1. Project Overview

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

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

The regional groundwater assessment will:

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

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

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

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

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

Appendix C includes the following:

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

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

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

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

Appendix F includes page-size copies of figures combining the M.D. of Bonnyville and Lakeland County.

[3] See glossary

2. Introduction

2.1 Setting

The M.D. of Bonnyville is situated in east-central Alberta. This area is part of the Alberta High Plains portion of the Interior Plains region (Ozoray, Wallick and Lytviak, 1980). The study area, defined here as 'the M.D.', includes parts of the area bounded by townships 055 to 066, ranges 01 to 10, west of the 4th Meridian. The province of Saskatchewan forms the eastern boundary of the M.D. The other M.D. boundaries follow township or section lines. The M.D. occupies part of the Churchill and North Saskatchewan River Basins.

Regionally, the topographic surface ranges from less than 525 to more than 725 metres above mean sea level (AMSL). The lowest elevations occur along the Beaver River (see overlay) where it leaves the M.D. in township 061, and the highest elevations are in the northwestern parts of the M.D., as shown on Figure 1 and Page A-3. The area is well drained by numerous streams, the main ones being the Beaver and Sand rivers.

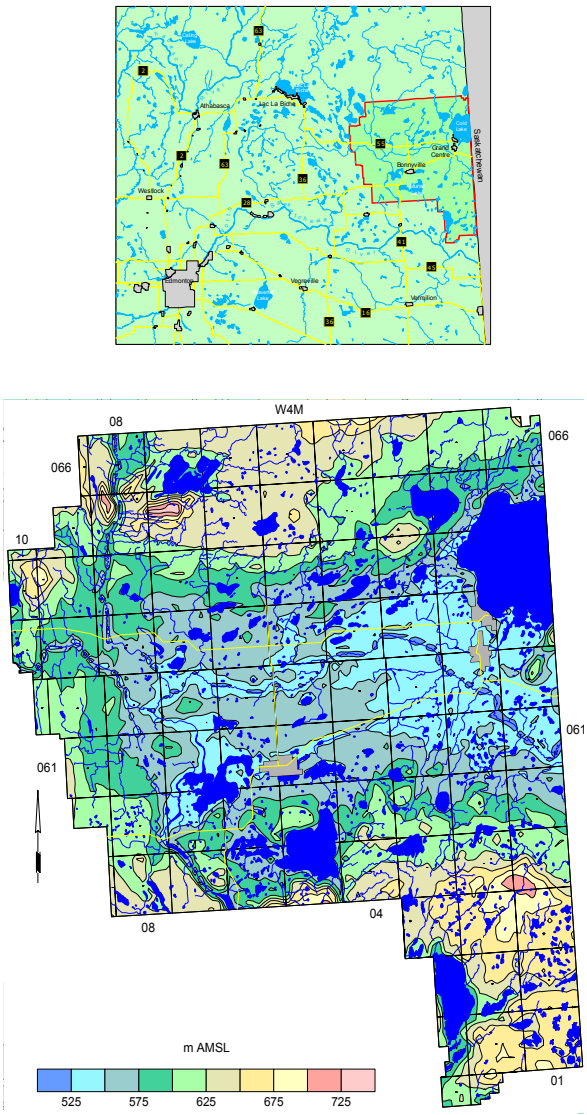

Figure 1. Index Map

2.2 Climate

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

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

The mean annual precipitation averaged from the Cold Lake meteorological station within the M.D. measured 433 millimetres (mm), based on data from 1952 to 1993. The annual temperature averaged 1.4° C, with the mean monthly temperature reaching a high of 17.0 °C in July, and dropping to a low of -17 °C in January. The calculated annual potential evapotranspiration is 508 millimetres.

