MANITOBA-MINNESOTA TRANSMISSION PROJECT

Biophysical Technical Data Reports

Manitoba-Minnesota Transmission Project Technical Data Report – Groundwater

Final Report

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Sign-off Sheet

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Abbreviations

AC	Alternating Current
EIS	Environmental Impact Statement
kV	Kilovolt
LAA	Local Assessment Area
mbgs	metres below ground surface
MCWS	Manitoba Conservation and Water Stewardship
MMTP	Manitoba-Minnesota Transmission Project
PDA	Project Development Area
PTH	Provincial Trunk Highway
RAA	Regional Assessment Area
RM	Rural Municipality
RVTC	Riel to Vivian Transmission Corridor
SLTC	Southern Loop Transmission Corridor
TDR	Technical Data Report
VC	Valued Component
WCSB	Western Canada Sedimentary Basin

Glossary

Term	Definition
Aquifer	A body of rock or sediment that is sufficiently porous and permeable to store, transmit, and yield significant or economic quantities of groundwater to wells and springs.
Aquitard	A confining bed and/or formation composed of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs, but stores ground water.
Artesian Aquifer	A body of rock or sediment containing groundwater that is under greater than hydrostatic pressure: that is, a confined aquifer. When an artesian aquifer is penetrated by a well, the water level will rise above the top of the aquifer.
Bedrock	The solid rock that lies beneath the soil and other loose material on the Earth's surface.
Carbonate	A rock made up primarily of carbonate minerals (minerals containing the CO3 anionic structure).
Confined Aquifer	An aquifer that is bounded above and below by formations of distinctly lower permeability than that of the aquifer itself. An aquifer containing confined ground water. See artesian aquifer.
Converter Station	The terminal equipment for a high voltage direct current transmission line, in which alternating current is converted to direct current or direct current is converted to alternating current.
Domestic Well	A water well used to supply water for the domestic needs of an individual residence or systems of four or fewer service connections.
Environmental Impact Statement (EIS)	A document that presents the findings of an environmental assessment in response to specific guidelines or terms or reference. The term EIS is often used in the context of an assessment by a review panel and in the environmental

	assessment regimes of other jurisdictions..
Geographic Information System (GIS)	A computerized information system which uses geo-referenced spatial and tabular databases to capture, store, update, manipulate, analyze and display information.
Glaciofluvial	Descriptive of material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and may occur in the form of outwash plains, deltas, kames eskers, and kame terraces
Glaciolacustrine	Pertaining to, derived from, or deposited in glacial lakes; especially said of the deposits and landforms composed of suspended material brought by meltwater streams flowing into lakes bordering the glacier, such as deltas, kame deltas, and varved sediments.
Groundwater	Water that occurs beneath the land surface and fills the pore spaces of soil or rock below saturated zone.
Groundwater Recharge	The natural or intentional infiltration of surface water into the zone of saturation.
Groundwater Table	The upper surface of the zone of saturation in an unconfined aquifer.
Hydrology	The science dealing with the properties, distribution and circulation of water.
Overburden	The soil (including organic material) or loose material that overlies bedrock
Precambrian Bedrock	Extremely stable bedrock composed of ancient crystalline rocks whose complex structure attests to a long history of uplift and depression, mountain building and erosion. This bedrock was formed in the Precambrian era, which began with the consolidation of the earth's crust and ended approximately 4 billion years ago.
Recharge	Water added to an aquifer or the process of adding water to an aquifer. Ground water recharge occurs either naturally as the net gain from precipitation, or artificially as the result of human influence.

Stratigraphy	The science of rocks: It is concerned with the original succession and age relations of rock strata and their form, distribution, lithologic composition, fossil content, geophysical and geochemical properties-all characters and attributes of rocks as strata-and their interpretation in terms of environment and mode of origin and geologic history
Unconfined Aquifer	An aquifer which is not bounded on top by an aquitard. The upper surface of an unconfined aquifer is the water table

1.0 INTRODUCTION

Manitoba Hydro is proposing construction of the Manitoba-Minnesota Transmission Project (MMTP) which includes construction of a 500 kV AC transmission line in southeastern Manitoba. The proposed Project would originate at the Dorsey Converter Station northwest of Winnipeg, then travel south around Winnipeg within planned utility corridors including the Southern Loop Transmission Corridor (SLTC) and the Riel to Vivian Transmission Corridor (RVTC) to just east of PTH 12. The line then continues southward across the rural municipalities of Springfield, Tache, Ste. Anne, La Broquerie, Stuartburn and Piney to the Manitoba-Minnesota border crossing located south of the community of Piney. The project also includes the construction of terminal equipment at the Dorsey Converter Station, and electrical upgrades within the Dorsey and Riel converter stations, and modifications at the Glenboro South Station requiring re-alignment of transmission lines entering the station.

This Technical Data Report (TDR) for groundwater was developed to support of the overall Environmental Impact Statement (EIS). For this assessment, groundwater is considered a pathway to an effect on a Valued Component (VC), rather than a VC itself.

Groundwater wells are an important source of fresh water for many uses including domestic, agricultural (livestock and irrigation), air conditioning and geothermal, municipal, industrial, and others. If there is a change in groundwater quality and/or quantity, it can have a affect on the uses described above. Therefore a change in the groundwater quality and/or quantity pumped from wells would be a mechanism of change for the Land and Resource Use VC. There is an interconnectvitiy between groundwater and surface water, with groundwater providing a source of recharge to streams (SRGMP 2010). This interconnectivity occurs in most physiographic and climatic settings (Winter *et al.* 1998). Therefore, change in groundwater quality/quantity as well as a release of groundwater into surface water could be a mechanism of change for the Fish and Fish Habitat VC.

1.1 BACKGROUND

1.1.1 Project Overview

The Project is described in three general regions: the upgrade work to the three stations, the additional transmission line constructed in the existing planned transmission utility corridors extending from Dorsey Converter Station to just east of PTH 12, and the new transmission line extending south from the Anola area to the border by Piney, Manitoba.

1.1.2 Spatial Boundaries

The following spatial boundaries were used to collect and analyze data for the Project:

1.1.2.1 Project Development Area (PDA)

The Project Development Area (PDA) is the area of physical disturbance from Project activities, within areas of construction activity for the Project, namely the Transmission Line ROW (80-100 m) and the three converter station improvement sites.

1.1.2.2 Local Assessment Area (LAA) and Regional Assessment Area (RAA)

There are multiple types of aquifers in the region. There are sand and gravel aquifers which vary in size and are not well mapped individually in the region. There are also bedrock aquifers that span the southern half of the province starting in the eastern portion of the province (in the area of the Project) and extending westward. Using aquifers to define either the Local Assessment Area (LAA) or Regional Assessment Area (RAA) produced many different sized study areas, could not be completed because of an absence of mapping and/or produced areas that extended far beyond the potential Project influence. Accordingly, aquifer extents were not utilized for the LAA or RAA for this Project.

Instead, because groundwater is defined as a pathway mechanism for the Land and Resource Use VC, the spatial boundaries of the Land and Resource Use Chapter of the EIS were reviewed and its LAA and RAA were adopted for use to provide groundwater data at the scale required. The RAA encompasses all of the rural municipalities that contain a portion of the Project. The LAA includes the PDA and a 1 km buffer on either side of the PDA for the existing transmission corridor and new ROW segments and a 1 km buffer around the station footprints to provide groundwater resource use data.

1.2 PURPOSE

The purpose of this TDR is to describe the existing conditions for groundwater in the area of the Project. Changes to groundwater quality or quantity can be a mechanism for change in Land and Resource Use and Fish and Fish Habitat. This TDR is supportive of the aforementioned VCs because of the linkage to groundwater.

This TDR describes how desktop information was gathered and the information gaps and limitations that were identified. Groundwater information identified as important to the above VCs as well as study area hydrogeology is included here to provide an overview of existing conditions for groundwater.

2.0 REVIEW OF EXISTING DATA SOURCES AND BASELINE DATA GAPS

2.1 SUMMARY OF EXISTING DATA SOURCES

The information described in this TDR comes from a synthesis of data for the Project area from a variety of literature sources and database information provided by Manitoba Conservation and Water Stewardship (MCWS).

To characterize the baseline conditions for the general geology, hydrogeology and groundwater use in the Project area, the following sources of information were reviewed:

- Groundwater resource literature:
  - Assiniboine Delta Aquifer Management Plan Round Table. 2005. Assiniboine Delta aquifer management plan. Planning for the future of the Assiniboine Delta Aquifer. Assiniboine Delta Aquifer Management Plan Round Table. http://www.gov.mb.ca/waterstewardship/reports/acquifer/assiniboine_delta_aquifermgmt_plan.pdf. Accessed June 30, 2015.
  - Betcher, R.N., Grove, G. and Pupp, C. 1995. Groundwater in Manitoba: Hydrogeology, Quality concerns, Management. NHRI Contribution No. CS-93017.
  - Ferguson, G., Woodbury, A., and Matile, G. 2003. Estimating Deep Recharge Rates beneath an Interlobate Moraine Using Temperature. Ground Water. 41(5): 640-646 pp.
  - Grasby, S.E., and Betcher, R.N. 2002. Regional Hydrogeochemistry of the Carbonate Rock Aquifer, Southern Manitoba. Canadian Journal of Earth Sciences. 39: 1053-1063 pp. doi: 10.1139/E02-021.
  - Klassen, R.W., Wyder, J.E., and Bannatyne, B.B. 1970. Bedrock Topography and Geology of Southern Manitoba. Geological Survey of Canada. Paper 70-51. doi:10.4095/105649.
  - Manitoba Clean Environment Commission. 2007. *Report on Public Hearing: Pembina Valley Water Cooperative, Supplemental Groundwater Supply System*. Manitoba Clean Environment Commission.
  - Manitoba Conservation and Water Stewardship, n.d. Water Stewardship Division. Licensing, Regulation & Policy. http://www.gov.mb.ca/waterstewardship/licensing/wlb/index.html. Accessed June 15, 2015.

- MFEA (Manitoba Floodway Expansion Authority). 2004. Environmental Impact Statement. Proposed Floodway Expansion Project.

- Manitoba Industry. Economic Development and Mines, Manitoba Geological Survey, Surficial Geology Compilation Map Series, SG-62H, scale 1:250,000.

- Matile, G.L.D. and Keller, G.R. 2004a: Surficial geology of the Brandon map sheet (NTS 62G), Manitoba; Manitoba Industry. Economic Development and Mines, Manitoba Geological Survey, Surficial Geology Compilation Map Series, SG-62G, scale 1:250,000.

- Matile, G.L.D. and Keller, G.R. 2004b: Surficial geology of the Winnipeg map sheet (NTS 62H), Manitoba; Manitoba Industry. Economic Development and Mines, Manitoba Geological Survey, Surficial Geology Compilation Map Series, SG-62H, scale 1:250,000.

- Rutulis, M. 1974. Water Resources in the Winnipeg Region. Water Resources Branch, Department of Mines, Resources, and Environmental Management, Winnipeg.

- Rutulis, M. 1978a. Groundwater Resources in the Cypress Planning District. Manitoba Natural Resources. Water Resources Branch, Winnipeg.

- Rutulis, M. 1978b. Map of major flowing well areas. Province of Manitoba. Surveys and Mapping Branch. Groundwater Section, Water Resources Branch.

- Rutulis, M. 1984a. Groundwater Resources in the MacDonald-Ritchot Planning District. Manitoba Natural Resources. Water Resources Branch, Winnipeg.

- Rutulis, M. 1984b. Groundwater resources in the R.M. of Taché Planning District. Manitoba Natural Resources. Water Resources Branch, Winnipeg.

- Rutulis, M. 1985a. Hydrogeology in the Vicinity of the Glenboro Sewage Lagoon System. Hydrotechnical Services. Hydrogeology Division. Winnipeg.

- Rutulis, M. 1985b. Springs in Southern Manitoba. Province of Manitoba Hydrogeological Section.

- Rutulis, M. 1986. Aquifer Maps of Southern Manitoba. Map 2 of 2. Sand and Gravel Aquifers. Manitoba Natural Resources. Water Resources Branch, Winnipeg.

- Rutulis, M. 1987. Aquifer Map of Southern Manitoba, Bedrock Aquifers. Manitoba Natural Resources. Water Resources Branch, Winnipeg. 1:2 300 000.

- Rutulis, M. 1990. Groundwater resources in the Rural Municipality of Springfield, Manitoba Natural Resources. Water Resources Branch, Winnipeg.

- SRGMP (Southeast Regional Groundwater Management Plan) Planning Group. 2010. Southeast Regional Groundwater Management Plan.
- Thorleifson *et al*. 1998. Hydrogeology and Hydrogeochemistry of the Red River Valley/Interlake Region of Manitoba (NTS 62H, 62I, 62O, 62P and 63B).
- Winter, T. C. *et al*. 1998. Ground Water and Surface Water: A Single Resource. U.S. Geological Survey Circular 1139.

- Provincial licensed groundwater well database and general provincial groundwater well database information provided by MCWS.
- Various personal communications with staff from the Groundwater Management Program of Manitoba Conservation and Water Stewardship.

2.2 DATA GAPS AND LIMITATIONS

Identified data gaps and limitations of the existing groundwater data Includes:

- Location, accuracy and completeness of the provincial groundwater well data. The data that exists in the provincial groundwater well database is submitted by the contractors that are drilling and installing the wells. The data is not necessarily complete for all wells, or able to be verified for accuracy (Hempel 2014, pers. comm.) as some wells do not have construction details included. Some wells also do not have water pumping data and therefore the descriptions only include wells that have existing data. The recorded wells have been drilled over a number of decades and at different times of the year. Therefore, the static water level data that is measured when the wells are initially installed only represents one point in time. Groundwater levels can vary due to interannual, seasonal and longterm variations.
- Many of the groundwater well locations are also recorded as a centrepoint within a river lot or quarter section (or section) of land rather than the exact location of the well. The user of the database therefore does not know where on the piece of land the well is located precisely, but instead has a more general understanding of well location. This more general understanding of well location is sufficient to describe existing groundwater conditions in the region, but may result in a summary which includes a higher number of wells within the LAA.
- Using groundwater well data for the location of aquifers is only assessing aquifers that have the volume, capacity and/or quality for a groundwater well. There will be other aquifers that exist within the RAA that are not mapped or have groundwater wells installed into them.
- Location, accuracy and completeness of groundwater use licence data. This data contains locations that are at different stages in the provincial approval process (application process underway, approved licence issued, waiting for assessment of application, etc.).

- Water capacity reported within the groundwater-use licence data is the maximum that is allowed each year according to the approved or submitted application. The location may not be using that amount of water each year.
- MCWS, Groundwater Management Program was contacted to request baseline data for pesticides in the provincial groundwater monitoring wells within the RAA. The provincial groundwater monitoring wells are not sampled for pesticides and have not been historically and therefore do not have baseline pesticide (herbicide) water well data available (Phipps 2015, pers. comm.).

3.0 METHODS

3.1 DESKTOP DATA COLLECTION METHODS

The approach taken to understand the current groundwater regime in the area of the Project involved the collection, review, and desktop synthesis of the available geological and hydrogeological information.

3.2 DATA MAPPING

The groundwater data mapping involved the use of geographic information system (GIS) mapping. Bedrock and surficial geology for the study area were obtained from available online resources (Betcher *et al.* 1995; Matile and Keller 2004a, b). Data was mapped according to geologic eras.

The occurrence of sand and gravel aquifers in the area of the Project were obtained from paper maps created by MCWS (Rutulis 1986). The maps were then then converted to tiff files, imported into ArcMap and georeferenced by Stantec. Georeferencing is the process of aligning the original document with spatial data. Once georeferenced, the sand and gravel aquifers were digitized (traced) in order for them to become projected shapefiles. The data was mapped and the sand and gravel aquifers symbolized according to type.

Maps of flowing well areas and springs (*i.e.*, artesian groundwater conditions) were also originally obtained from MCWS (Rutulis 1984b, 1985a, 1990). The maps were then converted to tiff files, imported into ArcMap and georeferenced to create shapefiles of areas of fresh or saline flowing wells and fresh water springs.

Groundwater and surface water use can require a licence by the Water Use Licensing Section of MCWS. Generally if water is used in volumes of greater than 25,000 L/day then a water use license from MCWS allocating a certain volume of water for that individual or corporation's use is required (MCWS, Water Stewardship Division, 2015). Groundwater-use licence data was obtained from MCWS. An outline of the RAA was provided using GIS to MCWS. MCWS then supplied a dataset of the groundwater-use licence locations, wells and dugouts within this area. The projects included were at various stages of approval and, therefore, some may not have yet been operating as outlined in the licence application. The data was mapped by type of water usage and maximum annual allowed capacity of the licensed groundwater supply wells.

MCWS also provided the provincial GWDrill groundwater well database for the wells that are located within the RAA for use with GIS. The well data provided included the well identification number, location, status, and water use. The well locations were generally referenced as the center of the quarter section of land, section of land or river lot. Well locations were then shown on the map according to their water use category (air conditioning/geothermal, domestic, industrial, irrigation, livestock, municipal, or unknown/other). Some wells are used for multiple uses and therefore were displayed as multi-use wells. Wells were not included on the map or in the summary statistics if their well status was indicated as sealed as this terminology denotes well decommissioning. This dataset also included some well construction information. Some of the wells in the database did not have construction details included. Therefore, those wells were not included in the casing depth or well completion depth summaries. An additional dataset was received from MCWS that contained information on water pumping data for the wells. This dataset was connected to the general well database using the well identification numbers. The pumping data was used for data summaries and to create a map showing the depth to groundwater. The depth to groundwater was the depth to groundwater measured in the wells once they were installed prior to their pumping test.

Wells located within the LAA were selected using GIS if the referenced point was inside the defined spatial boundaries, or if the outline of the LAA intersected any portion of the quarter section, river lot, or section of land on which the well was reported to be located. Database information was summarized according to each rural municipality within the RAA. Wells were not selected within the PDA for the well summaries because the well data is mapped too coarsely for accurate representation within this area. As a result, well data metrics were completed for the LAA and well data was qualitatively summarized within the RAA. The metrics included the number of wells by water use category including:

- Domestic.
- Municipal.
- Agricultural use including irrigation, livestock and aquaculture.
- Industrial.
- ‘Other’ use including geothermal, air conditioning, dewatering, observation, recharge, test wells, and other/unknown.

4.0 EXISTING ENVIRONMENT

The following presents a summary of the baseline groundwater data identified as required to support the assessment of the pertinent VCs.

4.1 GENERALIZED GEOLOGY

Regional generalized geology is described in this section based on available bedrock data and surficial geology data within the project RAA. It is organized by the region of Manitoba that the project components are located in being southeast Manitoba (Existing Corridor, New ROW, Dorsey Converter Station, and Riel Converter Station) and the RM of South Cypress (Glenboro) Area (Glenboro South Station).

