, and a short aquifer test be conducted. An attempt to update the quality of the entire database is not recommended.

Before an attempt is made to provide a major upgrade to the level of interpretation provided in this report, the accompanying maps and the groundwater query, it is recommended that the 30 water wells listed in Appendix E for which water well drilling reports are available, plus the nine M.D.–operated water wells, be subjected to the following actions (see pages C-2 to C-3):

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

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

A list of the 39 water wells that could be considered for the above program is given in Appendix E and on the CD-ROM.

An attempt to link the AENV groundwater and licensing databases was 54% successful in this study (see CD-ROM); forty-six percent of the 97 licensed and/or registered water wells do not appear to have corresponding records in the AENV groundwater database. There is a need to improve the quality of the AENV licensing database. It is recommended that attempts be made in a future study to find and add missing drilling records to the AENV groundwater database and to determine the aquifer in which the authorized non-exempt water wells are completed.

While there are a few areas where water-level data are available at different times, on the overall, there are an insufficient number of water levels to set up a groundwater budget. One method to obtain additional water-level data is to solicit the assistance of the water well owners who are stakeholders in the groundwater resource. In the M.D. of Rocky View and in Flagstaff County, water well owners were being provided with a tax credit if they accurately measured the water level in their water well once per week for a year. A pilot project indicated that approximately five years of records are required to obtain a reasonable data set. The cost of a five-year project involving 50 water wells would be less than the cost of one drilling program that may provide two or three observation water wells. Monitoring of water levels in domestic and stock water wells is a practice that is recommended by PFRA in the “Water Wells That Last for Generations” manual and accompanying videos (Buchanan, Bob (editor). Alberta Agriculture, Food and Rural Development, 1996).

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

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

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

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

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

**Groundwater is a renewable resource and it must be managed.**

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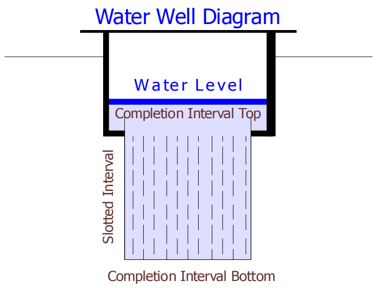
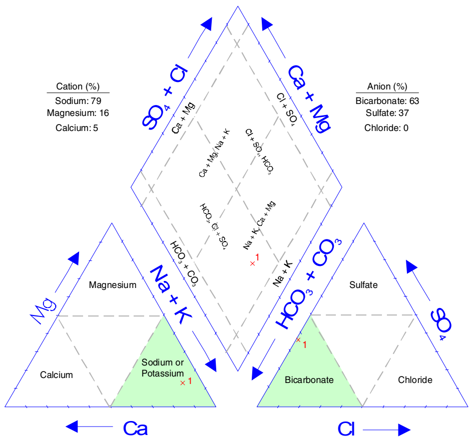
# 10 GLOSSARY

| | |
|---|---|
| Anion | negatively charged ion |
| Aquifer | a formation, group of formations, or part of a formation that contains saturated permeable rocks capable of transmitting groundwater to water wells or springs in economical quantities |
| Aquitard | a confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer |
| Available Drawdown | in a confined aquifer, the distance between the non-pumping water level and the top of the aquifer<br>in an unconfined aquifer (water table aquifer), two thirds of the saturated thickness of the aquifer |
| Borehole | includes all “work types” except springs |
| Completion Interval | see diagram |
| 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 |
| Dfb | one of the Köppen climate classifications; a Dfb climate consists of warm to cool summers, severe winters, and no dry season. The mean monthly temperature drops below -3° C in the coolest month, and exceeds 10° C in the warmest month. |
| 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 |



***Completion Interval***

| | |
|---|---|
| mm | millimetres |
| m²/day | metres squared per day |
| m³ | cubic metres |
| m³/day | cubic metres per day |
| mg/L | milligrams per litre |
| Median | the value at the centre of an ordered range of numbers |
| 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 |
| 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<br>Apparent Transmissivity: the value determined from a summary of aquifer test data, usually involving only two water-level readings<br>Effective Transmissivity: the value determined from late pumping and/or late recovery water-level data from an aquifer test<br>Aquifer Transmissivity: the value determined by multiplying the hydraulic conductivity of an aquifer by the thickness of the aquifer |



***Piper Tri-Linear Diagram***

| | |
|---|---|
| Water Well | a hole in the ground for the purpose of obtaining groundwater; “work type” as defined by AENV includes test hole, chemistry, deepened, well inventory, federal well survey, reconditioned, reconstructed, new, old well-test |
| Yield | a regional analysis term referring to the rate a properly completed water well could be pumped, if fully penetrating the aquifer<br>Apparent Yield: based mainly on apparent transmissivity<br>Long-Term Yield: based on effective transmissivity |
| AAFC-PFRA | Prairie Farm Rehabilitation Administration Branch of Agriculture and Agri-Food Canada |
| AENV | Alberta Environment |
| AMSL | above mean sea level |
| BGP | Base of Groundwater Protection |
| DEM | Digital Elevation Model |
| DST | drill stem test |
| EUB | Alberta Energy and Utilities Board |
| GCDWQ | Guidelines for Canadian Drinking Water Quality |
| IAAM | *Infinite Aquifer Artesian Model.* The mathematical model is used to calculate water levels at a given location. The model has been used for more than 17 years by HCL for several hundred groundwater monitoring projects. The model aquifer is based on a solution of the well function equation. The simulation calculates drawdown by solving the well function equation using standard approximation methods. The drawdown at any given point at any given time uses the method of superposition. |
| NPWL | non-pumping water level |
| TDS | Total Dissolved Solids |
| WSW | Water Source Well or Water Supply Well |

# 11 CONVERSIONS

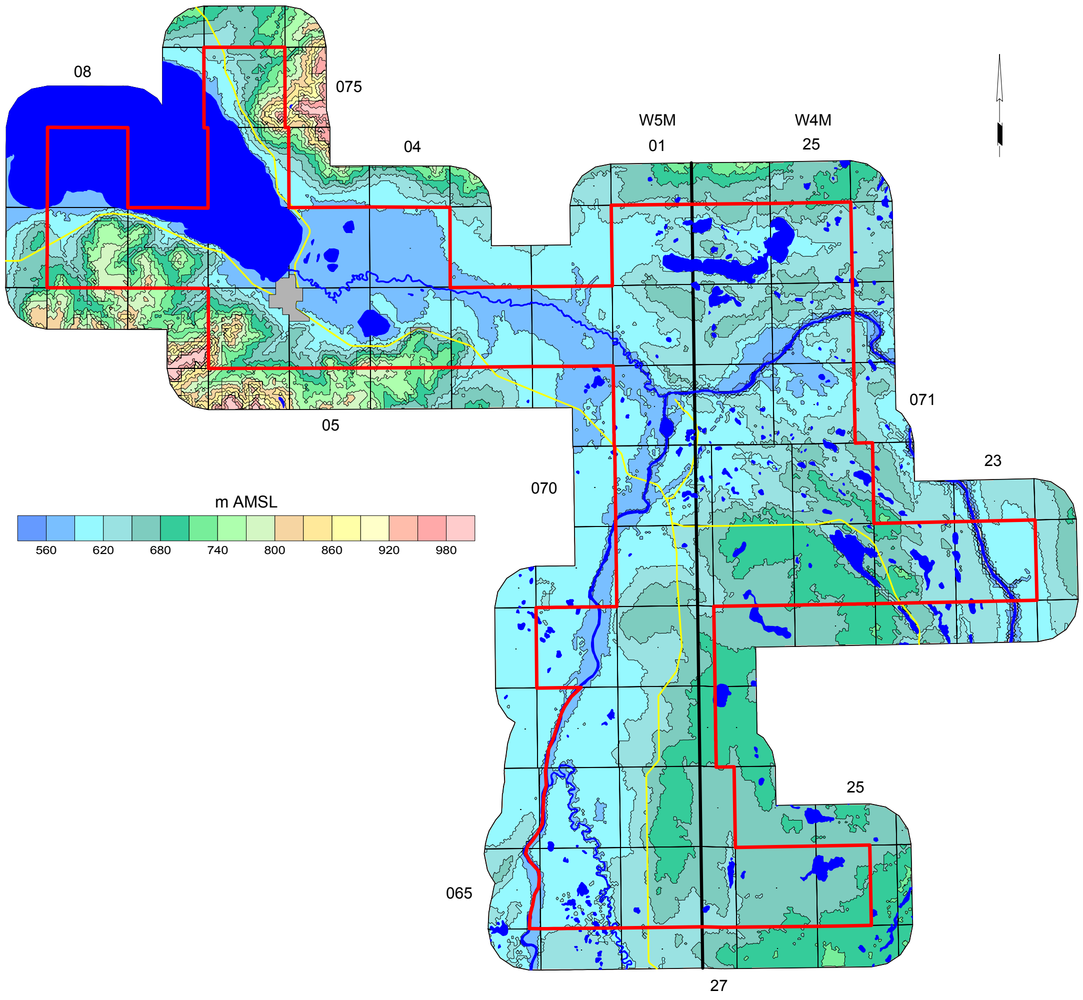
| Multiply | by | To Obtain |
|---|---|---|
| **Length/Area** | | |
| feet | 0.304 785 | metres |
| metres | 3.281 000 | feet |
| hectares | 2.471 054 | acres |
| centimetre | 0.032 808 | feet |
| centimetre | 0.393 701 | inches |
| acres | 0.404 686 | hectares |
| inchs | 25.400 000 | millimetres |
| miles | 1.609 344 | kilometres |
| kilometer | 0.621 370 | miles (statute) |
| square feet (ft$^2$) | 0.092 903 | metres (m$^2$) |
| metres (m$^2$) | 10.763 910 | square feet (ft$^2$) |
| metres (m$^2$) | 0.000 001 | kilometres (km$^2$) |
| **Concentration** | | |
| grains/gallon (UK) | 14.270 050 | 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 | 0.219 974 | ipgm |
| 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 (m | 0.152 759 | igpm |
| **Pressure** | | |
| psi | 6.894 757 | kpa |
| kpa | 0.145 038 | psi |
| **Miscellaneous** | | |
| Celsius | F° = 9/5 (C° + 32) | Fahrenheit |
| Fahrenheit | C° = (F°- 32) * 5/9 | Celsius |
| degrees | 0.017 453 | radians |

# M.D. OF LESSER SLAVE RIVER NO. 124

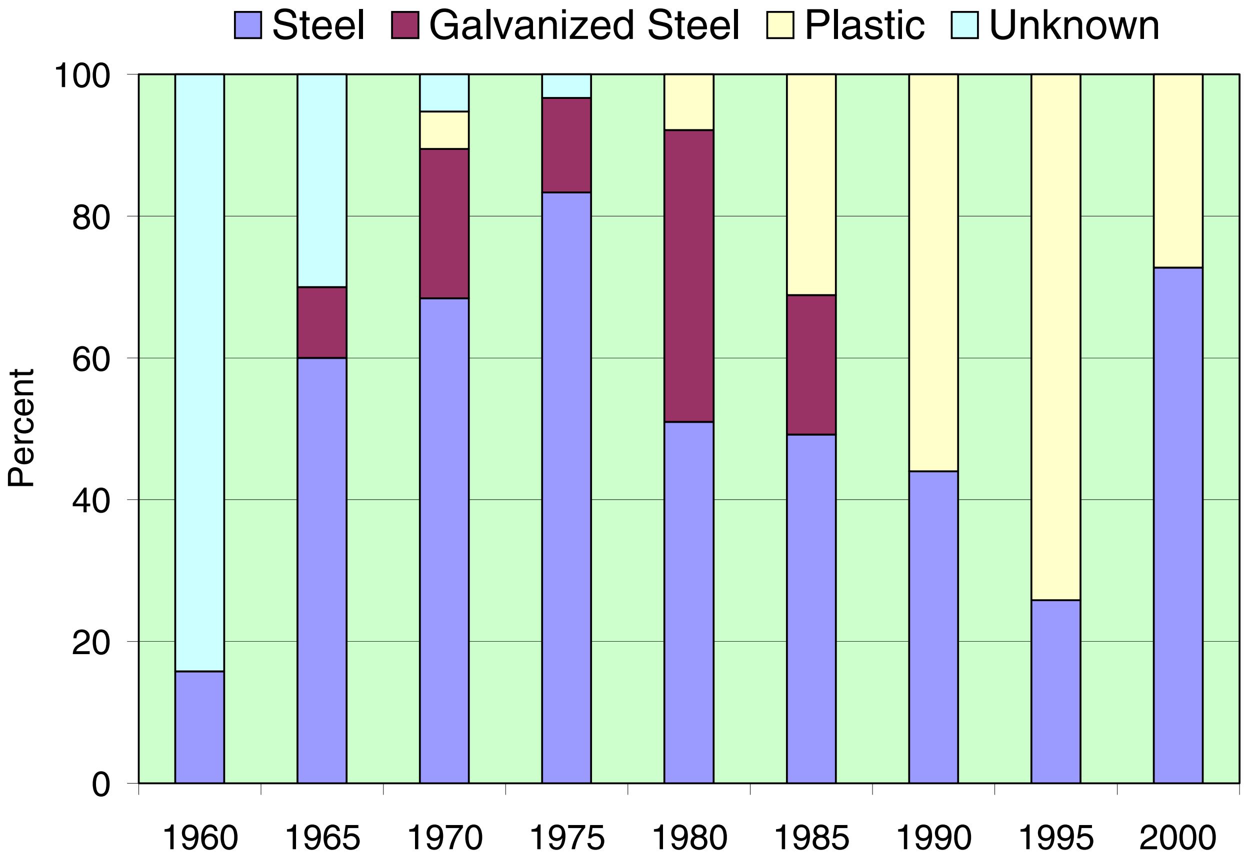
## Appendix A

## Hydrogeological Maps and Figures

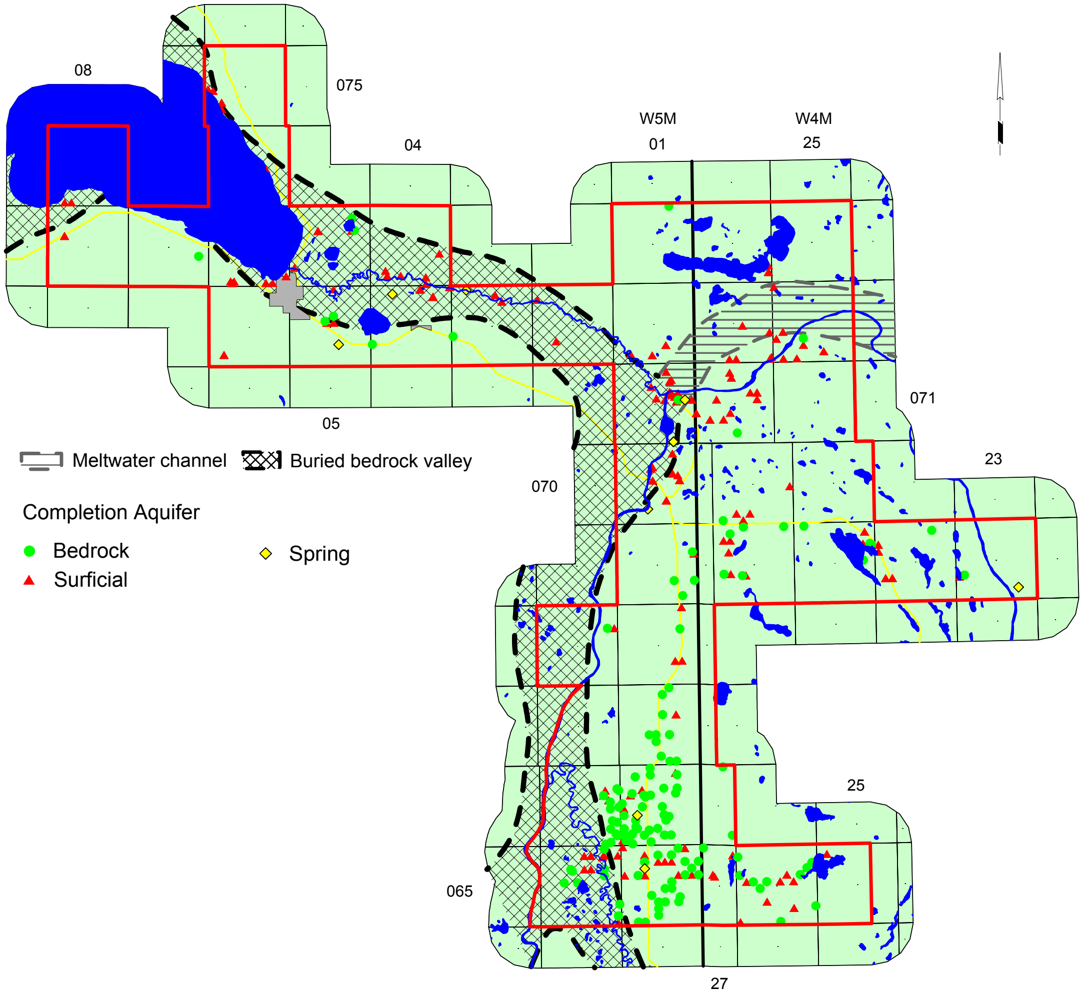
# Surface Topography



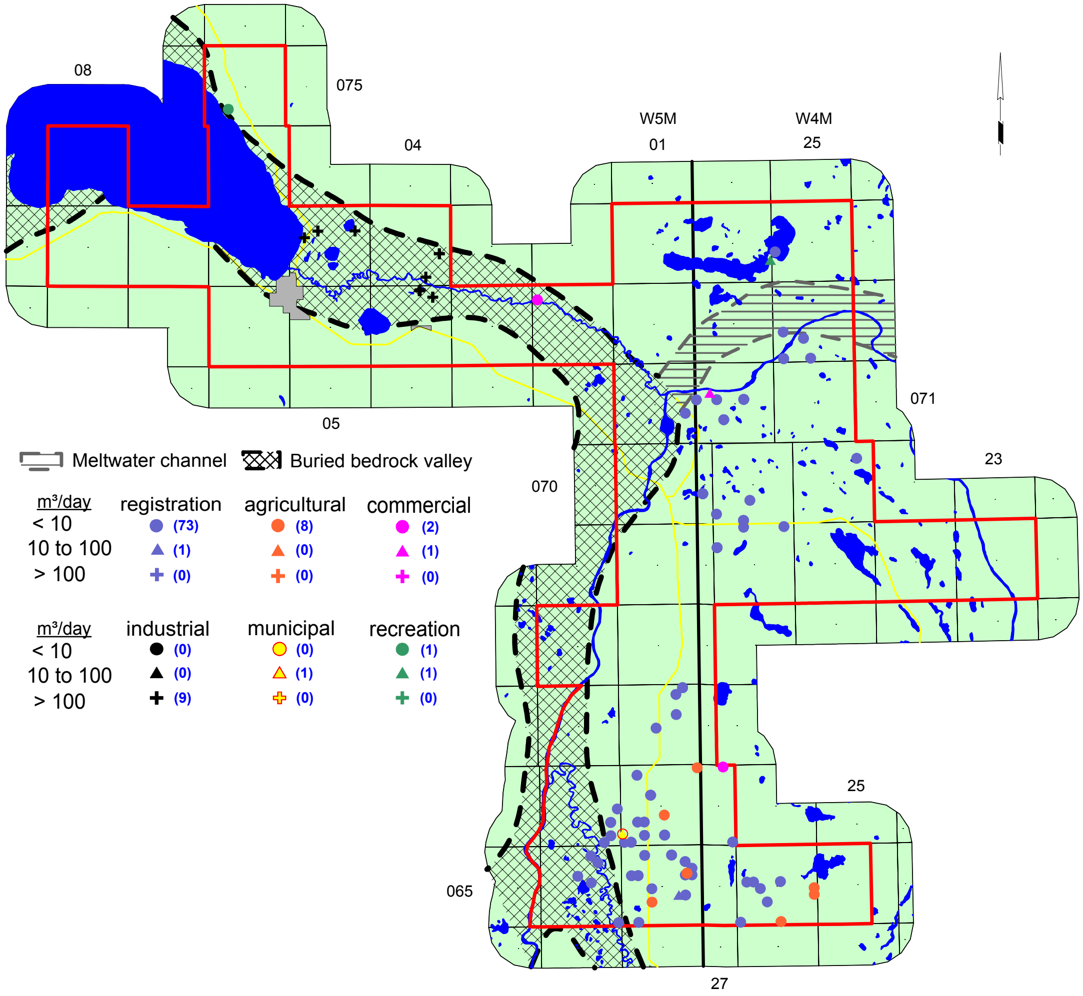
## Surface Casing Types used in Drilled Water Wells



# Location of Water Wells and Springs

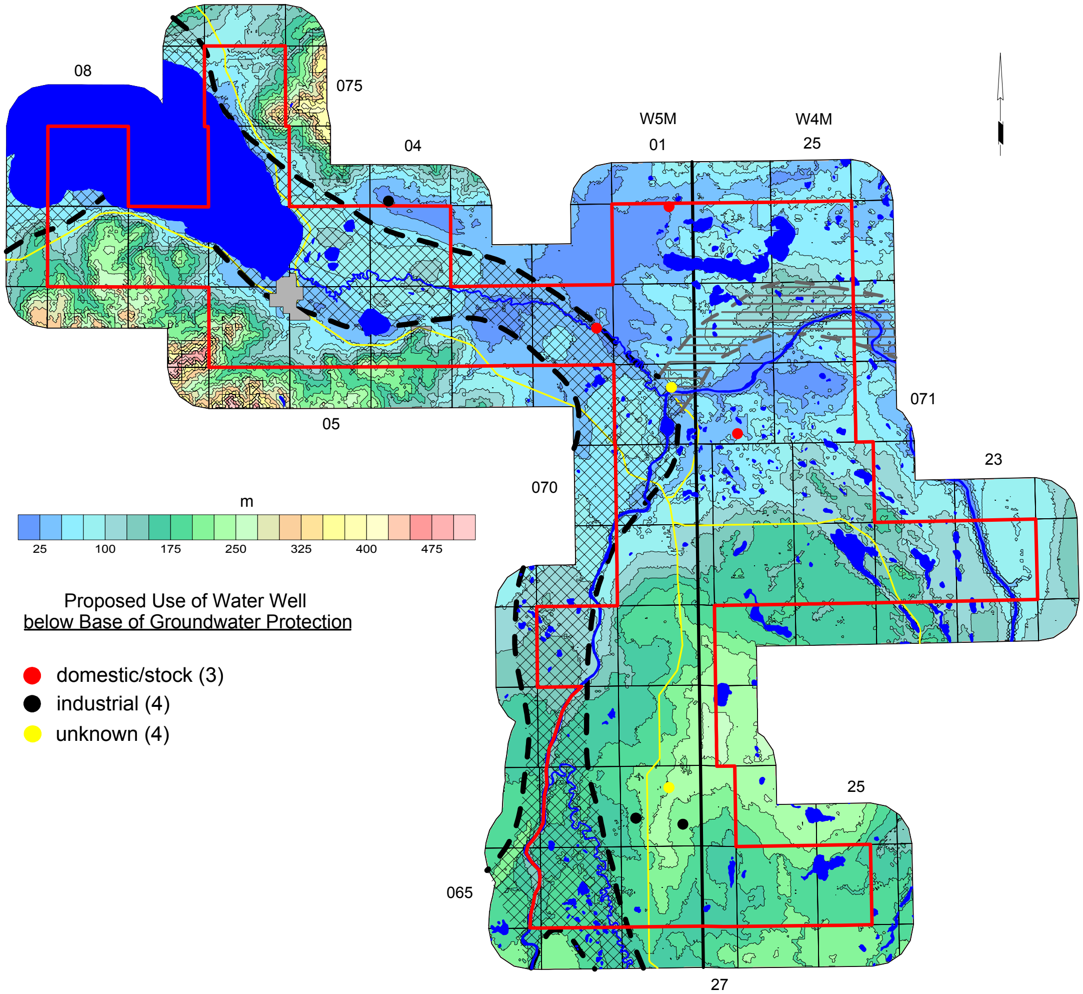


# *Licensed and Registered Groundwater Water Wells*



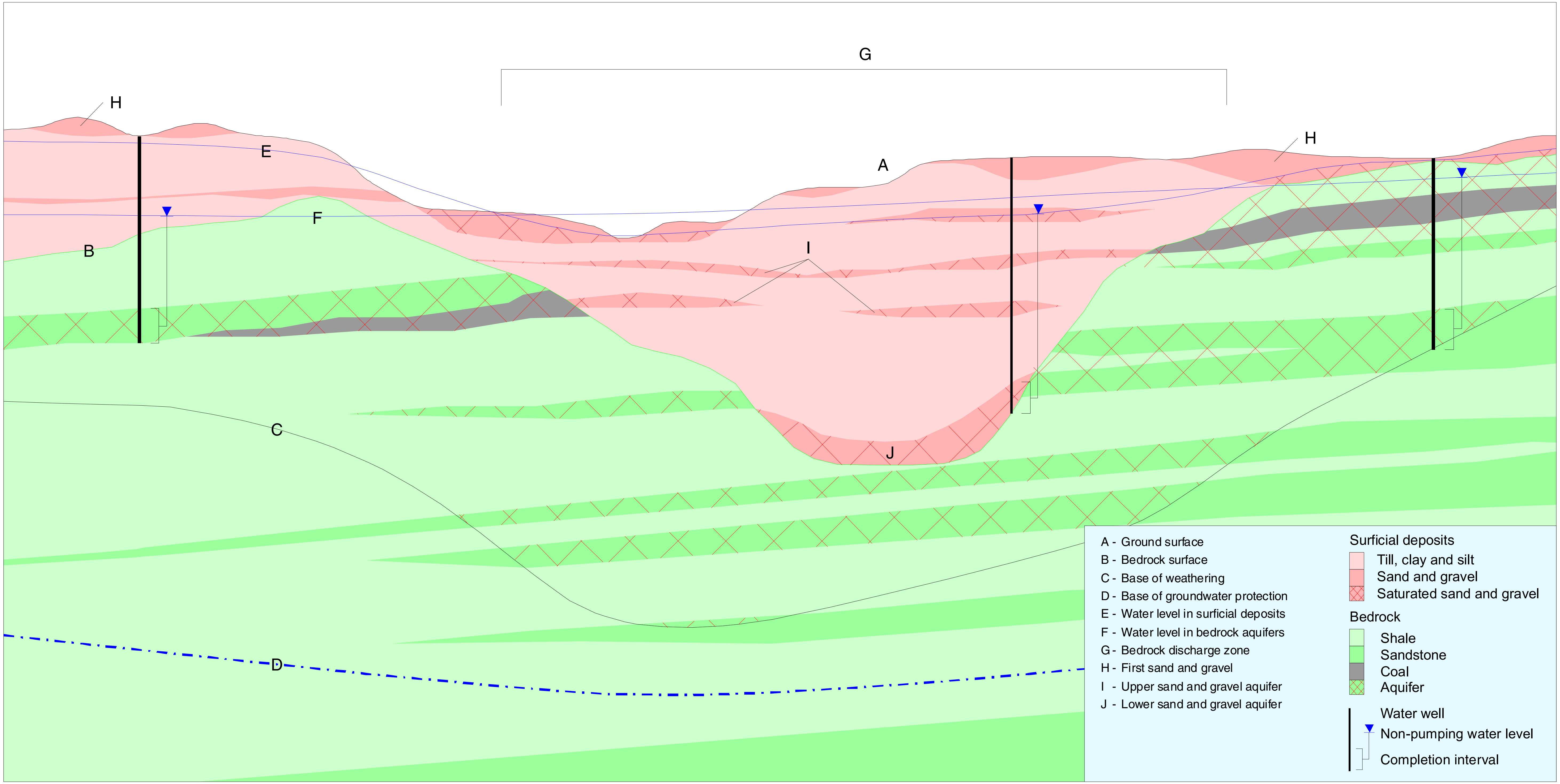
# Depth to Base of Groundwater Protection

