Groundwater Resources of the Whitemud Watershed

Prepared by:
David Toop
Groundwater Management Section
Manitoba Water Stewardship

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1.0 Introduction

The Whitemud Watershed drains an area stretching from the slopes of Riding Mountain to the south end of Lake Manitoba. The watershed ecompasses the lower slopes of Riding Mountain and the low plain area west of the lake, along with sandy lands of the northern portion of the Assiniboine Delta (ADA). Neepawa, Gladstone and McGregor are the largest communities in the watershed. The cities of Brandon and Portage La Prairie are located in nearby areas outside the watershed.

The Assiniboine Delta Aquifer, located in the south part of the watershed, is a regionally significant groundwater source. In the remainder of the watershed, aquifers are scattered. Bedrock aquifers contain salt water, leaving only overburden aquifers.

2.0 Water Supply

Groundwater is the main source of supply in the Whitemud River watershed. Groundwater discharge also provides baseflow to rivers and streams and contributes water to marshes and wetlands found in significant portions of the watershed.

Groundwater, defined as all water below the water table, is obtained from aquifers. The type of aquifer used at a source depends on location within the watershed. Groundwater in the Whitemud Creek Watershed is almost entirely sourced from shallow overburden aquifers consisting of gravel, sand and silt. Most of these aquifers are shallow, small, low yielding and scattered. The notable exception is Assiniboine Delta Aquifer (ADA), which is a fairly reliable water source covering a broad area at the south end of the watershed. The Whitemud River Watershed encompasses the northern extent of the Assiniboine Delta Aquifer (ADA), accounting for about 35% of the aquifer. Water from the ADA is used to irrigate crops and related food processing industry, making it a significant feature of the local economy. The ADA is a reliable water source for domestic supply. However, in a number of basins, the licensed supply of groundwater is fully allocated.

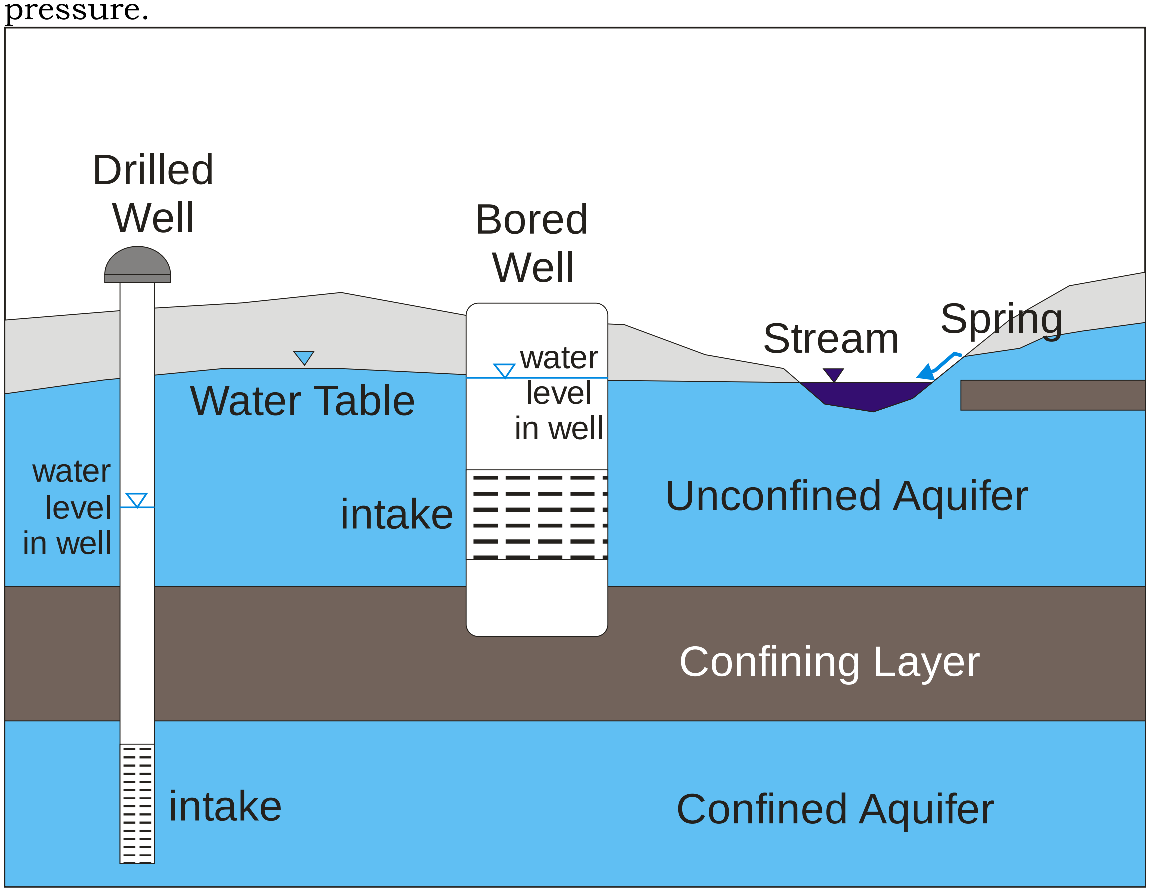
A few wells along the Manitoba Escarpment are completed in shale. Groundwater quality is the controlling factor in well supply. Wells drilled into deep overburden or bedrock are likely to encounter saline water. As a consequence, most wells in the watershed are relatively shallow, generally less than 30 m (100 ft) deep.

Large diameter bored wells are commonly used in areas where aquifer yields are low or unreliable, such as in silt or silty sands. The large diameter of the well bore compensates for this by adding additional storage.

Deep bedrock and overburden aquifers are present, but the water quality is rarely conductive to development. These deeper aquifers include deeply buried sands and gravels, Devonian and Jurassic aged limestone and dolomite (carbonate) bedrock, Cretaceous sandstone bedrock and fractured shale bedrock. Fractured shale along the Manitoba escarpment accounts for a small number of wells and is the most common bedrock completion in the watershed.

In the lowland areas, particularly around Lake Manitoba, water tables are high and can interfere with agricultural practices.

Figure 1 illustrates a bored well in an unconfined aquifer with a water table, compared to a drilled well in a deep confined aquifer that is under pressure.



3.0 Acts and Regulations

Groundwater in Manitoba is regulated under a number of Acts and Regulations: *The Environment Act*; *The Water Safety Act*; *The Water Rights Act*; *The Ground Water and Water Well Act* and *The Health Act*. Other Acts may indirectly affect groundwater. For example, groundwater may be affected by developments covered under *The Mines and Minerals Act*.

The Environment Act is the key piece of legislation protecting groundwater quality, while *The Water Rights Act* is the key piece of legislation governing the management of groundwater supplies. *The Ground Water and Water Well Act* deals with water well regulation. The Act covers all sources of groundwater and all water wells completed by a drilling contractor before and after the Act was introduced in 1963. With the exception of controlling flowing wells and pollution prevention, the Act does not cover household wells dug by the well owner with their own equipment.

4.0 Groundwater Management

Groundwater is managed sustainably if the rate of water removal does not cause long term, irreversible declines in water levels or other undesirable impacts. This means that the amount of water being removed is within an acceptable groundwater budget. A budget is determined by estimating the amount of groundwater in storage, based on well tests and hydrogeological mapping, as well as the amount of water entering and leaving the aquifer through recharge and discharge.

To determine the maximum amount that can be removed within the budget requires knowledge of the recharge rate, and also understanding the hydraulic and water quality responses to pumping and how this may affect surrounding well owners.

A significant portion of the Whitemud Watershed is covered by the Assiniboine Delta Aquifer (ADA). The ADA is distinctive in that it has its own Aquifer Management Plan (Water Stewardship, 2005). This plan overrides individual watershed plans. The plan set out three main goas of aquifer protection, sustainable use and sustainable economic development, while considering land and water resources and interests of stakeholders. The ADA is divided into subwatersheds, which are individually managed. The ADA straddles the Whitemud Watershed and the Central Assiniboine Watershed. The ADA is a reliable source of good quality water. It is heavily utilized for specialized farming and some sub-basins are fully allocated for groundwater.

Annual yield is equivalent to the annual amount of recharge to an aquifer. Manitoba allocates for licensed use, up to 50% of the ADA's annual yield. The remainder is reserved to sustain the environment and for domestic users. In the Upper Whitemud East, allocation has been reduced to 15% and in Upper Whitemud West it is 30%. The lower allocation was put in place to protect streamflow for downstream users.

