MUNICIPALITE
RITCHOT
MUNICIPALITY

Municipalité de/Municipality of Ritchot
352 rue Main/Main Street, St. Adolphe, MB, R5A 1B9
T: (204) 883-2293 F: (204) 883-2674 www.ritchot.com

Ms. Agnes Wittmann
Director
Environmental Approvals Branch]
Environment and Climate
14 Fultz Boulevard
Winnipeg MB R3Y 0L6

Dear Ms. Wittmann,

**Subject: Hydrogeological Investigations for the Municipality of Ritchot Proposed Municipal Groundwater Supply Alterations – Randolph Road Well Field SE 8-7-5 EPM – Randolph Road, Municipality of Hanover, Manitoba**

Please see the attached report detailing the proposed municipal groundwater supply alteration for the existing Randolph Road Well Field, located on SE 8-7-5 EPM, with the Municipality of Hanover. The Municipality of Ritchot retained Friesen Drillers Limited to develop and prepare this document.

Out Contact person for this project will be:
Mike Dumaine – Municipality of Ritchot Public Works Manager – 204.223.4174 (mdumaine@ritchot.com).
The technical contact for this project will be our consulting hydrogeological Engineer:
Ms. Paulynn Estrella-Legal, P.Eng. – Friesen Drillers Limited – 204.326.2485 ext. 105

The Municipality of Ritchot has reviewed and accepted the attached report. This project will provide the necessary increased municipal water supply to support the current and future growth of the Municipality of Ritchot.

We look forward to working with the Environmental Approvals Branch through our proposed alteration request application. If you have any further questions, please fell free to contact the undersigned at any time.

Sincerely,

[redacted]

Mitch Duval
Chief Administrative Officer – Municipality of Ritchot

# Notice of Alteration Form

Manitoba

| | |
|---|---|
| File No. : | Environment Act Licence No. : 2415 R |
| Legal name of the Licencee: Municipality of Ritchot | |
| Name of the development: Randolph Road Well Field | |
| Category and Type of development per Classes of Development Regulation: Water Development and Control | Withdrawal of water 200 dam³ - 10,000 dam³ per |
| Licencee Contact Person: Mitch Duval<br>Mailing address of the Licencee: 352 Main Street<br>City: St. Adolphe Province: Manitoba Postal Code: R5A 1B9<br>Phone Number: (204) 883-2293 Fax: Email: cao@ritchot.com | |
| Name of proponent contact person for purposes of the environmental assessment (e.g. consultant): Paulynn Estrella-Legal | |
| Phone: (204) 326-2485<br>Fax: | Mailing address: 307 PTH 12 N, Steinbach, Manitoba |
| Email address: paulynn@friesendrillers.com | |
| Short Description of Alteration *(max 90 characters)*: Pump installation/mechanization and request 788 dam3/yr allocation on (Licence 2014-014) | |
| Alteration fee attached: Yes: ☐ No: ☑<br>If No, please explain: Cheque to be mailed by MWSB | |
| Date: 2023-09-29 | Signature: [redacted]<br>Printed name: Mitch Duval |

A complete Notice of Alteration **(NoA)** consists of the following components:

- ☑ **Cover letter**
- ☑ **Notice of Alteration Form**
- ☑ **1 hard copy and 1 electronic copy of the NoA detailed report** (see "Information Bulletin - Alteration to Developments with Environment Act Licences")
- ☑ **$500 Application fee, if applicable** (Cheque, payable to the Minister of Finance)

**Submit the complete NoA to:**
Director, Environmental Approvals Branch
Manitoba Environment and Climate
14 Fultz Blvd
Winnipeg, Manitoba R3Y 0L6
EABDirector@gov.mb.ca

**For more information:**
Phone: (204) 945-8321 Fax: (204) 945-5229
https://www.gov.mb.ca/sd/permits_licenses_approvals/eal/licence/index.html

**Note: Per Section 14(3) of the Environment Act, Major Notices of Alteration must be filed through submission of an** Environment Act Proposal Form (see "Information Bulletin – Environment Act Proposal Report Guidelines")

Friesen DRILLERS

# Proposed Municipal Groundwater Supply Alteration
# Randolph Road Well Field - Municipality of Ritchot

# Environment Act Licence
# Notice of Alteration

October 2023

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Report to:

THE MANITOBA WATER SERVICES BOARD

**The Manitoba Water Services Board**

and

MUNICIPALITÉ RITCHOT MUNICIPALITY

**Municipality of Ritchot**

# Proposed Municipal Groundwater Supply Alteration
# Randolph Road Well Field - Municipality of Ritchot

## Environment Act Licence
## Notice of Alteration

[redacted]

**October 13, 2023**

Prepared by: [redacted] Date: October 13, 2023
Paulynn Estrella-Legal, B.Sc.(Mn.E.), P.Eng.

Reviewed by: [redacted] Date: Oct. 13/2023.
Jeff J. Bell, B.Sc.(G.E.), P.Eng

Approved by [redacted] Date: October 13, 2023
Jason D. Friesen

307 PTH 12 N Steinbach, MB. R5G 1T8 Phone 204-326-2485 Fax 204-326-2483 Toll Free-1-888-794-9355

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**Attachments -** Hydrogeological Investigations for the Municipality of Ritchot – Proposed Municipal Groundwater Supply Alteration – Randolph Road Well Field

# 1. INTRODUCTION

Friesen Drillers Limited (FDL) is pleased to submit this notice of alteration (NoA) report to detail the proposed groundwater supply alteration for the Municipality of Ritchot. The Municipality of Ritchot water supply system is licenced under Environment Act Licence No. 2415R. This NoA report focuses on the hydrogeological aspects of mechanizing the existing Randolph Road Well Field, located on SE 8 - 7 - 5 EPM to support the current and future growth of the municipality.

The Municipality of Ritchot, with a recorded population of 7,469 individuals in 2021 (Statistics Canada) has two existing groundwater supply well fields. One well field (Randolph Road Well Field), located along Randolph Road, on SE 8-7-5 EPM, is comprised of several relief wells installed in the carbonate aquifer. The relief wells were used to prevent hydraulic rupture on the base of a major drainage canal passing through the area. The discharge from the relief wells was originally piped and discharged to the Red River. The Municipality of Ritchot expressed interest in utilizing the discharge for municipal water supplies and was granted a water rights licence to obtain groundwater freely discharging from the well field in 1993. Due to the unique circumstances of the well field's establishment, the current water rights licence for the site restricts the Municipality of Ritchot from installing pumps in the wells to increase groundwater flows.

The PR 305 Well Field was installed in 2004/2005 to supplement the inconsistent and gradually decreasing yield from the Randolph Road Well Field. In 2018/2019, at the request of the Municipality of Ritchot and the Manitoba Water Services Board, Friesen Drillers completed a hydrogeological study to increase the allocation of the PR 305 Well Field (Friesen Drillers, 2019). It was evident in the investigation that the increased allocation from the PR 205 Well Field is only able to provide a portion of the total estimated groundwater demand to fully support the current and future growth of the Municipality and that additional groundwater supply sources would be needed. No alterations are expected on the PR 305 Well Field for this application.

Friesen Drillers was retained by the Municipality of Ritchot and the MWSB to evaluate the feasibility of mechanizing the Randolph Road Well Field in October of 2020. At the time, the estimated groundwater supply that would be required for the site was 396.26 U.S.G.P.M (25 L/s).

More recent peak water demand estimation from the MWSB and WSP (2023), using the 2021 census data for the Municipality of Ritchot (Statistic Canada, 2021) indicated that during peak water demand, the Municipality of Ritchot would require up to 1,189 U.S.G.P.M. (75 L/s) of combined flow. Since the PR 305 Well Field is currently licensed to provide up to 555 U.S.G.PM. (35 L/s), the Municipality would require a water supply source able to provide up to 634 U.S.G.P.M. (40 L/s), during times of peak water demand.

The Randolph Road Well Field investigation included a public engagement and consultation program undertaken by Landmark Planning in addition to the hydrogeological investigations completed by Friesen Drillers. The hydrogeological investigations included preliminary well assessments and redevelopment of the existing 8-inch diameter, PVC cased wells on the Randolph Road Well Field, a 72 hour-constant rate pumping test, followed by a 4-hour specific capacity test, with monitoring, groundwater sampling, hydrogeological analysis, and reporting.

After the preliminary testing, only Well No. 1 and Well No. 2 were found to have sufficient well yield to be used as municipal supply wells. Thus, further testing were only completed on the two higher

yielding wells. During the 72-hour test, approximately 20 feet of drawdown was recorded at the pumping well, pumping at 390 U.S.G.P.M. Less than 20 feet of drawdown was recorded at the pumping well during the specific capacity test, pumping at 396 U.S.G.P.M. Additional details of the testing are discussed on pages 57 to 79 of the attached hydrogeological report

Under normal seasonal and climatic groundwater level fluctuations, the Randolph Road Well Field should be able to supply and average of 396 U.S.G.P.M (25 L/s) and up to 634 U.S.G.P.M. (40 L/s) of groundwater during peak water demand. Assuming an average flow rate of 396 U.S.G.P.M., this translates to an annual allocation of 639.16 acre feet/year (~788.39 $dam^3$/year). During normal operation, the well field is expected to generate moderate amounts of additional drawdown (4 – 12 ft.) within 1 mile of the site. It is acknowledged that the well field would need to operate both Well No.1 and Well No. 2 during peak water demand, leaving no back-up water supply at the site.

Since the attached hydrogeological report is written with the modification of the Environment Act licence for the R.M. of Ritchot in consideration, this report will provide additional details regarding the NoA and highlight the areas in the existing report where required information may be located.

## 2. PROJECT OVERVIEW

The project background and description of the Randolph Road Well Field are discussed in detail in the hydrogeological technical assessment, pages 8 to 13.

The current population trends are discussed in the attached hydrogeological report, on pages 18 to 20, and in the water supply requirements section on page 20.

The Randolph Road Well Field is located on SE 8-7-5 EPM. The existing wells are within the provincial road allowance right of way. The mineral rights for the site are held by the Crown.

The funding of this project is jointly provided by the R.M. of Ritchot and the Province of Manitoba through the MWSB.

The current water rights licence, permit applications, and the requirements for an environment act licence are discussed on pages 14 to 16 of the attached document. A copy of the current water rights and Environment Act licences for the existing groundwater supply systems for the Municipality of Ritchot are attached as Appendix B of the hydrogeological report attached to this document.

The Landmark Planning and Design Inc. has undertaken a public consultation process as part of the Randolph Road Well Field project. Details of the public consultation aspects are attached as appendix A of the attached report.

# 3. Description of the Existing Environment in the Project Area

A comprehensive description of the existing environment is contained in the attached hydrogeological report pages 21 to 24.

The prevailing climate, meteorological conditions and analysis of the nearest hydrograph stations are detailed in the attached report, on page 21 and pages 28 to 45.

The nearest man-made surface water body is the south lateral drain extension of the Manning Canal, approximately 0.18 miles (0.29 km) to the east of the site and another tributary of the Manning Canal approximately 0.85 miles (1.37 km) to the west of the site. Tourond Creek is a natural surface water body located approximately 2.40 miles (3.86 km) southwest of the site.

There is over 90 feet of overburden material, comprised of clay, sand and gravel and glacial till, overlying the carbonate bedrock at the site that provides confinement and aquifer protection. The wells at the Randolph Road Well Field are also currently used to prevent basal heave caused by the high upward hydraulic pressure from the carbonate aquifer, at the bottom of the nearby canal. Mechanizing the wells would allow for increased pressure relief from the carbonate aquifer and reduced basal heave potential at the nearby canal.

There are no First Nations located in close proximity to the site. The proposed development is not expected to have significant effects on First Nations communities. This project is not expected to cause any issues for aboriginal treaty rights or affect traditional hunting/trapping/farming The closest First Nation to the project site is the Roseau River Anishinabe First Nation (Roseau River No. 2), located about 50km (31.1 miles) to the southwest of Randolph Road Well Field.

There are no known heritage resources in the immediate area of the Randolph Road Well Field and there are no expected changes relating to heritage area.

The existing wells are currently on the road allowance right of ways within the Municipality of Hanover and existing land use will not change. The Municipality of Ritchot owns the parcel of land where the mechanical building/ pump house is located. Land use adjacent to the site is predominantly agricultural and classified as agricultural general zone (Municipality of Hanover, 2023).

# 4. Mitigation Measures and Residual Environmental Effects

The predicted impacts on carbonate aquifer and the long-term aquifer response are discussed on pages 78 to 86 of the attached hydrogeology report.

# 5. Follow-up Plans, Monitoring, and Reporting

The follow-up plans, long term monitoring and reporting are discussed in the attached hydrogeology report, on pages 78 to 79, and pages 86 to 89.

It is anticipated that some of the recommendations detailed in the hydrogeology report will be reviewed by the staff of the Manitoba Environment and Climate – Drainage and Water Rights Licensing Branch (MEC-DWRLB).

# 6. Additional Water Supply Details

### *6.1. Existing System Use*

The Municipality of Ritchot operates the Randolph Road Well Field and the PR 305 Well Field. The existing licences and water use are discussed on pages 14 to 20 of the attached report.

# 7. Private Water Well Inventory

In order to assess the current conditions of water wells constructed within two mile radius, a desktop and a site specific well inventory of private and commercial wells were conducted.

Details of the inventory are discussed on pages 54 to 56 of the attached hydrogeological report. The specific details of the well inventory are contained in Appendix D of the report, which will be provided to MEC-DWRLB.

# 8. References

Friesen Drillers, 2019. *Rural Municipality of Ritchot – Supplemental Groundwater Supply Investigations* – unpublished report

Manitoba Agriculture, 1999. *Rural Municipality of Hanover Information Bulletin 98-26.* *< https://sis.agr.gc.ca/cansis/publications/surveys/mb/mbrm516/mbrm516_report.pdf> - accessed September 2023*

Manitoba Sports, Culture, and Heritage, 2023. Historic Resource Branch. <https://www.gov.mb.ca/chc/hrb/mun/index.html> - accessed September,2023

Manitoba Historical Society, 2023. Interactive Manitoba Historic Site Map < http://www.mb1870.org/mhs-map-2/map> - accessed September, 2023

Municipality of Hanover. Interactive Parcel Map < https://maps.hanovermb.ca/Viewer/index.html?viewer=Parcel> - accessed September, 2023

Statistics Canada, 2021. R.M. of Ritchot Census Profile 2021. <www.statcan.gc.ca> - accessed September, 2022

WSP, 2023. Municipality of Ritchot- Projection of Future Water Demands – unpublished memo

## 9. LIMITATIONS

The scope of this report is limited to the matters expressly covered and is intended solely for the client to whom it is addressed. Friesen Drillers Limited makes no warranties, expressed or implied, including without limitation, as to the marketability of the site, or fitness to a particular use. The assessment was conducted using standard engineering and scientific judgment, principles, and practices, within a practical scope and budget. It is based partially on the observations of the assessor during the site visit in conjunction with archival information obtained from a number of sources, which is assumed to be correct; except as provided, Friesen Drillers Limited has made no independent investigations to verify the accuracy or completeness of the information obtained from secondary sources or personal interviews. Generally, the findings, conclusions, and recommendations are based on a limited amount of data (e.g. number of boreholes drilled or water quality samples submitted for laboratory analysis) interpolated between sampling points and the actual conditions on the site may vary from that described above. Any findings regarding the site conditions different from those described above upon which this report was based will consequently change Friesen Drillers Limited's conclusions and recommendations.

## 10. DISCLAIMER

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# Proposed Municipal Groundwater Supply Alteration – Randolph Road Well Field Municipality of Ritchot

## September 2023

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Report to:

THE MANITOBA WATER SERVICES BOARD

**The Manitoba Water Services Board**

and

MUNICIPALITÉ RITCHOT MUNICIPALITY

**Municipality of Ritchot**

# Proposed Municipal Groundwater Supply Alteration – Randolph Road Well Field Municipality of Ritchot

[redacted]

**September 29, 2023**

Prepared by: [redacted] Date: Sept. 29, 2023

Paulynn Estrella-Legal, B.Sc.(Mn.E.), P.Eng.

Reviewed by: [redacted] Date: Sept. 29/2023

Jeff J. Bell, B.Sc.(G.E.), P.Eng

[redacted]

Approved by: [redacted] Date: Sept. 29/2023

Jason D. Friesen

307 PTH 12 N Steinbach, MB. R5G 1T8 Phone 204-326-2485 Fax 204-326-2483 Toll Free-1-888-794-9355

Friesen DRILLERS

**Acknowledgments**

Friesen Drillers acknowledges with appreciation the following individuals for their assistance and contributions during the completion of this study:

- The Municipality of Ritchot
  - Mr. Mitch Duval - Chief Administrative Officer
  - Mr. Mike Dumaine - Public Works Manager
  - Council

- The RM of Hanover
  - Mr. Luc Lahaie - Chief Administrative Officer
  - Council

- Manitoba Environment and Climate
  - Ms. Kylene Wiseman, P.Geo.
  - Mr. Ronaldo Miranda, P.Geo.
  - Mr. Bruce Webb, P.Eng.
  - Mr. Justin Vitt - Groundwater Information Specialist

**Study Team**

The study team consisted of the following individuals:

- Friesen Drillers Limited
  - Mr. Jeff Bell, B.Sc.(G.E.), P.Eng. – Hydrogeological Engineer
  - Ms. Paulynn Estrella-Legal, B.Sc.(Mn.E.), P.Eng. – Hydrogeological Engineer
  - Mr. Justin Neufeld, P. Geo. – Groundwater Geologist
  - Mr. Peter Friesen – Lead Driller and pumping test crew
  - Mr. Paul Sharples – Field Supervisor
  - Ms. Ashley Friesen – Pumping test crew
  - Mr. Jason Friesen – Operations Manager

Friesen Drillers acknowledges with appreciation the contributions of our project team members:

- Landmark Planning and Design Limited – Public consultation
  - Mr. Donovan Toews, B.Sc. MCP. – Planner and Public Consultation Specialist
  - Mr. Brennan Johnson, MCP. - Intermediate Planner

- ALS Laboratory Services and EIL (Environmental Isotope Laboratory) at the University of Waterloo.

**Notes**

The study utilized imperial measures, with the exception of water quality data and some velocity information, which were in metric measures. Use of the investigation results will follow the limitations and disclaimer in the report. Some of the data collected during this study was obtained from Manitoba Environment and Climate. Friesen Drillers has made no attempts to verify the information. It is assumed to be correct. The reports collected for background research on this aquifer have been obtained from public sources.

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**Executive Summary**

Friesen Drillers was retained by the Municipality of Ritchot (Municipality) and the Manitoba Water Services Board (MWSB) to undertake a hydrogeological investigation for the municipal groundwater supply alteration on the Randolph Road Well Field in order to support the immediate and future projected growth within the Municipality. The initial projected water demand for the Municipality was estimated to be about 792.5 U.S.G.P.M. (~50 L/s) (WSP, 2018), with up to 396.3 U.S.G.P.M. (~25 L/s) planned to be sourced from the Randolph Road Well Field. However, with the updated water demand estimation, the Municipality will now require a total maximum flow rate of 1,189 U.S.G.P.M. (~75 L/s) from the Municipality's existing well fields (WSP, 2023).

The Municipality of Ritchot's water supply is mainly derived from several relief wells on SE 8-7-5 EPM, along Randolph Road and the PR 305 Well Field, on NE 12-7-3 EPM. In 2018/2019, a hydrogeological investigation was completed on the PR 305 Well Field which resulted in the installation and testing of a 12-inch diameter, steel cased screened well and increased licensed annual water use allocation to 555 U.S.G.PM. (35 L/s) for the well field.

The Randolph Road wells are unique since the wells, completed in the carbonate aquifer, were originally installed to artificially lower the potentiometric surface in the carbonate aquifer and to relieve pressure from the base of a major drainage canal running across the area to prevent hydraulic rupture. The water use licence for the Randolph Road well field is distinct since it has no maximum limit on the amount of water discharged from the wells. However, the licence also restricts any pumping from the wells and only allows for the groundwater from the relief wells to free flow into the pipelines.

The PR 305 Well Field is currently licensed to provide up to 555 U.S.G.PM. (35 L/s) during peak demand, thus, the Randolph Road Well Field would require diverting up to 634 U.S.G.P.M. (40 L/s) during times of peak water demand. The estimated annual allocation requirement for the Randolph Road Well Field is approximately 639.16-acre feet/year (~788.39 $dam^3$/year).

As part of the investigations, the existing 8-inch diameter wells at the Randolph Road Well Field, Well No.1, Well No. 2, and Well No. 3, were assessed. Based on the assessment, only Well No. 1 and Well No. 2 were suitable to be used as municipal water supplies. A 72-hour pumping test and a specific capacity test was completed at the site at a rate of 390 U.S.G.P.M. (~24.6 L/s). Aquifer responses in both the sandstone and carbonate, at various distances, were monitored using a regional monitoring network comprised of new and existing monitoring wells. The groundwater quality was also monitored during the pumping tests which remained stable during the 72-hour test.

Based on the investigation results, the Randolph Road Well Field is capable of supplying the annual allocation of 788.39 $dam^3$ (639.16 acre feet) of groundwater, under normal seasonal and climatic conditions. The estimation assumes an average flow rate of 396 U.S.G.P.M. (~25 L/s) and peak flow rates of up to 634 U.S.G.P.M. (~ 40 L/s). During peak demand, both wells would need to run at full capacity. Thus, in order to gain some redundancy during periods of peak water demand, the wells would either need to be over drilled into 12-inch diameter wells or additional wells would need to be installed at the site.

The groundwater quality should be monitored closely, specially during the first five years of operating the well field at the increased allocation to determine groundwater quality changes.

It is recommended that the application process proceed for an increased groundwater supply allocation. This will include an application for the modification of a Class 2 Environment Act Licence. Further monitoring and reporting are recommended to monitor the aquifers in the area. Additional recommendations are contained in the report.

# Municipal
# Groundwater Supply Investigations
# Municipality of Ritchot
## September 2023

Friesen DRILLERS

307 PTH 12 N Steinbach, MB. R5G 1T8 Phone 204-326-2485 Fax 204-326-2483 Toll Free-1-888-794-9355

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# 1 INTRODUCTION

Friesen Drillers Limited is pleased to present this report detailing the results of our hydrogeological investigation for the Municipality of Ritchot.

The Municipality of Ritchot water supply is currently sourced from SE 8-7-5 EPM (Randolph Road) Well Field and from NE 12-7-3 EPM (PR 305) Supplementary Well Field. The Municipality of Ritchot water supply serves the communities of Ile des Chênes, St. Adolphe, Ste. Agathe, parts of Grande Pointe, as well as rural pipeline consumers (WSP, 2021).

The Randolph Road Well Field was originally established as pressure relief wells to prevent the hydraulic rupture of the nearby tributary of the Manning Canal. Due to this, the current groundwater licence for the site does not allow for pump installations at the Randolph Road Well Field site and only allows for diverting groundwater freely discharging from the wells. The supplementary PR 305 Well Field was developed in 2006 due to the declining and inconsistent amount of groundwater discharge from the Randolph Road Well Field.

In the last 10 years, the discharge from the Randolph Road Well Field, prompted by years with below average total annual precipitations, has been declining. Further, the frequency of the years with below average precipitation has increased since 2011. As such, the reliance of the Municipality of Ritchot on the PR 305 Well Field has also significantly increased.

In 2018, WSP Consulting prepared a Pre-Design Technical Memorandum #2 regarding water supply upgrades for the Municipality of Ritchot. The technical report indicated that the Municipality would require a maximum flow rate of 793 U.S.G.P.M. (50 L/s) to support the growth of the Municipality in the next 25 years (WSP, 2018).

In 2018/2019, the Municipality of Ritchot entered into a joint agreement with MWSB to retain Friesen Drillers to expand the PR 305 Well Field and to allow for increased pumping rates of up to 523 U.S.G.P.M. (35 L/s). The project was successful and resulted in increased annual and instantaneous flow rates for the site. However, additional water supplies were still needed to fully support the rapidly growing Municipality.

In October of 2020, the Municipality of Ritchot entered into a joint agreement with the Manitoba Water Services Board to complete the hydrogeological investigations relating to mechanizing the existing Randolph Road Well Field to provide the required 396.26 U.S.G.P.M. (25 L/s). This translates to an allocation of 639.16 acre feet/year (~788.39 $dam^3$/year). The Randolph Well Field investigation included a public engagement and consultation program undertaken by Landmark Planning in addition to the hydrogeological investigations completed by Friesen Drillers. The hydrogeological investigations included well assessments and redevelopment of the existing Randolph Road Well Field wells, a 72 hour-constant rate pumping test, followed by a 4-hour specific capacity test with monitoring, groundwater sampling, hydrogeological analysis, and reporting.

Recent data from the Municipality of Ritchot indicated that the expected 20 year growth estimated by WSP (2021) could be attained as early as 2032 (M. Dumaine, personal communications, July 2022). Additional estimations from the Manitoba Water Services Board in May 2023 increased the combined peak water demand for the Municipality of Ritchot to 1,189 U.S.G.P.M. (75 L/s) (N. Wittmeier, personal communications, May 2023).

The following report assumed a total raw water requirement of 1,189 U.S.G.P.M. (75 L/s) for both the PR 305 Well Field and the Randolph Road Well Field. Since the PR 305 Well Field is currently licensed to provide up to 555 U.S.G.PM. (35 L/s) during peak demand, the Randolph Road Well Field would require diverting up to 634 U.S.G.P.M. (40 L/s), during times of peak water demand. The estimated annual allocation requirement for the Randolph Road Well Field is approximately 639.16-acre feet/year (~788.39 $dam^3$/year). It is also anticipated that the Randolph Road Well Field will pump an average of 396.26 U.S.G.P.M. (25 L/s), during normal operations. This change will be further discussed in the data analysis section.

# 2 PROJECT BACKGROUND AND SCOPE OF SERVICES

## 2.1 PROJECT BACKGROUND

The Municipality of Ritchot currently derives raw groundwater supply from three, 8 inch diameter, PVC cased relief wells completed into the carbonate aquifer on SE 8-7-5 EPM (Randolph Road Well Field), within the Municipality of Hanover, and from two, 12 inch diameter PVC cased wells completed in the sand and gravel aquifer, on NE 12-7-3 EPM (supplementary well field / PR 305 Well Field). The well field locations, and surrounding settlements, towns and municipalities are shown in Figure 1.

In the 1960's to 1970's, several large-scale drainage and surface water control works were undertaken in the Province of Manitoba, with the Red River Floodway being the largest of these features. In southeast Manitoba, a number of major canals and drains were constructed to alleviate the flooding on the Seine River. One of these canals passes through the Municipality of Hanover towards Winnipeg and joins the Manning Canal.

During a wet spring in the mid 1970's the groundwater levels in the carbonate aquifer underlying the canal rose and the bottom of the canal hydraulically ruptured, causing a massive influx of groundwater into the canal and significant issues downstream. A local geotechnical /groundwater investigation revealed the basal rupture occurred as a result of the removal of the overburden material to construct the canal. Thus, when the groundwater level rose, there was not enough confining material to prevent the aquifer from leaking into the base of the canal.

Several relief wells were installed on SE 8-7-5 EPM, to artificially lower the potentiometric surface in the aquifer and relieve pressure from the base of the canal. The groundwater free flowed from the relief wells into an underground pipeline directed into the Red River for many years. Sometime

afterwards, the Municipality of Ritchot expressed interest in utilizing the water supply for municipal purposes within the Municipality.

