SECTION 5.4

La Salle River
Integrated Watershed Management Plan:
State of the Watershed Report
Groundwater Resources

Groundwater Management Section
March 2007

Manitoba Water Stewardship

Summary

Much of the La Salle River watershed has no potable groundwater supplies and the potable groundwater resources present are not uniformly distributed. Bedrock aquifers are saline to varying degrees and are not considered potable sources of water. The chance of developing potable water supplies only exists within limited areas of sand and gravel deposits within the overburden.

The salinity in the bedrock groundwater within the watershed decreases from approximately 10,000 mg/L in the southwest to 5,000 mg/L total dissolved solids towards the northeast. Outside of the watershed, towards the north and east, fresh water replaces the saline water. Water supplies, especially within the carbonate aquifer are generally good; groundwater from the carbonate aquifer may be useful for heating / cooling exchange systems or potentially other industrial uses.

Overburden aquifers consist of glacio-fluvial sand (Almasippi sand), paleo-channel and alluvial sand (aquifers of limited extent associated with stream and river deposited sediment), glacial outwash sand and gravel, and confined sand and gravel aquifers within or underlying glacial till. The Almasippi sand is fairly extensive west of a line from Elm Creek to Southport, however its thickness is variable and it is generally low yielding. Paleo-channel and alluvial aquifers are associated with pre-historic drainage and modern drainage systems and are very limited in size and extent. These are located primarily in the Oakville area and near modern rivers and streams. The only example of glacial outwash in the watershed is the Elie aquifer located northeast of the town of Elie. Confined sand and gravel aquifers are intersected in drill holes scattered throughout the watershed, but primarily in a bedrock depressional ‘trough’ which roughly lies in a line between Elm Creek and Southport. Confined sand and gravel aquifers within the glacial till are frequently located at depths below 20 metres.

Groundwater from overburden aquifers vary considerably in quality. Most wells completed in the overburden will yield hard to very hard water. Few groundwaters have hardness less than 200 mg/L $CaCO_3$, whereas most groundwater has hardness greater than 400 mg/L $CaCO_3$. Total dissolved solids ranges from 300 to 1,400 mg/L in shallow aquifers and up to approximately 5,000 mg/L in confined sand and gravel aquifers. The water quality decreases in confined sand and gravel aquifers that are located closer to the bedrock.

The Groundwater Management Section of Water Stewardship currently operates 18 monitoring wells, primarily to measure water levels, and one rain gauge within the watershed. Earliest monitoring began in 1960’s in the carbonate aquifer, primarily in response to the construction of the floodway. Town supply exploration and monitoring programs were carried out in the 1960’s (Elie) 1970’s (Oakville, Elm Creek) and monitoring in the Almasippi sand was added in the 1990’s.

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Introduction

Groundwater, like most natural resources, is the responsibility of the provinces. The transfer of responsibility for water from the federal government to the provinces began with *The Natural Resource Transfer Agreement* in 1930. Although groundwater was not specified, it was assumed to be included. In the same year Manitoba passed the *Water Rights Act* which was consequently amended it in 1959 to include groundwater. The 1959 *Water Resources Administration Act* was established to create a comprehensive water management agency. Shortly after, *The Ground Water and Water Well Act* (1963) passed and was meant to address drilling practices and groundwater data collection. Groundwater is regulated under a number of provincial acts including *The Environment Act, The Water Protection Act, The Health Act, The Drinking Water Safety Act, The Water Resources Conservation Act, The Planning Act, The Water Rights Act, The Ground Water and Water Well Act* and subsequent Regulations.

Early regional studies of groundwater and aquifers were carried out by the federal government. These consisted of door to door well surveys, township summaries of water supply and quality, regional maps of surficial geology, well locations and producing zones. Formal studies of groundwater were initiated by the province in the early 1960's and by the mid 60's the Groundwater Management Section began operating a monitoring well network.

The Groundwater Management Section (GMS) of Water Stewardship advises on groundwater management issues including allocation of groundwater and groundwater protection. The GMS operates a monitoring well network, from which data on groundwater conditions such as water levels and water quality is collected, stored and compiled. Studies meant to address specific aquifer or groundwater concerns have been carried out by the section as have regional groundwater resource mapping. Systematic hydrogeologic mapping was conducted from the 1960's through the 1980's consisting of regional stratigraphic drilling, pump testing, well data and quality compilations resulting in 11 regional groundwater availability map series on a scale of 1:250,000 completed by 1989. The Section has also prepared reports on hydrogeology and groundwater resources at various scales including towns, drainage basins, municipalities, planning districts and watersheds over the years.

The Ground Water and Water Well Act and Well Drilling Regulation require that water well drillers be licensed by the province and that the driller supply the province with a report of all wells drilled. The report should contain information on date and ownership, the well location, a description of the material drilled, and information on well construction and pump testing if completed. This information is stored within a database in the Groundwater Management Section.

A glossary of select terms is provided in Appendix A at the back of this report.

Groundwater Backgrounder

Groundwater is water that fills the pores and fractures in the ground. At some point as water recharges the soil and moves down through the profile all of the pore space will be saturated. The surface where this occurs is called the water table. Not only must sediment or rock be saturated to recover groundwater, it must also be permeable enough to allow the water to move at a reasonable rate. Because these properties are largely controlled by the material the water is moving through the geology of the formations are important in understanding water movement. Additionally the natural water quality which the water acquires depends on the materials it flows through.

Aquifers and Aquitards

A geologic formation from which economically significant quantities of water flows to a spring or can be pumped for domestic, municipal, agricultural or other uses is called an aquifer. From glacial times on (the Quaternary period of geologic time), aquifers are primarily formed within sand or gravel deposits. Within pre-glacial or bedrock formations, aquifers are formed from sandstone, hard fractured shale/siltstone or permeable limestone. Aquifers can be separated vertically by less permeable layers; layers that do not readily allow water flow or act as barriers to flow. These confining layers are called aquitards and are principally formed from glacial till or clay deposits in Quaternary sediments or by unfractured or soft shale, massive or unfractured limestone, or gypsum in bedrock layers.

During recharge rain moves vertically through the soil and shallow geologic horizons until it reaches the water table. The water table can be determined within a shallow dug or drilled hole by allowing the water level to come to a static or resting position. In permeable material the water table forms the top of an unconfined aquifer. In an unconfined aquifer the water table and consequently the amount of water in storage, moves up and down over the seasons or longer climatic periods in response to recharge or discharge from the aquifer.

If an aquifer is situated between aquitards and the water level in a well rises above the base of the upper confining unit the aquifer is called a confined aquifer. In a confined aquifer all of the pore space is filled with water and any addition or reduction of water in storage results in a change of water pressure in the aquifer. When the pressure in the aquifer is above the local ground surface, drilling into this formation will result is a flowing artesian well. Confined aquifers are recharged either at a location at higher elevation where the aquifer is no longer confined or it is recharged very slowly through the layers that confine it.

Groundwater discharge can be dispersed over large areas or focused, such as in springs and commonly discharge areas are topographically controlled. Springs form where the water table intersects the ground surface commonly in depressions or hillsides, including river banks. If a higher permeability layer overlies a lower permeability layer on a hillside or river bank the vertical flow of groundwater may be impeded by a low permeability layer causing the water to move laterally to discharge as a spring. Some springs are formed from flowing artesian aquifers where water moves up along fractures or are man-made resulting from unsealed boreholes or blow-outs at the bottom of excavations. Groundwater may also discharge over larger areas resulting in perennially wet areas, bogs or swamps.

