CENTRAL ASSINIBOINE AND LOWER SOURIS RIVER WATERSHED

GROUNDWATER RESOURCE INFORMATION

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1.0 INTRODUCTION

Groundwater is a major source of water supply for private domestic use as well as for municipal, industrial, commercial and agricultural purposes within the Central Assiniboine and Lower Souris River watershed. Groundwater discharge also provides base flow to rivers and streams and contributes water to marshes and wetlands. This makes groundwater a vitally important resource to the watershed.

A review of currently available groundwater resource information within the watershed has been completed using three main sources: groundwater reports, aquifer maps and the provincial computer data bases GWDrill and HYDATA. This report summaries the groundwater information, and provides a brief overview on existing aquifer management plans, provincial groundwater monitoring, acts and regulations, and groundwater issues and concerns within the watershed. A listing of reference material pertaining to the groundwater resources of the watershed is also provided.

2.0 GROUNDWATER INFORMATION

2.1 Availability

The availability of groundwater varies considerably across the watershed. In some areas sufficient quantities of groundwater are available for private, domestic use while in others the supply is inadequate. Larger quantities may also be available locally for municipal, industrial, commercial and agricultural uses.

The principle aquifers in the Central Assiniboine and Lower Souris River watershed are:

- sand and gravel; and
- shale bedrock

Maps of the approximate distributions of the sand and gravel and shale bedrock aquifers within the watershed are presented on Figures 1 and 2 respectively (modified after Rutulis, 1986a,b).

2.1.1 Sand and Gravel Aquifers

Sand and gravel aquifers are widely distributed across the watershed as shown on Figure 1. There are several major sand and gravel aquifers, including:

1) Assiniboine Delta Aquifer – located in the central/northeast part of the watershed
2) Oak Lake Aquifer – a small portion located in the western part of the watershed
3) Buried sand and gravel aquifer located east of Souris
4) Brandon Channel Aquifer Complex – located in the Brandon area
5) Spiritwood Aquifer System – located in the southwestern portion of the watershed
6) Spillway Aquifer – a small portion located in the eastern part of the watershed

As well, small or isolated lenses of sand and gravel occur throughout parts of the watershed, which form local aquifers.

A brief description of the various sand and gravel aquifers is provided below.

Assiniboine Delta Aquifer

The Assiniboine Delta Aquifer (ADA) is an almost totally unconfined sand and gravel deposit that covers about 3,900 square kilometres (1,500 square miles). Approximately two-thirds of the aquifer lies within the Central Assiniboine watershed – the remainder lies to the north within the adjacent Whitemud River watershed (refer to Figure 1).

The Assiniboine delta structure is the result of a very large glacial river depositing sediments into a large bay in Lake Agassiz created by a depression in the glacial till surface. The aquifer body is comprised of sands and in the western portion, some gravel. Given the dynamic deposition history, there can be considerable difference in the sand grain sizes and thicknesses over short distances. In general, as is characteristic of delta aquifers, the larger and heavier sediments were deposited first (near the mouth of the river in the west and central portions of the aquifer) and the smaller and lighter particles were dropped last (further out into the lake, near the northern, eastern and southern edges of the aquifer). As a result, higher groundwater withdrawal rates are attainable mainly in the west and central portions of the aquifer where the particle sizes are larger.

The ADA extends to ground surface except for a portion of the north western area (which lies in the Whitemud River watershed) where the aquifer is covered by a thin layer of clay. Along the western side the aquifer materials rest on glacial till. Throughout the rest of the area the aquifer is underlain by silt and silty clay that rests on glacial till. The glacial till overlies shale bedrock.

The thickness of ADA varies, from about five feet along the extremities of the aquifer to greater than 100 feet in the central part of the aquifer system. The sand and gravel units are generally thinner in the west, and through the north central and northeast parts the sand beds are generally thicker. The unsaturated thickness ranges from zero at Devils Punchbowl and Douglas Marsh to a maximum of about 70 feet.