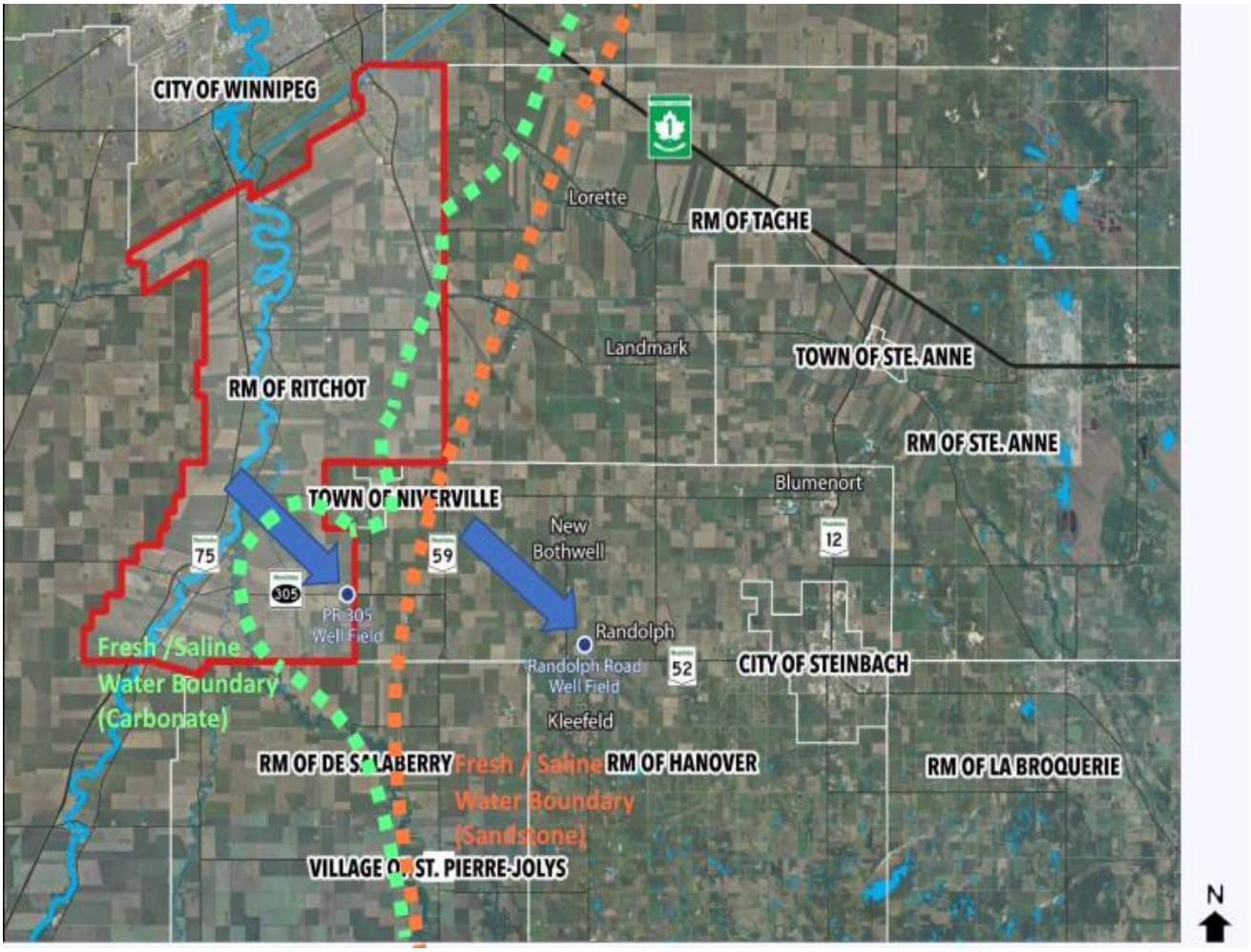


**Figure 1: Well Field Locations and Surrounding City, Municipalities and Towns**

(Modified from: Google Earth 2022, and Landmark Planning, 2022)
Note: Groundwater east of the boundaries are fresh (TDS values <1,000 mg/L), and brackish west of the boundaries. Sandstone boundary ( orange), Carbonate boundary ( green)

The Municipality of Ritchot was originally awarded a groundwater use licence to utilize the groundwater discharge from the pressure relief wells in 1993 (Original Licence #. 93-16). As part of the licence agreement, the Municipality of Ritchot was prohibited from installing pumps in the relief wells. The original relief wells were subsequently replaced by three 8 inch PVC cased wells in 2002. The groundwater use licence for the site was last renewed in 2014 (Licence # 2014-014).

Over the last 40 years or so, the Randolph Road wells have been successfully used as means of groundwater level control in the carbonate aquifer, at the site and surrounding areas, while preventing the hydraulic rupture of the bottom of the canal near the Randolph Road Well Field.

However, since the wells were primarily used to prevent hydraulic rupture at the base of the canal, the wells were only allowed to discharge freely into the waterlines, with no pumping equipment installed inside the wells. Thus, the yield of the wells as municipal water supply are highly affected by seasonal and climatic variations. The discharge rates from the wells are greatly reduced during times of below average total annual precipitation and during prolonged dry periods.

In 2004/2005, groundwater investigations were completed by A. Pedersen for the Municipality of Ritchot in order to develop a municipal well field off of PR 305, on NE 12-7-3 EPM. The investigations were completed with the aim of providing supplementary groundwater to the Municipality of Ritchot (Pedersen, 2005). The initial investigations were focused on the carbonate aquifer. However, due to development issues, the sand and gravel sequence found during the test drilling was ultimately utilized for the well field (Pedersen, 2005). The PR 305 Well Field was subsequently licensed to draw groundwater supply of up to a maximum of 285 U.S.G.P.M. from the sand and gravel aquifer overlying the carbonate bedrock.

The increasing growth rate of the Municipality of Ritchot, coupled with recent years of generally lower-than-average precipitation in southern Manitoba resulting in declining discharge from the Randolph Well Field, prompted the Municipality to look for additional sources of water supply in 2018. However, due to licensing restrictions/ pumping restrictions on the Randolph Road wells, as well as other potential issues with the aquifer limitation, potential third-party impacts, and limited funding available at the time, it became apparent that hydrogeological investigations geared towards investigating the potential of increasing the capacity and groundwater use allocation of the PR 305 Well Field would be more logical. The existing pipeline and infrastructure from the PR 305 Well Field were also planned to be utilized without any significant modifications providing some cost savings to the project.

In 2018, Friesen Drillers was retained through a joint agreement between the Municipality of Ritchot and the MWSB to increase the water use allocation for the PR 305 Well Field. The project resulted in the test well drilling, well installation and testing of a 12 inch diameter steel cased production well completed in the sand and gravel formation overlying the carbonate aquifer. Following the hydrogeological investigations, a notice of alteration (NoA) application to the Environment Act Licence was completed. The Environmental Act Licence and the Water Use Licence for the PR 305 were subsequently amended to include the PR 305 wells in the Environmental Act Licence and to allow for the pumping of up to 554.76 U.S.G.P.M. (35 L/s) from the PR 305 Well Field.

Based on the WSP Report (2018), even with the increased allocation from PR 305, the Municipality will still require additional reliable water supplies to support the future growth of the Municipality. Due to the infrastructure and wells already in place at the Randolph Well Field site, it was logical for the Municipality to look at the potential of mechanizing the Randolph Well Field site. Friesen Drillers was subsequently retained by the Municipality of Ritchot and the MWSB to undertake the investigations for the Randolph Road Well Field.

In May of 2023, MWSB updated the instantaneous groundwater supply requirements to 1,189 U.S.G.P.M. (75 L/s). With 554.76 U.S.G.P.M. being sourced from the PR 305 Well Field, the instantaneous water demand for Randolph Road Well Field was increased to 634.24 U.S.G.P.M., with a total annual allocation request of 639.16-acre feet/year.

## 2.2 SCOPE OF SERVICES

In the winter of 2020, the Municipality of Ritchot and the MWSB requested Friesen Drillers to submit a proposal to undertake the hydrogeological investigations to determine the aquifer capacity at the Randolph Well Field site, located within the boundaries of the Municipality of Hanover, and to determine if the well field is suitable for mechanization. The proposal was accepted, and Friesen Drillers was retained to undertake the approved scope of work.

The project was multi-disciplined as the water supply would also require a public consultation process as part of the formal application for the alteration of the Environmental Act Licence and the Water Rights Licence.

Friesen Drillers developed a team approach to the project, working with staff from Landmark planning and Design (Landmark) in order to undertake the consultation process.

The following scope of work was approved in the work plan and subsequently carried out:

- Undertake the consultation process and project initiation with the Municipality of Ritchot, the Municipality of Hanover and the MWSB.

- Undertake the consultation process with the stakeholders, including neighboring municipalities and private landowners within the study area.

- Prepare and apply for a Groundwater Exploration Permit for the site from the Manitoba Environment and Climate (MEC) – Drainage and Water Rights Licensing Branch (DWRLB).

- Review all of MEC hydrograph monitoring stations near the project site for long-term regional water levels and groundwater chemistry/isotopic chemistry.

- Undertake a well inventory within a 2.0 mile radius of the Randolph Well Field Site.

- Regular update meetings to be held during the course of the project with all groups and stakeholders.

- Complete the drilling and installation of observation wells in the carbonate/sandstone aquifer. The observation well locations to be planned for areas where available monitoring wells did not exist.

- Camera inspection, preliminary short term specific capacity testing and redevelopment of the 8 inch diameter production wells at the Randolph Well Field.

- Undertake a 3-day (72-hour) pumping and recovery test on one of the existing supply wells, utilizing an extensive monitoring network to measure the water level response over the pumping period.

- Groundwater sampling for routine geochemical analysis and stable isotope analysis.

- Undertake a shorter 4-hour specific capacity and recovery test on one of the existing supply wells to determine well capacities.

- Review the capacity of the well field and calculate the proposed impact from mechanizing the wells.

- Conduct a final round of landowner and stakeholder meetings, for those with a general interest in the project.

- Complete a detailed report of the technical investigations.

- Contingent upon the results of the investigations, prepare an Environment Act Notice of Alteration (NoA) application for the project.

Friesen Drillers received the approval to proceed in September 2020. It was acknowledged in the project proposal that the work would take about a year to complete, with the final reporting aimed for completion in the fall of 2021. However, due to the worldwide COVID-19 pandemic and prevalent drought conditions experienced in Southeast Manitoba in 2021, the project was delayed for a couple of years. The technical aspects of the project are described in this report, with a complete report on the public consultations by Landmark Planning and Design included as Appendix A.

# 3 AVAILABLE WATER SUPPLY OPTIONS CONSIDERED

Most of the communities within the Municipality of Ritchot are located on the brackish to saline portion of both the carbonate and sandstone formations. The existing PR 305 Well Field, located within the boundaries of the Municipality, is reasonably far from the fresh-brackish boundaries in the carbonate aquifer. However, the site is also hydraulically bounded since the underlying sandstone aquifer is saline/brackish. It is known that the carbonate aquifer in the PR 305 area exhibits karstic features and well development issues, therefore water supply investigations in 2018/2019 focused on the sand and gravel seam overlying the carbonate aquifer.

The Red River, located within 2 miles of Ste. Agathe, serves as a fresh surface water source for other communities in Manitoba. However, the exact allocation and licensing status on the Red River is not known at the present time. In addition, the water quality during floods could be highly variable and unacceptable with the current treatment technology used by the Municipality of Ritchot. Utilizing surface water would also require additional significant upgrades in the water treatment technology.

In Canada, various groundwater protection and surface water treatment acts were developed after the Walkerton and North Battleford tragedies in the early 2000's. The Safe Drinking Water Act was developed and put into force in 2001, in Manitoba. This act makes a strong technical distinction between groundwater and surface water. Surface water sources now require significantly more complex and expensive treatment to remove microorganisms such as Giardia, Cryptosporidium, various bacteria and viruses that can be present in surface water. The treatment process for surface water is significantly expensive compared to a groundwater source.

The Randolph Well Field wells were completed in the freshwater portion of the carbonate aquifer and have been utilized by the Municipality of Ritchot since 1993. The prevalent flowing artesian conditions in the area surrounding the Well Field site create some project complexities due to some older wells in the area which are equipped with shallow, single line suction pumps. In some households, water is allowed to freely discharge into the water lines with no pumps, making these types of hook-ups vulnerable to fluctuations in the groundwater levels.

As far as the authors are aware, the Municipality of Ritchot has not undertaken a comprehensive water supply sourcing study. This is likely not completed due to lack of other suitable options. Further, the wells and pipeline infrastructure are already in place, minimizing the amount of work needed to mechanize the Randolph Road Well Field. Groundwater is the only option considered by the Municipality of Ritchot and MWSB for this scope.

# 4 REGULATORY REQUIREMENTS FOR MUNICIPAL GROUNDWATER SUPPLIES

## 4.1 WATER RIGHTS ACT AND EXISTING LICENCES

The Province of Manitoba has the responsibility to distribute water under the Water Rights Act. This act requires that anyone using water exceeding 25,000 L/day for commercial, industrial, agricultural, and municipal use must obtain a licence under the act. This is also required for industrial and geothermal heating/cooling applications. Water rights licensing is based on a first in time, first in right procedure. For groundwater projects, an exploration permit is required prior to starting the project. In order to provide approval for the exploration permit, MEC – DWRLB reviews the available aquifer allocation (if available), to determine if the project is potentially suitable.

Upon completion of the testing of the project, MEC – DWRLB reviews the proponent's proposal to determine if third party impacts may result. If these impacts are present, mitigation factors may be required. These include such things as groundwater interference plans, well repairs, replacements, and pump inspections. These programs are usually undertaken by the proponent of the project. Reports are usually prepared for the project by a consulting hydrogeological engineer or hydrogeologist.

If the application is deemed acceptable and third-party impacts are managed or addressed, MEC-DWRLB will issue a licence for the diversion of groundwater. The proponent then has the right, under some conditions, to the water supply for a specific duration.

The Municipality of Ritchot currently holds two valid licences for their existing water supplies. One licence is for the diversion of groundwater from the Randolph Road Well Field, located within the Municipality of Hanover (Licence # 2014-014/ Original Licence. No. 93-16). The second licence (Licence No. 2019-115) is for the PR 305 Well Field, within the boundaries of the Municipality of Ritchot. Details of the current licences are attached as Appendix B. The main aspects are provided in the following sections.

### 4.1.1 Municipality of Hanover Relief Wells (Randolph Road Well Field)

(Licence # 2014-014/ Original Licence. No. 93-16) – allows for the diversion of all ground water flowing from three wells, within the government road allowance, on the SE 8-7-5 EPM. Groundwater is piped to the treatment plant close to Ste. Agathe.

- The licensee must accept all the water flowing from the wells.
- The licence is for municipal use.
- The licensee is prohibited from installing pumps in the wells in order to increase water flow.
- There are a number of additional conditions and clauses on the licence.
- The current water rights licence is valid for 10 years from date of issue (April, 2014).

### 4.1.2 Municipality of Ritchot Supplementary Well Field

Licence No. 2019-123 (Previous Licence No. 2011) – allows for the pumping of 639.65 acre feet/year (789 $dam^3$/year) from the sand and gravel aquifer, immediately overlying the carbonate aquifer, within the NE 12-7- 3 EPM.

- The maximum instantaneous flow rate of diversion shall not exceed 1.23 $ft^3/s$ (0.0350 $m^3/s$).
- The licence is for municipal use.
- Groundwater shall not be diverted during any period when the water level in the aquifer is below the casing of any project well.
- There are a number of additional conditions and clauses on the licence.
- The current water rights licence is valid until April 20, 2032.

## 4.2 Ground Water Exploration Permit Application

Friesen Drillers applied for a Groundwater Exploration Permit (GEP) on April 26, 2022. The application provided an estimate of maximum groundwater flow rates range between 396 to 476 U.S.G.P.M. However, it was anticipated in the application that the requested additional allocation could change considerably, based on the results of the testing and analysis.

MEC – DWRLB issued the permit authorization on April 29, 2022. There were a number of conditions on the permit authorization, which corresponded well with the defined scope of work for the project. The authorization permit allowed for the testing of the wells under the supervision of a consulting hydrogeologist or hydrogeological engineer licensed with Engineers and Geoscientists Manitoba (EGM).

A copy of the GEP application and subsequent authorization is attached as Appendix C.

## 4.3 Environment Act Licence

Under the Environment Act of Manitoba, in the event that a requested groundwater supply project exceeds 200 $dam^3$/year, a Class 2 Environment Act Licence is required. Environmental Act Licence is also required for other classes of development detailed in the Classes of Development Section, in the Environment Act of Manitoba.

When a new water supply is developed which exceeds 200 $dam^3$/year, or when an existing water supply is modified such as the proposed water use exceeds the 200 $dam^3$/year threshold, an Environment Act Proposal is prepared by the proponent for the project. This proposal usually

involves the identification of any potential environmental effects from the water supply diversion. The proposal usually identifies potential third-party impacts and possible effects. Mitigation measures are usually proposed and evaluated. The proposal is usually advertised for public comment and review. Often times, environmental groups and organizations review these proposals to ensure that environmental effects are taken into consideration. In the event that there is a significant amount of public opposition to a potential project, the Minister of MEC may order the Manitoba Clean Environment Commission (CEC) to hold public hearings to review the project and the proposed concerns. Although these public hearings are rare, they have been held for water supply projects in Manitoba in the past.

Copies of the Environment Act Proposals are also submitted to the Technical Advisory Committee (TAC), which consists of provincial and federal specialists who are able to provide technical expertise for review and comments. Often, water supply proposals involving groundwater use are reviewed by the Provincial Groundwater Management Section of MEC. If the environmental impacts are deemed to be minor, or the mitigation proposals are acceptable, the director will issue an Environment Act Licence for the development or project.

The requirement for environment act assessments for water supplies was put into force in the mid 1990's. As a result of this requirement, several water supply systems that did not originally obtain an Environment Act Licence would be requested to undertake this aspect upon a request for additional groundwater use allocation.

Prior to 2018, the Municipality of Ritchot held three Environment Act Licenses (Environmental Act Licence No. 1572, No. 2251 and No. 2415) for the pipelines for the Randolph Road Well Field and PR 305 Well Field. However, the licences did not include the use of the well fields as water supply sources.

In 2019, Friesen Drillers submitted a NoA application to the Environmental Approval Branch as part of the hydrogeological investigations on PR 305 Well Field. Once the approval process was completed, Environmental Act Licence No. 1572, No. 2251 and No. 2415 were rescinded and a revised Environmental Act Licence No. 2415R was issued to the Municipality of Ritchot. The revised Environmental Act Licence included the Randolph Road Well Field, the PR 305 Well Field, the raw water pipeline connecting all wells to the water treatment plant and reservoir east of Ste. Agathe, pipeline connecting the water treatment plant to the Municipality of Ritchot and the distribution systems serving the communities of Grande Pointe, Ile des Chênes, St. Adolphe, Ste. Agathe, and adjacent rural residential areas. A copy of the Environmental Act Licence No. 2415R is attached as Appendix B.

The planned amendments to mechanize the Randolph Road Well Field to obtain a more consistent flow from the wells would exceed the 200 $dam^3$/year threshold and would therefore, require that an Environmental Act Licence NoA application to be submitted.

# 5 POPULATION TRENDS AND WATER USE

The Municipality of Ritchot has experienced significant growth in the last few years. The population increased from 5,478 individuals in 2011 to 6,679 individuals in 2016 (Statistics Canada, 2016). This equates to an average of 4.4% growth rate per year.

The most current census data from 2021 shows that there were 7,469 individuals registered in the Municipality (Statistics Canada, 2021). Using the most current data, the average population growth rate of the Municipality in the last five years dropped slightly to approximately 2.4% per year.

The Water and Wastewater Management Plan Update for the MacDonald – Ritchot Planning District approximated that the population of the Municipality of Ritchot would be close to 12,390 residents by 2046, based on the 2016 population growth data (WSP, 2021). However, the report also mentioned that this is conservative and may change with changing development patterns in the area. Recent trends in the region show rapid population growth from nearby communities surrounding Winnipeg ( Statistics Canada, 2021). The Municipality of Ritchot also anticipates that the population could reach 12,400 residents as soon as 2032 (~10 years) (M. Dumaine, personal communications, July 2022). In September of 2023, WSP updated the 2046 population projection to 11,672 residents, based on the 2021 Statics Canada Census data.

The population record from Statistics Canada and the corresponding population projections scenarios from the Municipality of Ritchot and WSP (2023) are shown in Figure 2.

The estimated average groundwater consumption within the Municipality is 185 L/c.d (liters per capita per day) (WSP, 2018), which is significantly below the Canadian average (Government of Canada, 2019). This is largely due to the relatively small business/ commercial developments within the Municipality, some residents commuting daily to work in Winnipeg, Steinbach, Niverville and other neighboring communities, relatively newer housing developments with low – flow plumbing fixtures and water efficient appliances, and older homes having access to private wells for supplementary domestic use.

The groundwater consumption use is expected to increase to 200 L/c.d, as the commercial base develops and more jobs are created locally (WSP, 2023).

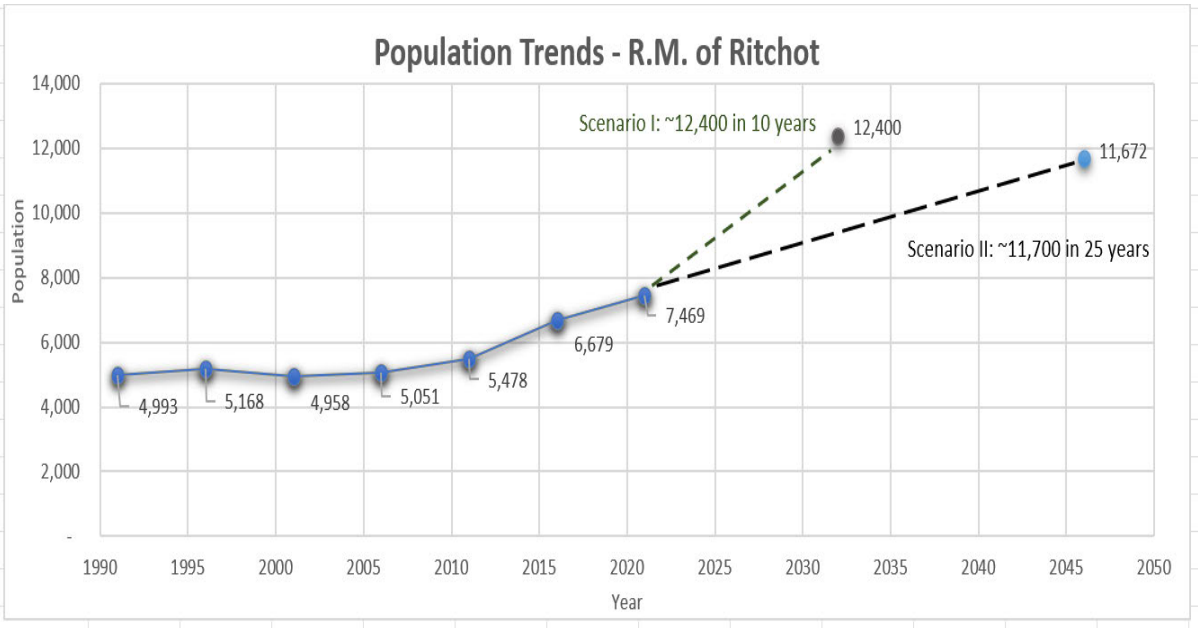


**Figure 2: Population Trends - Municipality of Ritchot**

(Data Source: Statistics Canada, 2021; WSP, 2023; and Municipality of Ritchot 2022)

The annual water use records were obtained from MEC - DWRLB. A plot of the Municipality of Ritchot's annual water usage and the most recent annual allocation for the PR305 Well Field is shown in Figure 3. It is worth noting that since the Randolph Road Well Field's primary function was to prevent basal rupture at the base of canal, there was no maximum allocation limit assigned to the discharge the Randolph Road Well Field, provided that no pumps were installed in the wells.

The Municipality of Ritchot's groundwater use has been relatively stable in the last 10 years. Naturally occurring groundwater discharge fluctuations due to seasonal and climatic effects, coupled with generally declining water discharge from the Randolph Road Well Field, due to years of below average total precipitation, have increased the Municipality of Ritchot's reliance on PR 305 Well Field for water supplies, in the recent years. Since the Randolph Road Well Field is currently restricted to obtaining water discharged from the wells without pumping, the yield of the well field is reliant on groundwater levels and is subject to seasonal and climatic variations. The average flow rate from the Randolph Road Well Field was estimated to be 193.37 U.S.G.P.M. (~12.2 L/s) in 2017 (WSP, 2018). There also have been a few occasions in the last three years when the Randolph Road Well Field ceased to flow (Municipality of Ritchot staff, personal communications, 2023).

These events led to the investigations to increase the water supply capacity and licence modifications on PR 305 in 2019 to secure a more reliable water supply source. Based on the most recent water use record, and with increasing reliance of the Municipality of Ritchot in the PR 305 Well Field, the annual water use from PR 305 Well Field amounts to approximately 39% of the increased annual allocation for the PR 305 Well Field site(MEC - DWRLB, 2022). The

decrease in water use from Randolph Road Well Field was due to significantly decreased discharge from the wells.

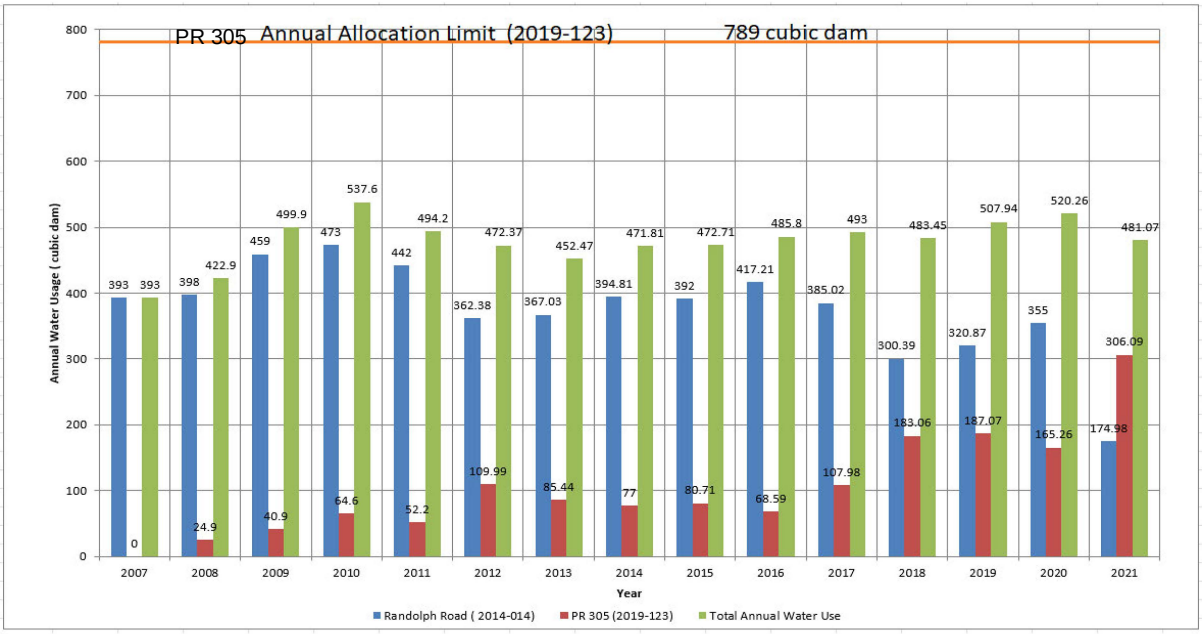


**Figure 3: Water Use Records - Municipality of Ritchot**

(Data Source: MEC - DWRLB, 2022)
Notes: Water use records show increasing reliance on PR 305 Well Field due to variable and declining discharge from Randolph Road Well Field.

# 6 WATER SUPPLY REQUIREMENTS

The Municipality of Ritchot has experienced a high population growth rate in recent years. Based on the statistical data, the population of the Municipality of Ritchot is expected to reach 11,672 by 2046 ( WSP, 2023). However, the Municipality of Ritchot is also predicting that the population of approximately 12,400 could be attained as early as 2032, based on current development plans and building applications for the R.M (M. Dumaine, personal communications, July 2022).

