

The Bronson Lake Formation overlies the Empress Formation and consists of glacial clayey till and clay and has an average thickness of less than ten metres. “The Bronson Lake Formation lies primarily within or along segments of the major buried valleys and channels”.

The Muriel Lake Formation overlies the Bronson Lake Formation and consists of glacial sand and gravel and is approximately 35 metres thick. “The Muriel Formation lies both within segments of the buried valleys and (meltwater) channels.”

There are two units that comprise the overlying Bonnyville Formation. Unit 1 overlies the Muriel Lake Formation and is composed of approximately 25 metres of clayey till. Unit 2 is composed of approximately 25 metres of sandy till. In the M.D., the Bonnyville Formation is the only widespread formation that is continuous.

The glaciolacustrine silt and clay, and minor sand and gravel deposits of the overlying Ethel Lake Formation, have an average thickness of two metres. In the M.D., the Ethel Lake Formation is widespread, but not continuous.

The overlying Marie Creek Formation is broken down into two units, each approximately 25 metres thick. Unit 2 is composed of clayey till and Unit 1 is characterized by a coarse sand deposit. The upper part of the Marie Creek Formation outcrops, as shown on Figure 13.

The overlying Sand River Formation consists of up to 25 metres of sand and gravel. The Formation is primarily recognized in outcrops and test holes.

The Grand Centre Formation is the uppermost Quaternary stratigraphic formation, exposed at surface, and is mainly less than 25 metres thick. There are four members that comprise the Grand Centre Formation and have been defined based on grain size. The four members are: the Vilna, Kehiwin, Reita Lake and Hilda Lake members. The Vilna and Hilda Lake members are glacial clayey till deposits, and the Kehiwin and Reita Lake members are clayey till deposits overlain by stratified sand and gravel in places (Andreashek and Fenton, 1989).

5.3.2 Aquifers

Of the 2,432 water well records with completion interval and lithologic information, such that the aquifer in which the water wells are completed could be defined, 2,425 are completed in surficial aquifers.

Assigning the water well to specific geologic units is possible only if the completion interval is identified. With this information, it has been possible to designate the specific surficial aquifer of completion for 2,405 water wells. Of the 2,405 water wells, 2,295 are water wells completed in the upper surficial deposits and 110 are completed in the lower surficial deposits. The remaining 20 of the total 2,425 surficial water wells are identified as being completed in more than one surficial aquifer. The surficial water wells are mainly completed in the Marie Creek, Bonnyville, and the Empress – Unit 3 aquifers, as shown in the adjacent table.

Geologic Unit	No. of Surficial Water Wells
Upper Surficial Deposits	
Grand Centre	157
Sand River	56
Marie Creek	581
Ethel Lake	237
Bonnyville	572
Muriel Lake	198
Bronson Lake	69
Empress - Unit 3	425
Empress - Unit 2	0
<i>Total</i>	2,295
Lower Surficial Deposits	
Empress - Unit 1	110
Multiple Completions	20
<i>Total</i>	2,425

Table 2. Completion Aquifer

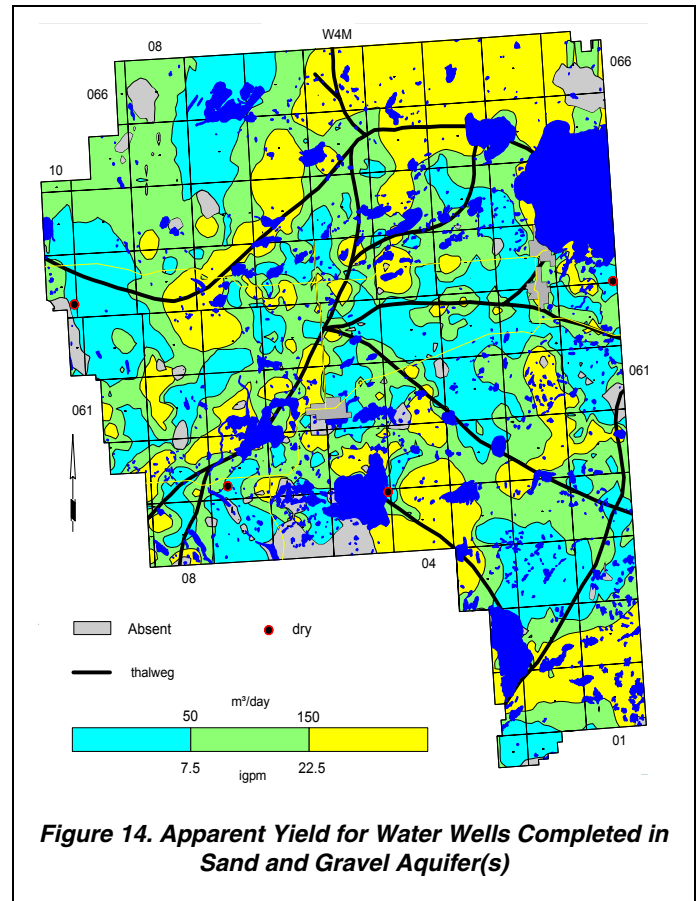
5.3.3 Sand and Gravel Aquifer(s)