It is estimated that the ADA contains about 12,000,000 acre-feet of water. Recharge of the aquifer is from local rainfall and snowmelt. Groundwater discharge provides significant base flow to rivers and streams and contributes water to marshes and wetlands. Groundwater flow within the portion of the aquifer located in the Central Assiniboine and Lower Souris River watershed is generally towards the Assiniboine River.

The chemical quality of groundwater in the ADA within the watershed is generally excellent to good with total dissolved solids (TDS) ranging from about 200 to 600 mg/L. Concentrations of naturally occurring arsenic and barium (Figures 3 and 4, respectively) have been found above the drinking water quality standard in some wells, with arsenic more common in deeper parts of the aquifer. Hardness, iron and manganese are common aesthetic water quality problems.

Local groundwater availability and usage within the ADA is based on the concept of aquifer sub-basins which have been determined from mapping of the aquifer's water table. Thirteen such aquifer sub-basins have been defined, six of which are primarily located in the Central Assiniboine and Lower Souris River watershed, namely

- Epinette Creek North
- Epinette Creek South
- Assiniboine East
- Assiniboine South
- Assiniboine West
- Assiniboine Souris

The availability and usage of groundwater varies among the aquifer sub-basins. The allocation limit for groundwater use within each sub-basin is based on the aquifer's available yield and licensing of 50% of the available yield. The remaining 50% is reserved for the environment (stream flows, wetlands, riparian vegetation) and domestic users. To date, this approach of aquifer management has provided sustainable development for domestic, municipal, industrial, commercial and agricultural use within the watershed.

Additional information on the ADA is contained in Render (June 1987), Render (September 1987), Frost and Render (2002) and the Assiniboine Delta Aquifer Management Plan (May 2005).

Oak Lake Aquifer

The Oak Lake Aquifer (OLA) is an almost totally unconfined sand and gravel deposit that covers about 2,100 square kilometres (800 square miles). Only a small area (about 5%) of the aquifer is located within a western portion of the Central Assiniboine watershed (refer to Figure 1).

The OLA rests on sandy silt which is underlain by clay and/or till. Beneath this lies shale bedrock. The aquifer is bounded on the west and south by glacial till plains; on the north side thin sand plains extend to the deeply incised valley of the Assiniboine River; the eastern side of the aquifer generally blends into an area of silt and clay.

The thickness of the OLA varies considerably from zero along the extremities of the aquifer to greater than 50 feet in the central and south-eastern portions of the aquifer system. The thickness is also quite variable over short distances. Within the western portion of the watershed in which the OLA lies, the aquifer thickness ranges from zero along the extremities to about 40 feet. The unsaturated thickness ranges from less than 5 feet to about 20 feet.

It is estimated that the OLA contains about 3,000,000 acre-feet of water. Recharge of the aquifer is mainly from local rainfall and snowmelt and, to a lesser degree, from stream flow in Pipestone and Stony Creeks. The aquifer discharges water mainly through springs in Oak Lake, Plum Creek, Maple Lake Drain, Souris River and wetland areas. Groundwater flow in the OLA is generally from west to east with flow also towards the lakes and surface waterways.

The chemical quality of groundwater in the OLA within the watershed is generally excellent to good with total dissolved solids (TDS) ranging from about 400 to 600 mg/L. Hardness, iron and manganese are common aesthetic water quality problems.

Local groundwater availability and usage within the OLA is based on the concept of aquifer sub-basins which have been determined from mapping of the aquifer's water table. Three such aquifer sub-basins have been defined including the Plum Creek sub-basin of which a portion lies within the Central Assiniboine and Little Souris River watershed.

The availability and usage of groundwater varies among the aquifer sub-basins. The allocation limit for groundwater use within each sub-basin is based on the aquifer's available yield and licensing of 50% of the available yield. The remaining 50% is reserved for environment (stream flows, wetlands, riparian vegetation) and domestic users. To date, this approach of aquifer management has provided sustainable development for groundwater use within the watershed.

