Groundwater Resources of the Westlake Integrated Conservation District

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1.0 Introduction

The Westlake Integrated Watershed encompasses poorly drained lowlands along the western shore of Lake Manitoba. The land is flat, with numerous ridges and swales that run north-south, mostly parallel to the lake. Ridges may be 400 to 800 metres wide, with swales or depressions up to 800 m wide. These interfere with the natural west to east drainage toward Lake Manitoba. Shallow lakes, marshes and swamps are widespread. Very few well defined natural stream channels exist in the area.

The area is a mixture of livestock farming, forests and wetlands, with an elevation of 247 m (812 ft) at the Lake Manitoba shoreline. Through most of the area, the ground elevation rises less than 30 metres above the lake, although it may get as high as 60m west of Alonsa. Many areas are only a few metres above lake level.

The region has few natural waterways. It is drained by numerous constructed drains including Rocklan Drain and by Garrioch Creek and the Crane River.

2.0 Previous Studies

The primary groundwater investigations for the area are Groundwater Resources in the Alonsa Conservation District, (Manitoba Conservation, 1980) and Groundwater Resources in the Neepawa and Area Planning District (Manitoba Conservation, 1979). Some of the southern part of the area is covered by aggregate mapping (Gartner Lee Associates, 1978) and Groundwater Availability Study #10: Dauphin Lake (Manitoba Natural Resources, 1973)

3.0 Water Supply

Groundwater is the main source of domestic supply in the Westlake Integrated Watershed area. Groundwater discharge also feeds baseflow to wetlands, creeks and drains and contributes water to the extensive marshes and wetlands found in significant portions of the watershed.

Groundwater, defined as all water below the water table, is obtained from aquifers. Aquifers in this area, in order of utilization are Devonian and Jurassic aged limestone and dolomite (carbonate) bedrock, near-surface sands and gravels and occasionally Jurassic aged sandstone bedrock and fractured shale bedrock.

Aquitards contain groundwater, but not in sufficient quantities to supply a well. Aquitards, which restrict groundwater flow, in this area are made up of clay and till drift, or shale and siltstone bedrock.

Groundwater is usually available in sufficient quantities for domestic supply. Water quality is a greater limiting factor than water availability, as many aquifers are high in dissolved salts.

4.0 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.

5.0 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, lakes, swamps and wetlands.

Deeper confined aquifers receive flow is from high points to the west of the watershed, such as the Manitoba escarpment and beyond. Flow may take weeks to tens or hundreds of years or more. The more distant the source and the longer the time the water spends in the ground, the saltier it becomes. High levels of dissolved salts may make the water of marginal quality, or even unpotable. Generally water levels in these aquifers are less susceptible to seasonal variation, but will rise and fall over series of wet or dry years. As a result, these aquifers are considered to be more reliable sources of water.

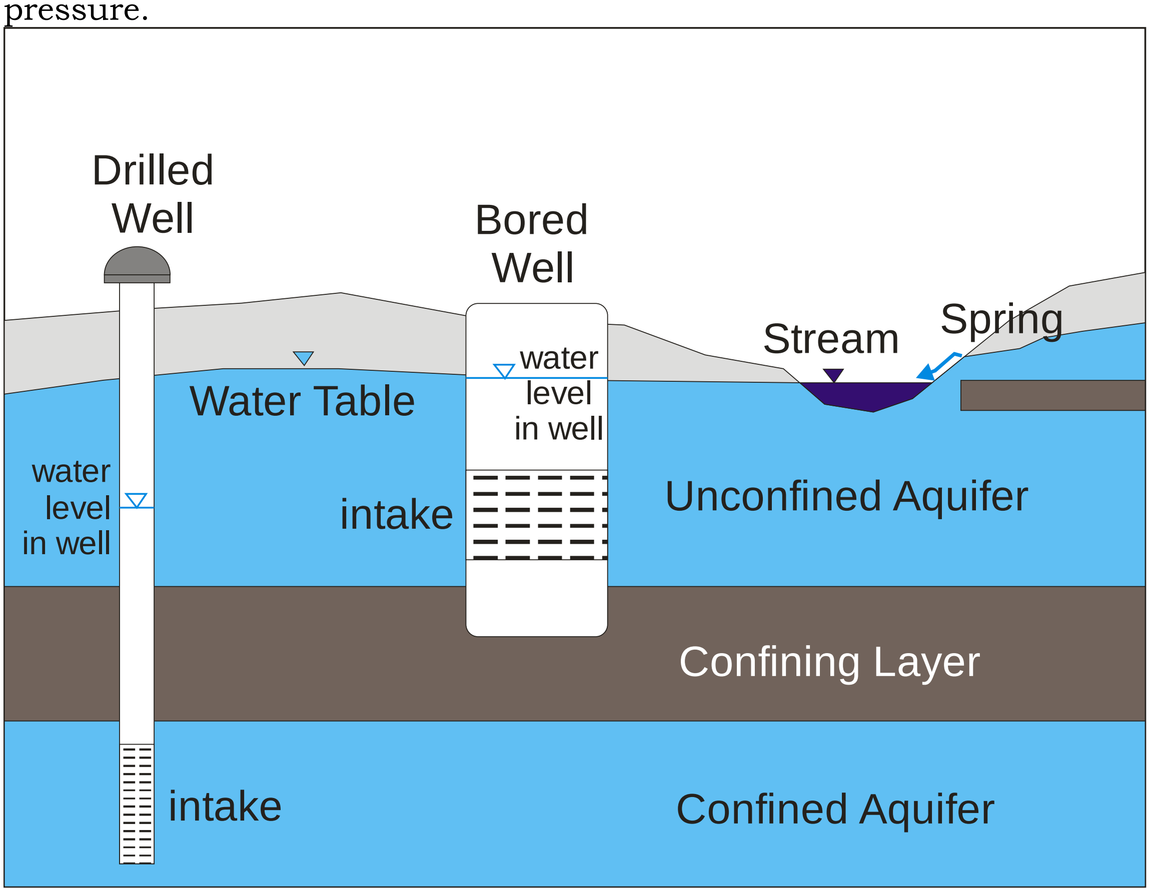
In shallow unconfined aquifers with a water table the groundwater usually originates from the same locality and contains few dissolved solids, in the low hundreds. Water may take days or weeks to move through the system. Water levels are likely to rise and fall on a seasonal basis, with low water levels occurring in late winter and during summer droughts.