Groundwater Flow

Groundwater moves from higher elevation to lower elevation or from higher pressure to lower pressure. The height of the water table or the pressure in an aquifer is called the hydraulic head. The difference in hydraulic head in an aquifer between two locations is used to determine the hydraulic gradient. The groundwater flow direction is from the higher to lower hydraulic pressure along the maximum slope of the hydraulic gradient. Typically, under ambient conditions, groundwater moves quite slowly. In unconfined aquifers the water table loosely mimics the surface elevation and in areas of low topographic relief the typical hydraulic gradient is in the range of one metre of water head decline per kilometer distance. The ability for a geologic material to move water is called hydraulic conductivity. The amount of groundwater that moves through a geologic material will depend upon both the hydraulic gradient, the hydraulic conductivity and the thickness of the aquifer.

Aquifer Studies and Groundwater Data

Early studies of the aquifers of southern Manitoba included work completed by the Geological Survey of Canada for regional resource mapping (Selwyn, 1890; Johnston, 1934; Charron, 1961) and to identify the salt water-freshwater boundary in bedrock (Charron, 1962). Groundwater resource compilations for portions of the watershed were completed by Charron (1961) for the Fannystelle area (Tps. 1 to 6, Rges. 1 to 5, W1). During this latter study 1710 homes were visited and water sources inventoried.

The province compiled the groundwater resources on a 1:250,000 map scale for the Brandon (62G) map sheet (Sie and Little, 1976) and the Winnipeg (62H) map sheet (Little, 1980). The LaSalle River watershed lies within these two Groundwater Availability Study areas. Additional provincial studies that include portions of the watershed include the Groundwater Resources (Synopsis) in the Portage La Prairie R.M. (1982), Groundwater Resources in the MacDonald – Ritchot Planning District (A Synopsis) (1984) and Aquifer Enhancement Investigations 1980-1986.

The provincial Groundwater Availability Studies include a set of diagrams showing the map sheet location, drift thickness, bedrock topography, surface deposits, a number of cross-sections and a table of selected well water chemistry. The Groundwater Availability series have formed the main regional scale compilation of groundwater data to date. The groundwater synopses consist of a brief description of groundwater resources and include maps.

Groundwater Data and Monitoring

The Groundwater Management Section of Water Stewardship maintains a database of well logs for the province. Based on the current data there are 1139 well and test hole records in the La Salle River Watershed (Figure 1). Almost half (523) of the logs are from test wells. Of the total number of logs, 166 record the end of hole in bedrock with the remaining holes were finished in overburden. Of the drillers logs more than 500 wells were reportedly completed in sand and gravel or silt and approximately 100 wells were completed in bedrock.

The Groundwater Management Section drilling and monitoring well installations began in 1963 and currently 18 active monitoring stations and one rain gauge are operated within the watershed (Figure 2). The province has an additional 38 wells within 10 km of the watershed boundary. Provincial monitoring wells have been installed in response to obtaining groundwater information on a regional basis and to monitor specific projects (i.e. construction of the floodway or identification of town water supplies) resulting in variable periods of record as wells are established and others are inactivated in response to groundwater information needs. Town supply exploration and monitoring programs were carried out in the 1960’s (Elie) 1970’s (Oakville, Elm Creek) and monitoring in the Almasippi sand was added in the 1990’s. In total the Groundwater Management Section has drilled or monitored a total of 150 sites, of which 115 were test holes and 35 have some amount of monitoring information.

The province also stores groundwater chemistry information from provincial monitoring wells, private wells sampled during various groundwater projects and results that are supplied to the province from drillers or other sources. The chemistry from the provincial monitoring wells is available to the public.

Bedrock Aquifers

Bedrock aquifers are present beneath the entire watershed. In succession overlying the pre-Cambrian basement are the sandstone aquifer within the Winnipeg Formation, limestone and dolostone aquifers of the Red River (subcrops only on the extreme eastern portion of the watershed), Stony Mountain, Stonewall, and Interlake (Ordovician and Silurian age). Above these lie Devonian through Jurassic age carbonates which contain interbedded shale and gypsum on the western side of the watershed. The Swan River Sandstone aquifer of Cretaceous age is only present on the extreme western portion of the watershed. None of the bedrock aquifers are considered potable water supplies and therefore few wells have been drilled into these aquifers.

Within the carbonate aquifers that underlie the watershed primary porosity will be quite low and generally not well interconnected and groundwater flow is primarily through bedding planes and secondary features that developed after the rock was deposited. These features include joints, fractures and solution channels which enhance permeability. Because of these features well yields can be quite variable depending on the permeable features and density of the features intersected within each drill hole. Well yields that have been reported in driller's logs vary from less than 0.1 L/s to greater than 18 L/s, with an average of 2.5 L/s.

Saline and brackish water is found within the bedrock aquifers of this area. The salinity is associated with long flow systems and increases towards the southwest, the origin of the saline water. The transition between salt and 'fresh' water occurs relatively abruptly, roughly at the location of the Red River on the east and a slightly more gradual transition to fresh-water north of the Assiniboine River.

This transition results from fresh (meteoric) water recharge in the Interlake area, southeast of Winnipeg, on the aquifers most easterly extent and in local areas where glacial outwash sand and gravel are hydraulically connected to the underlying carbonate aquifer. In areas where thick clay layers overly aquifers such as throughout much of the Red River Valley there is not expected to be any measurable local recharge to bedrock aquifers.

The total dissolved solids (TDS) of the carbonate aquifer groundwater ranges between 5,000 and 10,000 mg/L. The dissolved constituents are primarily composed of sodium (Na) and chloride (Cl) with lesser amounts of calcium (Ca) and sulphate (SO_4). Calcium and magnesium although not dominating the chemistry are of high enough concentration to make the water very hard. Dissolved iron (Fe) and fluoride (F) can also be high.

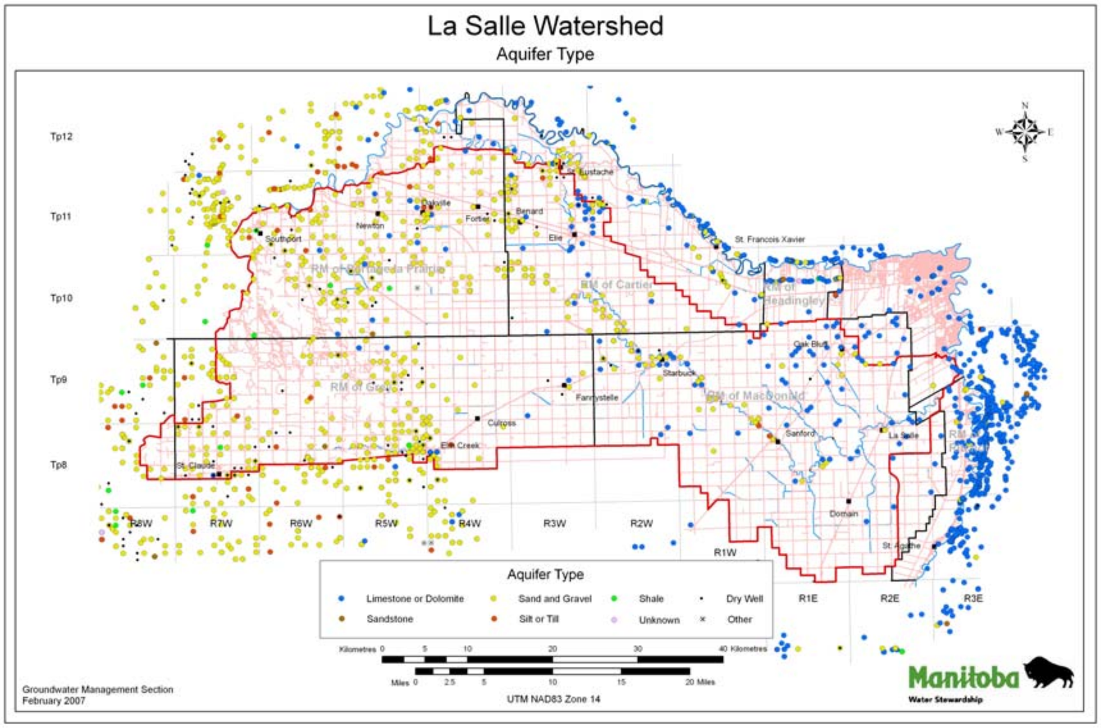

Figure 1. Location of well logs within the Provincial well database coded by aquifer material that the well is completed. Wells are displayed in the centre of the quarter-section in which they are drilled unless more accurate information is available. Multiple wells may be stacked at any one location.