4.1.1 Southeast Manitoba

4.1.1.1 Bedrock

The MMTP transmission line in the Existing Corridor and the new ROW will be constructed over the bedrock of the Precambrian Shield and one large sedimentary basin, the Western Canada Sedimentary Basin (WCSB), as defined below (Map 4-1 - Generalized Bedrock Geology).

The eastern edge of the WCSB begins in the southeastern portion of the area. The WCSB is characterized by gently southwestward dipping Paleozoic and Mesozoic rocks, and consists mainly of carbonate rocks with some clastic and evaporites (Betcher *et al*. 1995). Underlying the WCSB is the Winnipeg Formation, which is composed of quartzose sand, sandstone and shale. Precambrian rocks form the bedrock basement in eastern Manitoba, extending westward, as can be seen in Figure 3 of Grasby and Betcher (2002). The Precambrian rocks belong to the Churchill and Superior provinces and consist mainly of granitic and gneissic rock types (Betcher *et al.* 1995). The Interlake Group, comprising dolomite and minor thin sandy clay beds, and the Stonewall and Stony Mountain formations comprising dolomite and argillaceous limestone, cover the north-western portion of the area. The Red River Formation covers the north-eastern, central and part of the south-central portions of the area, and is composed of limestone, dolomitic limestone and dolomite. The Amaranth, Reston and Melita Formations cover most of the southern portion of the area, and are composed of anhydrite gypsum, shale, dolostone; argillaceous limestone and shale; and varicolored shale, calcareous shale and limestone, respectively (Betcher *et al*. 1995; Klassen *et al*. 1970).

The acid rock drainage potential in the RAA is low because surficial deposits cover the entire area, and are composed predominantly of glaciolacustrine and glaciofluvial deposits and till. Furthermore, the potential is low because the bedrock geology is dominated by limestones, sandstones, and shales of the WCSB. Also, the southeast corner of the RAA lies in the Superior Province of the Canadian Shield, where bedrock is predominantly granite, granodiorite, and related gneiss.

4.1.1.2 Overburden

The overburden in the northwestern part of the RAA, including the Dorsey Converter Station, SLTC, and the Riel Converter Station, consists of offshore glaciolacustrine sediments, which are composed of clay, silt and minor sand (Map 4-2 - Surficial Geology). The offshore glaciolacustrine sediments are approximately 1 to 20 m thick and are very low relief massive and laminated deposits that are deposited from suspension in offshore, deep water of glacial Lake Agassiz and were commonly scoured and homogenized by icebergs (Matile and Keller 2004b).

The overburden in the eastern and southern portions of the RAA, which mostly starts east of Provincial Highway 12, is complex (see Map 4-2 Surficial Geology). The northern and western portion of this area is predominantly a mixture of till (calcareous silt diamicton) approximately 1 to 75 m thick composed of subglacial deposits predominantly derived from Paleozoic dolomite and limestone, covered discontinuously by thin veneers (<1 m) of glaciolacustrine and glaciofluvial sediments. There are some smaller areas of marginal glaciolacustrine sediments that are composed of sand and gravel approximately 1 to 20 m thick; distal glaciofluvial sediments approximately 1 to 75 m thick, which have fine sand, minor gravel and thin silt and clay interbeds; proximal glacialfluvial sediments approximately 1 to 20 m thick, complex deposits composed of sand and gravel; and eolian sand with minor silt, which generally overlay deltaic sediments, coarse lacustrine sediments or glaciofluvial deposits (Matile and Keller, 2004b). Further east in the area, there is less till (calcareous silt diamicton) and more of the eolian sand, and a mixture of the till, marginal glaciolacustrine sediments, and the distal glaciofluvial sediments (main area northeast of Sandilands) (Matile and Keller 2004b).

4.1.2 RM of South Cypress (Glenboro) Area

4.1.2.1 Bedrock

The RM of South Cypress, Glenboro area, is underlain by Mesozoic sediments (Map 4-3 - Glenboro South Station Bedrock Geology). The Vermillion River Formation (Pembina Member) covers the area and comprises non-calcareous shale and bentonite (Klassen *et al*. 1970).

4.1.2.2 Overburden

The main surficial geology surrounding Glenboro and in the RM of South Cypress is distal glaciofluvial sediments (Map 4-4 - Glenboro South Station Surficial Geology), which are approximately 1 to 75 m thick, and have fine sand, minor gravel and thin silt and clay interbeds (Matile and Keller 2004a).

4.2 REGIONAL HYDROGEOLOGY AND GROUNDWATER USE

Regional hydrogeology and groundwater use is described in this section based on available aquifer data and recorded and licensed well records within the project RAA. It is organized by region of Manitoba the project components are located in being southeast Manitoba (Existing

Corridor, New ROW, Dorsey Converter Station, and Riel Converter Station) and the RM of South Cypress (Glenboro) Area (Glenboro South Station).

4.2.1 Southeast Manitoba

The main bedrock aquifer underlying the area traversed by the Project is the Carbonate Aquifer (Rutulis 1984a, b, 1990; SRGMP 2010). This aquifer is the largest freshwater aquifer in Manitoba and stretches from north of The Pas, Manitoba, southward through the Interlake region and along the east side of the Red and Rat rivers into Minnesota (Grasby and Betcher 2002). The groundwater in the aquifer becomes increasingly saline to the west (SRGMP 2010). The aquifer is overlain by clay and till that act as an aquitard, limiting the movement of water from the surface to the groundwater. The direction of fresh groundwater flow in the Carbonate Aquifer is generally westward (Rutulis 1984a, b, 1990; Betcher *et al.* 1995; SRGMP 2010). The freshwater yield from the Carbonate Aquifer is reported to be adequate to abundant for household and normal farm requirements in the area, but only bears fresh water in the area east of the Red and Rat rivers (Rutulis 1984a).

The Sandilands area in the southeast portion of the RAA is an important freshwater recharge area because of the relatively high permeability tills that are present in the area. This area is one of the two freshwater recharge areas for the carbonate rock aquifer in Manitoba (Thorleifson *et al*. 1998; Grasby and Betcher 2002; Ferguson *et al.* 2003) with the other being in the Interlake region of Manitoba outside of the RAA.

Flowing well and areas of springs are present within the RAA. A flowing well is a well that has a static water level above the adjacent ground surface and occurs when water pressure in the aquifer causes the water level to rise above the ground surface. Two large flowing well areas (fresh water) are located in the area traversed by the Project (Map 4-5 - Flowing Wells and Springs). One area stretches from Hazelridge in the north central part of the RM of Springfield down to the town of Ste. Anne in the RM of Ste. Anne. The second stretches from Giroux in the RM of Ste. Anne south to just south of Marchand in the RM of La Broquerie. Three smaller flowing well areas are located just west of the town of Ste. Anne, and around the communities of Ross and Piney (Rutulis 1985b)). There is one saline flowing well area in the southwest corner of the RM of MacDonald. There are also some areas of fresh water springs within the RAA including the RM of Piney and the RM of Springfield (see Map 4-5 - Flowing Wells and Springs).

Groundwater and surface water use in excess of 25,000 L/day requires a licence by the Water Use Licensing Section of MCWS (MCWS, Water Stewardship Division, 2015).

The majority of the licensed groundwater supply wells in the southern half of the RAA, RMs of Ste. Anne, La Broquerie, Stuartburn, and Piney, are for agricultural purposes (Map 4-6 - Licensed Groundwater Supply Wells (Final Preferred Route)). The RM with the highest density of licensed groundwater supply wells is the RM of La Broquerie with mostly agricultural wells (maximum annual volume of 10 dam^3 [10,000 m^3] to 100 dam^3 [100,000 m^3]) and one industrial well (maximum annual volume of 25 dam^3 [25,000 m^3]). The northern half of the RAA has a mixture of all groundwater use categories; agricultural, domestic, industrial, irrigation, municipal and other.

The highest density of groundwater wells is within the northeastern portion of the RAA (Map Series 4-100 - Groundwater Wells) in the RMs of Springfield, Tache, Ritchot, Ste. Anne and the northern half of the RM of La Broquerie. The RM of Rosser in the northeastern portion of the RAA also has a high density of groundwater wells. Smaller localized areas of groundwater wells can be seen in the southern half of the RAA in the RMs of Stuartburn and Piney. Groundwater well completion depths and uses are summarized for the areas around the transmission line in Section 4.3.

4.2.2 RM of South Cypress (Glenboro) Area

The principal aquifer in the RM of South Cypress and Glenboro area is an extensive sand and gravel aquifer called the Assiniboine Delta Aquifer (Map 4-7 - Glenboro South Station Sand and Gravel Aquifers) (Rutulis 1978a and Assiniboine Delta Aquifer Management Plan Round Table 2005). The thickness of the aquifer south of the Assiniboine River varies from more than 10 m up to 30 m in some places. Regional groundwater flow in the area is generally towards the north (Rutulis 1985a and Assiniboine Delta Aquifer Management Plan Round Table 2005). Groundwater quality ranges from good to excellent in the area. Freshwater springs in the RM of South Cypress occur along the sides of the Assiniboine River Valley in the Shilo/Spruce Woods Forest and Provincial Park area north of Glenboro South Station (Rutulis 1985b).

The majority of the licensed groundwater supply wells are located in the southern third of the RAA in the RM of South Cypress (Map 4-8 - Glenboro South Station Licensed Groundwater Supply Wells and Dugouts) and are for irrigation purposes. Approximately half of the licensed wells are approved to use a maximum annual volume of between 100 dam^3 and 1,000 dam^3 (100,000 m^3 and 1,000,000 m^3) and the other half of them did not have usage volumes designated. There are five licensed wells for municipal purposes (unknown to 50 dam^3/yr [50,000 m^3/yr]) and two for agricultural purposes (3 dam^3/yr [3,000 m^3/yr] to 8 dam^3/yr [8,000 m^3/yr]).

The lowest density of groundwater wells is in the northeastern portion of the RM of South Cypress (Map 4-9 - Glenboro South Station Groundwater Wells). Majority of the wells are listed as Other usage and are mostly used for test or observation wells. Completion depths and uses are summarized for the LAA by rural municipality in Section 4.3.

4.3 LOCAL HYDROGEOLOGY AND GROUNDWATER USE

Local hydrogeology and groundwater use is described in this section based on available surficial geology data, aquifer data, and recorded and licensed well records within the project LAA. The LAA may traverse areas of soil and or groundwater contamination. Areas with soil contaminant impacts can indicate potential impacts to groundwater due to the interactions of groundwater with the soil and the contaminants in the soil. Locations with known soil contaminant impacts are included within the Soils and Terrain Technical Data Report.

4.3.1 Existing Transmission Corridor

The MMTP travels through the Existing Corridor including the Southern Loop Transmission Corridor (SLTC) and the Riel to Vivian Transmission Corridor (RVTC). The typical stratigraphy in the Existing Corridor is clay and till overburden (Offshore Glaciolacustrine Sediments) over dolomitic and limestone bedrock with both the Red River and the Floodway being contained within the clay/till overburden. Near the eastern portion of the Existing Corridor southeast of Glass, Manitoba, the surficial geology changes to a calcareous silt diamicton while the bedrock remains the same (see Map 4-1 - Generalized Bedrock Geology and Map 4-3 - Glenboro South Station Bedrock Geology). The groundwater flow on the east side of the City of Winnipeg and the Floodway is generally from east to west and west of the Red River the groundwater flow is generally east towards the Red River (MFEA 2004). West of the Red river, in most of the western portion of the SLTC, groundwater in the carbonate aquifer is saline and non-potable (Rutulis 1984a). The MMTP tower foundations are not expected to be installed deeper than 11 meters, which is above the clay/till overburden throughout the entire Existing Corridor (i.e., above the average base of the floodway) (MFEA 2004).

There are four licensed groundwater supply wells that have potential to be within the LAA of the Existing Corridor (see Map 4-6 - Licensed Groundwater Supply Wells (Final Preferred Route)) Two wells are agricultural (livestock) wells, one is for recreation, and the other is for heating/cooling. They are within quarter sections or river lots that overlap the LAA. Two wells are located in the RM of Rosser, with their maximum allowable volume ranging from approximately 50 dam^3/yr (50,000 m^3/yr) to 198 dam^3/yr (198,000 m^3/yr) and the other two are in the RM of Springfield with their maximum allowable volume ranging from approximately 20 dam^3/yr (20,000 m^3/yr) to 32 dam^3/yr (32,000 m^3/yr).

There are approximately 618 groundwater wells in the LAA in the Existing Corridor with the majority of the wells being used for “domestic” purposes followed by “other” use and then “agricultural” use.

The most shallow recorded well hole completed in the LAA was 8.2 metres below ground surface (mbgs) in the RM of Springfield and the deepest well completed was 115.9 mbgs along the LAA in the RM of Ritchot. The most shallow cased well was 5.8 mbgs in the RM of Springfield, with the City of Winnipeg and the RMs of Headingly and Rosser having at least one well in the LAA cased to a depth less than 10 mbgs. The deepest well casing completed was 91.5 mbgs in the LAA in the RM of Springfield.

Table 4-1 Summary of Well Water Use For the Existing Corrdior Local Assessment Area

Rural Municipality	Total Wells	Domestic	Municipal	Agricultural	Industrial	Other
City of Winnipeg	155	102	0	2	1	54
Headingly	35	27	0	3	0	6
MacDonald	26	18	0	1	2	5
Ritchot	82	69	0	0	1	14
Rosser	23	17	0	5	1	3
Springfield	297	252	0	16	0	45
Existing Corridor Total	**618**	**485**	**0**	**27**	**5**	**127**

Note: Agriculture water use includes irrigation and livestock and Other water use includes geothermal, air conditioning, dewatering, observation, recharge, test wells, and other/unknown. Some wells are used for multiple uses.
Source: MCWS GWDrill Database.

Table 4-2 Summary of Well Construction For the Existing Corridor Local Assessment Area

Rural Municipality	Well Completion Depth (mbgs)		Casing Completion Depth (mbgs)	
	Minimum	Maximum	Minimum	Maximum
City of Winnipeg	15.6	91.5	9.4	55.5
Headingly	11.9	103.6	8.2	28.5
MacDonald	10.4	103.7	10.7	39.3
Ritchot	24.4	115.9	16.8	43.3
Rosser	12.2	62.8	8.8	31.7
Springfield	8.2	115.8	5.8	91.5

A review of the pumping data for groundwater wells (near the SLTC) after their installation, showed that locations with recorded groundwater levels aboveground prior to pumping (flowing wells) were located near the community of Headingly. Locations with recorded groundwater levels aboveground prior to pumping near the RVTC portion of the Existing Corridor were located south of Anola. The eastern portion of the Existing Transmission Corridor LAA located in the RM of Springfield traverses a previously mapped area of freshwater flowing wells south of the community of Glass, Manitoba and extending to the eastern extent of the RVTC which corresponds with the pumping data (see Map 4-5 - Flowing Wells and Springs and Map Series 4-200 - Depth to Groundwater in Wells).

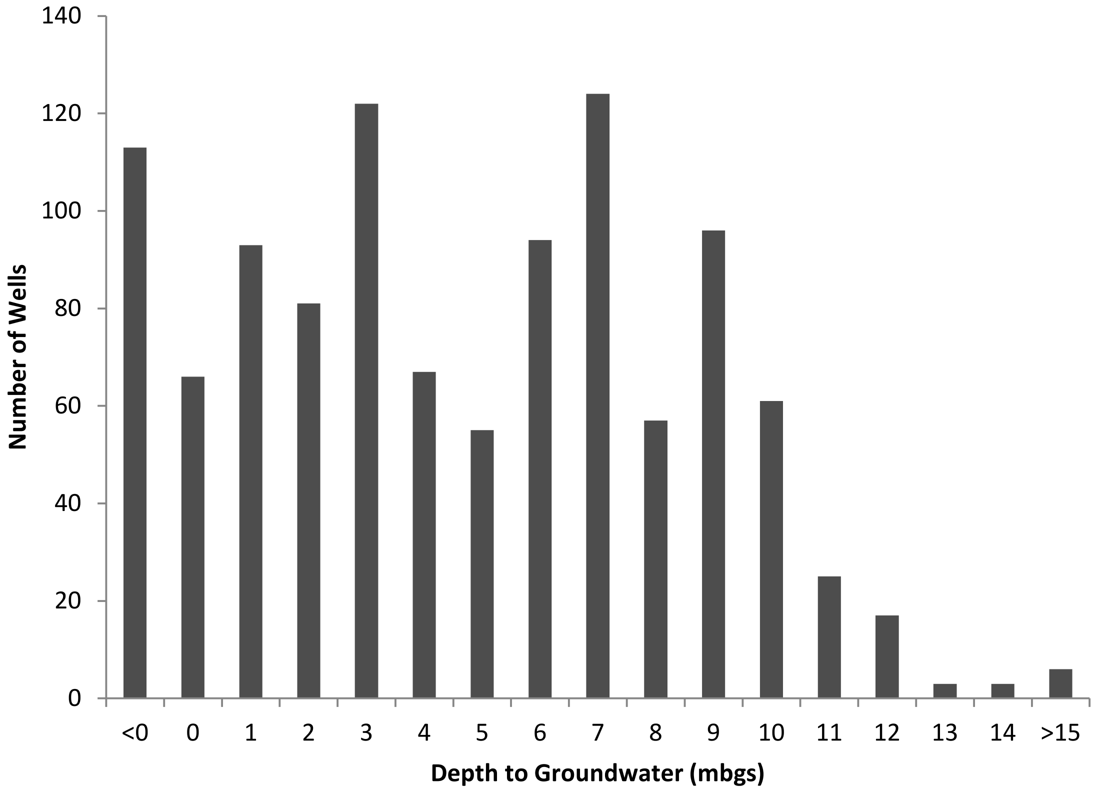

Figure 4-1 Depth to Groundwater in Wells in the Project LAA

4.3.2 New Right-of-Way

The hydrogeology of the New ROW can be generally described by the Winnipeg Formation sandstone aquifer underlying the carbonate aquifer which has various sand and gravel aquifers overlying throughout. Use of the sand and gravel aquifers is more predominant south of Richer, Manitoba (SRGMP 2010). Sand and gravel aquifers are shown on Map 4-10.

The surficial geology of the area is complex. The majority of the LAA for the New ROW traverses areas with lenses of sand and gravel aquifers (see Map 4-10 - Sand and Gravel Aquifers). The LAA passes over two areas of major buried sand and gravel aquifers, with one located south of the community of Richer and the second located south of the community of Piney. There are many individual sand and gravel aquifers in southeast Manitoba, in which the LAA is located. Many of the individual sand and gravel aquifers have not been well characterized (SRGMP 2010). A study of the hydrogeology located east of the New ROW in the Sandilands area identified seven significant layers; the Upper Sand Unit, the Upper Silt Unit, the Lower Sand Unit, the Lower Till Formation, the Red River Formation, the Winnipeg Formation, and the Precambrian basement complex (Manitoba Clean Environment Commission 2007).