A significant portion of the Whitemud River Watershed is underlain by scattered drift aquifers, which are not individually mapped. Where these are not available groundwater must be obtained from seepage from silt or till using large diameter bores for storage. These aquifers are too small in scale to develop aquifer budgets.

When groundwater budgets are not known, it is still possible to manage the resource on a well by well basis, providing that the cumulative demands of the existing wells are not causing long term detrimental effects on surrounding wells or groundwater features.

Groundwater pumping tests are carried out when a well is required for more than simply domestic use and a license is required. Groundwater pumping tests are done to determine the maximum sustainable pumping rate of the well and to assess the potential effects on water levels in surrounding wells. The pump test is able to tell us whether recharge is sufficient to offset water withdrawals at this site and to provide assurance that groundwater development is within the ability of the aquifer to supply this water without there being adverse effects.

Groundwater availability is concern in the Whitemud Watershed where aquifers are not locally available. Water may have to be distributed by pipeline, sourced from known aquifer areas like the ADA (Render, 1989) or the Ogilvie Aquifer (Render, 1994). The Town of Neepawa obtains its water supply directly (wells) and indirectly (groundwater fed surface reservoir) from the ADA.

5.0 Previous Work

Groundwater in the area was mapped as part of 1:250,000 hydrogeological mapping series for Neepawa (Betcher, 1989) and Brandon (Little and Sie, 1978). Studies covering parts of the basin include Rutulis (1979) "Groundwater Resources in the Neepawa Planning

District"; Rutulis (1981) "Groundwater Resources in the Willowbend Creek Watershed"; Little (1981) "Groundwater Availability in the Almasippi Soils area. and Render (1994) "The water supply capacity of the Olgilvie Aquifer".

A considerable amount of study has gone into the ADA including mapping, division in to groundwater sub-basins, monitoring and development of groundwater budgets (Render, 1987; Render, 1989). An aquifer management plan has been developed for the area (Water Stewardship, 2005).

Studies on the ADA, often included extensive exploration, core logging, aquifer testing and monitoring. This work is summarize in Table 1

Table 1

Year	Author	Organization	Type of Work
1934	Johnson	GSC	Surface Geology
1959	Halstead	GSC	Surface Geology
1964-1968	Pederson	Manitoba	Drilling Exploration
1975-1980			Irrigation developments in West and Central ADA
1980-1986	Render	Manitoba	Extensive Field Studies; monitoring and aquifer budgets*
1993	Render	Manitoba	Expanded monitoring network**

- *comprehensive field studies including 103 test holes, collection and analysis of 2000 soil samples, installing 62 monitoring stations, pump testing at 20 monitoring stations and 18 farm irrigation wells, setting up precipitation and streamflow stations. Monitoring network based on Thiessen polygons 36 sq miles in area (1 per township).
- **1993 installed 25 monitoring station for water levels and soil moisture plus 6 rain gauge stations.

6.0 Geology and Aquifers

Cretaceous shales and Jurassic shales, sandstones and limestone form the bedrock in the region. While aquifers do occur in limestone, sandstone and fractured shale, these are generally not used because the water us usually saline.

Aquifers are found in overburden, in the Assiniboine Delta Aquifer, fluvial deposits and scattered sand bodies in till. Sands and gravels are more common along the base of the Manitoba Escarpment and in the southeast part of the watershed.

6.1 Surficial Geology and Hydrogeology

Surficial deposits, often referred to as “overburden” or “drift”, are glacial and post-glacial in origin. There is evidence that preglacial or glacial buried valley deposits may also be present in some areas, but this is unconfirmed.

The most extensive overburden aquifer is the Assiniboine Delta Aquifer (ADA) in the south central part of the map sheet area where thick surficial sands containing good quality groundwater extend over a broad area. Saturated sand thicknesses vary from approximately two to thirty metres within the outlined boundaries of the aquifer.

Till is present in most areas outside of the ADA. The till layer is made up of a mixture of unsorted clay, silt, sand, gravel and boulders, derived from local sedimentary bedrock, and it contains sand and gravel beds. Texture runs from stony clay to gravelly clay, often with boulders.

Aquifers are found within or at the base of the till. Groundwater quality varies considerably with location and deteriorates rapidly with depth. The only aquifers available for fresh groundwater supplies tend to be thin surficial sands an silty sands laid down in Lake Agassiz and shallow sands and gravels within glacial till. Quite often these aquifers cover a limited area, are thin, have poor permeability or have small saturated thicknesses. (Rutilis 1979). Near Lake Manitoba, till is overlain by a thick layer of clay and silty sand from Lake Agassiz. The fine grained deposits inhibit groundwater movement and have a negative influence on groundwater resources.

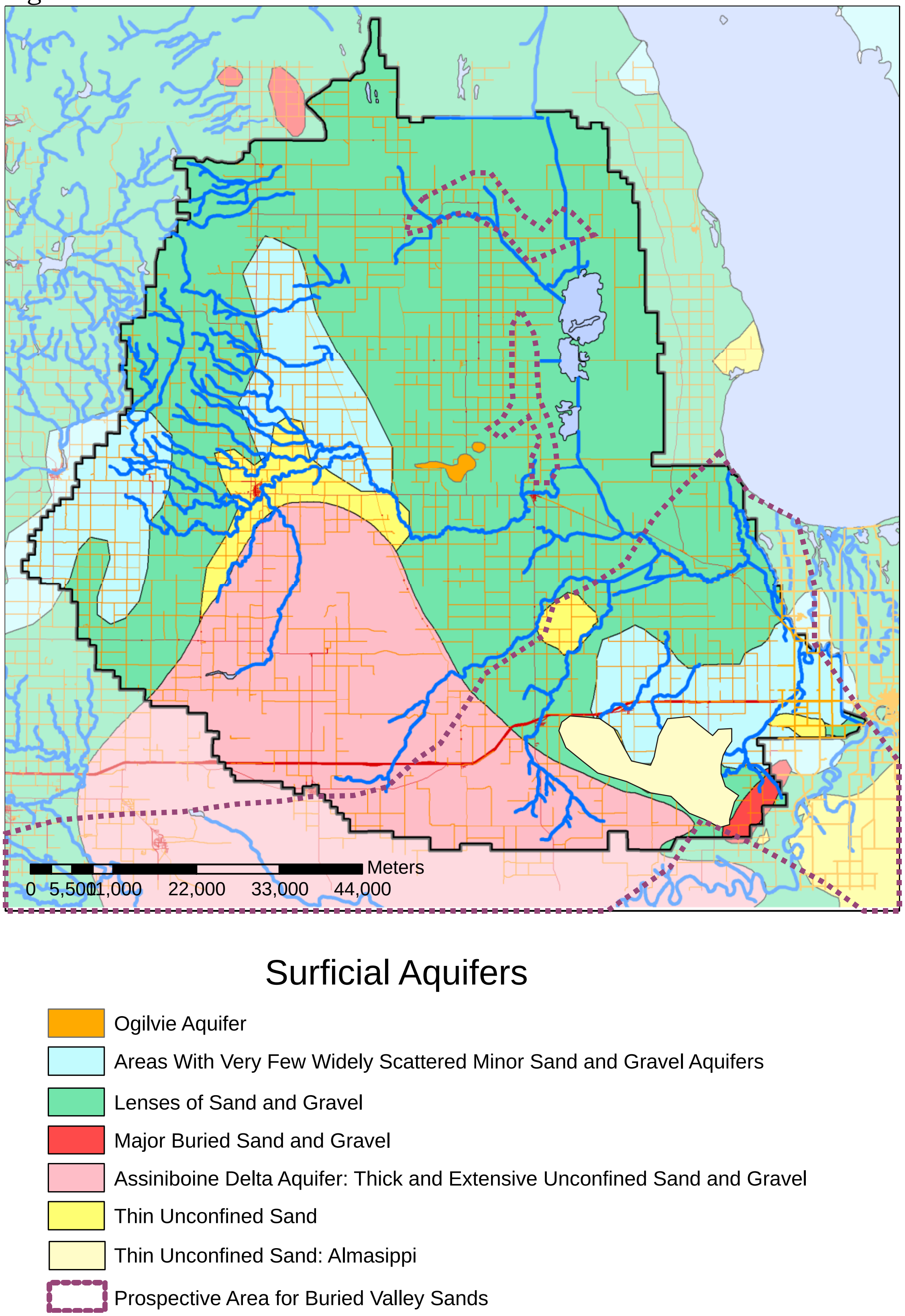
Overburden thickness varies from about 5 metres around parts of Riding Mountain, to over 130 metres in towards the centre of the Assiniboine Delta Aquifer. Drift tends to be thicker in the southern third of the watershed, where it is generally more than 50 metres thick. In the northern two thirds, it is mostly less than 50 metres thick. Thicker areas of drift correspond to areas where bedrock elevation is low. Sand and gravel occur as isolated lenses inter-bedded in the till, at the clay-till contact and at the base of the till. These are more common in areas where bedrock is low and till is thick (Rutilis 1981).

