

# Hydrogeology of the Pas Area of Manitoba

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## Summary

Studies of the unique geology and hydrogeology in The Pas have been limited due to the smaller population density and reasonably close surface water resources that exist in this area. This abstract presents an interesting case of a reworked buried valley that exists in the Paleozoic bedrock.

The area is underlain by predominantly Silurian dolomite. Successive, karstic environments developed at the end of the Silurian, and again at the end of Mississippian time, as a result of extensive continental uplifts. A channel was eroded, which resulted in a substantial paleovalley which extends throughout the area. The channel was later infilled with sediments from the Cretaceous period. Glacial and lacustrine sediments have been deposited over the bedrock complex. Subsequent reworking of this channel has had a significant impact on the current location of the Saskatchewan River.

Two major flow systems occur in the Carbonate Aquifer in the area. An upland area with little protective cover to the north of the Town, serves as a major freshwater recharge area. This freshwater meets saline brines from the south. A saline/freshwater water quality mixing zone exists within the paleochannel under the Saskatchewan River.

The aquifer has been developed for water supply and industrial use in the area. The karstic features and water quality changes provide significant challenges for water supply investigations.

Additional investigations, test drilling, monitoring, and sampling are required to provide better management of the groundwater resources in The Pas. A groundwater protection program should be developed for the upland area.

## Introduction

The Pas area, which is located approximately 650 km northwest of Winnipeg, Manitoba, along the Saskatchewan/Carrot/Pasquia River system, has been the subject of limited geological/hydrogeological investigations in the past 30-40 years. The only such regional investigation into the hydrogeology/geology of the area was conducted by the Manitoba Water Resources Branch in 1971-1972 (Pedersen, 1973).

The region itself contains several fast growing communities and industries, which are becoming increasingly reliant upon the underlying carbonate aquifer for fresh water supplies.

## Geology and Hydrogeology

The area lies within the northern portion of the Western Canada Sedimentary Basin. Paleozoic deposits overlie the penneplaned Precambrian bedrock surface. The Paleozoic deposits consist of the following geological units (Bezys, 1992):

## Geology and Hydrogeology (cont'd)

- Moose Lake Formation (Silurian dolomite) ~ sub crop to ~ 17 m below grade.
- U2 Marker (Silurian dolomite) ~ 17 to 18 m below grade.
- Atikameg Formation (Silurian dolomite) ~ 18 to 23m below grade.
- Moose Lake Formation (Silurian dolomite) ~ 23 to 29 m below grade.
- U1 Marker (Silurian dolomite) ~ 29 m below grade.
- Moose Lake Formation (Silurian dolomite) ~ 29 to 38 m below grade.
- U1 Marker (Silurian dolomite) ~ 38 m below grade.
- Fisher Branch Formation (Silurian dolomite) ~ 38 to 59 m below grade
- Stonewall Formation (Early Silurian/Late Ordovician dolomite) ~ 59 to 75 m below grade.
- Stony Mountain Formation (Ordovician dolomite) ~ 75 to 102 m below grade.
- Red River Formation (Ordovician dolomite) ~ 102 to 150 m below grade.
- Winnipeg Formation (Ordovician sandstone and minor shale) ~ 150 to 158 m below grade.
- Precambrian weathered surface ~ 158 m below grade.

At the close of the Silurian Period, and again at the end of the Mississippian Period, major erosional unconformities, in the vicinity of the current location of the Town of The Pas, resulted in major karstic environments. The unconformities were brought about by continental uplifts. As a result a large channel was incised by meteoric water, about 30 to 40 m into the Paleozoic bedrock.

The paleochannel was subsequently infilled with Cretaceous Swan River Formation clays, silts, and fine sands. Sometime following the Cretaceous, a third karstic environment developed on the upland areas, which caused extensive dissolution of the surficial carbonate bedrock. A cross section example is shown below as Figure 1. A key plan is shown as Figure 2.

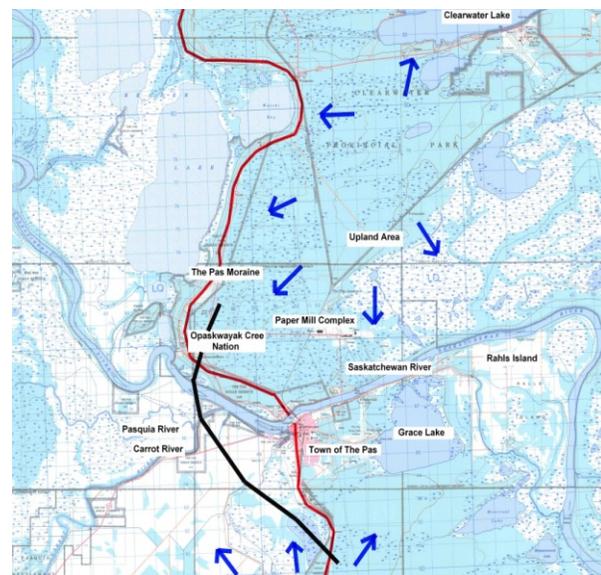
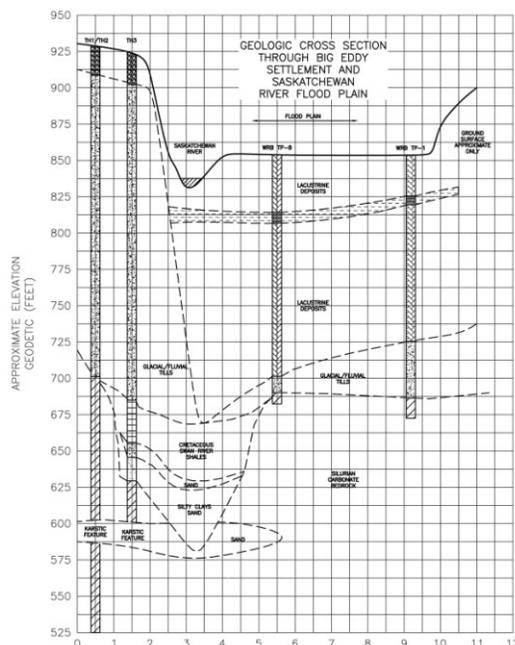