The primary sources of groundwater in the M.D. are the aquifers in the surficial deposits. Since the sand and gravel aquifer(s) are not everywhere, the actual aquifer that is developed at a given location is usually dictated by the aquifer that is present. In the M.D., the thickness of the sand and gravel aquifer(s) is generally less than 30 metres, but can be more than 30 metres at the confluence of the Buried Helena and Sinclair valleys (Page A-20 and on CD-ROM). The non-pumping water-level surface in the sand and gravel aquifer(s) is a subdued replica of the topographic surface (see CD-ROM) and is sloped toward the Beaver River.

The adjacent map shows expected yields for water wells completed in sand and gravel aquifer(s). Over approximately 5% 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., there are 1,582 surficial water wells that have apparent yield values. The locations of four dry test holes are shown on the adjacent figure. Based on the aquifers that have been developed by existing water wells, these data show that water wells with yields of more than 50 m³/day from sand and gravel aquifer(s) can be expected in most of the M.D. The most notable areas where yields of more than 100 m³/day are expected are mainly in association with the buried bedrock valleys. The apparent yields tend to be more variable in areas of meltwater channels.

Of the 1,582 water well records with apparent yield values, 1,575 have been assigned to aquifers associated with specific geologic units. Forty-seven percent (742) of the 1,582 water wells completed in



the sand and gravel aquifer(s) have apparent yields that are less than 50 m³/day, 26% (419) have apparent yield values that range from 50 to 150 m³/day, and 27% (421) have apparent yields that are greater than 150 m³/day, as shown in Table 3.

Aquifer	No. of Water Wells with Values for Apparent Yield	Number of Water Wells with Apparent Yields		
		<50 m ³ /day	50 to 150 m ³ /day	>150 m ³ /day
Grand Centre	77	61	13	3
Sand River	39	25	8	6
Marie Creek	374	237	91	46
Ethel Lake	170	84	46	40
Bonnyville	376	183	106	87
Muriel Lake	150	48	46	56
Bronson Lake	50	13	12	25
Empress - Unit 3	259	80	71	108
Empress - Unit 2	0	0	0	0
Empress - Unit 1	80	10	26	44
Multiple Completions	7	1	0	6
Totals	1,582	742	419	421