Other types of overburden deposits include a few beach ridges between Neepawa and Gladstone and west of Jackfish Lake along the plain on the west side of Lake Manitoba. These form sand ridges 1-4 m, which are covered with thin blanked or sand and silt and are separated by swamps and swamp deposits.

Lacustrine deposits of clay and silt are found around Jackfish Lake and on west side of Lake Manitoba. Deltaic deposits make up the ADA. Some glaciofluvial deposits of gravel, sand and silt occur in a small area west of Neepawa.

The distribution of overburden aquifers is shown in Figure 2.

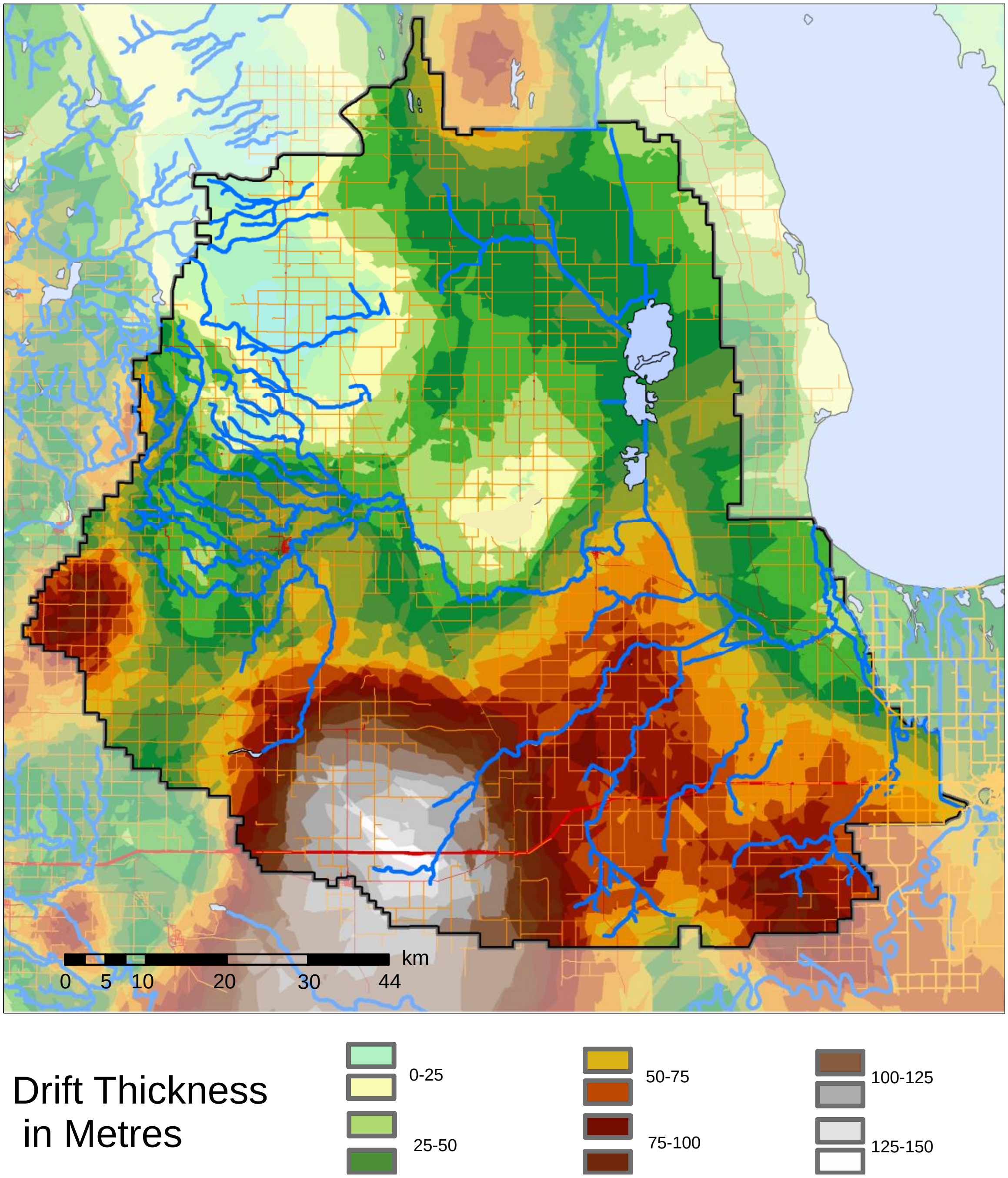
Figure 2.


Meters
0 5,500 11,000 22,000 33,000 44,000
Surficial Aquifers
Ogilvie Aquifer
Areas With Very Few Widely Scattered Minor Sand and Gravel Aquifers
Lenses of Sand and Gravel
Major Buried Sand and Gravel
Assiniboine Delta Aquifer: Thick and Extensive Unconfined Sand and Gravel
Thin Unconfined Sand
Thin Unconfined Sand: Almasippi
Prospective Area for Buried Valley Sands