2.3 Background Information

2.3.1 Number, Type and Depth of Water Wells

There are currently records for 5,858 water wells in the groundwater database for the M.D., of which a proposed use is available for 5,167 water wells. Of the 5,167 water wells, 4,844 (94%) are for domestic/stock purposes. The remaining 323 water wells were completed for a variety of uses, including municipal, industrial, observation, irrigation, investigation, dewatering and monitoring. Based on a rural population of 8,069 (Phinney, 2002), there are 1.9 domestic/stock water wells per family of four. Of the 4,650 domestic or stock water wells with a completed depth, 3,954 (85%) are completed at depths of less than 50 metres below ground level. Details for lithology[4] are available for 3,635 water wells.

2.3.2 Number of Water Wells in Surficial and Bedrock Aquifers

There are 2,432 water well records with completion interval and lithologic information, such that the aquifer in which the water wells are completed can be identified. The water wells that were not drilled deep enough to encounter the bedrock plus water wells that have the bottom of their completion interval above the top of the bedrock are water wells completed in surficial aquifers. Of the 2,432 water wells for which aquifers could be defined, 2,425 (99.7%) are completed in surficial aquifers, with 75% having a completion depth of less than 50 metres below ground level. From Figure 2, it can be seen that most water wells in the M.D. are completed in aquifers in the upper surficial deposits. The water wells completed in the lower surficial deposits mainly occur along the linear bedrock lows. The lowest elevation of the linear bedrock low is the thalweg.

The data for seven 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.

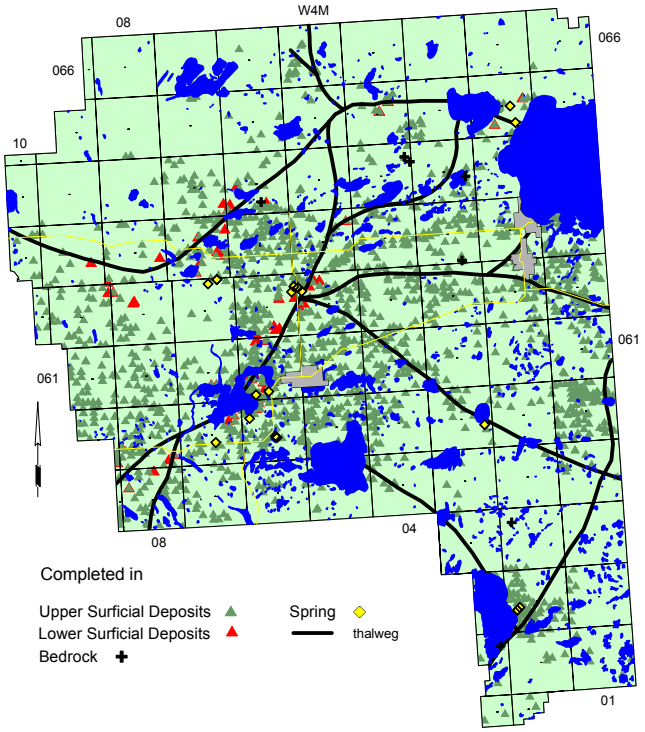

Figure 2. Location of Water Wells and Springs

There are currently records for 18 springs in the groundwater database; these springs generally occur in the vicinity of linear bedrock lows and are mainly at a surface elevation of less than 525 metres AMSL. Of the 14 springs having total dissolved solids (TDS) values, eleven have TDS concentrations of less than 1,000 milligrams per litre (mg/L). The springs have total hardness values that average 321 mg/L. There are no available flow rates in the groundwater database for the springs within the M.D.