*(modified after EUB, 1995)*

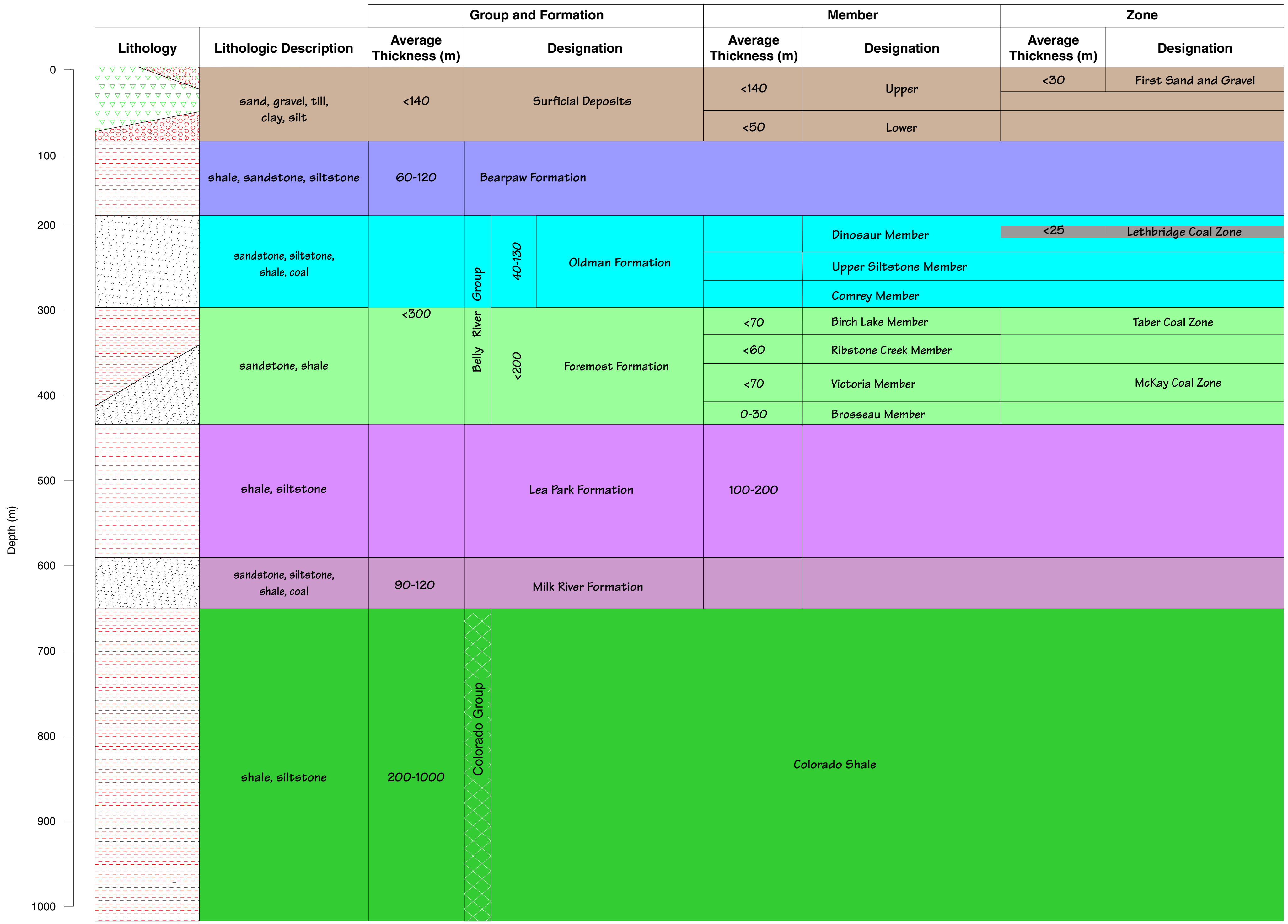


## *Generalized Cross-Section*

*(for terminology only)*

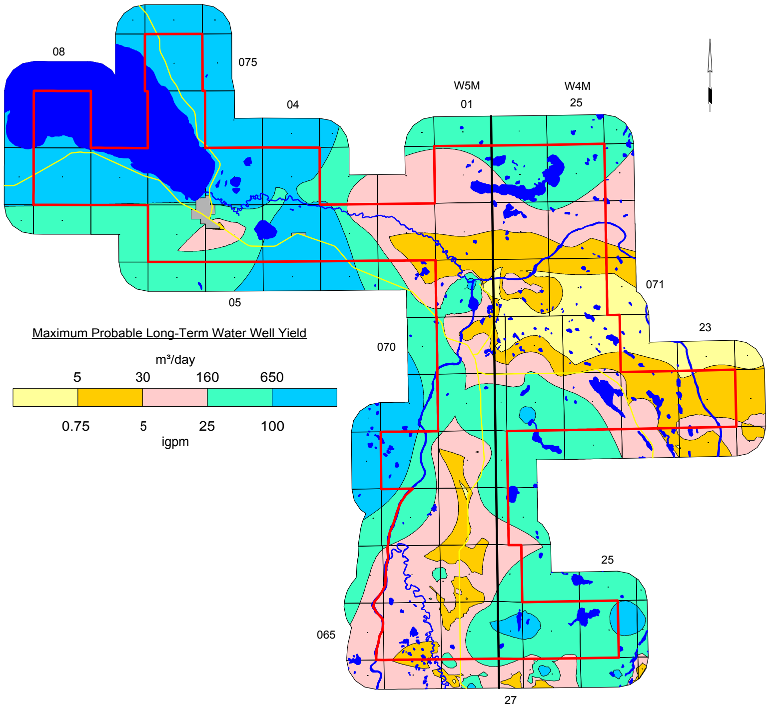


## Geologic Column

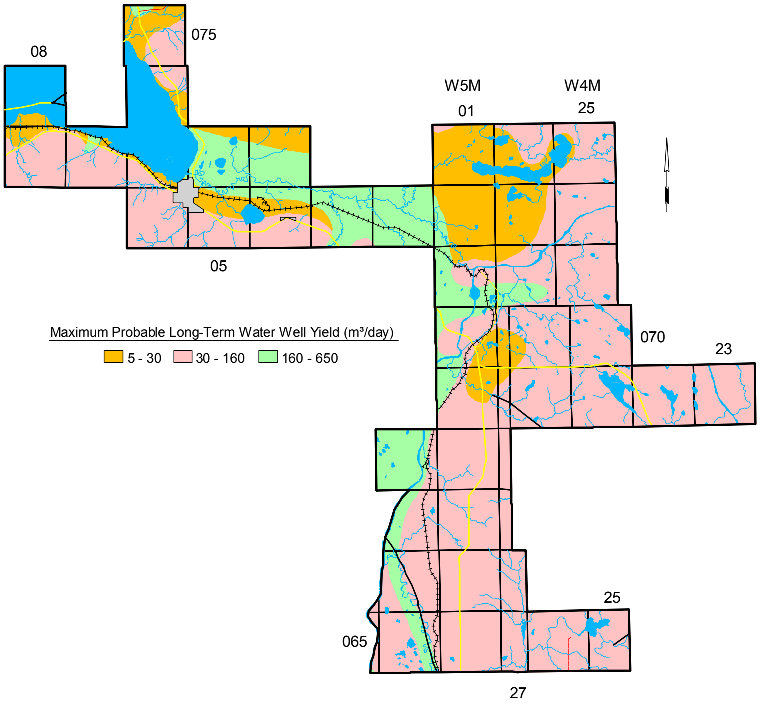


| Lithologic Description | Group and Formation | | | | Member | | Zone | |
|---|---|---|---|---|---|---|---|---|
| | Average Thickness (m) | Designation | | | Average Thickness (m) | Designation | Average Thickness (m) | Designation |
| sand, gravel, till, clay, silt | <140 | Surficial Deposits | | | <140 | Upper | <30 | First Sand and Gravel |
| | | | | | <50 | Lower | | |
| shale, sandstone, siltstone | 60-120 | Bearpaw Formation | | | | | | |
| sandstone, siltstone, shale, coal | <300 | Belly River Group | 40-130 | Oldman Formation | | Dinosaur Member | <25 | Lethbridge Coal Zone |
| | | | | | | Upper Siltstone Member | | |
| | | | | | | Comrey Member | | |
| sandstone, shale | | | <200 | Foremost Formation | <70 | Birch Lake Member | | Taber Coal Zone |
| | | | | | <60 | Ribstone Creek Member | | |
| | | | | | <70 | Victoria Member | | McKay Coal Zone |
| | | | | | 0-30 | Brosseau Member | | |
| shale, siltstone | | Lea Park Formation | | | 100-200 | | | |
| sandstone, siltstone, shale, coal | 90-120 | Milk River Formation | | | | | | |
| shale, siltstone | 200-1000 | Colorado Group | | Colorado Shale | | | | |

# Hydrogeological Maps

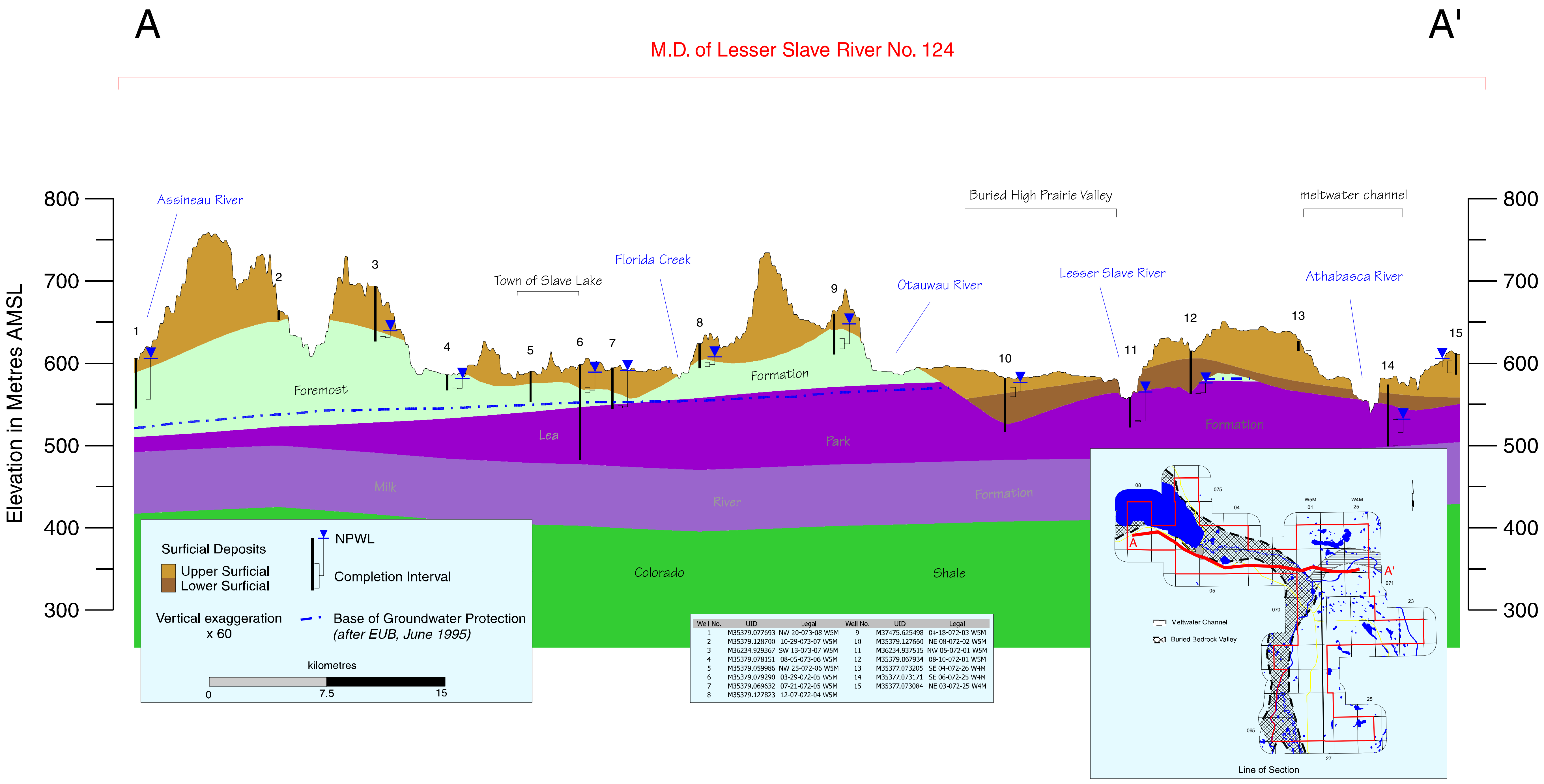


2003 Hydrogeological Consultants (HCL)



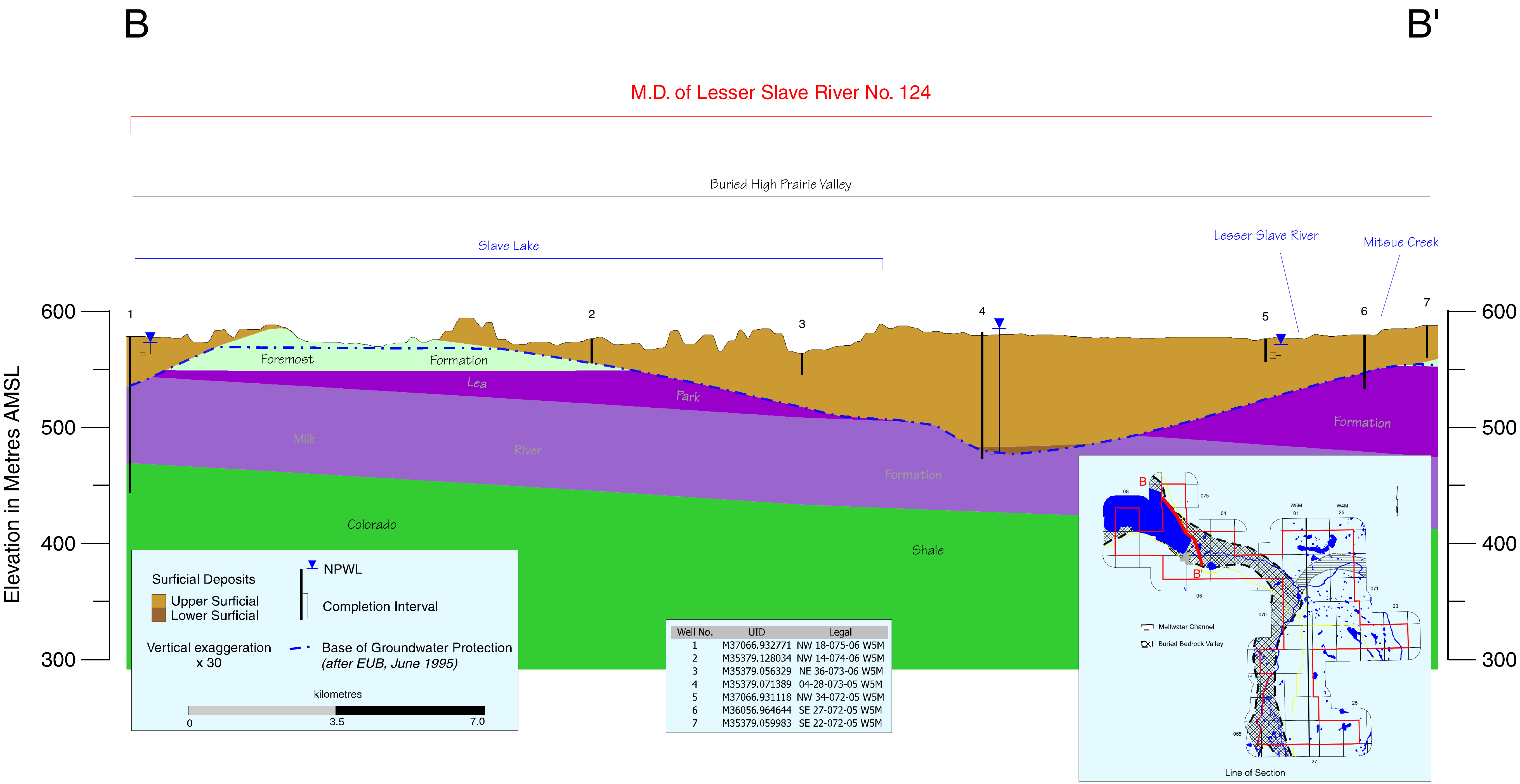
1973, 1977, 1980 Alberta Research Council

# Cross-Section A - A'



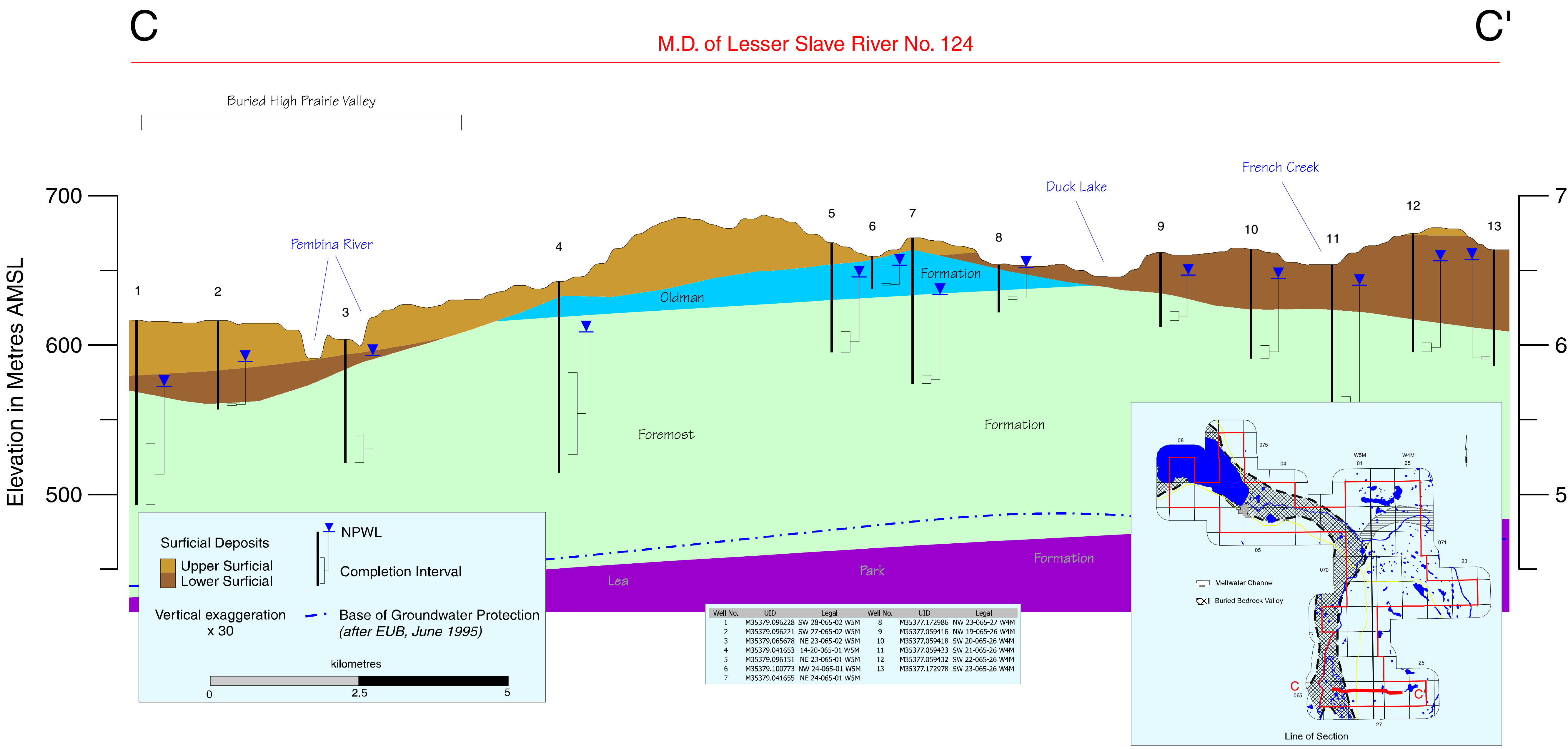
| Well No. | UID | Legal | Well No. | UID | Legal |
|---|---|---|---|---|---|
| 1 | M35379.077693 | NW 20-073-08 W5M | 9 | M37475.625498 | 04-18-072-03 W5M |
| 2 | M35379.128700 | 10-29-073-07 W5M | 10 | M35379.127660 | NE 08-072-02 W5M |
| 3 | M36234.929367 | SW 13-073-07 W5M | 11 | M36234.937515 | NW 05-072-01 W5M |
| 4 | M35379.078151 | 08-05-073-06 W5M | 12 | M35379.067934 | 08-10-072-01 W5M |
| 5 | M35379.059986 | NW 25-072-06 W5M | 13 | M35377.073205 | SE 04-072-26 W4M |
| 6 | M35379.079290 | 03-29-072-05 W5M | 14 | M35377.073171 | SE 06-072-25 W4M |
| 7 | M35379.069632 | 07-21-072-05 W5M | 15 | M35377.073084 | NE 03-072-25 W4M |
| 8 | M35379.127823 | 12-07-072-04 W5M | | | |

## Cross-Section B - B'



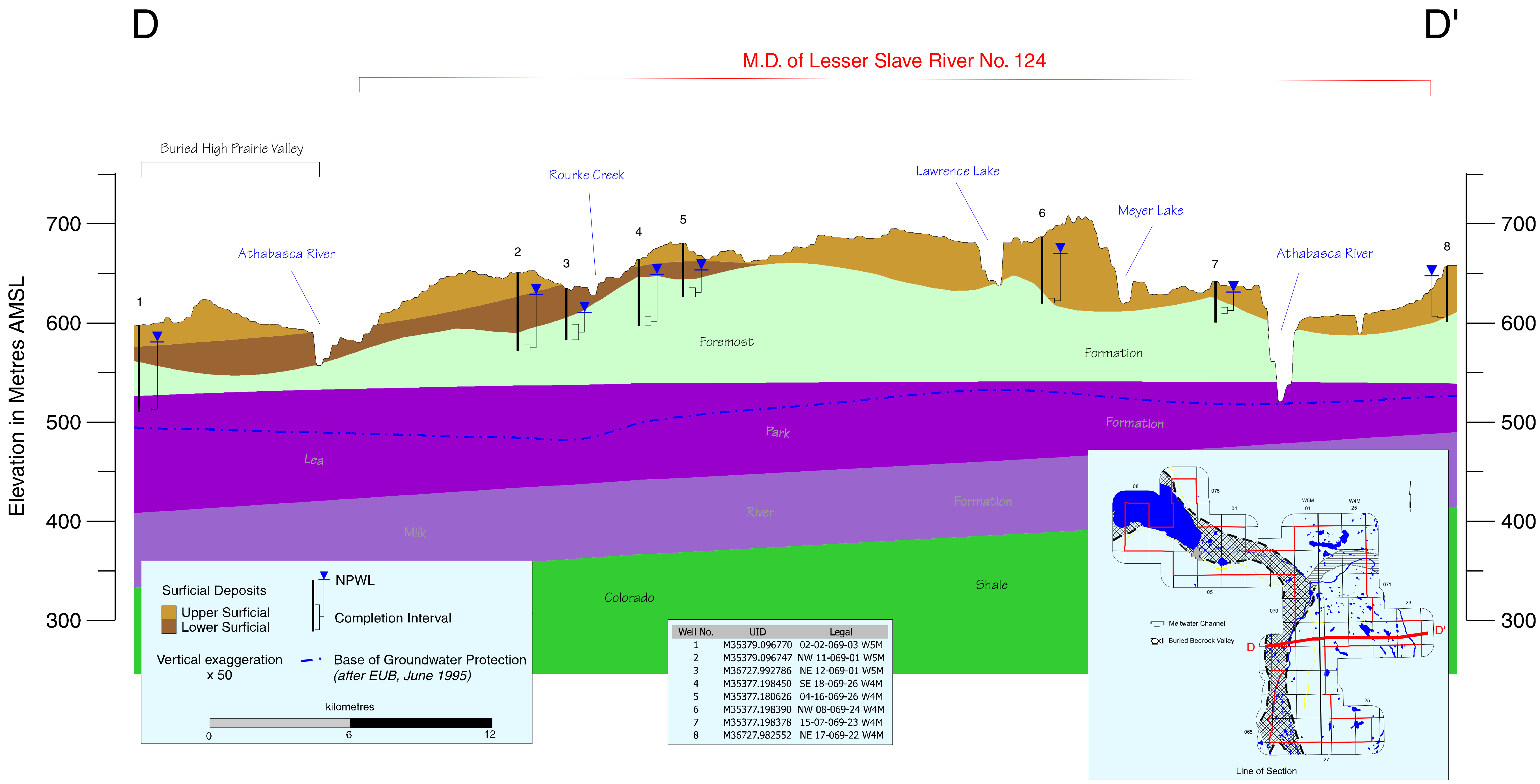
| Well No. | UID | Legal |
|---|---|---|
| 1 | M37066.932771 | NW 18-075-06 W5M |
| 2 | M35379.128034 | NW 14-074-06 W5M |
| 3 | M35379.056329 | NE 36-073-06 W5M |
| 4 | M35379.071389 | 04-28-073-05 W5M |
| 5 | M37066.931118 | NW 34-072-05 W5M |
| 6 | M36056.964644 | SE 27-072-05 W5M |
| 7 | M35379.059983 | SE 22-072-05 W5M |

## Cross-Section C - C'



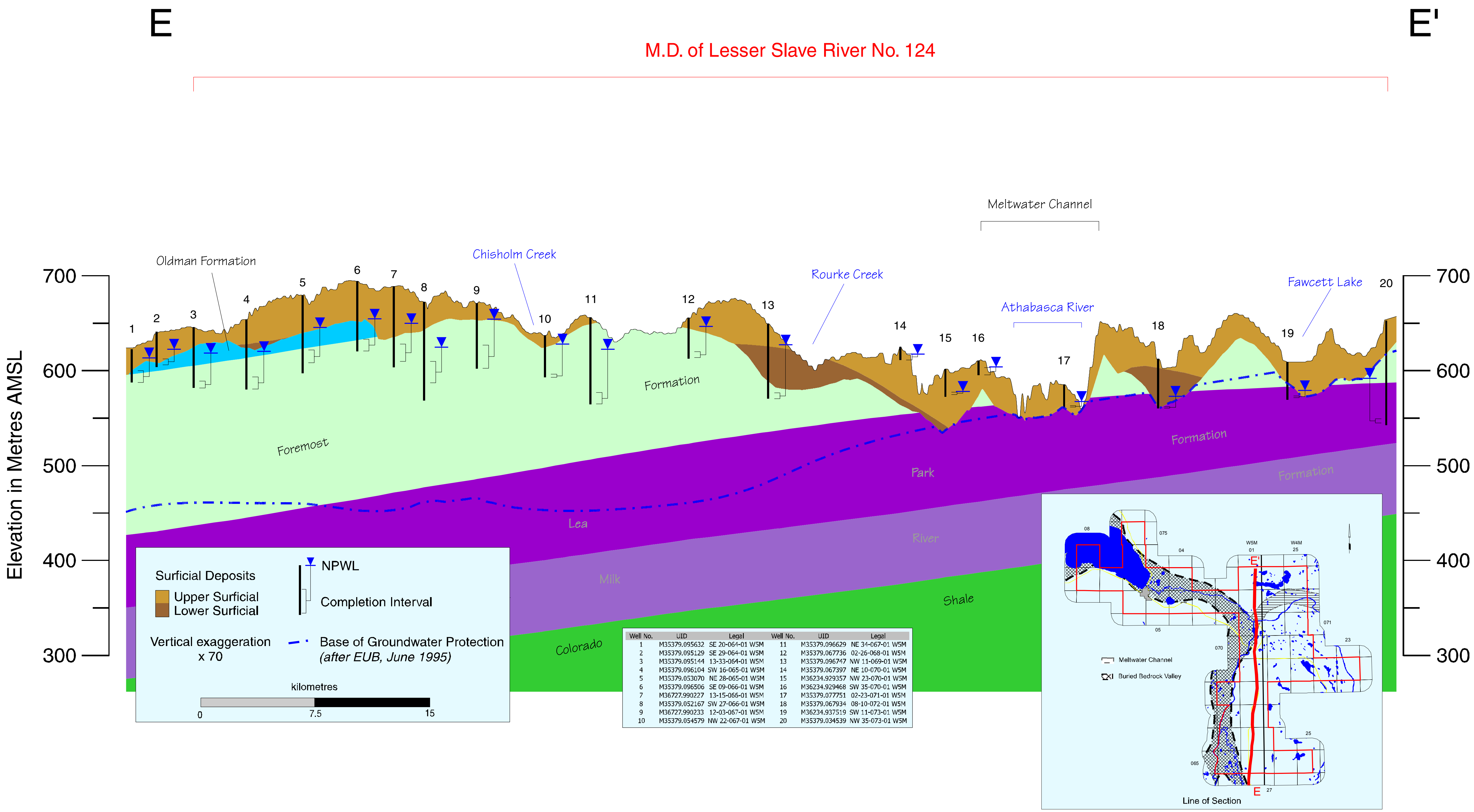
| Well No. | UID | Legal | Well No. | UID | Legal |
|---|---|---|---|---|---|
| 1 | M35379.096228 | SW 28-065-02 W5M | 8 | M35377.172986 | NW 23-065-27 W4M |
| 2 | M35379.096221 | SW 27-065-02 W5M | 9 | M35377.059416 | NW 19-065-26 W4M |
| 3 | M35379.065678 | NE 23-065-02 W5M | 10 | M35377.059418 | SW 20-065-26 W4M |
| 4 | M35379.041653 | 14-20-065-01 W5M | 11 | M35377.059423 | SW 21-065-26 W4M |
| 5 | M35379.096151 | NE 23-065-01 W5M | 12 | M35377.059432 | SW 22-065-26 W4M |
| 6 | M35379.100773 | NW 24-065-01 W5M | 13 | M35377.172978 | SW 23-065-26 W4M |
| 7 | M35379.041655 | NE 24-065-01 W5M | | | |

## Cross-Section D - D'



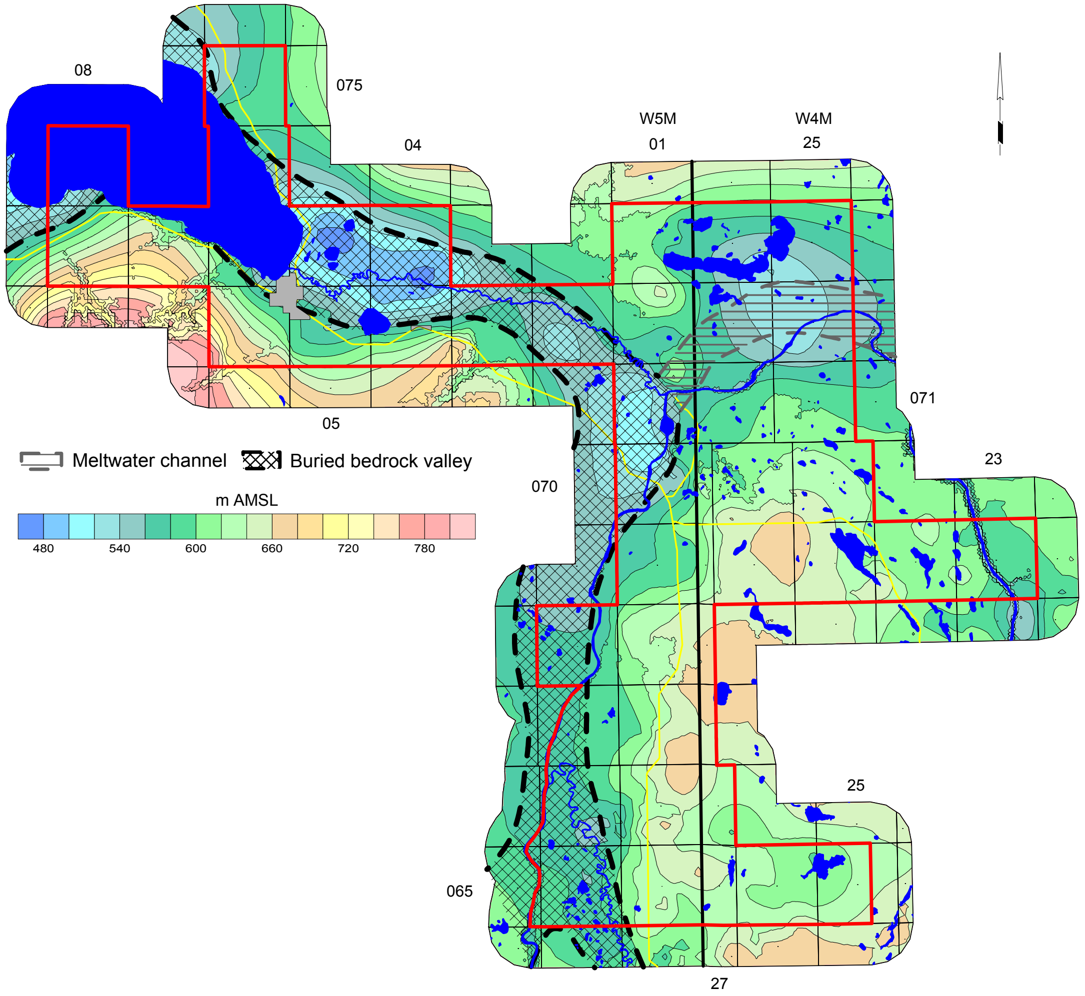
| Well No. | UID | Legal |
|---|---|---|
| 1 | M35379.096770 | 02-02-069-03 W5M |
| 2 | M35379.096747 | NW 11-069-01 W5M |
| 3 | M36727.992786 | NE 12-069-01 W5M |
| 4 | M35377.198450 | SE 18-069-26 W4M |
| 5 | M35377.180626 | 04-16-069-26 W4M |
| 6 | M35377.198390 | NW 08-069-24 W4M |
| 7 | M35377.198378 | 15-07-069-23 W4M |
| 8 | M36727.982552 | NE 17-069-22 W4M |