There are six licensed groundwater supply wells that have potential to be within the New ROW LAA (see Map 4-6 - Licensed Groundwater Supply Wells (Final Preferred Route)) All six are agricultural wells (livestock, irrigation and aquaculture) within quarter sections that have a portion that overlap the LAA. One well is in the RM of Springfield, one in the RM of Ste. Anne, and three are located in the RM of La Broquerie with their maximum allowable volume ranging from approximately 13 dam^3/yr (13,000 m^3/yr) to 81 dam^3/yr (81,000 m^3/yr). Many wells are mapped to the centroid of the river lot or quarter section of land they are located in and the well could be located anywhere on the quarter section. Therefore, there is potential that these wells may be located within the LAA.

There are 702 recorded groundwater wells in the New ROW LAA with majority of the wells being used for domestic purposes followed by agriculture and other types. Some of the wells are used for multiple purposes and each of those occurences are included as a count under the well use columns. Accordingly, the well use totals do not sum to the total wells in the area. The total well column is the actual total number of individual wells in the New ROW LAA.

Table 4-3 Summary of Well Water Use For the New ROW Local Assessment Area

Rural Municipality	Total Wells	Domestic	Municipal	Agricultural	Industrial	Other
LaBroquerie	228	198	1	27	2	19
Piney	27	22	0	7	0	3
Springfield	27	23	0	5	0	3
Ste.Anne	211	176	0	40	0	37
Stuartburn	39	21	0	9	0	13
Tache	170	165	0	14	0	5
Total in New ROW LAA	**702**	**605**	**1**	**101**	**2**	**80**
Note: Agriculture water use includes irrigation and livestock and Other water use includes geothermal, air conditioning, dewatering, observation, recharge, test wells, and other/unknown. Some wells are used for multiple uses.						

The most shallow completed well hole was 1.8 mbgs in the RM of La Broquerie and the deepest well hole completed was 90.0 mbgs along the LAA in the RM of La Broquerie. The most shallow cased well was 0.9 mbgs in the RM of Ste. Anne, with the RMs of Piney, Tache, Stuartburn, Springfield and Rosser all having at least one well in the LAA cased to depths of less than 10 mbgs. The deepest cased well was 77.8 mbgs in the LAA in the RM of La Broquerie.

Table 4-4 Summary of Well Construction for the New Right-of-way Local Assessment Area

Rural Municipality	Well Completion Depth (mbgs)		Casing Completion Depth (mbgs)	
	Minimum	Maximum	Minimum	Maximum
La Broquerie	1.8	90.0	4.9	77.8
Piney	15.9	76.9	8.5	56.4
Springfield	7.3	78.4	5.7	68.9
Ste. Anne	2.7	72.2	0.9	62.5
Stuartburn	2.4	87.2	2.1	64.7
Tache	4.3	75.3	4.3	44.8

The northern portion of the New ROW LAA within the RM of Springfield traverses an area of freshwater flowing wells at the origin of the New ROW south of the community of Anola (see Map 4-5 - Flowing Wells and Springs and Map Series 4-200 - Depth to Groundwater in Wells) and extends down to the boundary of the RM of Tache. The LAA also passes through an area of freshwater flowing wells approximately 4 km north and south of the community of La Broquerie. The LAA crosses through an area of flowing wells south of the community of Piney in the far southeasterly portion of the transmission line. A review of the pumping data for groundwater wells (near the New ROW route) after their installation, showed that locations with recorded groundwater levels aboveground prior to pumping were consistently located in the flowing well areas shown on Map 4-5 - Flowing Wells and Springs and Map Series 4-200 - Depth to Groundwater in Wells.

4.3.3 Stations

4.3.3.1 Dorsey Converter Station

The hydrogeology beneath the Dorsey Converter Station is also generally the Winnipeg Formation sandstone and carbonate aquifer and the Carbonate Aquifer is also used for local groundwater supply. The Carbonate Aquifer is overlain by 0-12 m of clay underlain by glacial till (Rutulis 1974). There are two licensed groundwater supply wells potentially located within the LAA of the Dorsey Converter Station (see Map 4-6 - Licensed Groundwater Supply Wells (Final Preferred Route)). These wells are used for heating and cooling. The volumes of maximum annual usage range from approximately 100 dam^3/yr (100,000 m^3/year) to 5,923 dam^3/year (5,923,000 m^3/year).

There are approximately 47 recorded groundwater wells in the Dorsey Converter Station LAA with majority of the wells being used for domestic purposes followed by other and industrial well types. Some of the wells are used for multiple purposes. There are wells within the current Dorsey Converter Station but there are no known wells within the area of the planned Dorsey Converter Station expansion.

Table 4-5 Summary of Well Water Use For the Local Assessment Area of the Stations

Station	Total Wells	Domestic	Municipal	Agricultural	Industrial	Other
Dorsey	47	19	2	2	9	17
Riel	35	32	0	2	0	2
Glenboro	3	3	0	3	0	0

Note: Agriculture water use includes irrigation and livestock and Other water use includes geothermal, air conditioning, dewatering, observation, recharge, test wells, and other/unknown. Some wells are used for multiple uses.
Source: MCWS GWDrill Database.

The most shallow well hole completed in the stations LAA was 11.6 mbgs and the deepest was 91.5 mbgs. The most shallow cased well was 7.1 mbgs while the deepest cased well was 38.1 mbgs.

The LAA may traverse areas of soil and or groundwater contamination. Locations with known soil contaminant impacts are included within the Soils and Terrain Technical Data Report. Areas with soil contaminant impacts can indicate potential impacts to groundwater due to the interactions of groundwater with the soil and the contaminants in the soil.

4.3.3.2 Riel Convertor Station

The hydrogeology beneath the Riel Converter Station is generally the Winnipeg Formation sandstone and carbonate aquifers. The upper carbonate aquifer is used for local groundwater supply for domestic and agricultural/livestock supply. The Carbonate Aquifer is overlain by 20 to 30 m of clay at the Converter Station Site (Rutulis 1990). There are no licensed groundwater supply wells within the LAA around the Riel Converter Station (see Map 4-6 - Licensed Groundwater Supply Wells (Final Preferred Route)).

There are approximately 35 recorded groundwater wells in the Riel Converter Station LAA with majority of the wells being used for domestic purposes followed by agriculture and industrial well types. Some of the wells are used for multiple purposes as can be seen in Table 4-5.

The most shallow well hole completed in the Riel LAA was 22.9 mbgs and the deepest was 83.8 mbgs. The most shallow cased well was 13.7 mbgs while the deepest recorded cased well in the Riel LAA was 39.9 mbgs. There are wells within the current Riel Converter Station.

4.3.3.3 Glenboro South Station

In the RM of South Cypress, where Glenboro South Station is located, the main bedrock material consists of a soft clayey shale formation. The bedrock is overlain by till, then clay and silt and then sand (Rutulis 1978a). A large unconfined sand and gravel aquifer underlies the area of Glenboro South Station known as the Assiniboine Delta Aquifer (see Map 4-7 - Glenboro South Station Sand and Gravel Aquifers).

There are no reported licensed groundwater supply wells or dugouts located within the LAA around the Glenboro South Station (see Map 4-8 - Glenboro South Station Licensed Groundwater Supply Wells and Dugouts).

There are approximately three groundwater wells in the LAA of the Glenboro Station and all of the wells are being used for domestic and livestock purposes as can be seen in Table 4-5. The most shallow uncased well was 13.7 mbgs and the deepest was 23.8 mbgs. The most shallow cased well was 10.7 mbgs and the deepest was 20.4 mbgs. There are no known wells within the Glenboro Station PDA.

5.0 ENVIRONMENTALLY SENSITIVE SITES

Environmentally sensitive sites (ESS) are locations, features, areas, activities or facilities that are identified to be environmentally, socially or economically important or sensitive to disturbance and require protection and mitigation during Project construction and operation and maintenance. Sensitive sites traversed by the Project or in the immediate vicinity of Project components and subject to effects from the Project are included. These sites are assessed for potential environmental effects and appropriate mitigation measures are identified within the EIS. In order to provide protection during the construction and maintenance and operation phases of the Project, ESS will be included in the Environmental Protection Plan.

Areas of freshwater flowing wells and springs have been identified as ESS for groundwater. These sites were discussed in Section 4.2 and 4.3. Locations of these ESS are summarized in Table 5-1, below.

Table 5-1 Environmentally Sensitive Sites for Groundwater

ESS Name	ESS Description	Rationale
Areas of Freshwater Flowing Wells and Springs	Aquifer areas with known flowing wells and springs in the following generalized locations: • South of Glass to southern limits of the RM of Springfield. • Approximately 4 km north and south of the community of La Broquerie. • East of Sundown. • Around Piney.	Installation of tower foundations and geotechnical drilling have the potential to disturb groundwater quantity through the unintended discharge of aquifers in artesian areas of flowing wells and springs.

6.0 SUMMARY

Manitoba Hydro is proposing to construct and operate the Manitoba-Minnesota Transmission Project (MMTP), a 500 kilovolt (kV) alternating current transmission line in southeastern Manitoba and associated station upgrades. This technical data report (TDR) has been prepared as a supporting document for the EIS of MMTP (the Project).

The purpose of this TDR is to describe the existing conditions for groundwater in the area of the Project. For this assessment, groundwater is considered a pathway to an effect on a valued component, rather than a valued component itself. Changes to groundwater quality or quantity can be a mechanism of change in Land and Resource Use. Groundwater wells are an important source of fresh water for many uses including air conditioning and geothermal, domestic, agricultural (livestock and irrigation), municipal, industrial, and others. If there is a change in groundwater quality and/or quantity it can have an affect on the uses described above. Therefore a change in the groundwater quality and/or quantity pumped from wells would be a mechanism of change for the Land and Resource Use VC. There is an interconnectvitiy between groundwater and surface water with groundwater providing a source of recharge to streams (SRGMP 2010). This interconnectivity occurs in most most physiographic and climatic settings (Winter et al. 1998). Therefore, change in groundwater quality/quantity as well as a release of groundwater into surface water could be a mechanism of change for the Fish and Fish Habitat VC.

The main bedrock aquifer underlying the area traversed by the Project (aside from Glenboro South Station) is the Carbonate Aquifer (Rutulis 1984a, b, 1990). The freshwater yield from the Carbonate Aquifer is reported to be adequate to abundant for household and normal farm requirements in the area, but only bears fresh water in the area east of the Red and Rat rivers south of Winnipeg (Rutulis 1984a; SRGMP 2010). The Sandilands area in the southeast portion of the RAA is an important freshwater recharge area for the carbonate aquifer because of the relatively high permeability tills that are present in the area (Thorleifson *et al*. 1998; Grasby and Betcher 2002; Ferguson *et al.* 2003).

The principal aquifer in the RM of South Cypress and Glenboro area is an extensive sand and gravel aquifer called the Assiniboine Delta Aquifer (Rutulis 1978a and Assiniboine Delta Aquifer Management Plan Round Table 2005). Groundwater quality ranges from good to excellent in the area.

There are freshwater artesian or flowing well areas within the Project LAA and RAA. There is one saline flowing well area, in the RAA, in the southwest corner of the RM of Macdonald but there are no saline flowing well areas within the LAA. There are four freshwater flowing well areas located in the LAA traversed by the MMTP. One area stretches from Hazelridge in the north central part of the RM of Springfield down to the town of Ste. Anne in the RM of Ste. Anne. The second stretches from Giroux in the RM of Ste. Anne south to just south of Marchand in the RM of La Broquerie. The other two are located around the communities of Ross and Piney. An additional flowing well area is located around the community of Sprague, outside of the LAA. There are also some areas of fresh water springs located between the communities of Sundown and Carrick in the southeast area of the RAA.

There are 1,405 groundwater wells within the LAA of the Project with the majority of the wells being used for domestic purposes. The well casing completion depths ranged from 0.9 mbgs to 91.5 mbgs, which shows that there is a range of sand and gravel aquifer use and bedrock aquifer use. There are 11 groundwater wells, within the LAA, with withdrawls large enough (>25,000 L/day) to require a licence under the *Water Rights Act*. The majority of them are being used for agriculture (livestock, irrigation and aquaculture).

The Project area has complex hydrogeology with numerous sand and gravel aquifers and two bedrock aquifers, one beneath the other. The surficial and bedrock aquifers are used for all purposes within the study area.

The LAA may traverse areas of soil and or groundwater contamination. Locations with known soil contaminant impacts are discussed within the Soils and Terrain Technical Data Report. If soil impacts are in contact with groundwater, there is a potential for groundwater to become impacted.

The assessment of change to groundwater use considering groundwater quantity and quality is included within Chapter 16 Land and Resource Use, Chapter 8 Fish and Fish Habitat and the assessment of accidents and malfunctions related to potential groundwater effects are discussed in Chapter 20 Accidents and Malfunctions.

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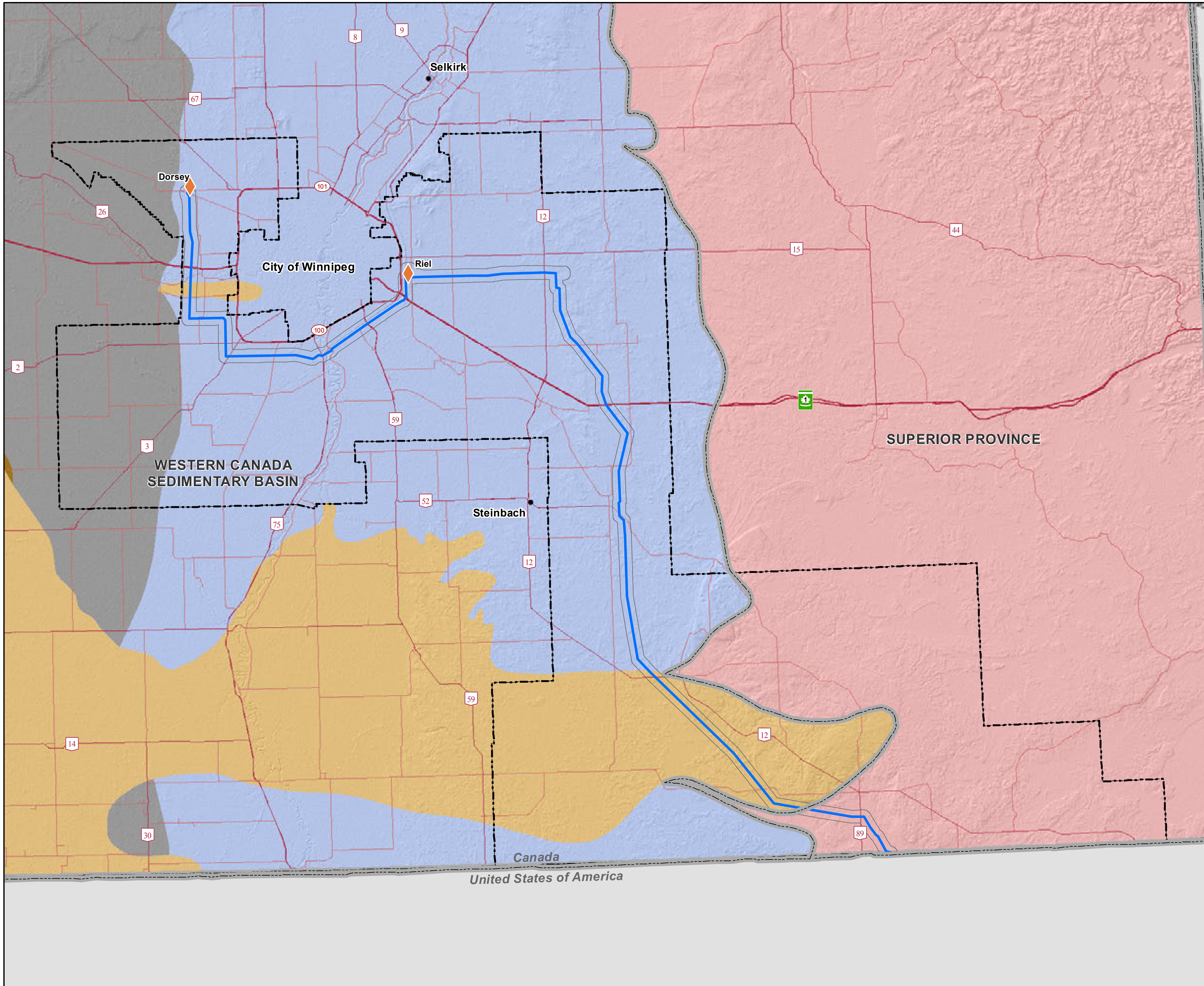


Manitoba Hydro

Manitoba-Minnesota Transmission Project

Project Infrastructure

- Converter Station (Existing)
- Final Preferred Route (FPR)

Bedrock Geology

- Geological Province

Era	Period	Major Rock Types
Mesozoic	Jurrasic	Shale, Limestone, Sandstone, Gypsum/Anhydrite
Paleozoic	Silurian	Dolostone, Shale
	Ordovician	Dolostone, Limestone, Shale, Basal Sandstone
Precambrian		Igneous and Metomorphic Crystalline Rocks

Assessment Area

- Land and Resource Use Local Assessment Area
- Land and Resource Use Regional Assessment Area