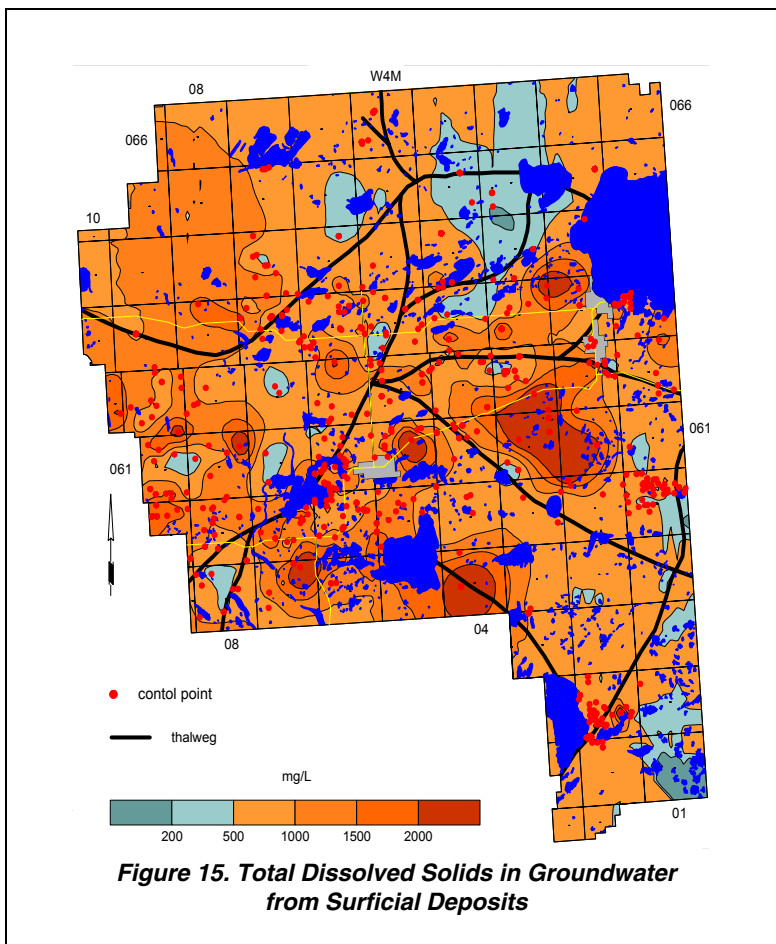
Table 3. Apparent Yield of Sand and Gravel Aquifer(s)

5.3.3.1 Chemical Quality of Groundwater from Surficial Deposits

The chemical analysis results of groundwaters from the surficial deposits indicate the groundwaters are generally chemically hard and high in dissolved iron. In the M.D. of Bonnyville, groundwaters from the surficial aquifers mainly have a chemical hardness of greater than 100 mg/L (see CD-ROM).

The Piper tri-linear diagram¹³ for surficial deposits (Page A-25) shows the groundwaters are mainly calcium-magnesium-bicarbonate-type waters. More than 80% of the groundwaters from the surficial deposits have a TDS concentration of more than 500 mg/L. Groundwaters having TDS concentrations of less than 500 mg/L occur mainly in the vicinity of the confluence of the Moore Lake Channel and the Buried Helena Valley. Groundwaters having TDS concentrations of more than 2,000 mg/L occur mainly east of the Buried Beverly Valley. The highest median TDS concentrations occur below the Ethel Lake Aquifer (see Tables 5 to 13).

There are groundwaters with sulfate as the main anion. The groundwaters with elevated levels of sulfate generally occur in areas where there are elevated levels of total dissolved solids. There are very few groundwaters from the surficial deposits with appreciable concentrations of the chloride ion and in 87% of the samples analyzed for surficial deposits in the M.D., the chloride ion concentration is less than 100 mg/L (see CD-ROM). The highest median chloride concentrations occur below the Bonnyville Aquifer (see Tables 5 to 13).



Constituent	No. of Analyses	Range for M.D. in mg/L			Recommended Maximum Concentration GCDWQ
		Minimum	Maximum	Median	
Total Dissolved Solids	663	85	6846	748	500
Sodium	610	4	1650	112	200
Sulfate	667	0	3900	92	500
Chloride	673	0	1500	10	250
Nitrate + Nitrite (as N)	470	0	52	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 Subcommittee on Drinking Water, March 2001

Table 4. Concentrations of Constituents in Groundwaters from Surficial Aquifers

In the M.D, 99% of the samples from surficial deposits analyzed for nitrate + nitrite (as N) concentrations are below the maximum acceptable concentrations (MAC) of 10 mg/L (see 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 SGCDWQ in the adjacent table. Of the five constituents that have been compared to the SGCDWQ, the median value of the TDS concentration exceeds the guidelines.

¹³ See glossary

5.3.4 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 isolated deposits are expected over approximately 95% of the M.D.

5.3.4.1 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 generally less than ten metres, but can be more than 20 metres in the linear bedrock lows (see CD-ROM).