## Cross-Section E - E'

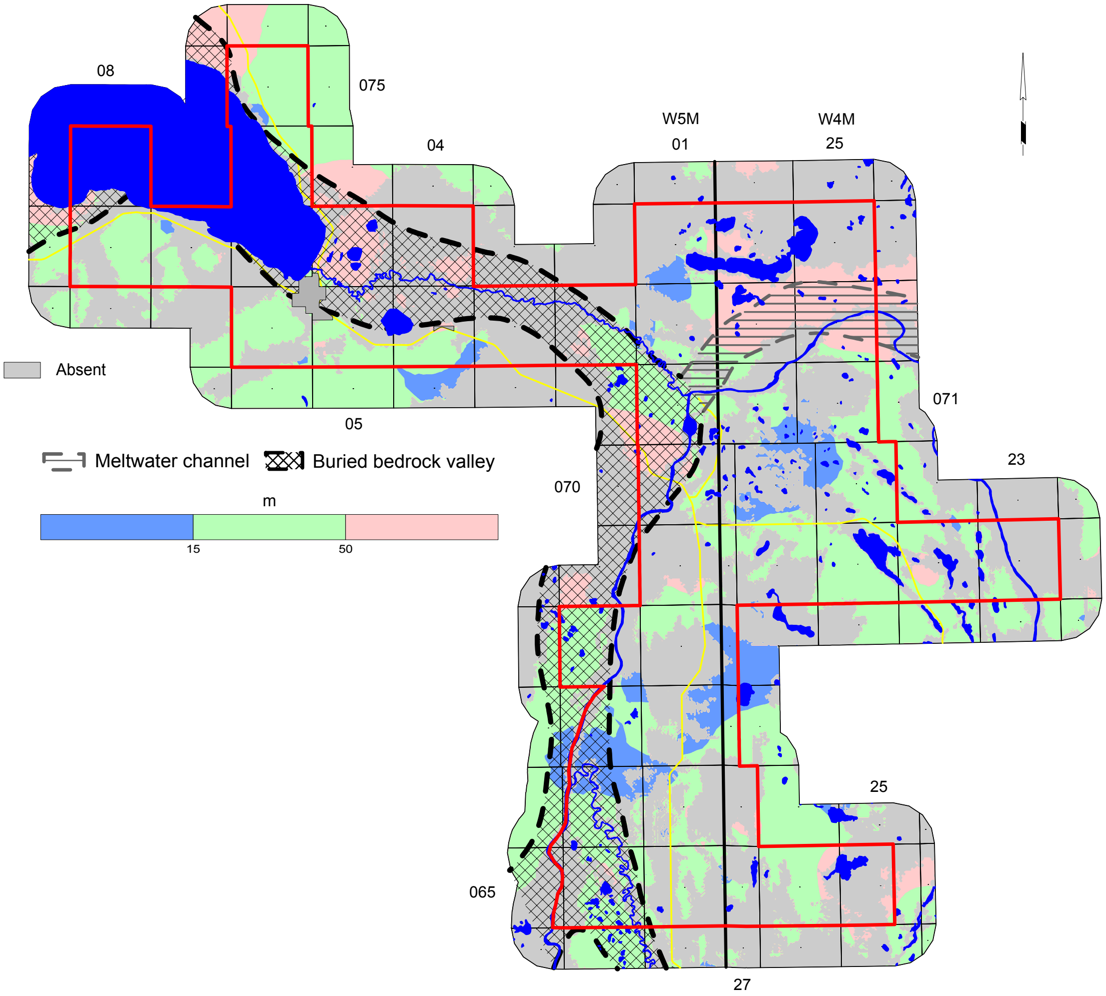


| Well No. | UID | Legal | Well No. | UID | Legal |
|---|---|---|---|---|---|
| 1 | M35379.095632 | SE 20-064-01 W5M | 11 | M35379.096629 | NE 34-067-01 W5M |
| 2 | M35379.095129 | SE 29-064-01 W5M | 12 | M35379.067736 | 02-26-068-01 W5M |
| 3 | M35379.095144 | 13-33-064-01 W5M | 13 | M35379.096747 | NW 11-069-01 W5M |
| 4 | M35379.096104 | SW 16-065-01 W5M | 14 | M35379.067397 | NE 10-070-01 W5M |
| 5 | M35379.053070 | NE 28-065-01 W5M | 15 | M36234.929357 | NW 23-070-01 W5M |
| 6 | M35379.096506 | SE 09-066-01 W5M | 16 | M36234.929468 | SW 35-070-01 W5M |
| 7 | M36727.990227 | 13-15-066-01 W5M | 17 | M35379.077751 | 02-23-071-01 W5M |
| 8 | M35379.052167 | SW 27-066-01 W5M | 18 | M35379.067934 | 08-10-072-01 W5M |
| 9 | M36727.990233 | 12-03-067-01 W5M | 19 | M36234.937519 | SW 11-073-01 W5M |
| 10 | M35379.054579 | NW 22-067-01 W5M | 20 | M35379.034539 | NW 35-073-01 W5M |

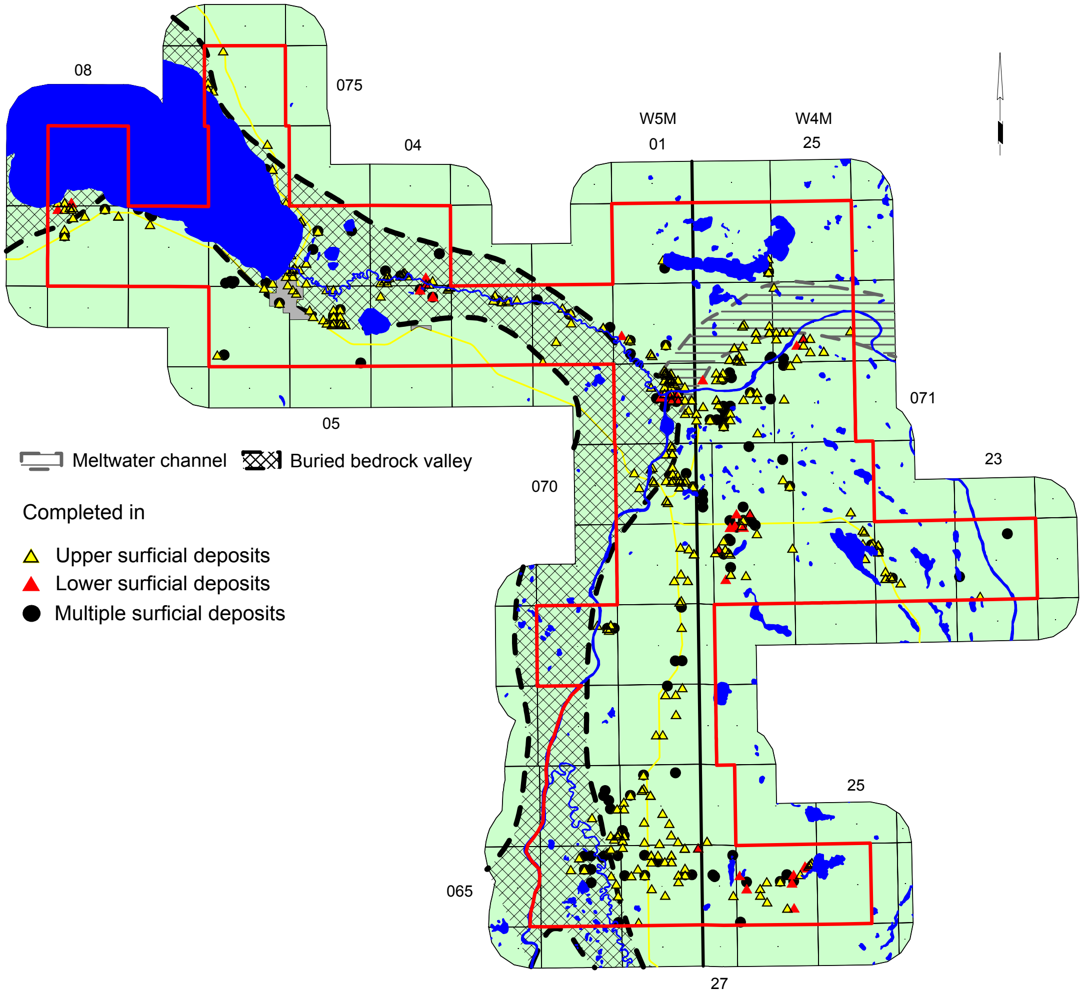
# Bedrock Topography



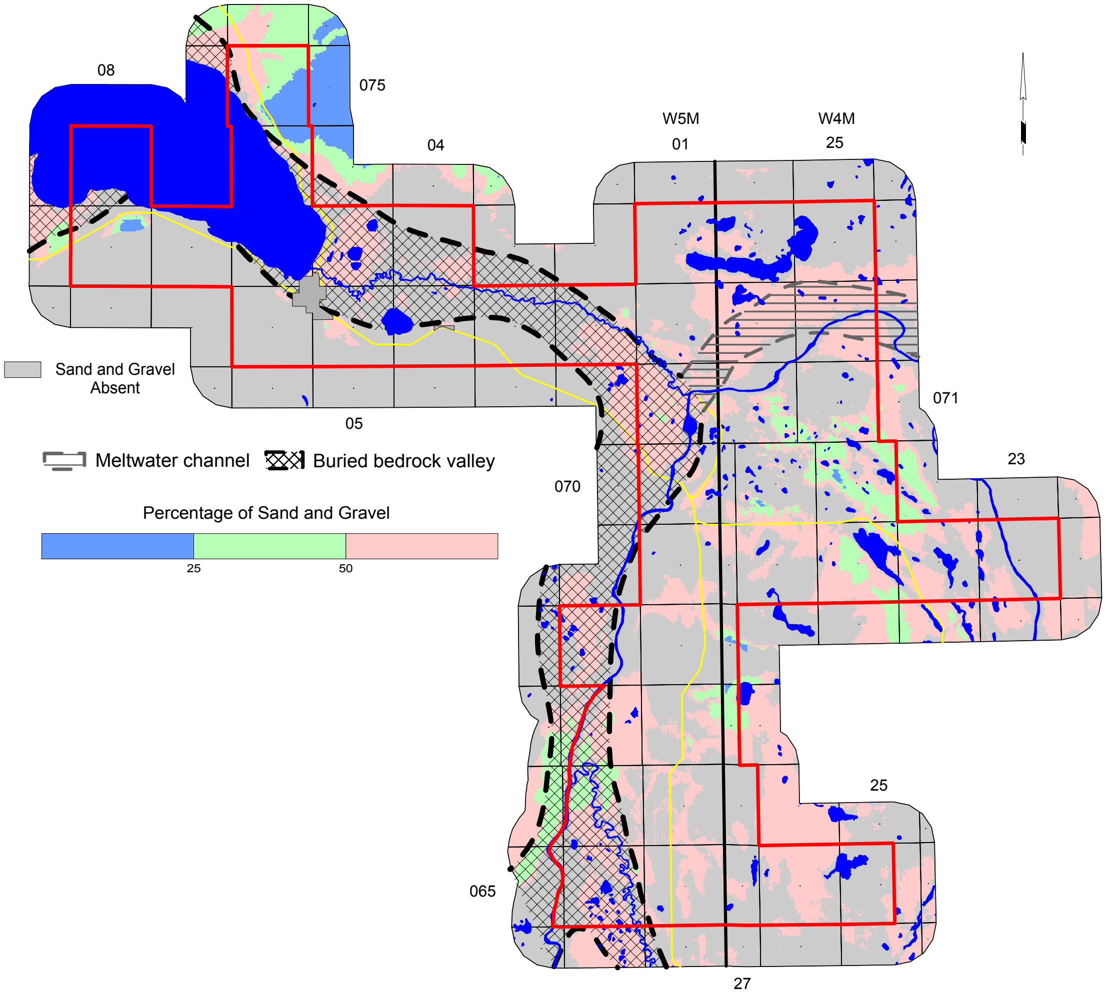
# Thickness of Sand and Gravel Deposits



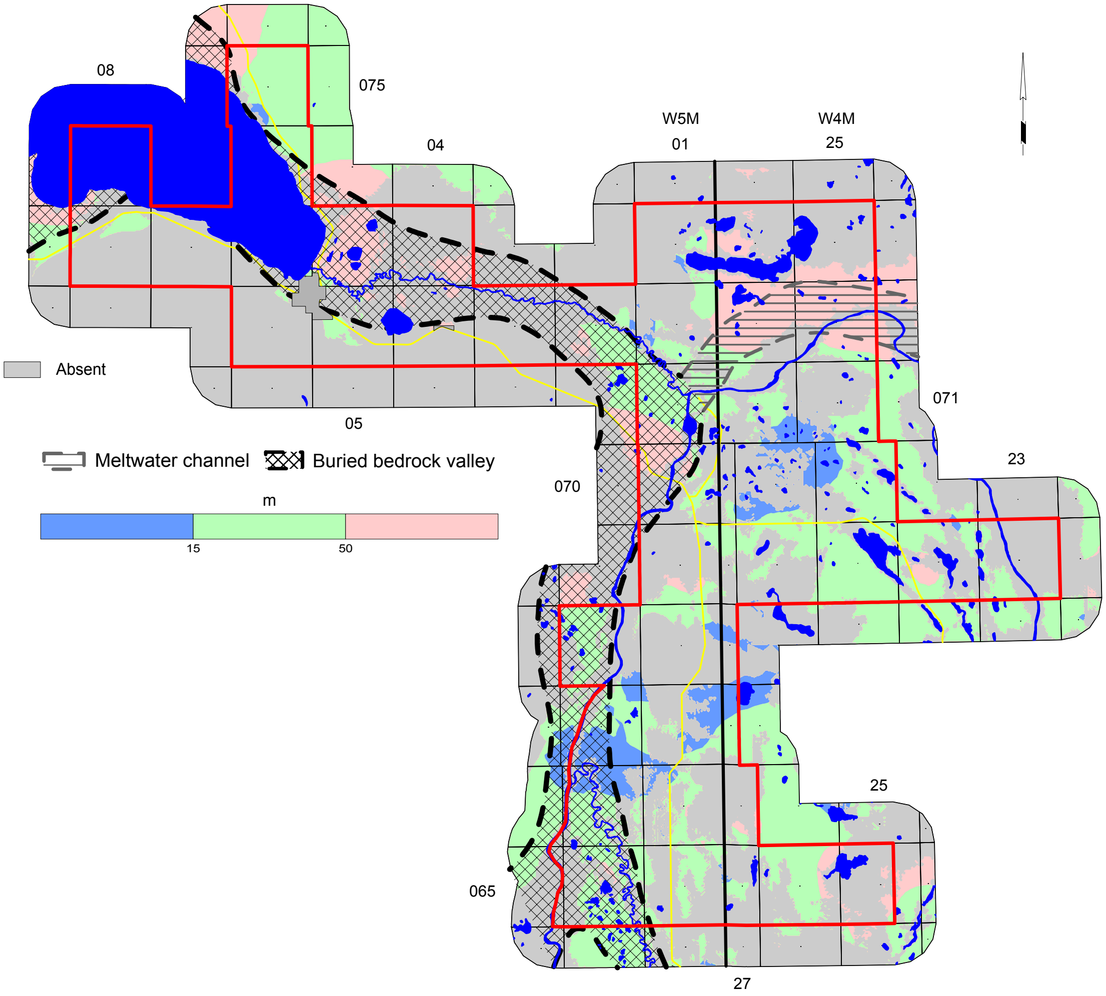
# Water Wells Completed In Surficial Deposits



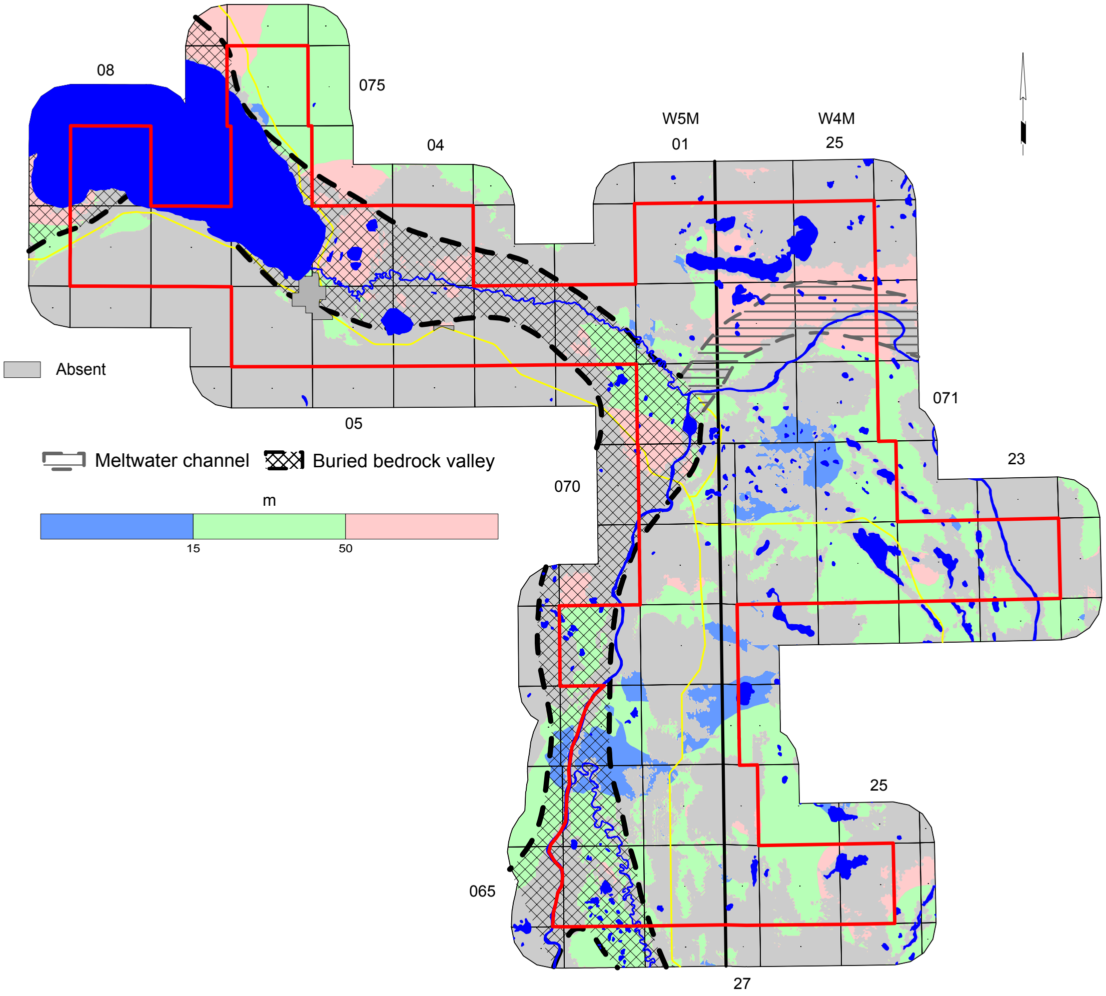
# Amount of Sand and Gravel in Surficial Deposits



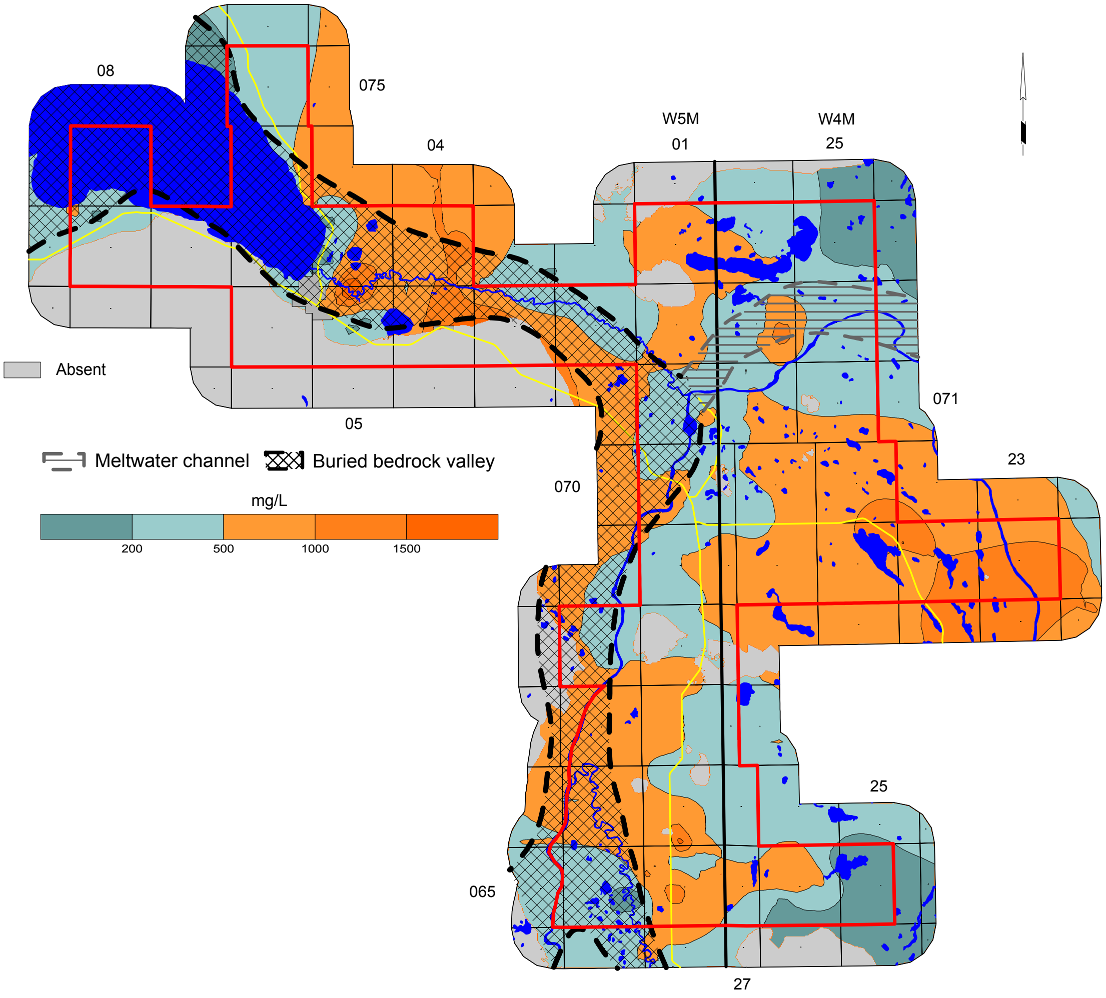
# Thickness of Sand and Gravel Aquifer(s)



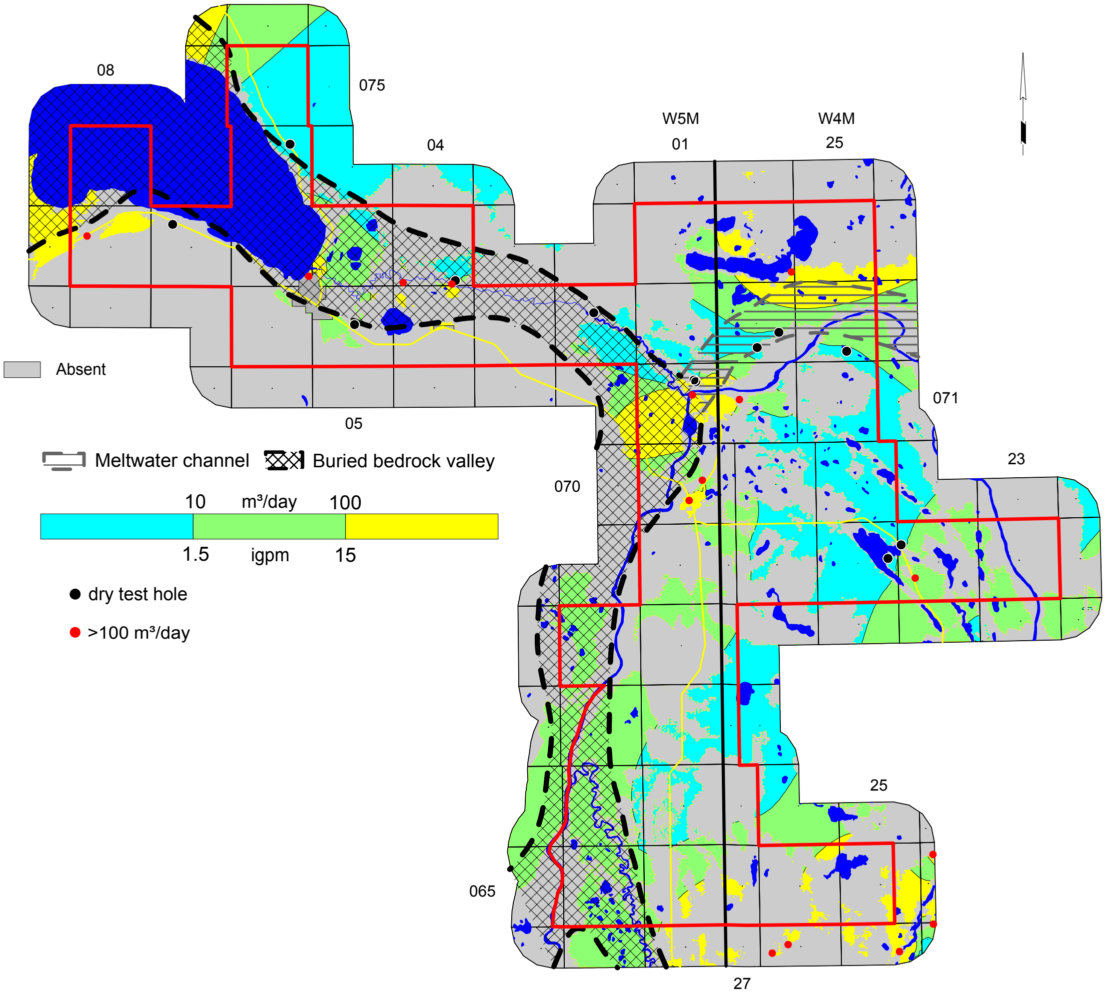
# Apparent Yield of Water Wells Completed in Sand and Gravel Aquifer(s)



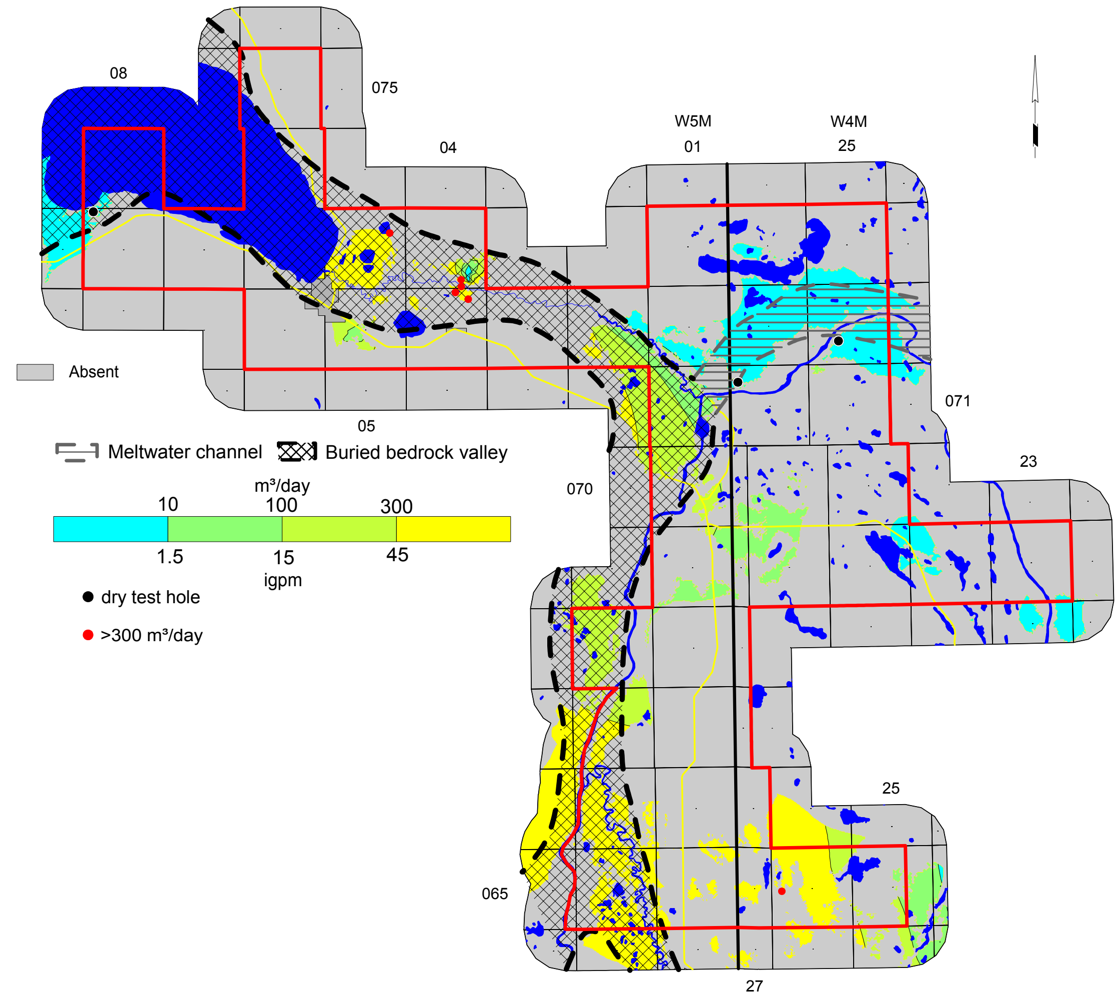
# *Total Dissolved Solids in Groundwater from Surficial Deposits*