In the Westlake integrated watershed there is not a lot of topographic relief. The lack of topographic relief means that local flow systems are not able to penetrate deeply into aquifers. As a result they may be overpowered by more regional systems trying to reach the surface or mixing may occur between systems of shallow and deep origin.

Wells with the best quality water will tend to be shallow and will draw upon local surface water sources to replenish supply. The small areas that they draw upon means these aquifers are more easily impacted by changes to the environment. Changes to the land surface, such as the establishment of drains, has the potential to alter local groundwater flow patterns and subsequent groundwater quality causing it to improve or deteriorate. Contaminants on the surface can more readily enter this groundwater zone.

Large diameter bored wells are commonly used in areas where groundwater sources are shallow and variable, making aquifer yields are low or unreliable. The large diameter of the well bore compensates for limited supply by adding additional storage. They are generally less than 20 m deep.

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.



In the Westlake integrated watershed, the deep regional flow system comes to the surface along the western shore of Lake Manitoba and Ebb and Flow Lake where it is a source of salty groundwater. In western and central areas, local flow systems dominate in the sands and gravels in the drift and in the upper bedrock. Water quality is better in this region, where aquifers receive more local recharge. Regional flow systems are potentially a source of flowing wells.

Care should be taken in areas known to have flowing wells, to ensure that the flow of water can be controlled, both during the drilling process and through proper well construction and completion. The wells must be properly sealed to ensure that water does not leak around the casing.

Flowing wells and high water table areas (less than 2 m deep) exist around Lake Manitoba, Ebb and Flow Lake and other lakes. Flowing wells may flow year round, or seasonally. The uncontrolled discharge of water from flowing wells may contribute to drainage problems and waterlogging of soils. It may also be a factor in icing of drains, flooding in springtime and subsequent damage to infrastructure. If the discharging water is saline, it may also have negative effects on surface water quality. A reduction in the availability of water supply from the aquifer may occur.

6.0 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. We do not know enough about groundwater recharge and discharge rates in the Westlake Integrated Watershed to develop water 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.

It appears that groundwater resources are sufficient to supply existing development, as demand is low. In some areas water quality, rather than quantity may be the primary constraint. This is particularly the case along the west shore of Lake Winnipegosis. To date, demands have been relatively low. Should there be a large scale demand for groundwater in the future; additional assessment of long-term sustainability would be needed at that time.

Land use changes such as land clearing, road building, dams or drains, may also affect local water budgets to some degree by affecting recharge and discharge patterns

7.0 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 no Provincial groundwater observation wells in this watershed area.

8.0 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 is less susceptible to contamination, but natural salinity may be a major issue. Hardness may be an issue in carbonate rock and in this region. Salinity may be high enough to require treatment for human consumption, while usually is acceptable for livestock. It may also reach the point where it is not potable.

Sampling shows that water chemistry can be quite variable throughout the region, ranging from 300 mg/L TDS to over 7,000 mg/L. In general, water tends to be more saline in bedrock wells than in wells completed in shallow sands and gravels, but there is no distinct demarcation. Water quality is best in the central part of the watershed in Townships 22 to

24, where TDS concentrations are generally under 1000 mg/L, or under 2000 mg/L in Townships 20 to 25. Water quality is poorer outside these areas where several thousand mg/L TDS is the norm (Map 3).

Of the samples on file, approximately 50% of the 65 samples from the Carbonate Aquifer had TDS concentrations exceeding 2000 mg/L, and only about 15% of samples had less than 1000 mg/L.

Sands and gravels fared better. Of 49 samples, 57% had TDS concentrations under 2000 mg/L and 41% of samples had less than 1000 mg/L.

Of six samples from sandstone and shale, one was under 1000 mg/L TDS and an additional one was under 2000 mg/L.

Most groundwater problems in the area are caused by a regional salty water flow system present in the deeper aquifers and his intruded into shallow water bearing formations in the northern and southern parts of the integrated watershed. Water quality can be excellent to not potable.