Additional information on the OLA is contained in Render (September 1987) and the Oak Lake Aquifer Management Plan (March 2000).

Buried Sand and Gravel Aquifer east of Souris

A major buried sand and gravel aquifer is located east of Souris (refer to Figure 1). Existing information indicates the aquifer is limited in size however its boundaries have not been well defined. In general, the aquifer is confined and appears to be overlain by about 18 to 24 metre (60 to 80 feet) of clay and glacial till and underlain by shale bedrock. The thickness of the sand and gravel deposit varies from about 9 to greater than 18 metres (30 to >60 feet). Its yield varies significantly - the most productive part of the aquifer lies north of Highway No. 2 within portions of Township 8 in Ranges 19W, 20W and 21W. Reported well yields range from about 1 to 2 L/s (13 to 26 Igpm) with yields over 7 L/s (approx. 100 Igpm) possible. This aquifer is the source of water supply for the Town of Souris municipal system and is also a source of water supply for domestic and agricultural use. The long-term sustainable yield of the aquifer is unknown.

The availability of water quality data is quite limited. Based on available data the chemical quality of groundwater is fair with the electrical conductivity ranging from about 1,000 to 1,400 µS/cm. Hardness, iron and manganese are also expected to pose aesthetic water quality problems.

Brandon Channel Aquifer Complex

The Brandon Channel Aquifer Complex is located in the Brandon area (refer to Figure 1). The aquifer complex is a hydraulically complicated assemblage of bedrock channel, intertill, unconfined surficial and alluvial aquifers separated by till and clay aquitards (Wiecek, April 27, 2000). The current understanding of the aquifer complex is that it consists of two major sand and gravel aquifers, the Assiniboine Valley Alluvial Aquifer and the Brandon Channel Aquifer. The geologic structure and hydrogeologic conditions of the aquifer complex are not thoroughly understood at this time. A brief summary of the aquifer complex is provided below.

The Assiniboine Valley Alluvial Aquifer appears to be a generally east-west trending feature within the valley of the Assiniboine River within Ranges 18W and 19W. The lateral (generally north and south) boundaries of the aquifer system are considered confined within clay and/or tills of the valley walls and underneath by shale bedrock and/or till. The aquifer system consists of an upper confined sand and gravel unit ranging in depth from about 2 to 12 metres (6 to 40 feet) and a lower confined sand and gravel unit ranging in depth from about 15 to 30 metres (50 to 100 feet) and separated by clay. It is assumed that the Assiniboine River is hydraulically connected to the upper sand and gravel aquifer and is a significant source of recharge to the aquifer. The long-term sustainable yield of the Assiniboine Valley Alluvial Aquifer is unknown.

Water quality data is not available for the upper confined aquifer. Based on limited water quality data available for the lower confined aquifer, the quality of groundwater in the lower aquifer is good with a TDS of about 800 mg/L. The water is hard; iron and manganese are expected to pose aesthetic water quality problems.

The City of Brandon relies on the Assiniboine River as its main water supply. However, the City is also licensed to use the lower confined sand and gravel aquifer as an alternate municipal water supply, specifically as an emergency supply with a maximum withdrawal rate of 350 L/s (4,600 Igpm) and a maximum diversion amount of 2,955 cubic decametres in any one year.

The Brandon Channel Aquifer is a deep buried sand and gravel channel aquifer. It is a generally east-west trending linear feature located east of Brandon within Township 10, Range 18W. Its extent outside this area is currently not well defined. The aquifer is confined and is located at a depth in the range of about 30 to greater than 90 metres (100 to >300 feet). The overlying soils consist of layers of clay, till and sand and gravel of various thickness. The long-term sustainable yield of the Brandon Channel Aquifer is unknown.

The chemical quality of groundwater in the Brandon Channel Aquifer is generally good to fair with total dissolved solids (TDS) ranging from about 600 to 2,000 mg/L. Hardness, iron and manganese are common aesthetic water quality problems.

A number of industries have developed groundwater supplies from the Brandon Channel Aquifer. All groundwater withdrawal is licensed through Water Rights Licensing.

