5.3.6 *Marine* Foremost Aquifer

There is no detailed discussion for the *marine* Foremost Aquifer in this report; however, a discussion of the four sandstone members that comprise the *marine* Foremost Aquifer is provided in the following sections.

5.3.7 Birch Lake Aquifer

The Birch Lake Aquifer comprises the porous and permeable parts of the Birch Lake Member. Structure contours have been prepared for the top and bottom of the Member, which underlies the southeastern two-thirds of the M.D. The structure contours show the Member being mostly less than 30 metres thick. The thickness of the Birch Lake Member is generally less than 20 metres in the southern part of the M.D., or the Member is absent.

5.3.7.1 Depth to Top

The depth to the top of the Birch Lake Member is mainly less than 80 metres below ground level, but can be more than 180 metres in the southern part of the M.D.

5.3.7.2 Apparent Yield

The apparent yields for individual water wells completed through the Birch Lake Aquifer are mainly in the range of 30 to 100 m³/day. The areas where water wells with higher yields are expected are mainly in the northwestern and eastern parts of the M.D.

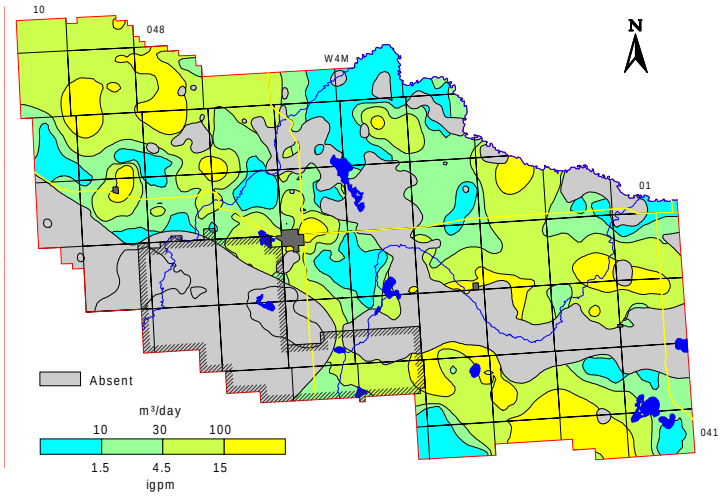

Figure 21. Apparent Yield for Water Wells Completed through Birch Lake Aquifer

A groundwater program was completed for the Village of Irma in 1982 in 16-28-045-09 W4M. A water test hole was completed in the Birch Lake Aquifer to be used as a water supply well. A 50-hour pumping and recovery aquifer test conducted with this water test hole indicated a long-term yield of 230 m³/day (Hydrogeological Consultants Ltd., June 1982).

5.3.7.3 Quality

The groundwaters from the Birch Lake Aquifer are mainly sodium-bicarbonate or sodium-sulfate types (see CD-ROM). The TDS concentrations are expected to be mainly less than 1,500 mg/L. The higher values are expected to be in the northwestern part of the M.D. The sulfate concentrations are mainly less than 500 mg/L. Chloride concentrations in the groundwaters from the Birch Lake Aquifer are mainly less than 100 mg/L.

5.3.8 Ribstone Creek Aquifer

The Ribstone Creek Aquifer comprises the porous and permeable parts of the Ribstone Creek Member. Structure contours have been prepared for the top and bottom of the Member, which underlies 90% of the M.D. The structure contours show the Member being mostly less than 20 metres thick.

5.3.8.1 Depth to Top

The depth to the top of the Ribstone Creek Member is mainly less than 120 metres below ground level but can be more than 220 metres in the southeastern part of the M.D.

5.3.8.2 Apparent Yield

The apparent yields for individual water wells completed through the Ribstone Creek Aquifer are mainly in the range of 10 to 100 m³/day. The areas where water wells with higher yields are expected are mainly in the northwestern and southeastern parts of the M.D.