5.3.4.2 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 anticipated groundwater apparent yield in the Upper Sand and Gravel Aquifer is based on the expected yields of single water wells obtaining water from the total accessible seven glacial aquifers that comprise the Upper Sand and Gravel Aquifer.

The apparent yields for water wells completed through this Aquifer are expected to be mainly less than 150 m³/day, as shown on the adjacent figure. The large area of higher yields shown in the northeastern part of the M.D. is based on a few control points.

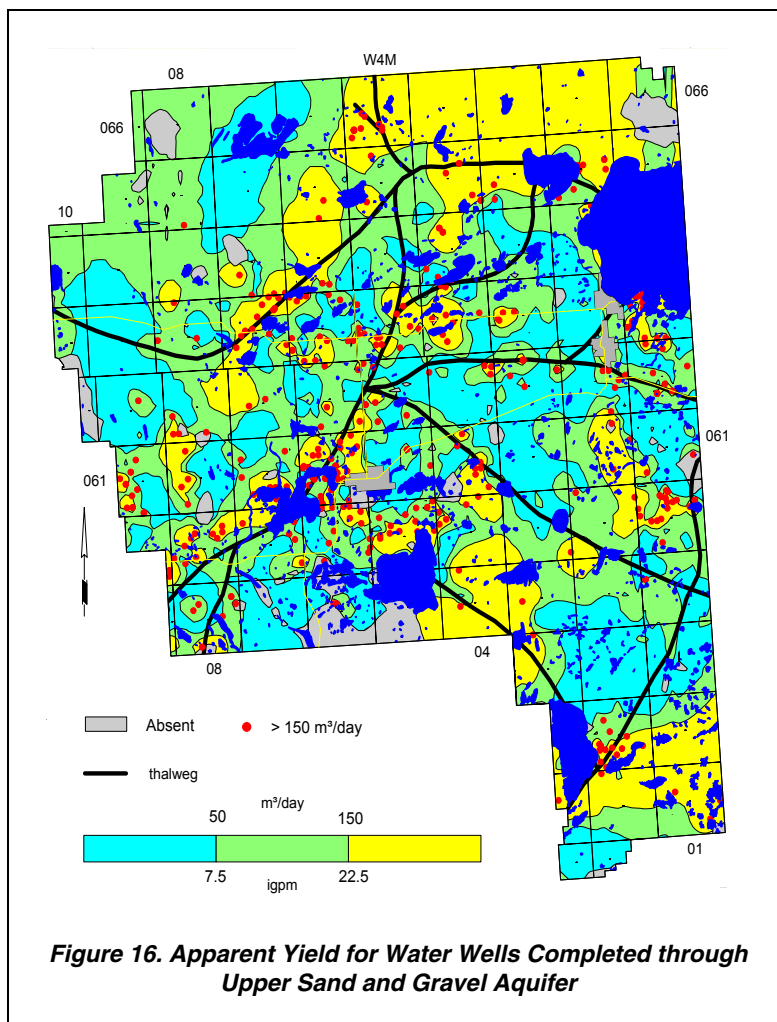


Figure 16. Apparent Yield for Water Wells Completed through Upper Sand and Gravel Aquifer

5.3.5 Grand Centre Aquifer

The Grand Centre Aquifer comprises the permeable parts of the Grand Centre Formation, as defined for the present program. The Grand Centre Formation is the uppermost formation, is present over most of the M.D., and has a thickness that is mainly less than 25 metres.

5.3.5.1 Depth to Top

The depth to the top of the Grand Centre Formation is a function of the thickness of the postglacial stratified deposits. The Grand Centre Formation lies at the surface in most places, except where it is buried by postglacial stratified sediment (Andriashek and Fenton, 1989).

5.3.5.2 Apparent Yield

The apparent yields for individual water wells completed through the Grand Centre Aquifer are mainly in the range of 20 to 50 m³/day, with nearly 80% of the values being less than 50 m³/day (Table 3). Shown on the adjacent map is the location of one dry test hole in 02-01-063-01 W4M.

In the M.D., there are eight licensed groundwater water wells completed through the Grand Centre Aquifer, with a total authorized diversion of 60 m³/day; seven of the eight licensed users are for agricultural purposes. Five of the eight licensed water wells could be linked to a water well in the AENV groundwater database.