Spiritwood Aquifer System

The Spiritwood buried valley is a buried bedrock valley, lacking surface expression, which formed prior to the end of the last glaciation and was subsequently buried beneath glacial fill. It is best known in North Dakota, where it was originally identified and where it constitutes an important source of groundwater. The Spiritwood buried valley extends north into Manitoba where it has the potential to be a locally significant groundwater supply. It crosses into Manitoba just east of Turtle Mountain in Township 1, Range 14 W. From here it extends about 50 km as far north as the Souris Gorge. The extent of the aquifer system northwards towards the City of Brandon is currently under investigation.

The Spiritwood buried valley in North Dakota and in Manitoba has a wide, flat bottomed channel with steep sides. In Manitoba, the aquifer system is buried beneath about 20 to 45 metres (60 to 150 feet) of glacial till, with a maximum valley depth exceeding 90 metres (300 feet) in a few locations. Aquifer materials consist of confined discontinuous sand and gravel deposits found at different levels and positions within the valley and having variable lateral extent

Recent investigations have been undertaken to better define the Spiritwood Aquifer system. Manitoba Water Stewardship conducted an exploration drilling program north of the Pembina Spillway and south of the City of Brandon in 2009 to help define the extent and characteristics of the aquifer system (Toop, in preparation). The Geological Survey of Canada (GSC) completed a helicopter-borne time-domain electromagnetic survey in 2010 to test the effectiveness of commercial airborne time-domain electromagnetics for mapping and characterizing buried valley aquifers in the Canadian Prairies (Oldenborger et. al., 2010). Additional studies may be warranted if the results of these investigations continue to support the Spiritwood Aquifer system as having the potential to be a locally significant groundwater supply.

Additional information on the Spiritwood Aquifer is contained in Betcher et. al. (2005).

Spillway Aquifer

A portion of the Spillway Aquifer is located in the eastern part of the watershed in Township 7, Range 11W. It is part of a larger aquifer system (which includes the Delta, Beach and Silt/Sandy Sand Aquifers) that extends to the east (to Treherne) into the adjacent Boyne River watershed.

The Spillway Aquifer lies in an intermittent and meandering fashion at the base of the Boyne River spillway. The aquifer consists of sand and gravel deposits, covered by significant thickness of clay. Test drilling is required to find productive deposits and to determine their capacity. Groundwater quality is generally poor with good quality water only in the Pellys Lake area.

Additional information on the Spillway Aquifer is contained in Wiecek and Render (1998) and the Stephenfield Lake Watershed Management Plan (June 2005).

Aquifers as Lenses of Sand and Gravel

A considerable portion of the watershed is mapped as areas where aquifers occur as lenses of sand and gravel (refer to Figure 1). Within these areas aquifers typically occur in glacial till and other surficial deposits. The depth and size of the aquifer can vary significantly, from a few to more than 30 metres (3 to >100 feet) in depth and from less than a hectare (2.5 acres) to several square kilometres (1 to 2 square miles) in area. Well yields can also range significantly, from less than 0.1 L/s to more than 7 L/s (approx. <1 to >100 gallons per minute). And water quality can range from excellent to very poor.

Minor sand and gravel aquifers

Sand and gravel aquifers are mostly absent within these areas as shown on Figure 1. Some of these areas are underlain by shale bedrock aquifers (refer to Figure 2) which may provide groundwater as a source of water supply.

2.1.2 Shale Bedrock Aquifers

The Odanah Member of the Pierre shale forms a regionally important aquifer in the watershed (refer to Figure 2). Permeable zones in the Odanah shale consist of fractured zones, joints and bedding planes through which groundwater can flow and be extracted for water supply purposes. It is these permeable zones which form and is termed the shale aquifer. The intact shale rock matrix itself has a low permeability and does not transmit water at sufficient quantities for water supply purposes. The rock matrix however, as part of the overall shale rock system, may receive and transmit substantial quantities of water over long periods of time.