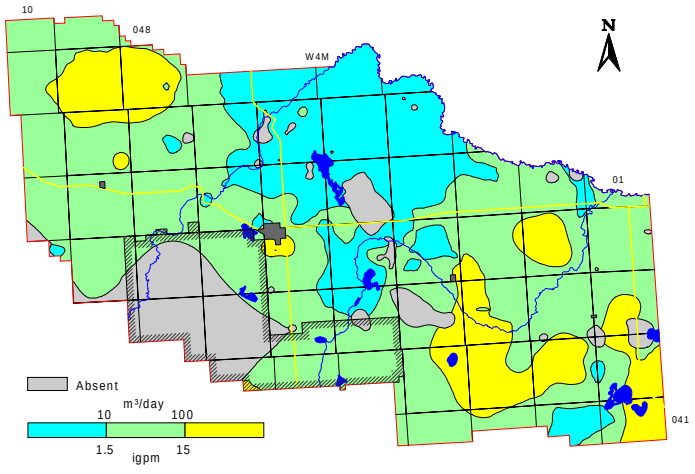

Figure 22. Apparent Yield for Water Wells Completed through Ribstone Creek Aquifer

A study conducted for the Village of Edgerton indicated a long-term yield of 229 m³/day for a water supply well completed in the Ribstone Creek Aquifer (Hydrogeological Consultants Ltd., March 1983).

5.3.8.3 Quality

The groundwaters from the Ribstone Creek Aquifer are mainly a sodium-bicarbonate type (see CD-ROM). The TDS concentrations range from less than 500 to more than 1,500 mg/L. The sulfate concentrations are mainly less than 500 mg/L. Chloride concentrations in the groundwaters from the Ribstone Creek Aquifer are mainly less than 250 mg/L. The higher chloride values occur primarily in the southeastern part of the M.D.

5.3.9 Victoria Aquifer

The Victoria Aquifer comprises the porous and permeable parts of the Victoria Member. Structure contours have been prepared for the top and bottom of the Member, which underlies the M.D. The structure contours show the Member being mostly less than 30 metres thick.

5.3.9.1 Depth to Top

The depth to the top of the Victoria Member is mainly less than 140 metres below ground level but can be more than 220 metres in the southern part of the M.D.

5.3.9.2 Apparent Yield

The apparent yields for individual water wells completed through the Victoria Aquifer are mainly in the range of 10 to 100 m³/day. The areas where water wells with higher yields are expected are mainly in the central parts of the M.D., particularly in ranges 03 through 06, W4M.

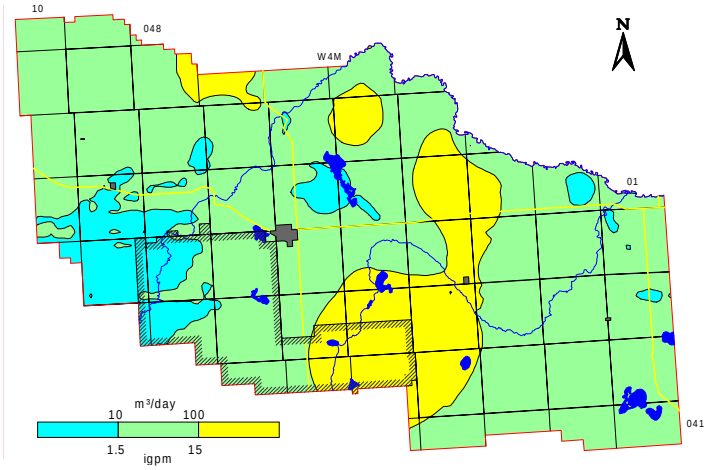

Figure 23. Apparent Yield for Water Wells Completed through Victoria Aquifer

The Victoria Aquifer was encountered by water test holes drilled for Husky Oil Operations Ltd. in SW 09-046-06 W4M. The projected long-term yield from one of the water test holes completed in the Victoria Aquifer is more than 100 m³/day (Hydrogeological Consultants Ltd., April 1985b). This long-term yield of 100 m³/day is higher than the apparent yields determined from individual water wells completed through the Victoria Aquifer.

5.3.9.3 Quality

The groundwaters from the Victoria Aquifer range from being sodium-bicarbonate to calcium-magnesium-chloride types (see CD-ROM). The TDS concentrations range from less than 500 to more than 2,000 mg/L; the values increase mainly to the north. The sulfate concentrations are mainly less than 250 mg/L. Chloride concentrations in the groundwaters from the Victoria Aquifer are mainly less than 250 mg/L. The higher values are expected in the central and eastern parts of the M.D.

