GROUNDWATER RESOURCES IN THE
BROKENHEAD PLANNING DISTRICT

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Prepared by:
M. Rutulis
Planning Branch
1 INTRODUCTION

The purpose of this report is to provide an assessment of groundwater resources in the Brokenhead Planning District for the Municipal Planning Branch.

The assessment is based on available information consisting of reports on groundwater resources in the District and surrounding area (Harron, 1974; Lebedin, 1978), data from groundwater investigations carried out by this Branch, water well drillers' reports, and soil maps.
2 GEOLOGY

2.1 Bedrock

2.1.1 Bedrock Units: The bedrock in the District may be divided into the following three major units:

(1) carbonate rock (limestone and dolostone),
(2) shale and sandstone, and
(3) granitic rocks.

The main features of the stratigraphy in the District are depicted in the diagram in Figure 1 and the areal extent of the bedrock units is indicated in Figure 2. As indicated in Figure 3, the depth to bedrock in the District ranges from zero to 50 metres (0 - 165 ft).

2.1.2 Granitic Rocks: Granitic rocks underlie the surficial deposits in most of the area east of the Brokenhead River (Figure 2). It is the oldest rock unit in the area and underlies the other rocks in the District (Figure 1). In the Brokenhead Planning District the granitic rocks are massive and have very few fractures. Hence, the rocks are practically impermeable and form the base of the zone in which significant quantities of groundwater may move or may be stored.

2.1.3 Shale and Sandstone: The surficial deposits are underlain by inter-bedded shale and sandstone beds in a 0.5 km (kilometres) to 2 km (0.3 - 1.3 miles) wide belt west of the granitic bedrock (Figure 2). The shale and sandstone formation extends into the western part of the District but there it is overlain by carbonate rock (Figure 1). The sandstone beds appear to be more common in the lower part of the unit than in the upper part of it. The total thickness of the shale and sandstone formation is up to 35 m (110 ft). The sandstone beds are permeable and, therefore can store and transmit groundwater.

2.1.4 Carbonate Rock: Throughout the western half of the District (Ranges
and in fairly extensive areas in the eastern half (Figure 2) the bedrock is carbonate rock consisting of limestone and dolostone. The thickness of the carbonate rock unit ranges from around 15 m (50 ft.) near the eastern edge of the carbonate rock area to more than 75 m (225 ft.) at the western boundary of the District. In most of the carbonate bedrock area the depth to bedrock ranges from 10 m to 30 m (30 - 100 ft.); in a few small areas near Garson and Tymbull it is less than 10 m (30 ft.) and at some locations along the eastern side of it is more than 30 m (100 ft.). In general the carbonate bedrock surface is fairly flat. Major buried bedrock valleys in the carbonate bedrock exist east of Beauprejou and west of Ladywood (Figure 3). The carbonate rock commonly contains permeable fractured zones that permit groundwater movement through the rock.

2.2 Surficial Deposits

2.2.1 Units of Surficial Deposits: The following main units of surficial deposits may be discerned in the District:

(1) till,
(2) clay and silt,
(3) sand,
(4) sand and gravel, and
(5) peat.

The areal extent of the surface deposits is shown on the map in Figure 4. The total thickness of the surficial deposits or glacial drift in the District is indicated in the depth to bedrock map (Figure 3).

2.2.2 Till: Till is common at the surface in the southern and southwestern parts of the District (Figure 4) and it underlies the other deposits in much of the rest of the area. Included in the till unit are lenses of sand and gravel interbedded in the till. The permeability of the till is very low and there-
fore it retards groundwater movement. The lenses of sand and gravel, how-
ever, may contain appreciable quantities of water.

2.2.3 Clay and Silt: Clay and silt deposits form the upper layer of the
surficial deposits in most of the eastern half of the District and fill
depressions in the till in the western half. The clay and silt deposits
have very low permeability and, therefore, groundwater movement through
the clay and silt zone is practically nil.

2.2.4 Sand: Extensive sand deposits are found at the surface in the northwest
corner of the District and in several smaller areas east and southeast of Beausejour
(Figure 4). In addition to the exposed sand deposits extensive sand layers
are common below the clay and silt zone in the eastern half of the District.
The sand deposits in the northwest quarter of the district are 10 m to 20 m
thick (30 - 65 ft.). The smaller surface sand deposits are not quite as
thick. The sand deposits underlying the clay and silt area generally are
less than 10 m (30 ft.) thick. The sand deposits have fairly high permea-
bility and porosity. Consequently, the sand layers constitute zones that
can transmit and store large quantities of groundwater.