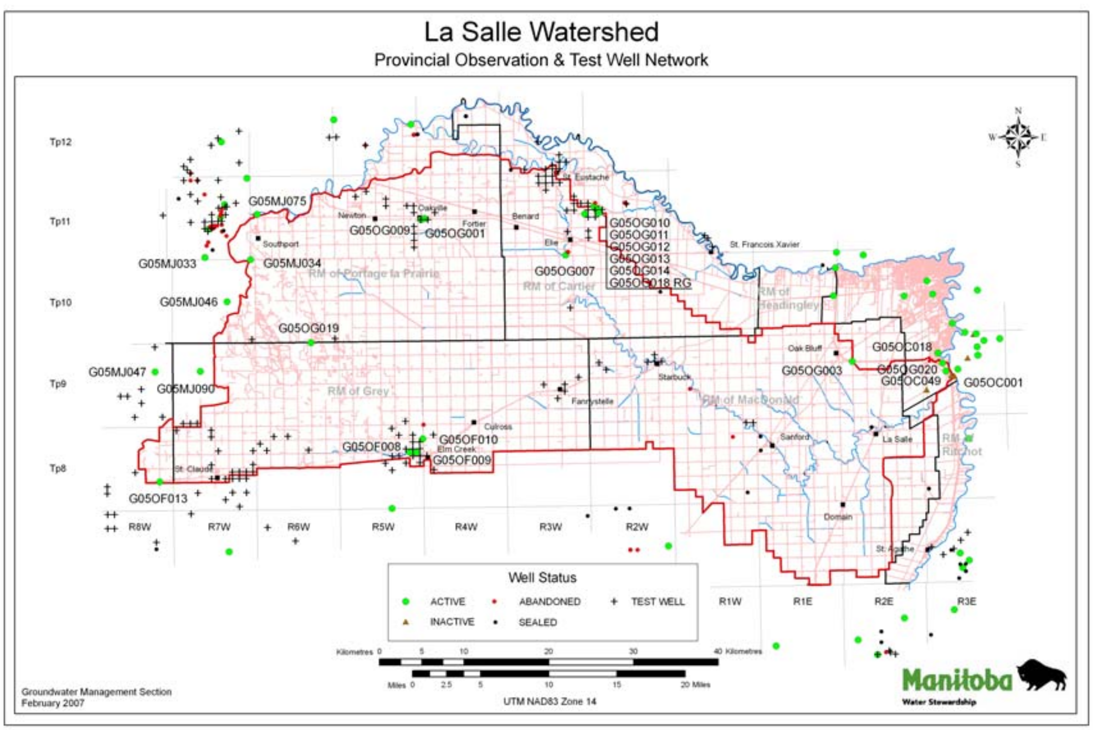

Figure 2. Location of Groundwater Management drilling activity including status with active observation wells labeled. Active stations are currently collecting data; inactive stations have collected observations during some period in the past; sealed wells are wells that have recently been sealed with an available well sealing log; method of abandonment is not available for abandoned holes but common practices at the time of abandonment most likely would have been used.

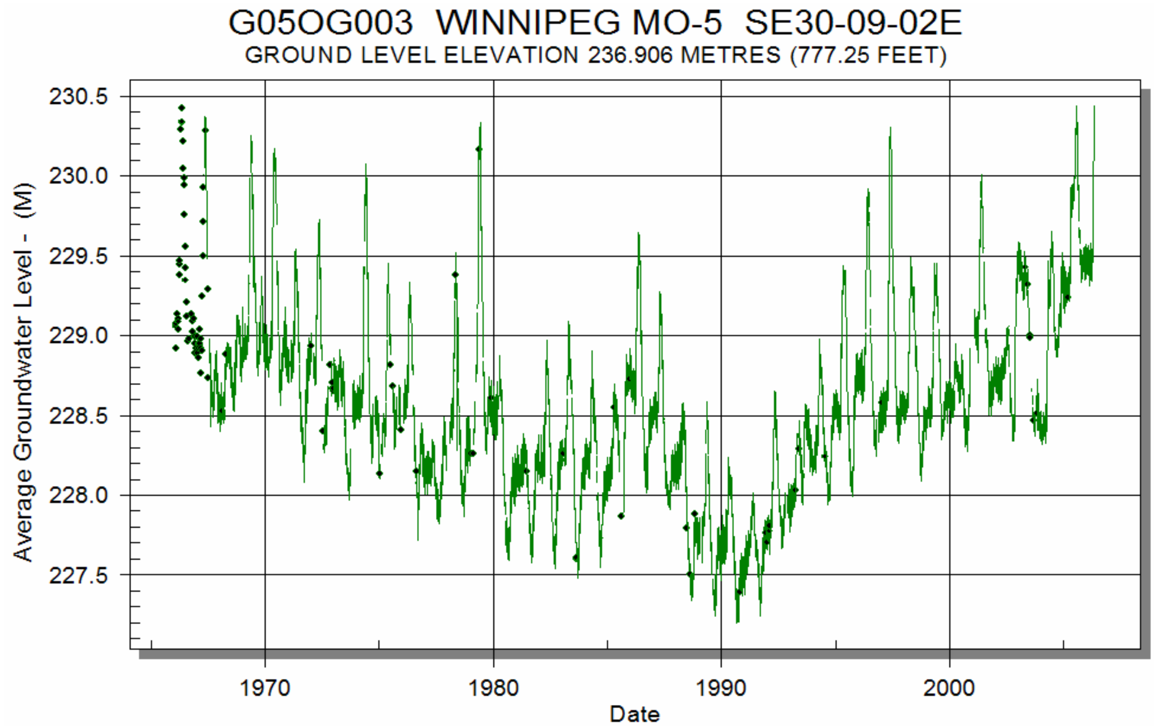

Figure 3 Groundwater elevations are monitored continuously such as at station G05OG003, which started monitoring in 1966 and has the longest continuous record in the watershed. This well is 44.5 meters deep and is completed as an open hole within the carbonate rock. See Figure 2 for location.