5.3.10 Brosseau Aquifer

The Brosseau Aquifer comprises the porous and permeable parts of the Brosseau Member. Structure contours have been prepared for the top and bottom of the Member, which underlies the western two-thirds of the M.D. The structure contours show the Member being mostly less than 20 metres thick. The amount of hydrogeological information for the Brosseau Aquifer interval is very limited.

5.3.10.1 Depth to Top

The depth to the top of the Brosseau Member is mainly less than 160 metres below ground level but can be more than 280 metres in the southern part of the M.D.

5.3.10.2 Apparent Yield

There are eight water well records in the database with sufficient information to calculate apparent yields for individual water wells completed through the Brosseau Aquifer. Half of the apparent yields are less than 50 m^3/day and the other half are greater than 250 m^3/day, with the largest being 1,530 m^3/day.

The Brosseau Aquifer was encountered by at least three water test holes drilled for Husky Oil Operations Ltd. in 12-14-045-06 W4M. The projected long-term yield for one of the water test holes completed in the Brosseau Aquifer is 140 m^3/day (Hydrogeological Consultants Ltd., April 1985c).

5.3.10.3 Quality

There are four water well records in the database with sufficient information to determine the chemical type of groundwaters from the Brosseau Aquifer. The groundwaters are either sodium-bicarbonate-chloride or sodium-chloride-type waters.

There are only five water well records in the database with TDS concentrations; the values are mainly between 1,500 and 2,000 mg/L. The four records with sulfate concentrations are below 20 mg/L. The five records with chloride concentrations in the groundwater from the Brosseau are mainly greater than 250 mg/L in the M.D.

5.3.11 Lea Park Aquitard

The Lea Park Formation is composed mainly of shale and has a very low permeability. In most of the area, the top of the Lea Park coincides with the Base of Groundwater Protection. In some areas, the Base of Groundwater Protection extends above the Brosseau Member. A map showing the depth to the Base of Groundwater Protection is given on page 6 of this report, in Appendix A, and on the CD-ROM.

6 GROUNDWATER BUDGET

6.1 Hydrographs

There are five locations in the M.D. where water levels are being measured and recorded with time. Two sites are observation water wells that are part of the AEP regional groundwater-monitoring network. Observation Water Well (Obs WW) No. 140 is in 13-20-043-06 W4M and Obs WW No. 145 is in 11-31-044-06. Both observation water wells are located in the vicinity of the Town of Wainwright; their hydrographs are shown in the adjacent figure. The three other groundwater monitoring sites are part of the Husky Oil Operations Ltd. (Husky) facility in 10-16-046-06 W4M.

The two AEP Obs WWs are completed in different aquifers. AEP Obs WW No. 140 is completed at a depth from 126.5 to 129.5 metres below ground level in the Lower Sand and Gravel Aquifer associated with the Buried Wainwright Valley, less than ten kilometres south of the Town of Wainwright. AEP Obs WW No. 145 is completed open hole from 40.5 to 87.5 metres below ground level in the Birch Lake Aquifer, one of the main aquifers used as a water supply by the Town of Wainwright until 1985.

A comparison between the elevation of the non-pumping water levels in these two observation water wells (Figure 25) shows that the water level in the Birch Lake Aquifer has been more than five metres above or below the water level in the Lower Sand and Gravel Aquifer. Between 1974 and 1986, the hydraulic gradient was from the Lower Sand and Gravel Aquifer toward the Birch Lake Aquifer. This relationship shows that when the Town of Wainwright was using groundwater, there was a hydraulic gradient from the Lower Sand and Gravel Aquifer toward the Birch Lake Aquifer. From 1987 to 1992, the water level in the Birch Lake Aquifer is at a higher elevation than the water level in the Lower Sand and Gravel Aquifer. Under this condition there is a hydraulic gradient from the Birch Lake Aquifer toward the Lower Sand and Gravel Aquifer.