2.2.5 Sand and Gravel: Only minor sand and gravel deposits are found at the surface
in the area. Most of these deposits are in the form of long narrow ancient
beach ridges. However, large buried sand and gravel deposits are fairly
common in the area; they may occur interbedded in or at the base of other
surficial deposits. Extensive layers and lenses of sand and gravel are
common in the eastern half of the district where they underlay the clay and
silt or are interbedded in the till. Because the sand and gravel deposits
are permeable they form zones through which appreciable groundwater move-
ment can take place.

2.2.6 Peat: In a few places near the eastern boundary and near the north-
west corner of the district the inorganic deposits are overlain by peat
3 GROUNDWATER

2.1 Aquifers

3.1.1 Definition and Classification: In the discussion of the geology of the District it was indicated that some of the bedrock units and some of the surficial deposits readily transmit and store groundwater. The rock formations and the surficial deposits that yield water to wells at a rate sufficient for water supply are called aquifers.

The following four kinds of aquifer can be discerned in the District:

(1) Extensive sand and gravel,
(2) Lenses of sand and gravel,
(3) Carbonate, and
(4) Sandstone

The areal extent of the aquifers may, in the case of the lenses of sand and gravel, the areas where they may occur are indicated on the aquifer map in Figure 5.

3.1.2 Extensive Sand and Gravel:

The extensive sand and gravel aquifers are continuous over large areas and exist at almost every point in the areas indicated on the aquifer map (Figure 5). Areas where numerous overlapping smaller aquifers occur at different depths and, therefore, a sand and gravel aquifer likely exists at any location, are also shown as extensive aquifers.

The thickness of the extensive sand and gravel aquifers ranges from one metre up to 25 m (80 ft.). The depth to the aquifers ranges from zero to more than 30 m (100 ft.). The depth to bedrock (Figure 3) indicates the maximum depth at which sand and gravel aquifers may be found.

Some of the more extensive and thickest sand and gravel aquifers exist in the northwestern part of the District and along P.T.H. No. 44 near the eastern boundary of the District.
Depending on aquifer conditions the yield of properly designed wells in the extensive sand and gravel aquifers may range from about 1 L/s (Liter/second) to more than 40 L/s (13 - 800 I.G.P.M.). An adequate supply of water for domestic requirements could be obtained at almost any point in the extensive sand and gravel aquifer area.

3.1.3 Lenses of Sand and Gravel: In contrast to the extensive sand and gravel aquifers, the aquifers classified as lenses of sand and gravel are small and are randomly scattered throughout the other surficial deposits. Hence, these aquifers do not exist at every point in the areas in which they form the most common or only aquifer (Figure 3). Consequently in these areas water may not be available at the site where it is required and test drilling may be required to find an adequate supply.

The yield of most properly installed wells in the lenses of sand and gravel is likely to be adequate for domestic requirements and at some locations the yields may be up to 10 L/s (320 I.G.P.M.).

Sand and gravel aquifers also exist in the carbonate aquifer area but usually they are not developed, because it is simpler, and usually less expensive, to install wells in the carbonate aquifer. However, at some locations, because of shallower depth and better quality water, it may be advantageous to develop the sand and gravel aquifers instead of the rock aquifer.

3.1.4 Carbonate Rock:

The carbonate rock that underlies more than one half of the District forms the most extensive aquifer in the area; it extends for many miles south, west and north of the District. The main water bearing zone usually is in the upper 15 m (50 ft.) of the rock. The aquifer is continuous throughout the area indicated on the aquifer map (Figure 3) and water can be obtained at any point.
Exceptional conditions, however, may exist and at some locations it may be necessary to drill to a considerable depth into the rock or to drill several test holes to find an adequate supply.

A second water bearing zone is common at the base of the carbonate strata. In some places in the southern part of the district water in the lower zone may be salty. The two water bearing zones of the carbonate rock merge near the eastern edge of the aquifer where the rock thins out.

Almost all wells in the carbonate rock should yield adequate to abundant water supply for domestic and farm requirements. In some parts of the aquifer conditions are likely to be favorable for high capacity wells. The yields of high capacity wells could be up to 30 L/s (1000 g.p.m.).