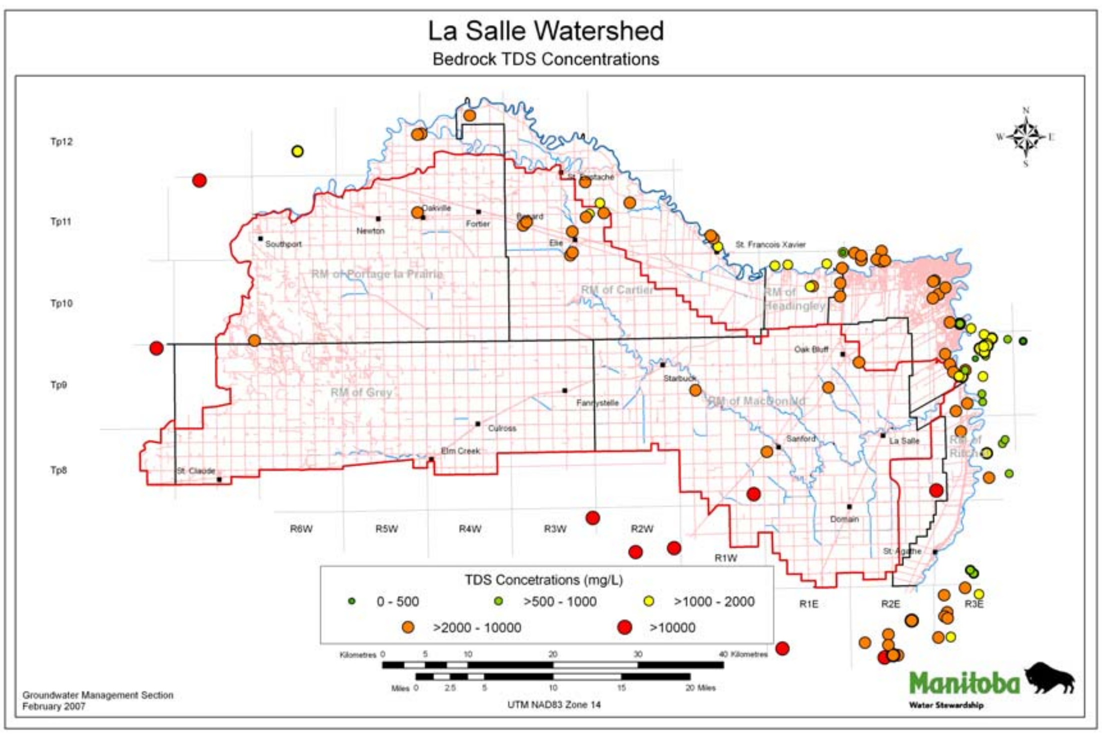

Figure 4. Display of total dissolved solids (TDS) in groundwater from bedrock wells within and including a 1(Km buffer around the watershed. Few samples are available from within the watershed. The fresher water is evident east of the Red River on this diagram. Lower TDS north of Elie results from recharge to the carbonate through the outwash gravel deposits of the Elie pit.

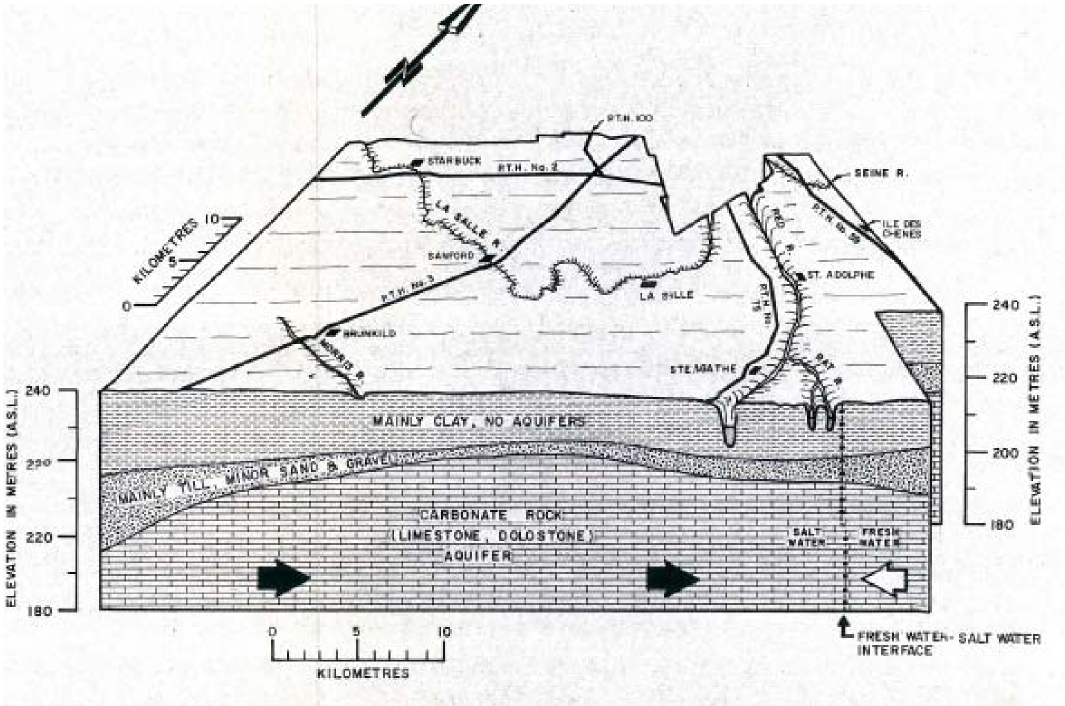

Figure 5. . Block Diagram showing an east-west geologic profile south of Brunkild (from Rutulis, 1984). Direction of saline water flow is designated by the black arrow and fresh water from the east by the white arrow. The depth to bedrock increases from the high point in the centre of the diagram towards the west.

Quaternary Aquifers

Within glacial and recent sediments aquifers are formed as sand and gravel within or at the base of glacial till, glacial outwash or alluvial sand deposited from modern or ancestral rivers or within a distal deltaic environment. Each of these aquifer types was deposited within a different geologic setting, each resulting in differences in characteristics such as aquifer extent, depth to water-bearing layers (Figure 6) and aquifer thickness (Figure 7); all of which have an influence on water availability, quantity and quality.

Glacio-Fluvial Sand Aquifers

Aquifers within the Almasippi sand are located on the western portion of the watershed (Figure 1) below the escarpment and above the glacial Lake Agassiz Burnside beach strandline. The Burnside strandline is located on the western side of Elm Creek and extends towards Southport. Along its reach the strandline largely separates the lacustrine clay to the east from the surficial fine Almasippi sand to the west. The Almasippi sands are shallow (Figure 6) and are variable in thickness ranging from a few metres up to eight or more metres (Figure 7). The texture consists of fine to medium grained sand with silty and or clayey stratification. The sand rests directly upon laminated lacustrine clay and silt.

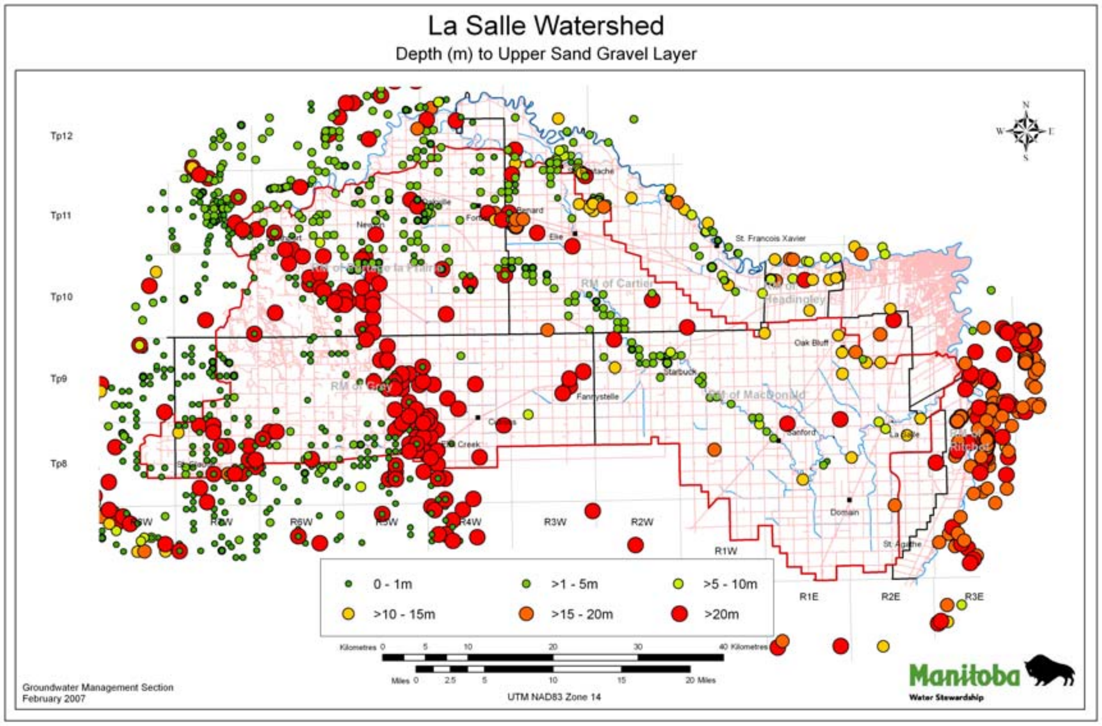

Figure 6. Diagram showing depth (m) to uppermost sand or gravel layer reported from all well logs. Almasippi sands, west of line joining Elm Creek with Southport, are at or near the ground surface. In the Oakville area sand is commonly within a couple of metres below ground, as it is in alluvial aquifers adjacent to the La Salle River. Deeper sand and gravel is encountered along the border between the Almasippi sand and lacustrine lake clay to the east. A few deeper sand/gravel layers are also scattered throughout the watershed and occur in areas of the Almasippi where shallow sand was not encountered.