Landbase

- City
- Trans Canada
- Provincial Highway
- Provincial Road

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015

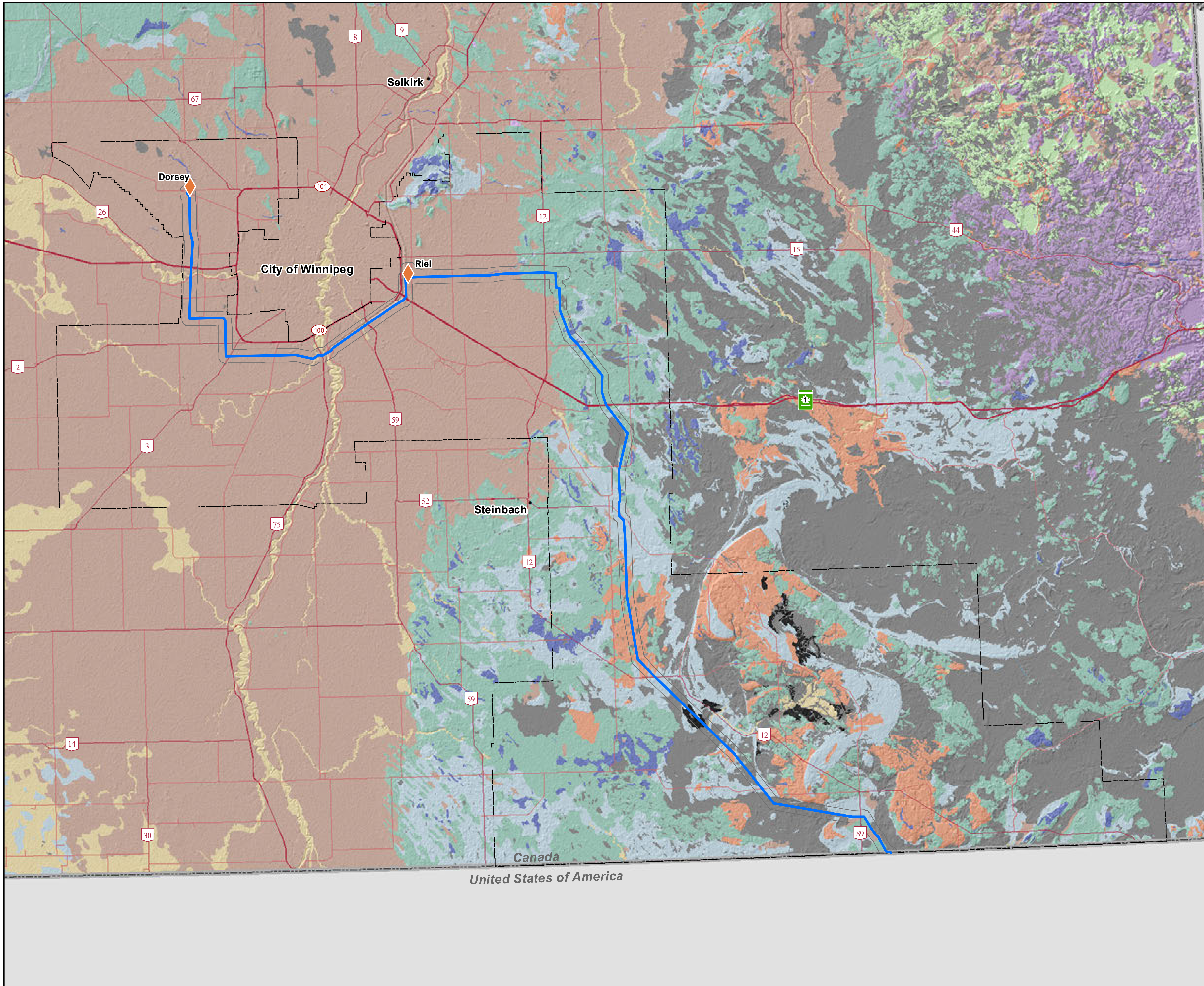
N

0 5 10 Kilometres
0 5 10 Miles

1:600,000

Generalized Bedrock Geology

Map 4-1



Manitoba Hydro

Manitoba-Minnesota Transmission Project

Project Infrastructure

- Converter Station (Existing)
- Final Preferred Route (FPR)

Surficial Geology

- Organic Deposits
- Shoreline Sediments
- Eolian
- Alluvial Sediments
- Marginal Glaciolacustrine Sediments
- Offshore Glaciolacustrine Sediments
- Distal Glaciofluvial Sediments
- Proximal Glaciofluvial Sediments
- Silt Diamicton
- Sand Diamicton
- Paleozoic Terrane
- Precambrian Terrane

Assessment Area

- Land and Resource Use Local Assessment Area
- Land and Resource Use Regional Assessment Area

Landbase

- City
- Trans Canada
- Provincial Highway
- Provincial Road

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015

N

0 10 Kilometres
0 5 10 Miles

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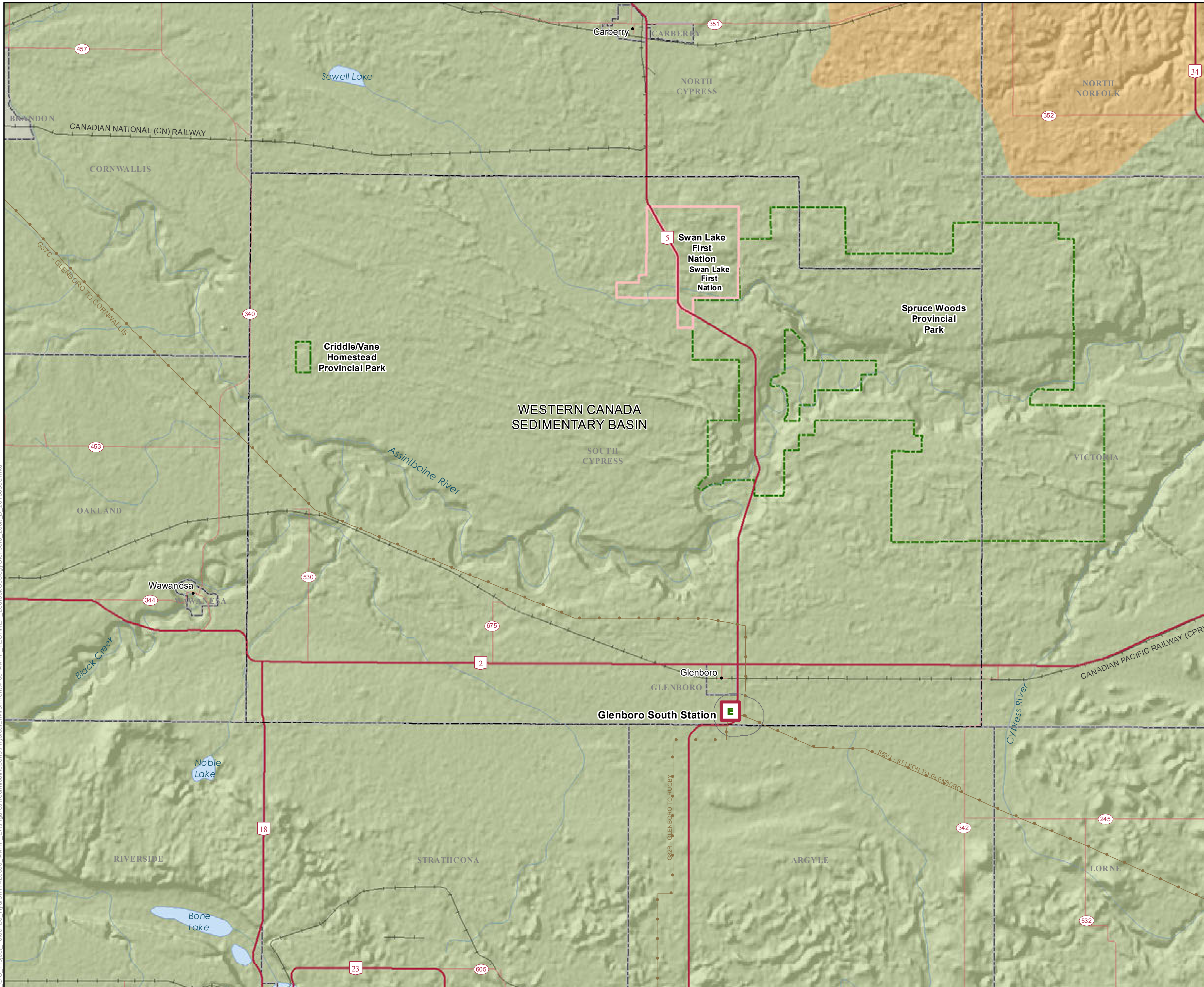
Surficial Geology

Map 4-2



Manitoba-Minnesota Transmission Project

Infrastructure

- Electrical Station
- Existing Transmission Line

Bedrock Geology

- Geological Province

Era	Period	Major Rock Types
Mesozoic	Cretaceous	Shale, Minor Sandstone and Limestone
	Jurassic	Shale, Limestone, Sandstone, Gypsum/Anhydrite

Assessment Area

- Land and Resource Use Local Assessment Area
- Land and Resource Use Regional Assessment Area

Landbase

- Provincial Highway
- Provincial Road
- Railway
- First Nation
- Rural Municipality
- Provincial Park
- Watercourse
- Waterbody

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015

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0 — 2.5 — 5 Miles

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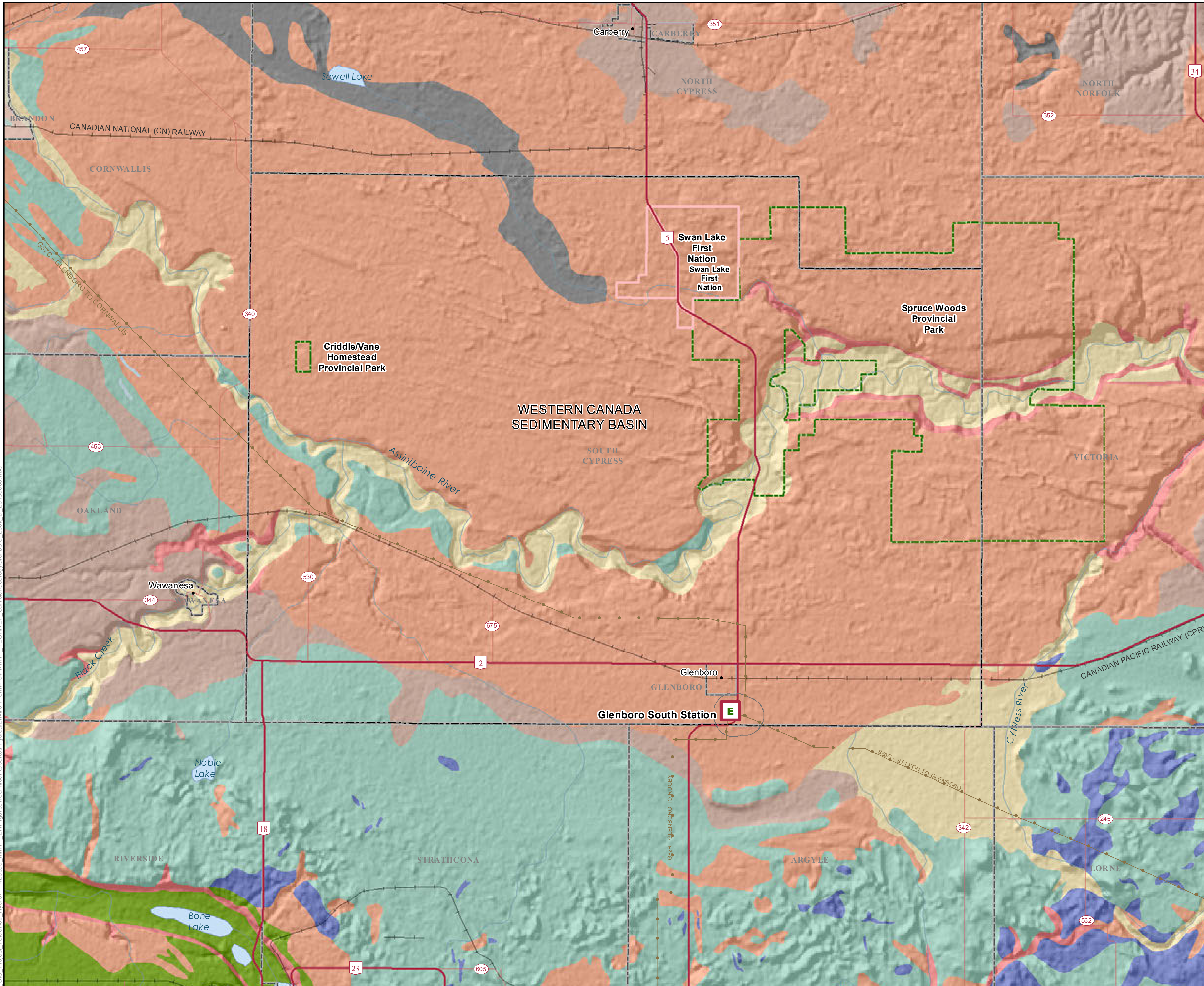
Glenboro South Station Bedrock Geology

Map 4-3



Manitoba Hydro

Manitoba-Minnesota Transmission Project

Infrastructure

- Electrical Station
- Existing Transmission Line

Surficial Geology

- Organic Deposits
- Colluvium
- Alluvial Sediments
- Marginal Glaciolacustrine Sediments
- Offshore Glaciolacustrine Sediments
- Distal Glaciofluvial Sediments
- Proximal Glaciofluvial Sediments
- Clay Diamicton
- Silt Diamicton

Assessment Area

- Land and Resource Use Local Assessment Area
- Land and Resource Use Regional Assessment Area

Landbase

- Provincial Highway
- Provincial Road
- Railway
- First Nation
- Rural Municipality
- Provincial Park
- Watercourse
- Waterbody

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015

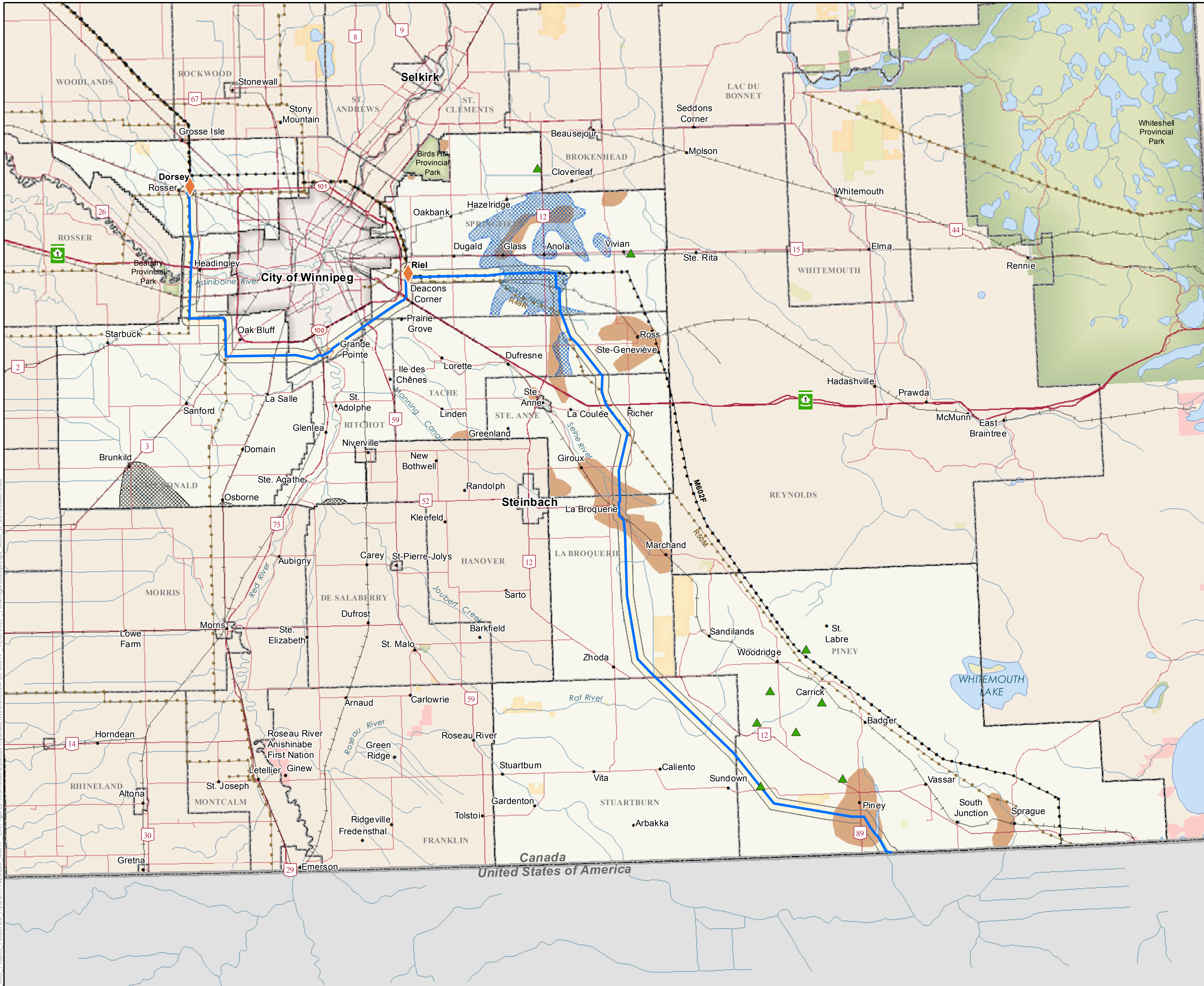
N

0 5 Kilometres
0 2.5 5 Miles

1:200,000

Glenboro South Station Surficial Geology

Map 4-4



Manitoba Hydro

Manitoba-Minnesota Transmission Project

Project Infrastructure

- Converter Station (Existing)
- Final Preferred Route (FPR)

Infrastructure

- Existing 500kV Transmission Line
- Existing 230kV Transmission Line

Flowing Wells and Springs

- Fresh Water Springs (Rutulis, 1985)
- Flowing Wells - Saline Water (Rutulis, 1985)
- Flowing Wells - Fresh Water (Rutulis, 1990)
- Flowing Wells - Fresh Water (Rutulis, 1985)

Assessment Area

- Land and Resource Use Local Assessment Area
- Land and Resource Use Regional Assessment Area

Landbase

- Community
- Railway
- Trans Canada
- Provincial Highway
- Provincial Road
- City
- First Nation Lands
- Ecological Reserve
- Wildlife Management Area
- Provincial Park
- Rural Municipality