[4] See glossary

2.3.3 Casing Diameter and Type

Data for casing diameters are available for 3,678 water wells, with 2,282 (62%) indicated as having a diameter of less than 275 mm and 1,396 water wells having a surface-casing diameter of more than 275 mm. The casing diameters of greater than 275 mm are mainly bored or dug water wells and those with a surface-casing diameter of less than 275 mm are drilled water wells. In addition to the 3,678 water wells that have been designated as either bored or drilled water wells based on casing diameter, another 830 water wells have been designated as bored or drilled water wells based on the drilling method only, with no casing size indicated on the water well record. Of the 830 water wells having no casing size, 384 are drilled water wells and 446 are bored water wells. Of the 4,508 drilled and bored water wells, 3,650 have a completion date and a completion depth. From 1965 to 2000, most of the water wells completed in the M.D. were drilled. The completion depths of drilled water wells are mainly greater than 50 metres and for bored water wells are mainly less than 30 metres (see CD-ROM).

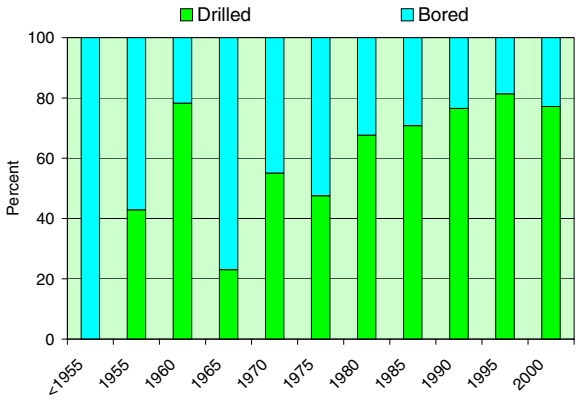

Figure 3. Casing Diameter Used in Water Wells

In the M.D., steel, galvanized steel and plastic surface casing materials have been used in 99% of the drilled water wells over the last 40 years. Until the mid-1960s, the type of surface casing used in drilled water wells was mainly undocumented. Steel casing was predominantly used in drilled water wells in the 1960s and 1970s but is currently being used in only 4% of the water wells drilled in the M.D. Galvanized steel surface casing was used in a maximum of 30% of the drilled water wells from the 1970s to the 1980s. Galvanized steel was last used in October 1984. Plastic casing was first used in May 1975 and is currently being used in 96% of the drilled water wells in the M.D.

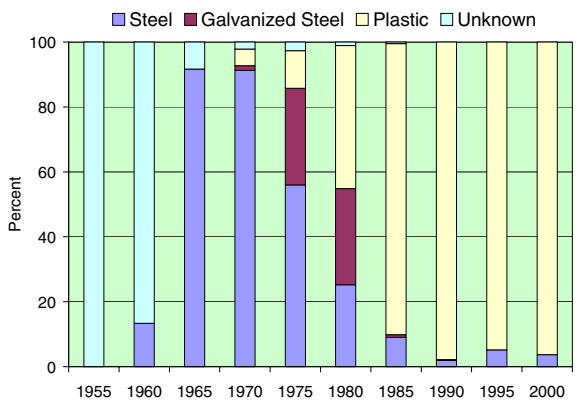

Figure 4. Surface Casing Types Used in Drilled Water Wells

2.3.4 Dry Water Test Holes

In the M.D., there are 7,109 records in the groundwater database. Of these 7,109 records, 171 are indicated as being dry or abandoned with “insufficient water”.

2.3.5 Requirements for Licensing

Water wells used for household needs in excess of 1,250 cubic metres per year (748 imperial gallons per day[5]) and all other groundwater use must be licensed. The only groundwater uses that do not need licensing are (1) household use of up to 1,250 m³/year and (2) groundwater with total dissolved solids in excess of 4,000 mg/L. In the last update from the Alberta Environment (AENV) groundwater database in September 2001, 139 groundwater allocations were shown to be within the M.D. Of the 139 licensed groundwater users, 94 (**which is 67% of all licensed water wells**) could be linked to the AENV groundwater database. Of the 139 licensed groundwater users, 66 are for agricultural purposes, 20 are for industrial, 17 are for exploration purposes, 11 are for municipal, seven are for commercial, six are for dewatering, and the remaining 12 are for registration, irrigation and recreation purposes. The total maximum authorized diversion from the water wells associated with