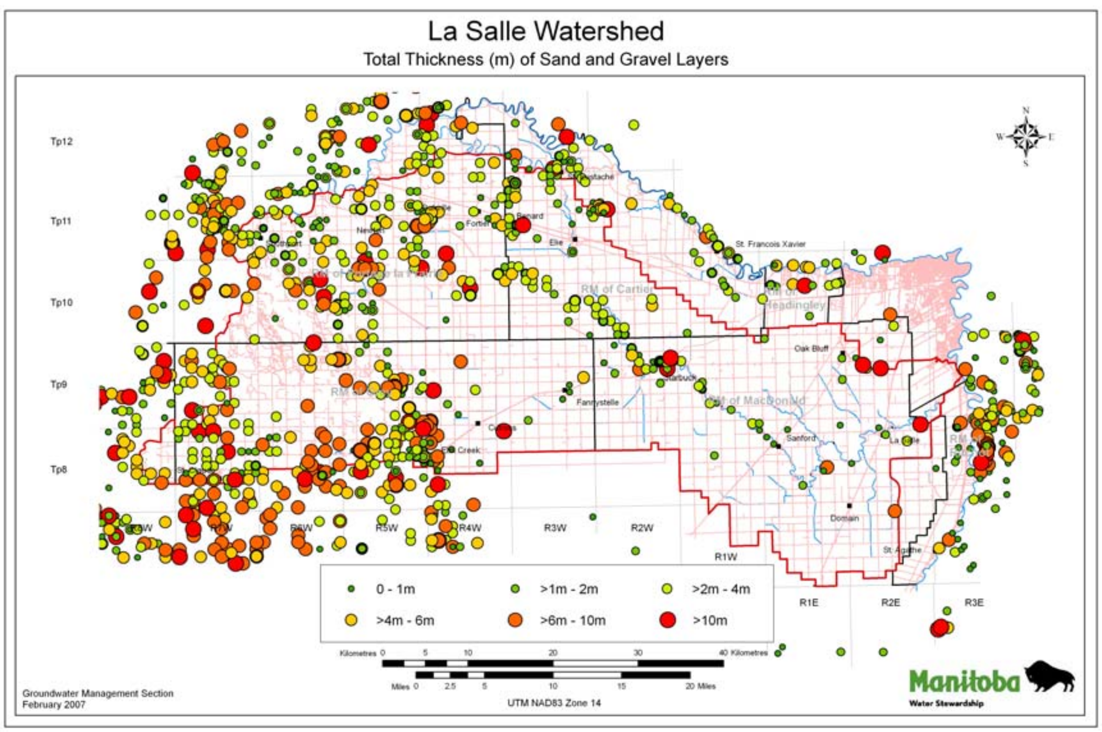

Figure 7. Diagram showing the total thickness of sand and gravel layers reported in any well log. Most aquifers adjacent to rivers (i.e. La Salle) or in paleo channels in the Oakville area are quite thin. Deep sand and gravel (compare to previous figure) are also commonly thin. In the Almasippi sand area the total thickness of sand and gravel is quite variable.

The groundwater within the Almasippi sand is exploited by both drilled and wide diameter bored / dug wells. Low yielding bored wells are commonly deepened below the water producing zone to provide additional storage in areas with low water supplies. Water levels vary throughout the year and can be near surface immediately after spring recharge and recede over the growing season and winter. Recharge of the unconfined aquifer is solely from local precipitation. Snow melt will contribute the largest proportion of recharge, however, rain events greater than the available water holding capacity of the soil will also result in recharge events. A typical hydrograph of groundwater levels is shown in Figure 8.

The regional groundwater flow direction in the Almasippi sand aquifer is predominantly from the west towards the east. The water levels will reflect the overall ground elevation on a regional scale. Minor topography changes and variability sediment such as increase in silt or clay content will affect the local flow direction. The regional gradient is in the range of approximately one to two metres per kilometer and transport rates are expected to be quite slow, in the order of a few metres per year. The regional water level in sand and gravel aquifers is illustrated in Figure 9.

Well yields are variable, but generally water supplies sufficient for domestic and livestock needs are obtained. Charron (1964) reports that, contrary to belief, few wells in this aquifer reportedly went dry during the 1930's drought. Test drilling may be beneficial to determine optimum well location because of the variability in sand thickness and uniformity.

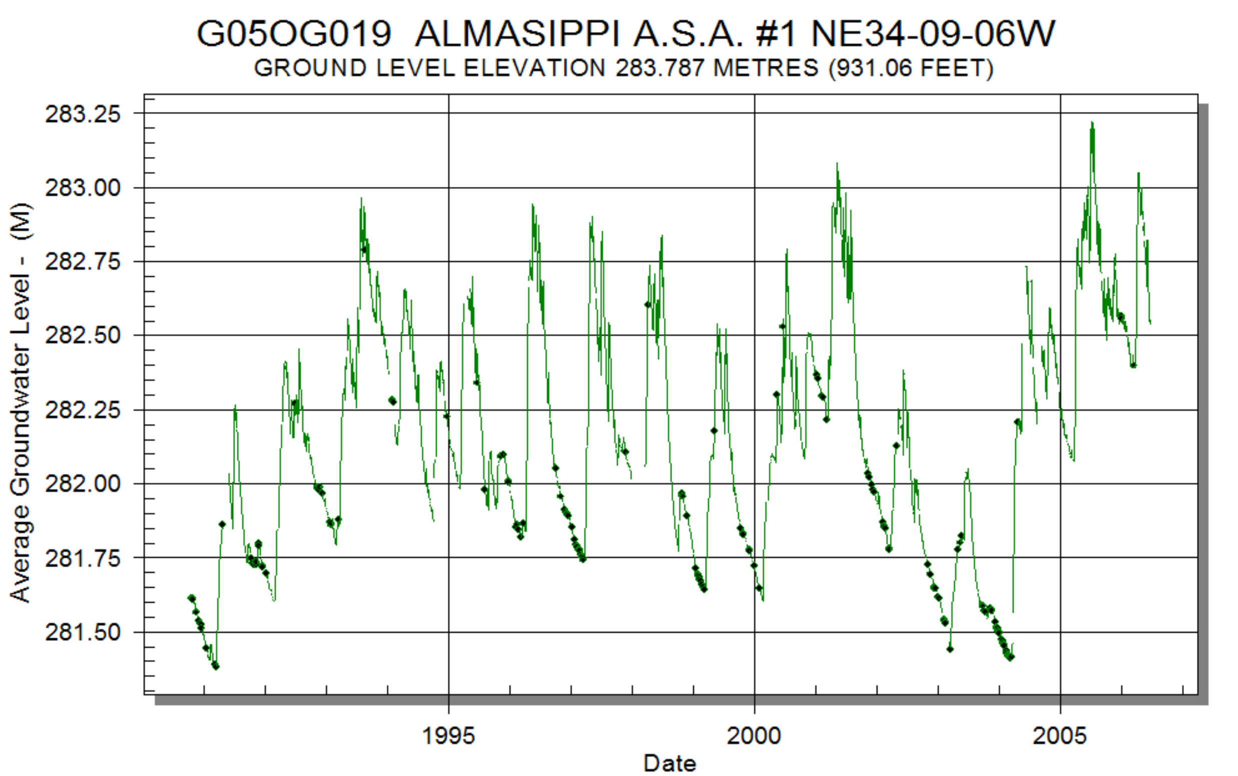

Figure 8. Hydrograph for site G05MJ019 monitoring water levels in the Almasippi sand shows water level spikes in response to spring recharge and recession through the fall and winter. The groundwater elevation is within a metre of the ground surface 283.79 metres above sea level after spring recharge in more than half the years of the monitoring record. See Figure 2 for location of well.