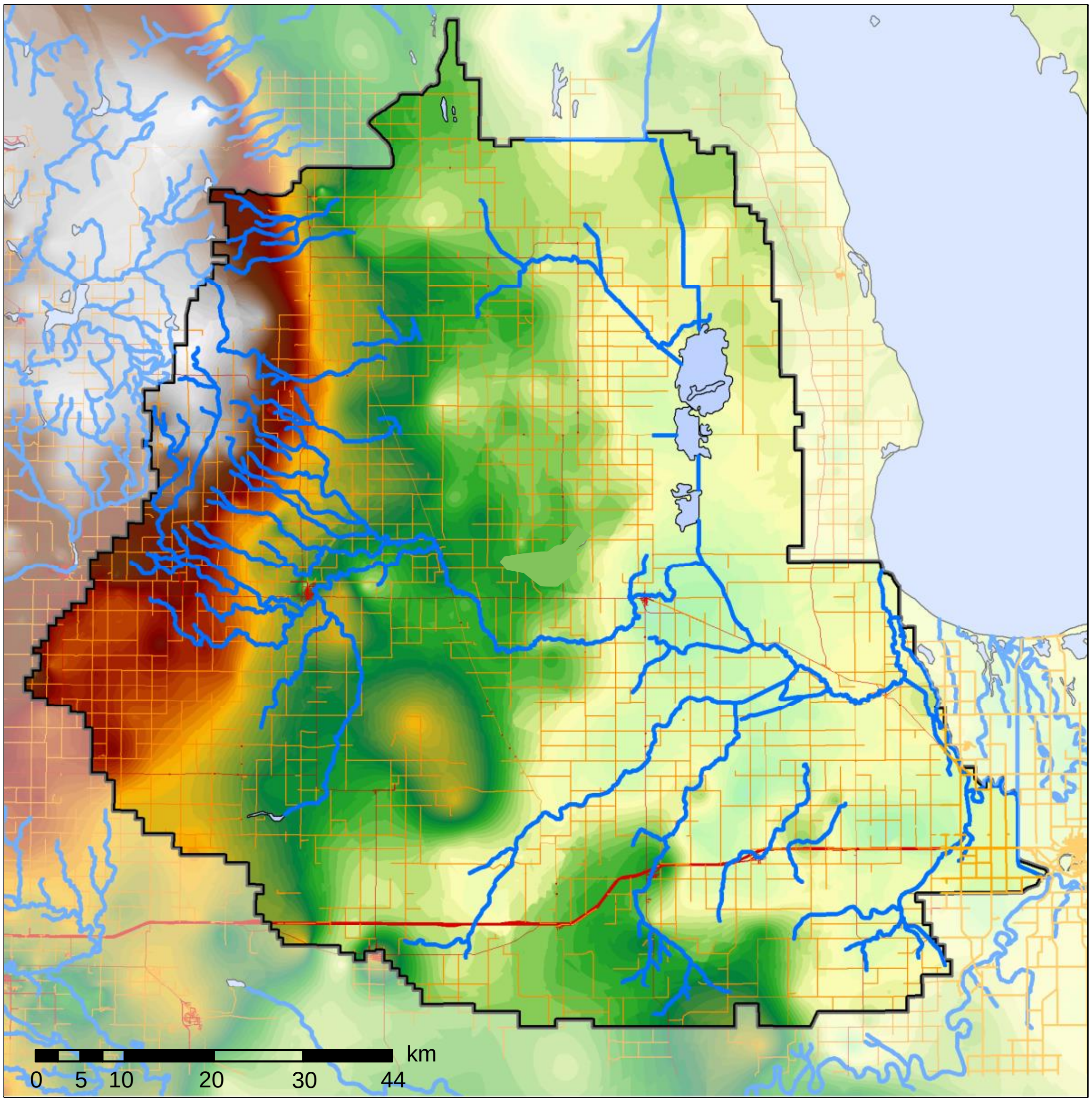
6.1.1 Buried Valley Aquifers

Bedrock topography, drift thickness and aquifer data indicate possibly two bedrock valleys, one entering the area from the southeast, the other from the southwest beneath the ADA. These converge in the region between Austin and Gladstone before heading northeast to Lake Manitoba. The bedrock valleys appear to be regional in extent and contain a variety of fill, including some sands and gravels at depth. The bedrock lows are 10 to 15 km wide and 65 to 70 m deep. Overburden thins toward Lake Manitoba becoming 25 to 30 m deep, likely a result of erosion. Previous studies have pointed to the presence of these buried valleys in the area when cross sections were constructed (Render, 1994; Betcher 1989). They may contain aquifer materials or till. Water quality is uncertain, but likely to be poor unless the aquifer has a nearby surface source of recharge.

Two areas of sand and gravel deposits, which may have a buried valley origin were found in the Glenella area, approximating the course of the Grass River, and a north-south feature in the Ogilvie-Plumas area west of Jackfish Lake. This feature includes the Ogilvie aquifer, which is situated along its margins.



km
0
5
10
20
30
44
Drift Thickness in Metres
0-25
25-50
50-75
75-100
100-125
125-150



Bedrock Topography
Elevation in Metres

200 - 300	500 - 600
300 -400	600 - 700
400 - 500	700 - 800

6.2.2 Ogilvie Aquifer

The Ogilvie Aquifer is a drift aquifer, which is locally significant because of lack of other groundwater supplies (Render, 1994). It is located 6 miles (10 km) northwest of Gladstone. The aquifer is the source of water for the village of Plumas via a pipeline and loading station. The aquifer consists of two segments. The eastern segment underlies about 1 square mile (2.6 km^2) and is up to 24 feet (7.5 m) thick. The western segment underlies 5 square miles (13 km^2) and is up to 60 feet (18m) thick. The aquifer lies on the northern edge of a larger buried valley feature.

The overlying till is 10 to 20 feet (3-6m)thick over the eastern segment and 20 to 40 feet (6-12m) thick over the western segment. The till is overlain by up to 15 feet (4.5 m) of fine sand, which contains 5 to 10 feet (1.5-3m) of saturated material. Recharge is sourced locally.

Water quality is TDS of 700 to 800 mg/L. The western aquifer is more brackish. Underlying bedrock consists of Jurassic Shale with some carbonate layers. The bedrock contains salts such as gypsum, which may be the source of some poor water quality in the overlying aquifer.

Recharge to the Ogilvie Aquifer was estimated at 45 acre feet (55,000 m^3) per year. Production is 21 acre feet (26,000 m^3) per year, with no indications of depletion. There are two observation wells in the aquifer: LL080 and LL081.

The land above the Ogilvie Aquifer was chosen as the site for an Amish settlement in 2006.

6.2.3 Almasippi Soils Area

The Almasippi Soils consist of belt of poorly drained surficial gravel, sands and silts, about 12 miles wide adjoining the northeast margin of the ADA, between the ADA and Lake Manitoba (Sie and Little, 1981). In most places the sands are less than 6 m thick, but in some areas may exceed 12m. Well yields in the Almasippi sands area are generally poor and large diameter bores are often necessary. Water chemistry ranges from a few hundred mg/L total dissolved solids to several thousand. Overall water quality is marginal. The region is considered problematic for groundwater development.

6.2.4 The Assiniboine Delta Aquifer (ADA)

The Assiniboine Delta Aquifer (ADA) is an unconfined sand and gravel deposit extending over 1500 square miles (3900 km^2) in south central Manitoba. It is found in the southern part of the Whitemud Watershed accounting for about 25% of the watershed. The ADA straddles the Whitemud and Central Assiniboine watersheds, with about 35% of the ADA falling within the Whitemud Watershed. A considerable amount of study has gone into the ADA, including mapping, modeling, monitoring and the development of an aquifer management plan.

The Assiniboine Delta Aquifer was created by a large glacial river depositing sediments into a bay in Lake Agassiz. The aquifer consists of silt, sand and gravel units. Deposits are mostly coarse gravel to medium sand in grain size. The aquifer averages 60 feet thick. Actual thicknesses vary from a few feet along the margins of the aquifer to over 100 feet at the centre. Lenses and beds can vary significantly over short distances. The aquifer extends to the surface. The top layers have been reworked by water and wind.

The topography of the ADA is mostly flat to rolling, with deep valleys around the Assiniboine and Whitemud rivers. Soils are loamy sand to clay loam, which are imperfectly drained. The area is mostly used for agriculture including dryland farming, livestock and irrigated crops, mostly potatoes. There is little surface runoff in the ADA. Streams form where the topography is below the ground surface. The few waterways that exist are dependent on springs and seepage to sustain their flow. Groundwater plays an important role in sustaining riparian areas and ecosystems.

Shallow sand aquifers are found in surface sand deposits that make up the ADA. They are continuous across most areas. Yields are often in the 1 to 5 or up to 10 igpm range. Shallow sands with a thin saturated zone are subject to drying up or reduced pumping rates during drought. Water quality in these aquifers is usually fair to excellent. Deeper sand aquifers are found in upland areas of the ADA. These aquifers consist of lenses of sand interbedded in clay, silt and silty sand at depth up to 50 m. Yield is low to moderate in the range of 1 to 65 igpm. Water quality in these deep aquifers is fair to excellent and is not affected by drought.

The permeable nature of the soils and exposure of the aquifer to the land surface makes it highly vulnerable to groundwater contamination. Sources of contamination include sewage, petroleum products and agricultural fertilizers. The aquifer supplies potable water for small town, domestic and farm water supplies and for irrigated crops.

The Assiniboine Delta Aquifer has been divided into 13 sub-Basins for management purposes. The basins represent groundwater sheds, which are more or less correlating with the surface watersheds. Seven of these basins are fully within the Whitemud watershed. Margins of two additional watershed were partially included in the Whitemud Planning area boundary. The watersheds are as follows:

1. Upper Whitemud West
2. Upper Whitemud East
3. Lower Whitemud East
4. Pine Creek North
5. Pine Creek South
6. Squirrel Creek North
7. Squirrel Creek South

Some margins of the following two watershed are within the Whitemud boundary:

1. Epinette Creek North
2. Assiniboine East

The sub-basins are based on the movement of groundwater, defined by mapping of the potentiometric surface (water table) using monitoring wells. Surface runoff in the region is minimal. The aquifer is probably a significant contributor of baseflow to the Whitemud River during low flow periods.

Water quality is good to excellent. EC varies from 200 to 700 uS/cm. Nitrate is variable and can be elevated above the CDWS guideline of 10 mg/L.

6.3 Bedrock Geology and Hydrogeology

Bedrock in the area is made up of Jurassic beds of shale, limestone, gypsum, anhydrite and sandstone, and Cretaceous shales and sandstones (Betcher, 1989). Jurassic carbonate and sandstone aquifers are found at exploitable depths through much of the central and eastern parts of the watershed. Bedrock aquifers are shown in Figure 4.

Groundwater quality is rarely acceptable for household use. High salinity or excessive sulphate concentrations make the water not potable. Groundwater chemistry in bedrock varies from $Na\text{-}SO_4\text{-}HCO_3$ near Riding Mountain to $Na\text{-}Ca\text{-}SO_4\text{-}Cl$ in the lowlands and has high salinity. The prevalence of poor water quality in most places means that bedrock forms the base of groundwater exploration. Groundwater quality is poor near Lake Manitoba and improves around the Manitoba Escarpment, where a few wells have been successfully completed in fractured shale.