9.0 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, shallow, bored wells, mostly in sand and gravel would be more at risk than deeper drilled wells in carbonate bedrock.

Vulnerability indicates a higher level of 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.

In the Westlake Integrated Watershed, wells less than 30 m (100 ft) deep are distributed throughout the watershed. Wells completed in sands and gravels rarely exceed this depth. Wells completed in the Carbonate aquifer are more varied in depth. A significant number are less than 30m, most are between 30 and 60 m depth (100 to 200 feet), and a fair number exceed 60 m. Carbonate wells greater than 60 m deep are mostly located in Tp 20-21, R 12-13 and in Tps 16 to 19 away from the lake and around Mooredale.

10.0 Geology and Aquifers

Three main aquifers are used for water supply: Jurassic and Devonian aged limestone and dolomite, which together make up the Carbonate aquifer, sand and gravel drift aquifers and Jurassic sandstones and shales.(Map 1)

10.1 Drift Geology and Hydrogeology

Surficial deposits, often referred to as “drift” are glacial and post-glacial in origin and are mostly comprised of till. Through most of the region, the drift is 20 to 40 metres thick. Drift thickness increases significantly in Tp21-22, R 12-13, reaching depths of 75 metres. Drift is thinnest in the RM of Lawrence and adjacent areas of RM Alonsa, in the 10 to 25 m range. (Map 2)

Buried sands and gravels are relatively common. In the southwest part of the Alonsa district, sand and gravel deposits more than 75 m thick have been reported, which may indicate a buried bedrock valley. Extensive sand and gravel deposits also seem to be common in the central areas of the watershed. These are likely outwash deposits left by proglacial streams. Information is insufficient to effectively map out subsurface gravel deposits.

Glacial till deposits are overlain by post-glacial sand and gravel deposits of deltaic, beach, and alluvial origin. These may constitute shallow aquifers. Beach ridges trend north-south and consist of sand and gravel up to 6 m (20 feet) thick. These are used as aquifers, although they are not particularly reliable because they are shallow and. They may be dry or have a low water table, because of their elevated position. Water quality is good, TDS less than 1000 mg/L, but can vary from location to location. These are typically of significance only in areas where deeper aquifers are too mineralized to be potable.

Swamps and swamp deposits are found in low-lying, poorly drained areas between beach ridges or adjacent to lakes. Most of the drainage is overlain by small pockets of thin swamp deposits made up of poorly decomposed organic materials. These are not significant as aquifers.

The elevation of the bedrock contact beneath the drift ranges in elevation between 200 and 300 m, with lower elevations found along the lakeshore and in Tp 21-22, R 12-13.

10.2 Bedrock Geology and Hydrogeology

The Carbonate Aquifer, consisting of Devonian and Jurassic limestones and dolomites is the primary bedrock aquifer. A small part of the watershed is underlain by Jurassic shales and sandstones of the Amaranth Formation in the area in and around Township 20, Range 13.

Carbonate Aquifer

Bedrock formations are generally flat-lying and dip very gently to the west. The integrated watershed is underlain almost entirely by the Carbonate Aquifer. In north and central parts of the watershed this consists of Devonian aged limestone and dolomite of the Souris River, Dawson Bay and Winnipegosis formations. South from Township 22 the Jurassic Reston Formation, lay on top of the Devonian carbonates Jurassic beds may be may be from zero to 40 m thick. The Reston Formation appears as a white limestone, shale and gypsum beds. Wells are usually completed in the limestone. Yields are poor in the shale and quality is poor in gypsum.

Groundwater flow through the aquifer is primarily through fractures, bedding planes and some inter-granular reef type porosity, which locally have been enhanced by dissolution or glacial action. Lower permeability zones are found in the aquifer as a result of either shale layers or low density of fracturing and may form layers that subdivide the aquifer.

The carbonate matrix often has low permeability resulting from poor interconnections between fractures, but may contribute or receive substantial quantities of water to the fractures over periods of time. The upper few metres to tens of metres of bedrock can be very permeable, caused by weathering, expansion of the rock from unloading and from glacial action. Yields from wells are generally sufficient for household requirements. Deeper parts of the aquifer are less likely to produce substantial amounts of water.

Water quality is variable depending on location and depth. Saline water enters the aquifer from depth. In more elevated areas, where fresh water is entering the aquifer from the surface it dilutes the salty. Water quality is reasonably good between townships 20 and 25, but deteriorates to the north and south. Yields can be in the .05 to 1 L/s range (7-14 igpm) or better.

In the southern part of the watershed, shallow sands and gravels are the preferred aquifer, as water quality deteriorates with depth and deeper carbonates may be too salty to use.

Jurassic Aquifer

The Jurassic aquifer in the area consists of the Melita Formation, which is made up of sandy, silty or clayey shales of various colours. The Melita Formation is generally not used as an aquifer, as yields are negligible and water quality is poor. It is found in Tp 20, R13 and adjacent areas.

11.0 Well Distribution and Groundwater Use

Wells are found in settled areas with agricultural lands.