Based on well survey information, it is not uncommon for more than one well to be used to supply a farmstead. In this type of setting wells 'going dry' may be more indicative of the aquifer inability to transport groundwater quickly or extent of the contributing sand than overall groundwater quantity.

Natural water quality is quite good with total dissolved solids in the 300 to 700 mg/L range. The water is relatively hard, 150 to 600 mg/L as $CaCO_3$, with most solutes comprised of calcium (Ca), magnesium (Mg), and bicarbonate (HCO_3). Chloride (Cl), sodium (Na) and sulfate (SO_4) are naturally quite low; generally less than 10, 15 and 30 mg/L, respectively. Because the sand commonly extends to the ground surface or has only a relatively thin cover of silt or finer material within the soil zone the risk of groundwater contamination is relatively high. There are few lab results with comprehensive analyses of drinking water quality parameters. Within the Groundwater Management Section database there are less than half a dozen coliform bacteria results and only a few more nitrate analyses. Although none of the nitrate analysis within the database are greater than the drinking water health-based guideline of 10 mg/L-N; there is measurable nitrate and coliform indicating the vulnerability of this type of aquifer and the wells commonly used to access the water within it. Well siting, maintenance and activities near the well area are important factors in obtaining and sustaining healthy water supplies.

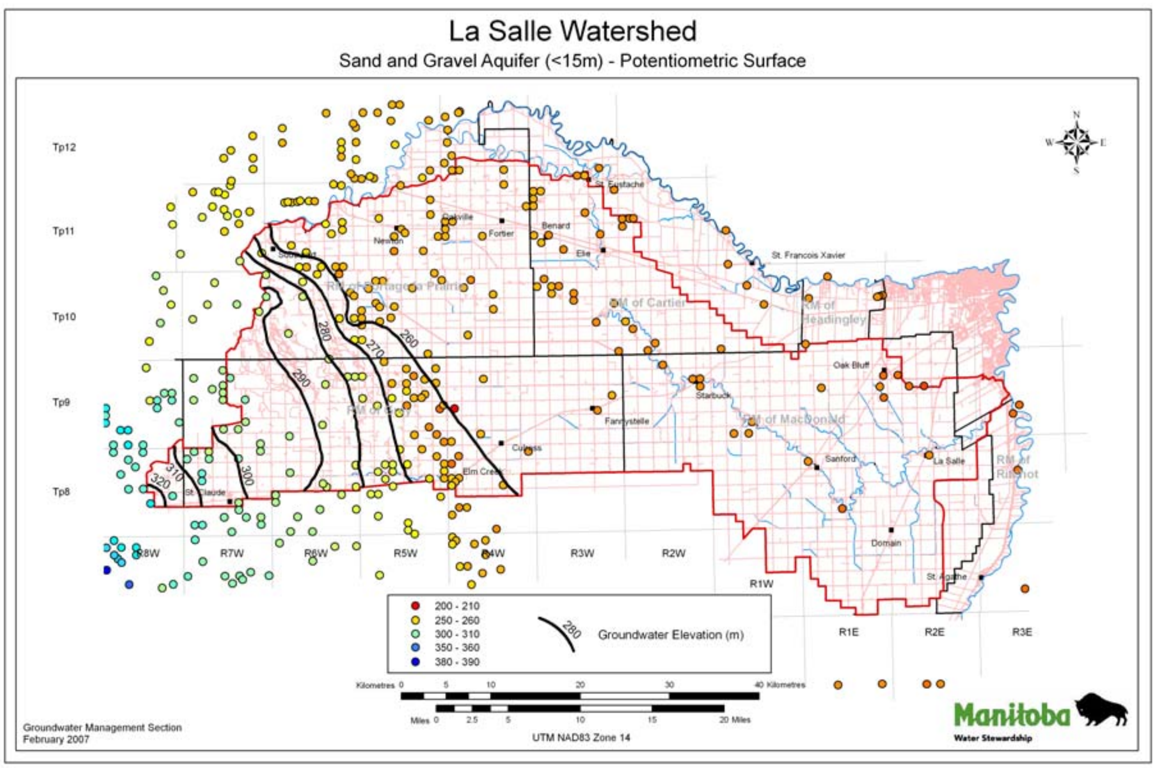

Figure 9. Contour diagram of water level elevations using information from the shallow wells completed in the Almasippi sand area. Contour intervals are 10 meters and show regional groundwater flow from the west to east-northeast.

Paleo-Channel and alluvial aquifers

Alluvial aquifers are found near modern streams and rivers, such as the La Salle and within the flood plain of the ancestral Assiniboine River. These aquifers were formed from sand and silt deposited on the banks and within the channel and because of the modes of deposition individual aquifers have a very limited aerial extent.

Paleo-channel aquifers were formed during the Holocene (post-glacial) by streams on the clay plain distributing the flow from the Assiniboine River as it came down the eastern edge of the escarpment. Channel aquifers are recognized visually as narrow slightly depressed meandering features on the ground surface. The channel widths range from less than 100 to several hundred metres and individual lengths can be traced for kilometers. The channels are in-filled with sand, silt and clay material and aquifers are discontinuous along the length of any one channel. These depressed areas collect run-off from the surrounding clay plain and may seasonally form intermittent water courses. Channel aquifers are present in the upper La Salle sub district, especially in the Oakville area. All of these aquifers are located near the surface and may have a meter or two of clay or silty-clay at the surface overlaying the sand.

In the Oakville area the channel aquifer had an influence on the settlement and placement of the homestead. Most farmyards in this area are located on a portion of a channel aquifer. The town of Oakville is built over a paleo-channel aquifer and previously exploited this water source for the town supply with wells located in the channel immediately south of town. The loading station south-west of town is also completed into the same channel.