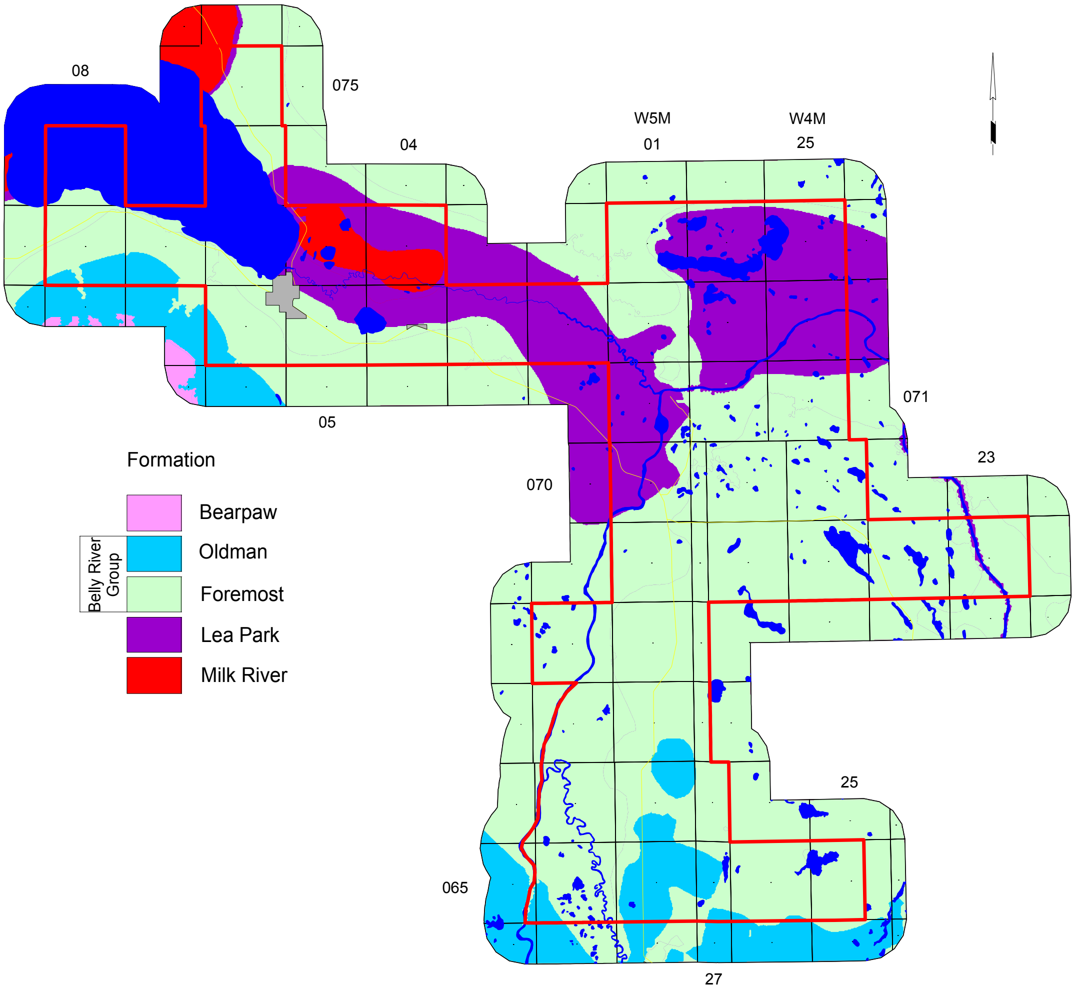
# Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer



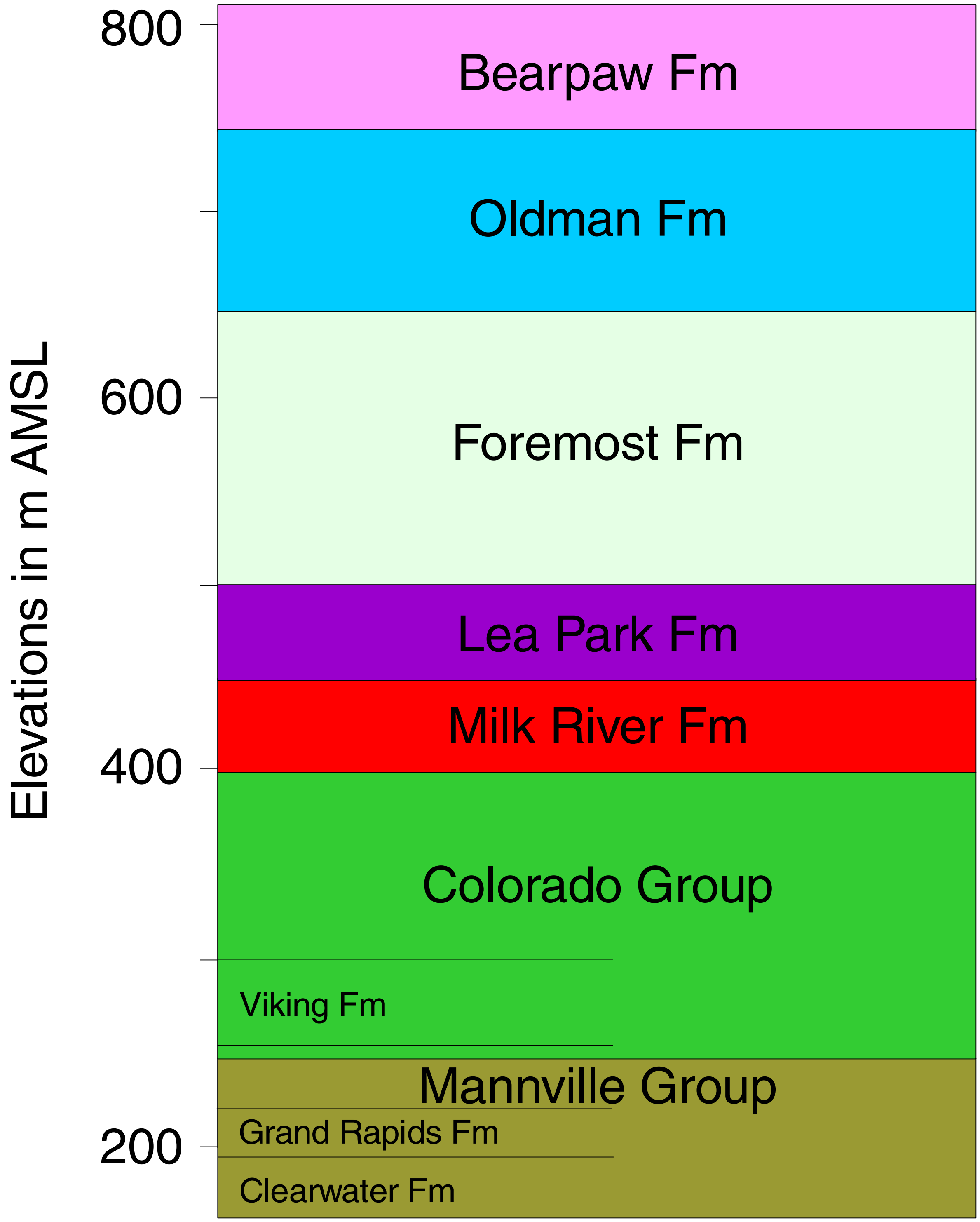
## *Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer*



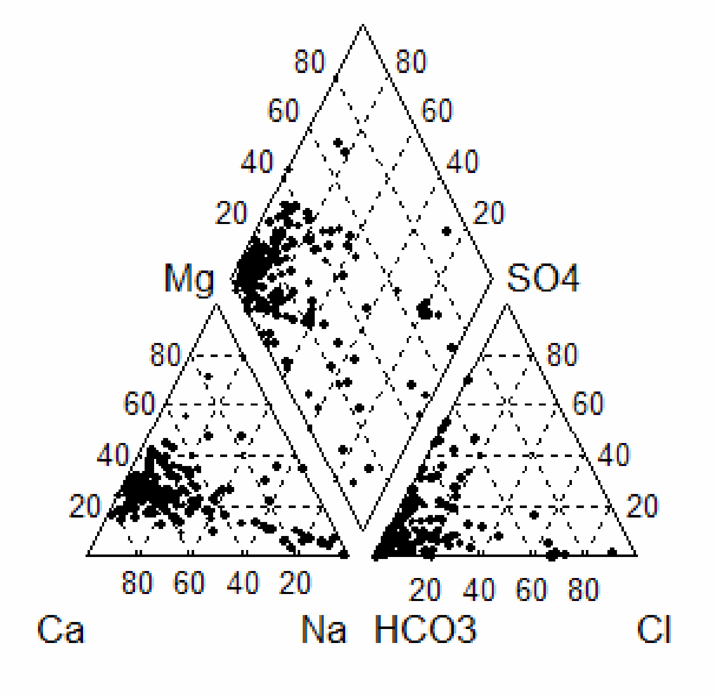
# Bedrock Geology



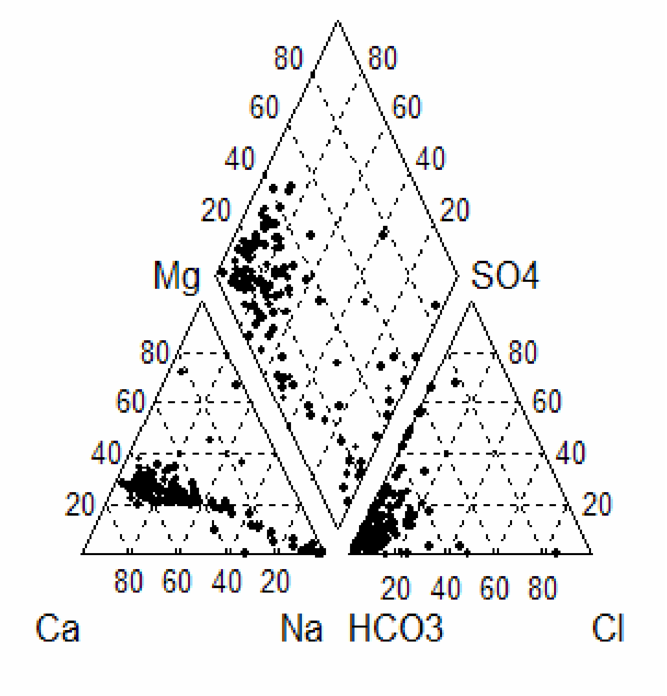
## Stratigraphic Section



# Piper Diagrams

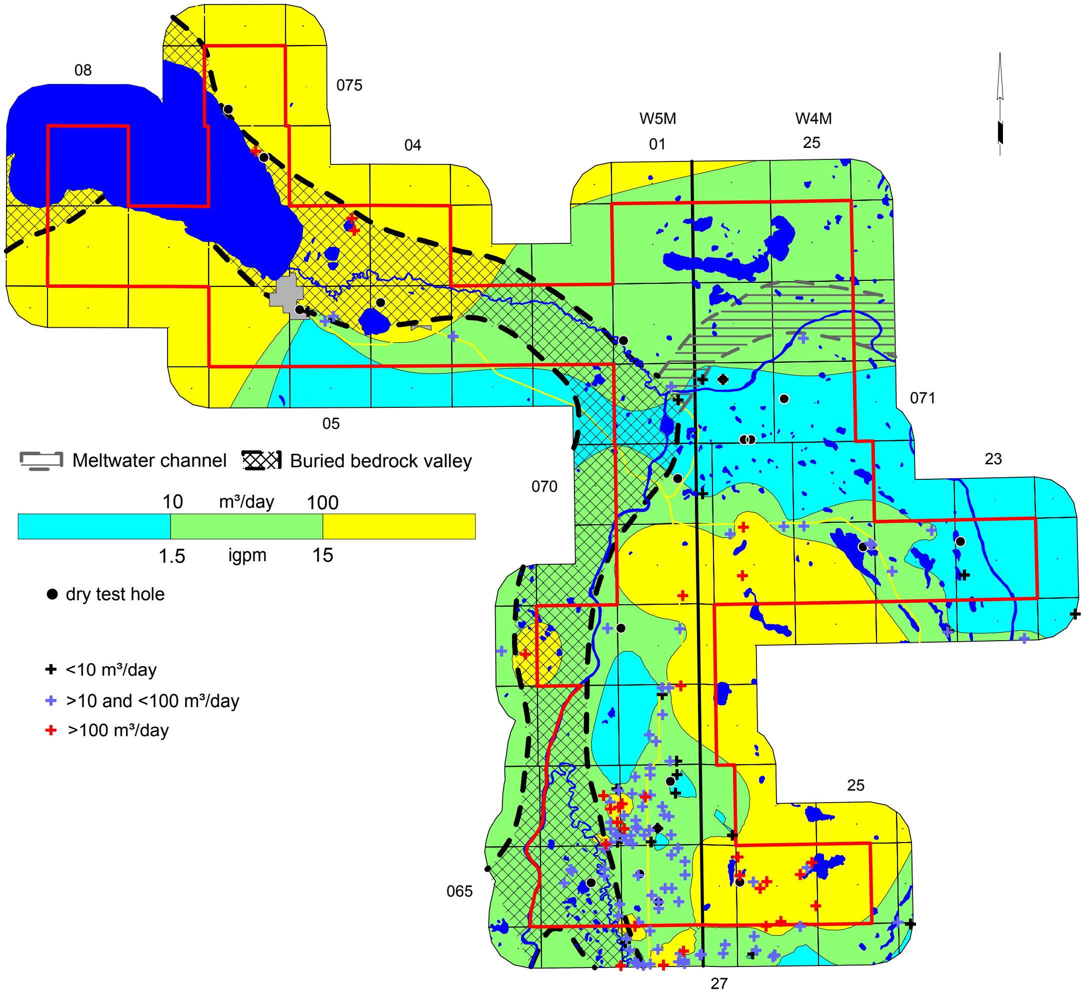


*Surficial Deposits*

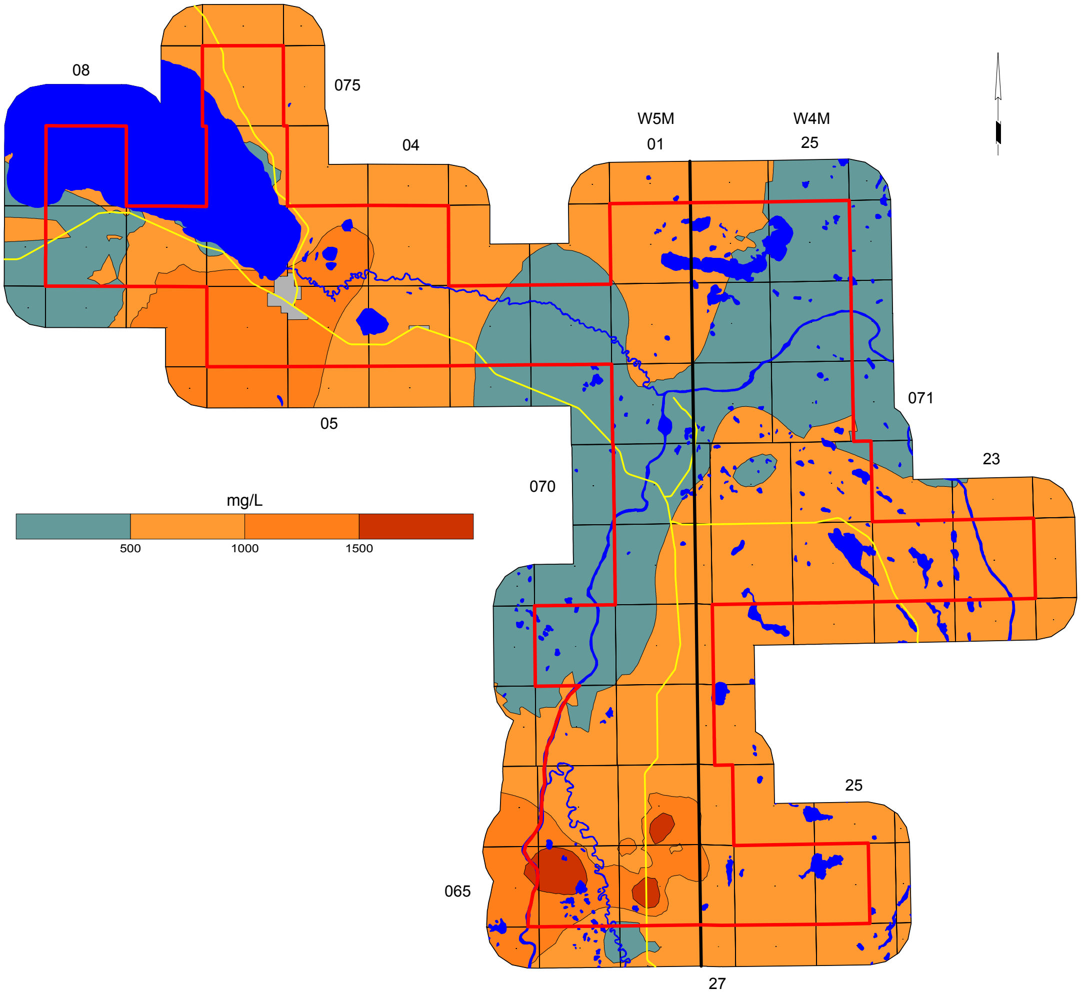


*Bedrock Aquifers*

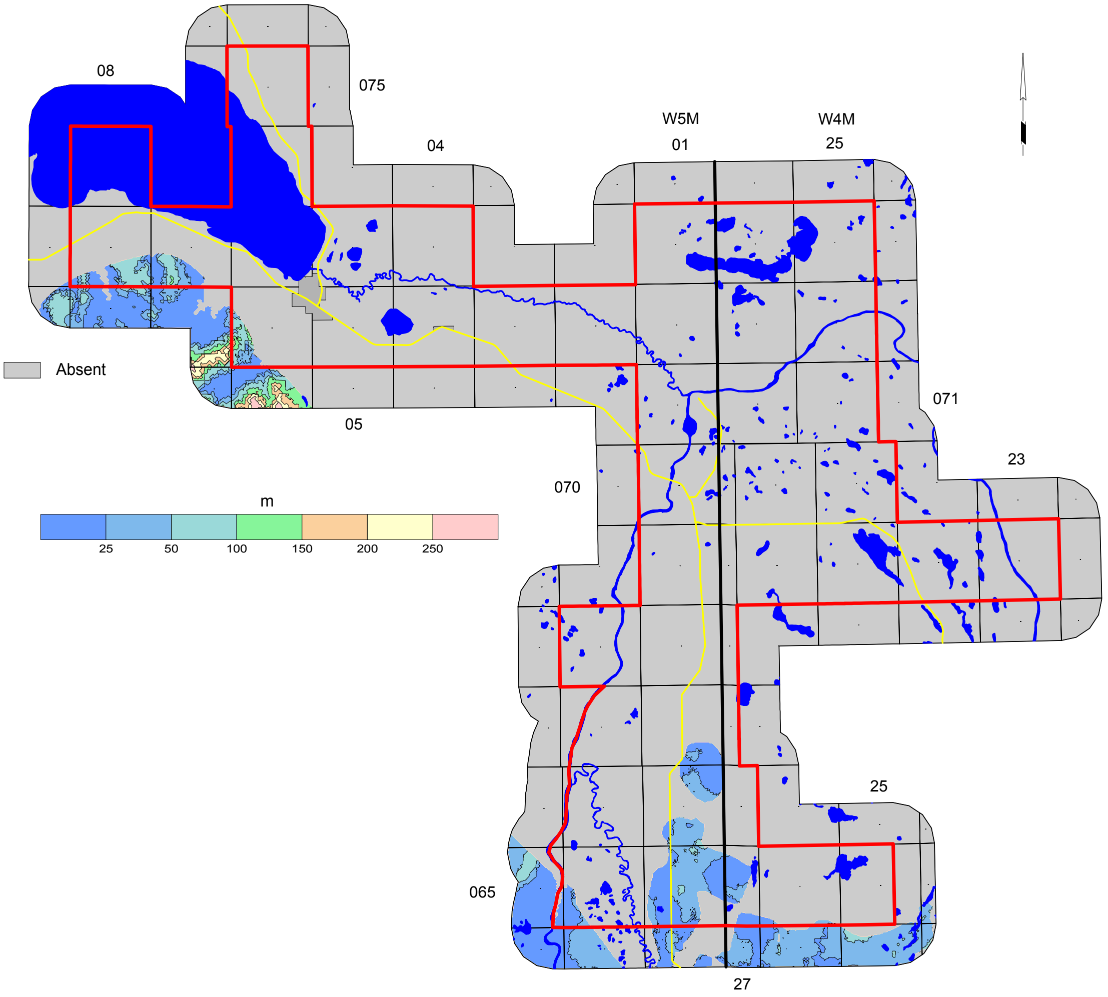
# Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)



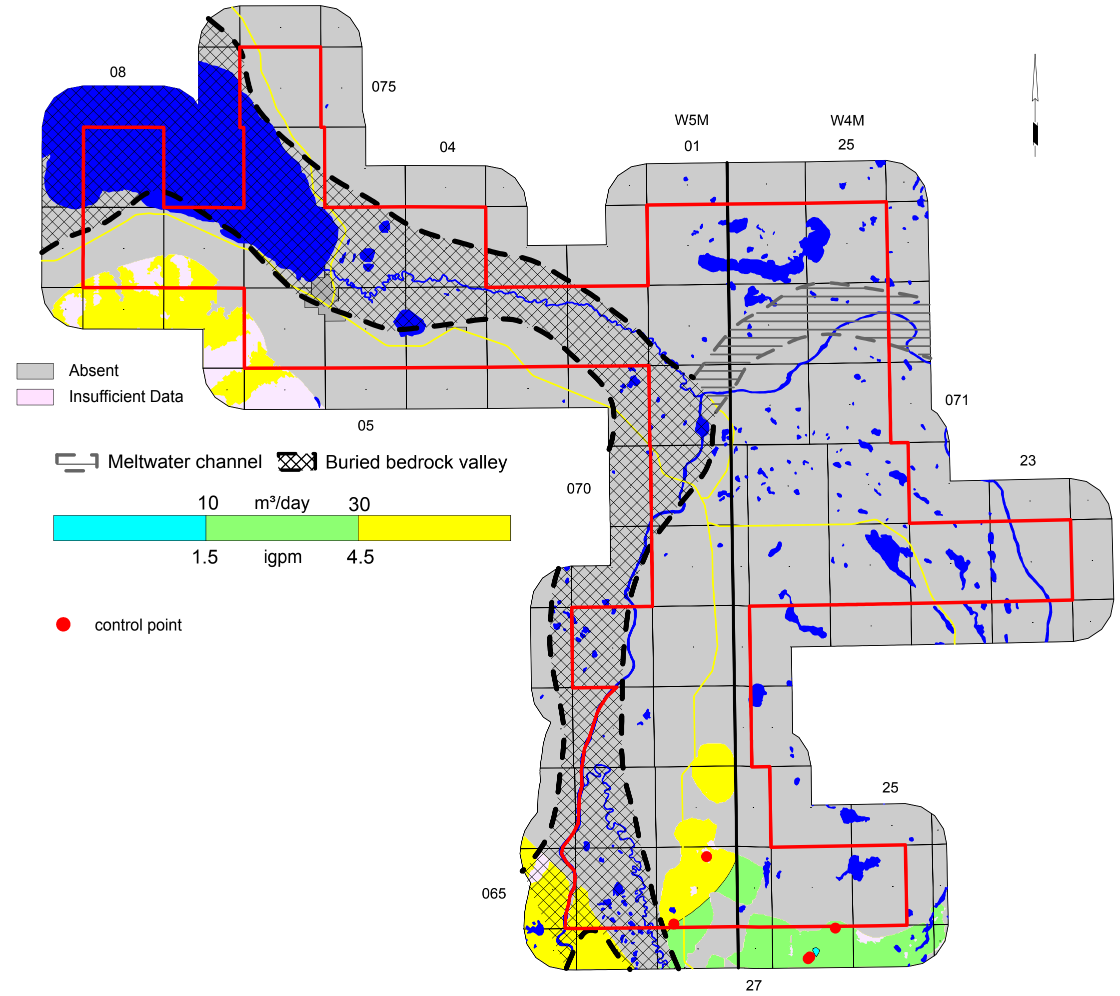
## Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)



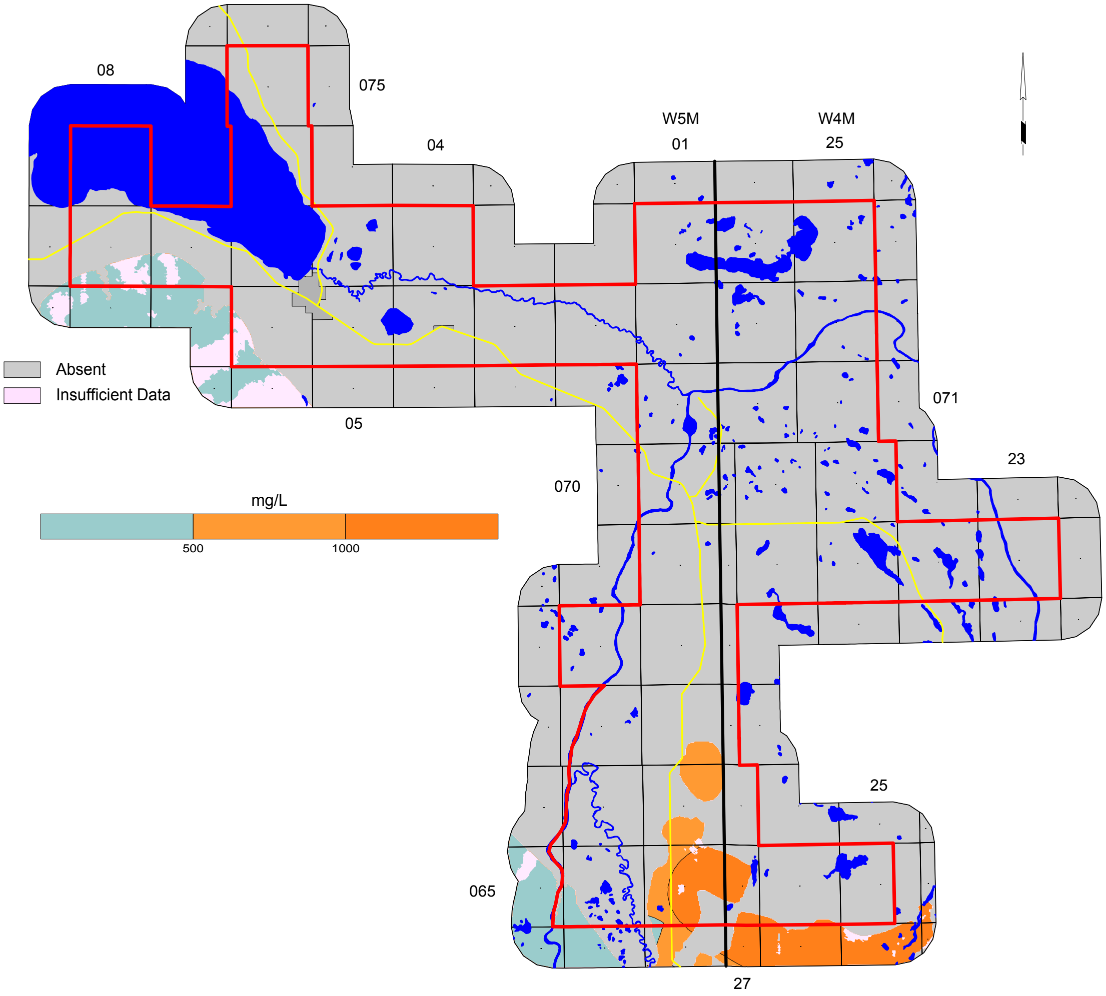
# *Depth to Top of Oldman Formation*



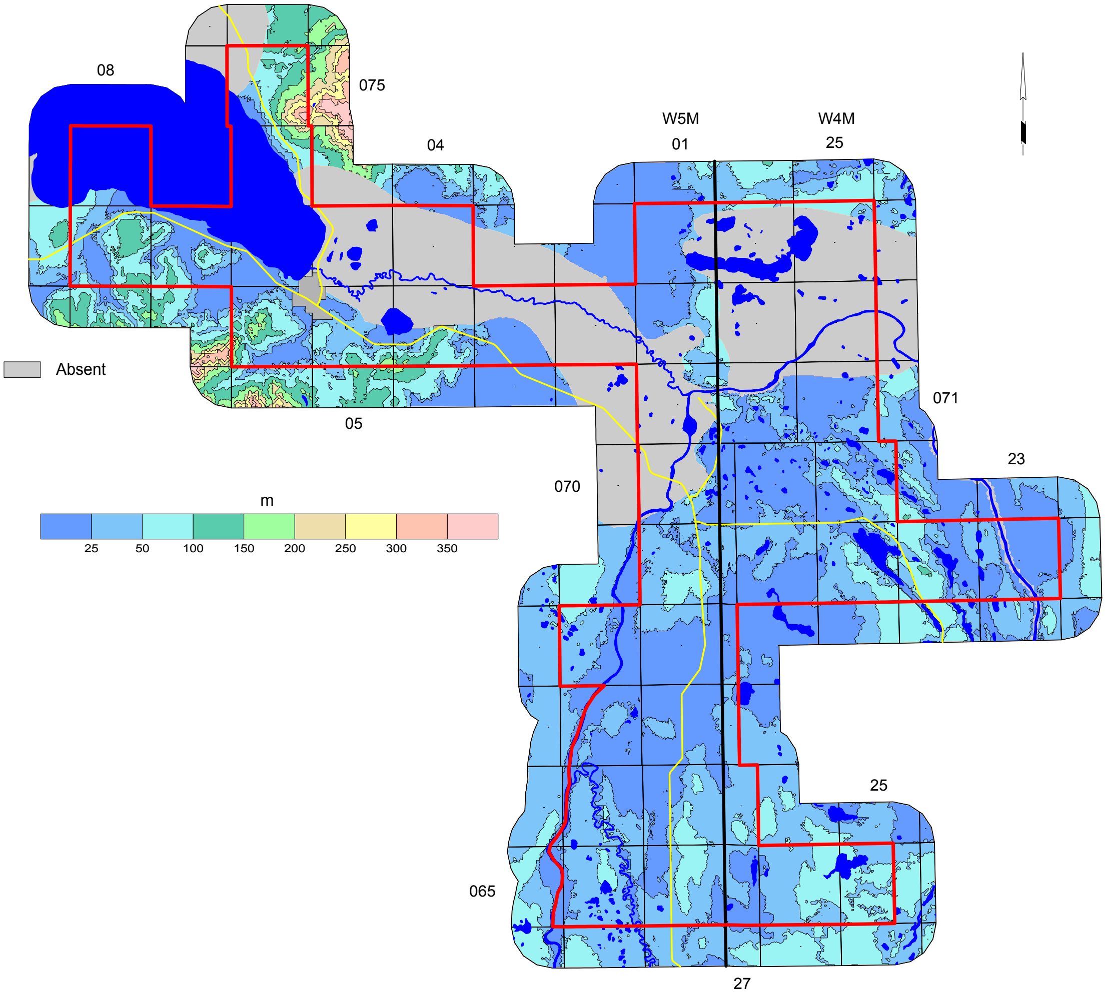
# Apparent Yield for Water Wells Completed through Oldman Aquifer