Wells in Water Stewardship’s database are classified according to aquifer type. There are 1242 wells listed for this watershed (Map 1). Of the main types of aquifers, around 47% of all wells were completed in the Carbonate aquifer (Map 5). Sands and gravels were the second most common aquifer with around 37% of wells (Map 4). Around 5% of wells were completed in sandstone and shale. Dry holes were reported 8% of the time.

Table 2. Number of Wells by Aquifer

AQUIFER TYPE	NUMBER OF WELLS	% OF WELLS
All aquifers (total)	1242	100
Limestone or Dolomite	589	47
Sand and Gravel	456	37
Sandstone	41	3
Shale	21	2
Silt or Till	12	1
Unknown	3	<1
Other	16	1
Dry (abandoned)	104	8

Wells completed in sand and gravel drift and wells completed in limestone and dolomite are found in all areas of the watershed. In the southern half of the watershed, which is underlain by Jurassic bedrock, a few of the deeper wells are completed in sandstone or shale, probably because no water was found in shallower Carbonate or drift. Drift would be the preferred aquifer, if sufficient water supplies are available.

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

DEPTH RANGE (M)	DEPTH (FT)	DRIFT	CARB-ONATE	SAND-STONE	SHALE	TILL & OTHER	DRY WELL	TOTAL	TOTAL %
<10m	0-33	64	11	0	0	7	30	112	9
10-20m	33-66	166	88	1	4	3	18	280	23
20-30m	66-98	141	92	4	5	4	29	275	22
30-40m	98-131	62	131	15	5	3	11	232	19
40-50m	131-164	11	98	5	3	0	5	122	10
50-60m	164-197	7	77	10	0	0	5	99	8
60-70m	197-230	1	50	5	2	0	1	59	5
70-80m	230-262	2	20	1	2	0	5	30	2
80-90m	262-295	1	9	0	0	0	0	10	1
90-100m	295-328	1	9	0	0	0	0	10	1
100-110	328-361	0	2	0	0	0	0	2	0
110-120	361-394	0	0	0	0	0	0	0	0
120-130	394-426	0	1	0	0	0	0	1	0
130-140	426-459	0	0	0	0	0	0	0	0
140-150	459-492	0	1	0	0	0	0	1	0

Most wells in the watershed are relatively shallow: 54% are less than 30 metres (100 feet) deep; 37% are between 30 to 60 metres (100 to 200 feet) and 9% were over 200 feet. The median depth of carbonate wells was in the 30 to 40 m depth range. Fro drift wells the median depth was in the 10 to 30 m depth range. Sandstone wells were generally deeper than 30 m. It is expected that bedrock wells would be deeper than drift wells. Of the drill holes, 77% were less than 30 m, likely indicating that these were bored wells and the maximum drilling depth had been reached for the boring type rig.

12.0 Local Groundwater Issues

Town Hall meetings were held in Toutes Aides, Eddystone, Amaranth and Alonsa. Groundwater is a primary source of drinking water. Drinking water issues are the main groundwater issue in the area. Sufficient groundwater supply is available for domestic needs. There are no areas of high demand for groundwater in the Westlake integrated watershed.

Water quality is the main issue. Water quality deteriorates in Township 26 northwards and Township 19 and south. In many areas the water is too salty to be used, or is excessively high in sulphates. Unfortunately, natural groundwater chemistry is not something that can be changed.

Protection of wells and aquifers from contamination was identified as a concern. This makes sense for this area, given the number of relatively shallow wells and high water table. More specifically, there is a need to better understand how to protect groundwater and wells from contamination. Large scale livestock operations were identified as one potential source of contaminants. Abandoned wells need to be sealed. A need to manage surface water in a way that protects groundwater was seen – especially if there is overland flooding or water logged soils related to drainage issues.

Wells that are improperly constructed, are poorly maintained or are in a low lying area are at a higher risk of becoming contaminated. Risk of contamination may be reduced by following certain steps.

- Locate the well a safe distance from sources of contamination and in an area where the water drains away from the site;
- Hire a licensed and reputable water well contractor to drill and install your water well and to hook up the distribution system;

- Once the well has been installed and before it is put into operation, ensure that the well, pump and water distribution system have been disinfected to kill any bacteria and
- Ensure wells that are no longer being used are properly sealed according to the standards set out in Manitoba's Guide for Sealing Abandoned Water Wells (Manitoba Conservation, 2002).

Iron in well water was an issue in some areas. This might be expected, since iron is often a common concern in shallow wells everywhere. Treatment options could be explored for iron and for salts.

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13.0 Summary and Next Steps

The Westlake Integrated Watershed encompasses a lowland area on the west shore of Lake Manitoba. Population density is relatively low, with settlement limited to agricultural lands. Large areas of swampy lowlands remain largely unsettled. Residents depend on groundwater for their domestic supplies. However, the lack of large population centres or major developments has meant that demands on groundwater have remained within the capacity of local aquifers to meet current needs.

This is borne out by local community consultation where supply limitations were not put forward as a concern. A second indicator that supplies are sufficient is the abundance of shallow wells (<30m) in the region. Residents have for the most part been able to find sufficient water supplies at a shallow depth.

The abundance of shallow wells combined with a high water table means that wellhead protection and/or aquifer protection are issues worth exploring for this watershed. Potential contamination sources are relatively few. Risks come from larger livestock and agricultural operations, and from overland flooding. Efforts to locate and properly seal abandoned wells and education on practical methods for well protection and maintenance are issues that should be explored.