Generally, water in the carbonate aquifer is of good quality; it is fairly hard but the hardness can be reduced by conventional softeners. (See Appendix A regarding quality description).

3.1.5 Sandstone: Sandstone aquifers are fairly common in the shale and sandstone bedrock area (Figure 2) but they are developed only in a small area near the northern boundary of the District. In the rest of the sandstone bedrock area the sandstone aquifers are not used because shallower sand and gravel aquifers are common and/or water in the sandstone is salty.

As shown in the diagram in Figure 1 the shale and sandstone unit that contains the sandstone aquifers underlies the carbonate rock in the western half of the District. Only a few wells in the carbonate bedrock area draw water from the sandstone aquifers. The usual reason for drilling through the carbonate aquifer into the sandstone aquifers is to obtain soft water where water in the carbonate aquifer is very hard. It should be noted, however, that at some locations the soft water from the sandstone aquifer may be salty and not potable. The salty water problem is discussed in more detail in Sections 3 and 4.
The yields of wells in the sandstone aquifers should be adequate for domestic and farm requirements and where conditions are exceptionally good, properly designed wells could yield more than 5 L/s (65 G.P.M.).

In the area north of the Community of Brokenhead water in the sandstone aquifers generally is of fair to good quality.

3.2 *Recharge:*

Ultimately the groundwater supply in an area depends on groundwater recharge in the area or adjacent area contributing to the groundwater flow system in the area.

In the Brokenhead Planning District the aquifers are recharged mainly in the areas where sand and gravel deposits and the carbonate rock are at or near ground surface. The total area in the District where these conditions exist is about 120 km$^2$ (square kilometres) or 120 x $10^6$ m$^2$ (47 square miles). Groundwater level monitoring indicates that groundwater recharge in good recharge areas in Manitoba is at least 0.05 m (2 inches) of water over recharge area. Hence, the recharge over the district is some $6 \times 10^6$ m$^3$/a (cubic metres per annum) or 190 L/s sustained pumping rate (4300 acre feet/year or 2500 I.G.P.M., respectively). In addition to the recharge within the District, the aquifers in the eastern half of the District are recharged by a flow system originating in the upland of Milner Ridge located a few miles east of the District. The Milner Ridge recharge area that may contribute to the aquifers in the District is about 50 km$^2$ or $50 \times 10^6$ m$^2$ (22 square miles). Hence, the recharge from that area is about $2.5 \times 10^6$ m$^3$/a or 80 L/s sustained pumping rate (2000 acre-feet/year or 1000 I.G.P.M., respectively). The total recharge contributing to the water supply in the district then is $8.5 \times 10^6$ m$^3$/a (6800 acre-feet/year or 270 L/s (3000 I.G.P.M.) sustained pumping rate. However, because of natural discharge not all of this water is available for development.
3.3 Availability

Fair to excellent quality groundwater for domestic and farm requirements is readily available throughout the western half of the district and in most of the eastern half. The only areas where groundwater may not be readily available at some locations are the areas where the aquifers are formed by scattered lenses of sand and gravel.

In many places in the carbonate rock and extensive sand and gravel aquifer areas (Figure 5) aquifer condition may be favorable for high capacity wells that could yield up to 30 L/s (800 G.P.M.).

Since a single residence with four persons requires about 1000 litres per day (225 G.P.D.) or 366 m³ per year (0.30 acre-feet/year) and the recharge is several million cubic metres (several thousand acre-feet) per year, the supply, no doubt, is adequate for thousands of residences and considerable other development.

3.4 Salty Groundwater Area

Salty water has been reported in several wells drawing water from the sandstone aquifers or from water bearing zones at the base of the carbonate rock (Figure 6). This indicates that in a large part of the District water in deep aquifers may be salty. The area where water in the sandstone aquifers and near the base of the carbonate rock likely is salty is indicated in Figure 6. In this area drilling into the deep aquifers is not recommended. If inadvertently or during exploration of deeper aquifers a well has penetrated a saltwater zone, the salty water should be properly sealed off to prevent saltwater intrusion into freshwater aquifers. A basic method for sealing off salty water is depicted in Appendix B.