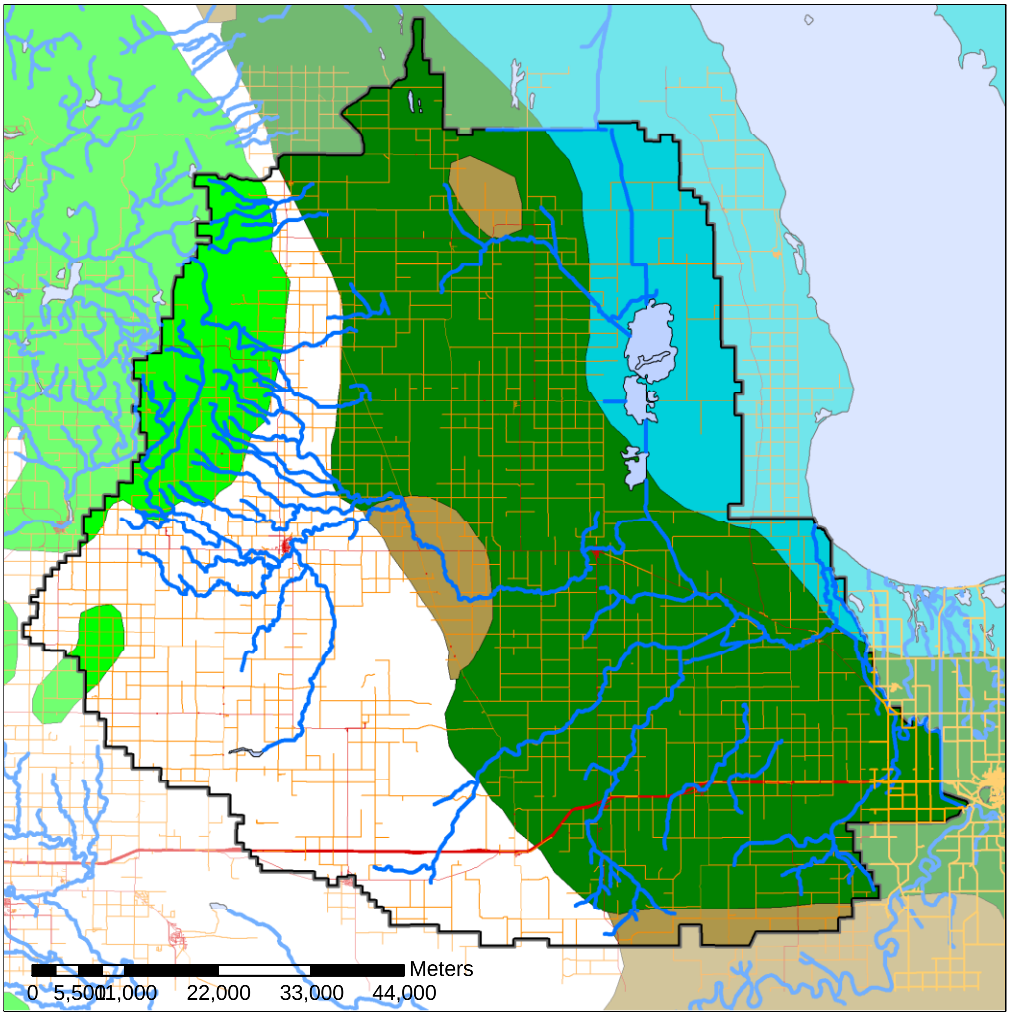
The formations are relatively flat-lying, dipping very gently to the west. Younger formations subcrop in higher elevation areas around the Manitoba Escarpment.

The bedrock formations in the watershed are listed in Table 2 and are described as follows:

Table 2. Bedrock Formations

AQUIFER TYPE	FORMATION	SUBCROP LOCATION	COMMON WELL DEPTHS	COMMENTS
Carbonate, shale and sandstone	Jurassic Reston-Melita	Fork River to Pulp River	<60m	
Sandstone	Cretaceous Swan River	Central plains/lowlands	20-80 m	Brackish to Saline; subcrops in RM Glenella and RM Lansdowne
Shale	Cretaceous Ashville, Favel, Vermilion River and Riding Mountain	Manitoba Escarpment	<70m	Shallow fractured shale may be suitable in some localities
Drift	Glacial	Entire area	<50 m	Buried valley aquifer may be present

Figure 3 Map of Bedrock Aquifers



Bedrock Aquifers

- Carbonate Rocks: Limestone and Dolomite
- Limestone, Sandstone, Shale (Jurassic Formations)
- No Bedrock Aquifers At Less Than 150 Metres
- Sandstone and Sand (Cretaceous Swan River Formation)
- Shale (Odanah Member of the Cretaceous Pierre Shale Formation)

6.3.1 Jurassic Aquifer (Amaranth, Reston and Melita Formations)

Jurassic formations are found under till in the eastern half of the watershed. In the western half of the watershed, the strata are beneath Cretaceous Formations, including the Swan River Formation. The Jurassic consists of the Amaranth, Reston and Melita Formations. Bedrock consists of basal red sandstone and siltstone overlain by gypsum or anhydrite (Amaranth Formation); beneath intebedded limestone, dolomite and shale (Reston Formation); and overlain by sandstone, shale and minor limestone (Melita Formation).

6.3.2 Sandstone Aquifer (Swan River Formation)

The Cretaceous Swan River Formation is found beneath till in a narrow area in RM Lansdowne and RM Glenella, west of Gladstone. The Swan River sandstones form a widespread aquifer. It is made up of sandstone, shale and minor lignite. Water in this aquifer is saline and not suited for domestic use.

6.3.3 Shale (Ashville, Favel, Vermilion River and Riding Mountain Formations)

Bedrock overlying the Swan River Formation consists of four Cretaceous formations: Ashville, Favel, Vermilion River and Riding Mountain. These are primarily composed of shale and constitute aquifers only when fractured. These are mainly accessed along the Manitoba Escarpment, where they subcrop. Cretaceous shales along the escarpment may form an aquifer where fractured, but yield and water quality can vary greatly.

7.0 Well Distribution, Aquifer Utilization and Groundwater Use

Wells in Water Stewardship's database lists 4922 water wells within the Whitemud Watershed. These are classified according to aquifer type in Table 2.

Table 2. Number of Wells by Aquifer

AQUIFER TYPE	NUMBER OF WELLS	% OF WELLS
All aquifers (total)	4922	100
Sand and Gravel	3515	71.4
Dry (abandoned)	875	17.8
Silt or Till	251	5.1
Shale	191	3.9
Limestone or Dolomite	36	0.7
Other / Unknown	36	0.7
Sandstone	18	0.4

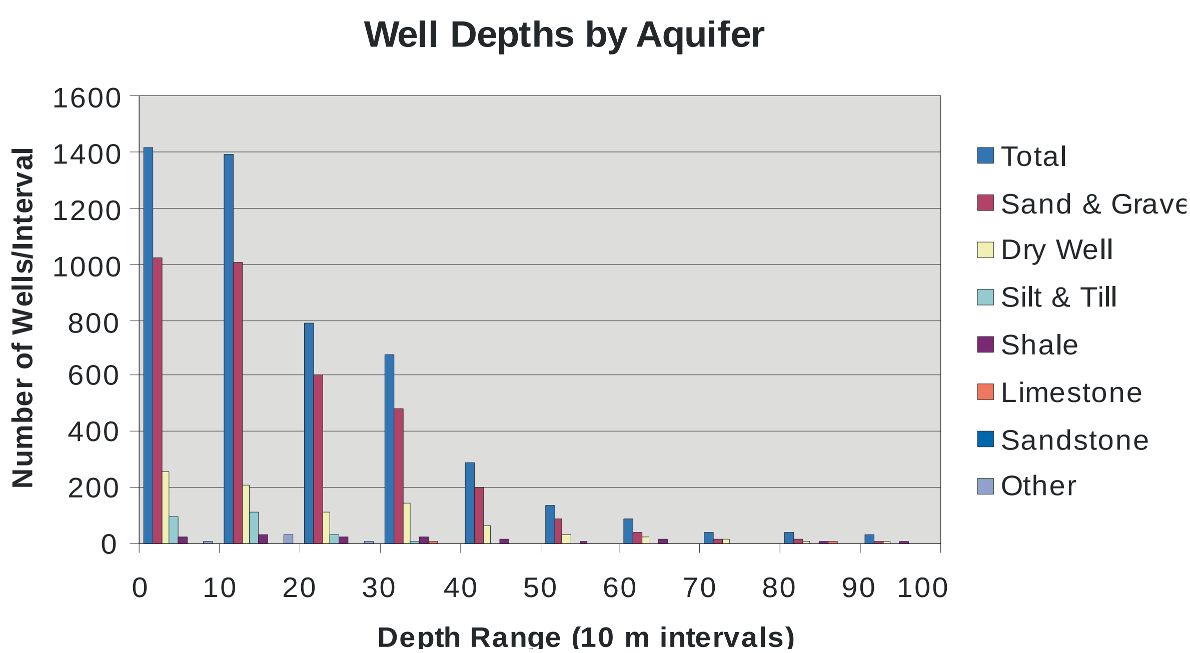
Wells completed in sand and gravel drift are found in all areas of the watershed and are the aquifer of choice throughout the watershed, accounting for 71% of wells in the database. Wells completed in "silt or till" account for an additional 5% of wells drilled. Dry and abandoned holes accounted for nearly 18% of all wells drilled, distributed throughout the watershed, although mostly absent on the ADA. Wells completed in shale account for nearly 4% of wells drilled. There are a few scattered shale wells, but most are completed in the Riding Mountain Formation found along the Manitoba Escarpment, and in the Jurassic Amaranth Formation in the region surrounding the village of Plumas. Only 36 wells, accounting for less than 1% of the total, are completed in limestone or dolomite. These are within the Amaranth Formation and are located within 50 to 60 km of the west shore of Lake Manitoba. A mere 18 wells are completed in sandstone, mostly in the Jurassic Amaranth Formation. Most are situated north of township 15.