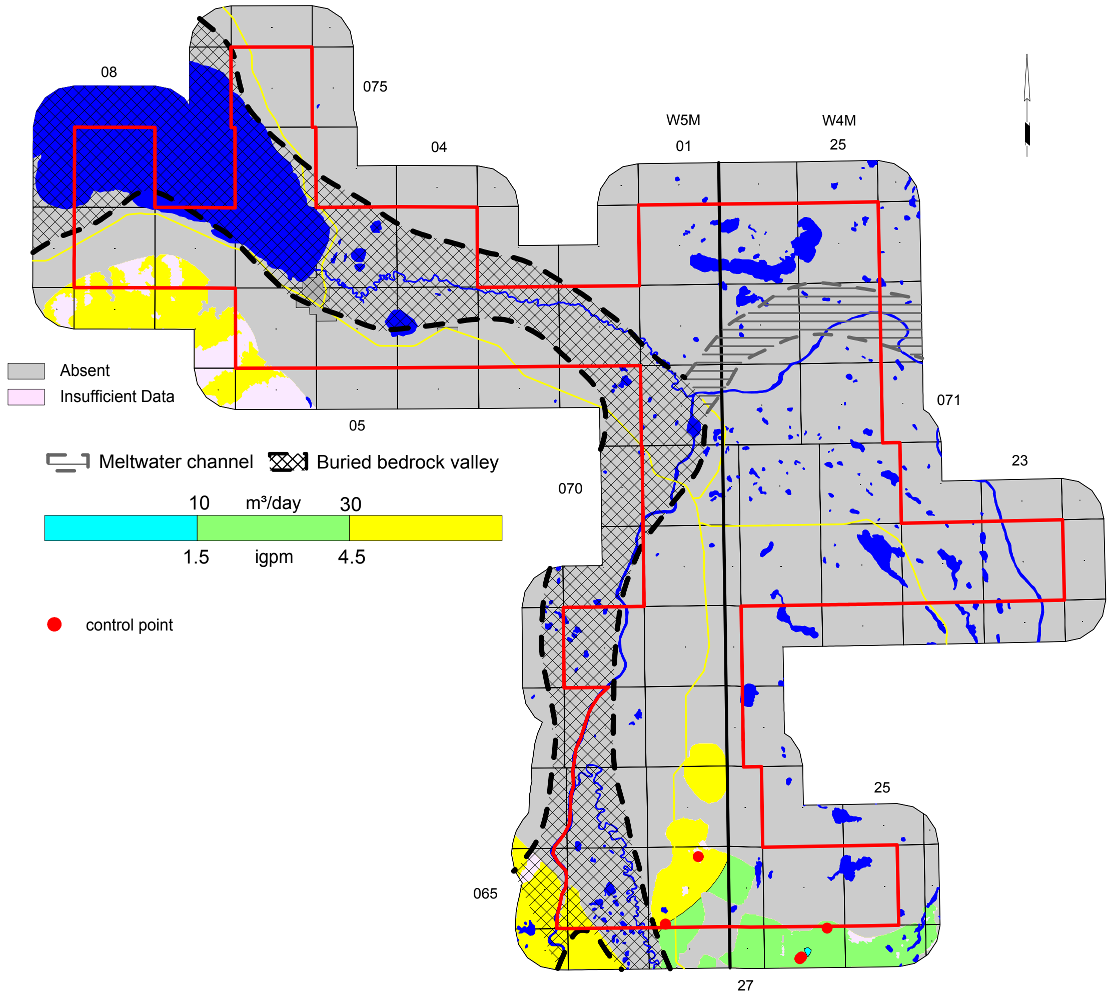
# Total Dissolved Solids in Groundwater from Oldman Aquifer



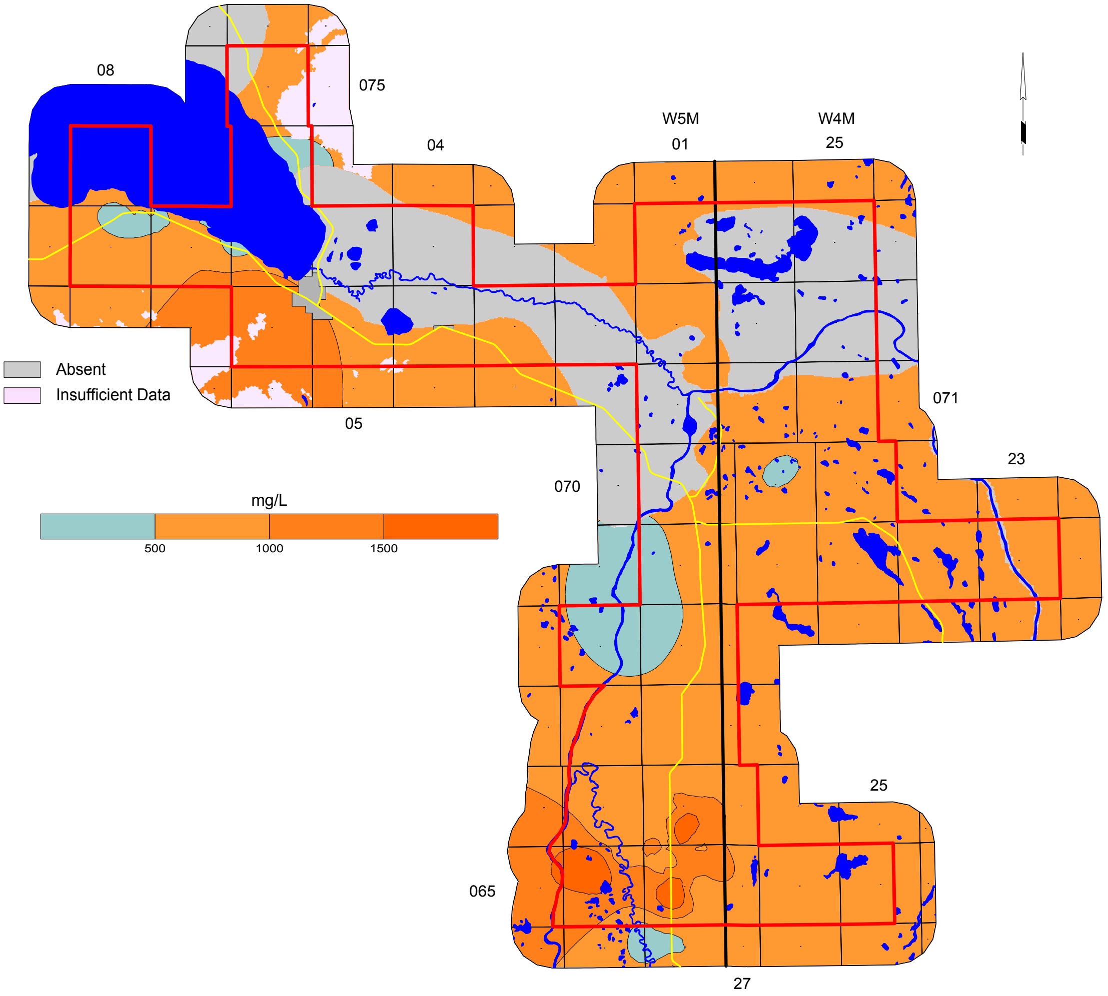
# Depth to Top of Foremost Formation



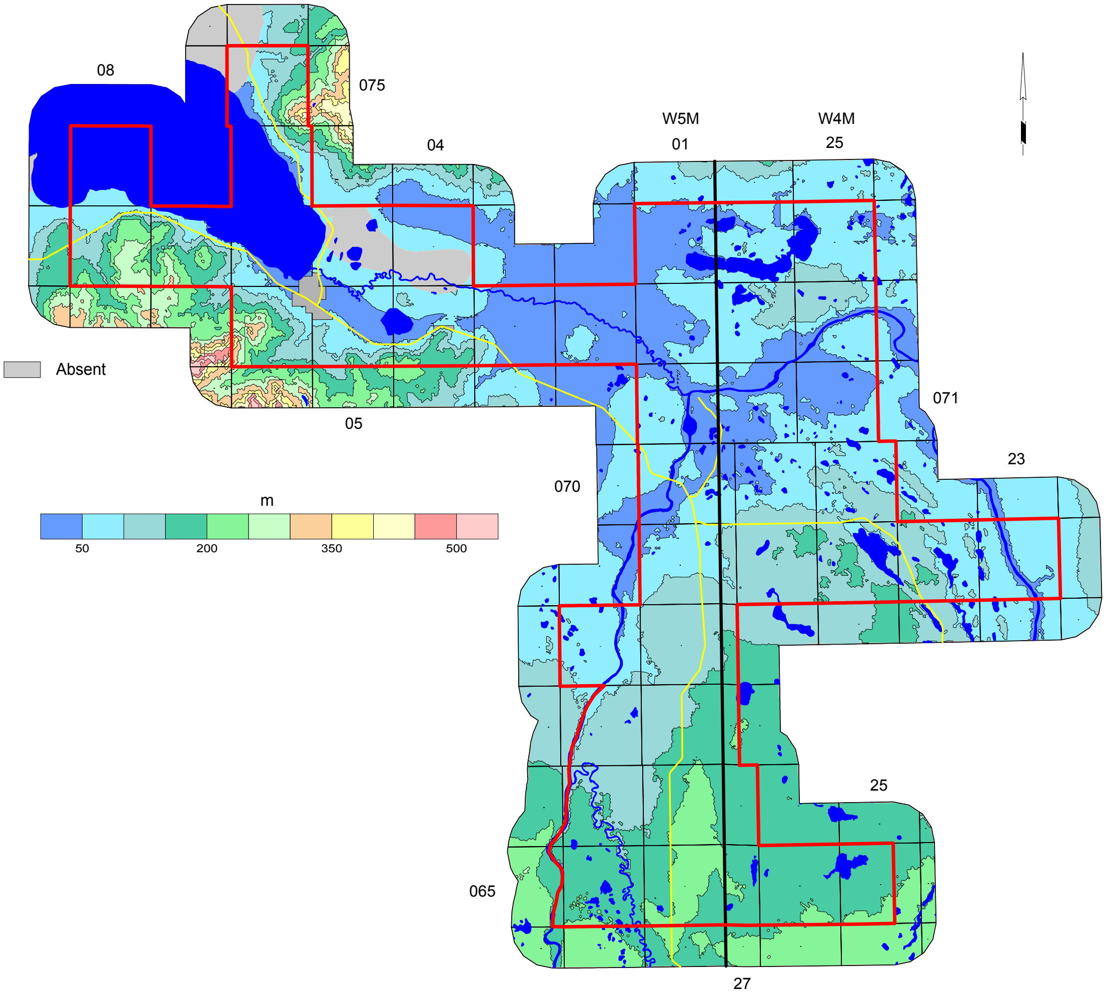
# Apparent Yield for Water Wells Completed through Foremost Aquifer



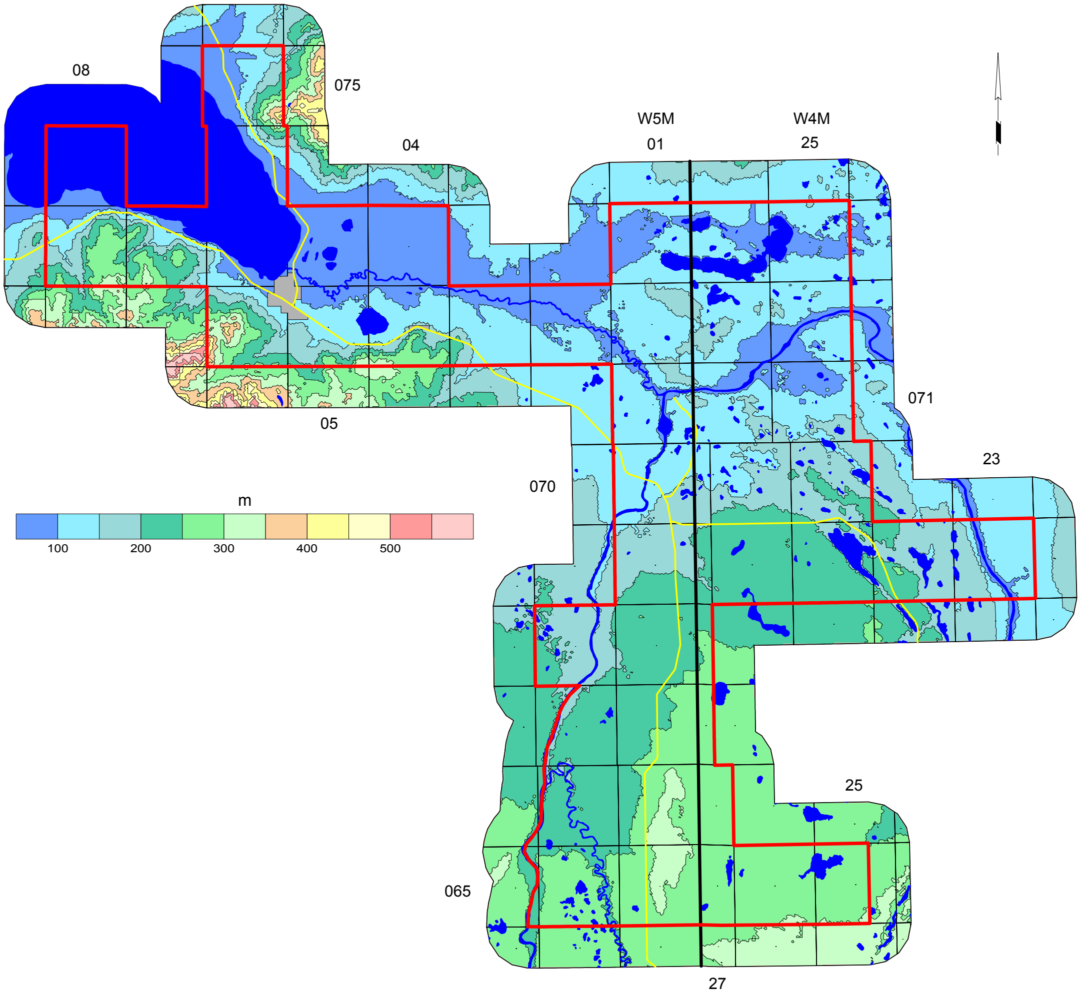
# *Total Dissolved Solids in Groundwater from Foremost Aquifer*



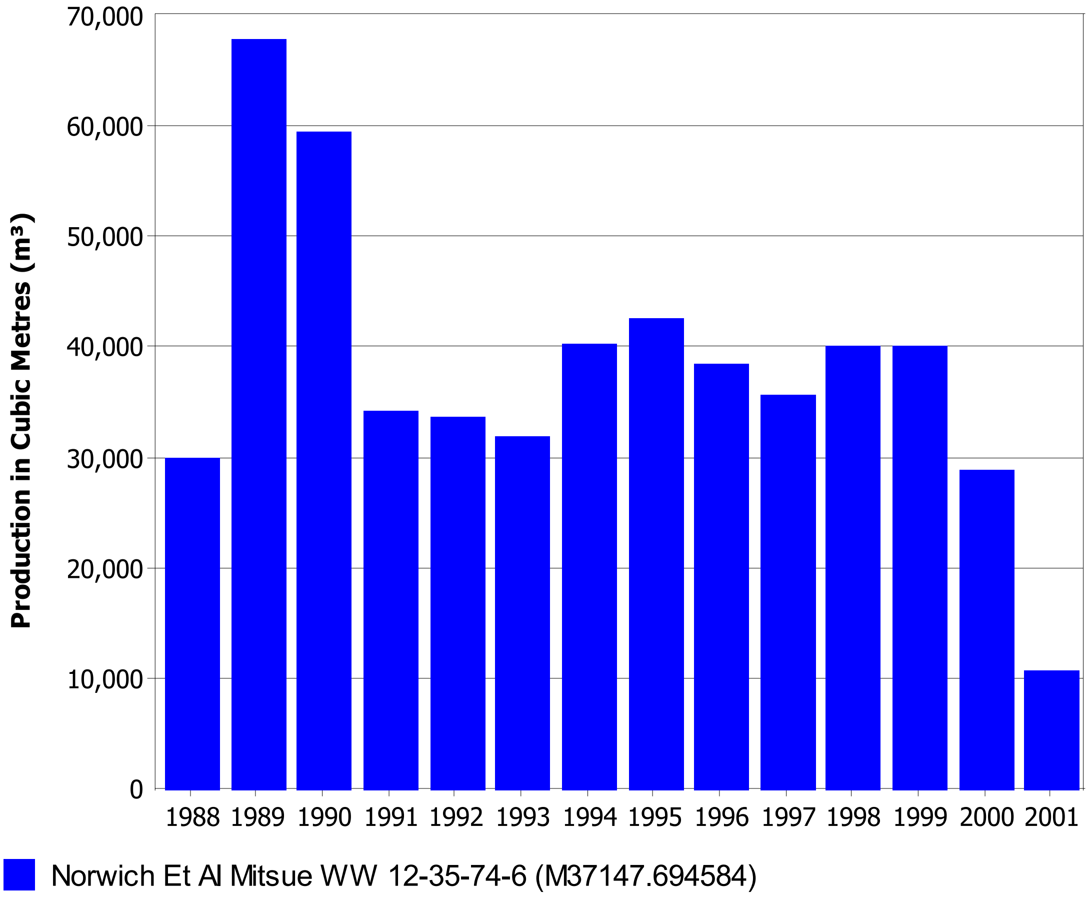
# Depth to Top of Lea Park Formation



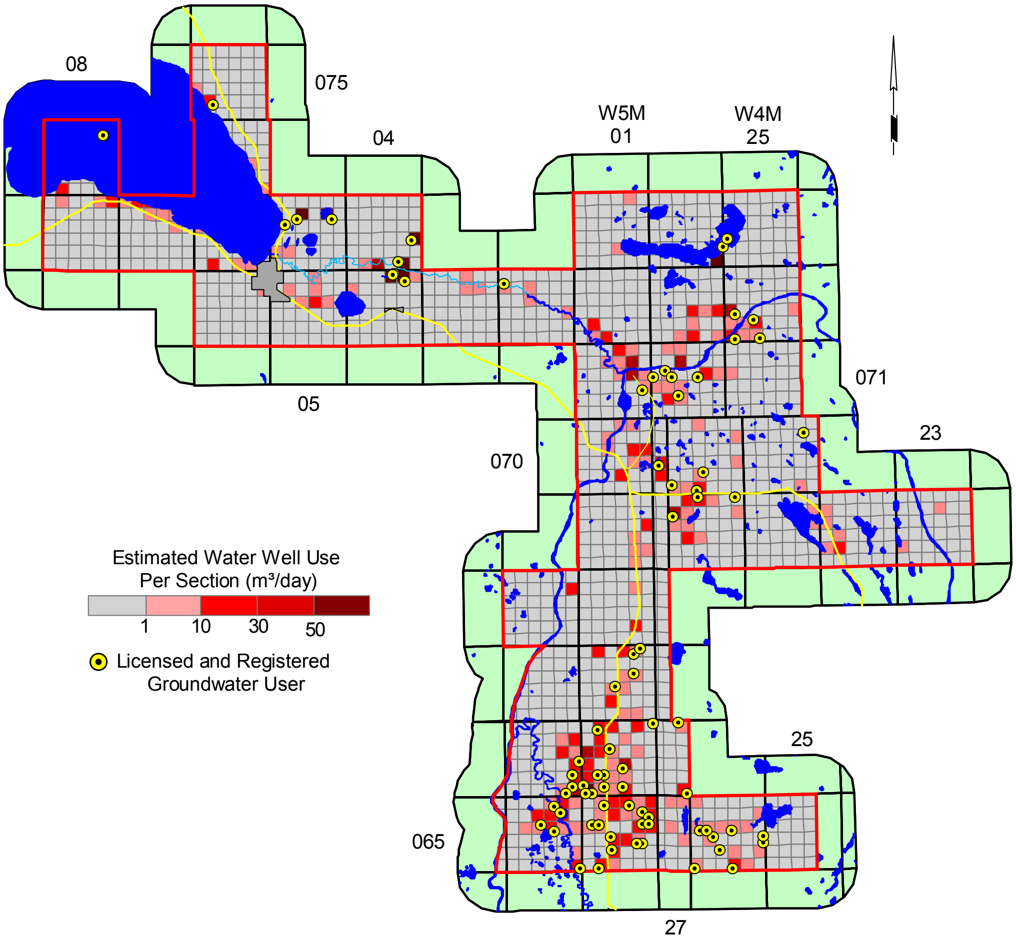
# Depth to Top of Milk River Formation



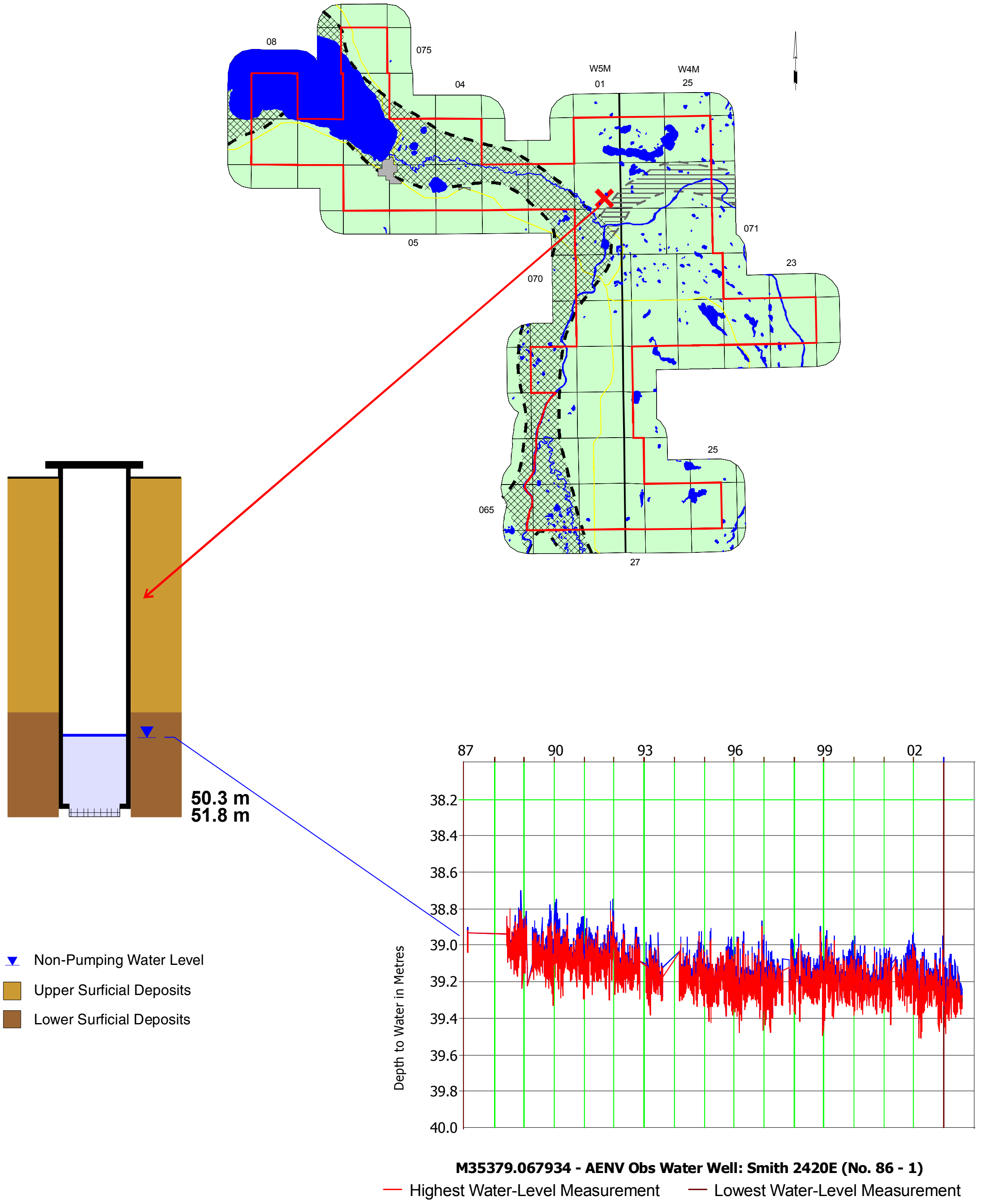
## Norwich Resources Water Source Well - Annual Groundwater Production



## *Estimated Water Well Use Per Section*



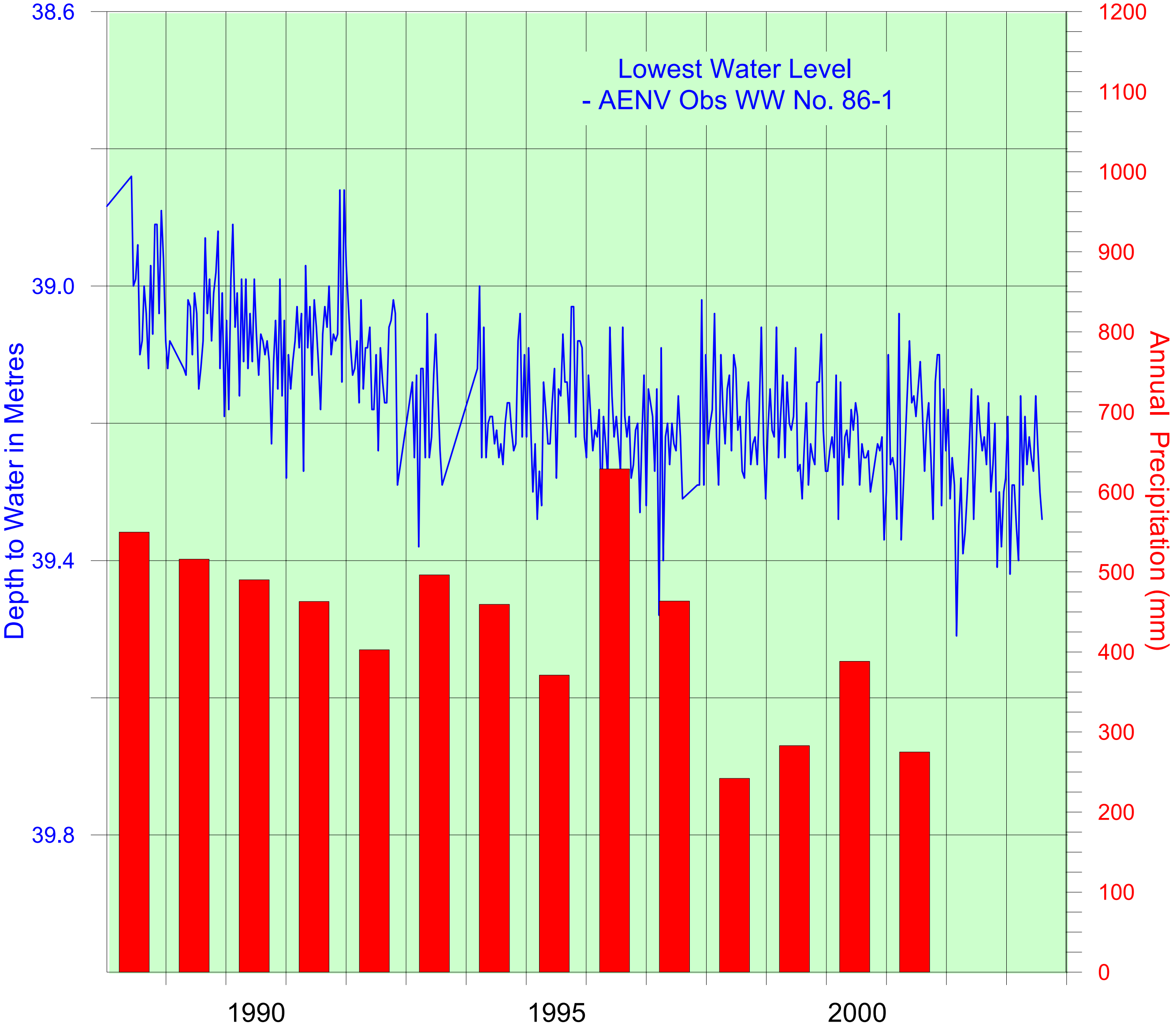
# *AENV Observation Water Well*



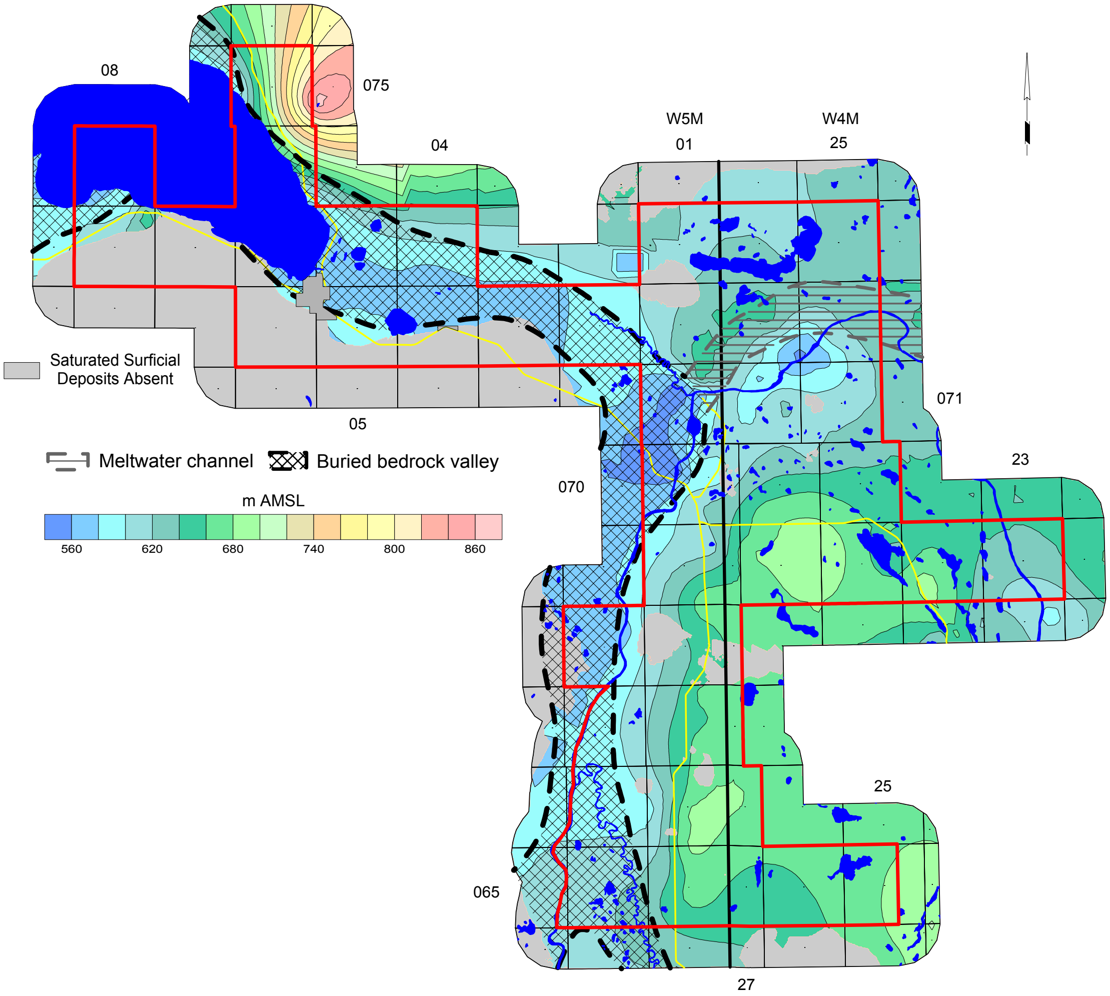
**M35379.067934 - AENV Obs Water Well: Smith 2420E (No. 86 - 1)**