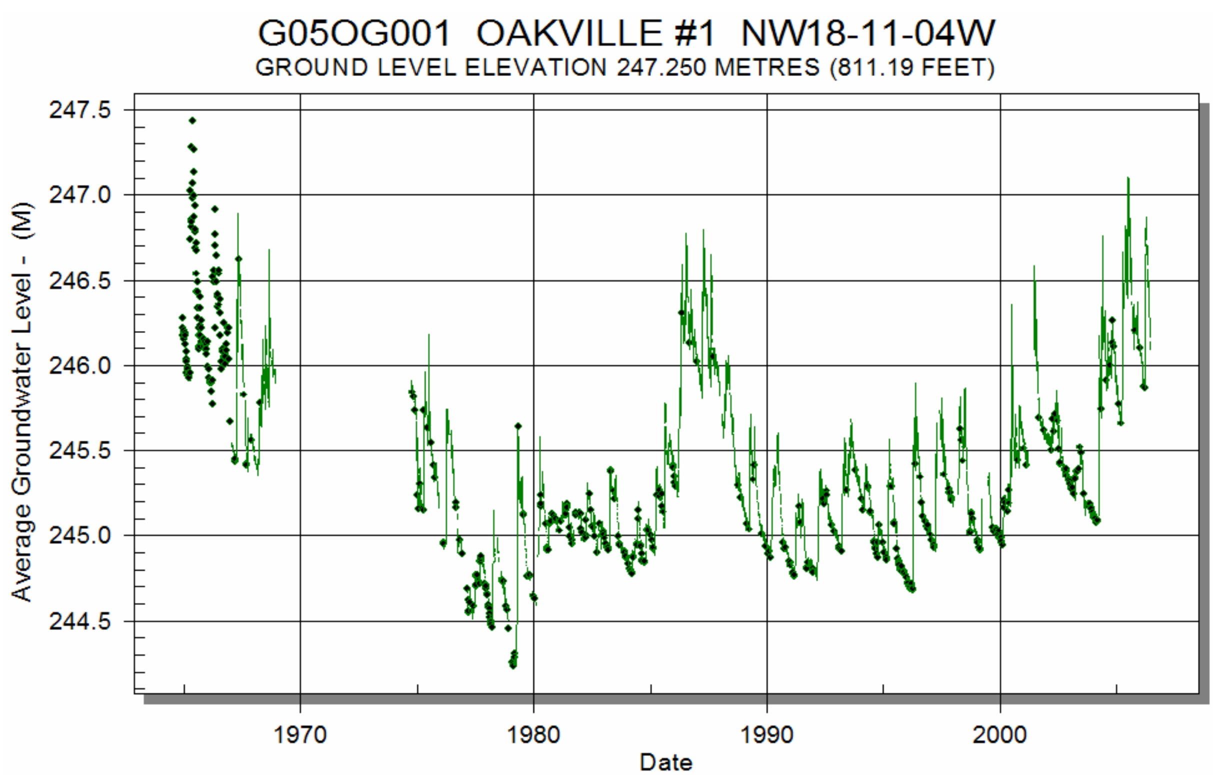

Figure 10. Hydrograph of groundwater elevations for a channel aquifer in the Oakville area is shown. The base of the aquifer this monitoring is installed is 240.85metres. See Figure 2 for location of site

Groundwater flow is dictated by the geometry of each aquifer and is restricted to within the channel outline. Channel aquifers are recharged directly from runoff within the channel depression and from surrounding land and respond quickly to recharge events.

Alluvial aquifers are stratified sediments deposited within the inner bank of stream meanders. As a stream meander length increases a greater amount of sediment is deposited on the inner portion of the meander bend. As the meander grows the extent of sand and silt deposition grows leading to the tendency of having larger water supplies and greater sand thickness within larger meanders.

Lithology of these aquifers typically consists of sand and silts. These may be separated vertically or cut-off horizontally from other permeable layers by clay. Commonly sand deposits are covered by finer textured sediments. In the upper La Salle sub-district there are few alluvial aquifers formed along the southward flowing portion of the La Salle River near Elie. The number of wells (Figure 1) increases as the river turns southeast following the ancestral Assiniboine River channel.

Wide diameter bored and dug wells are more commonly used in these aquifers than drilled wells. The advantage of wide diameter wells is they provide a reservoir in low yielding sediments. Well yields will be highly variable and because of the lack of continuity of aquifers a larger proportion of dry wells are expected during groundwater exploration.

Water quality in the alluvial aquifers ranges from good to fair. Total dissolved solids range from approximately 300 to 1400 mg/L with most solutes consisting of calcium, magnesium and bicarbonate. Hardness as CaCO3 ranges from less than 100 mg/L to more than 1000 mg/L. Natural water chemistry consist of chloride ranging from less than 10 to 100 mg/L, sulphate ranging from less than 10 to greater than 500 mg/L and sodium concentrations from less than 10 to more than 100 mg/L. Alluvial aquifers located within the meanders of modern rivers may hydraulically connect the well to the steam. If this is the case water supplies may be more certain, however water quality may be a greater concern because of the influence of surface water.

Glacial Outwash Sand and Gravel aquifers

Glacial outwash deposits result from direct melting of glaciers which deposit stratified sediment forming elongate sand and gravel deposits. The Elie pit located approximately four kilometers northeast of Elie is the only example of this type of aquifer within the watershed. Even though the surface exposure of this aquifer is quite small, less than a quarter section, locally it was an important water source providing the supply to the town of Elie and surrounding users. The aquifer had been exploited as a potable water source prior to the initial investigations which started in 1964 to delineate the aquifer and determine if it could meet the requirements of the town of Elie. The town supply well was completed in 1968.

The aquifer itself consists of stratified sand, gravel, silt, and clay deposit overlaying a thin till layer or at the southern portion of the aquifer lying directly on carbonate bedrock. The depth to bedrock varies from approximately 16 to 25 metres below ground.

Water quality in the Elie aquifer is generally quite good. Total dissolved solids ranges from 200 mg/L to approximately 500 mg/L from the sand and gravel as compared to approximately 3,000 mg/L in the underlying carbonate aquifer. The TDS of the upper portion of the carbonate aquifer immediately below the Elie aquifer is better quality than surrounding bedrock water because of the local recharge of meteoric water through the outwash sand and gravel. During the 1970's water quality as determined by water electrical conductivity, a measurement of salinity deteriorated in conjunction with increasing water usage. Increased pumping in excess of natural recharge from the sand and gravel was associated with an upwelling and mixing with more saline water from the bedrock (Figure 11).

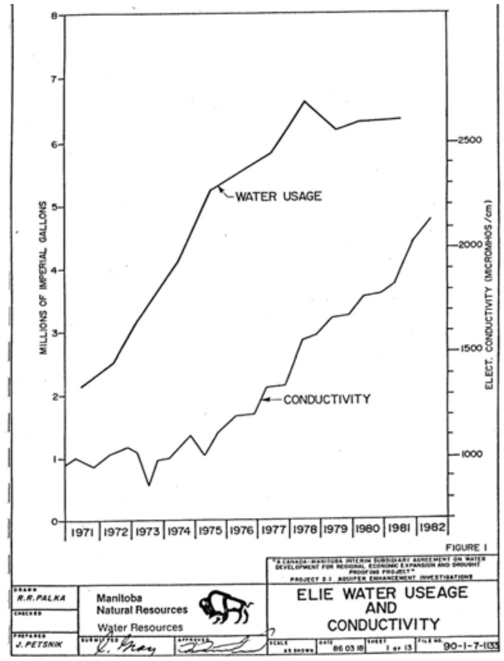

Figure 11. Graph of water usage and groundwater conductivity from the Elie town well. An increase in electrical conductivity indicates a greater salt load and influx of deeper saline water into the aquifer with pumping. Diagram from Petsnik, 1986.

Recharge to this aquifer is directly from precipitation to the open workings of the gravel pit and also through the soil cover overlying the sand and gravel where the gravel is not exposed. During the early to mid 1980's the Elie aquifer was studied because it was the only potable groundwater source in this area and to determine if enhanced artificial recharge could offset the water quality deterioration. The artificial recharge enhancement project (Petsnik, 1986) was planned to divert water from the La Salle River through surface drains to recharge the aquifer where it is exposed within the gravel pit. Because the water quality from the La Salle could not be assured to meet drinking water quality the feasibility study was abandoned.

Confined Sand and Gravel Aquifers

Confined sand and gravel aquifers are found as layers, or lenses within or underlying the glacial till. A scattering of test holes and wells have reported confined sand and gravel aquifers spread throughout the watershed however water quality is quite poor in most of these aquifers and is only acceptable quality for potable or livestock water needs in a narrow band running between the towns of Elm Creek and Southport.

The depth to sand and gravel aquifers is typically greater than 20 metres and aquifer thicknesses have been reported to range from less than one to 10 or more metres. Where the aquifers are separated from the surface or shallower sand and gravel aquifers the amount of recharge will be limited and even though the well yields can be large, ranging from less than 0.1 to greater than 10 L/s, the average being approximately 1.5 L/s, significant drawdown in production wells is expected. The specific capacity, a measure of the productivity of the well, ranges from less than one to more than 100 m^3 of water per day per metre drawdown in the well. Non-pumping water levels are in the range of six to 15 metres below ground.

Water quality is also highly variable ranging from relatively satisfactory to not being recommended as a potable source because of excessive hardness and total dissolved solids. Measured TDS is in the range of 500 to 5000 mg/L and hardness expressed as CaCO3 ranges from 300 to almost 2,000 mg/L. Chloride and sodium each range from 100 to 1000 mg/L and sulphate ranges from less than 100 to 2,000 mg/L. Most chemistry results are above the aesthetic objectives for drinking water for these major constituents.