The soils overlying the shale bedrock are predominantly glacial till but also include silt, clay and sand and gravel. The thickness of the soils overlying the shale bedrock varies. The overburden soils are typically less than about 10 metres (30 feet) in the eastern and central portions of the watershed but are generally thicker in the western portion, ranging from about 10 to greater than 30 metres (30 to >100 feet).

The shale aquifer is a significant source of water supply for farm, rural residential and municipal use in the southern regions of the watershed, particularly in those areas where sand and gravel aquifers are not present or are poor producers. The areal extent, thickness and hydraulic properties of the shale aquifer are typically quite variable and unpredictable. Yields from wells are typically less than 0.5 L/s (6.5 Igpm) but yields in excess of 1 L/s (13 Igpm) are not uncommon.

Groundwater quality is quite variable with water quality ranging from excellent to very poor. The concentration of total dissolved solids (TDS) range from about 500 mg/L to 9,000 mg/L. Water quality appears to decline with depth in many areas and tends to be slightly saline (TDS ranging from 2,500 to 5,000 mg/L) in portions of the shale bedrock aquifer located in the south-central and south-western regions of the watershed (refer to Figure 2). In these areas the groundwater supply in generally not potable but may be acceptable for some livestock and other uses.

Additional information on the shale aquifer is contained in Betcher et. al. (1995).

2.2 Recharge and Discharge

Groundwater exists in a long-term balance between recharge and discharge of water within an aquifer system. The fundamental mechanisms contributing to groundwater recharge and discharge within the Central Assiniboine and Lower Souris River watershed are generally well understood. However, with the exception of the Assiniboine Delta and Oak Lake aquifers, the understanding of recharge/discharge processes and rates, surface water/groundwater interactions and aquifer/aquitard dynamics is not well developed.

3.0 AQUIFER MANAGEMENT PLANS

Aquifer management plans have been developed for the Assiniboine Delta and Oak Lake aquifers. These are summarized below.

3.1 Assiniboine Delta Aquifer Management Plan

An aquifer management plan for the Assiniboine Delta Aquifer was implemented in 2005 (Assiniboine Delta Aquifer Management Plan, May 2005). The management plan included recommendations for four main action plans, namely monitoring & data analysis, water quantity/quality, irrigation co-management and awareness education. An action group comprised of local stakeholders and technical support personnel was formed to implement the action plans. The action group meets typically once to twice a year. An aquifer management board meets annually.

3.2 Oak Lake Aquifer Management Plan

An aquifer management plan for the Oak Lake Aquifer was implemented in 2000 (Oak Lake Aquifer Management Plan, March 2000). The management plan included recommendations for four main action groups, namely water quantity protection, water quality protection, education and monitoring. An action group comprised of local stakeholders and technical support personnel was formed to implement the action plans. The status of the action groups is unknown. An aquifer management board meets annually.

4.0 GROUNDWATER MONITORING

Groundwater monitoring is undertaken on a broad provincial scale by the Groundwater Management Section of Manitoba Water Stewardship. This Section maintains an extensive network of over 500 observation wells primarily within agro-Manitoba. Monitoring is carried out to establish trends and observe long-term changes in groundwater levels and water quality in most major aquifers in the province. Groundwater monitoring may also be mandated at specific sites in licences or permits issued under *The Environment Act* or licences issued under *The Water Rights Act*.

Within the Central Assiniboine and Lower Souris River watershed, a network of observation wells is maintained within the Assiniboine Delta Aquifer, Oak Lake Aquifer and Brandon Channel Aquifer Complex. Observation wells are also maintained within the Spillway Aquifer and a small portion of the shale bedrock aquifer. The locations of the observation wells in the sand and gravel and bedrock aquifers are shown on Figures 5 and 6 respectively. Little monitoring is completed in areas where only minor aquifers (such as lenses of sand and gravel) are located.