Table 3 and Graph #1 show the number of wells in ten metre intervals by aquifer type.

DEPTH RANGE (M)	DEPTH (FT)	SAND & GRAVEL	SILT OR TILL	SHALE	CARB-ONATE	SAND-STONE	OTHER & UNKNOWN	DRY WELL	TOTAL
<10m	0-33	1025	96	23	1	1	11	255	1412
10-20m	33-66	1005	110	36	2	2	29	206	1390
20-30m	66-98	607	31	22	1	4	12	109	786
30-40m	98-131	484	8	28	10	3	1	141	675
40-50m	131-164	201	4	16	4	0		68	293
50-	164-	86	2	10	0	4	1	31	134

60m	197								
60-70m	197-230	41	0	16	3	2	4	26	92
70-80m	230-262	15	0	4	2	0	0	16	37
80-90m	262-295	16	0	7	7	0	1	7	38
90-100m	295-328	10	0	11	1	0	0	8	30
100-110	328-361	4	0	6	3	1	0	2	16
110-120	361-394	5	0	3	1	0	0	4	13
120-130	394-426	4	0	3	0	0	0	1	8
130-140	426-459	5	0	1	0	0	0	0	6
140-150	459-492	4	0	1	0	0	0	0	5
150-160	492-525	1	0	0	1	0	0	0	2
160-170	525-558	1	0	0	0	0	0	0	1
170-180	558-590	0	0	0	0	0	0	0	0
180-190+	590-623	1	0	4	0	0	0	0	5

Graph#1



Most wells in the watershed are relatively shallow: 73% are less than 30 metres (100 feet) deep; 95% are less than 60 metres (200 feet) and 5% were over 200 feet. Wells completed in bedrock tended to be deeper than wells completed in overburden.

Most deeper wells were drilled as part of groundwater investigation programs and were sealed. Wells deeper than 120 metres into sand and gravel were drilled in 1964 and were sealed. Most but not all wells in the 90 to 120 metre range are sealed. The deepest producing well is located just east of McGregor and is 93 metres deep (PID 38627).

This analysis shows us that groundwater is obtained from shallow depths throughout the region. Some deeper holes have been drilled but were not completed. It is not clear whether this was because they were simply exploration holes for mapping purposes, or if there were yield or quality issues. Water quality appears to be a controlling factor in well development. If new water sources are to be found, they will likely be deeper than present sources and we will need to know more about their quality to see if they are viable.

8.0 Groundwater Monitoring

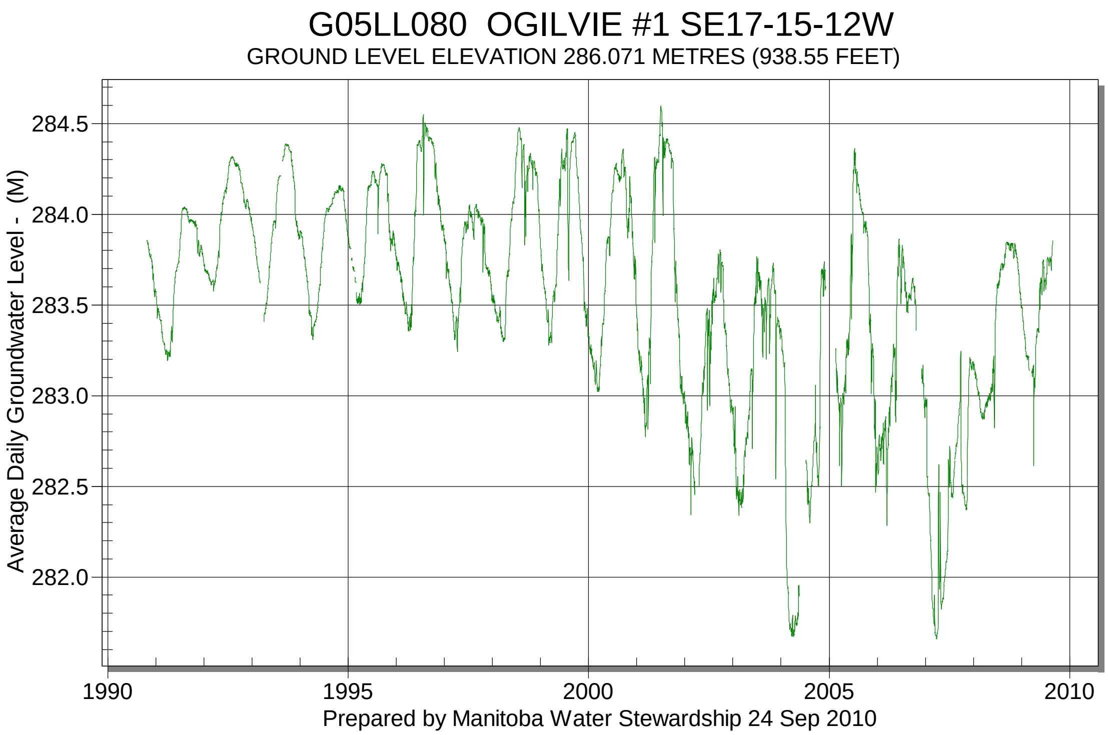
The Province of Manitoba through the Department of Water Stewardship, maintains a network of more than 500 groundwater observation wells in the agricultural regions of the province. Groundwater monitoring may also be mandated at specific sites in licenses or permits issued under *the Environment Act* or licenses issued under *The Water Rights Act*. Monitoring primarily involves continuously recording of water levels, plus occasional water quality sampling. This may be done in undeveloped areas to observe how the aquifer responds to the natural environment, or it may be done in developed areas to determine impacts on groundwater.

There are 93 provincial groundwater monitoring wells located in the Whitemud River Watershed. The Assiniboine Delta Aquifer accounts for most of the monitoring, with 81 wells, compared to 12 groundwater monitoring wells in the remainder of the Whitemud Watershed.

Monitoring of the ADA began in 1965 (Water Stewardship, 2005). Monitoring away from areas of development provides information on the elevation of the water table and the long-term response of the aquifer to rainfall and climatic conditions. Most wells on the aquifer fluctuate about 1 to 3 metres on average. Water levels were relatively high in the 1960s and 1970s, but dropped during the drought years from the mid 1980s to mid 1990s. Water levels have recovered in recent years.

Sample hydrographs are shown in graphs 2, 3 and 4. Graphs 2 and 3 show water levels dominated by climatic trends and mostly ambient conditions. Graph 4 shows water levels in decline near the village of Wellwood. A high concentration of irrigation wells have been constructed near Wellwood to pipe water to other parts of the ADA.

Graph 2.
Hydrograph of Ogilvie #1 Monitoring Well showing mostly ambient conditions.