— Highest Water-Level Measurement — Lowest Water-Level Measurement

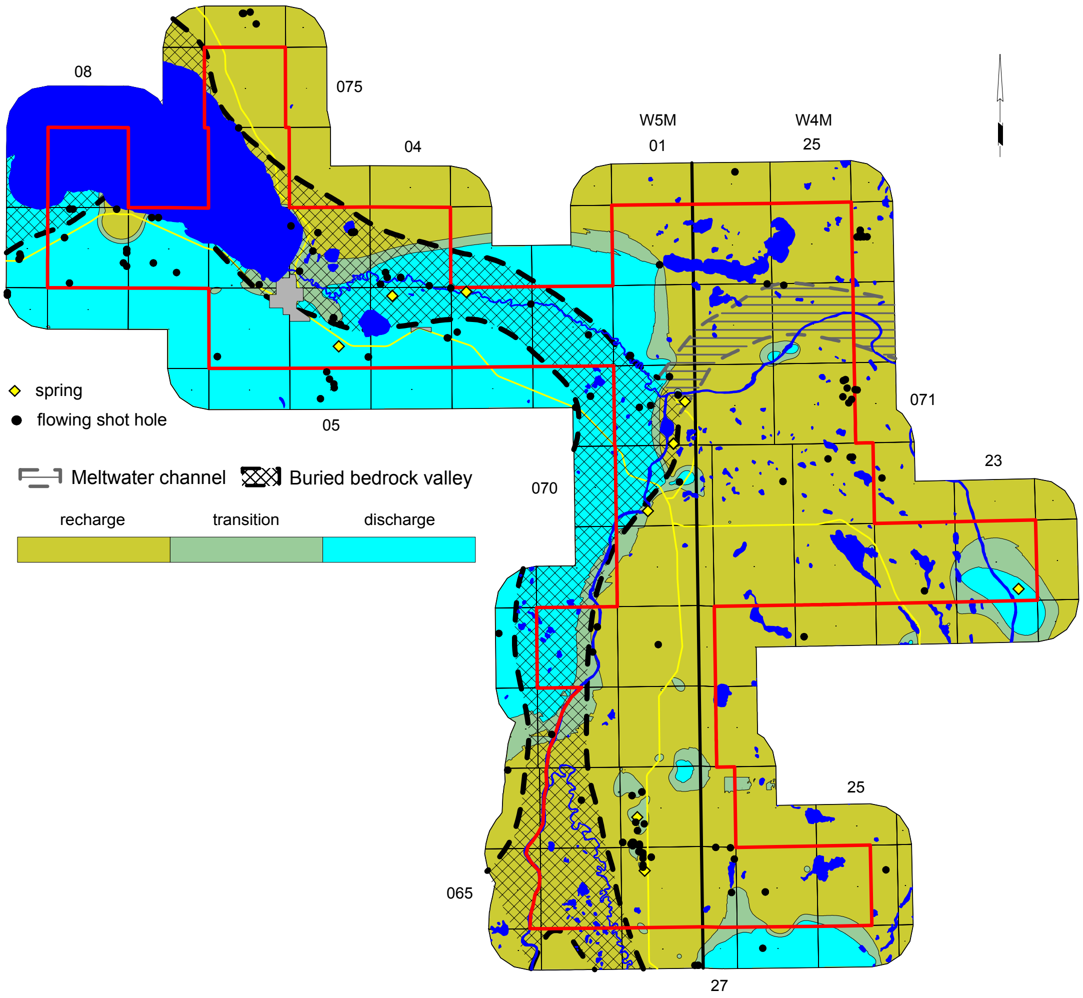
## *Annual Precipitation vs Water Levels in AENV Obs WW No. 86-1*



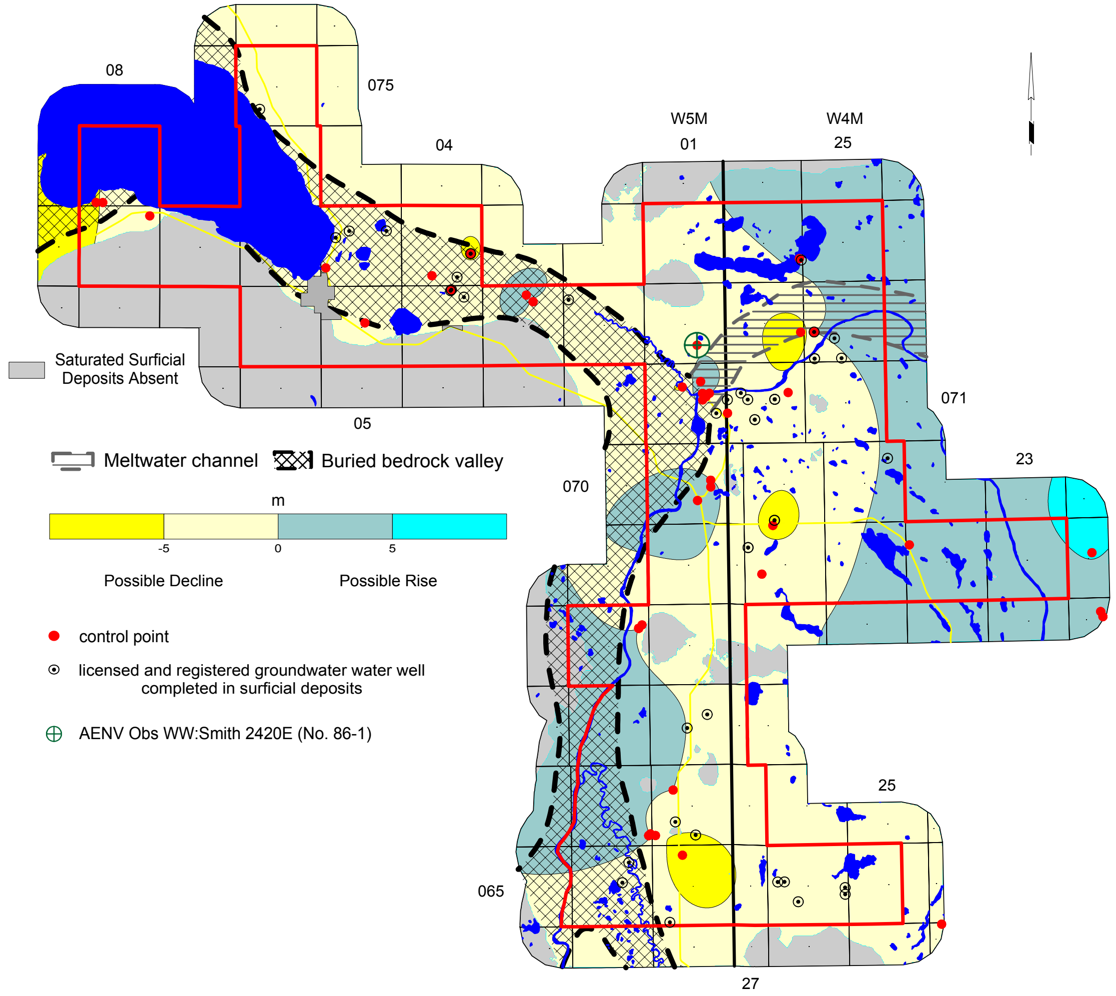
# Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep



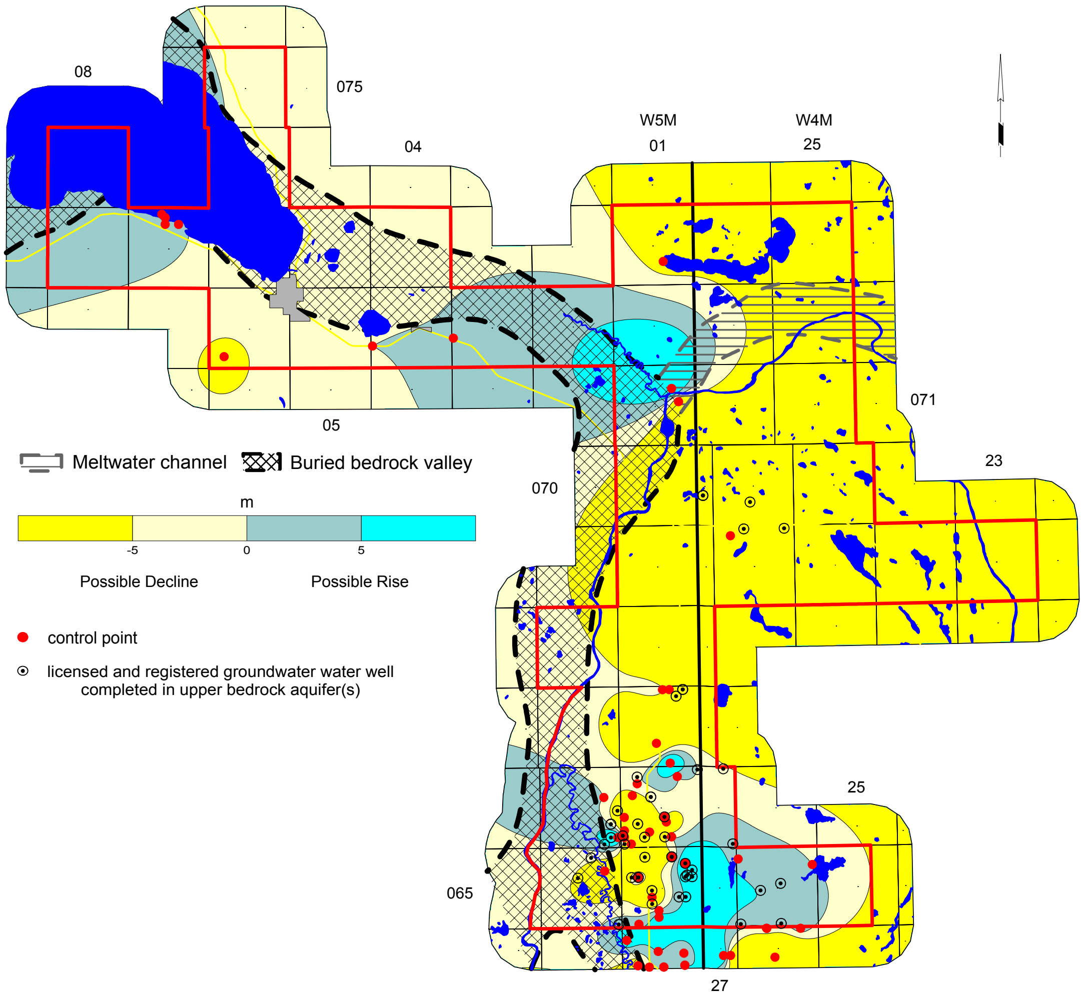
# Recharge/Discharge Areas between Surficial Deposits and Upper Bedrock Aquifer(s)



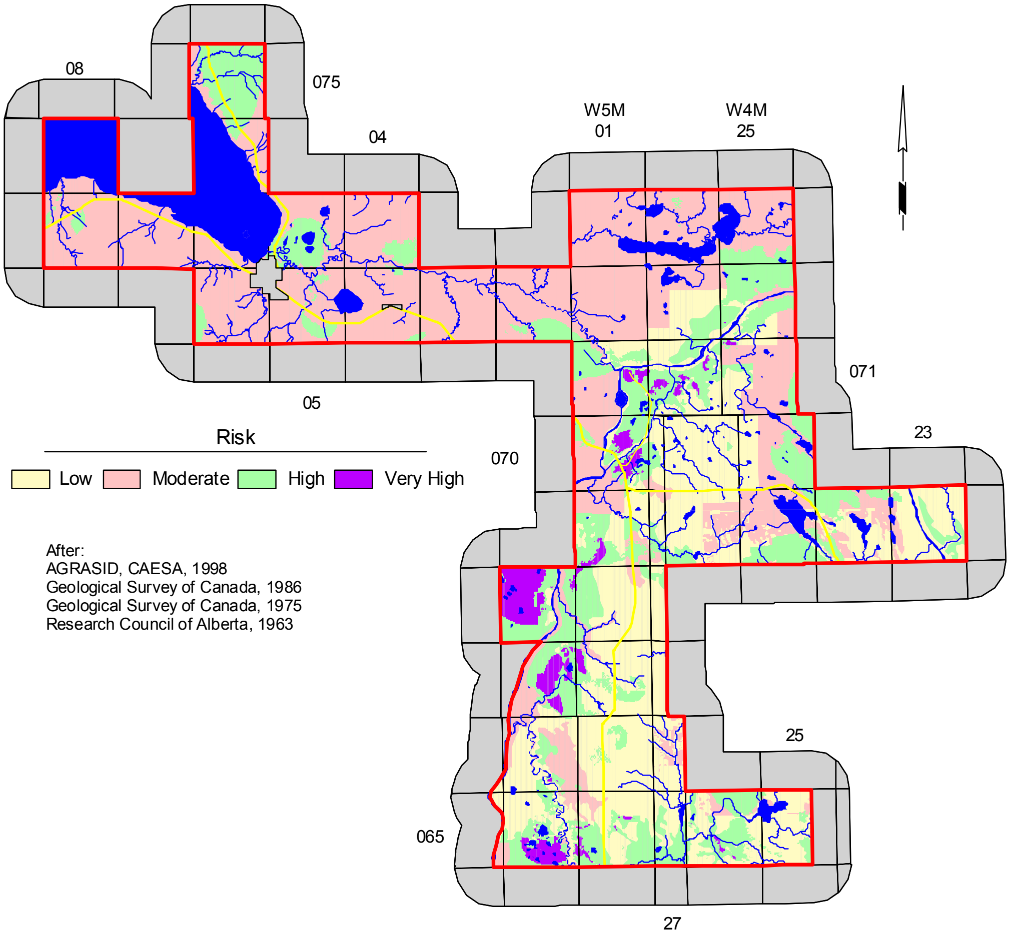
# *Changes in Water Levels in Surficial Deposits*



# *Areas of Potential Groundwater Depletion - Upper Bedrock Aquifer(s)*

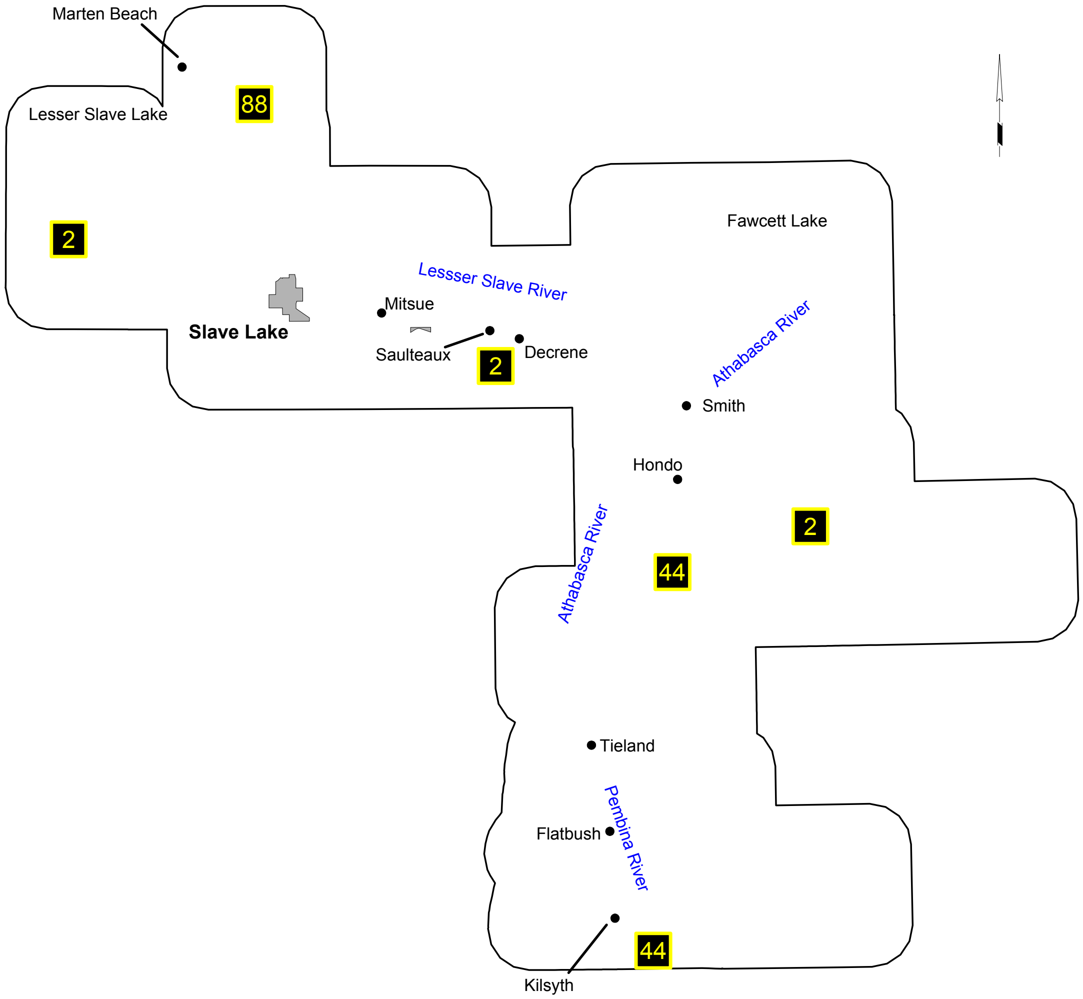


# Risk of Groundwater Contamination



After:
AGRASID, CAESA, 1998
Geological Survey of Canada, 1986
Geological Survey of Canada, 1975
Research Council of Alberta, 1963

## Overlay


Marten Beach
Lesser Slave Lake
88
2
Slave Lake
Lessser Slave River
Mitsue
Saulteaux
2
Decrene
Fawcett Lake
Athabasca River
Smith
Hondo
2
Athabasca River
44
Tieland
Pembina River
Flatbush
44
Kilsyth

# M.D. OF LESSER SLAVE RIVER NO. 124

## Appendix B

### Maps and Figures on CD-ROM

# MAPS AND FIGURES ON CD-ROM

## A 1) General

**A01** Surface Topography
**A02** Surface Casing Types used in Drilled Water Wells
**A03** Location of Water Wells and Springs
**A04** Minimum Depth of Existing Water Wells
**A05** Maximum Depth of Existing Water Wells
**A06** Difference Between the Maximum and Minimum Depth of Existing Water Wells
**A07** Depth to Base of Groundwater Protection
**A08** Hydrogeological Maps
**A09** Generalized Cross-Section (for terminology only)
**A10** Geologic Column
**A11** Cross-Section A - A'
**A12** Cross-Section B - B'
**A13** Cross-Section C - C'
**A14** Cross-Section D - D'
**A15** Cross-Section E - E'
**A16** Bedrock Topography
**A17** Bedrock Geology
**A18** Stratigraphic Section
**A19** Relative Permeability
**A20** Risk of Groundwater Contamination
**A21** Licensed and Registered Groundwater Water Wells
**A22** Estimated Water Well Use per Section
**A23** Water Wells Recommended for Field Verification

## 2) Surficial Aquifers

### B a) Surficial Deposits

**B01** Thickness of Surficial Deposits
**B02** Non-Pumping Water-Level Surface in Surficial Deposits Based on Water Wells Less than 20 Metres Deep
**B03** Total Dissolved Solids in Groundwater from Surficial Deposits
**B04** Sulfate in Groundwater from Surficial Deposits
**B05** Nitrate + Nitrite (as N) in Groundwater from Surficial Deposits
**B06** Chloride in Groundwater from Surficial Deposits
**B07** Total Hardness in Groundwater from Surficial Deposits
**B08** Piper Diagram - Surficial Deposits
**B09** Thickness of Sand and Gravel Deposits
**B10** Amount of Sand and Gravel in Surficial Deposits
**B11** Thickness of Sand and Gravel Aquifer(s)
**B12** Water Wells Completed in Surficial Deposits
**B13** Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)
**B14** Changes in Water Levels in Surficial Deposits

### b) First Sand and Gravel

**B15** Thickness of First Sand and Gravel

### b) Upper Sand and Gravel

**B16** Thickness of Upper Surficial Deposits
**B17** Thickness of Upper Sand and Gravel (not all drill holes fully penetrate surficial deposits)
**B18** Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

### c) Lower Sand and Gravel

**B19** Structure-Contour Map - Top of Lower Sand and Gravel Deposits
**B20** Depth to Top of Lower Sand and Gravel Deposits
**B21** Thickness of Lower Sand and Gravel Deposits
**B22** Apparent Yield for Water Wells Completed through Lower Sand and Gravel Aquifer
**B23** Non-Pumping Water-Level Surface in Lower Sand and Gravel Aquifer

# M.D. OF LESSER SLAVE RIVER NO. 124

## Appendix C

## General Water Well Information

# Domestic Water Well Testing

## *Purpose and Requirements*

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

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

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

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

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

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

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

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

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

## *Procedure*

### Site Diagrams

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

### Surface Details

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

### Groundwater Discharge Point

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

### Water-Level Measurements

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

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

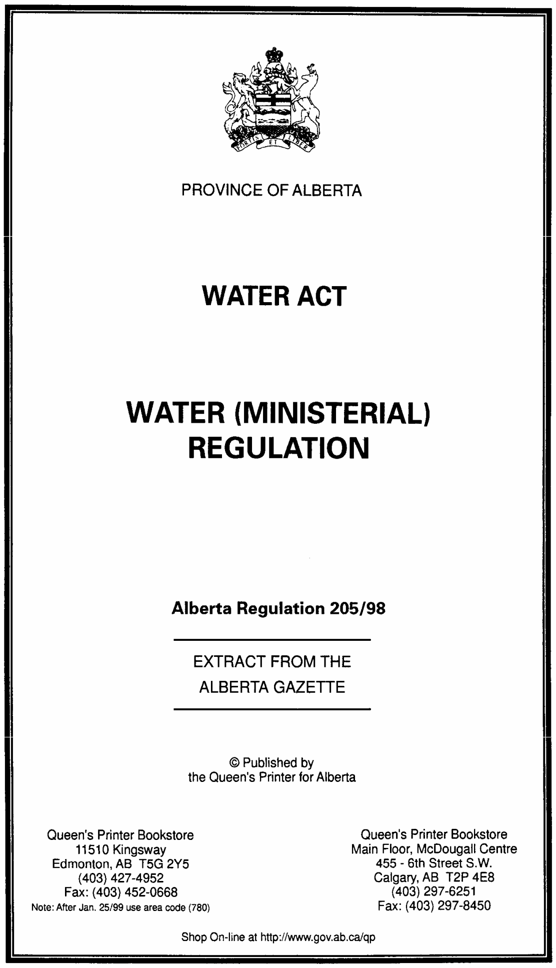
### Discharge Measurements

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

### Water Samples

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

# Water Act - Water (Ministerial) Regulation



PROVINCE OF ALBERTA

## WATER ACT

## WATER (MINISTERIAL) REGULATION

**Alberta Regulation 205/98**

EXTRACT FROM THE
ALBERTA GAZETTE

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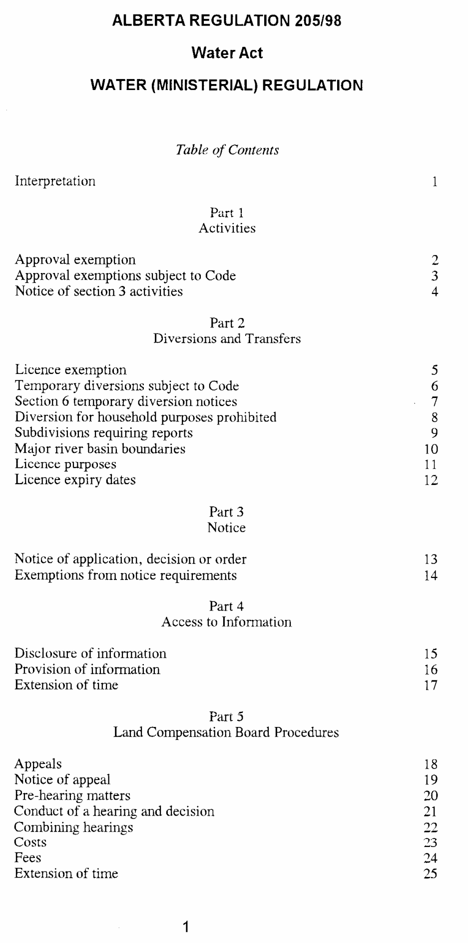

**ALBERTA REGULATION 205/98**

**Water Act**

**WATER (MINISTERIAL) REGULATION**

*Table of Contents*

1

# Chemical Analysis of Farm Water Supplies

**Adapted from Agdex 716 (D04) Published April 1991**

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

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

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

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

### Water Quality Criteria

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

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

### Sodium

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

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

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

### Potassium

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

### Calcium

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

### Magnesium

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

### Iron

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

### Sulphate (SO4)

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

### Chloride

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

### NO2 Nitrogen (Nitrite)

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

The concentration in livestock water should not exceed 10 ppm.