In a few places along the Brokenhead River north of Beausejour the salty water has intruded into some of the deeper sand and gravel aquifers. Fresh water
may not be available at some of these locations, if shallow aquifers do not exist above the salt water zone.

3.5 Flowing Well Areas

In several areas in the District water level in most wells rises above ground level. The flowing well areas are indicated on the flowing wall map in Figure 7. Because uncontrolled flowing wells may cause a number of problems, wells in these areas should be constructed so that discharge can be controlled. The problems caused by flowing wells are discussed and a suggested basic design for flowing wells is shown in Appendix C.

3.6 High Water Level Wells

In high water level wells the water level is below ground level but above or near the basement floor level. These conditions are common in flowing well and adjacent areas. High water level wells may cause some of the same problems (See Appendix D) as those caused by flowing wells. Hence, their construction should make provision for control of discharge in a similar manner to that of flowing wells (Appendix C).
4 GROUNDWATER POLLUTION HAZARD AREAS

Groundwater pollution hazard in the District exists in areas where sand and gravel deposits or carbonate rock are at or near the ground surface. The groundwater pollution hazard areas are outlined in Figure 8.

The sand and gravel deposits are considered as groundwater pollution hazard areas because they may be water bearing and septic tanks installed in the deposits or other sources of pollutants would be likely to cause aquifer pollution.

The areas where the carbonate rock is at or near the ground surface are at Garson, Tyndall and northwest of Tyndall. In some places within these pollution hazard areas the rock is only a metre (a few feet) below surface and groundwater pollution from septic fields and other sources is likely to take place.

Outside the groundwater pollution hazard areas indicated in Figure 8 the aquifers are covered by thick clay and/or till deposits and groundwater pollution is not likely.

Because in some parts of the municipality saline groundwater is found below fresh water zones, pollution of the fresh water aquifers by saline water flowing upward through test holes and abandoned wells is possible. Hence, the abandoned wells and test holes should be backfilled with clay, clayey sand or other materials that would prevent groundwater flow as shown in Appendix B.

In the groundwater pollution hazard areas at Garson, Tyndall and just north of Tyndall, where the carbonate rock is near the ground surface it frequently happens that only enough well casing is installed to reach the rock. Below that point an open hole is drilled through the rock until a satisfactory water bearing zone is encountered. Polluted water that may flow through the upper fractured zone of the rock can flow into the open hole and pollute water in the well and the aquifer. Similarly, in the case where the upper (and
usually shallow) water bearing zones of the rock is polluted but deeper zones are not, an open hole through the polluted zone allows the polluted water to mix with good water. To prevent the flow of polluted water from surface or shallow polluted water bearing zones into potable water zones, it is advisable to install grouted-in well casing through the dry rock and shallow water bearing zones.
5 SUMMARY

1. Groundwater for rural non-farm residential and farm requirements is readily available throughout the western half and in most of the eastern part of the District.

2. Groundwater is of acceptable quality for domestic water supply in west of the District.

3. The groundwater resources in the District are adequate for existing and for a considerable amount of new development.

4. In the central and southwestern part of the District salty water appears to be common in deep aquifers. Hence, developing deep aquifers should be avoided in this area.

5. Extensive flowing well areas exist in the parts of the District which are lower in elevation. Wells in the flowing well areas should be properly constructed to prevent uncontrolled groundwater discharge.

6. Groundwater pollution hazards exist in several areas in the District where sand and gravel deposits or carbonate rock are at or near the ground surface. Most of the groundwater pollution hazard areas are located in the western part of the District.
REFERENCES

J. E. Guarion, 1974; A Hydrogeological Study of the Selkirk Area, Manitoba, Inland Waters Directorate, Scientific Series No. 2.

J. Lebedin, 1978; Groundwater Resources of the Beausejour Area, Manitoba, Geology and Air Surveys Division, Prairie Farm Rehabilitation Administration.
APPENDIX A

GROUNDWATER QUALITY DESCRIPTIONS

To describe groundwater quality the terms excellent, good, fair, poor and combinations and modifications of them are used in this report. Unless other uses are specified these terms indicate how acceptable the water is for domestic use. The quality description is based on the total dissolved solids, the concentration of the common ions that affect quality, hardness, appearance, taste and odour of the water.

The meaning of the terms used for groundwater quality description is as follows:

1. **Excellent:** The water has no objectionable properties and treatment of it to improve quality is not necessary; the total dissolved solids concentration is less than 300 mg/L and hardness less than 250 mg/L.