Graph 3.
Hydrograph of Carberry Monitoring Well showing mostly ambient condtions

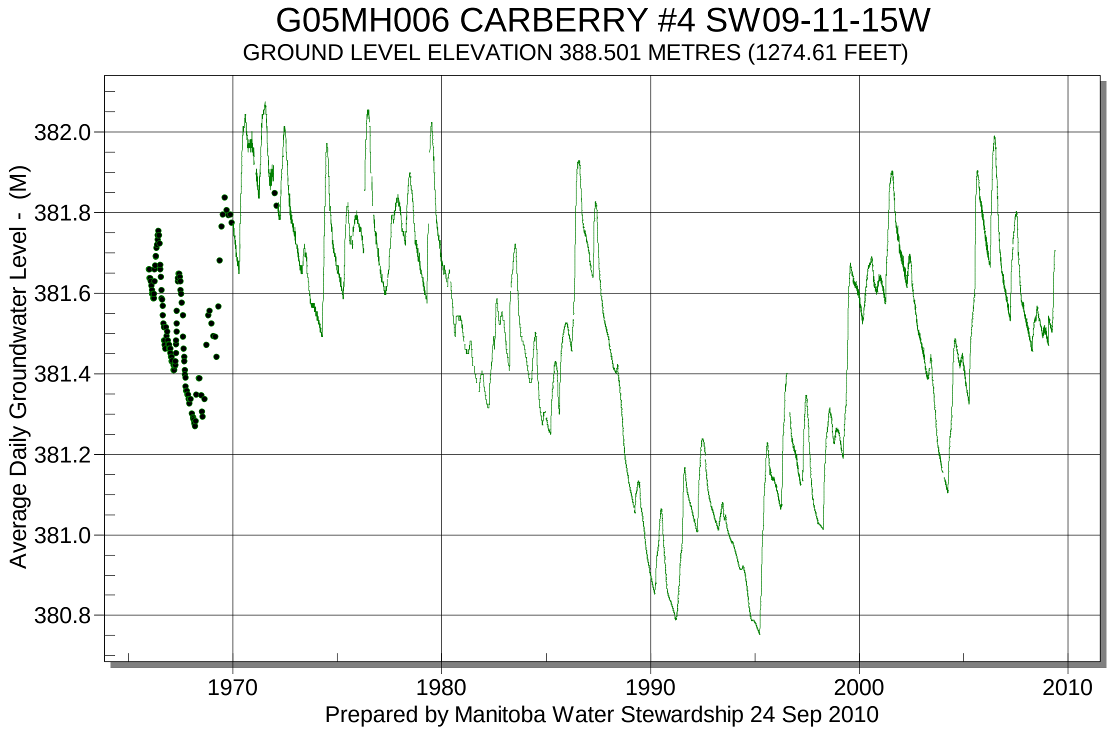


Figure 4. Example Hydrograph for ADA #4 Monitoring Well – Near Village of Wellwood, showing production effects

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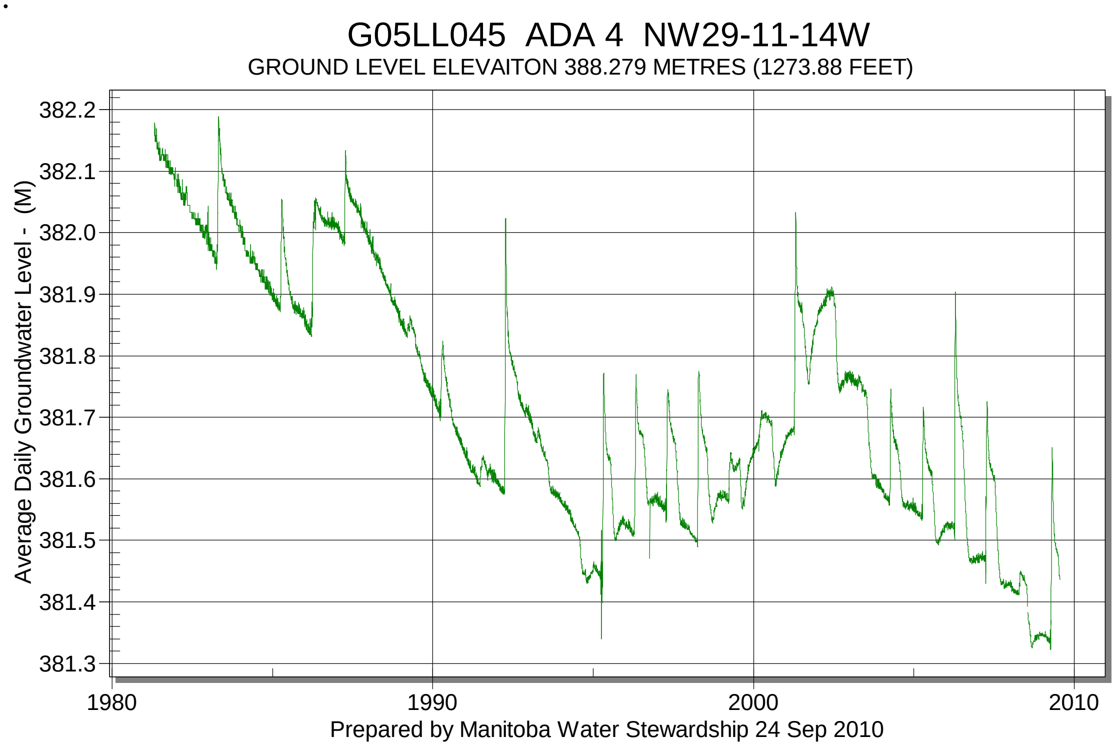

Ogilvie #1 Well (right) and rain gauge (left). Amish farm in background.

9.0 Groundwater Flow

Water enters the ground through recharge, is stored in aquifers and aquitards and exits through discharge. Groundwater storage is a balance between recharge and discharge. In the long term this is relatively stable. In the shorter term, storage may increase when surface water is plentiful or it may decrease during drought.

In general, groundwater recharge will occur in elevated areas and groundwater will discharge in low areas. In recharge areas, the water table is often deeper and levels vary more than you would find in a discharge area. Water quality is generally better, the closer you get to the point of recharge. Groundwater may be discharged at the surface by way of springs, it may be taken up by the roots of vegetation and transpired through the leaves, but most commonly it flows into the bottoms of streams or lakes.

In shallow unconfined aquifers with a water table the groundwater originates from the same locality and contains few dissolved solids, in the low hundreds. The local scale of the flow systems, and the small areas that they draw upon means that these aquifers are more easily impacted by changes to the environment. Water may take days or weeks to move through the system. Water levels are likely to rise and fall on a seasonal basis, with low water levels occurring in late winter and during summer droughts. Wells in this sort of aquifer may be considered undependable sources of water for this reason.

The Whitemud River Watershed is affected by local, intermediate and regional flow. Flow systems have importance for two reasons. Deeper flow systems have stable water levels that are not affected much by drought. Because of the long time in the system and the minerals in the surrounding rock, these systems often contain a lot of dissolved salts, which may make the water not potable.

The Assiniboine Delta Aquifer is situated in an elevated area along the Manitoba Escarpment and has porous materials extending to surface. Local flow systems are generated in the ADA upland and sandy areas in the lowland. The short travel time and inert, permeable sandy substrate means that the water has not picked up a lot of salts. A result is that fresh water is found at depth in that aquifer. It may take weeks or years for groundwater to make its way through the system.

Intermediate flow is found in the shallow bedrock. This flow is generated from Riding Mountain and flows east toward Lake Manitoba through permeable layers in bedrock and deeper overburden. Flow may take tens or hundreds of years.

The deepest confined aquifers have regional flow systems, where the source water often originates many hundreds of kilometers away and may take hundred to thousands of years to move through the system. Regional flow systems affect the water quality along the west side of Lake Manitoba. Salty water from the regional flow moves toward the surface, mixing with shallower, fresher water. Discharging flow systems may cause drainage problems, water-logging of soils, salinization and springs or flowing wells.

Deep flow systems which discharge along the west side of Lake Manitoba, have delivered salts into many of the region’s deeper aquifers. Better quality water is found where there is rapid recharge to near-surface aquifers, such as the ADA.

10.0 Groundwater Quality

Groundwater quality can vary considerably in aquifers and aquitards. Water that is found within or which must pass through aquitards, especially in deeper zones, may gain salts and other ions, which reduce water quality. Shallower groundwater in sands and gravels and shallow bedrock that has been refreshed locally by rain and snow has the best quality, although hardness and iron are sometimes an issue. It also is the most ready to receive contaminants from the surface, such as micro-organisms or chemicals. Deeper groundwater found mostly in bedrock tends to be softer and is less susceptible to contamination. Salinity is often an issue in deeper formations, making the water not potable. Regions along the west side of Lake Manitoba are affected by deep saline groundwater flow.

Groundwater quality is poor throughout the watershed with the exception of the ADA. The area between the Manitoba Escarpment and Lake Manitoba is part of a regional discharge area for deep saline waters and as a consequence groundwater quality in most bedrock and some overburden aquifers is affected by excessive salinity.