5.3.5.3 Quality

The groundwaters from the Grand Centre Aquifer are a calcium-magnesium-bicarbonate type (see Piper diagram on 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 Grand Centre Aquifer in the M.D. have been compared to the SGCDWQ and median

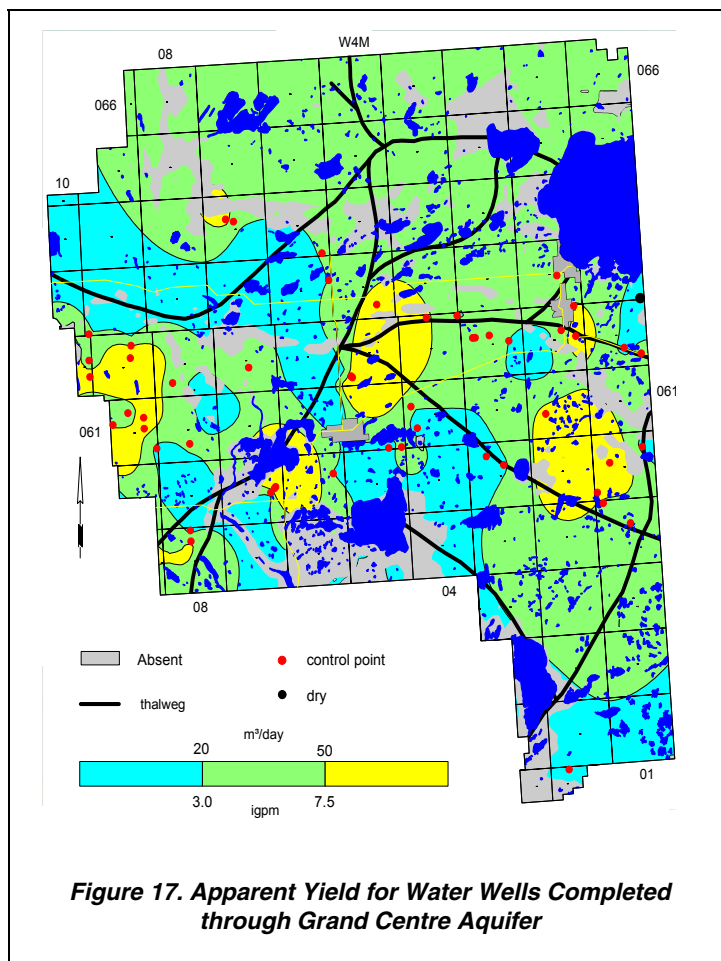


Figure 17. Apparent Yield for Water Wells Completed through Grand Centre Aquifer

Constituent	No. of Analyses	Range for M.D. in mg/L			All Surficial Median	Recommended Maximum Concentration GCDWQ
		Minimum	Maximum	Median		
Total Dissolved Solids	34	108	3586	554	748	500
Sodium	29	6.3	423	32	112	200
Sulfate	34	0	2071	46	92	500
Chloride	34	0	92	3	10	250
Nitrate + Nitrite (as N)	23	0	31	0.0	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)
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Table 5. Concentrations of Constituents in Groundwaters from Grand Centre Aquifer

concentrations from all surficial deposits in the adjacent table. Of the five constituents that have been compared to the SGCDWQ, the median value of the TDS concentration exceeds the guidelines but is below the median value of TDS for all surficial deposits.

The median concentrations of TDS, sodium, sulfate and chloride from water wells completed in the Grand Centre Aquifer are below the median concentrations from water wells completed in all surficial deposits.

5.3.6 Sand River Aquifer

The Sand River Aquifer comprises the permeable parts of the Sand River Formation, which underlies the Grand Centre Formation. Structure contours have been prepared for the top of the Sand River Formation. The structure contours show the Sand River Formation ranges in elevation from less than 550 to more than 675 metres AMSL and has a thickness of in the order of 25 metres (see CD-ROM).

5.3.6.1 Depth to Top

The depth to the top of the Sand River Formation ranges from less than five metres below ground level to more than 15 metres at the Formation edges (Page A-30).