### NO3 Nitrogen (Nitrate)

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

### Fluoride

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

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

### TDS Inorganic (Total Dissolved Solids)

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

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

### Conductivity

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

### pH

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

### Hardness

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

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

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

### Alkalinity

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

### Water Treatment

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

### Helpful Conversions

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

### References

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

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

# Additional Information

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

BOOKLET
Water Wells that Last (PFRA – Edmonton Office: 780-495-3307);
http://www.agric.gov.ab.ca/water/wells/index.html
Quality Farm Dugouts - http://www.agric.gov.ab.ca/esb/dugout.html

ALBERTA ENVIRONMENT

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

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

WATER WELL INSPECTORS
Jennifer McPherson (Edmonton: 780-427-6429)

WATER WELL LICENSING
Rob George (Edmonton: 780-427-6429)

GEOPHYSICAL INSPECTION SERVICE
Edmonton: 780-427-3932

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

UNIVERSITY OF ALBERTA – Department of Earth and Atmospheric Sciences - Hydrogeology
Carl Mendoza (Edmonton: 780-492-2664)

UNIVERSITY OF CALGARY – Department of Geology and Geophysics - Hydrogeology
Larry Bentley (Calgary: 403-220-4512)

FARMERS ADVOCATE
Dean Lien (Edmonton: 780-427-2433)

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

Curtis Snell (Westlock: 780-349-3963) - snellc@em.agr.ca
Tony Cowen (Edmonton: 780-495-4911) - cowent@agr.gc.ca

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

LOCAL HEALTH DEPARTMENTS

# M.D. OF LESSER SLAVE RIVER NO. 124

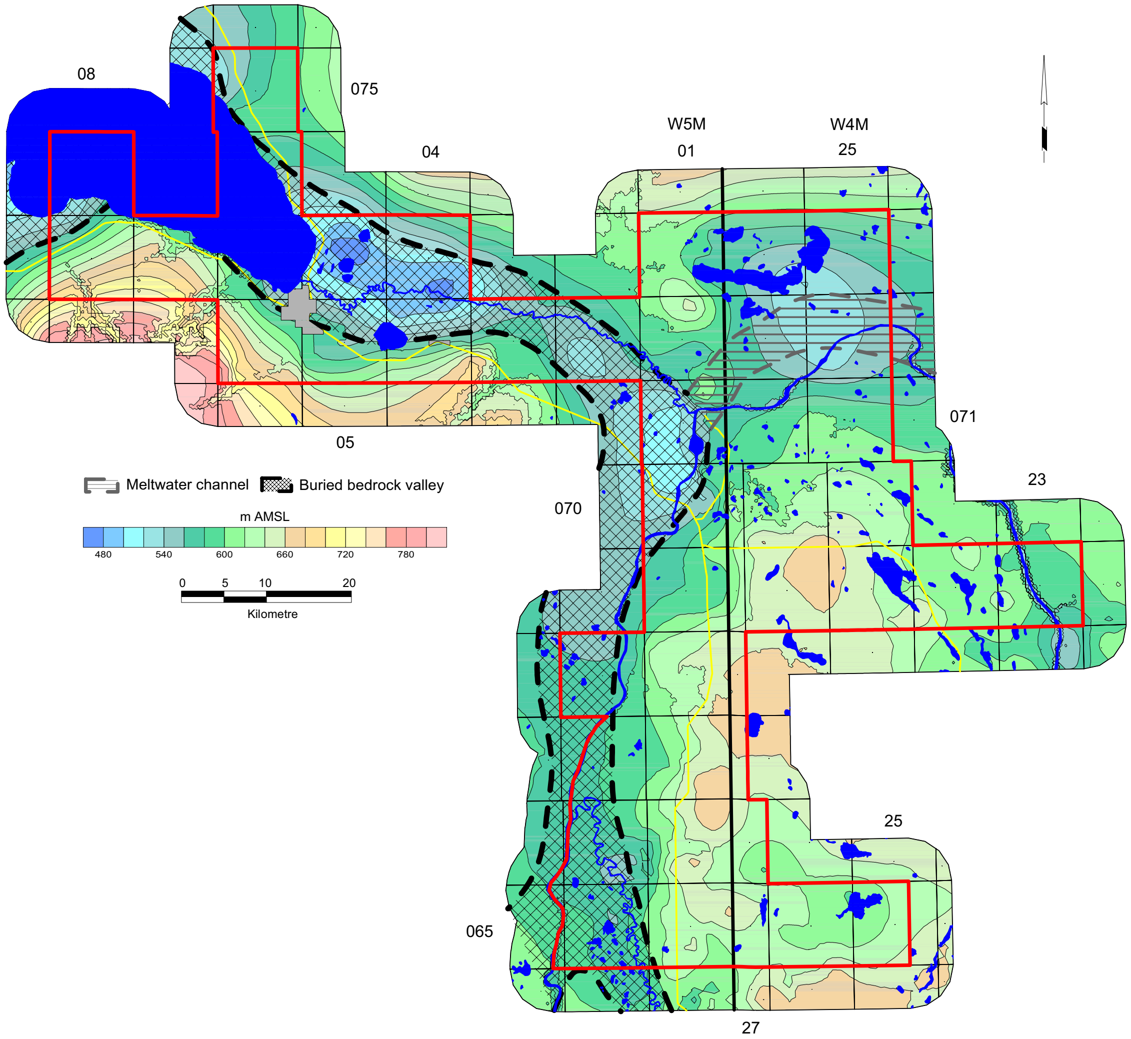
## Appendix D

## Maps and Figures Included as Large Plots

## *Bedrock Topography*

# M.D. of Lesser Slave River No. 124

Bedrock Topography



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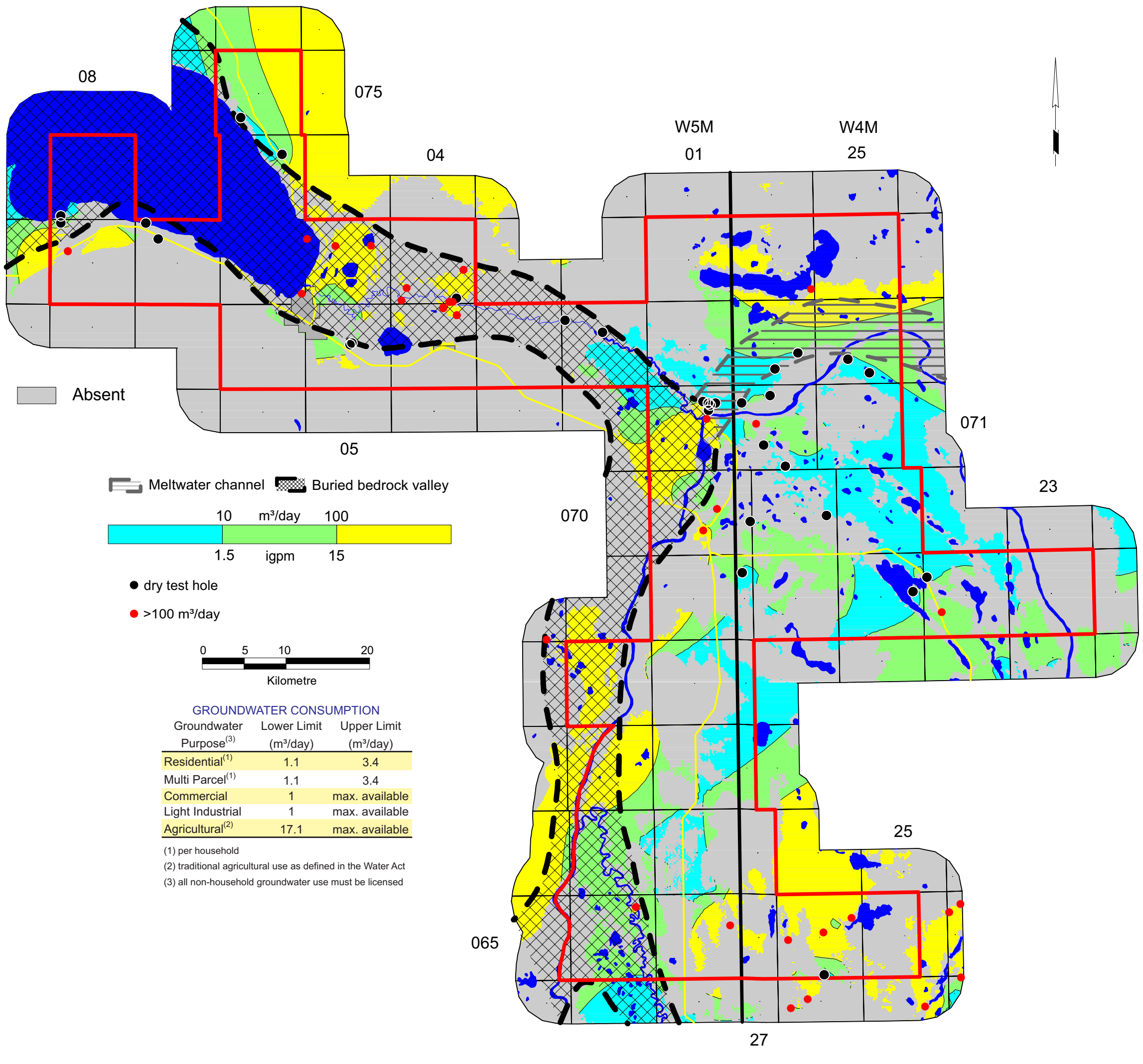
## *Apparent Yield for Water Wells Completed in Sand and Gravel Aquifer(s)*

# M.D. of Lesser Slave River No. 124

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



GROUNDWATER CONSUMPTION

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

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

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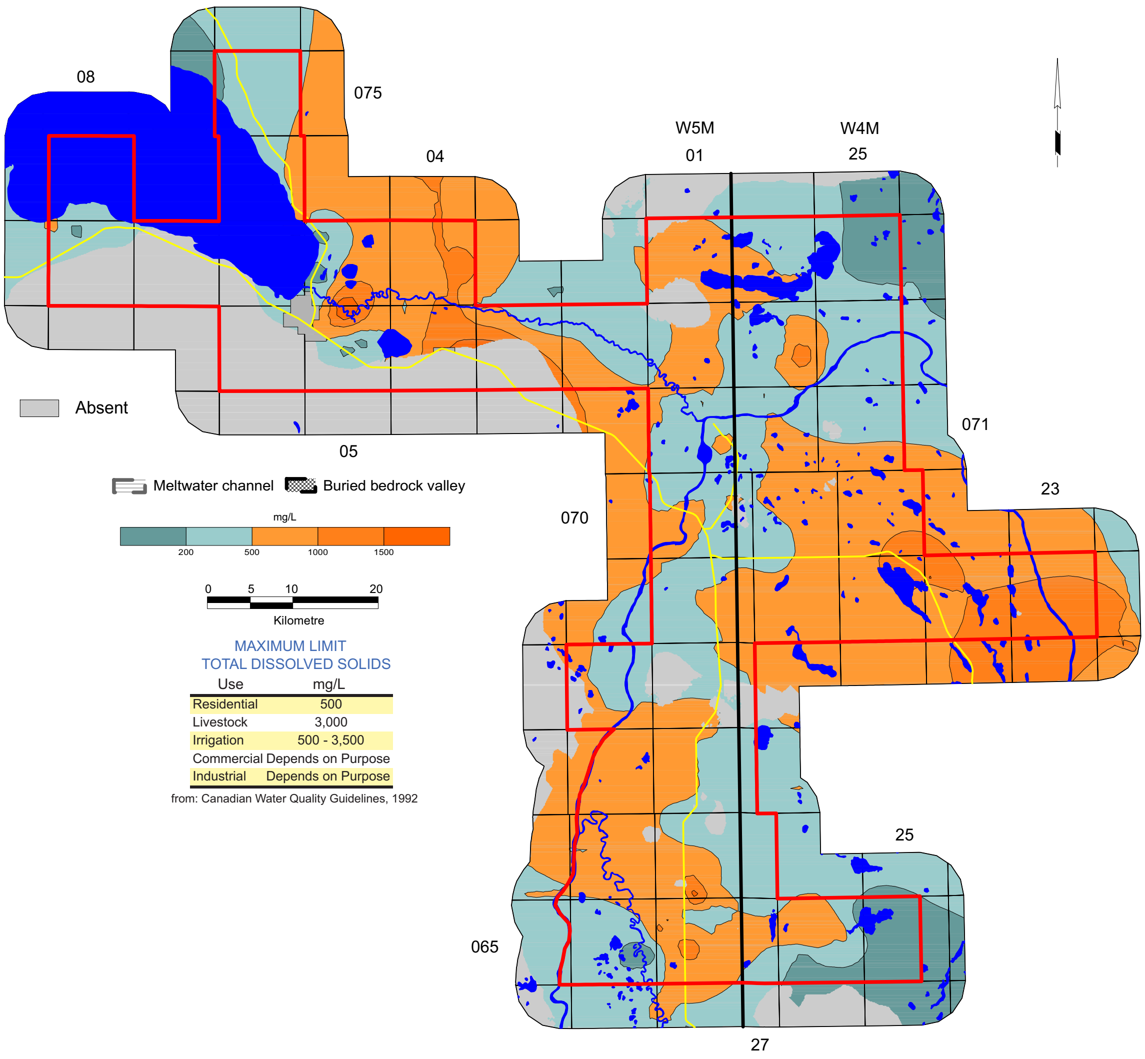
## *Total Dissolved Solids in Groundwater from Surficial Deposits*

# M.D. of Lesser Slave River No. 124

## Total Dissolved Solids in Groundwater from Surficial Deposits



MAXIMUM LIMIT
TOTAL DISSOLVED SOLIDS

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

from: Canadian Water Quality Guidelines, 1992

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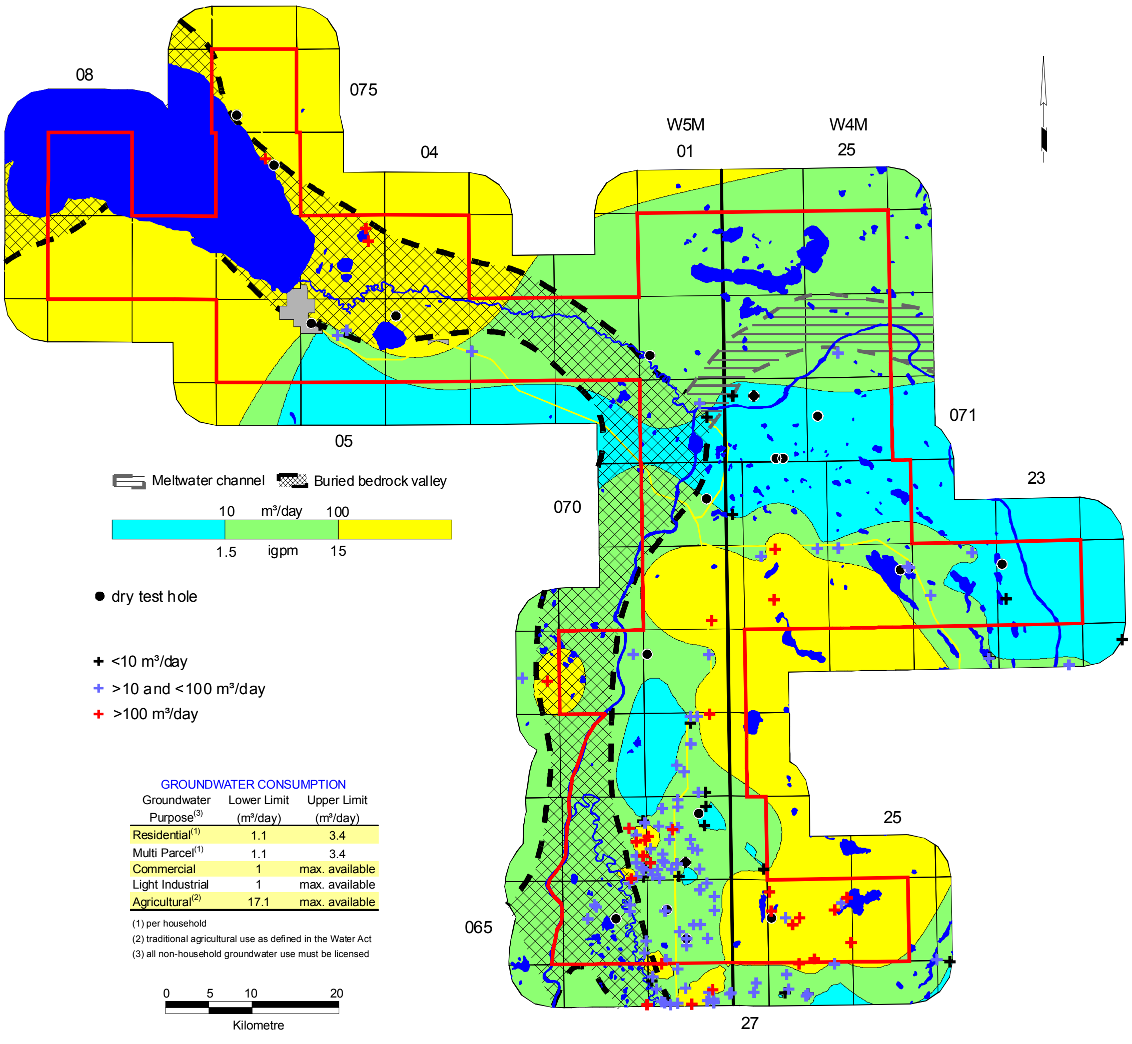
## *Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)*

# M.D. of Lesser Slave River No. 124

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



GROUNDWATER CONSUMPTION

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

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

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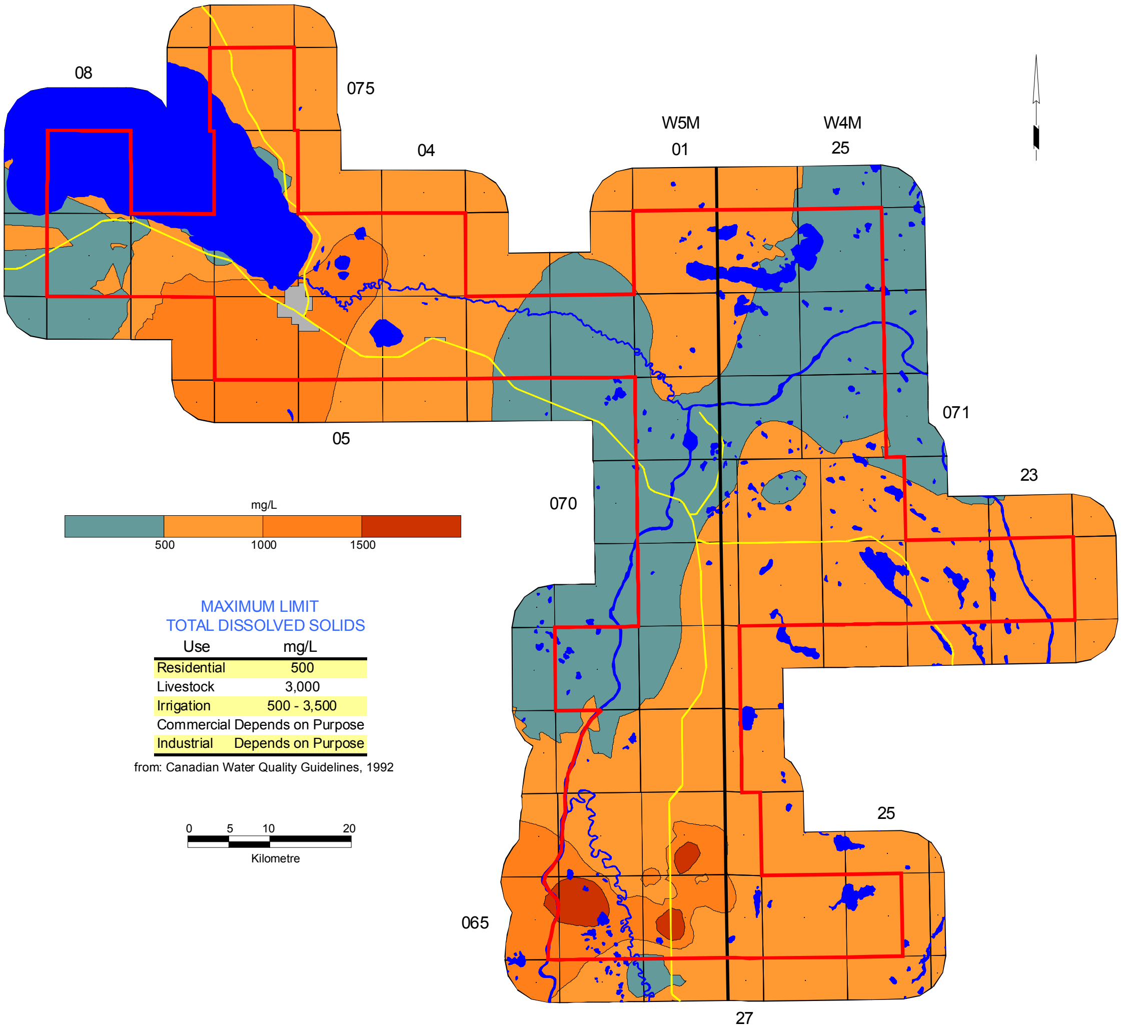
## *Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)*

# M.D. of Lesser Slave River No. 124

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



MAXIMUM LIMIT
TOTAL DISSOLVED SOLIDS

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

from: Canadian Water Quality Guidelines, 1992

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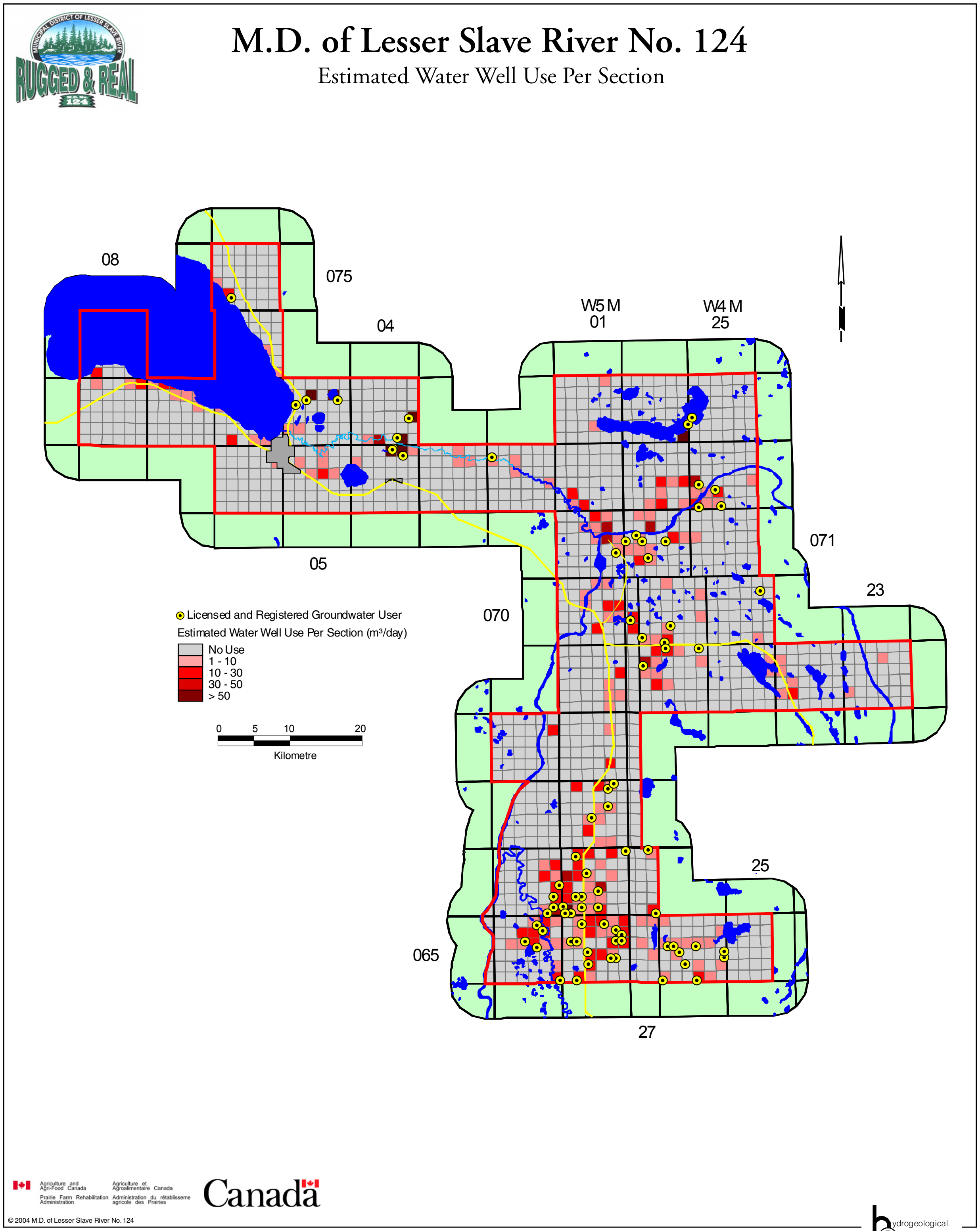
## *Estimated Water Well Use Per Section*



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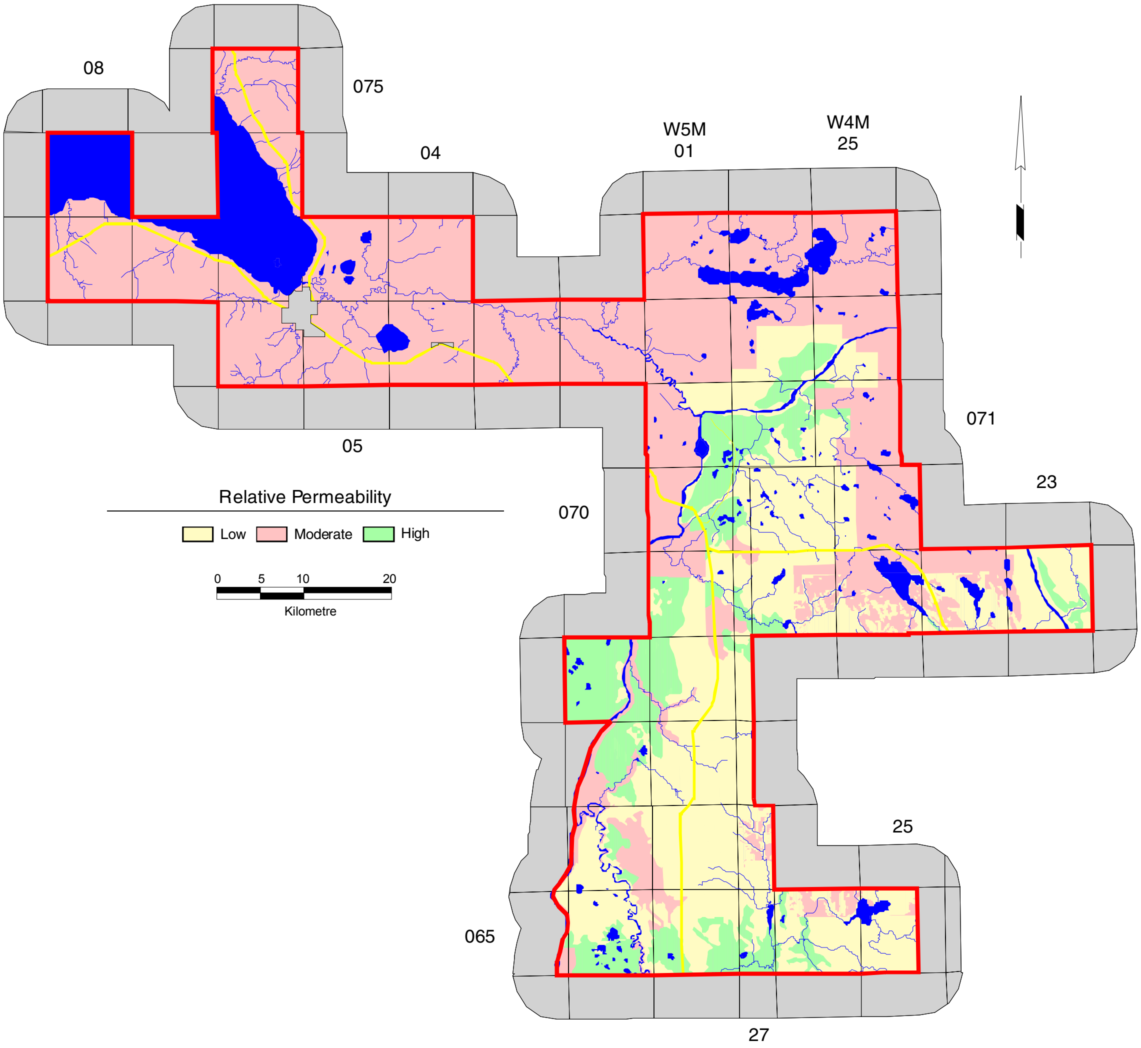
## *Relative Permeability*

# M.D. of Lesser Slave River No. 124

## Relative Permeability



After:
AGRASID, CAESA, 1998
Geological Survey of Canada, 1986
Geological Survey of Canada, 1975
Research Council of Alberta, 1963

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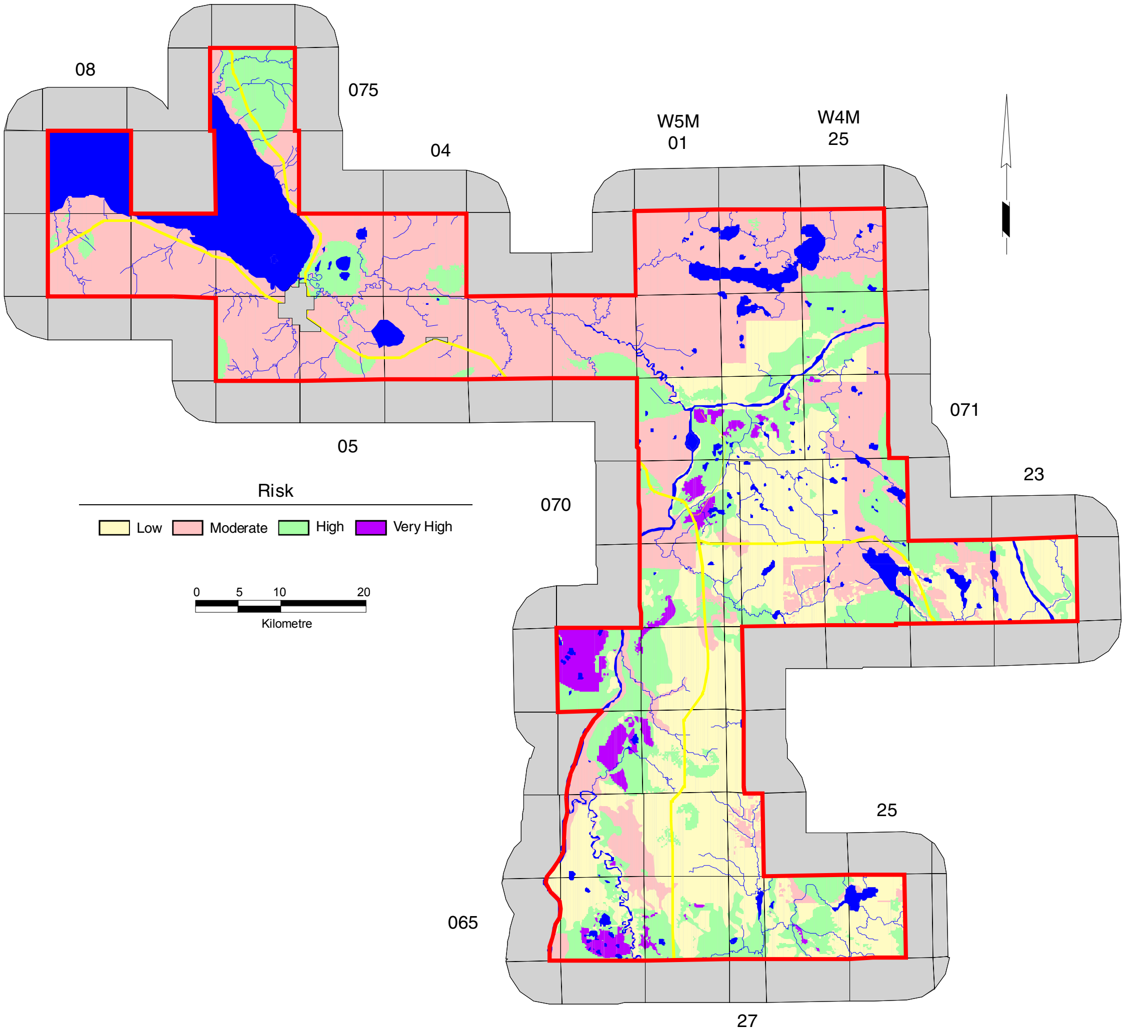
## *Risk of Groundwater Contamination*

# M.D. of Lesser Slave River No. 124

## Risk of Groundwater Contamination



After:
AGRASID, CAESA, 1998
Geological Survey of Canada, 1986
Geological Survey of Canada, 1975
Research Council of Alberta, 1963