Figure 1 (Left figure) – Typical cross section through the paleochannel.

Figure 2 (Right figure) – Key plan. Cross section location is shown in black. The Pas moraine is shown in red, while approximate groundwater flow directions are shown with in blue.

## Geology and Hydrogeology (cont'd)

One of the largest glacial features in Manitoba is The Pas Moraine, which extends north through the town, crossing the easterly paleochannel in the bedrock. The moraine is composed of a wedge of glacial tills and clays. Deltaic sediments were deposited in the low land areas west of The Pas Moraine through the former paleochannel. The Pas Moraine is shown below as Figure 3.

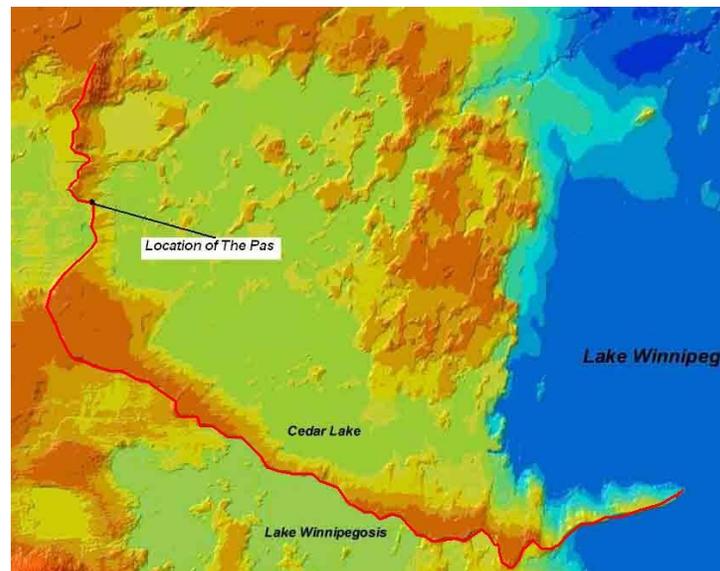


Figure 3 – The Pas Moraine. (MGS, 2006)

Two major flow systems exist in the area. Freshwater recharges the upland area where glacial drift cover is thin. Groundwater flow is radially outwards, meeting the deeper carbonate brines from the south. Water qualities vary substantially, with Total Dissolved Solids levels of 300 to 400 mg/L in the upland to 5,000 to 7,000 mg/L in the south. A groundwater mixing zone is present, following the Ghyben-Herzberg relationship. The Saskatchewan River appears to have some control the location of the water quality boundary, although brackish waters have been noted on both sides of the river near the Rahl's Island and Carrot River areas.

### Groundwater Use

The carbonate aquifer is a major source of water supplies for industrial, agricultural, and municipal use in the area. The largest user is the Opaskwayak Cree Nation, which is currently drawing in excess of 500 dam<sup>3</sup>/year. A large paper mill operation is estimated to use about 400 dam<sup>3</sup>/year for industrial process cooling applications during the summer. Both of these operations use water from the northerly, freshwater side, of the aquifer. Groundwater use south of the town has been restricted to geothermal and industrial requirements, due to the water quality.

### Conclusions

The paleochannel, combined with the infilled paleokarst and surface karstic features, are unique aspects of the complex hydrogeology in the area.

The saline freshwater boundary appears to be partially controlled by the Saskatchewan River, at least in some locations along the channel. Mapping of the 1000 mg/L total dissolved solid isocon is shown below as Figure 4.

## Conclusions (cont'd)



Figure 4 – 1,000 mg/L Total Dissolved Solids isocon.

Due to the increasing water supply requirements in the area, additional test drilling, monitoring, sampling, and investigation is needed to provide better management of the groundwater resources in the area. A groundwater protection plan should be developed for the upland recharge area.

Water supply investigations have been increasingly difficult in the area due to water quality challenges, and the extensive sediment infilled paleokarst.

## Acknowledgements

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