Details of the stratigraphic, construction and testing information for the observation wells are contained within the provincial GWDrill data base. Records of water level and quality data for the observation wells are maintained within the provincial GWDrill and HYDATA data bases. GWDrill and HYDATA are administered by Manitoba Water Stewardship. Information on well records, water levels and water quality is available upon request from the Groundwater Management Section.

5.0 ACTS AND REGULATIONS

Groundwater is a provincial resource that is regulated under a number of Acts (*The Environment Act, The Water Protection Act, The Drinking Water Safety Act, The Water Rights Act, The Ground Water and Water Well Act, The Health Act* and others) and regulations. Groundwater may also be impacted by developments and so may be considered within *The Mines and Minerals Act* for instance.

The Ground Water and Water Well Act and Well Drilling regulation are key pieces of legislation for the management and protection of the provinces groundwater resources. The Act and regulation are administered by Manitoba Water Stewardship. The Act applies to all sources of groundwater and to all water wells whether drilled or developed before or after the Act was established in 1963. Specifically, the Act:

- licenses all persons engaged in the business of drilling water wells;
- allows access and inspection of all water wells or operations, and to all records, plants or equipment;
- allows undertaking of surveys of groundwater resources and studies of the conservation, development and utilization of groundwater;
- allows control of flow from water wells;
- requires all reasonable precautions be taken to prevent contamination of groundwater via water wells; and
- allows establishment of regulations related to the conservation, development and control of groundwater resources and the drilling and operation of water wells and the production of groundwater there from.

The province is currently reviewing the need to update *The Ground Water and Water Well Act* in order to address a number of items not currently included in legislation or where strengthening of legislation is needed to provide additional protection to groundwater and aquifers.

6.0 ISSUES AND CONCERNS

There are several issues and concerns related to groundwater within the Central Assiniboine and Lower Souris River watershed that could be considered in the development of the watershed management plan. These are summarized below.

6.1 Vulnerable Groundwater Areas

Vulnerable groundwater areas are often defined as those areas having high potential for contamination of groundwater from sources at or near ground surface regardless of how local or extensive an aquifer may be. The degree to which aquifers are vulnerable to contamination from the surface will largely depend upon the thickness and properties of the material overlying the aquifer and the properties of the contaminant. As a general “rule of thumb” aquifers that are overlain by six metres (20 feet) or more of low permeability material (such as clay or till) are considered as having low potential for contamination from surface sources. Aquifers consisting of sand and/or gravel or fractured bedrock that are exposed at or near the surface are more vulnerable to water degradation from surface activities and would be considered as having high potential for contamination.

Existing well information records and groundwater maps can be used to help assess the vulnerability of a groundwater area. For example, those portions of the Assiniboine Delta and Oak Lake aquifers located within the Central Assiniboine and Lower Souris River watershed would be considered as having high potential for contamination of groundwater because of their relatively unconfined nature (i.e., lack of overlying low permeability soils). Buried sand and gravels aquifers such as those near Brandon and Souris would be considered as having low potential for contamination of groundwater because of their relatively confined nature (i.e., adequate thickness of overlying low permeability soils).

Existing well information records and groundwater maps however may not always be adequate to define aquifer vulnerability especially on a local or site specific scale. Subsequently, if adequate information is not available, then a site specific investigation should be undertaken to assess the vulnerability and potential for contamination of groundwater. The degree of detail for a site specific investigation would depend on the proposed site use and potential for contamination of the underlying soil and groundwater.

6.2 Groundwater Quality

The quality of groundwater is variable throughout the watershed. The water quality parameters most commonly found at concentrations exceeding health guidelines are total dissolved solids, iron and manganese. Hardness is also a common aesthetic problem. Elevated concentrations of naturally occurring trace elements (primarily arsenic and barium) have also been found at concentrations exceeding health guidelines in sand and gravel aquifers in some areas of the watershed.