Water Supply

East of a line from Elm Creek to Southport potable groundwater is limited to channel and alluvial deposits of limited extent. West of this line groundwater is generally easily accessed but well yields will generally be relatively low but sufficient in most areas for farm supplies. Charron (1964) reported that in spite of many potable wells being constructed into shallow sand aquifers that these aquifers were quite resistant to drought and with few exceptions continued to supply water during the drought of 1930’s. Water is available in some areas from deeper confined aquifers. These have primarily been discovered along the Elm Creek to Southport line at depths below 20 metres and scattered throughout the area east of this line at somewhat shallower depths. The confined aquifers east of this line are not sought after for potable supplies because of poor quality.

Groundwater Use

Driller logs specify the intended water use for new production wells. Well use can be recorded as single or multiple uses. Within the La Salle watershed the following water uses are recorded: 317 domestic, 67 livestock, 183 combined domestic and livestock, 31 municipal, 9 industrial, 2 combined air conditioning / heating and domestic 5 air conditioning / heating, and 3 wells completed for other use. Domestic and combined domestic and livestock use is the most frequent well use.

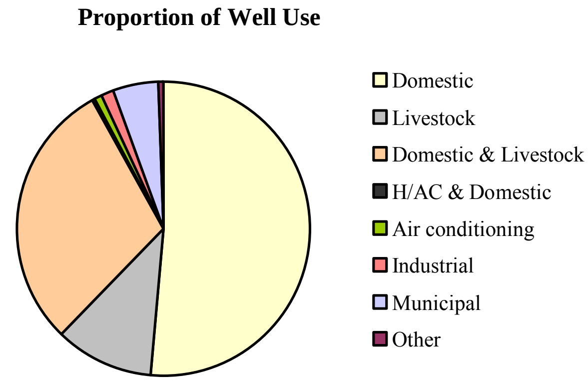

Figure 12. Proportion of well use within the watershed: the largest number of wells are used as domestic supplies, the second most common use is combined domestic and livestock.

Private Well Water Quality

There is little information with the Groundwater Management Section for routine water quality from domestic wells within the water shed. Water quality surveys were conducted by the Geological Survey of Canada during their regional well survey in the early 1960's and domestic wells were sampled as part of the Rural Groundwater Quality Initiative by the province in 1999-2000.

Where information is available for nitrate, well completion and lithology, the evidence shows that the depth to the uppermost sand and gravel and the depth below ground of the well screen or perforations are important factors on nitrate concentrations in the well water. Where the depth to the uppermost sand in a well it is greater than about three metres and the depth to the perforations is at least 6 metres there is a reduced risk of measuring nitrate above the drinking water guideline value of 10 mg/L of nitrate as Nitrogen. However nitrate can still be detected in wells that are deeper, even wells more than 40 metres deep have had measurable nitrate.

Total coliform bacteria are commonly detected in private well water. The presence of coliform bacteria is an indicator that the factors may exist where there are pathways for well water to be contaminated with water from the ground surface or from near surface. Well owners that have had positive coliform results need to assess their well for security and maintenance. Fact sheets are available from the province to help in sampling and interpreting the results of tests.

Water quality deteriorates with the proximity of sand and gravel aquifers to the bedrock. Most shallow aquifers have better natural water quality whereas deeper aquifers have higher TDS, however shallower wells are more prone to contamination.

Availability of Data and Information Gaps

Well log and groundwater information is stored by the Groundwater Management Section. Results from past well surveys indicate that only about half of the wells in service are recorded and the accuracy of the location of the majority of wells is to the quarter section on which it is drilled. Wells are often located in areas of convenience, in the same general areas as potential contamination sources and neglected, abandoned or unused wells can act as a direct conduit from the surface to aquifers. Abandoned, unsealed wells located these areas should be sealed to lessen the potential spread of contaminants to an aquifer. The knowledge of accurate well location is an important step in identifying sites for future well sealing. The province does not have access to well surveys conducted by other organizations; additional information on wells and locations would be beneficial in managing the provinces groundwater resources.

Groundwater forms the baseflow to streams. When run off from the land surface ceases the water sustaining the flow the streams comes from groundwater. There is little knowledge of the contribution of groundwater to streams. It is expected that within the clay plain shallow water contribution to streams and rivers would largely be restricted to alluvial sediments near the rivers (release from bank storage). Streams and drains originate on the eastern limit of the Almasippi sand and the Burnside beach; the contribution of groundwater to these surface water features is not quantified.

Issues, Concerns and Recommendations

- There are limited potable groundwater resources within the watershed. Much of the groundwater is present in aquifers that potentially are vulnerable to water quality degradation.
- Thin aquifers and aquifers of limited extent will be more prone to droughts.
- High use groundwater withdrawals require assessment on an individual project basis.
- Groundwater level monitoring by the province will continue as required.
- In cooperation with CD a well inventory should be completed along with general field chemistry assessment – include: well inventory, GPS coordinates, construction with rudimentary water quality, and comprehensive chemistry on select wells.
- Groundwater Management Section is committed to completing new set of groundwater map compilation based on the watershed scale. These will be produced in a digital format

Vulnerable Groundwater Areas / Well-head Protection

Previous well surveys by Manitoba and other provinces show that well location, construction and maintenance are important factors in man-made water quality problems. Because much of the potable water in the watershed is accessed by shallow wide diameter wells water quality problems can be expected to occur. The watershed authority should encourage owners of private wells to self-assess or have their well assessed for physical conditions that may affect water quality. Water testing should be encouraged for all drinking water sources on a regular basis.

Community or municipal wells require well specific assessment to determine the vulnerability in the development of well head protection policies. As a minimum the individual characteristics of each well, aquifer and geology should be considered to assess vulnerability.

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Appendix A

Definition of Terms

Definitions

Alluvial	Sediment deposited by running water.
Aquifer	A porous and permeable geologic formation that is saturated and capable of producing useful quantities of water to wells or springs.
Aquifer, confined	An aquifer that is overlain by a layer of material with considerably lower permeability. The water within the aquifer is under pressure so that it rises above the top of the aquifer material in a well drilled into the aquifer; synonym: artesian.
Aquifer, unconfined	An aquifer where the water table forms the upper boundary.
Aquitard	A saturated low permeability unit that does not yield water readily.
Hardness	A property of water that reduces the effectiveness of soap. It is primarily caused by calcium and magnesium ions; expressed in ppm (parts per million) CaCO3, or as gpg (grains per gallon U.S.) where one gpg equals 17.1 ppm.
Hydraulic conductivity	The rate that water moves through water is able to move through a permeable material.
Hydraulic gradient	The change in hydraulic head over a given distance in a direction which produces the maximum rate of decrease of hydraulic head.
Hydraulic head	The total water pressure, generally expressed as elevation.
Lacustrine sediment	Sediment deposited within lakes.
mg/L	milligrams per litre; a common unit of measure for solutes in most groundwater, it is equivalent to a part-per-million.
Outwash	Stratified sand and gravel washed out from a glacier by meltwater streams and deposited in front of an active glacier.
Overburden	Unconsolidated material overlying bedrock. In Manitoba overburden is derived during glaciation or more recent time.
Permeability	The property or capacity of a porous rock, sediment or soil to transmit water, it is a measure of ease that water will flow.
Quaternary	The period of geologic time most noted for glaciation beginning between 2 and 3 million years ago and extending to the present.

Specific capacity	It is an expression of the productivity of a well obtained by dividing the rate of discharge of a well per unit of drawdown during pumping.
Total Dissolved Solid	(TDS) a measure of the concentration of dissolved minerals in water expressed in mg/L or ppm.
Water table	The surface where all the pore space is filled with water and can be observed by measuring the water level in shallow wells installed into the zone of saturation.
Well yield	The volume of water discharged from a well, frequently determined during short-term pump tests immediately after drilling the well.