The WSP (2021) study estimated the need for a combined groundwater flow rate of up to 792.52 U.S.G.P.M. (50 L/s) from PR 305 and Randolph Road Well Field for intermediate to long term groundwater supplies. Recent estimates completed by MWSB in May of 2023 (N. Wittmeier, personal communications, May 2023) and recalibrated projection of future water demands (WSP, 2023), indicated that a maximum total peak flow rate of 1,189 U.S.G.P.M. (75L/s) would be required to fully support the growth of the Municipality in the next 10 to 20 years. With the PR 305 Well Field being able to provide up to 554.76 U.S.G.P.M. during peak demand, the Randolph Road Well Field will require a maximum instantaneous flow rate of 634.24 U.S.G.P.M. (40 L/s) and an annual allocation of 639.16-acre feet/ year.

# 7 REVIEW OF LOCAL FIRST NATIONS

The closest First Nation to the project site is the Roseau River Anishinabe First Nation (Roseau River No. 2), located about 50km (31.1 miles) to the southwest of Randolph Road Well Field.

# 8 SITE SETTING

The Municipality of Ritchot borders the south of the City of Winnipeg and extends 22 kilometers to the south along both sides of the Red River, covering an area of approximately 34,200 hectares. Due to its close proximity to the City of Winnipeg, the capital city of the province, the Municipality has a strong potential for further growth. This has been reflected through the expansion of the residential housing within the Municipality in recent years.

The Municipality of Ritchot area lies firmly within the Red River Drainage Basin. Typically, surface drainage is directed towards the Red River which flows through Winnipeg, into the Lake Winnipeg system, and ultimately discharges into Hudson's Bay. The climate in the area is continental and shows typical variability of seasons and precipitation. The average total annual precipitation is around 541 mm/year (Environment Canada, 2022). The average daily temperature in southern Manitoba from 1981 to 2010 ranged from -16.4 to 19.7 degrees Celsius (Environment Canada, 2022)

The Red River flood events have been a major population driver within the Municipality, in the past. This is reflected in the population drop from 1997 to 2001 as a result of the 1997 Red River flood.

### 8.1.1 PR 305 Well Field

The supplementary Well Field site for the Municipality is located off of PR 305, approximately 3.22 miles west of PTH 59 and PR 305 junction, within the Municipality of Ritchot. The address for the site is 1776 PR 305. The site is shown on the subsequent page as Figure 4.

The following property uses surround the site:

- North: PR 305, followed by treed area and agricultural lands/farm.
- East: Agricultural lands/ farmlands.
- South: Agricultural/farmlands, barn, and farmhouse
- West: Farmlands/ agricultural lands.

The topography in the area is generally of low relief. Surface drainage is generally towards the Red River, through ditches and the Tourond Creek, located about 2 miles west of the site. The site elevation is approximately 775 feet above sea level.

The local sewer system is assumed to be by private septic tanks or fields. Water supplies for the area are mainly provided by private residential wells. The typical land use surrounding the site is mainly for agricultural purposes.

**Figure 4: PR 305 Well Field**

(Modified from: Google Earth, 2023)

### 8.1.2 Randolph Road Well Field

The Randolph Road Well Field site is located outside of the Municipality of Ritchot and within the boundaries of the Municipality of Hanover, on SE ¼ 8-7-5 EPM. Specifically, the Randolph Road Well Field site is located immediately west of the Road 26 East and Randolph Rd. intersection, approximately 1 mile north of PTH 52 and approximately 7.5 miles east of the Municipality of Ritchot boundary .

Within the Municipality of Hanover, the neighboring communities to the site includes the Local Urban District of Kleefeld, approximately 3 miles south of the site, the Local Urban District of New Bothwell approximately 3 miles to the northwest of the site and the settlement of Randolph, approximately 2 miles east of the site.

The location of the Randolph Road Well Field and the existing production wells is shown in Figure 5.

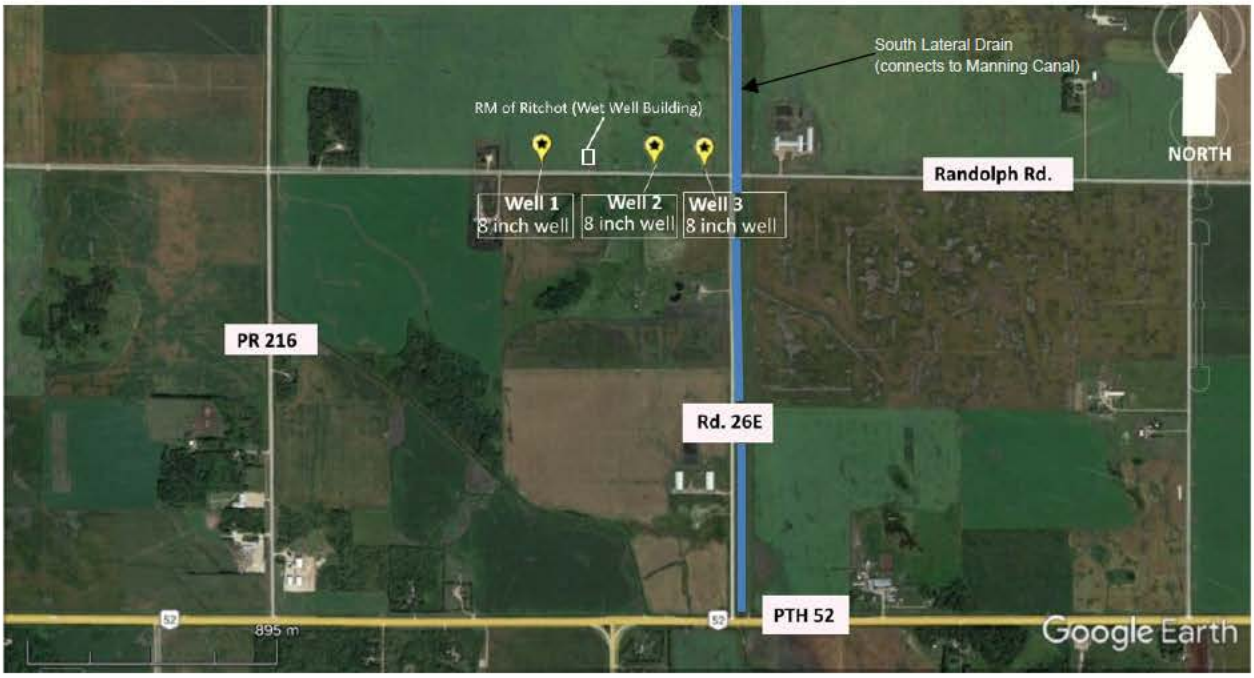


**Figure 5: Randolph Road Well Field**
(Modified from: Google Earth, 2023)

The following property uses surround the site:

- North: Agricultural/ farmlands, followed by a barn site, agricultural lands and rural residential site.
- East: Road 26 East, followed by South Lateral Drain, a tributary of the Manning Canal, followed by a barn site followed by agricultural lands/ farmlands
- South: Randolph Road, followed by agricultural/farmlands, followed by a rural residential site, followed by more agricultural lands and a barn site
- West: Farmlands/ agricultural lands, followed by a rural residential site, followed by agricultural/ farmlands, followed by a rural residential site and PR 216

The topography in the area is generally of low relief with very little slope towards the west. The site elevation is approximately 806 feet above sea level. Surface drainage near the site is generally towards the Red River, through ditches and canals. The local sewer system is assumed to be by private septic tanks or fields. Water supplies for the area are mainly provided by private residential wells. The typical land use surrounding the site is mainly for agricultural purposes (farmlands and barn sites).

# 9 GEOLOGY OF THE MUNICIPALITY OF RITCHOT WELL FIELDS

## 9.1 BEDROCK GEOLOGY

The water supply well fields operated by the Municipality of Ritchot (Randolph Road and PR 305 Well Field) are located within the eastern fringes of the Western Canadian Sedimentary Basin (WCSB), or the Williston Basin. The WCSB is a widespread wedge-shaped sedimentary basin with Precambrian bedrock as the basement feature. Figure 6, shown below, details the extent of the WCSB, and shows the location of the study area.

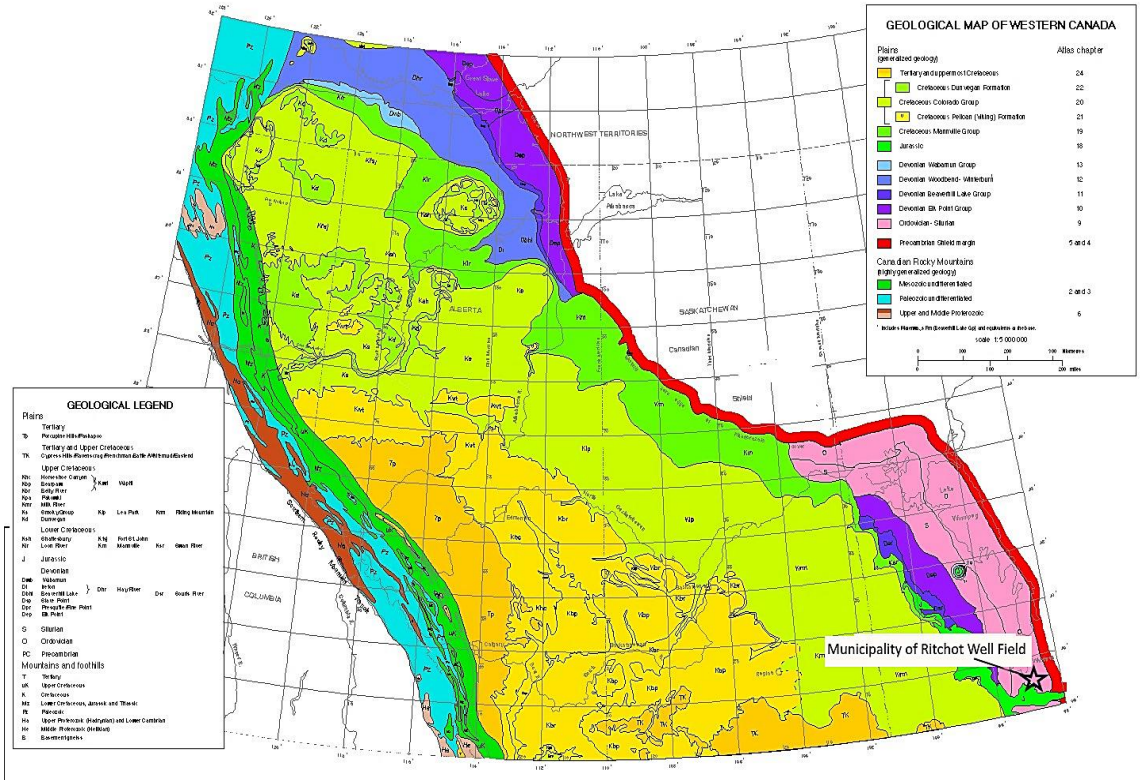


**Figure 6: WCSB showing the Municipality of Ritchot**

(Modified from - Alberta Geological Survey, 2009).

The WCSB extends throughout the central Canadian plains and underlies about 1.4 million km$^2$ (Alberta Geological Survey, 2009). The basin extends north into the Northwest Territories, west along the eastern flanks of the Rocky Mountains, and east into central Manitoba.

Precambrian igneous and metamorphic rocks, which form the basal geologic unit across the WCSB, lie at a depth of approximately 550 feet below grade within the study area. The depth from the surface to the Precambrian basement increases towards the west by approximately 5 to 10 feet every mile. This westward sloping structure is observed throughout southeastern Manitoba in each of the formations of the WCSB.

A regional cross section of southeast Manitoba, passing through the City of Winnipeg and showing the formations present in the area, is shown as Figure 7.

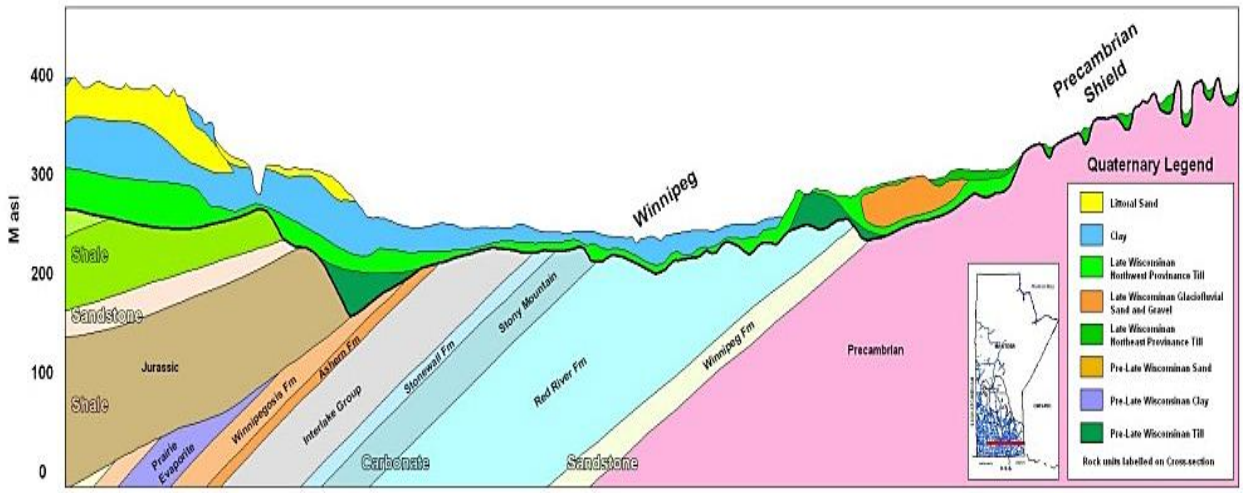


**Figure 7: Geological cross section through Southern Manitoba**

(Modified Source: Manitoba Geological Survey, 2013)

Overlying the Precambrian surface is the Winnipeg Formation Sandstone. The sandstone sequence is approximately 80 to 150 feet thick in the Municipality of Ritchot and surrounding areas and consists predominantly of layered silica sandstone and marine shales. The sandstone is known to be very weakly cemented, especially throughout the portion of the formation identified as the Carman Sands (Betcher, 1986). A substantial number of wells have been drilled into the Winnipeg Formation in various places within southeastern Manitoba.

There is a fresh-saline water boundary a few miles east of the PR 305 Well Field site and the underlying Winnipeg Formation Sandstone is expected to be saline (Betcher et.al, 1995). The saline/ freshwater boundary in the formations present in the area, as well as the location of the Well Fields are in Figure 1. Since the Winnipeg Formation Sandstone is noted to be saline at the PR 305 Well Field site, hydrogeological investigation completed at the site in 2019 was not directed in testing the Winnipeg Formation Sandstone.

While the Randolph Road Well Field is located in the freshwater portion of the Winnipeg Sandstone Formation, the existing wells proposed to be mechanized at the site were completed in the Red River Formation. Therefore, other than installing multi-level monitoring wells and recording groundwater levels, no further testing of the Winnipeg Formation Sandstone was completed in the investigation.

A thin sequence of marine shales, varying between ten to twenty feet in thickness, overlie the Winnipeg Formation. The shale acts as an aquitard creating separation, to some extent, between the underlying Winnipeg Formation Sandstones and the Red River Formation.

The Red River Formation, which typically consists of alternating layers of limestone and dolostone with very thin basal shale layers, is a relatively thick carbonate sequence overlying the Winnipeg Formation Sandstone. There is a conformable transfer between the Winnipeg and Red River Formations. The Red River Formation and the overlying carbonate units are collectively called the carbonate evaporite unit in Manitoba. This unit extends south of the Municipality of Ritchot area and north through the Manitoba Interlake, extending as far north as The Pas and beyond. The upper surfaces of the carbonate bedrock have been eroded and highly damaged by erosional unconformities and Pleistocene glaciations. The surface has also been impacted by karstic processes in the geologic past. Groundwater quality of the Red River Formation is fresh, with total dissolved solids concentrations less than 1,000 mg/L, on both the PR 305 Well Field site, and at the Randolph Road sites.

## 9.2 SURFICIAL GEOLOGY

The surficial geology in the vicinity of the PR 305 Well Field and the Randolph Road Well Filed area is predominantly composed of offshore glaciolacustrine sediments such as clay, silt, minor sand and gravel. These sediments are generally of very low relief and are laminated (Matile and Keller, 2004). Calcareous silt diamicton derived from Paleozoic dolomite and limestone and some minor glaciofluvial sediments are also present in areas to the south and to the west of the Randolph Road Well Field (Matile and Keller, 2004).

The upper carbonate bedrock surface in the southeast Manitoba region was extensively eroded during the pre-glacial and glacial periods. This erosion resulted in significant damage to the upper bedrock surfaces in the form of joint sets, fractures, and voids, along with extensive karstic development. Some of these erosional features have been infilled with more recent sediments. A dense basal till unit, with localized layers of sand and gravel, was deposited directly on the carbonate bedrock surface during cycles of glaciation. Consequently, a portion of the originally highly permeable fractures in the bedrock has been infilled, lowering the permeability of the carbonate.

During the final glacial retreat, a pro-glacial lake developed which resulted in the deposition of water laid tills and glacio-fluvial silty grey clays. These overburden materials act as a confining layer across much of southeastern Manitoba. In the Municipality of Ritchot area, the overburden

clay and glacial till is shown to have a total thickness of up to 80 feet. The glacial till is typically found in the lower 25 to 50 feet of the surface deposits.

Within the PR 305 Well Field site, a localized till/bedrock contact sand and gravel deposit was found during the 2004/2005 investigations by A. Pedersen. The sand and gravel deposit were approximated to be up to 30 feet in thickness. The productions wells, Supply Well 4 and Supply Well 5, were completed in this deposit.

Well drilling records show that intertill sand deposits of up to 50 feet in thickness were noted to be present in the Randolph Road Well Field area (GWDRILL, 2022). Sand deposits are generally encountered between 22 feet to 50 feet below grade in the area.

Figure 8 shows the surficial deposits present in the region.

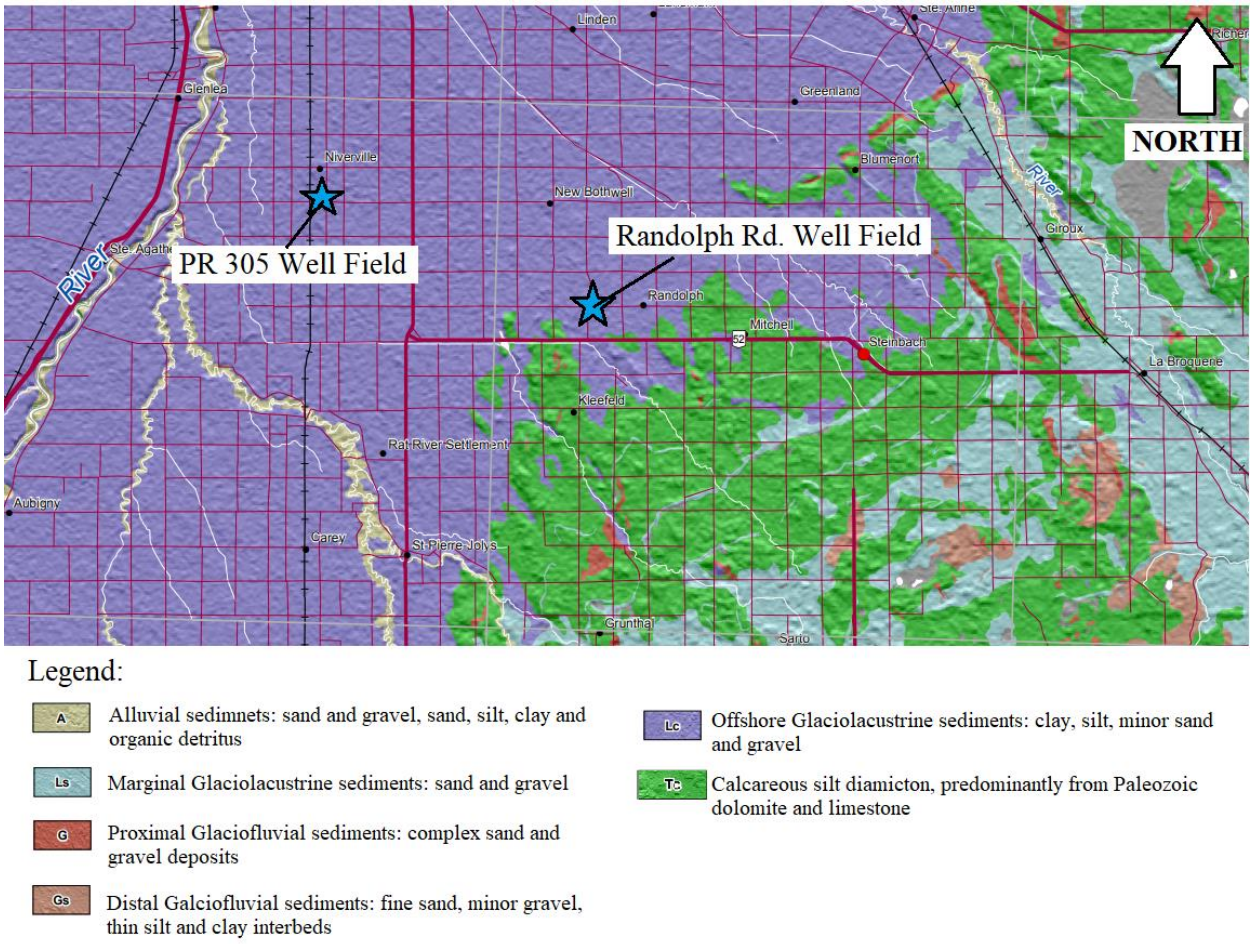


**Figure 8: Surficial geology of the Municipality of Ritchot showing the PR 305 Well Field**

(Modified source – Matile, 2004)

# 10 HYDROGEOLOGY

The general hydrogeological conditions of the area were determined from a review of the applicable hydrogeological reports and information available through MEC.

Groundwater aquifers in the PR 305 Well area can be found in the overburden till (in specific places) and the Red River Formation carbonate. The Winnipeg Formation (Betcher et al., 1995) is thought to be brackish in the area and has limited development potential. The groundwater aquifers present in the Randolph Road Well Field area are found in the overburden (in some places), the Red River Formation and the Winnipeg Formation Sandstone.

Significant sand and gravel aquifers are present within the overburden sediments in some areas in southeastern Manitoba. However, the inter-till sand and gravel aquifers are generally of limited areal extent and are, therefore, considered to have limited development potential (Betcher, 1995). A map showing the regional sand and gravel aquifers present near PR 305 and Randolph Road Well Field is shown as Figure 9.

The area encompassing the PR 305 Well Field indicated sporadic sand and gravel deposits; with no major deposits forming a regional aquifer in the overburden. Field testing completed at the PR 305 in 2004/2005 (Pedersen, 2005) and in 2018/2019 (Friesen Drillers, 2019) found substantial thickness of sand and gravel deposit overlying the carbonate aquifer at the well field site. Based on several field testing at the site, the sand and gravel appear to have a strong hydraulic connection to the underlying bedrock and could be treated as an aquifer system.

Borehole construction logs obtained from the provincial database, GWDRILL (2022), show that sand and gravel deposits are present in the overburden in the Randolph Road Well Field area. These deposits are located intertill in some places and are known to directly overly the carbonate aquifer, in other places, forming an aquifer system with the carbonate aquifer.

The fact that the Randolph Road Well Field wells, completed in the carbonate aquifer, were successfully used to depressurize the aquifer and prevent basal heave in the segment of the Manning Canal passing through the area shows a strong hydrogeological connection between the carbonate aquifer and the overburden.

Given the groundwater quality boundary conditions present in the area, the hydrogeology is quite complex. The overlying carbonate aquifer is fresh while the underlying sandstone aquifer is brackish (≥1,000 mg/L TDS) in the PR 305 Well Field site while both the sandstone and carbonate aquifers are fresh in the Randolph Road Well Field site. The saline/brackish water boundary in the Winnipeg Formation is located 2 miles east of the PR 305 Well Field site. Interconnecting well completions in the Steinbach and Blumenort area increases the complexity of the hydrogeology of the region. Figure 1, previously shown on page 10, illustrates the fresh-salt water boundaries in the Winnipeg Formation and overlying Red River Formation.

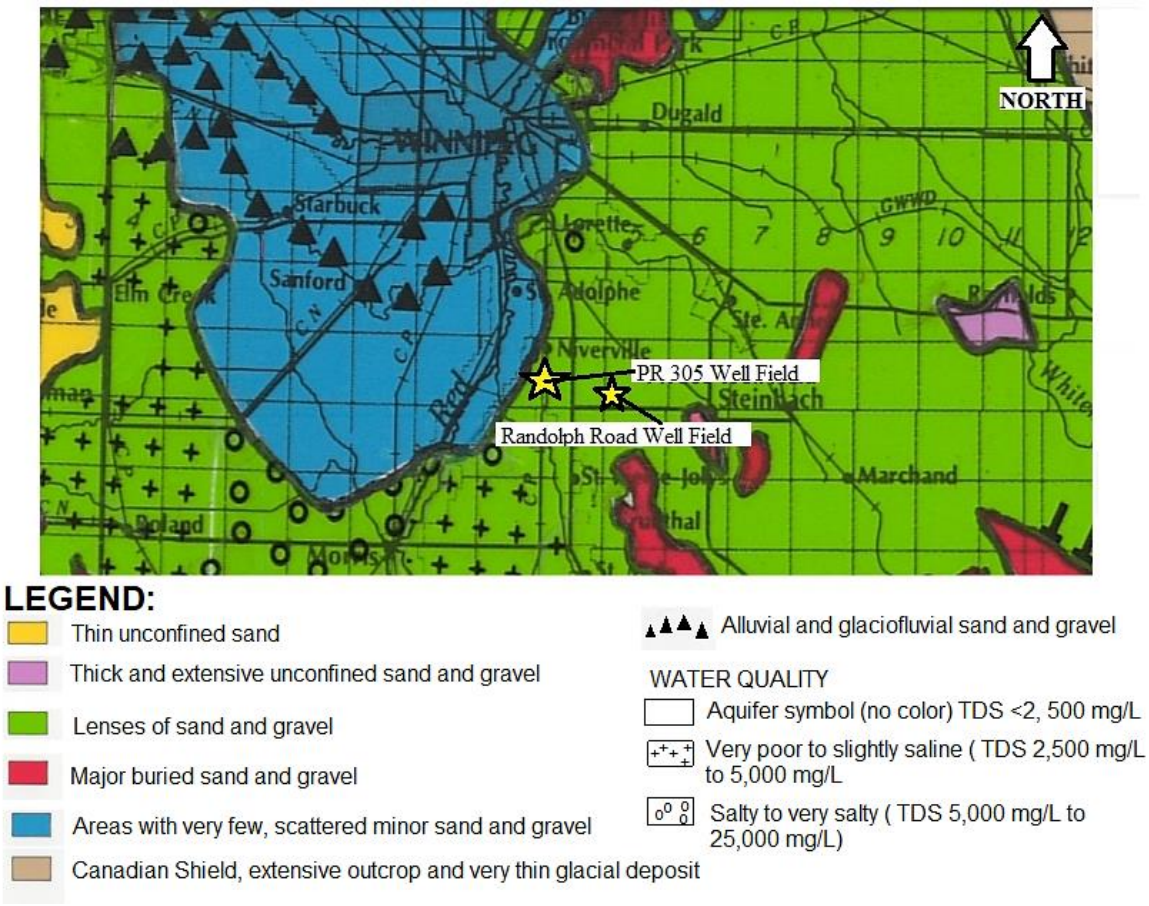


**Figure 9: Sand and Gravel Aquifer Map**

(Modified from: Rutulis, 1986)

Regional groundwater flow in the carbonate aquifer is from southeast to northwest in the Municipality of Ritchot and Municipality of Hanover area. Groundwater flow in the carbonate bedrock of the Red River Formation generally occurs in the fracture and joint sets in the rock. The size, extent, and interconnectivity of the fracture system govern horizontal and vertical groundwater movement through the bedrock. Due to this geologic condition, aquifer transmissivity and storativity can vary significantly over a relatively short distance, resulting in substantial variations in well yield (Render, 1970). Due to its extensive distribution and relatively good water quality, the Red River Formation constitutes a significant water supply resource throughout the central portion of Manitoba and has been developed for municipal, commercial, and private water supply systems (Betcher et al., 1995).