Bacteria and nitrate are the most common types of well water contamination found in private wells. Bacterial contamination tends to be associated with localized bacterial sources, as well as shallow and poorly constructed or maintained wells. Nitrate contamination tends to be associated with localized nitrate sources, particularly for shallow constructed wells. The occurrence of bacteria and nitrate is more common in shallow wells completed in unconfined aquifers or in aquifers located close to ground surface rather than in wells completed in confined and/or deep aquifers. In addition, both bacteria and nitrate levels may change over time, varying with both the season and the weather.

Well owners should test their well water regularly to better understand its quality and identify possible health related and aesthetic concerns. However, regular testing is most often not done. Measures could be undertaken to promote the regular testing of well water quality, particularly for the following parameters:

- bacteria
- nitrate
- trace elements

6.3 Water Well Construction, Maintenance and Protection

The responsibility lies with the owner of a water well to ensure their well and water distribution system is properly constructed and maintained and that the well provides water that is safe for drinking. Unfortunately, groundwater investigations conducted by Manitoba Water Stewardship throughout regions of the province indicate that well water contamination is often caused by improper or poorly constructed or maintained wells. Wells and water distribution systems also deteriorate over time and at some point will need repair or replacement.

The following measures are recommended to help reduce the risk of well water contamination:

- retain an experienced and licensed well drilling contractor for the drilling and construction of a water well;
- locate the water well at a safe distance from potential sources of contamination and in an area away from surface runoff from potential sources;
- ensure an experienced and licensed contractor completes the hook-up of the water well to the water distribution system (using pitless well construction);
- after the water well has been completed but before it is put into operation, ensure the well, pump and water distribution system are disinfected to kill any bacteria that may be present;
- wells within any designated flood area within the watershed should have adequate well head protection to ensure flood waters do not enter directly into the well; and

- ensure old wells are properly sealed to the standards recommended in Manitoba's Guide for Sealing Abandoned Water Wells (Manitoba Conservation, 2002).

The above measures could be incorporated into future source water/well head protection plans for the watershed.

7.0 GLOSSARY OF GROUNDWATER RELATED TERMS

Aquifer – A water bearing geologic formation that is capable of producing water to wells or springs in sufficient quantities to serve as a source of water supply.

Aquifer Sub-basin – The land area from which sub-surface water moves between groundwater divides and stream systems.

Alluvial Aquifer – Aquifer materials laid down by physical processes in river channels or on floodplains.

Aquifer System – A hydraulically interconnected layered rock sequence including both aquifers and aquitards, which forms an identifiable unit between the recharge and discharge areas of a groundwater flow system.

Aquitard – A confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer. An aquitard does not readily yield water to wells or springs, but may serve as a storage unit for groundwater.

Arsenic – Most of the arsenic found in Manitoba well water occurs naturally. It is a result of groundwater coming into contact with rocks or soils containing arsenic. The MAC for arsenic in drinking water is 0.01 mg/L.

Available Yield – A scientific-based estimate of the amount of groundwater that can be extracted from an aquifer without causing a permanent lowering of the aquifer's water levels.

Bacteria – A microscopic organism that includes total coliform and E.coli bacteria. Groundwater is not a natural medium for total coliform bacteria, so their presence is used as an indicator of water contamination. The MAC for drinking water is zero total coliform organisms per 100 mL.

Barium – Barium found in Manitoba well water usually occurs naturally. It is the result of groundwater coming into contact with bedrock or minerals containing barium. The MAC for arsenic in drinking water is 1.0 mg/L.

Baseflow – That part of the stream flow that is derived from inflow of groundwater to the stream.

Confined Aquifer – An aquifer bounded above and below by impermeable beds, or by beds of distinctly lower permeability than that of the aquifer itself; an aquifer containing confined groundwater.

Discharge – As related to aquifer discharge, groundwater flows towards the surface and may escape as a spring, seep, or baseflow or by evaporation or transpiration.

Electrical Conductivity – Capability of a unit volume of water containing dissolved inorganic chemical constituents to conduct electric current. Electrical conductivity generally increases linearly with increases in total dissolved solids. The values are expressed as the reciprocal of electric resistance at 25 degrees C, as microsiemens per centimeter (µS/cm).

