# C. Bedrock

### 1) Geological Characteristics

The upper bedrock in Special Areas and the M.D. includes the Paskapoo Formation, the Edmonton Group, the Bearpaw Formation and the Belly River Group. The adjacent bedrock geology map has been prepared in part from the interpretation of geophysical logs related to oil and gas activity.

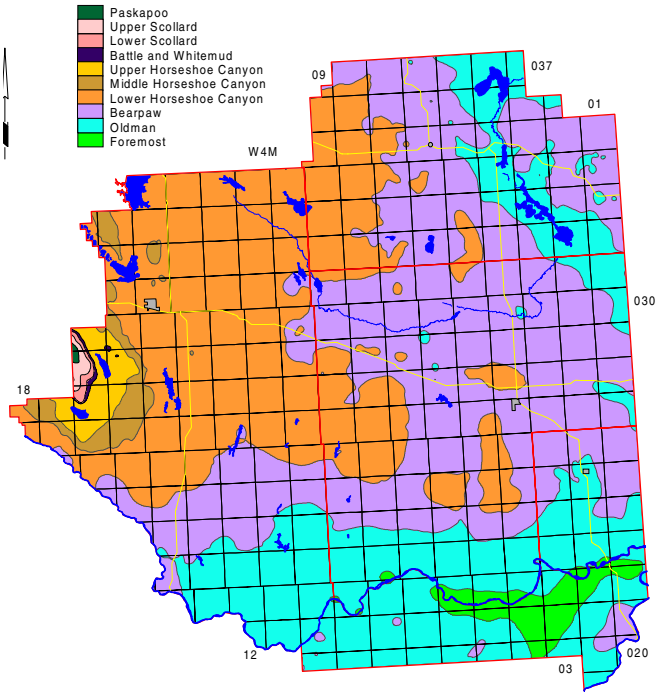


***Figure 16. Bedrock Geology***

The Paskapoo Formation consists of cycles of thick, tabular sandstones, siltstone and mudstone layers (Glass, D. J. [editor], 1990). The Paskapoo Formation is the upper bedrock in parts of townships 029 and 030, range 16, W4M. The maximum thickness of the Paskapoo Formation can be 800 metres, but in the project area, the thickness is less than 30 metres. The Paskapoo Formation consists of the Dalehurst, Lacombe and Haynes members (Demchuk and Hills, 1991); in the project area, only the Haynes Member is present. There will be no direct review of the Paskapoo Aquifer in the body of this report; however, structure-contour maps are included in Appendix A, and on the CD-ROM.

The Edmonton Group consists of fresh and brackish-water deposits of fine-grained sandstone and silty shale, thick coal seams, and numerous bentonite beds (Carrigy, 1971). The Edmonton Group includes the Scollard, Battle, Whitemud and Horseshoe Canyon formations. The Edmonton Group is the upper bedrock in the western part of the project area. The thickness of the Edmonton Group varies from 300 to 500 metres, but in the project area, the thickness is less than 350 metres. In the project area, the Scollard, Battle, Whitemud and Upper Horseshoe Canyon formations have limited importance and there will be no direct review of these aquifers in the body of this report. However, some maps associated with the Edmonton Group are included in Appendix A and on the CD-ROM. Because the Battle and Whitemud formations are thin, they are included as part of the Upper Horseshoe Canyon Formation and are not shown separately except on the bedrock geology map.

The Horseshoe Canyon Formation consists of deltaic[16] and fluvial sandstone, siltstone and shale with interbedded coal seams, bentonite and thin nodular beds of ironstone. Because of the low-energy environment in which deposition occurred, the sandstones, when present, tend to be finer grained. The lower 60 to 70 metres and the upper 30 to 50 metres of the Horseshoe Canyon Formation can include coarser grained sandstone deposits.

The Bearpaw Formation is the upper bedrock in most of the east-central part of the project area and is generally less than 100 metres thick in the project area. 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”

[16] See glossary

(Catuneanu et al, 1997). The border between the bottom of the Bearpaw Formation and the uppermost part of the Belly River Group was used as a geological marker in the e-log interpretation.

The Belly River Group in the project area has a maximum thickness of 300 metres and includes the Oldman and Foremost formations. The Foremost Formation includes the marine facies[17] within the project area. The Oldman Formation is present under most of the project area, but subcrops mainly in the southern and northeastern parts of the project area and has a maximum thickness of 130 metres. The Oldman Formation is composed of sandstone, siltstone, shale and coal deposited in a continental environment. The Oldman Formation is composed of three parts: (a) the Comrey, (b) the Upper Siltstone and (c) the Dinosaur members. The uppermost part of the Dinosaur Member is the Lethbridge Coal Zone. Sandstone is predominant in the Comrey Member, the Upper Siltstone is mainly siltstone, and the Dinosaur Member includes shale and coal deposits.