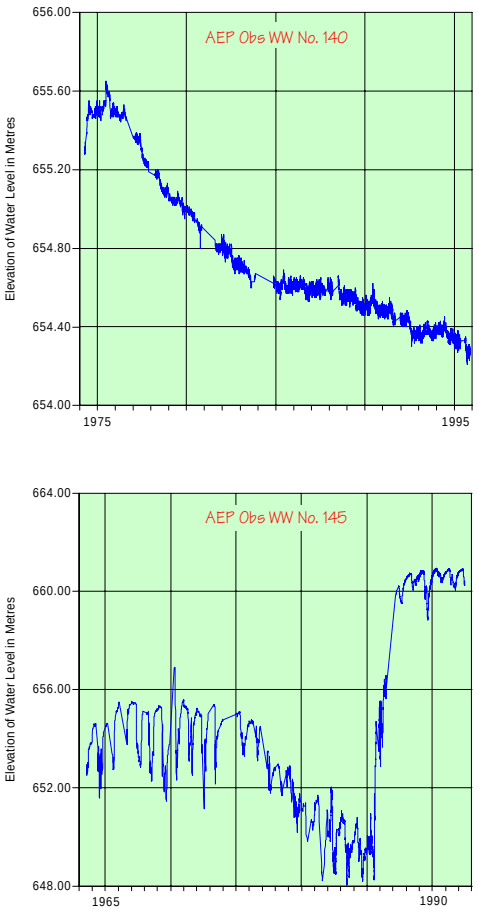

Figure 24. Hydrographs - AEP Observation Water Wells

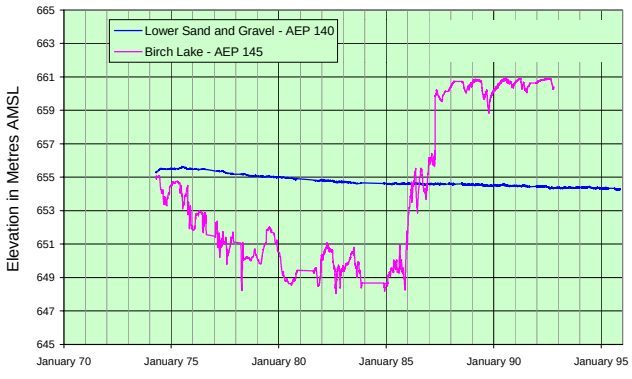

Figure 25. Water Levels in AEP Obs WWs

The Husky water source well and one observation water well in 10-16-046-06 W4M are completed in the Lower Sand and Gravel Aquifer associated with a meltwater channel. The 07-15 Obs WW is completed in the Upper Sand and Gravel Aquifer. The water source well has been used to divert 400,000 cubic metres of groundwater from the Lower Sand and Gravel Aquifer from 1987 to 1997. The water levels have been measured in the three water wells since 1987.

6.2 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 those parts of the various aquifers within the M.D. of Wainwright.

The flow through each aquifer assumes that by taking a large enough area, an aquifer can be considered as homogeneous, the average gradient can be estimated from the non-pumping water-level surface, and flow takes place through the entire width of the aquifer. Based on these assumptions, the estimated lateral groundwater flow through the individual aquifers can be summarized as follows:

Aquifer Designation	Transmissivity (m^2/day)	Gradient (m/m)	Width (km)	Main Direction of Flow	Quantity (m^3/day)	Authorized Diversion (m^3/day)
Surficial Deposits					5,925	770
Upper Sand and Gravel	30	0.002	80	South	4,800	673
Lower Sand and Gravel	50	0.0015	15	East	1,125	97
continental Foremost					400	52
West of the Battle River	5	0.002	20	South	200	
East of the Battle River	5	0.002	20	West	200	
Birch Lake					940	1,129
Northwest	6	0.002	20	Southeast	240	
Central	5	0.002	10	Northwest	100	
Northeast	6	0.002	30	Northeast	360	
Southeast	3	0.002	40	North	240	
Ribstone Creek					1,320	837
South of the Battle River	8	0.002	60	Northeast	960	
West of the Battle River	6	0.002	30	South	360	
Victoria					1,100	1,337
South of the Battle River	8	0.0015	75	Northeast	900	
West of the Battle River	4	0.0015	40	South	200	
Brosseau					450	
South of the Battle River	3	0.0015	50	Northwest	225	
West of the Battle River	3	0.0015	50	Southeast	225	

The above table indicates that there is more groundwater flowing through the aquifers than has been authorized to be diverted from the individual aquifers, with the exceptions of the Birch Lake and Victoria aquifers. However, because of the very approximate nature of the calculation of the quantity of groundwater flowing through the individual aquifers, more detailed work is required to establish the flow