Groundwater quality in overburden aquifers varies widely ranging from total dissolved solids (TDS) values less than 250 mg/L in some shallow sands to 23,000 mg/L near Gladstone. On the escarpment the groundwater is Ca-Mg-HCO3 type with TDS if 500 to 3000 mg/L. The more mineralized water has higher SO4 concentrations.

East of the Manitoba Escarpment groundwater in sand and gravel aquifers ranges from fresh Ca-Mg-HCO_3 type water to saline Na-Cl-SO_4 type water. Fresh groundwater is available on the Assiniboine Delta Aquifer and in many shallow (<10 m) sand and gravel deposits. Water is saline in most intermediate to deep aquifers (>20m). The complex hydrogeology of the region makes generalization difficult as fresh groundwater is found in some aquifers at considerable depth, while saline groundwater may be found in some areas at less than 10m.

11.0 Aquifer Protection

Vulnerable aquifers may be defined as locations where the aquifer is found close to the ground surface and unprotected from impacts originating at the land surface by sufficient thickness of overlying low permeability clays and tills. This is particularly the case of shallow aquifers because the well intake is close to the surface. Groundwater in aquifers in these areas is more likely to be susceptible to contamination by natural and anthropogenic microorganisms, or inorganic, or organic substances.

A variety of methods have been developed to determine aquifer vulnerability, some quite complex. Generally in Manitoba, if the top of an aquifer is within six metres of ground surface it is considered vulnerable. For this region, the Assiniboine Delta Aquifer, which outcrops at surface is more vulnerable than most other overburden aquifers, which have some amount of overlying till or clay.

Vulnerability indicates areas that could be at risk, if a contamination source is present. Vulnerability will not predict that contamination will or will not occur or the severity of am impact.

It is the responsibility of a well owner to ensure that their water supply is properly constructed and maintained. Water well contamination often results from improper construction, maintenance or protection of wells. Protecting a well from contamination is an important consideration when choosing a well site and for construction and maintenance. Wells should be located on elevated sites where surface water will drain away from the well bore. The well casing should be intact and the well annulus sealed with grout. Wells should be properly maintained and properly sealed when they are no longer needed. Land use planning, whether it is local farming practices, or siting of industrial, residential, transportation of waste storage facilities can be used to ensure that wells are protected. Regulatory controls and engineering techniques can also be helpful.

12.0 Local Groundwater Issues

The Whitemud Watershed faces a number of groundwater constraints and management issues. Groundwater availability is limited in areas off the Assiniboine Delta Aquifer. A pipeline has been built to bring water from the ADA to supply the Town of Neepawa. A Proposal to develop a groundwater supply on the ADA at Hummerston for the Westlake Pipeline proved too contentious. The Westlake Pipeline was to serve the Town of Gladstone and rural communities to the north. An alternative pipeline is going ahead, with a water supply coming from the Portage la Prairie region.

The ADA has sufficient supply for domestic use. Licensed groundwater use on the ADA is fully allocated, with the exception of the Squirrel Creek North and South basins. With no new groundwater licenses allowed, rural development through specialized agriculture is curtailed.

Allocation limits are lower for the Upper Whitemud West and Upper Whitemud East sub-basins because these are used for the Town of Neepawa's water supply. Until recently Neepawa obtained its water supply from the Lake Irwin Reservoir, situated on the Whitemud River. As a consequence, flows on the river had to be protected and the allocation limit for the aquifer was set at 15% instead of 50%. In recent years (200) Neepawa switched to a groundwater supply within the basins, near Oberon, with a second well under construction further south.

Irrigation of a variety of crops is economical with existing irrigation systems. Irrigation wells are mostly located on the western end of the aquifer, where there is a larger saturated thickness and coarser-grained deposits, which are able to supply high-capacity wells. These supply sites are often not situated where soils are conducive to growing potatoes and pipelines are constructed to move the water from where it is available to areas where soils are good. The Squirrel Creek basins are at the eastern end of the ADA. Finer-grained sediments in these basins means that well yields are generally insufficient for development of high capacity wells needed for irrigation.

Irrigation wells are often clustered in areas where high yields are present. Monitoring shows some longer-term decline happening near Wellwood. Should the decline continue, it may have the potential to impact domestic and community water sources on the ADA.

Currently, potatoes are the only crop with sufficient payback for the setup of new irrigation operations. The closure of basins within the aquifer to new licensed development means building pipelines to take water from one watershed to another or has caused some residents to find ways to extract water on the sly. Irrigators do not always collect and submit water use records. As a consequence, actual water usage cannot be confirmed.

Water quality protection on the ADA is concerned mainly with leaching of potentially harmful contaminants and nitrates. Baseline nitrate levels have risen in some areas of the ADA, however overall water quality remains good to excellent.

13.0 Summary and Next Steps

The Whitemud River Watershed has two distinct areas in relationship to groundwater supply. The northern two thirds of the watershed is generally lacking in secure supplies of potable groundwater. The southern third is covered by the northern portion of the Assiniboine Delta Aquifer. Groundwater supply on the aquifer is generally sufficient for domestic supply and of good quality. However, in most basins, licensed use is fully allocated.

The ADA is an important source of groundwater for irrigation, which supports a potato growing and processing industry. The ADA also has been seen as a potential source of water for regions off the delta where supply is unreliable. Water demand has been growing on the ADA and issues relating to licensed water use and aquifer budgets are likely to arise. The ADA is exposed at the surface making it vulnerable to contamination. Sources of contamination need to be contains and monitoring in place. The ADA has been extensively studied and has its own aquifer management plan, which would supersede the watershed plan.

In the northern two thirds of the watershed, located outside of the ADA, water supplies can be difficult to obtain. Water must be obtained from relatively shallow sources, usually from glacial sands and gravels in overburden. Deeper bedrock sources are usually too saline to use. Regional supply and distribution systems or groundwater treatment options may have to be considered.

Our review of groundwater resources in the region indicated the possible presence of a shallow fluvial type aquifer near Glenella and a deeper buried valley type aquifer running beneath the ADA and continuing east to Lake Manitoba. These regions should be further examined for aquifer potential. The presence of the aquifers needs to be confirmed through study of existing well records and possibly some exploration. In addition, chemistry records need to be reviewed to see if water from these sources is usable.

14.0 References

Betcher, R. N. 1989. Groundwater Availability Map Series. Neepawa Area (62J). Manitoba Natural Resources, Water Resources.

Burton, S.L. and M.C. Ryan. 2000. Environmental fate of Nitrogen in the Assiniboine Delta Aquifer. LTCS Land Resource Consulting Services.

Frost, L.H. and F.W. Render. 2002. Hydrogeological Summary of the Assiniboine Delta Aquifer. For Assiniboine Delta Aquifer Management plan Technical/Background Report.

Haltsead, 1959. Groundwater Resources of the Brandon Map Area, Manitoba. Canada Department of Mines and Technical Surveys, Geological Survey of Canada, Memoir 300.

Johnson, W.A. 1934. Surface Deposits and Groundwater Supply of Winnipeg Map Area, Manitoba. Canada Department of Mines, Bureau of Economic Geology, Geological Survey Memoir 174.

Little J and D. Sie, 1978. Groundwater Availability Map Series. Brandon Area (62G). Manitoba Natural Resources, Water Resources.

Little, J. 1981. Groundwater Availability in the Almasippi Soils Area of South-Central Manitoba. Groundwater Availablility Study Report #18, Planning Division, Manitoba Department of Natural Resources, Water Resources Branch.

Pedersen, A., 1968. Preliminary Appraisal, Groundwater Availability Study, Carberry Area, Manitoba Water Resources Branch Internal Report.

Render, F.W. 1987. Aquifer Capacity investigations 1980-1986, Manitoba Water Resources.

Render, F.W. 1987. Water Supply Capacity of the Assiniboine Delta Aquifer. Canadian Water Resources Association, 40th Annual Conference, Winnipeg

Render, F.W. 1989. Effects of Pumping Groundwater at Hummerston for the Westlake Pipeline, Hydrotechnical Services., Manitoba Water Resources.

Render, F.W., 1994. The Water Supply Capacity of the Ogilvie Aquifer. Manitoba Department of Natural Resources, Water Resources Branch.

Rutulis, M. 1979. Groundwater Resources in Neepawa and Area Planning District. Manitoba Conservation, Water Resources Branch.

Rutulis, M. 1981. Groundwater Resources in the Willowbend Creek Watershed. Manitoba Conservation, Water Resources Branch. 22pp.