2. **Good:** The water has higher mineral concentration than the excellent water and is rated less than excellent mainly because of higher hardness; the total dissolved solids concentration ranges from 500 to 1000 mg/L and hardness is from 250 to 500 mg/L. The hardness is likely to cause incrustation of kitchen utensils. The water can be used without treatment or, if desired, the hardness can be readily reduced.

3. **Fair:** The water has one or more objectionable properties and fairly commonly may require treatment to improve quality. The most common undesirable property is high hardness; it ranges from 500 to 1000 mg/L. The hardness can be reduced to acceptable level with conventional water softeners. The water may have high enough sulphate, iron and chloride ion concentrations to slightly impair its taste or, in the case of sulphate, have a laxative effect on persons not used to it.
The total dissolved solids concentration of the water is from 1000 to 2000 mg/L.

4. **Poor**: The water has one or more serious undesirable properties and it is difficult to impossible to improve the water quality by conventional water treatment. The water commonly is very hard (more than 1000 mg/L) and it may be difficult (also expensive) or impractical to reduce the hardness with conventional water softeners. The water may also have a very high sulphate ion concentration (500 to 2000 mg/L). In some places the water may be rated as poor quality because of high sodium chloride (salt) concentration, which makes it taste salty. The water may be also less than desirable in appearance and may have unpleasant odour.

5. **Very Poor**: The undesirable properties of the water are just below a tolerable limit.
PROVINCE OF MANITOBA
DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL MANAGEMENT
WATER RESOURCES DIVISION

BASIC WELL DESIGN
FOR
SEALING OFF HIGHLY MINERALIZED (SALTY) WATER
APPENDIX C

Flooding Wells

Numerous flowing well areas exist in Manitoba. In the flowing well areas the water level in most wells rises above ground level and in others it is near ground level. Some of the wells may flow when groundwater levels are high and stop flowing during periods of low levels.

Uncontrolled discharge from flowing wells may cause some of the following problems:

1. Icing up of drains, that, in turn, result in ice covered roads and flooding during spring runoff;
2. Damage to roads, bridges and drains;
3. Damp basements;
4. Damage to buildings due to excessive soil moisture or ice;
5. Wet and swampy yards and fields;
6. Flooding of septic tank drain fields.

In view that the above problems caused by uncontrolled flowing wells are likely to affect the well owner, his neighbours and public property in the vicinity, wells in flowing well areas should be constructed so that discharge can be controlled.

The discharge from flowing wells can be brought under control by proper well construction. A basic design for controlled flowing wells is shown in the illustration on the next page.
APPENDIX D

High Water Level Wells

High water level wells are wells where the water level is below ground level but above or near the basement floor level.

If high water level wells are not properly designed they may cause problems similar to some of those caused by flowing wells, such as:

1. Damp basements,
2. Flooding of septic tank drain fields,
3. Unnecessary pumping from sumps,
4. Damage to foundations and basement floors.

The problems are caused by water seeping or flowing up outside the well casing and then flowing through the backfill of water pipe excavations towards the building. If well pits are used to make connections between the well and the water pipe these problems may be caused by water flowing from the well into the pit and thence to the basement.

To prevent the above problems wells in high groundwater level areas should be constructed in the same manner as controlled flowing wells. The basic design for high water level wells is shown in Appendix C.
LEGEND

- SAND, MINOR GRAVEL
- SAND AND GRAVEL (MAINLY BEACH DEPOSITS)
- CLAY AND SILT
- TILL, (INCLUDES THIN SAND, GRAVEL AND CLAY OVER TILL)
- PEAT

NOTE MODIFIED AFTER MANITOBA SOIL SURVEY REPORTS NO. 5 AND NO. 16

TWO HEADED PLANNING DISTRICT

SURFACE DEPOSITS
**LEGEND**

- **Q_{w0}** Salty water well and depth to aquifer in metres.
- **□** Area where salty water may occur in deep wells drilled to the base of the carbonate rock or into the sandstone aquifers.

**Figure 6**

**Brokenhead Planning District**

**Province of Manitoba**

Department of Environment and Conservation

Water Resources Division

**Occurrence of Salty Groundwater**
LEGEND

FLOWING WELL AREA