Test drilling and pumping tests completed by Friesen Drillers in the carbonate bedrock in the southeastern area of Manitoba indicate transmissivity values ranging from 30,000 to 150,000 U.S.G.P.D./ft. Due to the fractured nature of the bedrock aquifer, the transmissivity varies substantially within short distances.

## 10.1 REGIONAL GROUNDWATER RECHARGE/DISCHARGE

The majority of the recharge to the Red River Formation carbonate and Winnipeg Formation Sandstone aquifers occurs from a major sand and gravel moraine series, known as the Sandilands area, that lies to the east. Within the Sandilands, coarse sands, gravels, silts and clays lie directly on the bedrock sub crop of both Paleozoic sequences. These highland moraines accept snow melt run off and rainfall and impose an elevated hydraulic head on the regional groundwater systems. The exact amount of groundwater recharge to the formations has not been determined by research. This recharge area is illustrated in Betcher and Ferguson (2003) as coarse sands, gravels, silts and clays lying directly on the bedrock sub crop of both Paleozoic formations is shown as Figure 10.

Groundwater discharge in the area occurs through a variety of means. The carbonate aquifer is known to discharge into the Red River Floodway, and into other creeks, drains and streams. There is also evidence that suggests that some groundwater is discharged into the Red River, near the City of Winnipeg. A significant amount of groundwater also likely discharges into Lake Winnipeg (Betcher et al., 1995). In addition, extensive domestic, agricultural, and municipal groundwater well consumption occurs on the aquifer, although the extent of development is somewhat less within the boundaries of the Municipality of Ritchot area. Groundwater discharge in the Winnipeg Formation occurs predominantly through domestic, farm and municipal well pumping, and basal discharge into Lake Winnipeg.

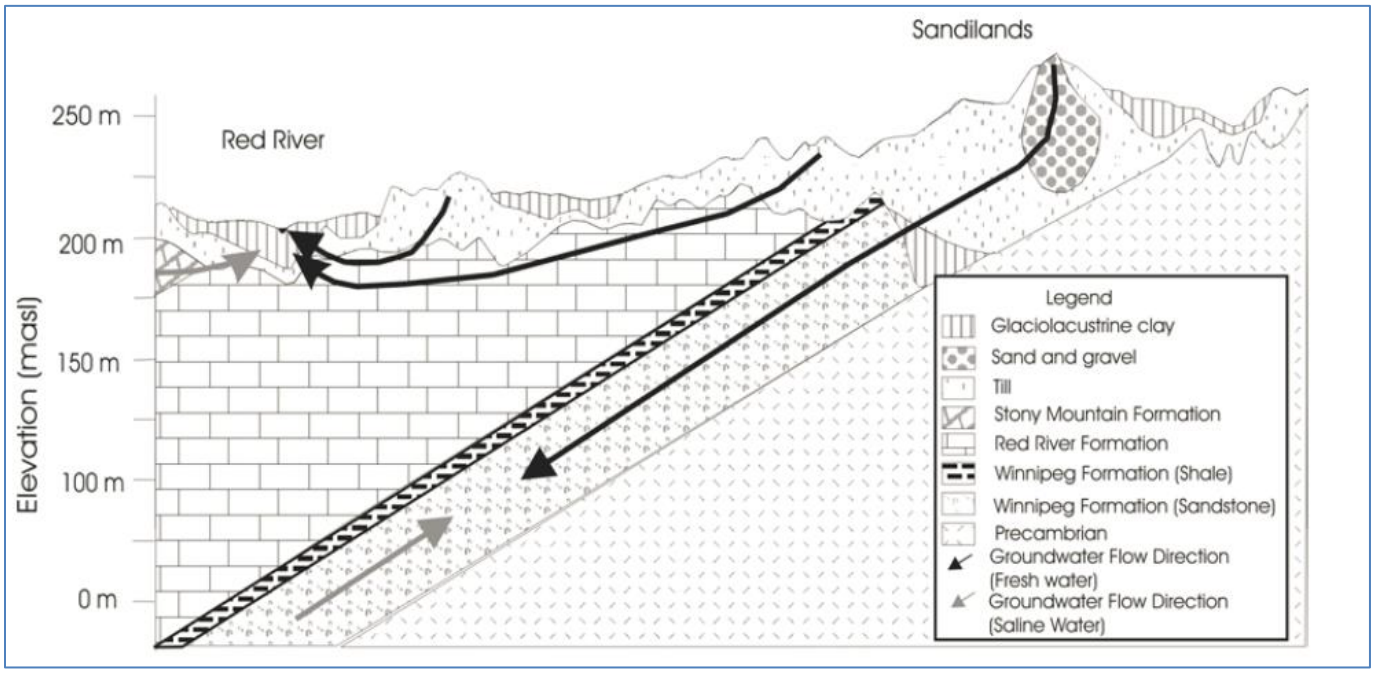


**Figure 10: Schematic Groundwater Recharge Dynamics – Southeastern Manitoba**

(Source: Betcher and Ferguson, 2003)

## 10.2 Regional Hydrograph Review

In order to review the regional groundwater flow directions and the long-term response in the sand and gravel, carbonate and sandstone aquifers over the last 50 years across the area, several MEC hydrograph stations were accessed for potentiometric elevations. The provincial stations reviewed for the investigations are provided in Table 1. The locations of the observation wells are shown on the subsequent page as Figure 11.

**Table 1: Provincial Monitoring Stations**

| Table 1<br>Municipality of Ritchot – Aquifer Hydrograph Monitoring Stations<br>Proposed Rural Municipality of Ritchot Water Supply Alteration<br>Randolph Road Well Field - SE 8-7-5 EPM | | | | |
|---|---|---|---|---|
| **No.** | **Station Identifier** | **Start Year** | **Aquifer** | **Location** |
| 1 | G05OE016 | 1980 | Carbonate | SE 5-7-5E |
| 2 | G05OE019 | 1980 | Carbonate | NE 5-7-5E |
| 3 | G05OE020 | 1981 | Carbonate | NE 33-6-4E |
| 4 | G05OE029 | 2009 | Carbonate | SW26-6-6E |
| 5 | G05OE030 | 1992 | Carbonate | NE 27-6-6E |
| 6 | G05OE031 | 1992 | Carbonate | NW 3-7-6E |
| 7 | G05OE032 | 1992 | Carbonate | SE 31-6-7E |
| 8 | G05OE042 | 1997 | Carbonate | NE 35-4-7E |
| 9 | G05OE049 | 2002 | Carbonate | NE 25-7-6E |
| 10 | G05OE050 | 2002 | Carbonate | SW 7-8-6E |
| 11 | G05OE052 | 2003 | Carbonate | SE 6-8-4E |
| 12 | G05OE053 | 2003 | Carbonate | NE 15-7-3E |
| 13 | G05OE054 | 2003 | Carbonate | SE 19-7-4E |
| 14 | G05OE055 | 2003 | Carbonate | SE 29-6-3E |
| 15 | G05OE056 | 2003 | Carbonate | NE 22-6-3E |
| 16 | G05OE057 | 2003 | Carbonate | RIVER LOT 0570 - Parish of Ste. Agathe |

**Table 1**
**Municipality of Ritchot – Aquifer Hydrograph Monitoring Stations**
**Proposed Rural Municipality of Ritchot Water Supply Alteration**
**Randolph Road Well Field - SE 8-7-5 EPM**

| No. | Station Identifier | Start Year | Aquifer | Location |
|---|---|---|---|---|
| 17 | G05OE072 | 2006 | Carbonate | NW21-8-5E |
| 18 | G05OH009 | 1964 | Carbonate | SW 3-9-4E |
| 19 | G05OE002 | 1969 | Sand and Gravel | NE 4-7-3E |
| 20 | G05OE017 | 1980 | Sand and Gravel | SE 5-7-5E |
| 21 | G05OE025 | 1982 | Sand and Gravel | NE 27-6-5E |
| 22 | G05OE028 | 1992 | Sand and Gravel | SE 31-6-7E |
| 23 | G05OE046 | 1997 | Sand and Gravel | NE 7-7-7E |
| 24 | G05OE051 | 2002 | Sand and Gravel | NE 9-7-3E |
| 25 | G05OE069 | 2006 | Sandstone | NE 25-7-6E |
| 26 | G05OE070 | 2006 | Sandstone | SE 7-8-6E |
| 27 | G05OE071 | 2006 | Sandstone | NW21-8-5E |
| 28 | G05OE073 | 2007 | Sandstone | SE 34-8-4E |

To determine the regional groundwater level trends in the carbonate aquifer, three provincially maintained monitoring station records completed in the carbonate aquifer (G05OE019, G05OE050, and G05OE053) were plotted against the regional precipitation in the area in Figure 12, shown on the subsequent page.

Through a review of the precipitation data and hydrographs, the following can be noted. The average annual precipitation in the area is typically around 541 mm/year (from 1980 to 2022), with typical seasonal and climatic variations (Environment Canada, 2022). Some years, for example, recorded total annual precipitation over 800 mm, while drier years recorded less than 400 mm of total annual precipitation. Precipitation records show that there have been more frequent years with below average precipitation in since 2011.

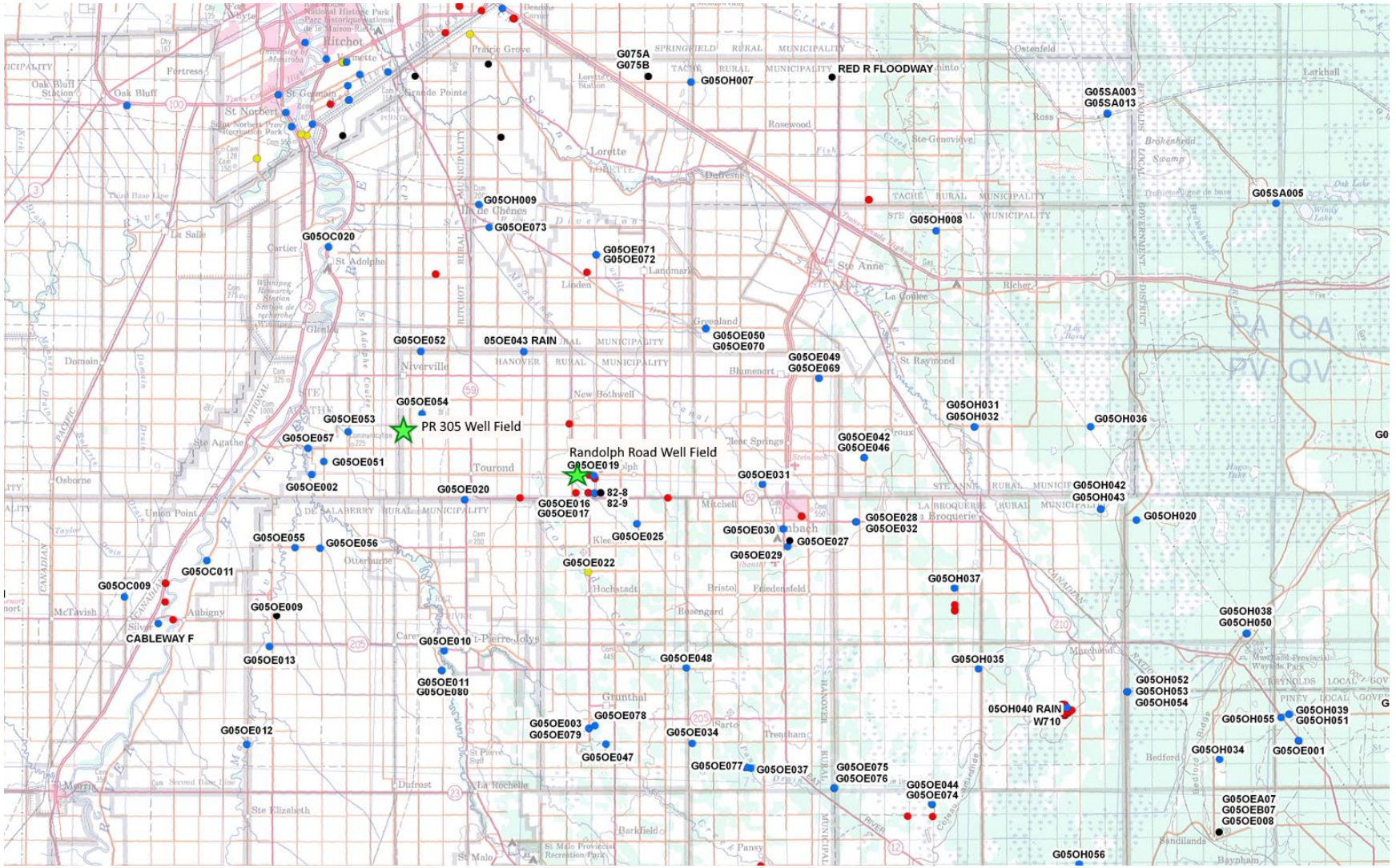


**Figure 11: Provincial monitoring well location – Municipality of Ritchot**

(Source : MEC, 2014; C. Romano) Legend: Blue – active; Yellow – Inactive; Red – Sealed; Black - Unknown

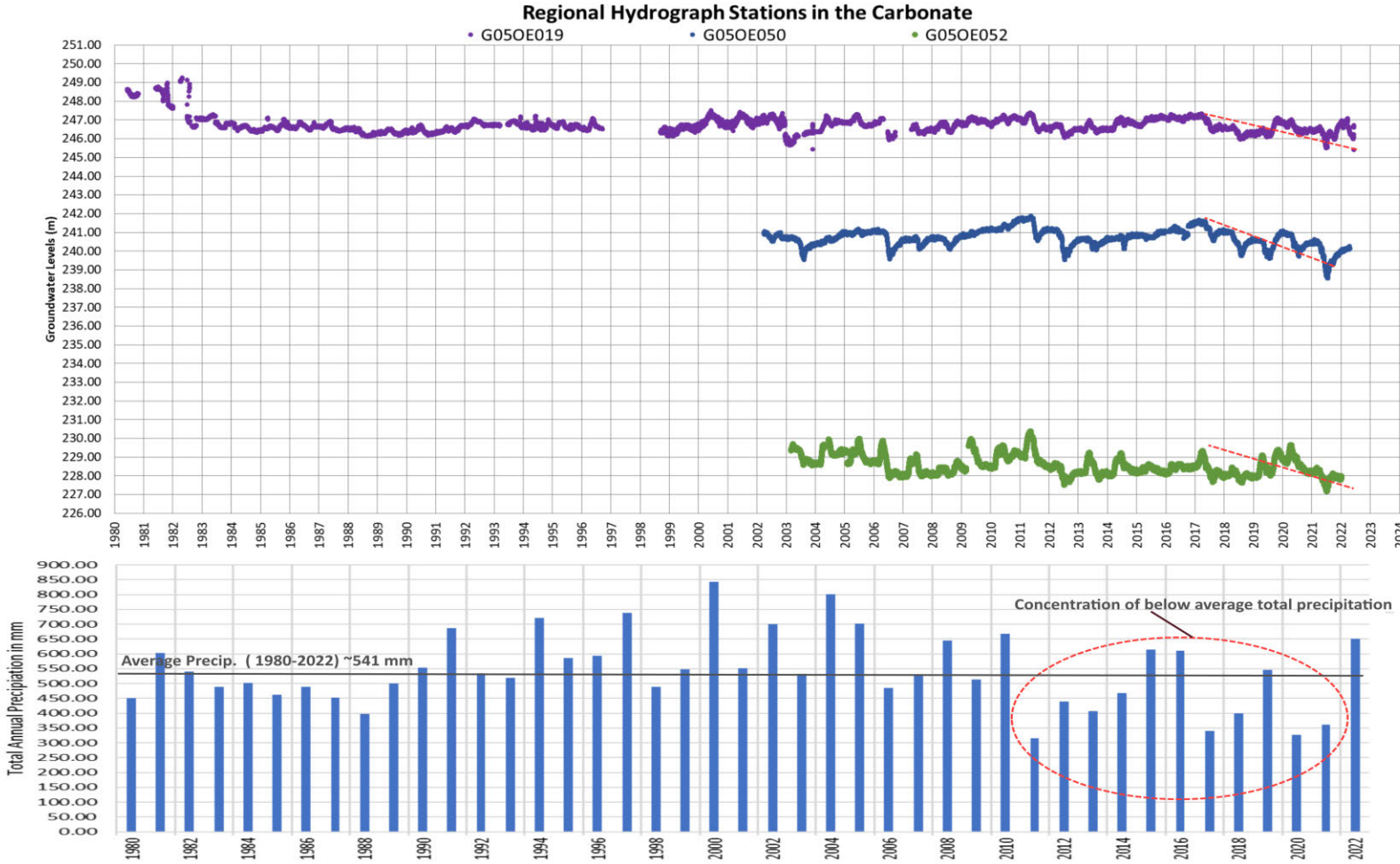


**Figure 12: Regional Hydrograph Station and Precipitation Records**

(Data Sources: MEC, 2022 and Environment Canada, 2022)

It is apparent from Figure 12 that the annual fluctuations in the area are in the range of 1 to 2 meters (approximately 3 to 6 ft). The hydrographs generally show similar groundwater trends. Groundwater levels rise in the early spring with the spring thaw and generally decline in the late fall. The increased frequency of below average precipitation in the region has created a slightly declining trend in the groundwater levels in the carbonate aquifer since 2017. This is due to the concentration of years with below average precipitation in the region. It should be noted however, that the groundwater levels in the carbonate aquifer typically recover during years with normal to above average precipitation. The records generally indicate a fairly stable hydrograph response, with occasional minor depressions and rises associated with seasonal and climatic variation. Long term monitoring has not revealed any inexplicable or localized progressive drawdown in the area in the carbonate aquifer.

Since the Randolph Road Well Field wells are currently operated without pumps, the discharge rate from the wells is highly variable, and is strongly influenced by the groundwater levels in the carbonate aquifer, which in turn responds to the total annual precipitation.

Figure 13, shown on the subsequent page, illustrates the relationship between the water levels from the nearest provincially maintained hydrograph station (G05OE019), the total flow rates produced from the Randolph Road Well Field and the effects of the total annual precipitation on the aquifer levels and the well field discharge. It is important to mention that the highest recorded groundwater level fluctuation in the area was approximately 9 feet, which occurred in the 1980's, when the original wells were first put into service. It should also be noted that the wells were initially intended to dissipate the head in the carbonate formation and currently act as a groundwater control to lower the hydraulic pressure from the aquifer, as intended. While the discharge rates from the wells are variable, the water demands of the Municipality of Ritchot are constant. Thus, the need to mechanize the wells in order to provide a more reliable water supply source for the municipality.

Long term monitoring records are only available in the carbonate aquifer in the region, with the first stations being installed in the carbonate aquifer in the 1960's as part of the initial floodway construction. Monitoring of the sandstone aquifer has been a more recent addition in the early 2000's.

In 2006/2007, MEC began a project to investigate groundwater resources in the southeast. A number of long-term hydrograph stations in the carbonate aquifer were twinned with observation well stations completed into the Winnipeg Formation.

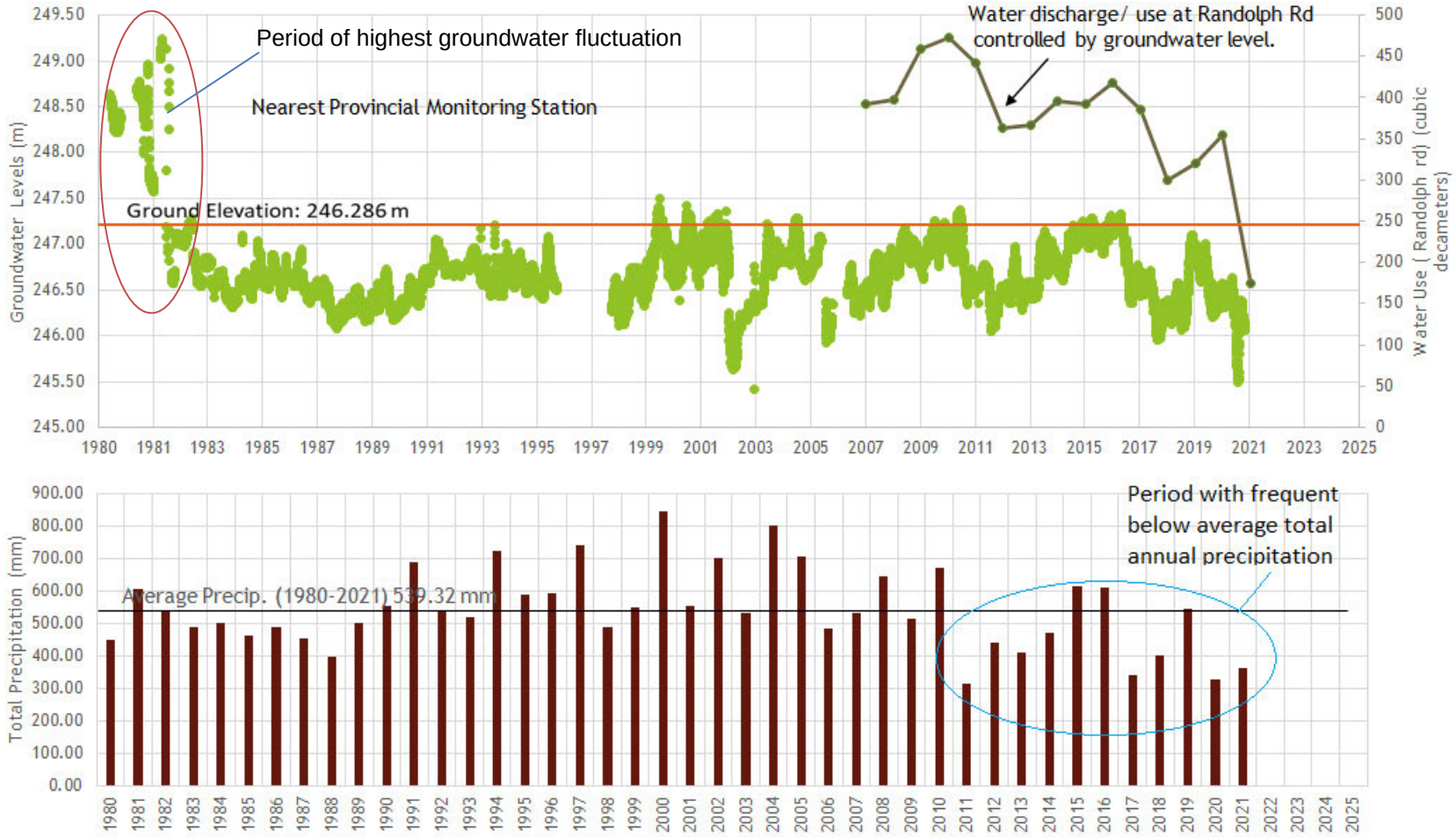


**Figure 13: Relationship between Precipitation, Water Levels and Groundwater discharge**

(Data Sources: MEC, 2022, Municipality of Ritchot, 2021, and Environment Canada, 2022)

Although the record is relatively short and a slight head difference is present, the hydrographs appear to be an exact image of each other, with each aquifer displaying similar changes in static water levels. This relationship between the sandstone and carbonate is demonstrated in the hydrograph record from station G05OE050/G05OE070, shown below as Figure 14. The hydrograph record at G05OE050/G05OE070 reflects conditions in a fairly "undeveloped" area of both aquifers, which are not overly affected by the pumping of either aquifer.

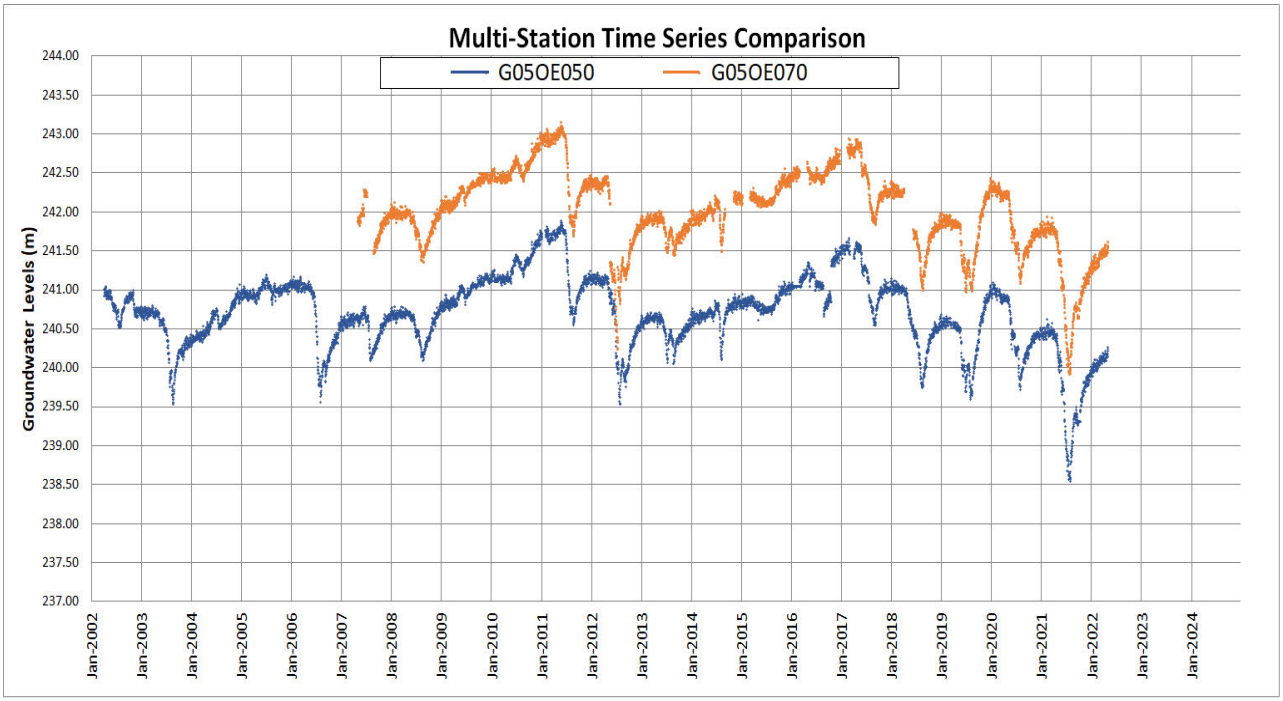


**Figure 14: Multi-station Hydrograph Comparison**

( Data Source: MEC, 2022)

An opportunity was presented, as part of this project, to conduct further monitoring of the relationship between the carbonate and sandstone aquifers in the Blumenort, New Bothwell, Steinbach and Randolph Well Field area. This project allowed for the instrumentation and monitoring of several wells completed into the carbonate and sandstone aquifer.

In Blumenort, New Bothwell, Randolph Well Field, and Steinbach, static water levels in the Winnipeg Formation are generally higher than water levels in the overlying carbonate aquifer. This condition has been documented in the area as far back as the early 1900's. It was known by local well drillers that drilling into the Winnipeg Formation sandstone would result in flowing conditions (J. Friesen, personal communication, 2007). However, pumping from the sandstone could sometimes cause the reversal of water levels in both aquifers.

For example, Figure 15, shown on the subsequent page, illustrates the hydraulic relationship between the sandstone and carbonate aquifer at the Granny's Poultry site in Blumenort wherein

the sandstone aquifer is extensively developed and the carbonate aquifer is utilized to a much lesser extent. The trends illustrate almost similar responses to pumping. The more irregular, cyclical pumping nature at the site is quite evident, along with their 5 days per week working schedule, with weekends off. During periods of operation, the levels in the sandstone aquifer decline to levels lower than the carbonate aquifer. The water use throughout the plant is also clearly not regular or consistent in any way, with some weeks using more water than others. Overall, the recovery data on the weekends is very consistent and regular. Despite the level reversal at times, is still evident that both formations showed similar trends in water levels.