[5] see conversion table on page 57

these licences is 34,560 cubic metres per day (m³/day), although actual use could be less. Of the 34,560 m³/day, 23,398 m³/day (68%) is authorized for industrial purposes and 6,840 m³/day (20%) is for exploration purposes. The remaining 3,822 m³/day (11%) is allotted for dewatering, municipal and agricultural use as shown below in Table 1. A figure showing the locations of the licensed users is in Appendix A (Page A-7) and on the CD-ROM. Table 1 also shows a breakdown of the 139 licensed groundwater allocations by the aquifer in which the water well is completed. The largest total licensed allocations are in the Empress – Unit 3 and Bonnyville aquifers. Of the 9,265.9 m³/day licensed groundwater use in the Empress Aquifer – Unit 3, 89% of the groundwater allocation is from six injection water wells in 12-10-066-05 W4M.

	No. of	Licensed Groundwater Users* (m³/day)										
Aquifer **	Diversions	Agricultural	Commercial	Dewatering	Exploration	Industrial	Irrigation	Municipal	Recreation	Registry	Total	Percentage
Upper Surficial	26	111.5	0.0	0.0	0.0	1,702.2	0.0	0.0	0.0	12.4	1,826.1	5
Grand Centre	8	59.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	59.8	0
Sand River	2	13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	0
Marie Creek	17	72.7	3.4	1,841.8	0.0	0.0	3.4	0.0	0.0	0.0	1,921.3	6
Ethel Lake	7	32.1	3.4	0.0	0.0	0.0	0.0	13.5	23.6	0.0	72.6	0
Bonnyville	19	84.5	0.0	0.0	0.0	6,228.1	0.0	101.4	0.0	2.2	6,416.2	19
Muriel Lake	8	98.1	0.0	0.0	0.0	0.0	0.0	398.8	0.0	0.0	496.9	1
Bronson Lake	9	59.8	0.0	0.0	0.0	1,702.2	0.0	310.9	0.0	0.0	2,072.9	6
Empress - Unit 3	21	96.0	50.7	0.0	0.0	8,214.4	0.0	898.0	6.8	0.0	9,265.9	27
Empress - Unit 1	4	10.1	0.0	0.0	0.0	4,250.2	0.0	13.5	0.0	0.0	4,273.8	12
Bedrock	1	0.0	0.0	0.0	0.0	1,301.1	0.0	0.0	0.0	0.0	1,301.1	4
Unknown	17	0.0	0.0	0.0	6,840.0	0.0	0.0	0.0	0.0	0.0	6,840.0	20
Total	139	637.8	57.5	1,841.8	6,840.0	23,398.2	3.4	1,736.1	30.4	14.9	34,560.1	100
Percentage		2	0	5	20	68	0	5	0	0	100	

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

Table 1. Licensed Groundwater Diversions

Based on the 2001 Agriculture Census, the calculated water requirement for 166,774 livestock for the M.D. is in the order of 8,776 m³/day. This value does not include domestic animals, but does include intensive livestock use. Of the 8,776 m³/day average calculated livestock use, AENV has licensed a groundwater diversion of 638 m³/day (7%) and licensed a surface-water diversion of 107 m³/day (<1%). The remaining 93% of the calculated livestock use would have to be from unlicensed sources.

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[6] method to prepare a depth to the Base of Groundwater Protection surface. This depth, for the most part, would be the maximum drilling depth for a water well for agricultural purposes or for a potable water supply. If a water well has total dissolved solids exceeding 4,000 mg/L, the groundwater use does not require licensing by AENV. In the M.D., the depth to Base of Groundwater Protection ranges from less than 40 metres to more than 220 metres below ground level in the western part of the M.D., as shown on Figure 5 and on some cross-sections presented in Appendix A, and on the CD-ROM. The main area where the depth to Base of Groundwater Protection is less than 40 metres is south of the Town of Bonnyville.

[6] See glossary