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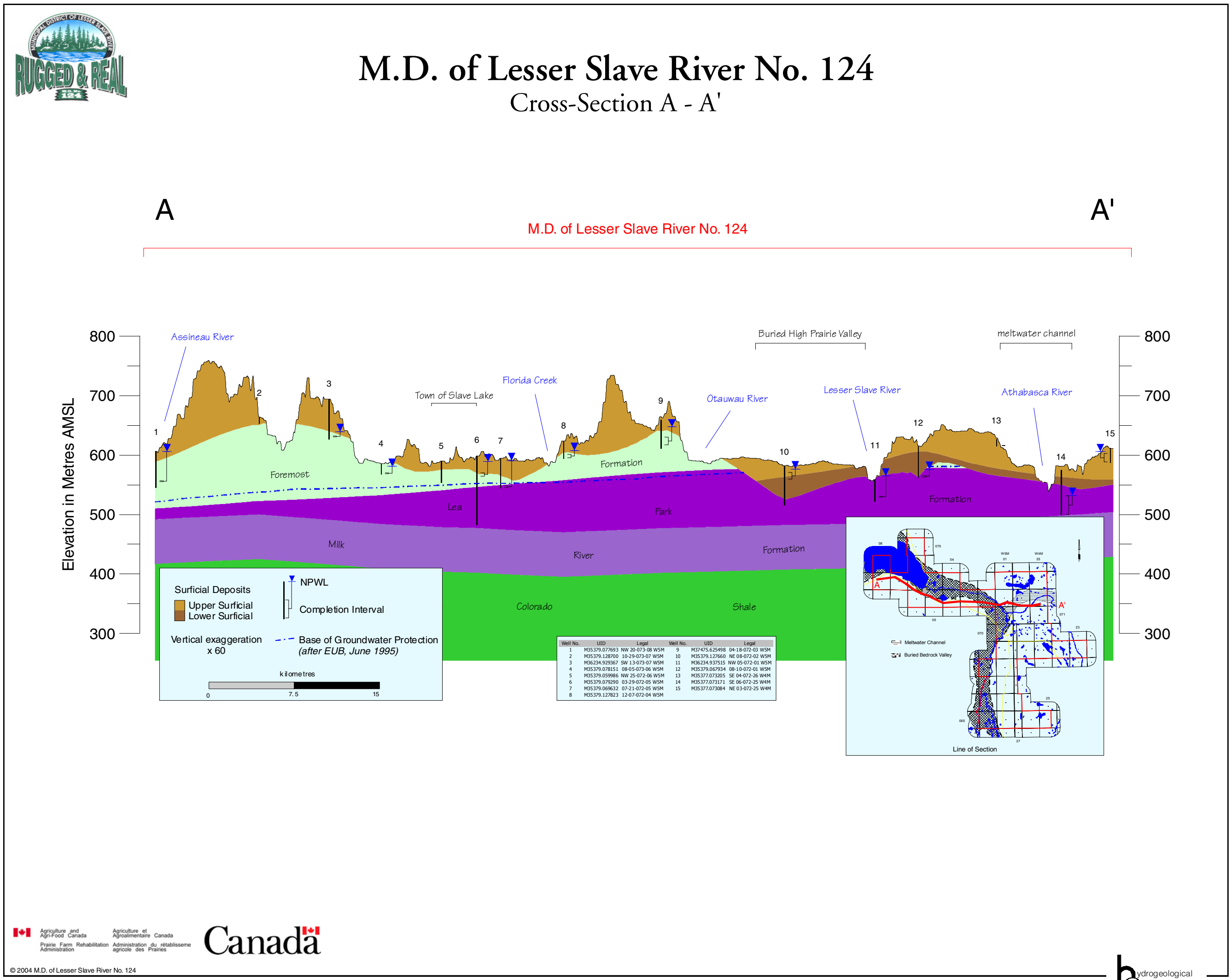
## *Cross-Section A - A'*



M.D. of Lesser Slave River No. 124
Cross-Section A - A'

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| 2 | M35379.128700 | 10-29-073-07 W5M | 10 | M35379.127660 | NE 08-072-02 W5M |
| 3 | M36234.929367 | SW 13-073-07 W5M | 11 | M36234.937515 | NW 05-072-01 W5M |
| 4 | M35379.078151 | 08-05-073-06 W5M | 12 | M35379.067934 | 08-10-072-01 W5M |
| 5 | M35379.059986 | NW 25-072-06 W5M | 13 | M35377.073205 | SE 04-072-26 W4M |
| 6 | M35379.079290 | 03-29-072-05 W5M | 14 | M35377.073171 | SE 06-072-25 W4M |
| 7 | M35379.069632 | 07-21-072-05 W5M | 15 | M35377.073084 | NE 03-072-25 W4M |
| 8 | M35379.127823 | 12-07-072-04 W5M | | | |

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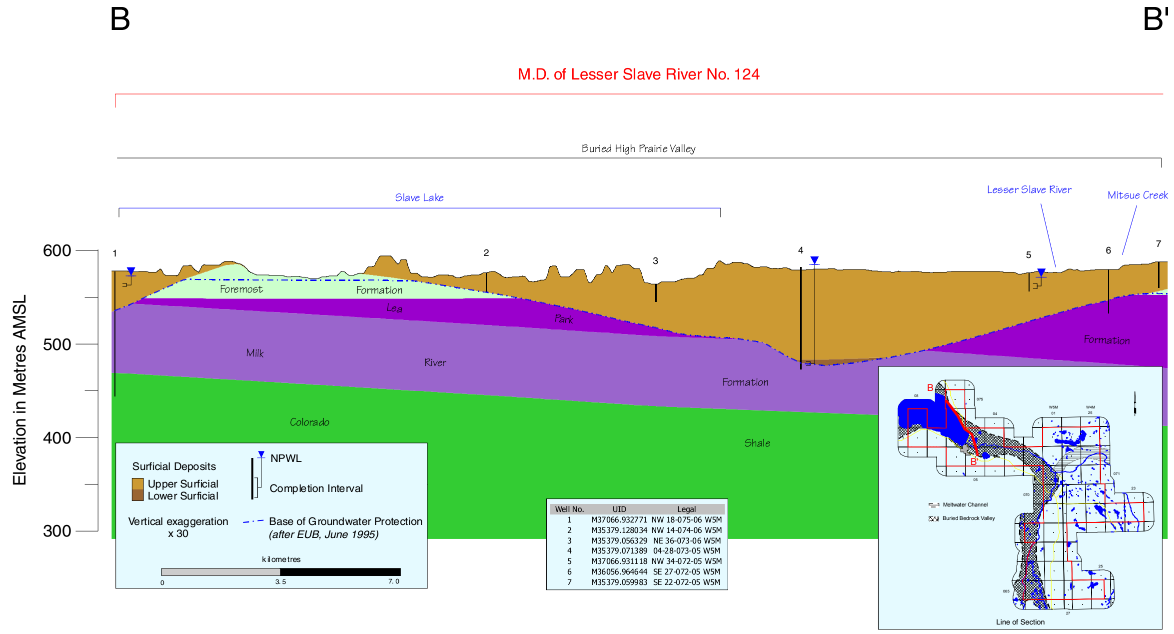
## *Cross-Section B - B'*

# M.D. of Lesser Slave River No. 124

## Cross-Section B - B'



| Well No. | UID | Legal |
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| 1 | M37066.932771 | NW 18-075-06 W5M |
| 2 | M35379.128034 | NW 14-074-06 W5M |
| 3 | M35379.056329 | NE 36-073-06 W5M |
| 4 | M35379.071389 | 04-28-073-05 W5M |
| 5 | M37066.931118 | NW 34-072-05 W5M |
| 6 | M36056.964644 | SE 27-072-05 W5M |
| 7 | M35379.059983 | SE 22-072-05 W5M |

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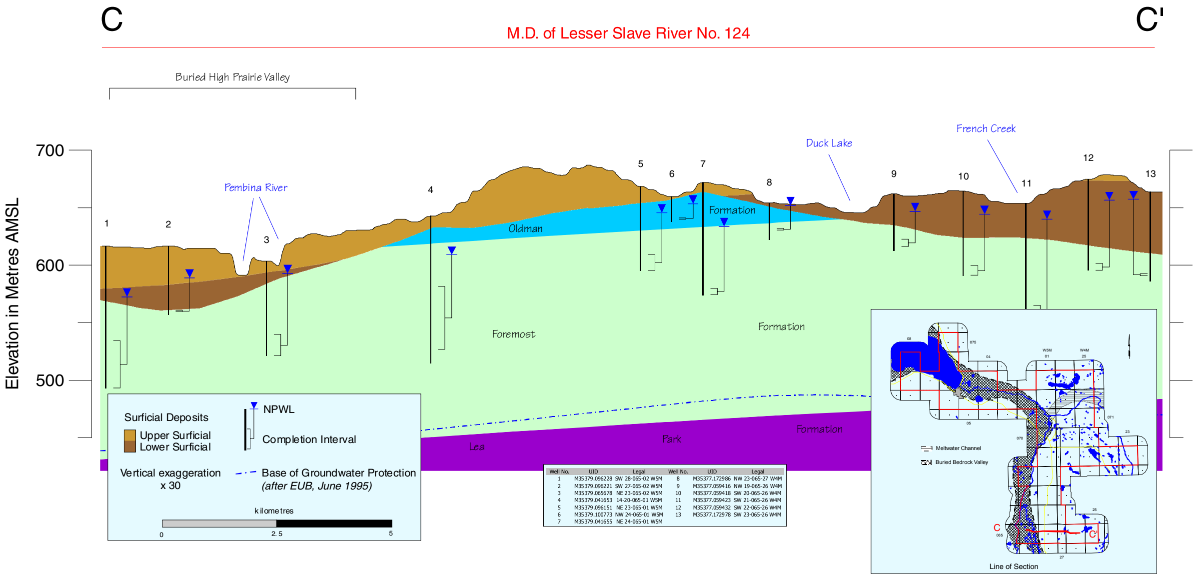
## *Cross-Section C - C'*

# M.D. of Lesser Slave River No. 124

## Cross-Section C - C'



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| 2 | M35379.096221 | SW 27-065-02 W5M | 9 | M35377.059416 | NW 19-065-26 W4M |
| 3 | M35379.065678 | NE 23-065-02 W5M | 10 | M35377.059418 | SW 20-065-26 W4M |
| 4 | M35379.041653 | 14-20-065-01 W5M | 11 | M35377.059423 | SW 21-065-26 W4M |
| 5 | M35379.096151 | NE 23-065-01 W5M | 12 | M35377.059432 | SW 22-065-26 W4M |
| 6 | M35379.100773 | NW 24-065-01 W5M | 13 | M35377.172978 | SW 23-065-26 W4M |
| 7 | M35379.041655 | NE 24-065-01 W5M | | | |

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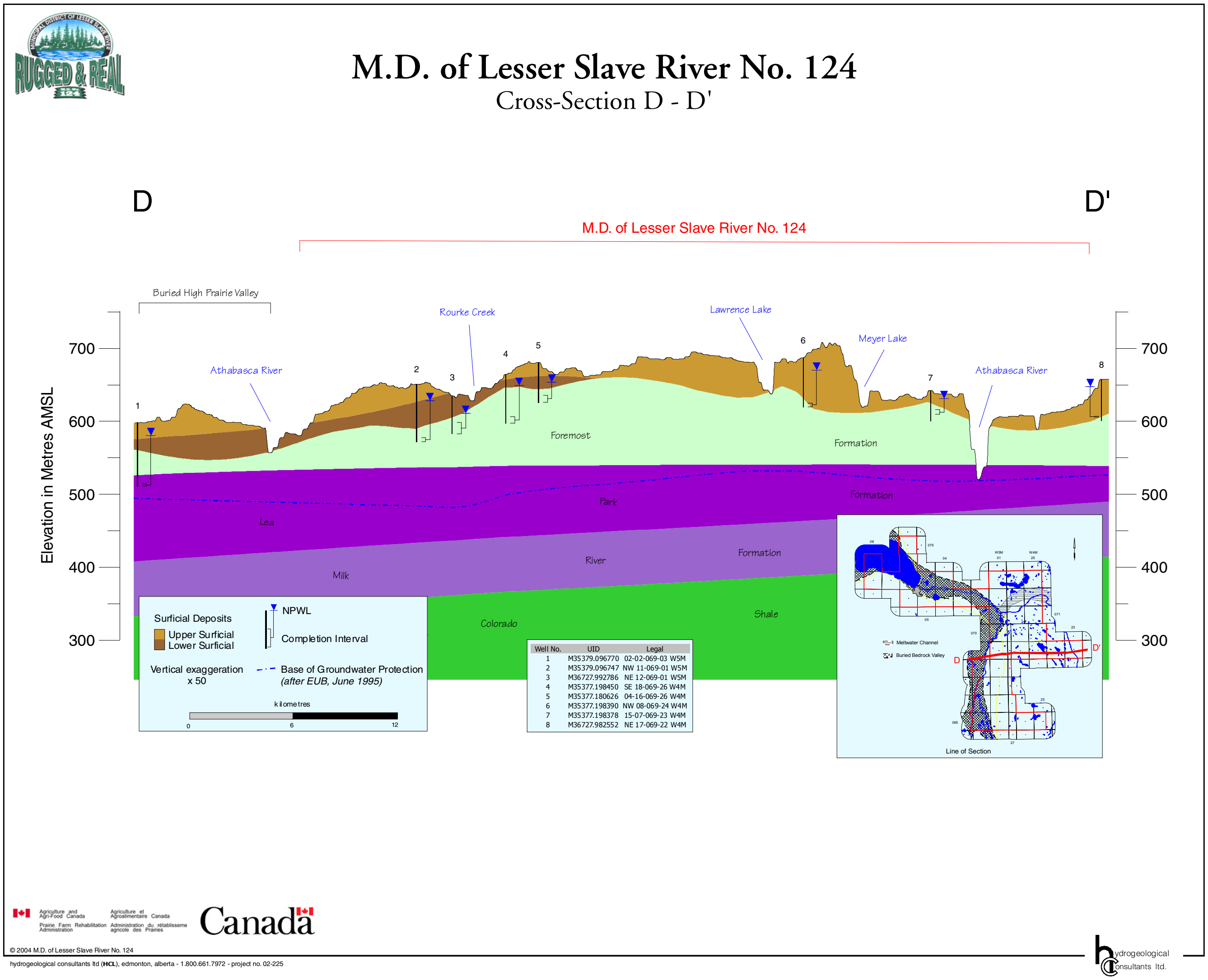
## *Cross-Section D - D’*



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| 3 | M36727.992786 | NE 12-069-01 W5M |
| 4 | M35377.198450 | SE 18-069-26 W4M |
| 5 | M35377.180626 | 04-16-069-26 W4M |
| 6 | M35377.198390 | NW 08-069-24 W4M |
| 7 | M35377.198378 | 15-07-069-23 W4M |
| 8 | M36727.982552 | NE 17-069-22 W4M |

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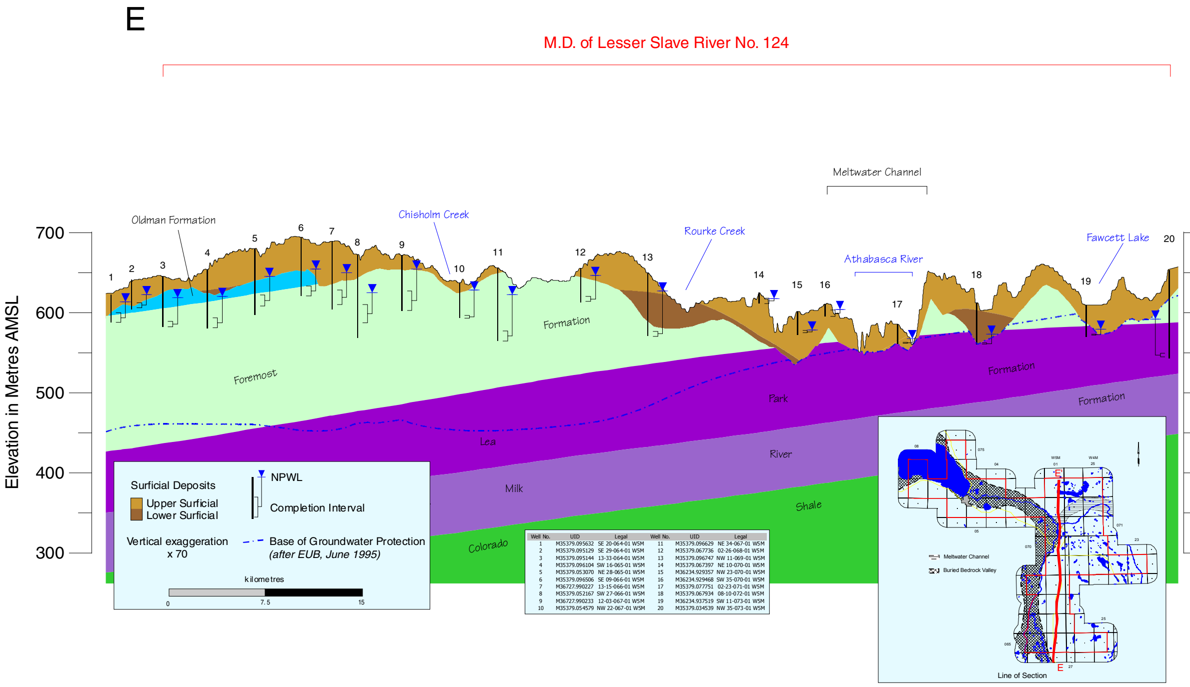
## *Cross-Section E - E’*

# M.D. of Lesser Slave River No. 124

## Cross-Section E - E'



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| 2 | M35379.095129 | SE 29-064-01 W5M | 12 | M35379.067736 | 02-26-068-01 W5M |
| 3 | M35379.095144 | 13-33-064-01 W5M | 13 | M35379.096747 | NW 11-069-01 W5M |
| 4 | M35379.096104 | SW 16-065-01 W5M | 14 | M35379.067397 | NE 10-070-01 W5M |
| 5 | M35379.053070 | NE 28-065-01 W5M | 15 | M36234.929357 | NW 23-070-01 W5M |
| 6 | M35379.096506 | SE 09-066-01 W5M | 16 | M36234.929468 | SW 35-070-01 W5M |
| 7 | M36727.990227 | 13-15-066-01 W5M | 17 | M35379.077751 | 02-23-071-01 W5M |
| 8 | M35379.052167 | SW 27-066-01 W5M | 18 | M35379.067934 | 08-10-072-01 W5M |
| 9 | M36727.990233 | 12-03-067-01 W5M | 19 | M36234.937519 | SW 11-073-01 W5M |
| 10 | M35379.054579 | NW 22-067-01 W5M | 20 | M35379.034539 | NW 35-073-01 W5M |

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# M.D. OF LESSER SLAVE RIVER NO. 124

## Appendix E

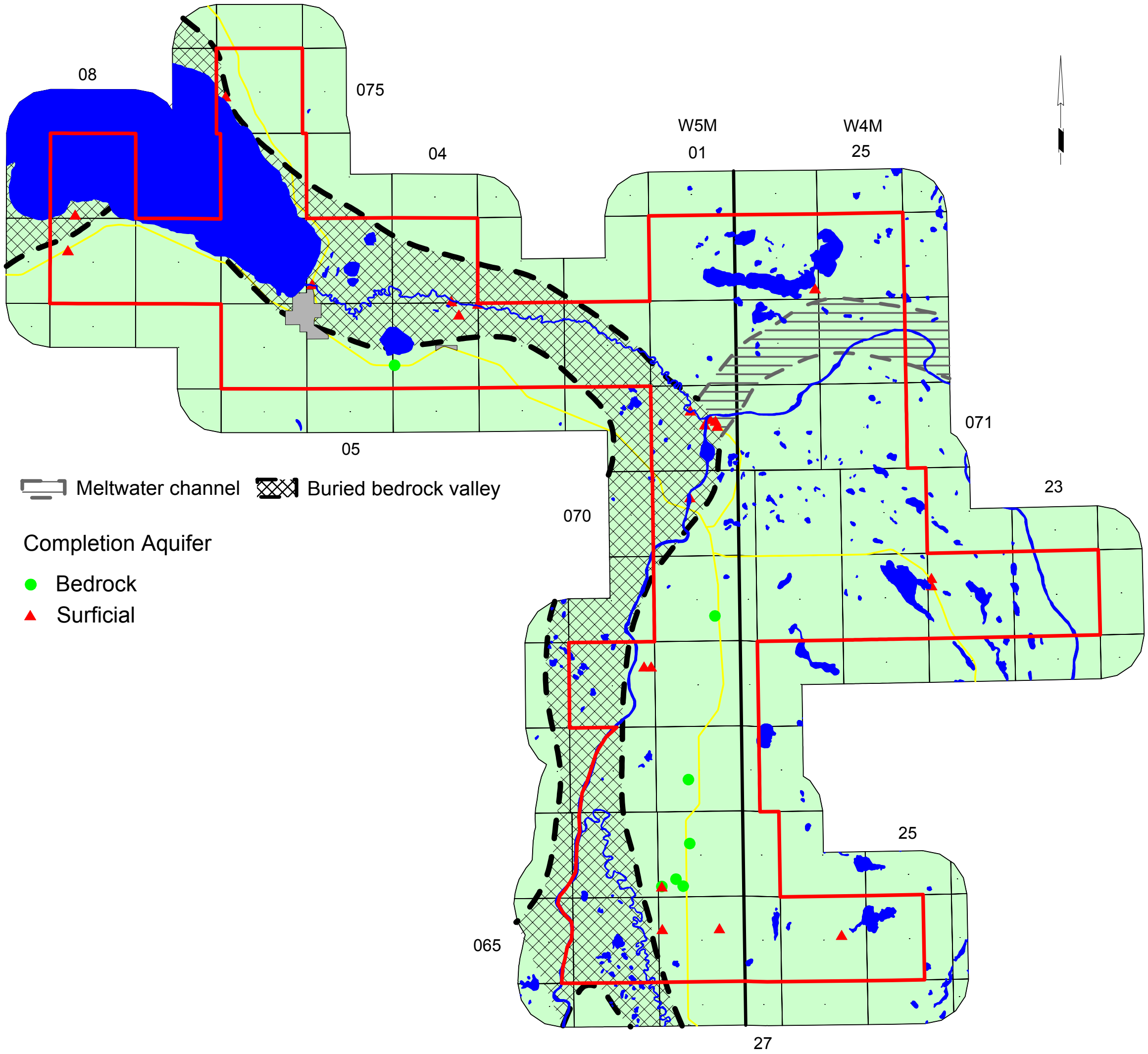
### Water Wells Recommended for Field Verification

including

### M.D.-Operated Water Wells

## *Water Wells Recommended for Field Verification*

*(details on following pages)*



## WATER WELLS RECOMMENDED FOR FIELD VERIFICATION

| | | Aquifer | Date Water | Completed Depth | | NPWL | | |
|---|---|---|---|---|---|---|---|---|
| Owner | Location | Name | Well Drilled | Metres | Feet | Metres | Feet | UID |
| Alberta Department of Highways | NW 20-073-08 W5M | Surficial | 28-Oct-78 | 50.59 | 166.0 | -0.03 | -0.1 | M35379.077693 |
| Alberta Recreation & Parks | 10-18-075-06 W5M | Upper Surficial | 05-Jul-86 | 10.06 | 33.0 | 4.99 | 16.4 | M35379.128089 |
| Chambers, Gerald | SE 28-071-01 W5M | Upper Surficial | 03-Jun-78 | 10.67 | 35.0 | 5.49 | 18.0 | M35379.128293 |
| Chisholm Mills | SW 25-068-02 W5M | Lower Surficial | 25-Aug-80 | 40.84 | 134.0 | 27.98 | 91.8 | M35379.096466 |
| Chisholm, Hamlet Of/ALTA Env | SE 25-068-02 W5M | Lower Surficial | 23-Aug-80 | 40.84 | 134.0 | 27.74 | 91.0 | M35379.097072 |
| Colguhoun, Norman | NW 06-066-01 W5M | Foremost | 06-Mar-86 | 64 | 210.0 | 22.55 | 74.0 | M35379.096316 |
| Coop Lumber Mill | 12-23-071-01 W5M | Upper Surficial | 06-Sep-72 | 13.41 | 44.0 | 2.13 | 7.0 | M35379.127780 |
| Cross Lake Prov Park | SW 23-065-26 W4M | Surficial | 15-Mar-79 | 73.15 | 240.0 | 6.71 | 22.0 | M35377.172978 |
| Department of Highways | NW 20-073-08 W5M | Upper Surficial | 10-Jun-60 | 12.5 | 41.0 | 1.84 | 6.0 | M37066.937817 |
| Department of Highways#Mitsue Camp | 12-07-072-04 W5M | Foremost | 22-Sep-67 | 28.04 | 92.0 | 16.15 | 53.0 | M35379.127823 |
| Fawcett Lk Properties | NE 01-073-26 W4M | Surficial | 22-Oct-80 | 6.1 | 20.0 | 2.44 | 8.0 | M35377.073276 |
| Federated Co-ops Ltd. | SE 22-071-01 W5M | Surficial | 06-Nov-69 | 23.77 | 78.0 | 14.63 | 48.0 | M37066.937645 |
| Flatbush Community Hall | NW 06-066-01 W5M | Surficial | 29-Sep-74 | 38.71 | 127.0 | 8.02 | 26.3 | M35379.096289 |
| Fleming | 06-30-069-24 W4M | Upper Surficial | 23-Jun-74 | 8.4 | 27.6 | 7 | 23.0 | M36477.802617 |
| Heffel, Danny | SW 16-067-01 W5M | Foremost | 22-May-86 | 56.39 | 185.0 | 10.67 | 35.0 | M35379.061582 |
| Kubel, Nelson | 06-07-073-05 W5M | Upper Surficial | 10-May-84 | 13.41 | 44.0 | 1.52 | 5.0 | M35379.127657 |
| Maxwell Energy Corporation | 04-02-073-04 W5M | Surficial | 04-Mar-94 | 101.8 | 334.0 | 4.27 | 14.0 | M35379.104487 |
| Mendryk, Stan | NW 19-065-01 W5M | Surficial | 01-Mar-71 | 27.13 | 89.0 | 5.18 | 17.0 | M35379.096110 |
| Mittelstadt, Richard | NE 05-066-01 W5M | Foremost | 01-Dec-82 | 50.29 | 165.0 | 28.95 | 95.0 | M35379.064770 |
| Ntonowich, Walter | SW 08-066-01 W5M | Foremost | 05-Sep-78 | 24.69 | 81.0 | -0.3 | -1.0 | M35379.096481 |
| Owens, Sid | 02-28-070-01 W5M | Upper Surficial | 03-Jun-82 | 15.85 | 52.0 | 11.28 | 37.0 | M35379.126880 |
| Penner, Jake & Clara | SE 05-074-08 W5M | Lower Surficial | 12-May-85 | 6.71 | 22.0 | 3.66 | 12.0 | M35379.128069 |
| Reason, Rob | NW 11-069-01 W5M | Foremost | 27-Oct-80 | 79.24 | 260.0 | 22.55 | 74.0 | M35379.096747 |
| Sam Labacon Centre | NE 36-072-04 W5M | Upper Surficial | 25-Jul-84 | 11.9 | 39.0 | 0.6 | 2.0 | M36076.566313 |
| Schultz, Clara L | NW 23-065-01 W5M | Upper Surficial | 04-Jul-75 | 22.55 | 74.0 | 19.2 | 63.0 | M35379.096128 |
| Smith Curling Rink | 02-23-071-01 W5M | Surficial | 02-Oct-74 | 23.77 | 78.0 | 17.74 | 58.2 | M35379.077751 |
| Smith School | ··-23-071-01 W5M | Lower Surficial | 29-May-62 | 12.19 | 40.0 | 8.23 | 27.0 | M35379.128220 |
| Strach, Randy | NW 21-066-01 W5M | Foremost | 28-Oct-86 | 36.57 | 120.0 | 7.62 | 25.0 | M35379.097116 |
| Trans World Oil And Gas Ltd. | 02-35-072-04 W5M | Surficial | 04-Aug-00 | 108.2 | 355.0 | 13.13 | 43.1 | M36754.408844 |
| Zemrau | NE 01-073-26 W4M | Upper Surficial | 22-Oct-77 | 75.59 | 248.0 | 64.75 | 212.4 | M35377.050554 |
| | 11-19-069-24 W4M | Upper Surficial | 05-Jul-74 | 32.9 | 107.9 | 18.29 | 60.0 | M36477.802536 |

## M.D. OF LESSER SLAVE RIVER-OPERATED WATER WELLS

| | | Aquifer | Date Water | Completed Depth | | NPWL | | |
|---|---|---|---|---|---|---|---|---|
| Owner | Location | Name | Well Drilled | Metres | Feet | Metres | Feet | UID |
| Alberta Environment | 08-10-072-01 W5M | Surficial | 28-May-87 | 51.81 | 170.0 | 39.01 | 128.0 | M35379.067934 |
| Alberta Environment | SW 36-069-25 W4M | Upper Surficial | 02-May-88 | 6.1 | 20.0 | 1.28 | 4.2 | M35377.198429 |
| Alberta Environment | SW 02-072-01 W5M | Upper Surficial | 02-May-88 | 15.24 | 50.0 | 12.24 | 40.2 | M35379.077850 |
| Alberta Environment | NW 18-075-06 W5M | Upper Surficial | 01-Mar-00 | 16.15 | 53.0 | 4.86 | 15.9 | M37066.932771 |
| Chisholm, Hamlet Of/ALTA Env | SE 25-068-02 W5M | Surficial | 23-Aug-80 | 40.84 | 134.0 | 27.74 | 91.0 | M35379.097072 |
| Cross Lake Prov Park | 11-23-065-27 W4M | Foremost | 17-Mar-77 | 23.47 | 77.0 | | | M35377.172982 |
| Cross Lake Prov Park | SW 23-065-26 W4M | Surficial | 15-Mar-79 | 73.15 | 240.0 | 6.71 | 22.0 | M35377.172978 |
| Cross Lake Prov Park | 11-23-065-27 W4M | Surficial | 16-Mar-77 | 23.47 | 77.0 | | | M35377.172985 |
| Cross Lake Prov Park | NW 23-065-27 W4M | Surficial | 30-Sep-76 | 23.47 | 77.0 | 2.13 | 7.0 | M35377.172986 |