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015

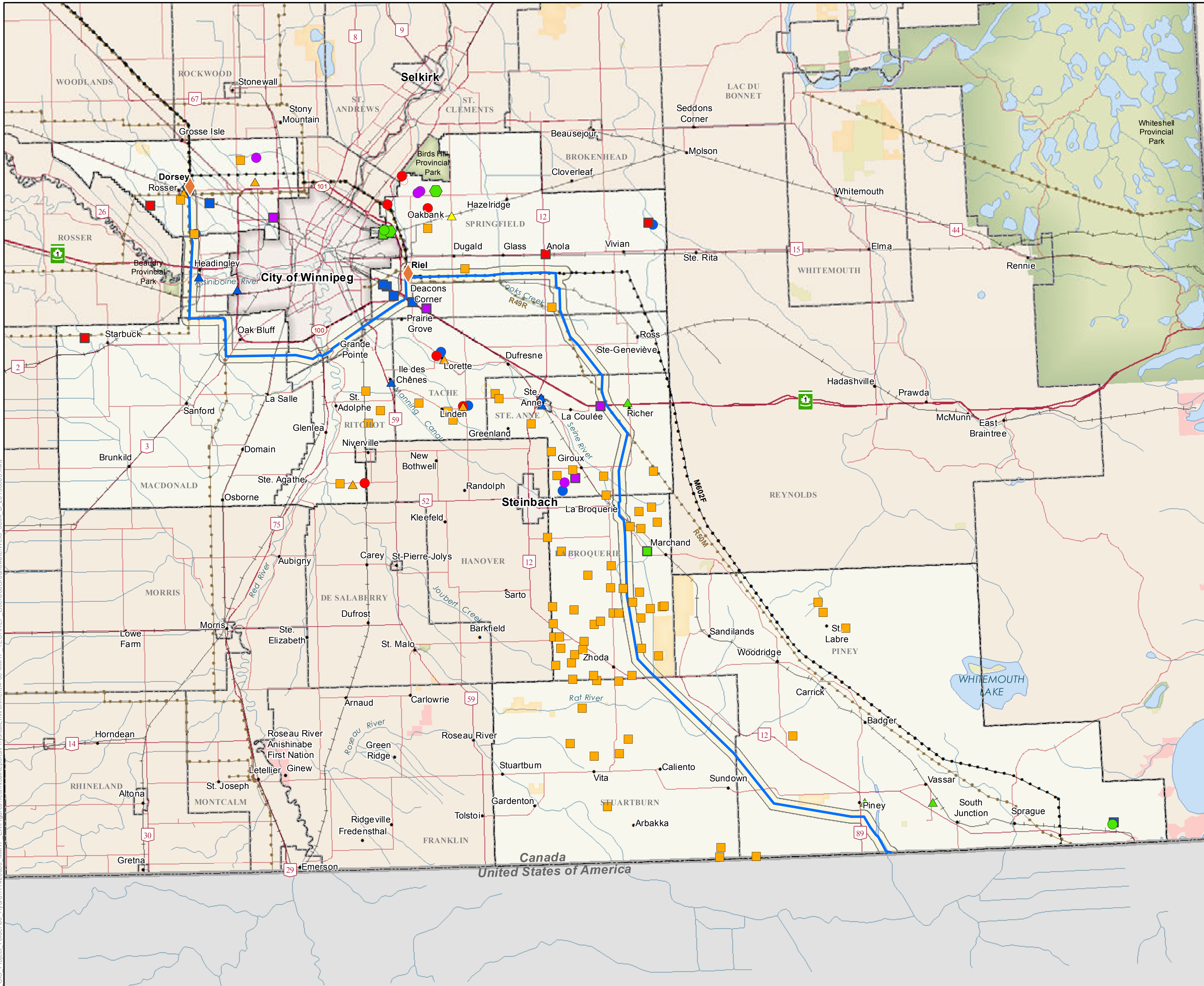
N

0 10 Kilometres
0 5 10 Miles

1:600,000

Flowing Wells and Springs

Map 4-5



Manitoba Hydro

Manitoba-Minnesota Transmission Project

Project Infrastructure

- Converter Station (Existing)
- Final Preferred Route (FPR)

Infrastructure

- Existing 500kV Transmission Line
- Existing 230kV Transmission Line

Water Usage (Maximum Annual Volume (1000 m^3))[1]

Agricultural
- No Data
- 0 - 10
- 10 - 100

Domestic
- 0 - 10

Industrial
- No Data
- 0 - 10
- 10 - 100
- 100 - 1000
- 1000+

Irrigation
- No Data
- 10 - 100
- 100 - 1000

Municipal
- No Data
- 10 - 100
- 100 - 1000

Other
- No Data
- 0 - 10
- 10 - 100
- 100 - 1000
- 1000+

Assessment Area

- Land and Resource Use Local Assessment Area
- Land and Resource Use Regional Assessment Area

Landbase

- Community
- Trans Canada Highway
- Provincial Highway
- Provincial Road
- City / Town
- First Nation Lands
- Rural Municipality
- Ecological Reserve
- Crown Land
- Wildlife Management Area
- Provincial Park
- Watercourse
- Waterbody

Source:
1. Licensed Surface Water and Groundwater, 2014, Manitoba Conservation and Water Stewardship

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015

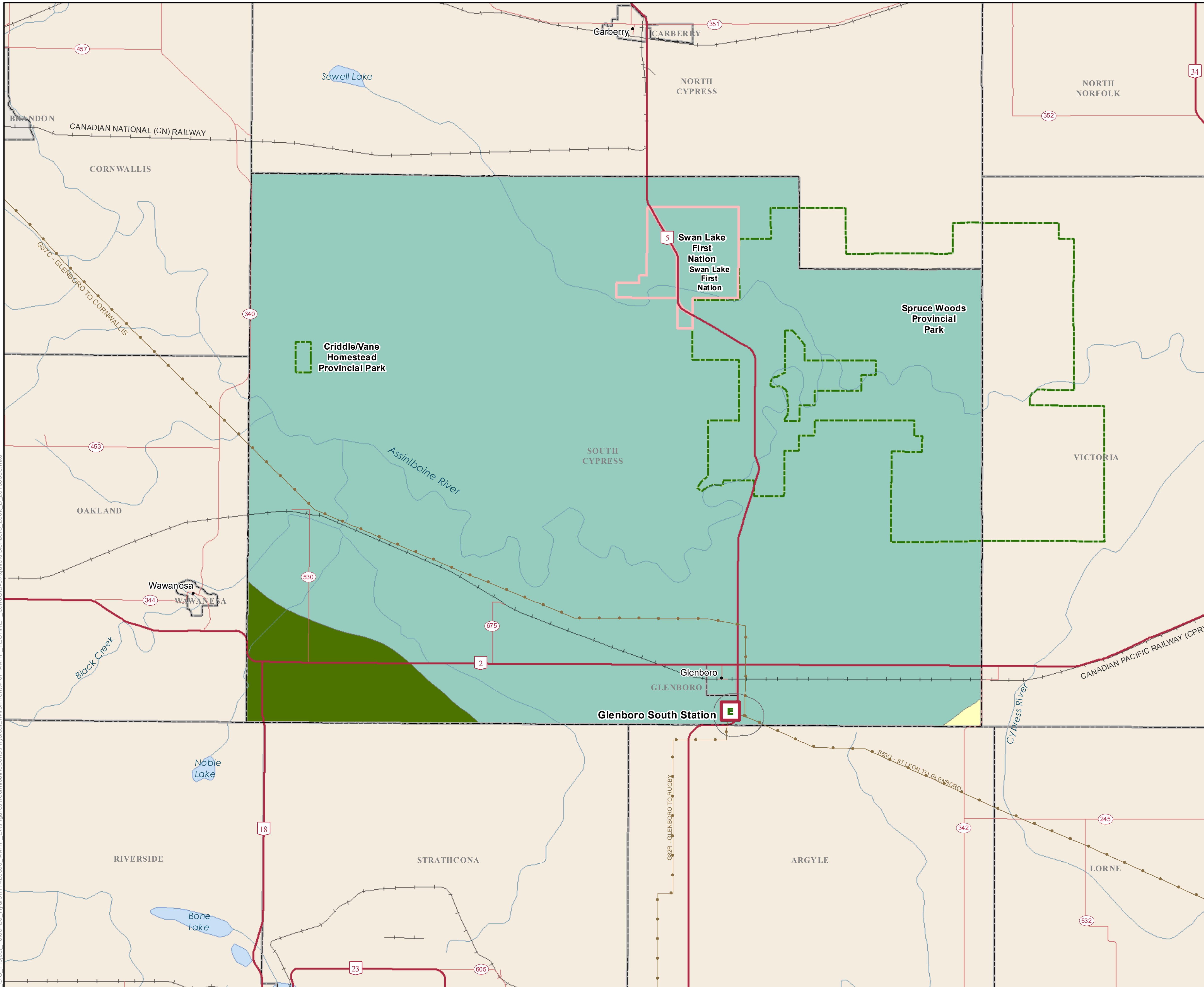
N

0 10 Kilometres
0 5 10 Miles

1:600,000

Licensed Groundwater Supply Wells

Map 4-6



Manitoba Hydro

Manitoba-Minnesota Transmission Project

Infrastructure

- Electrical Station
- Existing Transmission Line

Sand and Gravel Aquifers

- Areas With Very Few Widely Scattered Minor Sand and Gravel Aquifers
- Lenses of Sand and Gravel
- Thick and Extensive Unconfined Sand and Gravel

Assessment Area

- Land and Resource Use Local Assessment Area
- Land and Resource Use Regional Assessment Area

Landbase

- Provincial Highway
- Provincial Road
- Railway
- First Nation
- Rural Municipality
- Provincial Park
- Watercourse
- Waterbody

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015

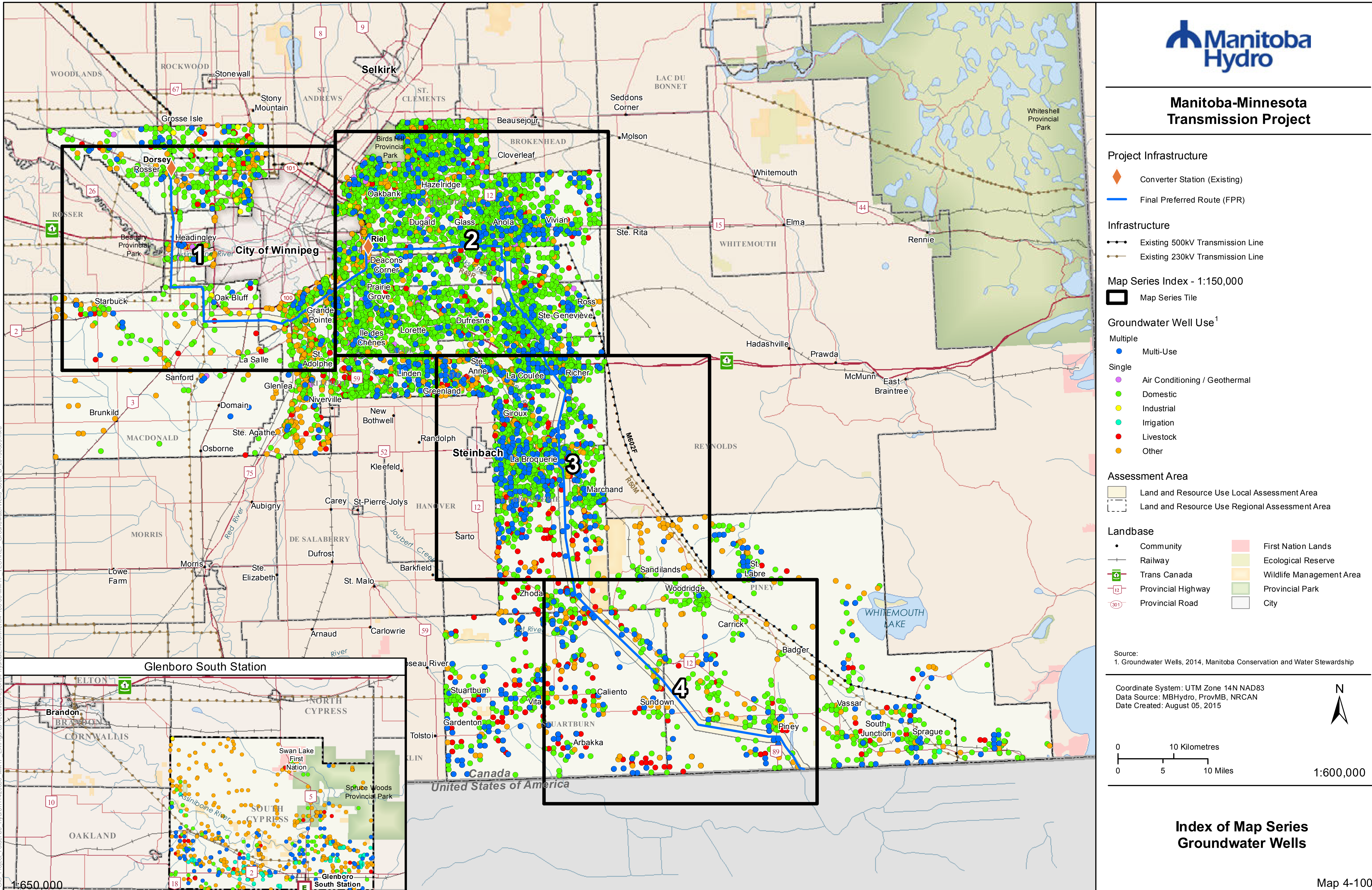
N

0 5 Kilometres
0 2.5 5 Miles

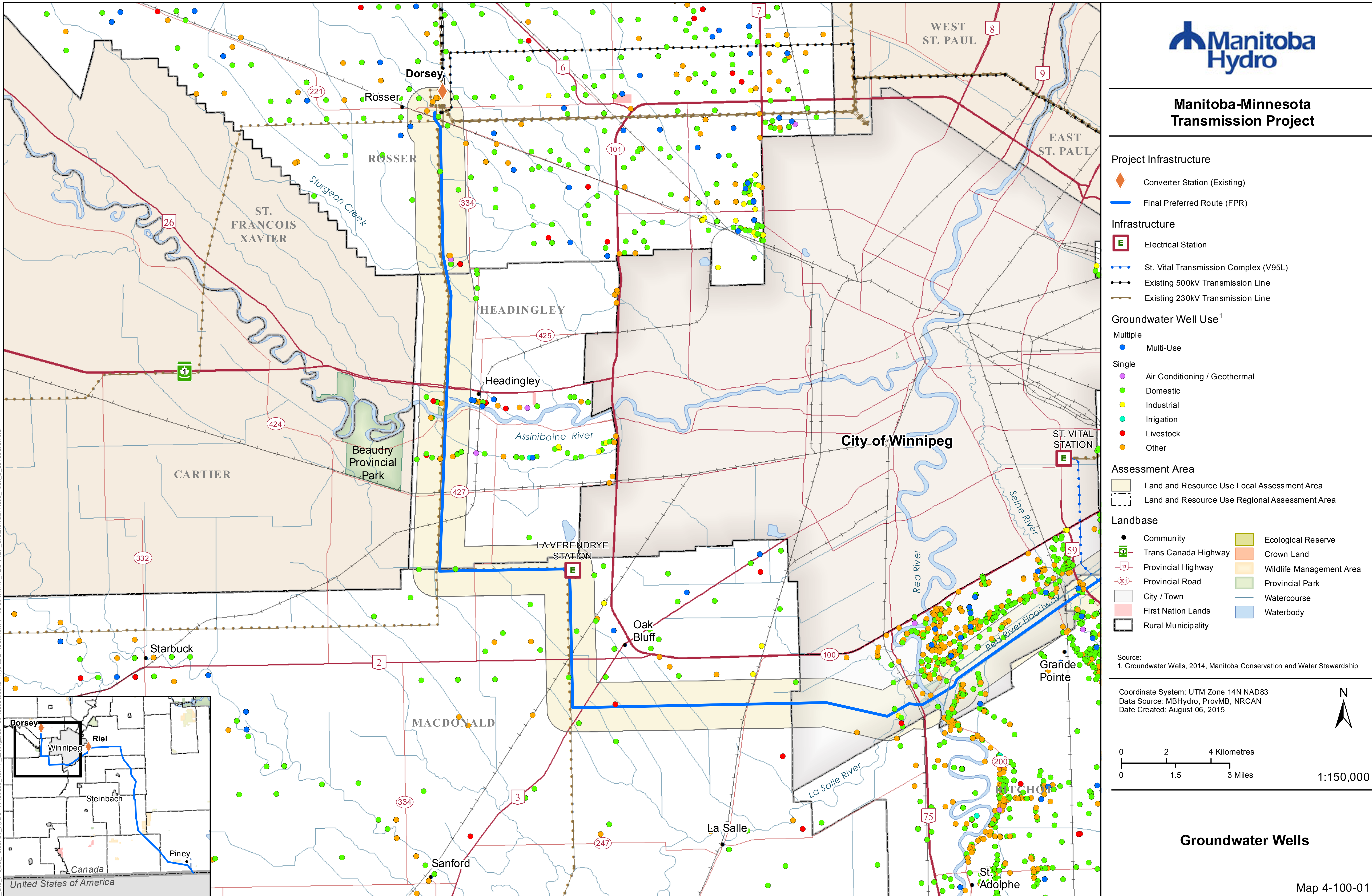
1:200,000

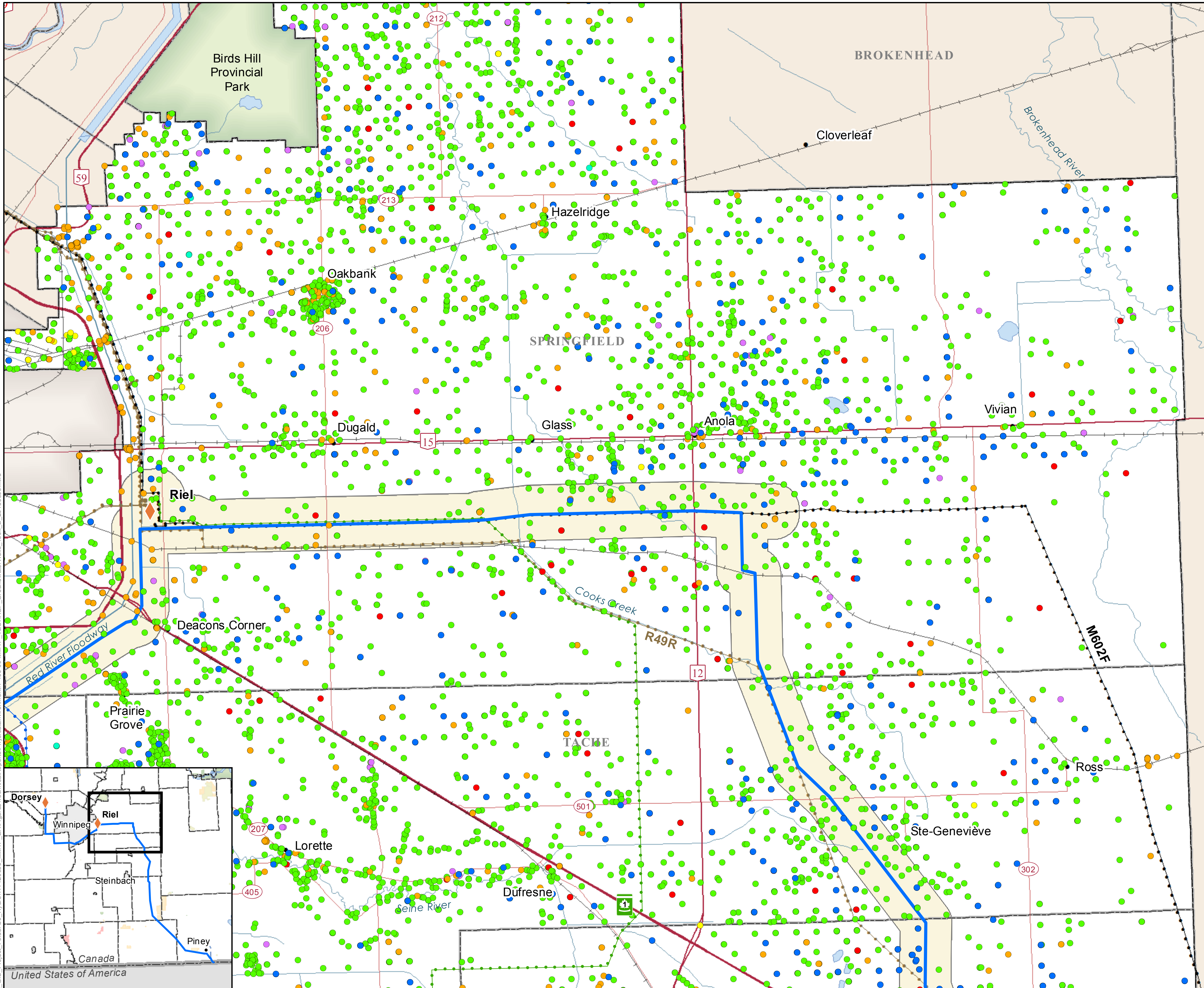
Glenboro South Station Sand and Gravel Aquifers