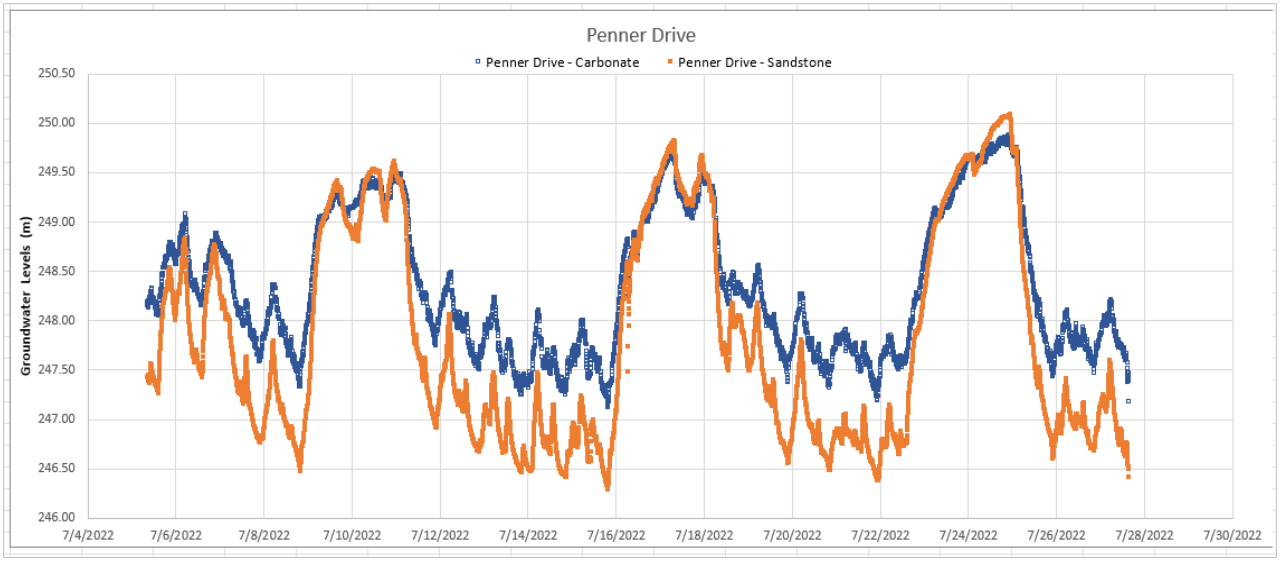


**Figure 15: Sandstone and Carbonate levels near major pumping site in Sandstone**

(Source: Friesen Drillers, 2022)

The Steinbach Well Field close to Main Street showed similar responses in the carbonate and sandstone aquifer, despite the fact that the City of Steinbach has been exclusively pumping from the carbonate aquifer in the last 30 years. Figure 16 shows the responses in the carbonate and sandstone aquifer in the existing Well Field. The responses demonstrate the level of interconnectivity between the two formations in the area. The sandstone aquifer appears to be almost perfectly connected in this location, with slightly different boundary conditions.

While the records are relatively very short, similar regional trends have been observed in the carbonate and sandstone aquifers from the newly installed nested monitoring well close to the Randolph Road Well Field. The hydrograph record is shown as Figure 17. Groundwater levels were up to 1.0 m (~3.3 feet) higher in the sandstone than in the carbonate aquifer. This is expected as carbonate aquifers are mainly developed in the area for water supplies, although interconnecting boreholes are also present. The hydrograph also shows that through the pumping of the carbonate aquifer, there is an immediate, yet somewhat dampened response in the underlying sandstone unit.

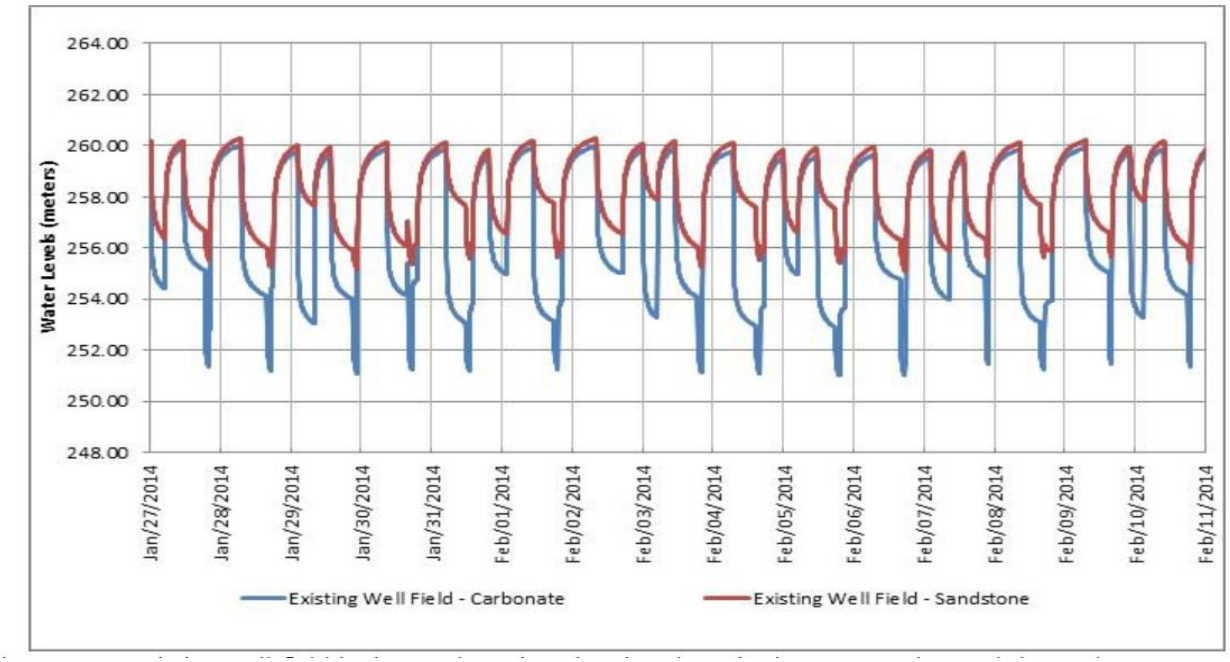


**Figure 16: Nested Observation Wells in Carbonate and Sandstone Aquifers – Near Steinbach the Steinbach Well Field on close to Main Street**

(Source: Friesen Drillers, 2014)

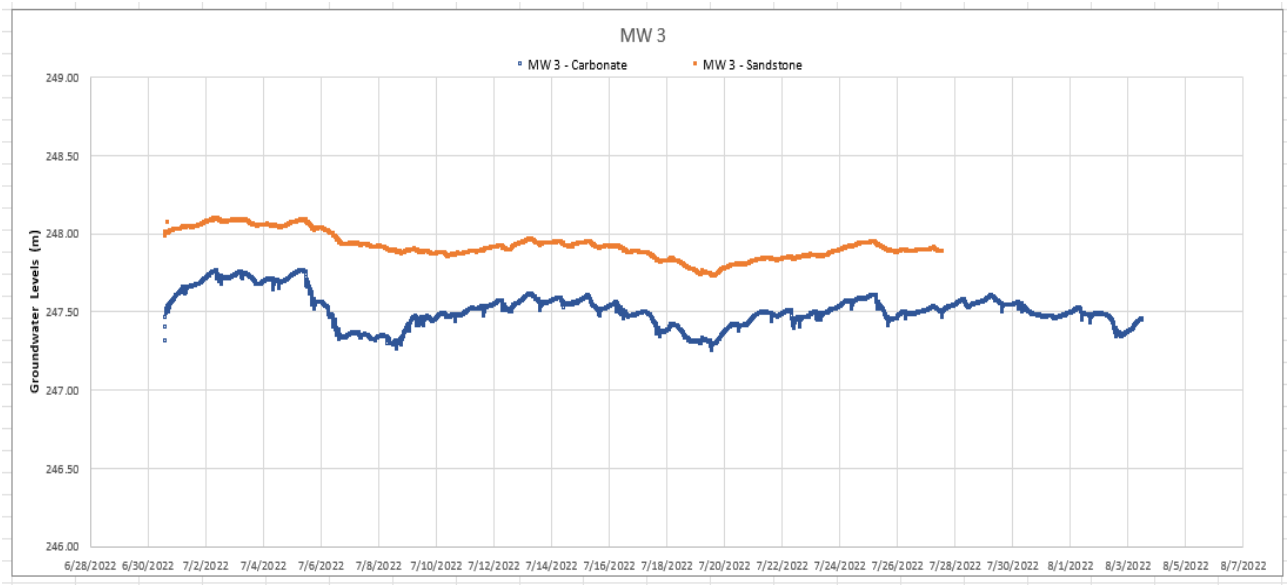


**Figure 17: Water levels in the Sandstone and Carbonate Aquifer near the Randolph Well Field Site**

(Source: Friesen Drillers, 2022)

It is interesting to note however, that testing and monitoring in some areas in southeast Manitoba indicate some separation between the two aquifer levels. Thus, while there is a strong hydraulic connection between the two formations in some places in southeast Manitoba, there are still places in the southeast where the responses from each formation are somewhat isolated.

For example, the water levels recorded close to the new Steinbach Well Field shown below as Figure 18, demonstrated significant differences in the carbonate and sandstone aquifer response during the period of record. Pumping at the more recent Steinbach Well Field was from the carbonate aquifer. The response in the carbonate aquifer was evident while the response of the water levels in the sandstone aquifer was highly muted. There appeared to be localized strong isolation of hydraulic stresses between the two aquifers. A similar trend has been observed during the pumping test completed in 2017 for the new Town of Niverville Well Field located approximately 1 mile west of the Town of New Bothwell. The recorded responses from both aquifers and that barometric pressure at the time of the pumping test are shown in Figure 19. In both instances, the levels recorded in the sandstone aquifer were also up to 1.0 m (~3.3 feet) higher than the levels in the carbonate aquifer.

Based on the regional relationship between the carbonate and sandstone levels, it is prudent to consider the effects of pumping on both aquifers in investigations completed in the area.

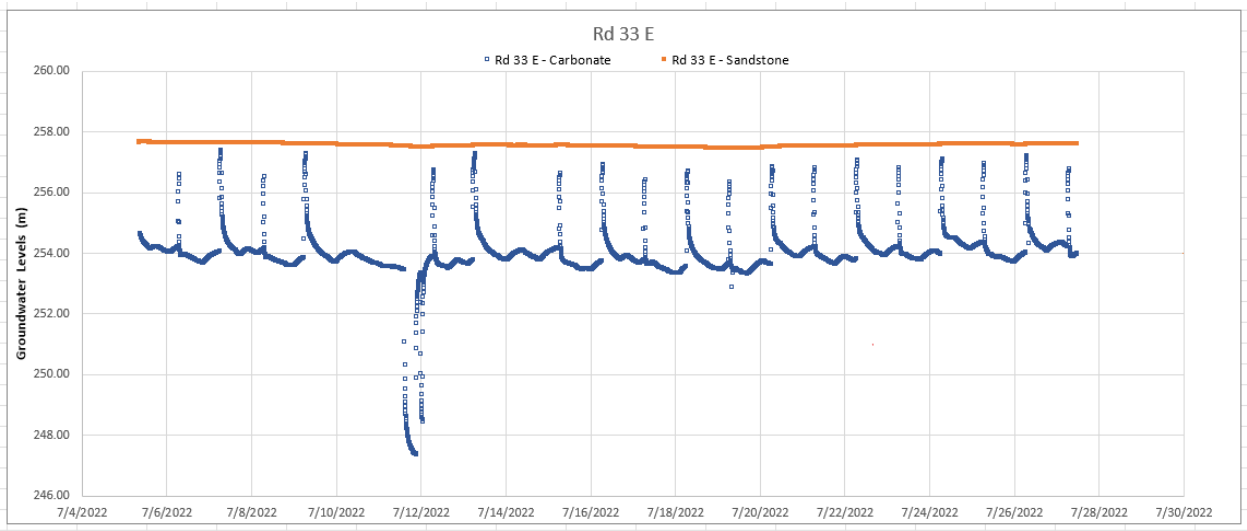


**Figure 18: Water levels observed in the Sandstone and Carbonate Aquifers near the new Steinbach Well Field**

(Data Source: Friesen Drillers, 2022)

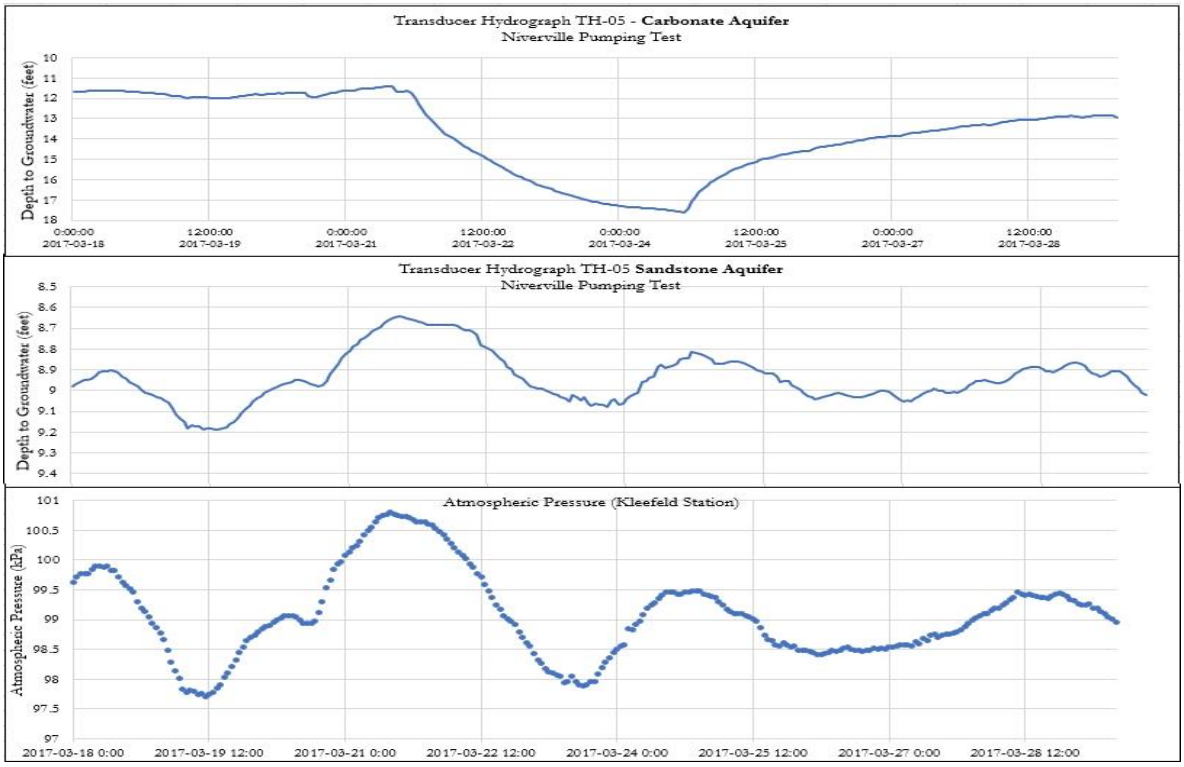


**Figure 19: Water level response and barometric pressure during the Niverville pumping test**

Note: Barometric pressure changes at the site closely resemble the fluctuations of the sandstone aquifer. (Source: Environment Canada, 2022 and Friesen Drillers, 2017)

As part of the MEC investigations into the aquifers in the southeast in 2008, Wang et. al. (2008), noted that most hydrograph records recovered after the 1991 dry period, with the exception of an area located southeast from Niverville and west of Steinbach. Wang et. al. (2008) concluded that this was the result of development pressure, as it was in a negative drawdown condition. The area is shown on a subsequent page as Figure 20.

This concept is somewhat difficult to accept, as there are no major production wells or consumptive groundwater users in the area, other than the LUD of Landmark, which does not consume a significant amount of groundwater, at the time of writing the Wang et. al. (2008) study.

It is speculated that the situation Wang (2008) refers to is drawdown in an area of constant head that has resulted from a project conducted by MEC in the 1970's, when the Seine River diversion channel was dug through the area. In an area west of Steinbach, the drain base of a tributary of the Manning Canal was subject to repeated blow outs from the high artesian Carbonate Aquifer conditions that were present. In order to lower the hydraulic heads in the area, relief wells were constructed and were allowed to drain through a pipeline to the Red River. Eventually this water was collected by the Municipality of Ritchot and became later known as the Randolph Road Well Field. The wells apparently discharged over 500 U.S.G.P.M. per well when originally

constructed. Since the installation, the static water levels have declined somewhat to the point that the flow rate is considerably less. According to some residents in the area, the drawdown in the aquifer has been noted in wells located several miles to the north, near the communities of Landmark and New Bothwell.

Figure 20 shows a negative drawdown of about -7 in the area around the LUD of Landmark, and about -1 in the area around Randolph Well Field. The units are not depicted on the map**,** although the rest of the paper uses meters. It is speculated that the "negative drawdown" discussed by Wang et. al. is a result of the MEC artificial head lowering and constant Carbonate Aquifer conditions caused by the south lateral drain head lowering project. Thus, the current water levels in the area are the new "state of equilibrium" for the area. It was noted by Wang (2014 – personal communication) that the discharge wells have been operating since the 1980's, and that the effects would already be complete by 1991. It should be noted that there are cases where 20 years or more may be required to observe the stabilization of groundwater levels resulting from long term discharge conditions. An example of this is the Red River Floodway, which took more than 20 years for the effects to stabilize.

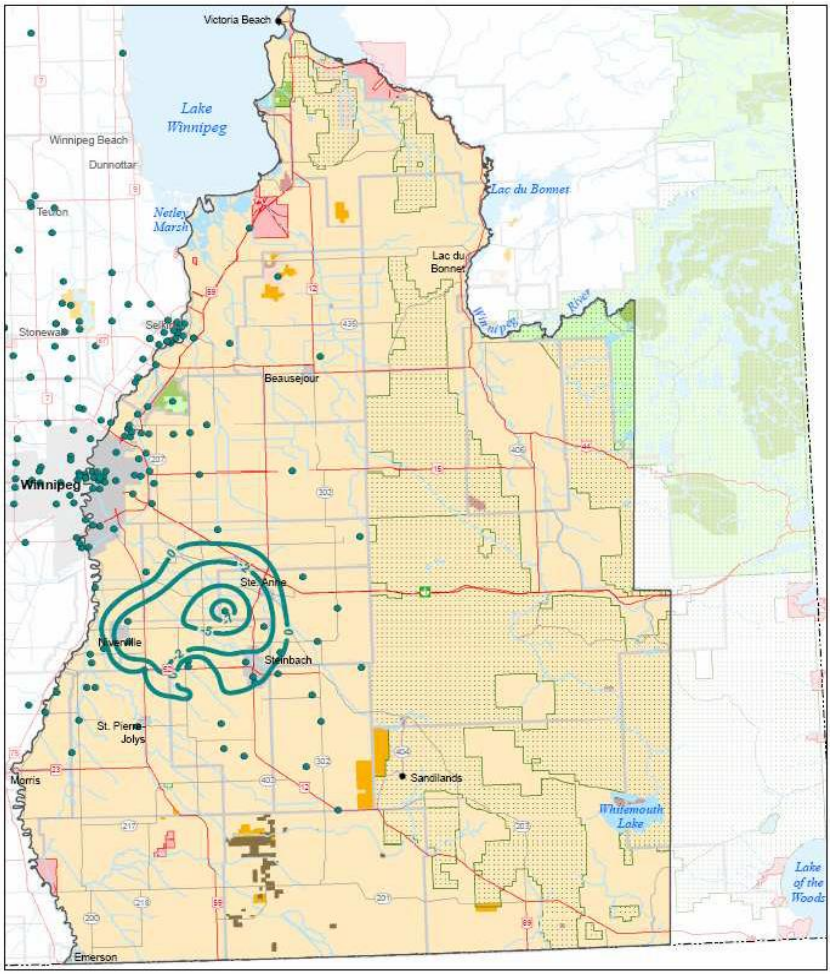


**Figure 20: Negative Drawdown in the Carbonate Aquifer – Southeast Manitoba**

Note: units not specified. (Source: Wang, et. al., 2008)

## 10.3 POTENTIOMETRIC SURFACE AND GROUNDWATER FLOW

Regional groundwater flow in both the sandstone and carbonate aquifers is generally from east to west in southeast Manitoba. The potentiometric surfaces in both carbonate and sandstone aquifers were mapped as Figure 21 and Figure 22. It is evident from these figures that the groundwater flow directions and hydraulic heads in both formations are similar.

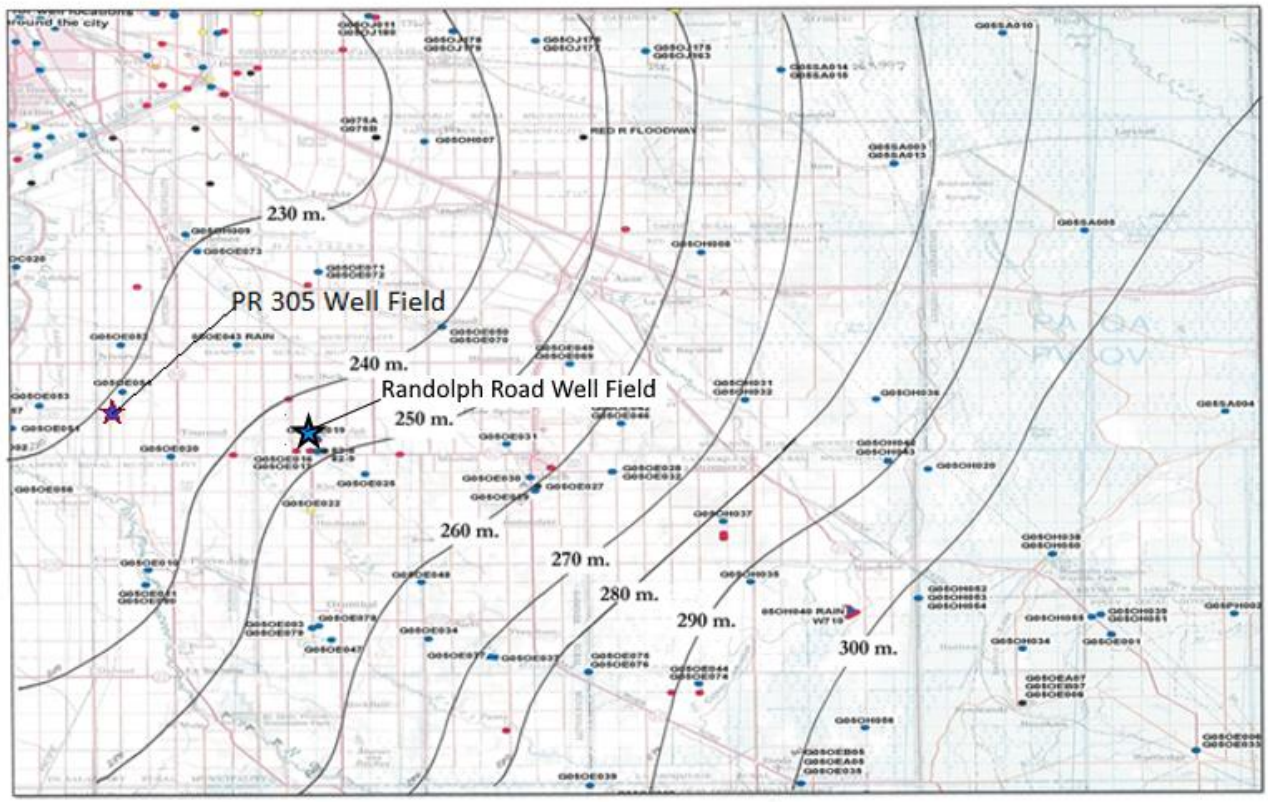


**Figure 21: Groundwater flow in the carbonate aquifer - Southeast Manitoba**

(Data source: MEC, 2014)

Groundwater flow in the carbonate bedrock generally occurs through secondary features such as fractures, bedding planes and joint sets in the rock. The size, extent, and interconnectivity of the fracture system govern horizontal and vertical groundwater movement through the bedrock (Betcher et. al., 1995). Due to this geologic condition, aquifer transmissivity and storativity can vary significantly over a relatively short distance, resulting in substantial variations in well yield.

Groundwater flow in the Winnipeg Formation Sandstone is through the weakly cemented, poorly consolidated quartzose sandstone. The thin marine shale sequence acts as an aquitard between the sandstone and carbonate aquifers (Betcher et. al., 1995).

The hydraulic gradient in the carbonate aquifer in the Municipality of Ritchot Randolph Road Well Field area was determined to be about $8.49 \times 10^{-4}$, and a resultant vector of about 312 degrees. The flow direction in the sandstone was estimated to be almost the same, with a similar gradient.

The carbonate bedrock in the southeastern area of Manitoba generally has moderate to high permeability, with transmissivity values ranging from 30,000 to 150,000 U.S.G.P.D./ft. Due to the fractured rock nature of the aquifer, the permeability varies substantially with distance. Wang et al., (2008) determined the hydraulic conductivity of the Winnipeg Formation Sandstone to be about 2.38 x $10^{-5}$ m/s. Assuming about 100 feet on average for a formation thickness, the transmissivity was estimated to be about 5,000 U.S.G.P.D. /ft. on average.

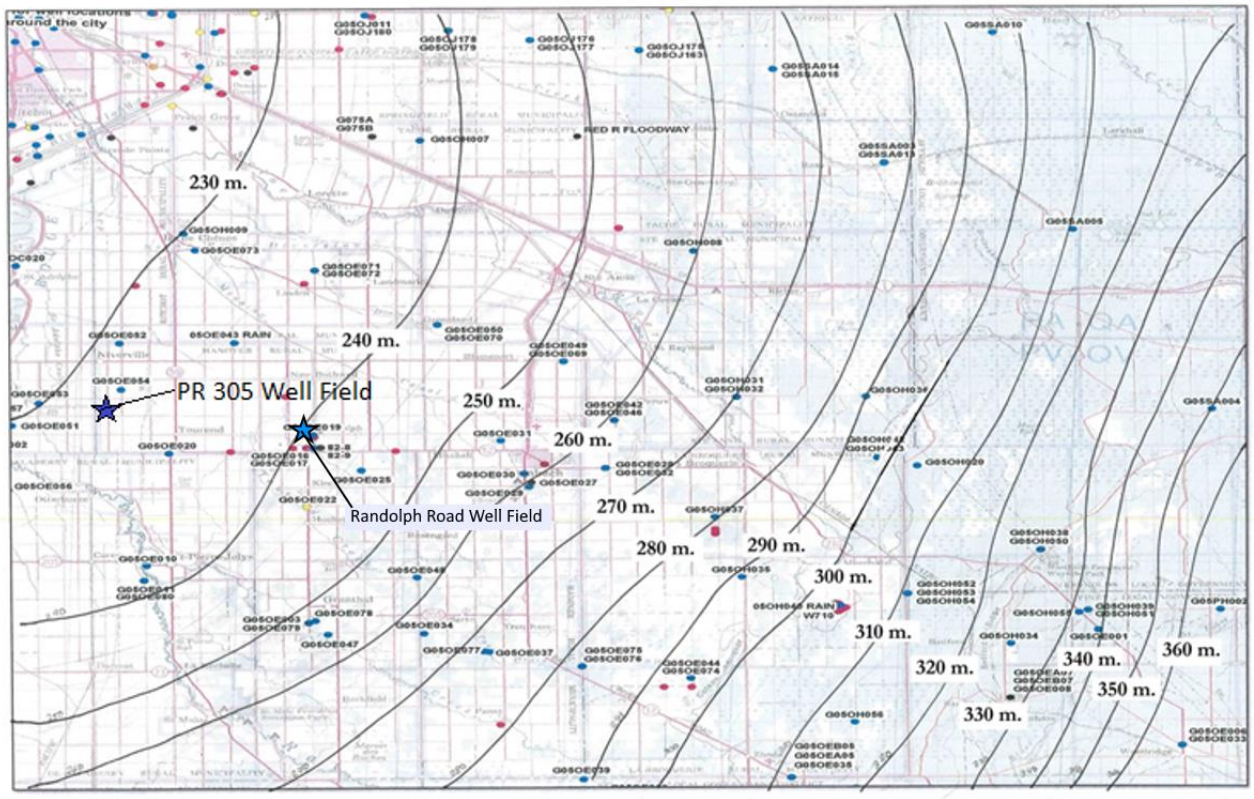


**Figure 22: Groundwater flow in the sandstone aquifer - Southeast Manitoba**

(Data source: MEC, 2014)

## 10.4 INTERCONNECTION OF REGIONAL AQUIFERS

Inter-formational flow between the overlying carbonate aquifer system and the underlying Winnipeg Formation has been of considerable interest in the southeast Manitoba region, particularly east of the Municipality of Ritchot and the PR 305 Well Field, towards the Randolph Road Well Field, where both aquifers are fresh and are considered major groundwater aquifers (Betcher, 1986). The thin marine shale sequence overlying the sandstone is thought to be a highly effective aquitard, thereby isolating the two units. Betcher (1986) suggested the significant geochemical differences between the two formations as evidence of the effectiveness of the aquitard. In the Winnipeg area, the Winnipeg Formation shale separates the saline/brackish glaciogenic groundwater of the formation with the overlying freshwater of the carbonate aquifer.