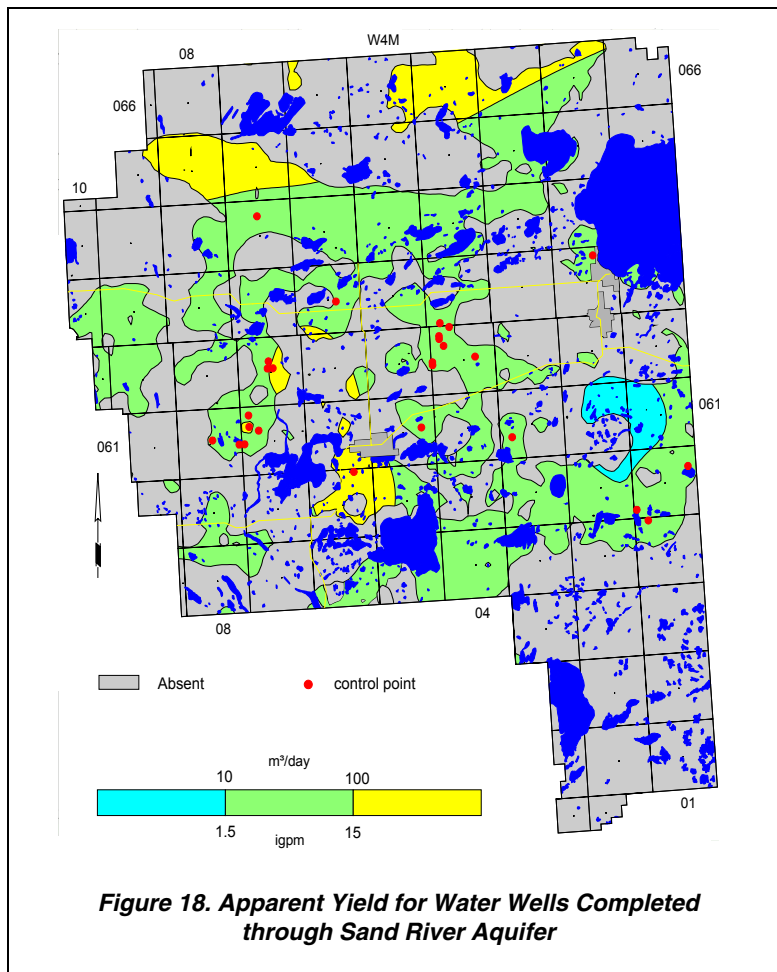
5.3.6.2 Apparent Yield

The apparent yields for individual water wells completed through the Sand River Aquifer range mainly from 10 to 100 m³/day. The largest number of control points are in townships 061 and 062, ranges 03 to 05, and ranges 07 and 08, W4M. In the M.D., there are no control points from the groundwater database for the Sand River Aquifer north of township 064, W4M.

In the M.D., there are two licensed water wells that are completed in the Sand River Aquifer, with a total authorized diversion of 13.5 m³/day; both are for agricultural purposes. Both licensed water wells could be linked to a water well in the AENV groundwater database.

5.3.6.3 Quality

There are sufficient data from three water wells to determine the groundwater type from the Sand River Aquifer; these data show that the groundwaters are calcium-magnesium bicarbonate and calcium-magnesium-sulfate types (see Piper diagram on 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 Sand River Aquifer in



the M.D. have been compared to the SGCDWQ and median concentrations from all surficial deposits in the adjacent table. None of the median values of the five constituents that have been compared to the SGCDWQ exceed the guidelines.

The median concentrations of TDS, sodium, sulfate and chloride from water wells completed in the Sand River Aquifer are below the median concentrations from water wells completed in all surficial deposits.

Constituent	No. of Analyses	Range for M.D. in mg/L			All Surficial Median	Recommended Maximum Concentration GCDWQ
		Minimum	Maximum	Median		
Total Dissolved Solids	11	252	1196	465	748	500
Sodium	11	4	146	21	112	200
Sulfate	11	0	333	21	92	500
Chloride	11	0	27	2	10	250
Nitrate + Nitrite (as N)	7	0	1	0.0	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)
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 Federal-Provincial Subcommittee on Drinking Water, March 2001

Table 6. Concentrations of Constituents in Groundwaters from Sand River Aquifer