Water treatment options are another topic that should be addressed. Shallow wells are prone to problems with high iron or hardness. In parts of the watershed, high concentrations of total dissolved solids, sodium or sulphates make the water unusable.

14.0 References

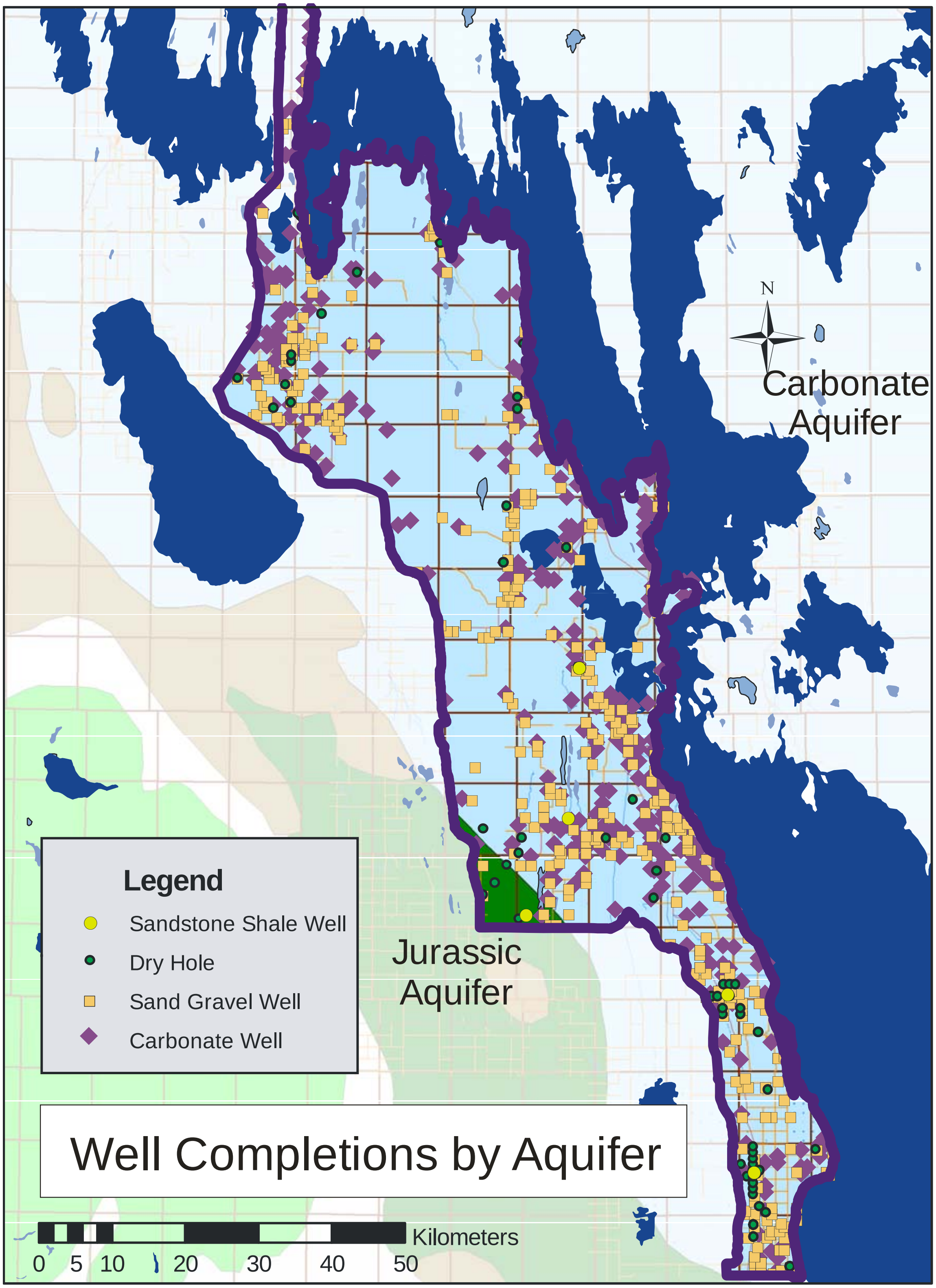
Gartner Lee Associates, 1978. Groundwater Aggregate Mapping.

Manitoba Water Stewardship, Water Resources Branch.1980. Groundwater Resources in the Alonsa Conservation District.