It is highly likely that some fluid movement occurs through the Winnipeg Formation shale. However, in applying the Ghyben-Herzberg relationship, similar hydraulic heads between the two aquifers would be expected to yield little fluid transfer between the two formations. In reviewing the theory of saline/freshwater boundaries in porous media aquifers, we note the Ghyben-Herzberg relation, which states that in the event of a 1.0 foot drop in the static water level of an unconfined coastal aquifer, the saline water interface will rise approximately 40 feet (Freeze and Cherry, 1979). The extent of the fluid movement between the two formations across the Winnipeg Formation shale is not completely known at this time.

Betcher and Ferguson (2003) reported that in some parts of southeastern Manitoba, particularly near the City of Steinbach, interconnecting boreholes have resulted in localized losses in the naturally softened groundwater from the Winnipeg Formation and localized water quality changes in the carbonate aquifer. They further estimated that the volumetric discharge between the carbonate aquifer and sandstone aquifer is approximately 750 L/day (~0.14 U.S.G.P.M) for every 1.0 meter (~3.3 ft.) of head difference between the two aquifer formations, as shown in Figure 23.

Around the Steinbach area, the Sandstone aquifer is thought to have approximately 1.5 meter of head above the carbonate aquifer level, under a no pumping state. This level rises somewhat towards the west. In Ile des Chênes, the groundwater level in the sandstone is about 3.5 m higher than the overlying carbonate aquifer. This is logical, as there are more opportunities for discharge on the carbonate aquifer than there would be for the Winnipeg Formation Sandstone aquifer. It is known that pumping either of the formations separately will cause a comparable decrease in aquifer pressure in the non-pumping formation, in some areas in southeast Manitoba.

In addition to the hydraulic relationship between the two aquifers, there is also a geochemical relationship between the two aquifers.

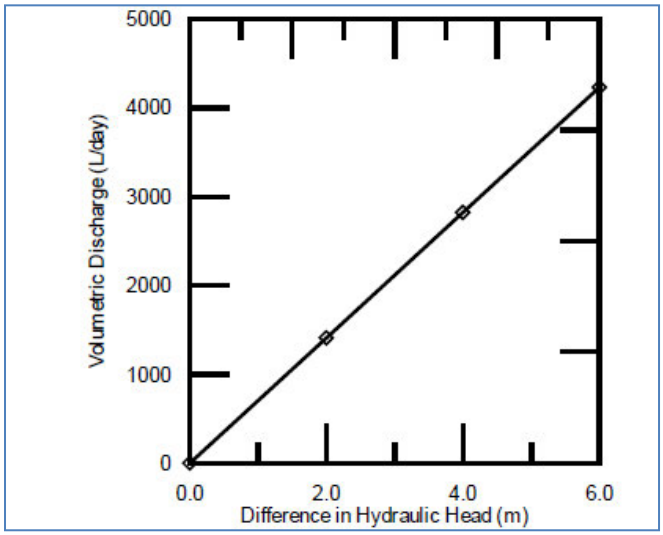


**Figure 23: Relationship of Volumetric Discharge for a Given Head Difference between the Carbonate Aquifer and the Sandstone Aquifer.** (Source: Betcher and Ferguson, 2003)

## 10.5 REGIONAL GROUNDWATER GEOCHEMISTRY

The geochemistry of the two bedrock aquifers in the southeast of Manitoba is complex. In the geologic past, prior to the start of the Pleistocene glaciations, it has been proposed that both aquifers contained saline or brackish groundwater (Betcher et al., 1995). Due to the recharge dynamics of the moraine features, the aquifers began to receive a large influx of freshwater recharge annually. This recharge resulted in a freshwater presence in both the Carbonate and Winnipeg Formation aquifers. The freshwater portion has formed a wedge in the southeast of the province. Figures 24 and 25 depict the freshwater portions of the carbonate and Winnipeg Formation aquifers, respectively. Groundwater with total dissolved solids (TDS) concentrations of less than 1g/L (1,000 mg/L) was considered freshwater.

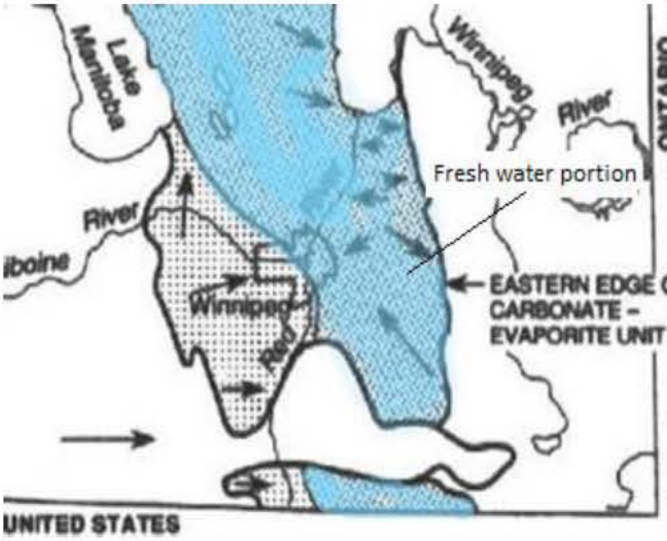


**Figure 24: Carbonate Aquifer freshwater areas**

Note: Blue shaded area contains TDS values less than 1 g/L (1,000 mg/L).

(Source: Betcher et al., 1995.)

**Figure 25: Sandstone Aquifer freshwater areas**

Note: Green shaded area contains TDS values less than 1 g/L (1,000 mg/L).

(Source: Betcher et al., 1995.)

The total dissolved solids and chloride concentration data from provincially maintained regional monitoring stations in the area were also obtained and mapped to provide more detail to the Betcher (1995) mapping of the freshwater-brackish water boundary close to the Randolph Well Field area. The density of the hydrograph stations provides a reasonable density for the purposes of mapping of the regional groundwater quality within the southeast. The resulting freshwater-brackish water boundary is shown in Figure 26.

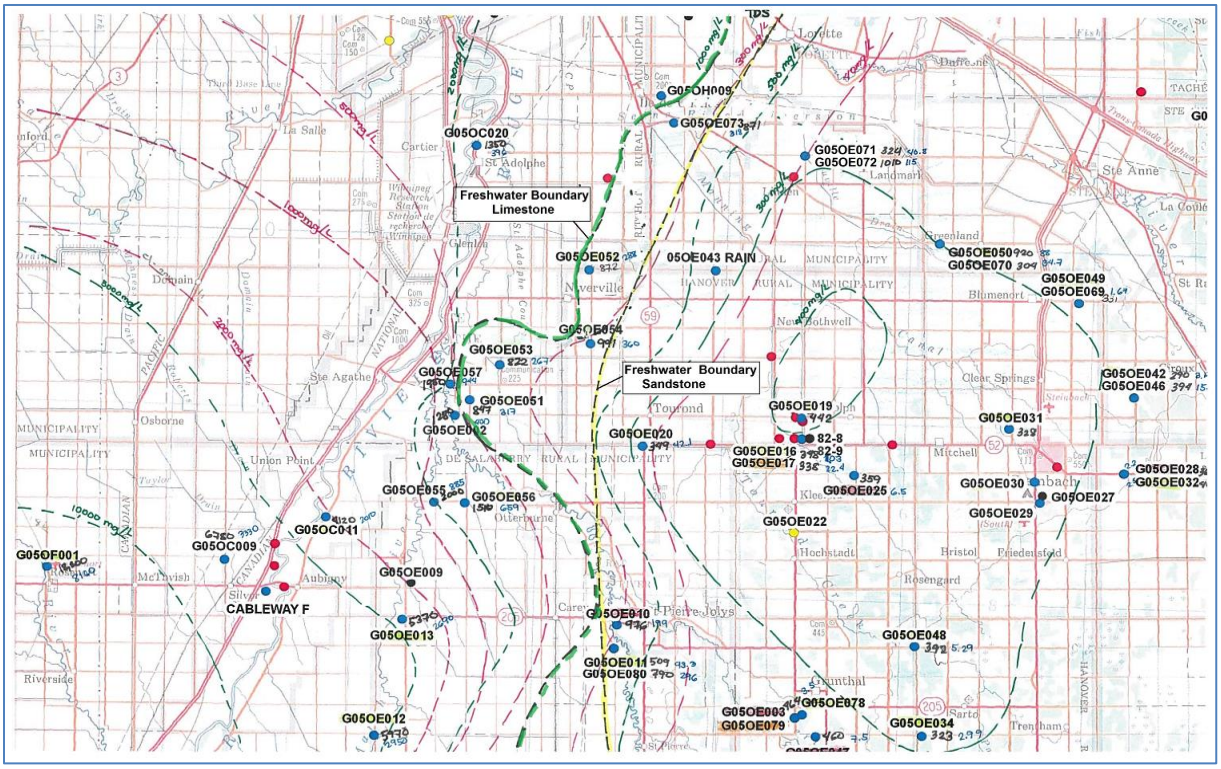


**Figure 26: Freshwater Boundaries of the Carbonate and Sandstone Aquifers**

Note: Green lines – TDS, Red lines –Chlorides

(Source: Modified from Betcher 1992 and MEC, 2014 – Chris Romano)

Available geochemistry data from provincially maintained monitoring stations were also utilized to create a trilinear diagram to compare the regional chemistry in the near the Randolph Road Well Field.

The following stations were used for the review.

- G05OE072 – Carbonate Aquifer
- G05OE052 – Carbonate Aquifer
- G05OE054 – Carbonate Aquifer
- G05OE053 – Carbonate Aquifer
- G05OE057 – Carbonate Aquifer
- G05OE055 – Carbonate Aquifer
- G05OE019 – Carbonate Aquifer
- G05OE050 – Carbonate Aquifer
- G05OE073 – Sandstone Aquifer
- G05OE071 – Sandstone Aquifer
- G05OE069 – Sandstone Aquifer
- G05OE070 – Sandstone Aquifer
- G05OE017 – Sand and Gravel Aquifer
- G05OE025 – Sand and Gravel Aquifer
- G05OE046 – Sand and Gravel Aquifer
- G05OE051 – Sand and Gravel Aquifer

The resulting figure is shown as Figure 27, below.

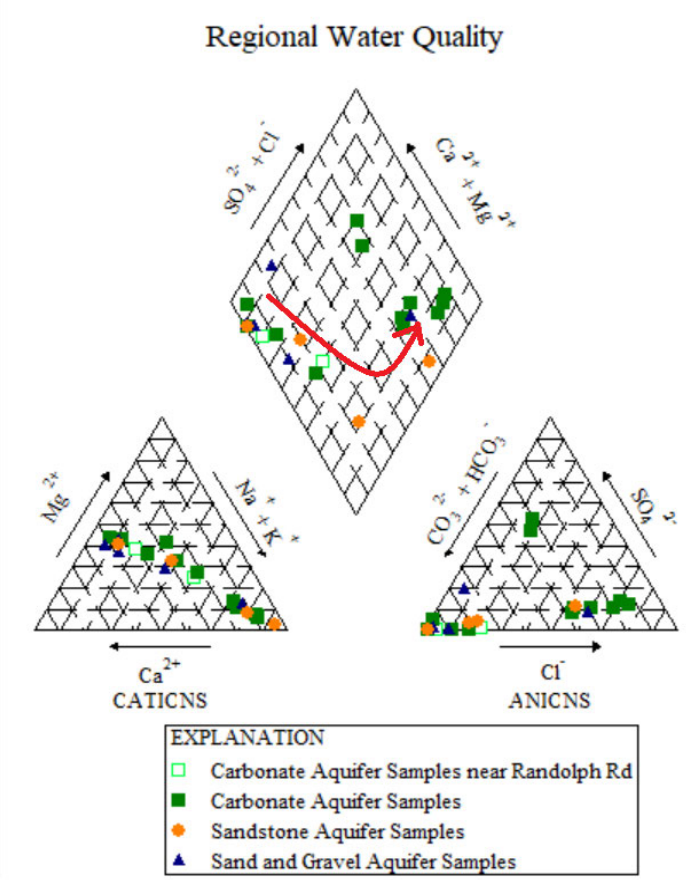


**Figure 27: Regional groundwater chemistry of the Carbonate, Sandstone and Sand and Gravel Aquifers**

Note: Red arrow shows generally increasing Calcium, Sodium and TDS concentrations from the southeast to the northwest. (Data Source: MEC, 2014 – Chris Romano)

Groundwater quality is variable in both sandstone and carbonate aquifers and generally declines towards the west (Betcher et al., 1995).

Groundwater flow from the recharge area results in increasing concentrations of major ions and total dissolved solids as it moves to the west. The flushing action of recent recharge through the aquifers acts as a natural softening of groundwater in the Winnipeg Formation. The freshwater does not move uniformly through the aquifer, as shown by Phipps et al., (2008). In addition, the range in ion concentrations between the carbonate aquifer, sandstone aquifer and sand and gravel formations are shown on Table 2.

**Table 2 – Comparison of sandstone, sand and gravel and carbonate aquifer routine geochemistry.**

| Table 2<br>Comparison of Carbonate, Sandstone and Sand and Gravel Groundwater Chemistry<br>Proposed Municipality of Ritchot Water Supply Alteration<br>Randolph Road Well Field - SE 8-7-5 EPM | | | |
|---|---|---|---|
| **Parameter** | **Carbonate Aquifer** | **Sandstone Aquifer** | **Sand & Gravel Aquifers** |
| Calcium (Ca) | 31.9 - 87.6 mg/L | 12.1 – 67.3 mg/L | 32.8 – 77.7 mg/L |
| Magnesium (Mg) | 16.3 - 71.8 mg/L | 3.88 – 35.4 mg/L | 29.7 – 35.6 mg/L |
| Sodium (Na) | 9 - 725 mg/L | 17.6 - 312 mg/L | 12.3 - 229 mg/L |
| Potassium (K) | 2.98 - 22.2 mg/L | 6.98 – 19.9 mg/L | 3.23 – 8.24 mg/L |
| Carbonate ($CO_3$) | < 0.5 mg/L | < 0.5 mg/L | < 0.5 mg/L |
| Bicarbonate ($HCO_3$) | 281 - 434 mg/L | 286 - 416 mg/L | 281 - 442 mg/L |
| Chloride (Cl) | 2.5 - 944 mg/L | 1.67 - 318 mg/L | 2.2 - 317 mg/L |
| Sulphate ($SO_4$) | <0.5 - 371 mg/L | <1 - 86.7 mg/L | <1 – 62.8 mg/L |
| Total Dissolved Solids (TDS) | 290 - 2000 mg/L | 304 - 871 mg/L | 338 - 847 mg/L |

(Data source: MEC, 2014 – Chris Romano)

Water quality in the carbonate aquifer system is complex and is representative of the proximity to recharge areas. As groundwater flows away from the recharge areas, the amount of TDS tends to increase. The increased TDS in the carbonate aquifer primarily results from increased ionic concentrations of sodium, potassium and sulfate and to a lesser extent, chloride (Betcher et al., 1995). The changing ionic composition is representative of a transition from subglacial recharge mixed with modern meteoric recharge to subglacial recharge mixed with older basin brines (Ferguson et al., 2003). Water quality is the poorest in the far western areas of the region, along the Red River where total dissolved solids can exceed 1,200 mg/L. Overall, post glacial water is actively moving through the system from southeast to northwest and radially outwards from the Sandilands area (Render, 1970).

Phipps et al., (2008) mapped the groundwater quality in the carbonate aquifer in southeastern Manitoba. This mapping, shown as Figure 28, illustrates the high variability of groundwater quality in the region.

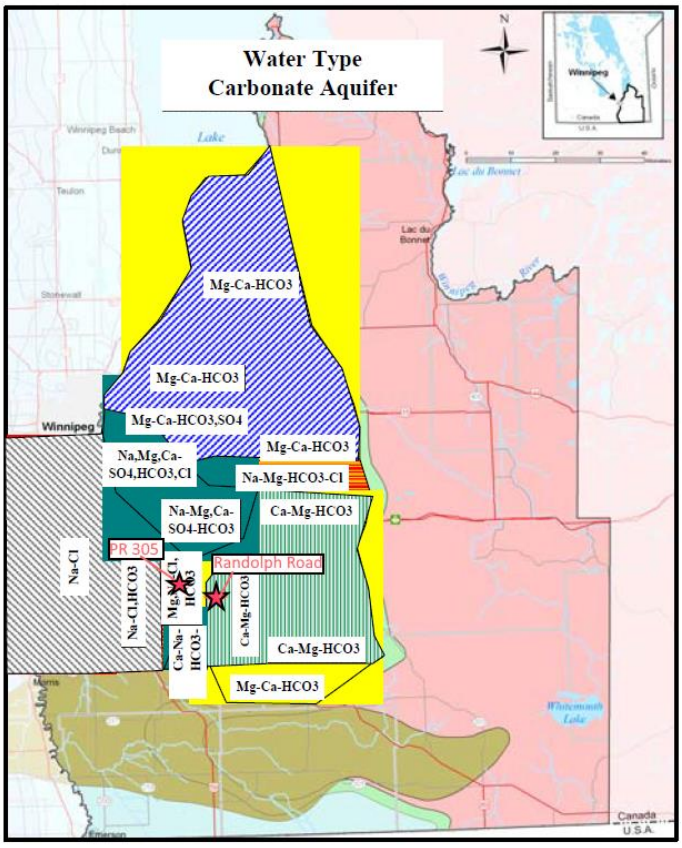


**Figure 28: Groundwater Types - Carbonate**

(Modified source: Phipps et al., 2008)

Groundwater chemistry ranges from good quality, Ca-Mg-$HCO_3$ type groundwater to poorer quality, Na-K-Cl/Sulfate type groundwater. Better quality groundwater is generally located towards the southeast of the region and gradually deteriorates towards the north and west, as would be expected from the regional flow dynamics.

The water supply well fields for the Municipality of Ritchot are of slightly different water quality. The groundwater from the carbonate aquifer underlying the PR 305 Well Field is of Na-Cl-$HCO_3$ type which is a result of the increase in ionic concentrations as the groundwater accumulates more dissolved components as it passes through the ground surface. The groundwater quality also changes to poorer quality water, as the groundwater moves towards the Red River, to the west of the site. The water quality of the carbonate aquifer underlying Randolph Road Well Field is classified as Ca-Mg-$HCO_3$ type which is typical of areas closer to the aquifer recharge.

The basal Winnipeg Formation sandstone is expected to be brackish within the PR 305 Well Field site. Near the Randolph Road Well Field Site, water quality changes to the Ca-Mg-$HCO_3$ type. In the Steinbach/Blumenort area, the water quality in the carbonate is expected to be very similar to the underlying sandstone aquifers. It is noted that the calcium and bicarbonate concentrations in

the sandstone exceed the concentrations in the carbonate aquifer, while the sodium, chlorides, and sulphates of the sandstone are lower (Bell, 2014).

Groundwater quality in the sand and gravel aquifers within the Municipality of Ritchot boundary is not well documented. There are no regionally mapped sand and gravel aquifers within the Municipality. Sand and gravel deposits near the Randolph Road Well Field are of the Ca- $HCO_3$ type. Groundwater from sand and gravel aquifers are generally relatively fresh with low TDS concentrations. In many places in Manitoba, groundwater in sand and gravel aquifers also contains elevated concentrations of iron. In addition, the shallow burial depth and unconfined aquifer conditions of many sand and gravel aquifers generally increase the potential for elevated nitrate concentrations, anthropogenic, and bacteriological risks. Local monitoring is important where sand and gravel aquifers are developed for water supplies.

It should be noted that in some places in southeast Manitoba, concentrations of barium have been reported to exceed 1.0 mg/L. The maximum acceptable concentration (MAC) of barium in drinking water was set to 1.0 mg/L in the past and was only increased to 2.0 mg/L in 2020 (Health Canada, 2022). This has been a concern in some parts of southeast Manitoba, particularly in the Kleefeld - Grunthal area where the Barium concentrations have sometimes exceeded the previous 1.0 mg/L limit. This has also been somewhat of an issue in areas where both carbonate and sandstone aquifers have been extensively interconnected. The reason for the increased barium is not well understood. However, it is probable that this was a result of groundwater mixing between the carbonate and sandstone aquifers in those areas. Betcher et al., (2003) suggested that barium concentrations in groundwater are controlled by barite solubility which increases when sulfate concentrations are very low (<15 mg/L).

The update in the MAC limits for barium concentrations to 2.0 mg/L meant that several water supply systems now fall within the drinking water standards without the requirement of water treatment to remove high barium in the groundwater.

The available chemistry data of the four nearest monitoring stations completed in the carbonate to the Randolph Road Well Field; GO5OE016, GO5OE019, GO5OE020, and GO5OE031 were reviewed for Barium concentrations. Based on available data, barium concentrations from the stations reviewed ranged from 0.191 mg/L to 0.31 mg/L and do not appear to be an issue in the area. However, it is recommended that continued groundwater sampling and monitoring be completed at the site.

In addition to barium, naturally occurring arsenic is also found in the groundwater in some parts of Manitoba. It should be noted though that the source and geochemical conditions producing the arsenic in the aquifers in Manitoba are still not well documented (Betcher, 1995). The water quality sampling of the four closest hydrograph stations produced Arsenic values between <0.0002 mg/L to 0.005 mg/L. The available data on arsenic values are below the MAC of 0.010 mg/L (Health Canada, 2022).

Fluoride concentrations exceeding the 1.5 mg/L MAC limit (Health Canada, 2022) is also known to exist in some areas southeast Manitoba. A review of the chemistry results of the four nearest hydrograph stations to the site indicated a range of concentrations between <0.1 mg/L to 0.71 mg/L in the area which falls below the MAC.

During field investigations in the southeast Manitoba by MEC, groundwater samples were collected for the analysis of the stable environmental isotopes of $^{18}$oxygen and deuterium. The ratios of the main isotopes that comprise the water molecule ($^{18}O/^{16}O$) and $^{2}H/^{1}H$ are important for hydrogeological investigations (Freeze and Cherry, 1979). The units are presented in delta (δ) units as parts per thousand or ‰, relative to standard mean oceanic water (SMOW) (Freeze and Cherry, 1979).

The isotopic composition of water dictates the freezing and vapour points, which leads to variable concentrations as a result of freezing, condensation, melting, and evaporation (Freeze and Cherry, 1979). As water evaporates from the ocean, there is a decline in the $^{18}O$ concentration by a specific amount. As the vapor condenses, the precipitation has a higher $^{18}O$ concentration. This process continues as the vapor moves inland and undergoes many cycles of condensation and evaporation. This fact makes deuterium and $^{18}O$ very useful for hydrogeological investigations, as the origin and mixing of different waters can be determined.

In order to determine the changes from local precipitation, deuterium and $^{18}O$ results are plotted against the local meteoric water line, which represents the typical concentration of recent precipitation events in the southeast. It should be noted that the term meteoric water, refers to water which is derived from precipitation and includes water found at the surface and in the shallow subsurface, including rivers and lakes.

Phipps et al., (2008), conducted sampling of approximately 50 MEC observation and monitoring wells in 2008, as part of the southeast groundwater study. These results were plotted against a local meteoric water line, which was determined to be $\delta^{2}H = 7.6 \cdot \delta^{18}O + 2.2$, which is virtually the same as the local meteoric water line (LMWL) for the Gimli area (IAEA, 2012).

The local isotope plots in southeast Manitoba is shown in Figure 29. The various aquifers in the southeast are identified in the plot.

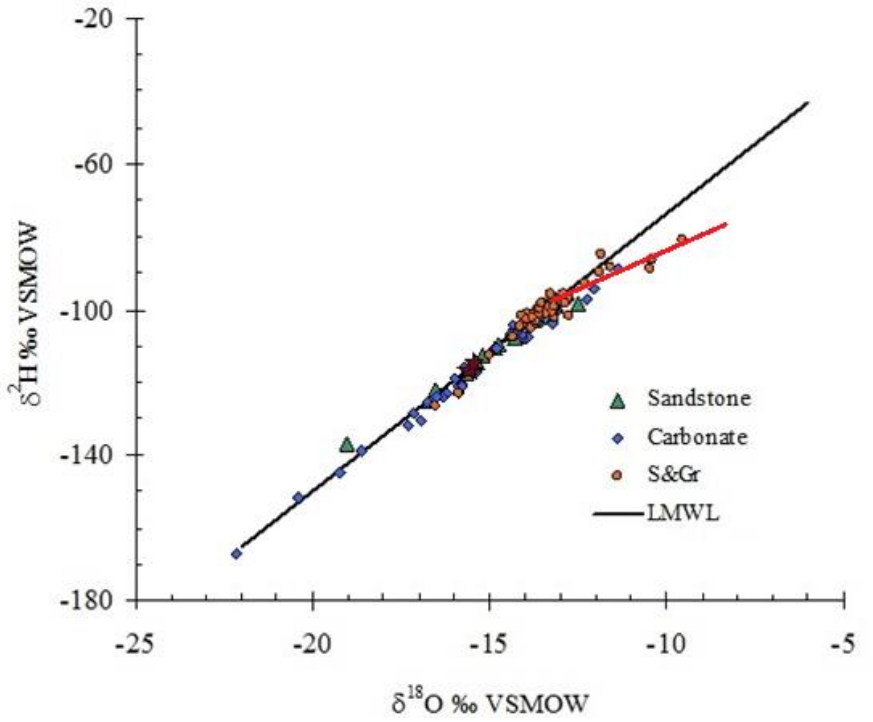


**Figure 29: Local isotopes in the southeast of Manitoba**

Note: red line approximates the evaporitic water line. (Source – Phipps et al., 2008)

The values indicate a range in isotopic concentration, however, nearly all groundwater samples plot along the LMWL, which suggests the water has undergone little modification since falling as precipitation. There is an indication of a slight slope change resulting from snow melt infiltration at the upper ranges of the plot, where sample points follow an evaporitic trend line (Fritz & Clark, 1997). The evaporitic isotopic values are predominantly from samples collected from sand and gravel aquifers, mostly obtained from the recharge moraine area. It should be noted that highly depleted samples are shown to the left on the local meteoric water line, which indicate recharge under very different climatic conditions. This is likely hold over water from the Pleistocene glaciations.

The isotope results indicated that the most recent groundwater is generally found in sand and gravel aquifers and in the eastern portions of the bedrock aquifers. Groundwater in both the carbonate and sandstone aquifers exhibited a full range of isotopic composition, from recent to ancient meteoric, with older waters typically located towards the west. These results are further evidence of the westerly flow regime through the region.