Electromagnetic (EM) Survey – EM conductivity techniques measure the apparent conductivity of the earth by applying a time varying magnetic field. The applied magnetic field induces eddy currents within subsurface conductors (buried channel valleys in this case), which in turn generate a secondary magnetic field that can be detected at the ground's surface or from low-flying aircraft.

Glacial Till – An unsorted glacial sediment deposited directly by the glacier. It may vary from clays to mixtures of clay, sand, gravel and boulders.

Groundwater – All water under the surface of the ground, whether in solid or liquid form.

Guidelines for Canadian Drinking Water Quality – Published by Health Canada on behalf of the Federal-Provincial-Territorial Committee on Drinking Water. Guidelines are either

- health-based which are established on the basis of comprehensive review of the known health effects associated with each contaminant, on exposure levels and on the availability of treatment and analytical technologies, and are listed as Maximum Acceptable Concentrations (MAC);

- based on aesthetic considerations (e.g., taste, odour) which take into account when these play a role in determining whether consumers will consider the water drinkable, and are listed as aesthetic objectives (AO); or

- based on operational considerations which factor in when the presence of a substance may interfere with or impair a treatment process or technology (e.g., turbidity interfering with chlorination or UV disinfection) or adversely affect drinking water infrastructure (e.g., corrosion of pipes), and are listed as Operational Guidance Values (OG).

Hardness – Water hardness is a traditional measure of the capacity of water to react with soap. Hard water requires a considerable amount of soap to produce a lather, and it also leads to scaling of hot water pipes, boilers and other household appliances. In fresh waters, the principal hardness-causing ions are calcium and magnesium. Although hardness may have significant aesthetic effects, a maximum acceptable level has not been established because public acceptance of hardness may vary considerably according to the local conditions.

Iron – The most common sources of iron in groundwater are naturally occurring, for example from weathering of iron bearing minerals and rocks. The AO for iron in drinking water is ≤0.3 mg/L.

Intertill – Deposits of glacial gravels, sands and silts positioned between layers of glacial till.

Manganese – The most common sources of manganese in groundwater are naturally occurring, for example from weathering of manganese bearing minerals and rocks. The AO for manganese in drinking water is ≤0.05 mg/L.

Natural Occurring Trace Elements – Trace elements are sometimes found in well water at concentrations exceeding health guidelines. In Manitoba, the trace elements arsenic, barium, boron, fluoride and uranium are naturally occurring and are a result of groundwater coming into contact with rocks, minerals or soils containing these elements.

Nitrate – The main form in which nitrogen occurs in groundwater. Decaying plant or animal matter, agricultural fertilizers, manure and domestic sewage are all sources of nitrate. The MAC for nitrate (as nitrogen) in drinking water is 10 mg/L.

Observation Well – A well used for the purpose of collecting groundwater information such as groundwater or quality.

Permeability – The ability of a water bearing material to transmit water.

Pitless Well Construction – Refers to use of a specially designed underground discharge assembly which is attached to a water well casing to provide a frost-free connection and water tight seal.

Potable – Suitable, safe, or prepared for drinking.

Recharge – As related to aquifer recharge, water that moves from the land surface or the unsaturated zone into the saturated zone.

Total Dissolved Solids (TDS) – TDS refers mainly to the inorganic substances that are dissolved in water. The effects of TDS on drinking water quality depend on the levels of its individual components; excessive hardness, taste, mineral deposition and corrosion are common properties of highly mineralized water. The AO for TDS in drinking water is 500 mg/L.

Unconfined Aquifer – An aquifer in which there are no confining beds between the capillary fringe and land surface, and where the top of the saturated zone (the water table) is at atmospheric pressure.

Unsaturated Zone – The zone between the land surface and the water table.

Water Table – The upper surface of groundwater below which soil is saturated with water that fills all voids and interstices, and where the pressure of water in the soil equals the atmospheric pressure.

Well Head Protection – Refers to protecting the water well and immediate area around the well from sources of potential groundwater contamination.

8.0 REFERENCES

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