The *marine* Foremost Formation is less than 180 metres thick and is positioned between the overlying Oldman Formation and the underlying Lea Park Formation. In the *marine* Foremost Formation, individual members have been identified. The members include both sandstone and shale units. For the present project, the individual members are identified by the designation given to the sandstone members, with the underlying shale member being considered as the shale facies of the sandstone member. For example in this report, the Birch Lake Member includes the Birch Lake Member (a sandstone deposit) and the underlying shale deposit. Eastward, the sandstone layers of individual members grade into marine shale deposits. In the project area, due to the limited data available for the members underlying the Birch Lake Member, this report will include a discussion on the Birch Lake Member only. Structure-contour maps for the underlying members are included in Appendix A, and on the CD-ROM.

In most of the area, the top of the Foremost Formation coincides with the Base of Groundwater Protection. A map showing the depth to the Base of Groundwater Protection is given on page 6 of this report, in Appendix A, and on the CD-ROM.

The present breakdown of the Foremost Formation would not be possible without identifying a continuous top for the Lea Park Formation. The top of the Lea Park Formation represents a geologic time border between the marine environment of the Lea Park Formation and the mostly continental environment of the Foremost Formation.

The top of the Lea Park Formation is the bottom of the higher resistivity layer that occurs within a few metres below a regionally identifiable bentonite marker, as shown in the adjacent e-log. This marker occurs approximately 100 metres above the Milk River shoulder.

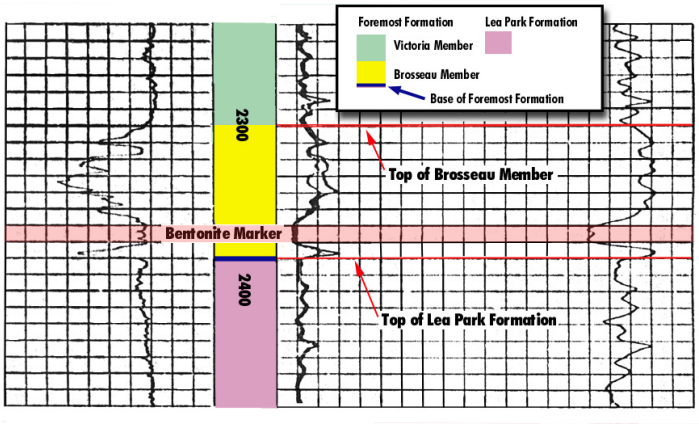


***Figure 17. E-Log showing Base of Foremost Formation***

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 no direct review of the Lea Park Aquitard in the body of this report. However, structure-contour maps associated with the Lea Park Aquitard are included in Appendix A and on the CD-ROM.

[17] See glossary

### 2) Aquifers

Of the 8,079 water wells in the database, 1,432 were defined as being completed below the top of bedrock. This designation is based on the top of the completion interval being below the top of bedrock. However, at least a reported completion depth is available for the majority of water wells and assigning the water wells to specific geologic units is possible only if the completion interval is identified. In order to make use of additional information within the groundwater database, it was assumed that if the total drilled depth of a water well was more than ten metres below the top of a particular geological unit, the water well was assigned to the particular geologic unit. With this assumption, it has been possible to designate the aquifer of completion for 4,455 additional water wells. There are 1,735 water wells that have been identified as being completed in bedrock aquifers above the Middle Horseshoe Canyon Formation or below the Birch Lake Member, or in more than one bedrock aquifer.

| Geological Unit | No. of Water Wells |
|---|---|
| Middle Horseshoe Canyon | 83 |
| Lower Horseshoe Canyon | 1,250 |
| Bearpaw | 1,656 |
| Oldman | 997 |
| Birch Lake | 166 |
| Other | 453 |
| Multiple Completions | 1,282 |
| Total | 5,887 |

***Table 5. Completion Aquifer***

The bedrock water wells are mainly completed in the Bearpaw, Lower Horseshoe Canyon and Oldman aquifers, as shown in the adjacent table. More than 20% of the bedrock water wells are likely to have multiple completions.