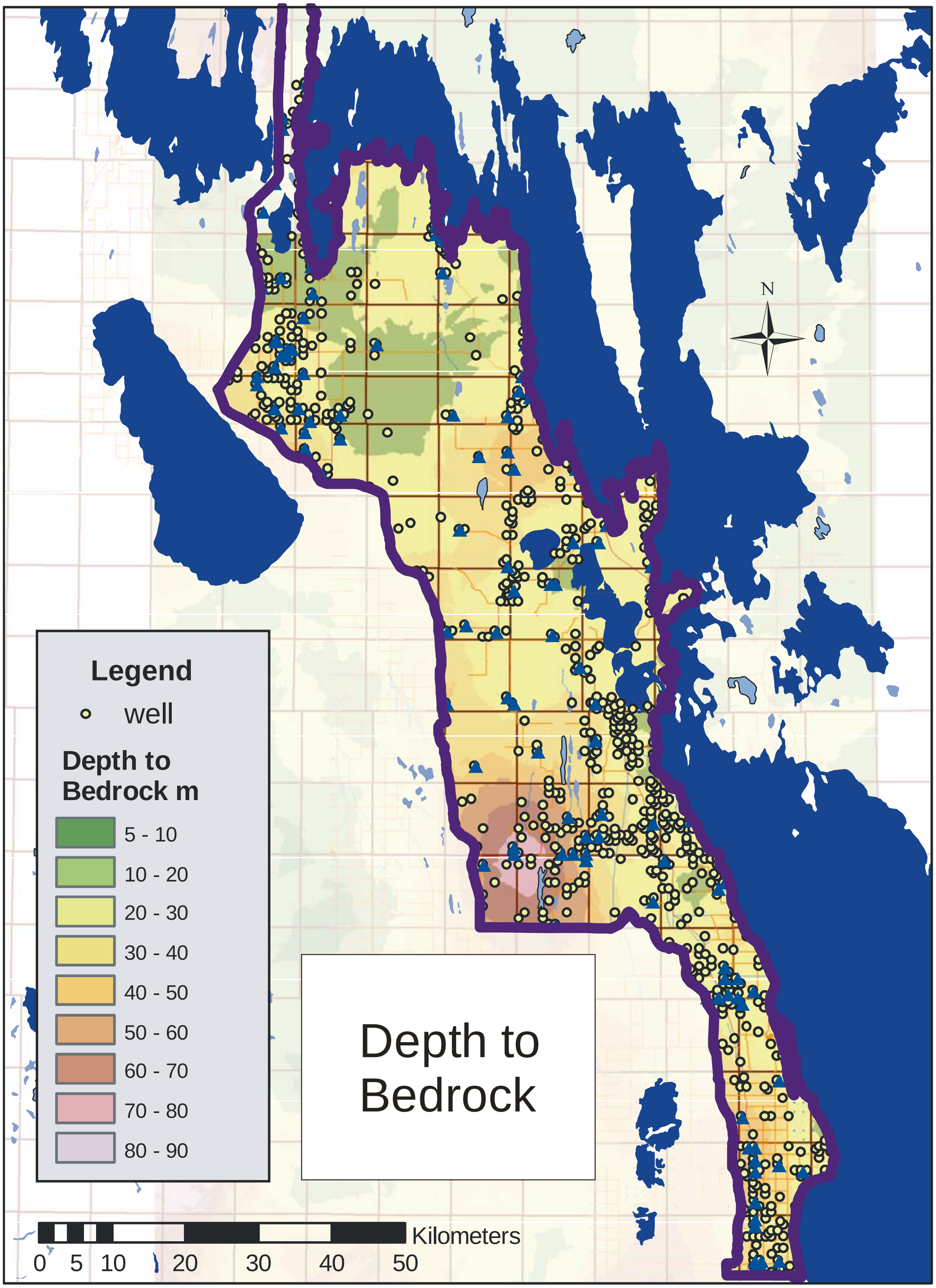
Manitoba Water Stewardship, Water Resources Branch, 1979, Water Resources. Groundwater Resources in the Neepawa and Area Planning District

Manitoba Water Stewardship, Water Resources Branch, 1973, Groundwater Availability Study #10: Dauphin Lake