Map 4-7



Manitoba Hydro
Manitoba-Minnesota Transmission Project
Project Infrastructure
Converter Station (Existing)
Final Preferred Route (FPR)
Infrastructure
Existing 500kV Transmission Line
Existing 230kV Transmission Line
Map Series Index - 1:150,000
Map Series Tile
Groundwater Well Use[1]
Multiple
Multi-Use
Single
Air Conditioning / Geothermal
Domestic
Industrial
Irrigation
Livestock
Other
Assessment Area
Land and Resource Use Local Assessment Area
Land and Resource Use Regional Assessment Area
Landbase
Community
Railway
Trans Canada
Provincial Highway
Provincial Road
First Nation Lands
Ecological Reserve
Wildlife Management Area
Provincial Park
City
Source:
1. Groundwater Wells, 2014, Manitoba Conservation and Water Stewardship
Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015
N
0 10 Kilometres
0 5 10 Miles
1:600,000
Index of Map Series
Groundwater Wells
Map 4-100
Glenboro South Station
1:650,000
Glenboro South Station
City of Winnipeg
Selkirk
Steinbach
Dorsey
Riel
1
2
3
4
Canada
United States of America
WHITEMOUTH LAKE
Whiteshell Provincial Park


Manitoba Hydro
Manitoba-Minnesota Transmission Project
Project Infrastructure
Converter Station (Existing)
Final Preferred Route (FPR)
Infrastructure
Electrical Station
St. Vital Transmission Complex (V95L)
Existing 500kV Transmission Line
Existing 230kV Transmission Line
Groundwater Well Use[1]
Multiple
Multi-Use
Single
Air Conditioning / Geothermal
Domestic
Industrial
Irrigation
Livestock
Other
Assessment Area
Land and Resource Use Local Assessment Area
Land and Resource Use Regional Assessment Area
Landbase
Community
Trans Canada Highway
Provincial Highway
Provincial Road
City / Town
First Nation Lands
Rural Municipality
Ecological Reserve
Crown Land
Wildlife Management Area
Provincial Park
Watercourse
Waterbody
Source:
1. Groundwater Wells, 2014, Manitoba Conservation and Water Stewardship
Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 06, 2015
N
0 2 4 Kilometres
0 1.5 3 Miles
1:150,000
Groundwater Wells
Map 4-100-01
Dorsey
Rosser
ROSSER
WEST ST. PAUL
EAST ST. PAUL
ST. FRANCOIS XAVIER
Sturgeon Creek
HEADINGLEY
Headingley
Assiniboine River
Beaudry Provincial Park
CARTIER
City of Winnipeg
ST. VITAL STATION
Seine River
Red River
Red River Floodway
LA VERENDRYE STATION
Oak Bluff
Starbuck
MACDONALD
La Salle River
La Salle
Sanford
Grande Pointe
St. Adolphe
RITCHOT
Riel
Winnipeg
Steinbach
Piney
Canada
United States of America



Manitoba Hydro

Manitoba-Minnesota Transmission Project

Project Infrastructure

- Converter Station (Existing)
- Final Preferred Route (FPR)

Infrastructure

- Bipole III Transmission Line (Approved)
- St. Vital Transmission Complex (V95L)
- Existing 500kV Transmission Line
- Existing 230kV Transmission Line

Groundwater Well Use[1]

Multiple

- Multi-Use

Single

- Air Conditioning / Geothermal
- Domestic
- Industrial
- Irrigation
- Livestock
- Other

Assessment Area

- Land and Resource Use Local Assessment Area
- Land and Resource Use Regional Assessment Area

Landbase

- Community
- Trans Canada Highway
- Provincial Highway
- Provincial Road
- City / Town
- First Nation Lands
- Rural Municipality
- Ecological Reserve
- Crown Land
- Wildlife Management Area
- Provincial Park
- Watercourse
- Waterbody

Source:
1. Groundwater Wells, 2014, Manitoba Conservation and Water Stewardship

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 06, 2015

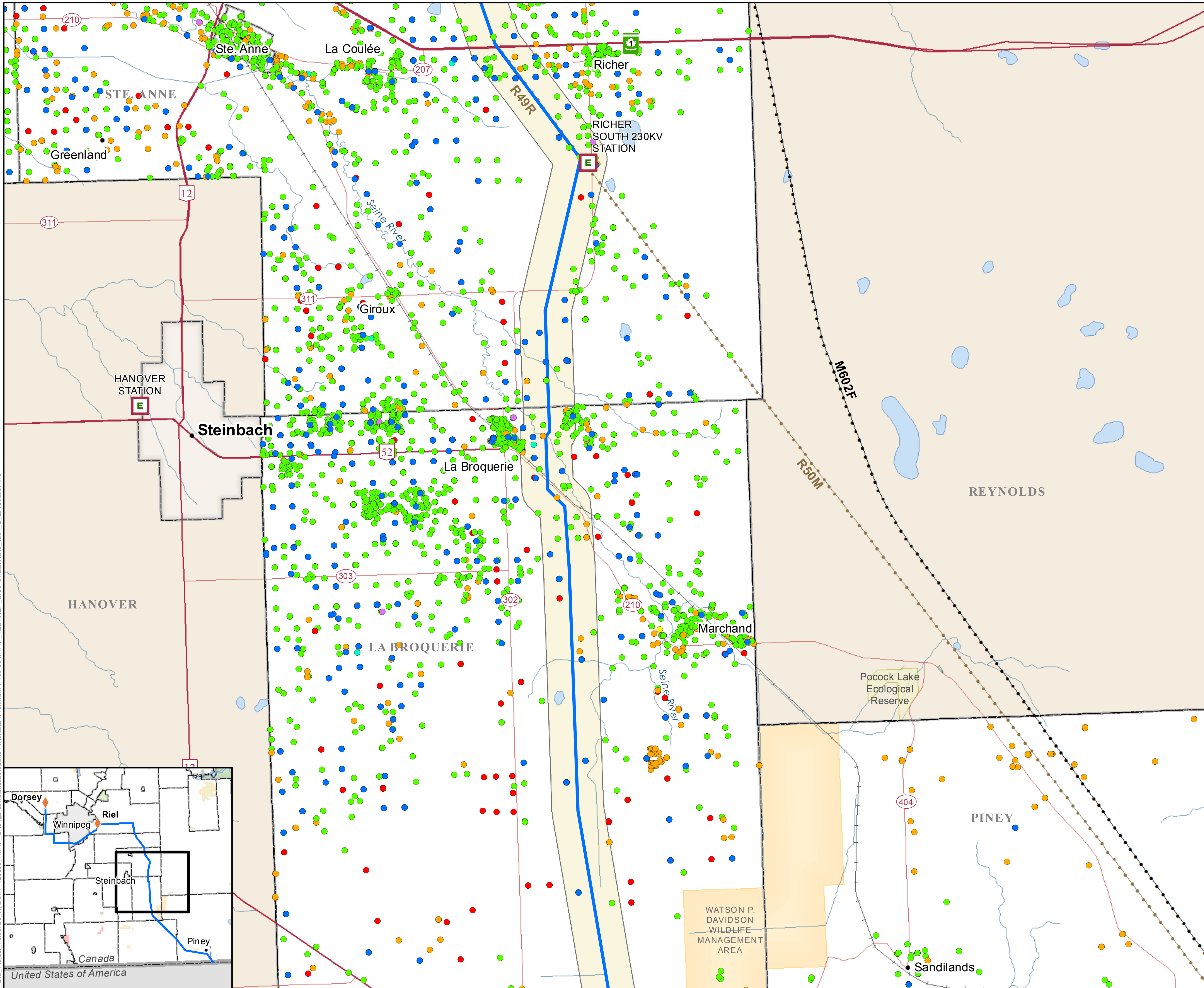
N

0 2 4 Kilometres
0 1.5 3 Miles

1:150,000

Groundwater Wells

Map 4-100-02



Manitoba Hydro

Manitoba-Minnesota Transmission Project

Project Infrastructure
- Final Preferred Route (FPR)

Infrastructure
- Electrical Station
- Existing 500kV Transmission Line
- Existing 230kV Transmission Line

Groundwater Well Use[1]
Multiple
- Multi-Use

Single
- Air Conditioning / Geothermal
- Domestic
- Industrial
- Irrigation
- Livestock
- Other

Assessment Area
- Land and Resource Use Local Assessment Area
- Land and Resource Use Regional Assessment Area

Landbase
- Community
- Trans Canada Highway
- Provincial Highway
- Provincial Road
- City / Town
- First Nation Lands
- Rural Municipality
- Ecological Reserve
- Crown Land
- Wildlife Management Area
- Provincial Park
- Watercourse
- Waterbody

Source:
1. Groundwater Wells, 2014, Manitoba Conservation and Water Stewardship

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 06, 2015

N

0 2 4 Kilometres
0 1.5 3 Miles

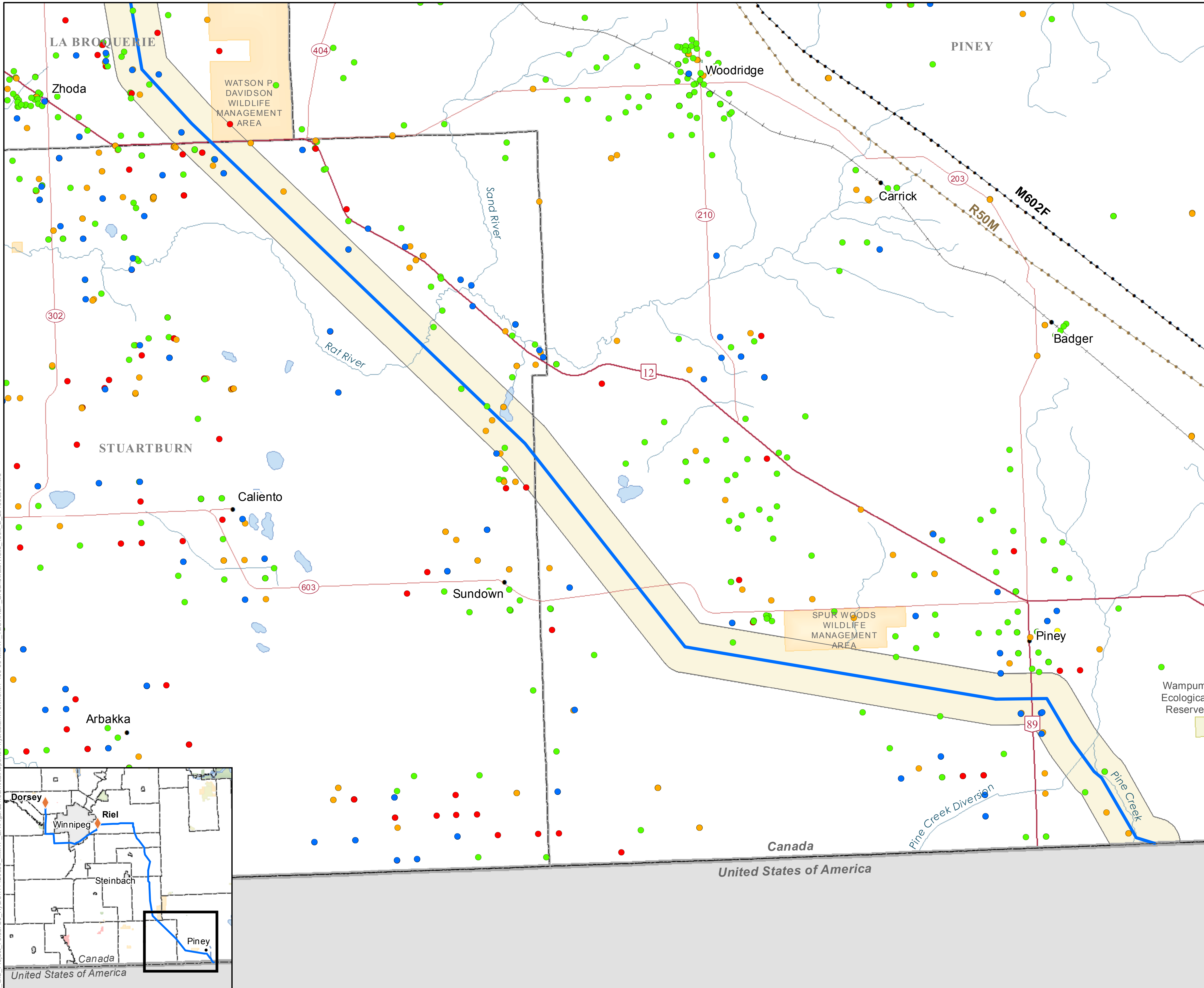
1:150,000

Groundwater Wells

Map 4-100-03

![Manitoba Hydro]

Manitoba-Minnesota Transmission Project



Project Infrastructure

- Final Preferred Route (FPR)

Infrastructure

- Existing 500kV Transmission Line
- Existing 230kV Transmission Line

Groundwater Well Use[1]

Multiple

- Multi-Use

Single

- Air Conditioning / Geothermal
- Domestic
- Industrial
- Irrigation
- Livestock
- Other

Assessment Area

- Land and Resource Use Local Assessment Area
- Land and Resource Use Regional Assessment Area

Landbase

- Community
- Trans Canada Highway
- Provincial Highway
- Provincial Road
- City / Town
- First Nation Lands
- Rural Municipality
- Ecological Reserve
- Crown Land
- Wildlife Management Area
- Provincial Park
- Watercourse
- Waterbody

Source:
1. Groundwater Wells, 2014, Manitoba Conservation and Water Stewardship

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 06, 2015

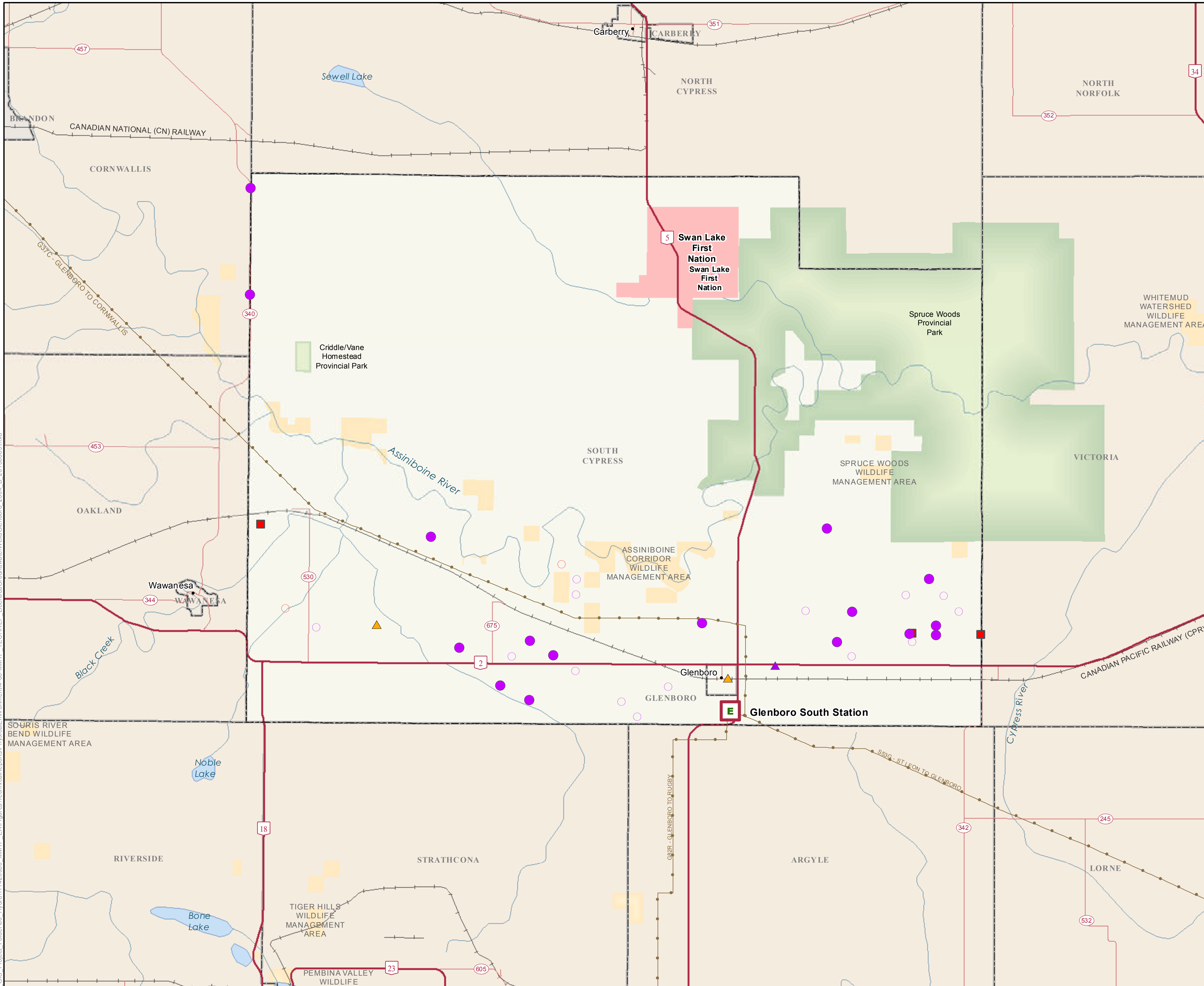
N

0 2 4 Kilometres
0 1.5 3 Miles

1:150,000

Groundwater Wells

Map 4-100-04



Manitoba Hydro

Manitoba-Minnesota Transmission Project

Project Infrastructure

- Electrical Station

Infrastructure

- Existing Transmission Line

Water Usage (Maximum Annual Volume (1000 m^3))[1]

Agricultural
- 0 - 10

Municipal
- No Data
- 10 - 100

Irrigation
- No Data
- 0 - 10
- 100 - 1000

Landbase

- Community
- Provincial Highway
- Provincial Road
- Railway
- City / Town
- First Nation
- Wildlife Management Area
- National/Provincial Park
- Rural Municipality