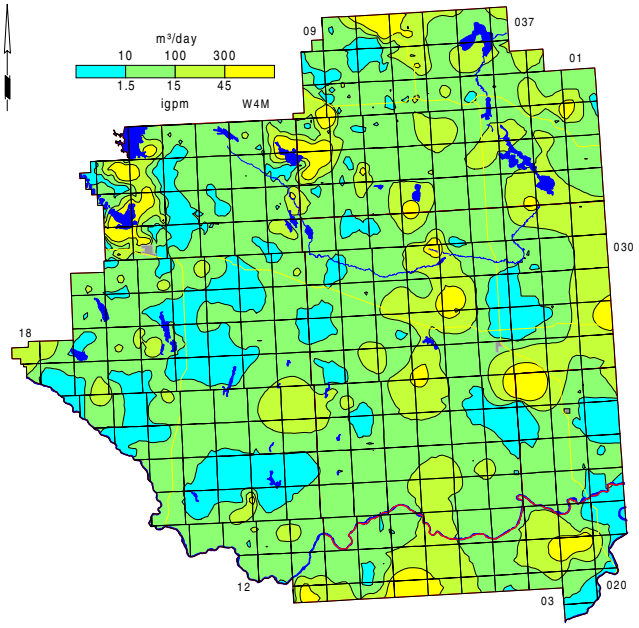


***Figure 18. Apparent Yield for Water Wells Completed in Upper Bedrock Aquifer(s)***

There are 1,257 records for bedrock water wells that have apparent yield values, 21% of all bedrock water wells. The water well yields in the upper bedrock aquifer(s) varies throughout the project area, but are mainly between ten and 100 m³/day. The water well yields of greater than 100 m³/day are scattered throughout the project area, but are scarcer west of range 08. The exceptions are the extreme northwestern part of the project area and near Kirkpatick Lake, in townships 033 and 034, ranges 09 and 10, W4M. In these areas water wells with yields of greater than 300 m³/day occur. The higher yield areas may identify areas of increased permeability resulting from the weathering process.

| Aquifer | No. of Water Wells with Values for Apparent Yield | Number of Water Wells with Apparent Yields <10 m³/day | 10 to 100 m³/day | >100 m³/day |
|---|---|---|---|---|
| Middle Horseshoe Canyon | 49 | 7 | 33 | 9 |
| Lower Horseshoe Canyon | 401 | 112 | 211 | 78 |
| Bearpaw | 351 | 84 | 207 | 60 |
| Oldman | 374 | 31 | 248 | 95 |
| Birch Lake | 23 | 0 | 13 | 10 |
| Totals | 1,198 | 234 | 712 | 252 |

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

Of the 1,257 water well records with apparent yield values, 1,198 have been assigned to aquifers associated with the specific geologic units that are being discussed in this report. Fifty-nine percent or 712 of the water wells completed in the bedrock aquifers have apparent yields that range from ten to 100 m³/day, and 21% or 252 have apparent yields that are more than 100 m³/day, as shown in the table above.

### 3) Chemical Quality of Groundwater

The TDS concentrations in the groundwaters from the upper bedrock aquifer(s) range from less than 500 to more than 3,000 mg/L. Approximately 55% of these groundwaters have a TDS content of more than 1,500 mg/L. The groundwaters with a TDS content of more than 3,000 mg/L occur mainly in the eastern two thirds of the project area.

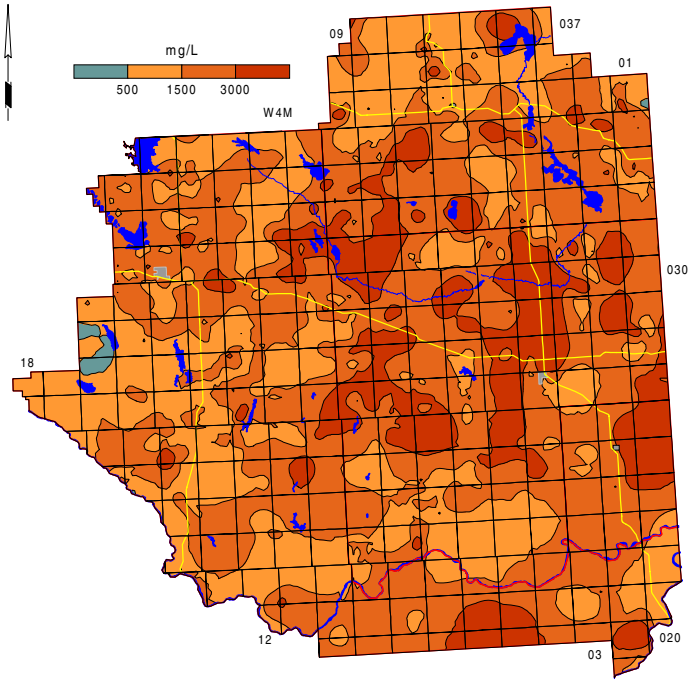


***Figure 19. Total Dissolved Solids in Groundwater from Upper Bedrock Aquifer(s)***

The relationship between TDS and sulfate concentrations shows that when TDS values in the upper bedrock aquifer(s) exceed 1,200 mg/L, the sulfate concentrations exceed 400 mg/L. Approximately 50% of the sulfate values are more than 500 mg/L. The chloride concentrations in the groundwaters from the upper bedrock aquifer(s) are less than 100 mg/L in more than 80% of the project area.

In 90% of the project area, the fluoride ion concentrations in the groundwaters from the upper bedrock aquifer(s) are less than 1.0 mg/L.

The Piper tri-linear diagrams [18] (see Appendix A) show that all chemical types of groundwater occur in the bedrock aquifers. However, the majority of the groundwaters are sodium-bicarbonate or sodium-sulfate types. There are some groundwaters from the upper bedrock aquifer(s) in which calcium and magnesium are the main cations. These groundwaters are usually from aquifers that are close to the bedrock surface.

[18] See glossary