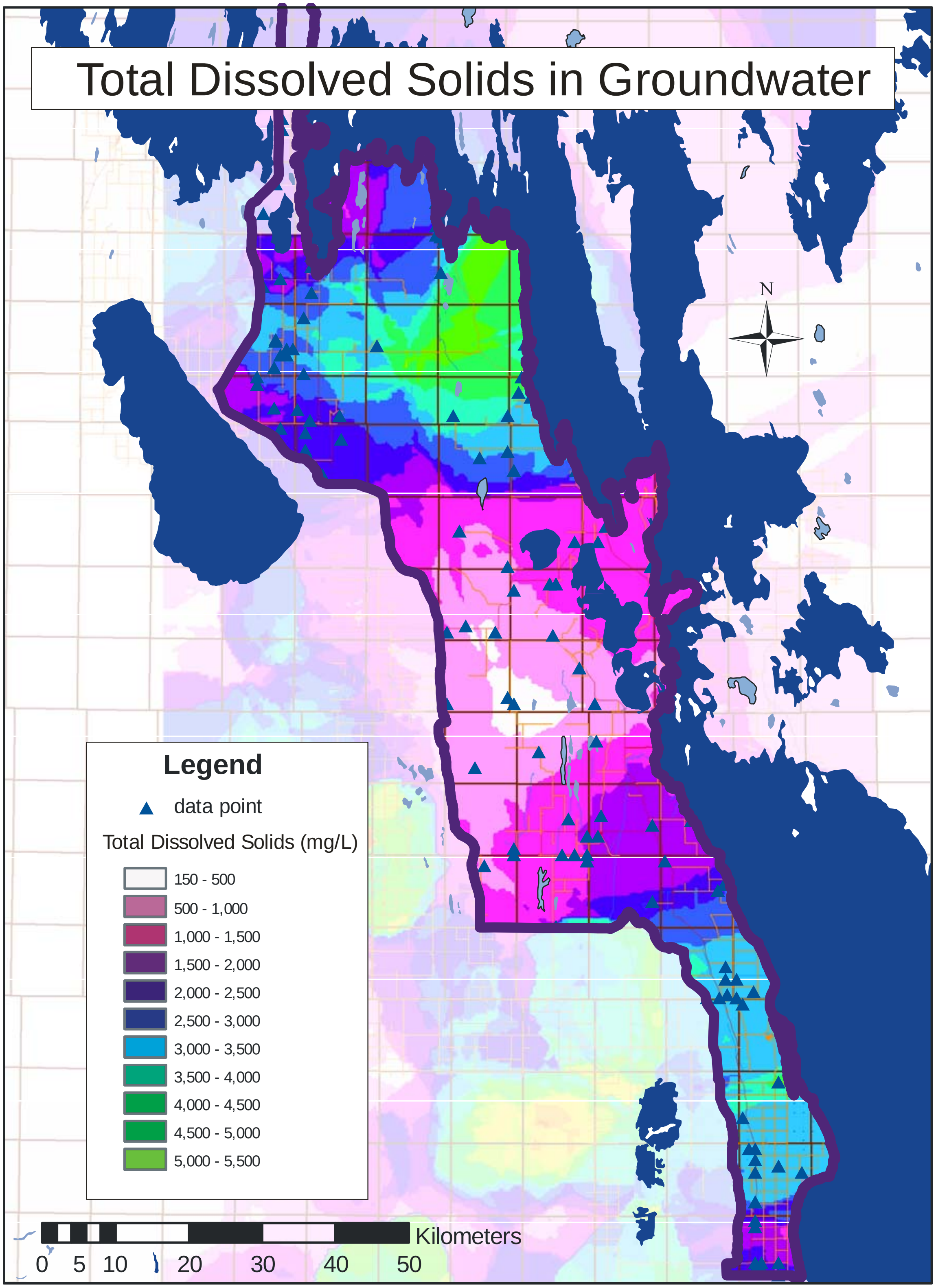
15.0 Maps



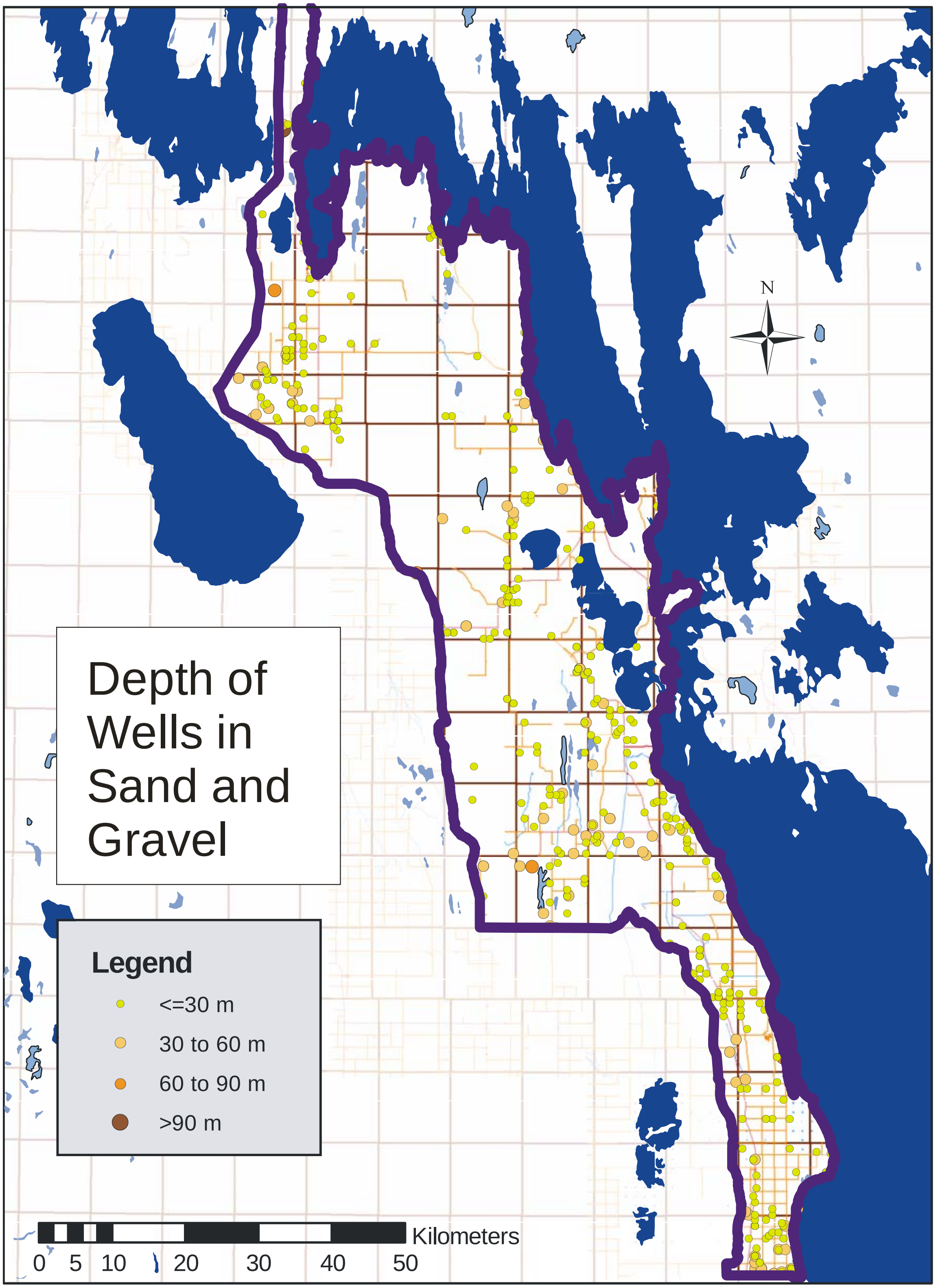
Map 1: Well completions by Aquifer



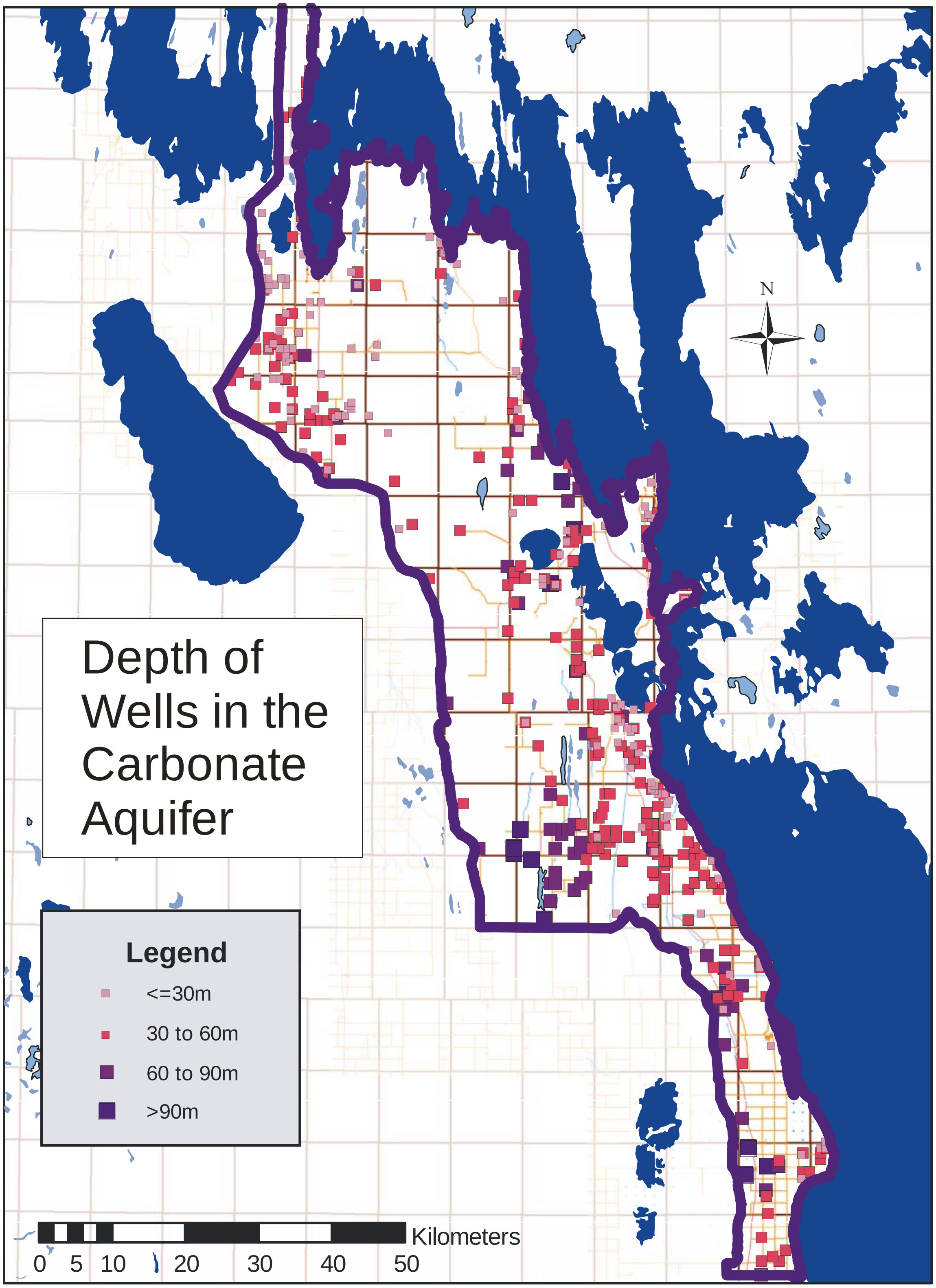
Map 2: Depth to Bedrock



Map 3: Total Dissolved Solids in Groundwater



Map 4: Depth of Sand and Gravel Wells



Map 5: Depth of Wells in Carbonate Aquifer