# 11 WELL INVENTORY

The Groundwater Exploration Permit issued by the Water Use Licensing Section stipulated that a well inventory with 1.0 mile radius (or greater) of the proposed well field is required for the project. There were no specific requirements for completing the inventory in the permit. The well inventory was completed in two parts. The first part was a desktop inventory using the provincial database, GWDRILL (2019). The second part of the well inventory was a site-specific well inventory with residents who allowed/arranged for the inspection. Due to the timing of timing of the project, the well inventory and the public consultation process was completed using virtual meetings and presentations to the residents. The well inventory consisted of phone interviews with the water well users registered in the area.

## 11.1 DESKTOP WELL INVENTORY (2.0-MILE RADIUS)

The review of the provincial database (GWDRILL, 2019) indicated that there are up to 168 water wells surrounding the Randolph Road Well Field site. Some of the well logs indicated drill dates as early as 1900's, however, it is evident that some of the older wells contained in the GWDRILL (2019) database have been subsequently replaced with newer PVC cased wells. The database included multiple water wells constructed for the same owner over the years. The current conditions of the wells in the database, other than those included in the site-specific well inventory, are not known. The range of well completion is between 1900 to 2018, with approximately 40 percent of the wells constructed in the 1990's or later.

Over 90 percent of the reported water wells were completed in the carbonate aquifer, with a minority of the wells completed in the overburden sand and gravel. Due to the generally ample water supply and good water quality from the carbonate aquifer, most of the wells were not completed in the deeper sandstone aquifer. The additional drilling depth, extra drilling cost, and the decreasing water quality to the west, has likely hindered drilling into the sandstone formation. Very few wells in the area were constructed to intersect the Winnipeg Formation Aquifer. There were a few observation and production wells completed in the overburden sand and gravel aquifer.

The majority of the wells in the area noted flowing conditions, with maximum recorded groundwater levels up to 17 feet above grade level. However, recent well installations in the area in the last 5 years generally recorded a range of groundwater levels within 10 feet from ground surface (above and below grade level).

In 2016, the Province of Manitoba mapped the flowing and high water level areas in Manitoba. The section of the map showing the Randolph Well Field is shown below as Figure 30. The map showed that the highest recorded water levels in the area is more than 3 meters (~9.84 feet) above grade level (Groundwater Management Section, 2016).

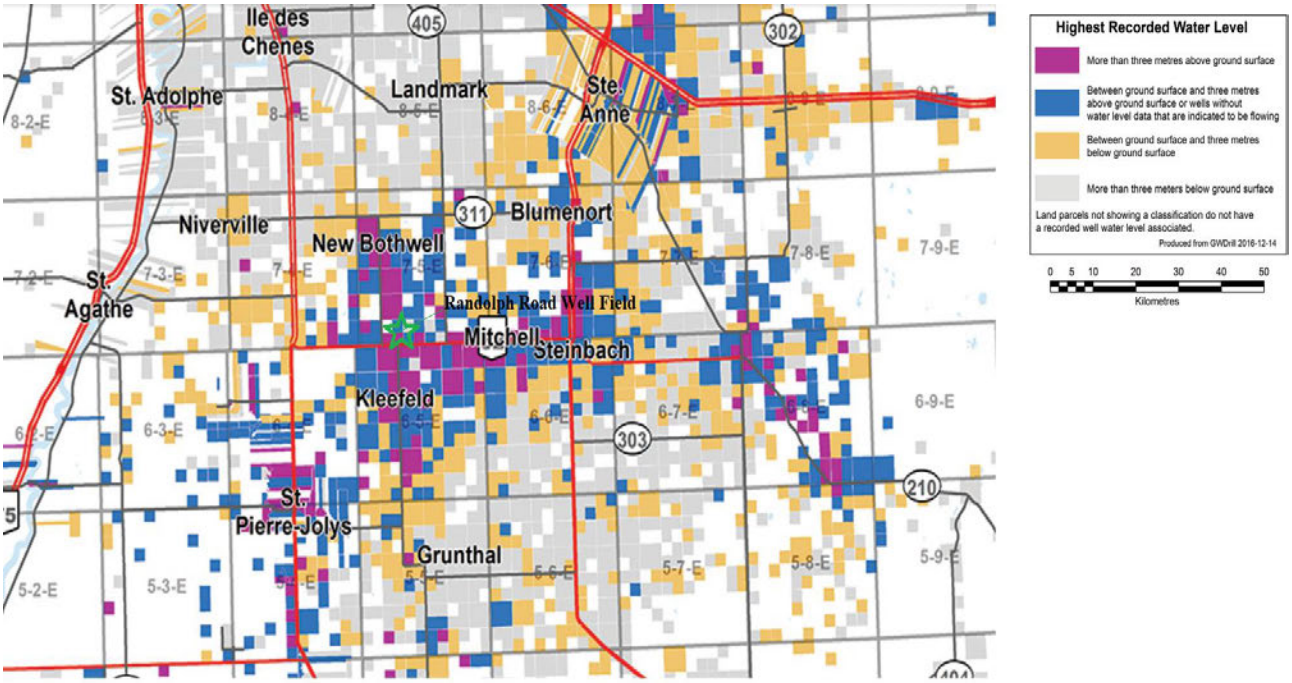


**Figure 30: Flowing and High Water Levels Map - Manitoba**

(Source: Groundwater Management Section, 2016)

The provincial database ( GWDRILL, 2019) noted 44 wells within 1 mile of the site. The majority of the wells listed in the GWDRILL (2019) database were noted to be outside of the 1-mile radius but within the 2-mile radius of the project site. The results of the 2-mile radius desktop well users' inventory is attached in Appendix D.

In addition to the GWDRILL (2019) database review, the Provincial Water Licensing Portal Mapping Tool was accessed to obtain information for existing water rights licenses in the area. Through a review of the files, a few hog barn operations in the area licensed to take groundwater were also noted within a two-mile radius of the site. The licence for each of these hog barn operations were less than 50 $dam^3$/year. The two major licensed users in the area are Bothwell Cheese and the Town of Niverville located over 3 miles from the Randolph Well Field site.

## 11.2 Site Specific Well Inventory (2.0-mile Radius)

The site-specific well inventory was completed from January to May 2022. During the initial public open houses and events for the project, Landmark Planning staff invited residents in the area to be part of the process by joining a mailing list for communication. A mailing list was also requested from the Rural Municipality of Hanover to send invitations for the well inventory. Once the well locations were finalized, staff from Landmark Planning sent letters to all landowners in the area

requesting participation in the well inventory. Registered letters were also sent to residents within 2-mile radius of the site to encourage participation.
A total of 27 landowners within the project site contacted Landmark Planning staff to arrange for the well inventory. Some of the participants have either multiple wells in their property or multiple sites. Overall, a total of 41 wells were recorded during the site-specific well inventory.

The site-specific well inventory was conducted through phone interview and made use of a short questionnaire to initiate the interview with participating well owner. The questionnaire included queries about well depth, drilling date, drilling company, pumping system, and water quality. In addition, the well users were requested to provide pictures of the wells and pumping system. Any questions, comments, and concerns from well owners presented during the interview were also documented. The details from the site-specific well inventory were cross referenced with the available logs from GWDRILL (2019). The results of the site-specific well inventory for the 27 residents, and a table of the results is included in Appendix D.

Approximately 30 percent of the wells in the inventoried area reported using submersible pumps. Most of the wells were using single line suction pumps. Due to the generally high static water levels in the carbonate aquifer, a few wells did not have pumps installed. Less than 35 percent of the wells were drilled after 1990 using modern PVC well casing and hook up. Well users who knew the approximate date of the well installation reported well installations between 1910 to 2020. Multiple residents reported losing pressure in 2020 and in 2021. Some residents also reported having leaking pipes and freezing well heads in the winter.

Overall, a significant number of wells in the area appear to be buried or do not appear to be maintained. It is highly likely that some of the older wells in the area have perforated casings which may potentially act as pathways for contaminants to enter the well. There are also unsealed abandoned wells in the area.

The majority of the well users in the area also reported hard water and high iron content which are typical in the carbonate aquifer in the Randolph/ New Bothwell /Kleefeld area.

In Manitoba, it is the well owners' responsibility to maintain their wells and manage the safety of their wells. Corroded and pitted well casing, broken well casing and casing joints, and wells in pits provide direct pathway for bacteria and other contaminants to enter the aquifer, creating safety concerns to the groundwater supply source. Groundwater quality should also be regularly checked if the well is used for human consumption. The specific capacity of wells typically decreases over time as build-up of sediments and/or mineral precipitates clog the production zone. As a result, water wells typically require redeveloping every 5 years or sooner, depending on water quality, as part of preventative maintenance to maintain the capacity of the wells.

# 12 FIELD INVESTIGATIONS AND TESTING

## 12.1 NEAR WELL MONITORING INSTALLATIONS

The monitoring network used to observe the effects of pumping at the Randolph Well Field site consisted of over 30 private and provincially maintained monitoring stations. Three new monitoring wells were also drilled and installed near the Randolph Road Well Field in June of 2022 to monitor groundwater levels near the site. The three monitoring wells were completed as multi-level wells, which allowed for water level measurements in both the sandstone and the carbonate aquifers near the Randolph Well Field site. As part of the GEP requirement, a permanent two inch observation well at a location determined by the hydrogeologist is required for the project. However, given the formational depths of the carbonate and the sandstone aquifer, 5-inch/ 2- inch diameter multi-level monitoring wells provide more reliable well completion. It should also be noted that existing provincial monitoring wells in the bedrock aquifers are also completed as either 5-inch diameter well in the carbonate or as 5-inch/2inch diameter multi-level monitoring wells in the carbonate and sandstone.

Prior to the start of the drilling, the well locations were selected by Friesen Drillers and the Municipality of Ritchot. The locations were also reviewed with staff from Municipality of Hanover though the Municipality of Ritchot. The monitoring well locations were selected with the aim of increasing the data density of the available regional monitoring network comprised of provincially maintained and privately owned monitoring wells in the area. The monitoring wells near the Randolph Road Well Field were drilled within the provincial right-of-way, along municipal roads. All underground and overhead services were cleared and marked by their respective utilities prior to conducting any drilling.

The monitoring wells were completed in a manner that would allow for monitoring of the carbonate and the sandstone aquifer. The monitoring well construction included installing 5-inch diameter PVC casing through the overburden, and into the upper bedrock, and setting the casing with a 3-tier stepdown socket. The well casing was cemented in place and the carbonate bedrock was drilled open hole to the top of the shale. A capacity test was completed on each monitoring well prior to advancing the borehole to the sandstone. The completion in the sandstone consisted of 2-inch diameter PVC liner with 20 feet of 0.010 inch slot PVC screens. The liner installations utilized shale traps for hydraulic separation between the carbonate and sandstone formations.

Following the drilling, each well was developed with compressed air until the discharge was visibly clean. After completion, each well was equipped with a well seal due to flowing conditions. The overburden stratigraphy at the drill sites consisted of up to 105 feet of overburden. The overburden consisted of varying thickness of glacial till, clay and some sand and gravel. The top of the limestone bedrock was noted to be between 97 to 105 feet below grade, with formational thickness ranging from 200 to 248 feet. The top of the sandstone formation was noted between 301 to 356 feet below grade.

Following site clean – up, the wells were located using a portable GPS unit. It should be noted that the accuracy of the GPS unit is +/- 5 m. The monitoring well locations near the Randolph Road Well Field are shown in Figure 31. The well construction details for the test wells are presented in Table 3. A copy of the well construction logs is attached in Appendix E.

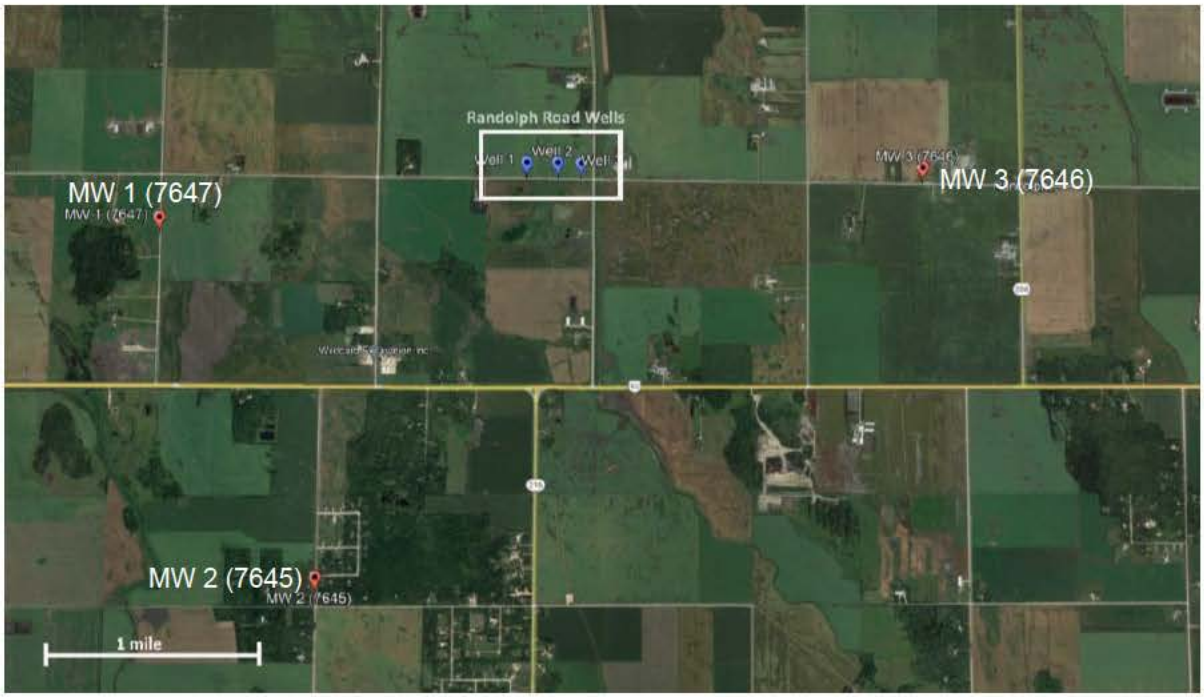


**Figure 31: New Near Well Monitoring Well Locations near Randolph Well Field**

(Modified from: Google Earth 2023)

**Table 3: Well construction details – Municipality of Ritchot – Monitoring Wells**

| Table 3<br>Well Construction Details - Monitoring Wells<br>Proposed Municipality of Ritchot Water Supply Alteration<br>Randolph Road Well Field - SE 8-7-5 EPM | | | | | |
|---|---|---|---|---|---|
| **Well ID (Tag #)** | **Casing Φ and Type** | **Limestone Monitoring Zone** | **Sandstone Monitoring Zone** | **UTM X** | **UTM Y** |
| 7647 (MW 1) | 5 inch PVC with 2 inch PVC | 101 – 331 feet b.g.l. | 337–357 feet b.g.l. | 651027.26 m E | 5489874.97 m N |
| 7645 (MW 2) | 5 inch PVC with 2 inch PVC | 106 – 353 feet b.g.l. | 356 – 376 feet b.g.l. | 652350.858 m E | 5487349.02 m N |
| 7646 (MW 3) | 5 inch PVC with 2 inch PVC | 99 – 297 feet b.g.l. | 306 – 326 feet b.g.l. | 656873.784 m E | 5490422.876 m N |

Note : * b.g.l. means below grade level. (Source: Friesen Drillers, 2023)

## 12.2 Regional Aquifer Monitoring Network

In addition to the three near field multi-level monitoring wells, Solinst M30/F100 Level transducers were also installed in private monitoring wells for groundwater monitoring. A total of 20 private wells, including the pumping well, were monitored during the pumping tests. Data was also requested from 14 provincially maintained monitoring stations. In total, the data collected from 34 monitoring stations, including the pumping well, private, and provincially maintained monitoring stations in the area were utilized for the pumping test.

The monitoring instruments were left in place for most of July. The transducers deployed were non vented type and barometric corrections were completed. The corrected transducers plots showing the water levels measured in each observation well are attached as Appendix F.

Following transducer installations, a geodetic survey was completed by Lawson Surveys on the private monitoring network to determine the exact monitoring well locations and well elevations. The regional monitoring well networks is shown in Figure 32. A copy of the geodetic survey is attached as Appendix G.

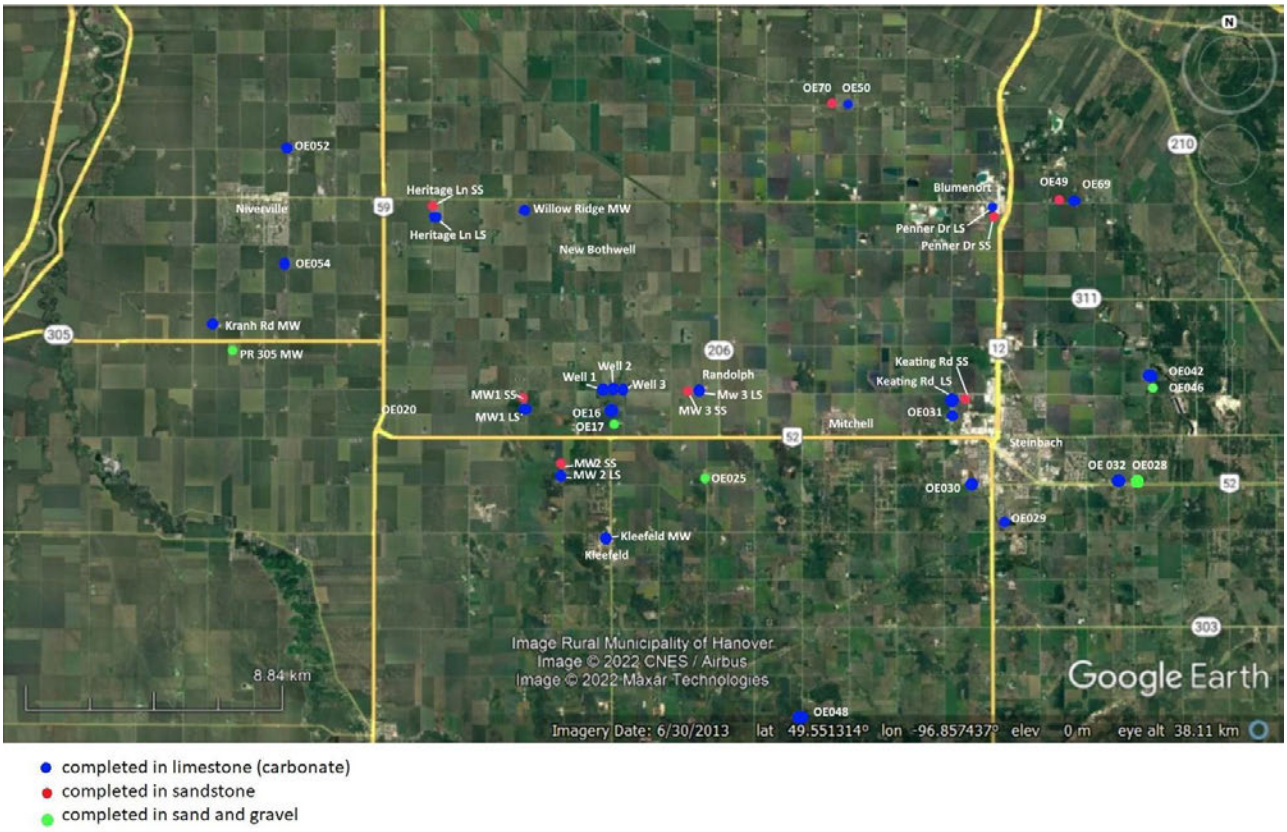


**Figure 32: Monitoring Network - Randolph Road Well Field**

(Data Source: GWDRILL, 2019 and Friesen Drillers, 2023)

**Table 4: Monitoring Network - Municipality of Ritchot**

| Table 4<br>Observation Well Locations<br>Proposed Municipality of Ritchot Water Supply Alteration<br>Randolph Road Well Field - SE 8-7-5E | | | |
|---|---|---|---|
| **Well Name** | **Radial Distance** | **Well Name** | **Radial Distance** |
| Well No. 2 (Carbonate) (pump well) | ~1 feet | Kranh Road (Carbonate) | ~44,294 feet |
| Well No. 1 (Carbonate) | ~1,312 feet | Penner Drive (Carbonate) | ~47,437 feet |
| Well No. 3 (Carbonate) | ~ 583 feet | Penner Drive (Sandstone) | ~47,437 feet |
| MW 1 (Carbonate) | ~ 10,122 feet | G05OE019 (Carbonate) | ~863 feet |
| MW 1 (Sandstone) | ~10,122 feet | G05OE016 (Carbonate) | ~ 4,085 feet |
| MW 2 (Carbonate) | ~ 11,289 feet | G05OE017 (Sand and Gravel) | ~ 4,176 feet |
| MW 2 (Sandstone) | ~ 11,289 feet | G05OE025 (Sand and Gravel) | ~ 14,907 feet |
| MW 3 (Carbonate) | ~ 9,277 feet | G05OE020 (Carbonate) | ~ 28,134 feet |
| MW 3 (Sandstone) | ~ 9,277 feet | G05OE030 (Carbonate) | ~ 44,013 feet |
| Rd 33 E (Carbonate) | ~ 38,278 feet | G05OE029 (Carbonate) | ~ 46,498 feet |
| Rd 33 E (Sandstone) | ~ 38, 278 feet | G05OE031 (Carbonate) | ~ 37,860 feet |
| Hanover Rd (Carbonate) | ~ 17,541 feet | G05OE054 (Carbonate) | ~ 39,412 feet |
| Kleefeld (Carbonate) | ~ 16,320 feet | G05OE052 (Carbonate) | ~ 46,089 feet |
| Kleefeld (Sandstone) | ~ 16,320 feet | G05OE050 (Carbonate) | ~ 40,954 feet |
| Willow Ridge Rd (Carbonate) | ~ 23,032 feet | G05OE070 (Sandstone) | ~ 40,948 feet |
| Heritage Lane (Sandstone) | ~ 29,068 feet | G05OE069 (Sandstone) | ~ 54,603 feet |
| PR 305 (Sand and Gravel) | ~ 43,254 feet | G05OE049 (Carbonate) | ~ 54,556 feet |

(Data Source: Friesen Drillers, 2022 and GWDRILL, 2019)

## 12.3 Production Well Inspections and Well Redevelopment

The current wells were drilled in 1992 and have been in operation since the early 1990's as municipal supply wells. Thus, other than well inspection, and well redevelopment, no major well drilling was completed. Details of the well construction are shown in Table 5 below. Copies of the well construction logs from the provincial database (GWDRILL, 2019) are attached as part of Appendix E.

**Table 5: Well Specific Details – Randolph Well Field Wells**

| Table 5<br>Well Construction Details<br>Proposed Municipality of Ritchot Water Supply Alteration<br>Randolph Road Well Field - SE 8-7-5 EPM | | | | | | |
|---|---|---|---|---|---|---|
| **Well Name** | **Drill Date** | **Casing Diameter and Type** | **Depth of Casing** | **Total Depth** | **UTM X** | **UTM Y** |
| Well No. 1 | Nov 2002 | 8 inch ⌀ PVC | 92 feet | 140 feet | 653665 m E | 5490378 m N |
| Well No. 2 | Nov 2002 | 8 inch ⌀ PVC | 94 feet | 140 feet | 654071 m E | 5490386 m N |
| Well No. 3 | Nov 2002 | 8 inch ⌀ PVC | 93 feet | 140 feet | 654248 m E | 5490387 m N |

Note: The existing wells were drilled in 2002 were drilled to replace the 1982 wells at the site.

(Source: GWDRILL, 2019)

The existing wells were assessed using a Laval borehole camera to determine the current well condition. Following well inspection, the wells were redeveloped using airlifting for a few hours to ensure that the production zones in the carbonate bedrock were free of sediments. Preliminary specific capacity tests were completed to determine the pumping potential of the wells. Based on the results of the preliminary testing, it was determined that Well No. 1 and Well No. 2, located to the west of Well No. 3, were significantly higher yielding. The well yield from Well No. 3 was marginal to be utilized for municipal water supplies. Thus, additional testing was only planned for Well No. 1 and Well No. 2. Details of the specific capacity tests are shown in Table 6.

**Table 6: Preliminary Specific Capacity Testing**

| Table 6<br>Preliminary Specific Capacity Test<br>Proposed Municipality of Ritchot Water Supply Alteration<br>Randolph Road Well Field - SE 8-7-5 EPM | | | | | |
|---|---|---|---|---|---|
| **Well** | **Pumping Time** | **Static Water Level** | **Pumping Water Level** | **Pumping Rate** | **Specific Capacity** |
| Well No. 1 | 1 hour | 1.85 feet b.t.o.c. | 4.95 feet b.t.o.c. | 118 U.S.G.P.M. | 38.06 U.S.G.P.M./ft |
| Well No. 2 | 1 hour | 3.5 feet b.t.o.c. | 5.85 feet b.t.o.c. | 112 U.S.G.P.M. | 47.66 U.S.G.P.M./ft |
| Well No. 3 | 1 hour | 1.80 feet b.t.o.c. | 63.0 feet b.t.o.c. | 50 U.S.G.P.M. | 0.82 U.S.G.P.M./ft |

Note: Water levels measured from top of casing. (b.t.o.c. = below top of casing)

(Source: Friesen Drillers 2022 Testing)

## 12.4 Aquifer Testing and Monitoring

In order to obtain aquifer parameters and to determine how the proposed supply well responds to pumping, a 72 hour (4,320 minute) pumping test was planned for the site. The testing duration was stated in the scope of work and the GEP authorized by MEC - DWRLB. The pumping test duration was chosen to firmly establish the drawdown around the well and allow sufficient time for the drawdown cone to expand from the site. The test duration would allow for the detection of boundary conditions in the area. Recovery was to be monitored to at least 90% of the static water level.

A 7.5 HP Berkeley submersible pump and motor was installed in Well No. 2 at a depth of 64 feet below grade. Power for the pumping test was supplied by an on-site portable generator. During the installation and set-up, the pump and motor were tested for one hour to verify the well yield and to set the discharge valve. This was completed a few days before the actual 72 hour test began. Drainage was piped approximately 200 feet to the nearest ditch which connected to the Manning Canal. The carbonate aquifer at the site is overlain by 62 feet of low permeability clay and glacial till, thus, recirculation of pumped water was not expected to occur for the duration of the test. The pumping test set up and the discharge route for the 72 hour pumping test are shown in Figure 33.

**Figure 33: Pumping Test Set-up - Randolph Road Well Field**

(Source: Friesen Drillers 2022 Testing)

The 72-hour pumping test at the site commenced on July 5th, 2022, and was completed on July 8th, 2022. The flow rate was maintained at 390 U.S.G.P.M. by using a 4 inch by 3-inch orifice meter. The flow rate was checked every hour. Water levels were monitored using a Solinst Water Level Meter in the pumping well. The water levels and pumping rates recorded at the pumping well during the 72-hour test are shown in Table 7. The responses at various observation wells are discussed in the data analysis section. The pumping test and recovery data is presented in Appendix H.

**Table 7: Long Term Pumping Test Details - Municipality of Ritchot**

| Table 7<br>Pumping Test Details – Long Term Pumping Test – Well No. 2<br>Proposed Municipality of Ritchot Water Supply Alteration<br>Randolph Road Well Field - SE 8-7-5 EPM | | | | |
|---|---|---|---|---|
| **Well** | **Pumping Time** | **Static Water Level** | **Pumping Water Level** | **Average Pumping Rate** |
| **Well No. 2** | 4,320 minutes<br>(72 hours) | 1.51 feet b.t.o.c. | 21.62 feet b.t.o.c. | 390 U.S.G.P.M. |

(Source: Friesen Drillers Pumping Test Data, 2022) (b.t.o.c. = below top of casing)

During the 72-hour pumping test, field measurements of basic water quality parameters were measured using calibrated field-testing equipment. The field measurements were taken to test the water quality prior to the release of $CO_2$ from the samples, which can affect the results over short periods of time and the results of are discussed in the Groundwater Geochemistry Section.