Source:
1. Licensed Surface Water and Groundwater, 2014, Manitoba Conservation and Water Stewardship

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 06, 2015

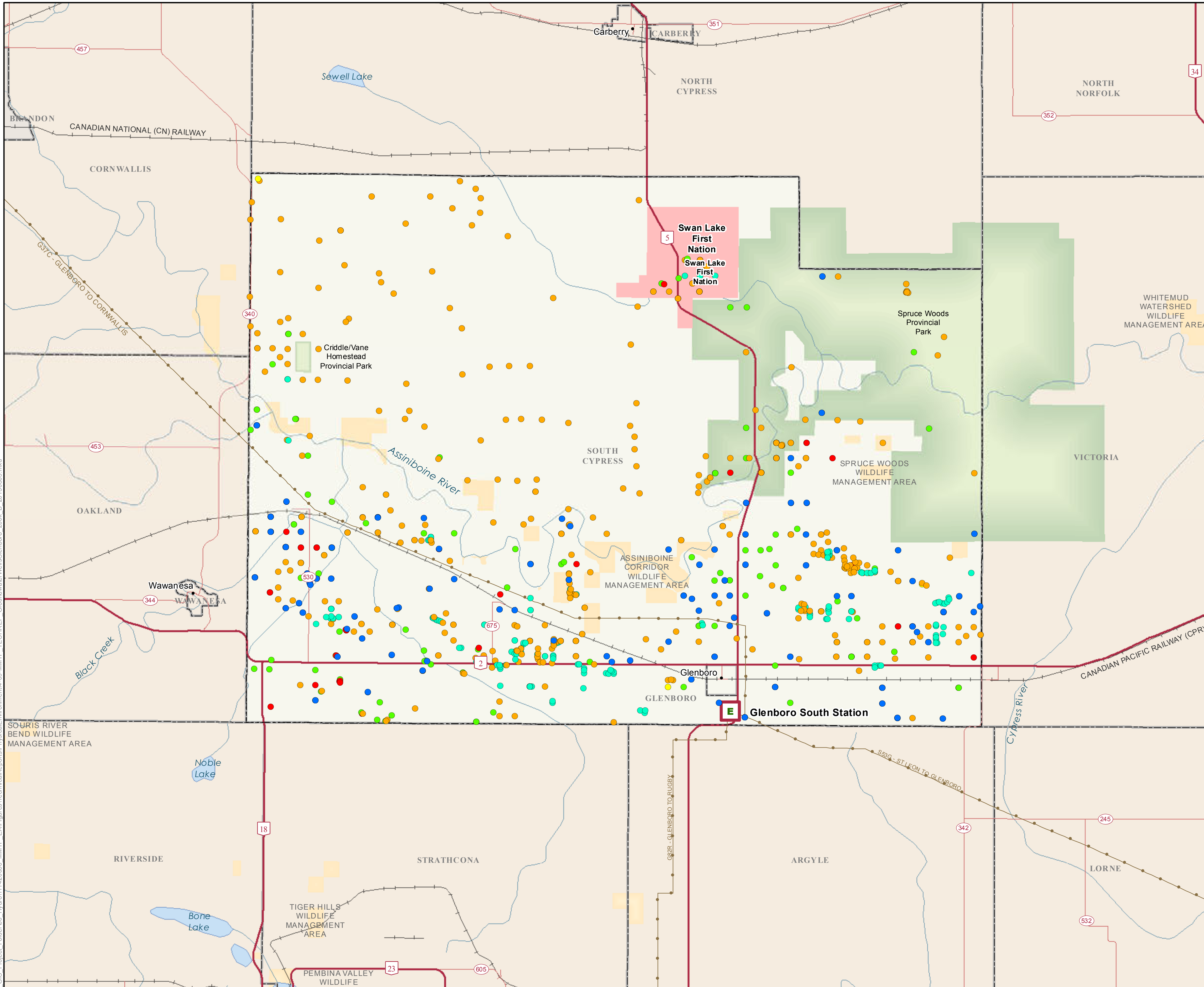
N

0 — 5 Kilometres
0 — 2.5 — 5 Miles

1:200,000

Glenboro South Station Licensed Groundwater Supply Wells and Dugouts

Map 4-8



Manitoba Hydro

Manitoba-Minnesota Transmission Project

Infrastructure

- Electrical Station
- Existing Transmission Line

Groundwater Well Use[1]

Multiple

- Multi-Use

Single

- Air Conditioning / Geothermal
- Domestic
- Industrial
- Irrigation
- Livestock
- Other

Landbase

- Community
- Provincial Highway
- Provincial Road
- Railway
- City / Town
- First Nation
- Wildlife Management Area
- National/Provincial Park
- Rural Municipality

Source:
1. Groundwater Wells, 2014, Manitoba Conservation and Water Stewardship

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 06, 2015

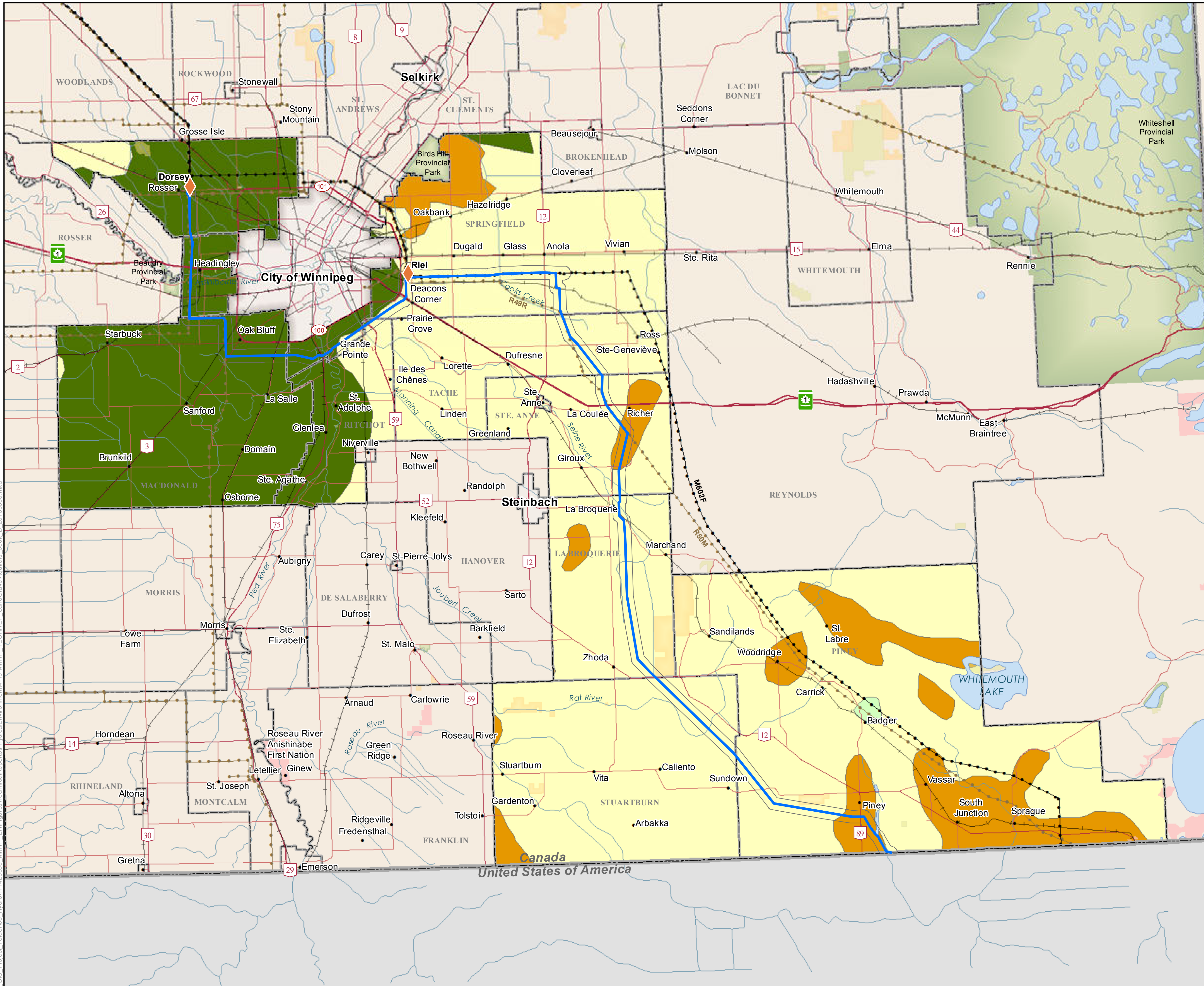
N

0 — 5 Kilometres
0 — 2.5 — 5 Miles

1:200,000

Glenboro South Station Groundwater Wells

Map 4-9



Manitoba Hydro

Manitoba-Minnesota Transmission Project

Project Infrastructure

- Converter Station (Existing)
- Final Preferred Route (FPR)

Infrastructure

- Existing 500kV Transmission Line
- Existing 230kV Transmission Line

Sand and Gravel Aquifers

- Areas With Very Few Widely Scattered Minor Sand and Gravel Aquifers
- Lenses of Sand and Gravel
- Major Buried Sand and Gravel
- Thin Unconfined Sand

Assessment Area

- Land and Resource Use Local Assessment Area
- Land and Resource Use Regional Assessment Area

Landbase

- Community
- Railway
- Trans Canada
- Provincial Highway
- Provincial Road
- City
- First Nation Lands
- Ecological Reserve
- Wildlife Management Area
- Provincial Park
- Rural Municipality

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015

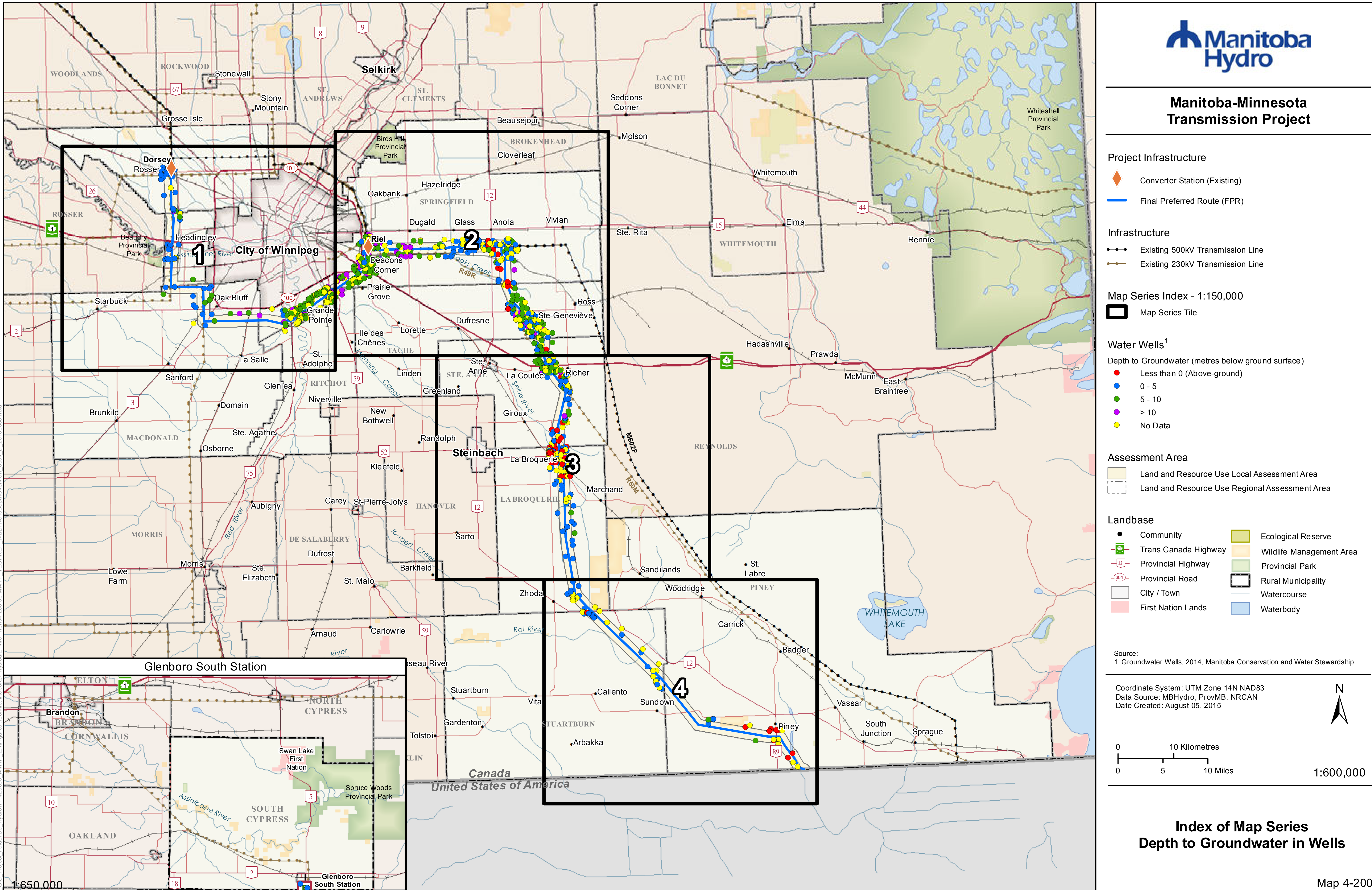
N

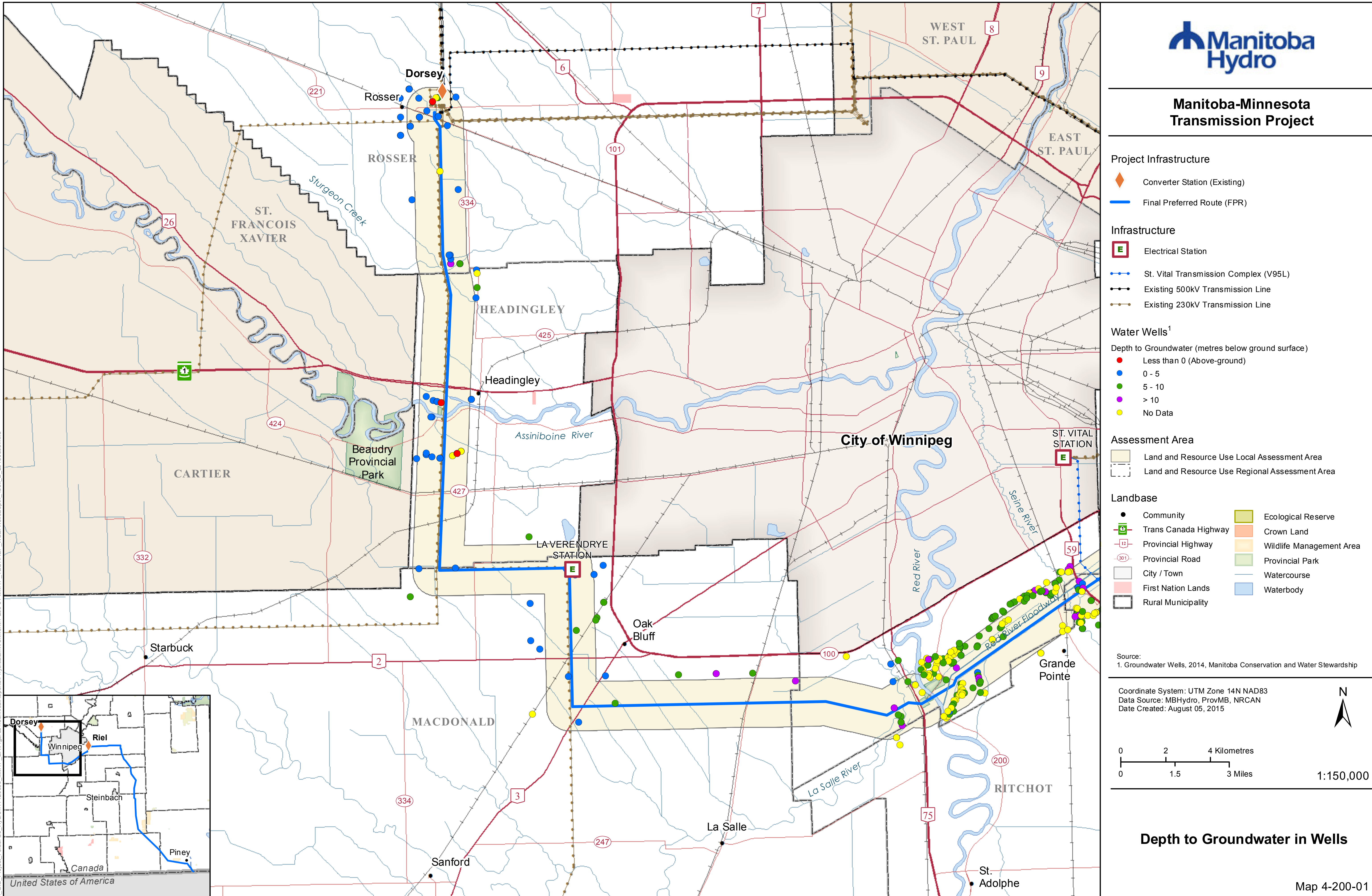
0 10 Kilometres
0 5 10 Miles

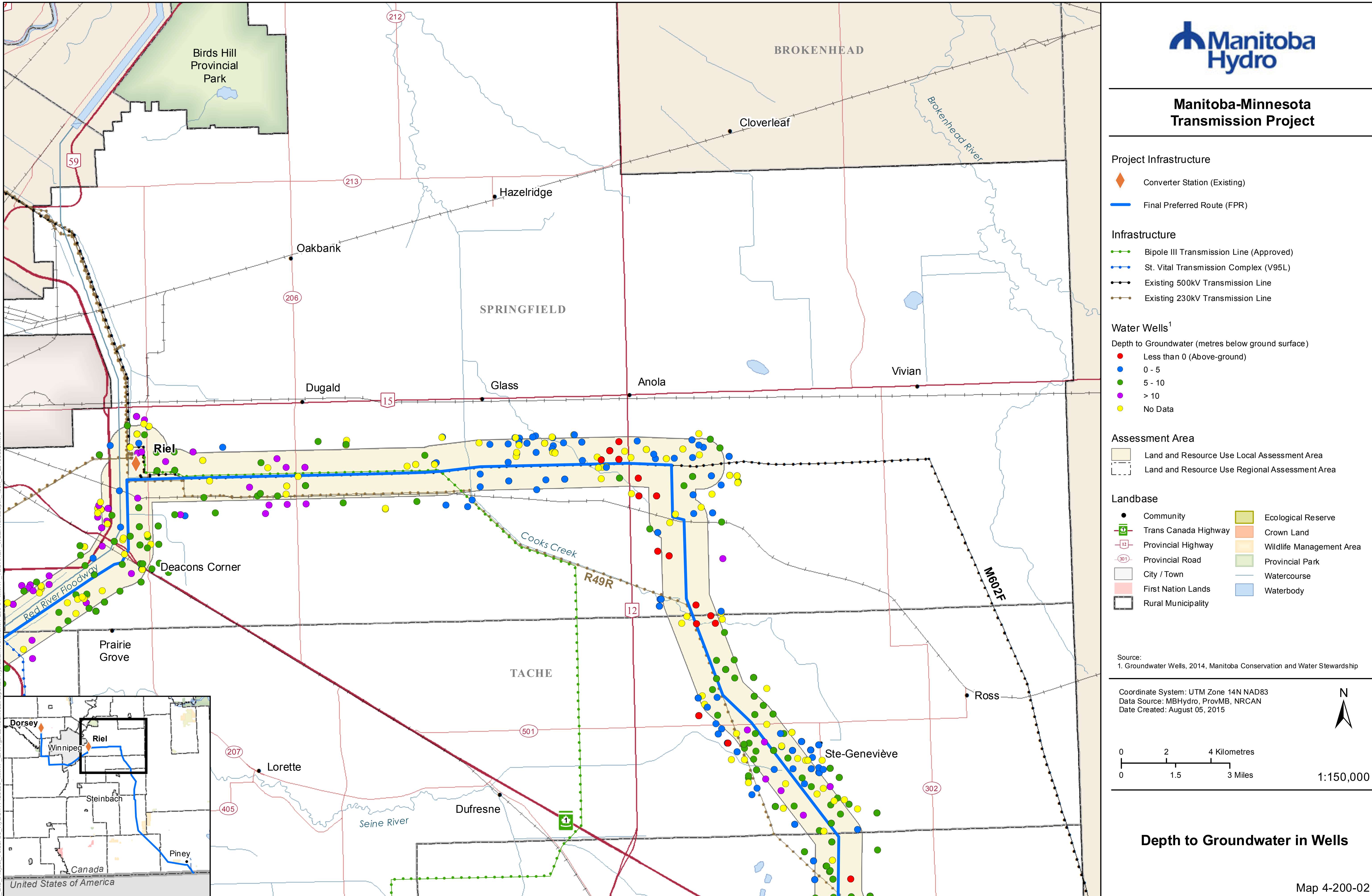
1:600,000

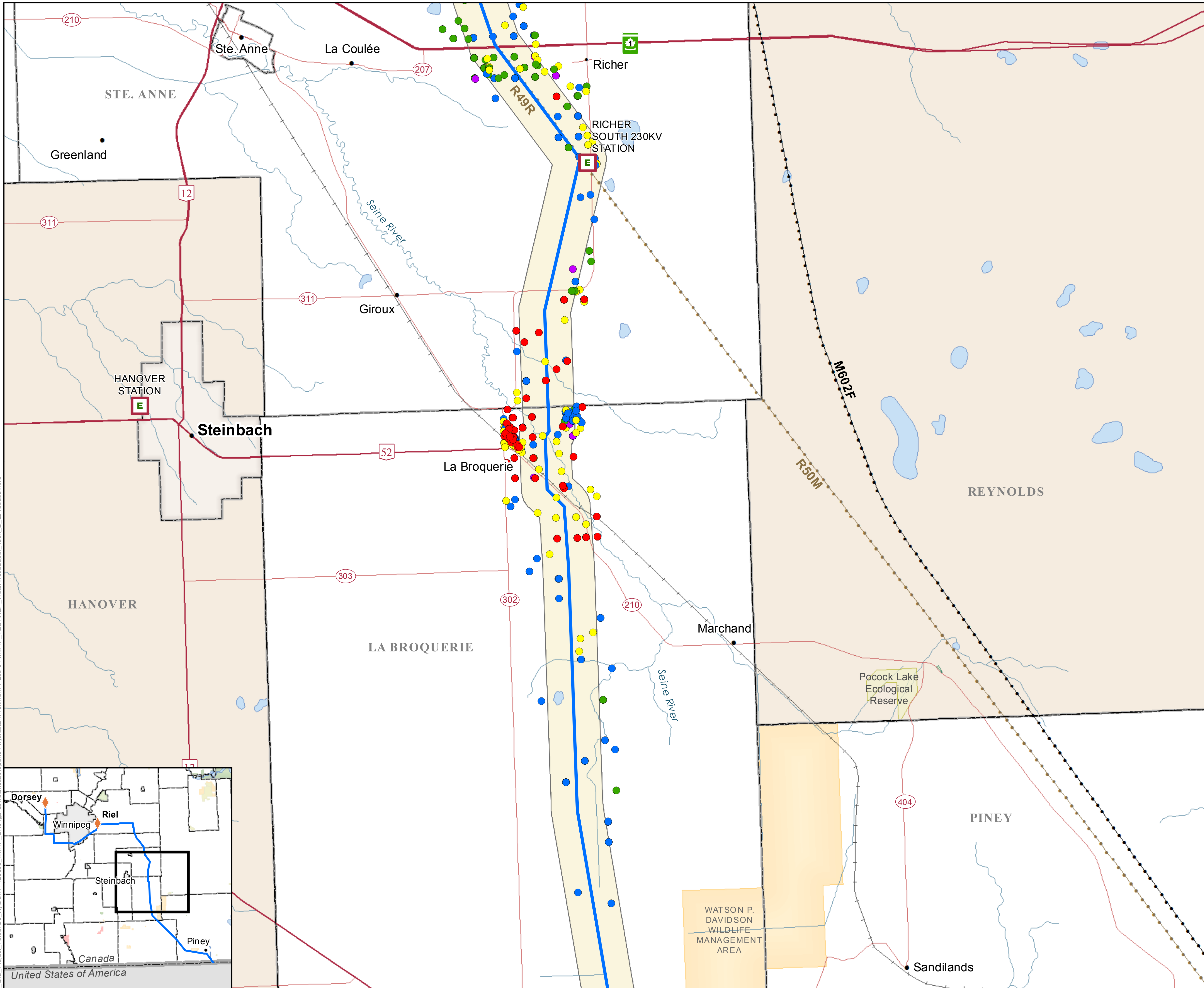
Sand and Gravel Aquifers

Map 4-10


Manitoba Hydro
Manitoba-Minnesota Transmission Project
Project Infrastructure
Converter Station (Existing)
Final Preferred Route (FPR)
Infrastructure
Existing 500kV Transmission Line
Existing 230kV Transmission Line
Map Series Index - 1:150,000
Map Series Tile
Water Wells[1]
Depth to Groundwater (metres below ground surface)
Less than 0 (Above-ground)
0 - 5
5 - 10
> 10
No Data
Assessment Area
Land and Resource Use Local Assessment Area
Land and Resource Use Regional Assessment Area
Landbase
Community
Trans Canada Highway
Provincial Highway
Provincial Road
City / Town
First Nation Lands
Ecological Reserve
Wildlife Management Area
Provincial Park
Rural Municipality
Watercourse
Waterbody
Source:
1. Groundwater Wells, 2014, Manitoba Conservation and Water Stewardship
Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015
N
0 10 Kilometres
0 5 10 Miles
1:600,000
Index of Map Series
Depth to Groundwater in Wells
Map 4-200
Glenboro South Station
1:650,000
Brandon
Glenboro South Station
Swan Lake First Nation
Spruce Woods Provincial Park
Assiniboine River
ELTON
NORTH CYPRESS
SOUTH CYPRESS
CORNWALLIS
OAKLAND
RIVERSIDE
1
2
3
4
Dorsey
Rosser
Riel
City of Winnipeg
Selkirk
Steinbach
Headingley
Oak Bluff
Starbuck
La Salle
Grande Pointe
Deacons Corner
Prairie Grove
Ste-Geneviève
Richer
La Broquerie
Marchand
Sandilands
Woodridge
Carrick
Badger
Sundown
Caliento
Piney
Vassar
South Junction
Sprague
Canada
United States of America
WHITEMOUTH LAKE
Whiteshell Provincial Park
Whitemouth
Elma
Rennie
Ste. Rita
Hadashville
Prawda
McMunn
East Braintree
Seddons Corner
Molson
Beausejour
Stonewall
Stony Mountain
Grosse Isle
Birds Hill Provincial Park
Cloverleaf
Oakbank
Hazelridge
Dugald
Glass
Anola
Vivian
Ross
Dufresne
Lorette
Ile des Chênes
Ste. Anne
La Coulée
Giroux
Greenland
Linden
Glenlea
Niverville
New Bothwell
Randolph
Kleefeld
St. Adolphe
Sanford
Domain
Brunkild
Ste. Agathe
Osborne
Aubigny
Carey
St-Pierre-Jolys
Sarto
Dufrost
Barkfield
St. Malo
Morris
Ste. Elizabeth
Lowe Farm
Arnaud
Carlowrie
Zhoda
Stuartburn
Gardenton
Vita
Tolstoi
Arbakka
St. Labre
Beaudry Provincial Park
WOODLANDS
ROCKWOOD
ST. ANDREWS
ST. CLEMENTS
LAC DU BONNET
BROKENHEAD
SPRINGFIELD
WHITEMOUTH
TACHE
RITCHOT
STE. ANNE
REYNOLDS
MACDONALD
HANOVER
LA BROQUERIE
MORRIS
DE SALABERRY
STUARTBURN
PINEY
ROSSER
Red River
Seine River
Cooks Creek
Joubert Creek
Rat River
Assiniboine River
R49R
M602F
R50M


Manitoba Hydro
Manitoba-Minnesota Transmission Project
Project Infrastructure
Converter Station (Existing)
Final Preferred Route (FPR)
Infrastructure
Electrical Station
St. Vital Transmission Complex (V95L)
Existing 500kV Transmission Line
Existing 230kV Transmission Line
Water Wells1
Depth to Groundwater (metres below ground surface)
Less than 0 (Above-ground)
0 - 5
5 - 10
> 10
No Data
Assessment Area
Land and Resource Use Local Assessment Area
Land and Resource Use Regional Assessment Area
Landbase
Community
Trans Canada Highway
Provincial Highway
Provincial Road
City / Town
First Nation Lands
Rural Municipality
Ecological Reserve
Crown Land
Wildlife Management Area
Provincial Park
Watercourse
Waterbody
Source:
1. Groundwater Wells, 2014, Manitoba Conservation and Water Stewardship
Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015
0 2 4 Kilometres
0 1.5 3 Miles
1:150,000
Depth to Groundwater in Wells
Map 4-200-01
Dorsey
Rosser
ROSSER
ST. FRANCOIS XAVIER
Sturgeon Creek
HEADINGLEY
Headingley
Assiniboine River
Beaudry Provincial Park
CARTIER
LA VERENDRYE STATION
Oak Bluff
Starbuck
MACDONALD
City of Winnipeg
ST. VITAL STATION
Seine River
Red River
Red River Floodway
Grande Pointe
La Salle River
La Salle
RITCHOT
St. Adolphe
Sanford
WEST ST. PAUL
EAST ST. PAUL
Riel
Winnipeg
Steinbach
Piney
Canada
United States of America


Manitoba Hydro
Manitoba-Minnesota Transmission Project
Project Infrastructure
Converter Station (Existing)
Final Preferred Route (FPR)
Infrastructure
Bipole III Transmission Line (Approved)
St. Vital Transmission Complex (V95L)
Existing 500kV Transmission Line
Existing 230kV Transmission Line
Water Wells[1]
Depth to Groundwater (metres below ground surface)
Less than 0 (Above-ground)
0 - 5
5 - 10
> 10
No Data
Assessment Area
Land and Resource Use Local Assessment Area
Land and Resource Use Regional Assessment Area
Landbase
Community
Trans Canada Highway
Provincial Highway
Provincial Road
City / Town
First Nation Lands
Rural Municipality
Ecological Reserve
Crown Land
Wildlife Management Area
Provincial Park
Watercourse
Waterbody
Source:
1. Groundwater Wells, 2014, Manitoba Conservation and Water Stewardship
Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015
N
0 2 4 Kilometres
0 1.5 3 Miles
1:150,000
Depth to Groundwater in Wells
Map 4-200-02
Birds Hill Provincial Park
BROKENHEAD
Cloverleaf
Brokenhead River
Hazelridge
Oakbank
SPRINGFIELD
Dugald
Glass
Anola
Vivian
Riel
Deacons Corner
Red River Floodway
Cooks Creek
R49R
M602F
Prairie Grove
TACHE
Ross
Ste-Geneviève
Lorette
Dufresne
Seine River
212
213
206
59
15
12
501
207
405
302
1
Dorsey
Winnipeg
Riel
Steinbach
Piney
Canada
United States of America



Manitoba Hydro

Manitoba-Minnesota Transmission Project

Project Infrastructure

- Final Preferred Route (FPR)

Infrastructure

- Electrical Station
- Existing 500kV Transmission Line
- Existing 230kV Transmission Line

Water Wells[1]

Depth to Groundwater (metres below ground surface)

- Less than 0 (Above-ground)
- 0 - 5
- 5 - 10
- > 10
- No Data

Assessment Area

- Land and Resource Use Local Assessment Area
- Land and Resource Use Regional Assessment Area

Landbase

- Community
- Trans Canada Highway
- Provincial Highway
- Provincial Road
- City / Town
- First Nation Lands
- Rural Municipality
- Ecological Reserve
- Crown Land
- Wildlife Management Area
- Provincial Park
- Watercourse
- Waterbody

Source:
1. Groundwater Wells, 2014, Manitoba Conservation and Water Stewardship

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015

N

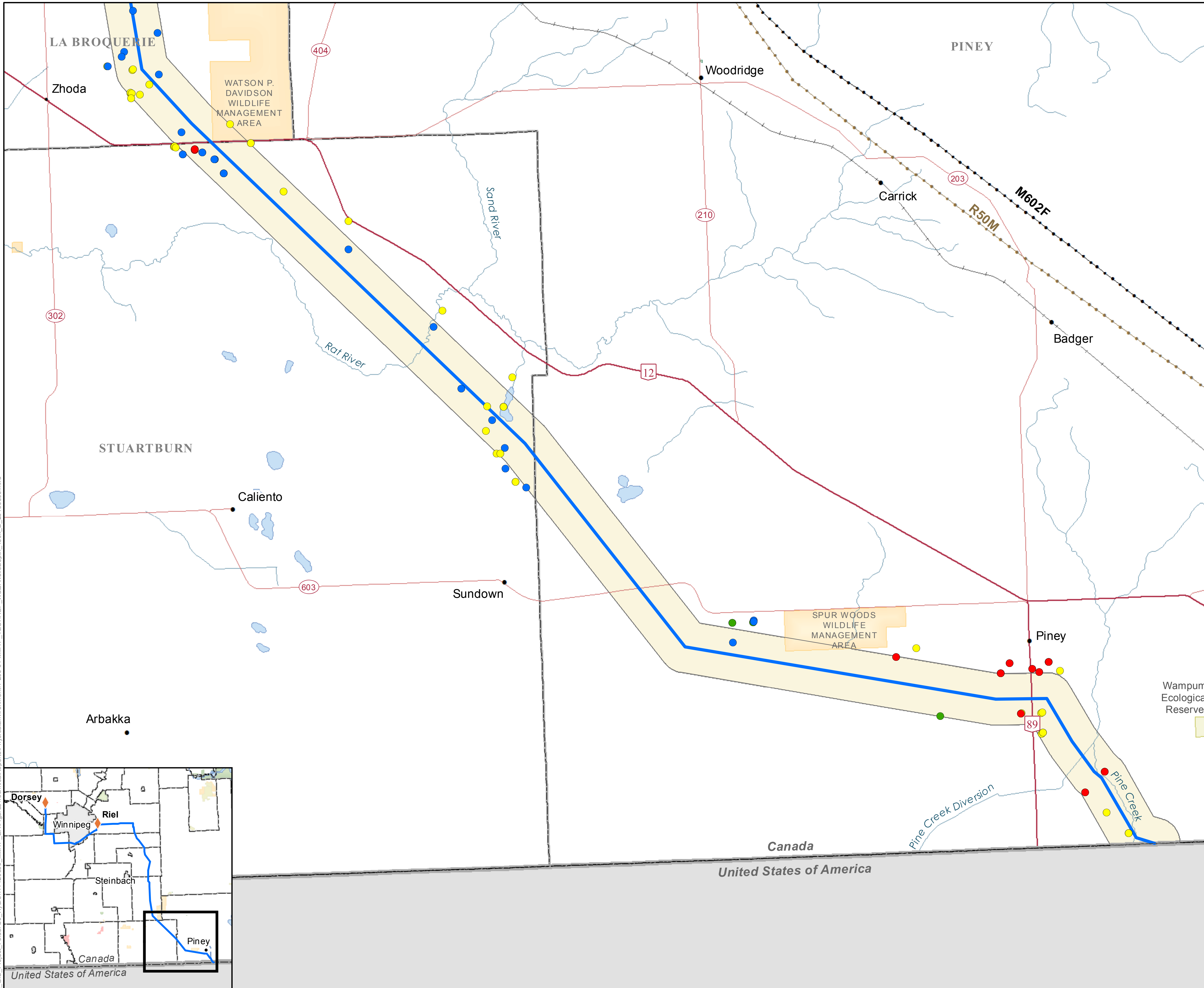
0 2 4 Kilometres
0 1.5 3 Miles

1:150,000

Depth to Groundwater in Wells

Map 4-200-03

G:_GIS_Project_Folder\00_Hydro\11420050_MMTP_EA\Figures\TechnicalReports\PhysicalEnvironment\4-200-01-MMTP_TECHREP_WaterWellsDepth_150k_B_20150805.mxd



Manitoba Hydro

Manitoba-Minnesota Transmission Project

Project Infrastructure

- Final Preferred Route (FPR)

Infrastructure

- Existing 500kV Transmission Line
- Existing 230kV Transmission Line

Water Wells[1]

Depth to Groundwater (metres below ground surface)

- Less than 0 (Above-ground)
- 0 - 5
- 5 - 10
- > 10
- No Data

Assessment Area

- Land and Resource Use Local Assessment Area
- Land and Resource Use Regional Assessment Area

Landbase

- Community
- Trans Canada Highway
- Provincial Highway
- Provincial Road
- City / Town
- First Nation Lands
- Rural Municipality
- Ecological Reserve
- Crown Land
- Wildlife Management Area
- Provincial Park
- Watercourse
- Waterbody

Source:
1. Groundwater Wells, 2014, Manitoba Conservation and Water Stewardship

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, ProvMB, NRCAN
Date Created: August 05, 2015

N

0 2 4 Kilometres
0 1.5 3 Miles

1:150,000

Depth to Groundwater in Wells

Map 4-200-04

G:_GIS_Project_Folder\00_Hydro\11420050_MMTP_EA\Figures\TechnicalReports\PhysicalEnvironment\4-200-01-MMTP_TECHREP_WaterWellsDepth_150k_B_20150805.mxd