In addition, groundwater samples were also collected from the well discharge once every 12 hours using the laboratory supplied sampling bottles. During the field testing, the field parameters were relatively stable and showed less than 10% of variation, thus, only samples collected every 24-hour intervals were submitted to ALS Laboratories for routine water quality parameters and metals scan analysis. The results are discussed in the Groundwater Geochemistry Section. Water samples were also collected for the analysis of environmental isotopes $^{18}$oxygen and deuterium. The geochemistry results are discussed in the data analysis section of this report.

Following the 72-hour pumping test, a capacity test was also completed on July 26th, 2022, on Well No. 1, to determine the specific capacity of the well. A 7.5 HP Berkeley submersible pump and motor was set at 64 feet from top of casing on Well No. 1 to complete the short-term pumping test. Power to the site was provided by a portable generator and water levels were recorded using a Solinst Water Level Meter. Details of the short-term pumping test are shown in Table 8.

**Table 8: Short Term Pumping Test Result - Municipality of Ritchot**

| Table 8<br>Pumping Test Details – Capacity Test – Well No. 1<br>Proposed Municipality of Ritchot Water Supply Alteration<br>Randolph Road Well Field - SE 8-7-5 EPM | | | | |
|---|---|---|---|---|
| **Well** | **Pumping Time** | **Static Water Level** | **Pumping Water Level** | **Average Pumping Rate** |
| **Well No. 1** | 240 minutes | 0.35 feet | 20.0 feet | 396 U.S.G.P.M. |

(Source: Friesen Drillers Pumping Test Data, 2022) (b.t.o.c. = below top of casing)

# 13 Data Analysis

## 13.1 Aquifer Testing Analysis

The Theis (1935) method is the most common approach for analyzing the results from aquifer pumping tests in confined aquifers.

Critical assumptions integral to the method are detailed as follows:

- Darcy's law is valid.
- The aquifer is horizontal and constant thickness.
- The aquifer is infinite in areal extent.
- The aquifer is bounded by impermeable strata above and below.
- Uniform hydraulic conductivity.
- Isotropic hydraulic conductivity.
- The head always remains above the top of the pumped aquifer.
- There are no water level changes not from pumping.
- Infinitesimal diameter of well.
- Fully penetrating the aquifer formation.
- Single pumping well.
- Constant pumping rate.
- Constant storage properties through time.
- The head is known everywhere prior to pumping.

Through a review of the assumptions, it can be seen that some of the assumptions for the analysis of the pumping tests conducted at the Randolph Well Field site are not fully satisfied for the Theis (1935) approach. For example, the aquifer is not infinite in areal extent, and conditions are far from isotropic. The aquifer is also a departure from the notion that the aquifer is bounded by impermeable strata above and below since interconnection of the Winnipeg Formation and the Red River Carbonate aquifer has been well documented in parts of the southeast Manitoba, particularly within the Steinbach-Blumenort area. Water well constructions interconnecting both formations are also present in the area. In addition, the well construction is not fully penetrating the entirety of the Carbonate Aquifer. However, this well construction is very common in the Carbonate Aquifer. During well drilling and installation, it is typical for the well driller to continue drilling until suitable water bearing fractures are encountered. Although this may or may not be totally correct in this instance, the Theis methodology follows the standard practice for aquifer analysis of this nature. It was further assumed that skin effects for the supply well would be minimal after the developing and jetting procedures.

The Theis (1935) approach is highly idealized to the assessment of the aquifer and represents the state of the art for the determination of aquifer parameters. The method has been found to be reasonably workable for aquifer evaluation, all over the world, for more than 80 years. In this case, conditions of the Theis (1935) approach are not being severely violated and the methodology is similar to other regional works conducted in the area.

The pumping test data was entered into AQTESOLV (Version 4.5 Professional), for analysis of aquifer parameters. The data was analyzed using the Cooper-Jacob (1946) time versus drawdown and composite analysis, and the Theis (1935) methods, although similar results should be expected, as the Cooper-Jacob method is a semi-log plot approximation of the Theis method.

In order to determine the acceptability of the results, a derivative analysis was also used (Bourdet et al., 1989). However, it was not plotted to maintain data clarity.

The aquifer response was noted in nearby monitoring stations completed in the carbonate aquifer. The sandstone aquifer also demonstrated a muted response to pumping. Overall, recorded drawdown was less than 2.0 feet past two miles of Well No. 2, during the 72 hour test and were generally masked by external pumping activities. The drawdown versus time plot of monitoring stations with discernible aquifer response is shown as Figure 34. Two transducers failed during the test and were not used for the analysis. Available transducer plots of the monitoring stations are shown in Appendix F.

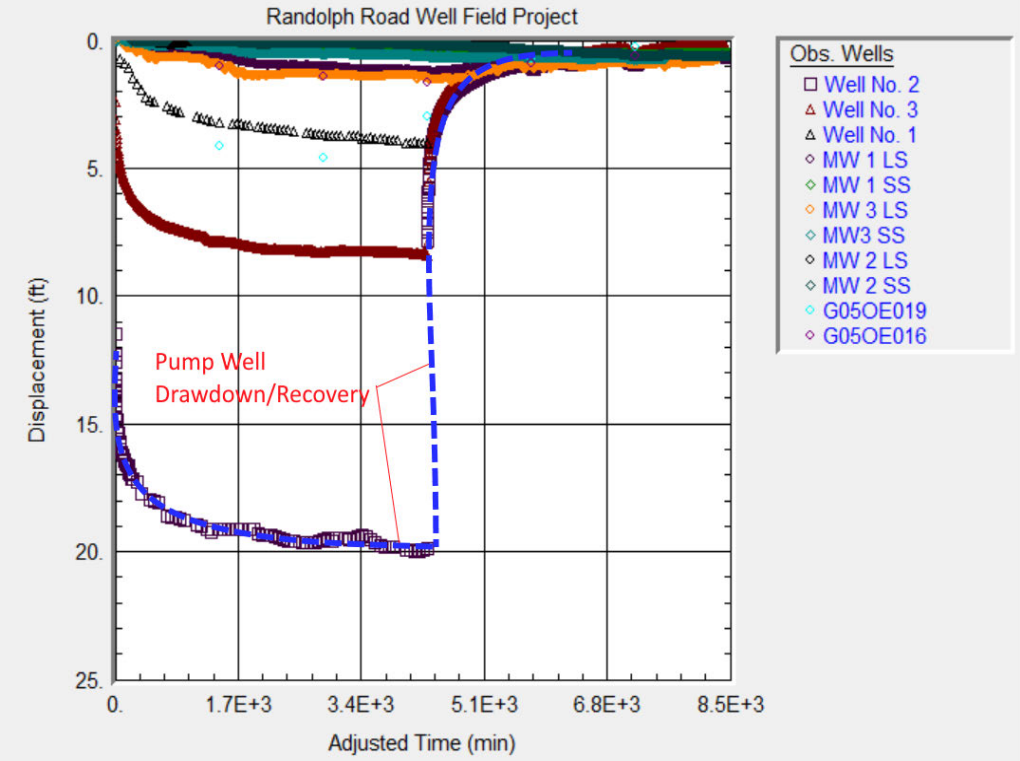


**Figure 34: Drawdown Versus Time – 72-hour Pumping Test**

Average Pumping Rate 390 U.S.G.P.M. (Source: Friesen Drillers Pumping Test Data, 2022)

The hydraulic parameters that were inferred from the data are shown on the following page as Table 9. In general, the aquifer was inferred to be confined and has an approximate transmissivity of about 50,000 U.S.G. /day/ft, based on the analysis of the results of the 72 hour, constant rate, single well pumping test. The storage coefficient was determined to be $2.0 \times 10^{-4}$ which is typical in the carbonate aquifer in Manitoba.

The Cooper-Jacob (1946) method was primarily used for the analysis since emphasis is not placed on the early time measurements. The pumping well configuration was not fully penetrating and the production well was only drilled into the upper portion of the carbonate bedrock. Background data/ reports available for the region provide evidence that the aquifer is not isotropic

and displays strong spatial variability as evidenced by the drastic change in the specific capacity between the main wells, Well No. 1 and Well No, 2 and the lower yielding Well No. 3. Following standard practice, the aquifer was assumed to be Theissian. Although this may or may not be totally correct in this instance, this methodology follows the standard practice for aquifer analysis of this nature. It was further assumed that the skin effect for the supply well would be minimal after developing jetting procedures.

**Table 9: Aquifer Parameters – 72 Hour Pumping Test - Municipality of Ritchot**

| **Table 9<br>Aquifer Parameters – 72 Hour Pumping Test<br>Proposed Municipality of Ritchot Water Supply Alteration<br>Randolph Road Well Field - SE 8-7-5 EPM** | | |
|---|---|---|
| **Well No. 2** | | |
| **Drawdown** | 20.11 ft. @ 390 U.S.GPM – 4,320 minutes (3 days) | |
| **Static Water Level** | 1.51 ft. below top of casing | |
| **Specific Capacity** | 19.39 U.S.GPM/ft. | |
| **Method** | **Transmissivity** | **Storativity** |
| Theis Method[1] | 50,200 U.S.G./day/ft. | $2.0 \times 10^{-4}$ |
| Cooper - Jacob Method[2] (time) | 50,200 U.S.G./day/ft. | $2.0 \times 10^{-4}$ |
| Cooper - Jacob Method[2] (composite) | 50,000 U.S.G./day/ft. | $2.0 \times 10^{-4}$ |
| Theis Recovery Method[3] | 50,200 U.S.G./day/ft. | N.A. |
| Notes: | 1 Theis (1935) method using AQTESOLV (Version 4.5 Professional)<br>2 Cooper - Jacob (1946) method using AQTESOLV (Version 4.5 Professional)<br>3 Theis Recovery (1935) method using AQTESOLV (Version 4.5 Professional) | |

(Source: Friesen Drillers Pumping Test Data, 2022)

The drawdown cone generated during the 72 hour pumping test is shown in Figure 35. It is apparent from the drawdown map that the drawdown cone which develops in higher transmissive conditions are generally shallower and extend a greater distance from the pump well (Freeze and Cherry, 1979). Consequently, aquifer response from pumping at the Randolph Road Well Field could be observed at a larger distance, albeit at a much smaller magnitude.

The Theis (1935), Cooper – Jacob (1946) time versus drawdown, Cooper – Jacob (1946) composite plot analysis, and Theis Recovery (1935) methods are shown on the subsequent pages as Figure 36, 37 38, and 39. The composite plot was also used to simplify the plots into plots with the same slope which are easily analyzed by the Copper – Jacob method (1946) to determine the bulk transmissivity of the aquifer in the area.

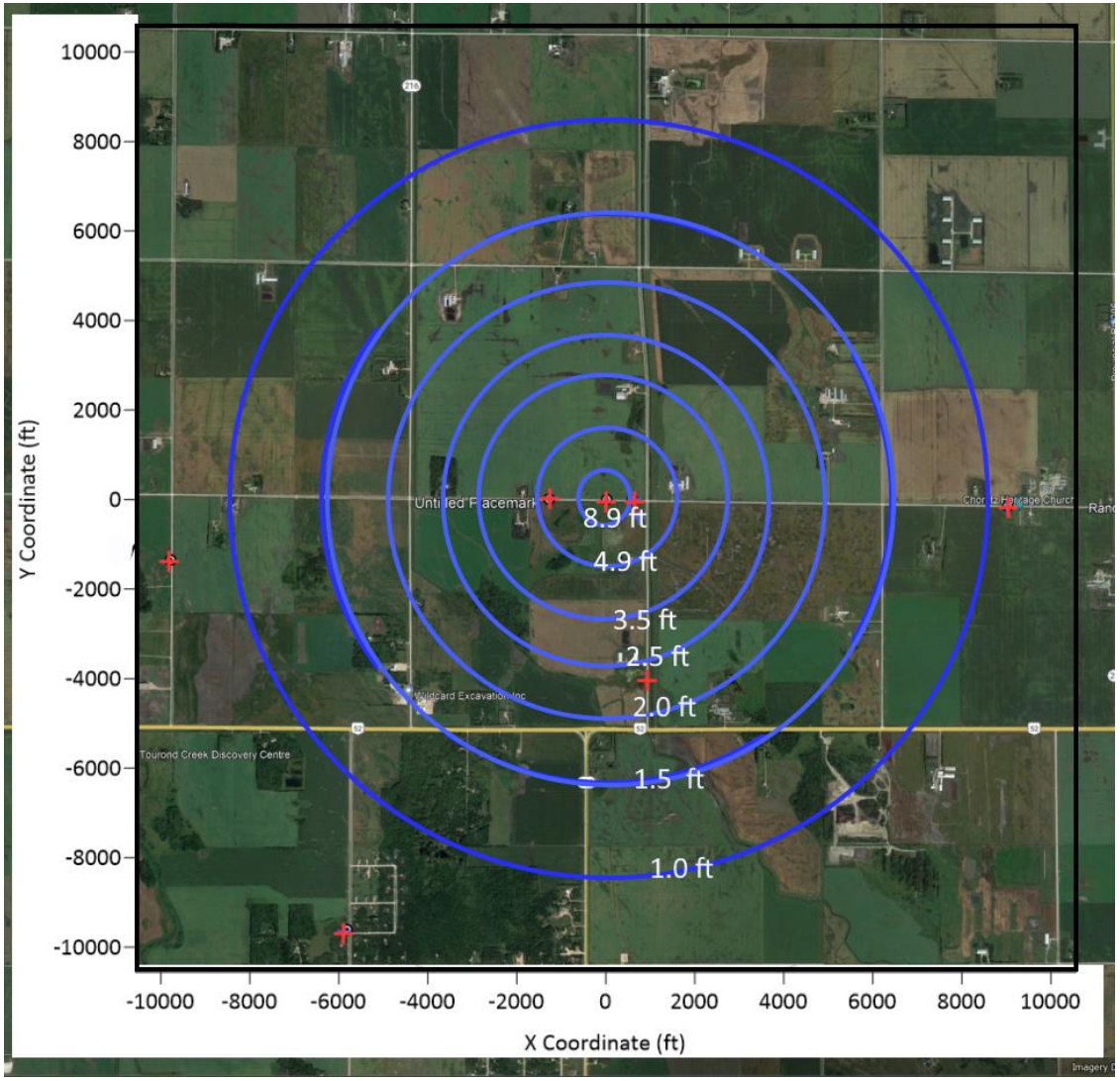


**Figure 35: Drawdown Cone Generated During the 72 hour Pumping Test**

(Source: Friesen Drillers Pumping Test Data, 2022)

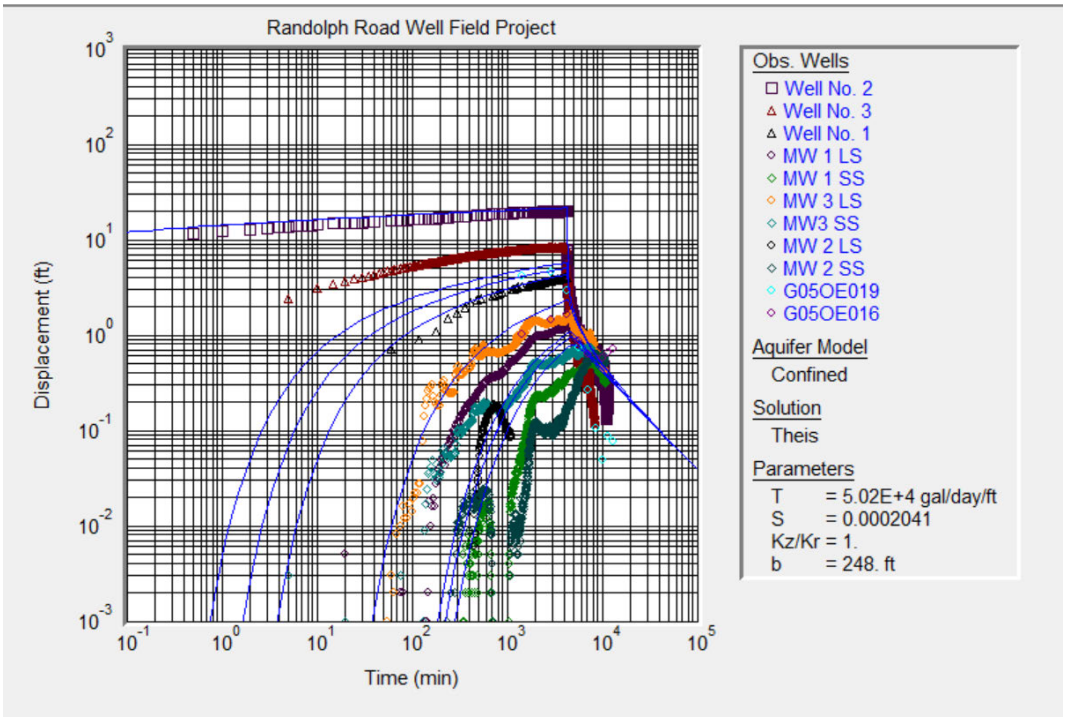


**Figure 36: Theis (1935) Analysis**

Average Pumping Rate 390 U.S.G.P.M. (Source: Friesen Drillers Pumping Test Data, 2022)

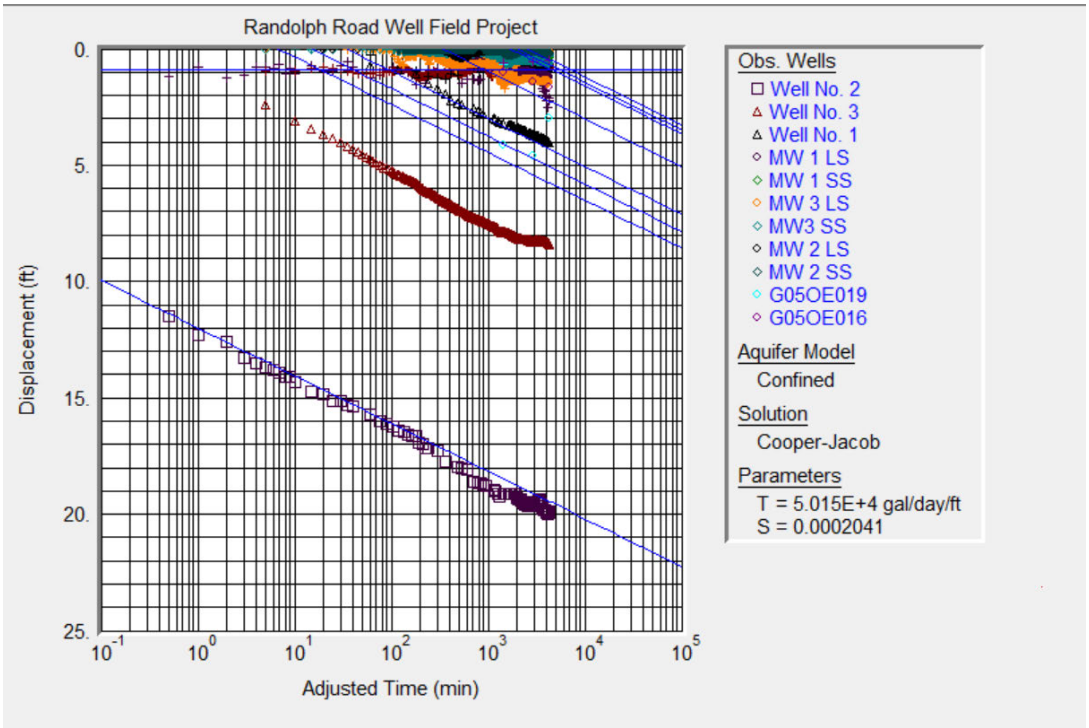


**Figure 37: Cooper - Jacob (1946 ) Plot**

Average Pumping Rate 390 U.S.G.P.M. (Source: Friesen Drillers Pumping Test Data, 2022)

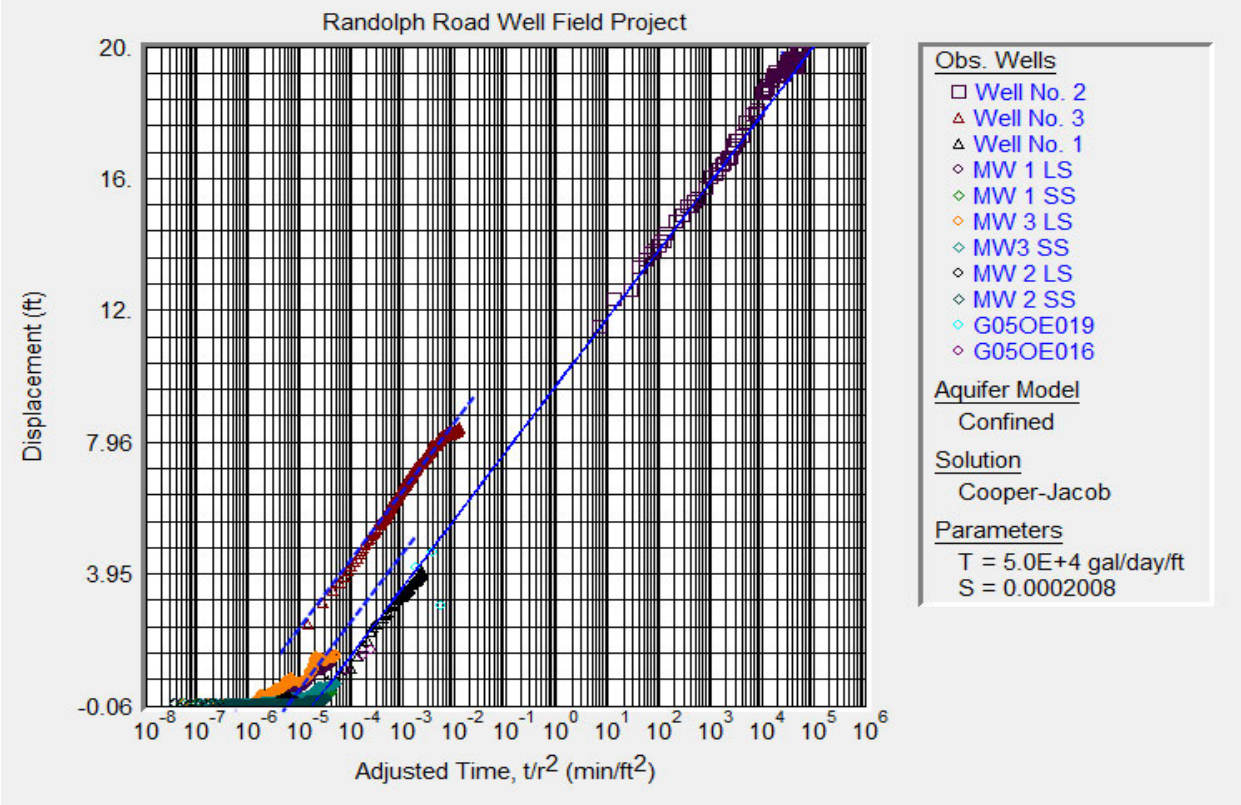


**Figure 38: Composite Analysis Plot**

Average Pumping Rate 390 U.S.G.P.M. (Source: Friesen Drillers Pumping Test Data, 2022)

The composite plot, shown as Figure 38 is an important tool in analyzing the bulk transmissivity of the aquifer when multiple observation wells are present (Moench, 2010). In the composite plot, the time is plotted over the squared distance of the monitoring well from the pump well. This method allows for the analysis of the bulk aquifer transmissivity using the Cooper-Jacob (1946) method rather than individual estimation of the transmissivity per observation well. In the composite plot, Well No. 1 and Well No. 2 plotted within the same line (solid blue line) while Well No. 3 and other monitoring wells plotted in lines with similar slopes (dashed blue lines). Analysis of the slopes using the composite plot and the Cooper- Jacob (1946) analysis indicate that the estimated bulk transmissivity of the carbonate aquifer was about 50,000 U.S.G. /day/ft.

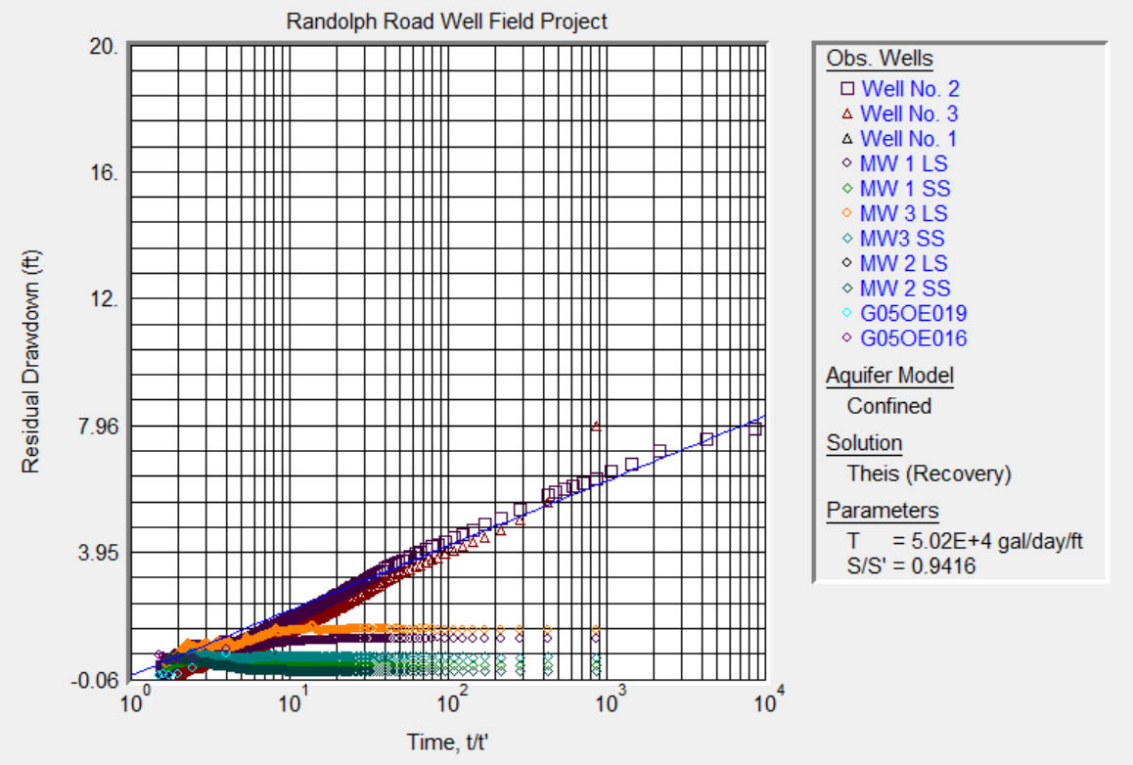


**Figure 39: Theis Recovery Plot**
(Source: Friesen Drillers Pumping Test Data, 2022)

The results from the Cooper – Jacob analysis indicate several positive and negative boundary conditions which appear as slope changes in the drawdown versus time plot. To further differentiate the slope changes, the drawdown plot of the pumping well was plotted with slightly bigger symbols on Figure 40. Apparent slope changes are also marked in the figure. It should be noted that excluding the casing storage, departures from the normal aquifer response are very slight, typically 2 feet of less, and are more notable in monitoring stations located further from the Randolph Well Field. The overall total drawdown generated at the pumping well is also relatively shallow ( less than 20 feet) for the duration of the 72 hour pumping test.

Observed slope changes are as follows:

Slope 1 – Time : 0 to 10 minutes (casing storage)

Slope 2 – Time : 10 to 700 minutes (normal aquifer response)

Slope 3 – Time : 700 to 1,200 minutes (negative slope change) – associated with external pumping effects.

Slope 4 – Time: 1,200 to 4,320 minutes (complex response showing negative and positive slope changes) – aquifer response associated with pumping from the pumping well coupled with external pumping and recovery and changing transmissive conditions.

The detectable external pumping effects from pumping at distance is a notable characteristic of higher transmissive conditions. The pumping effects are typically minor but the drawdown cone could extend great distances. Available drawdown in the area is also generally over 90 feet and groundwater levels in the area are typically high.

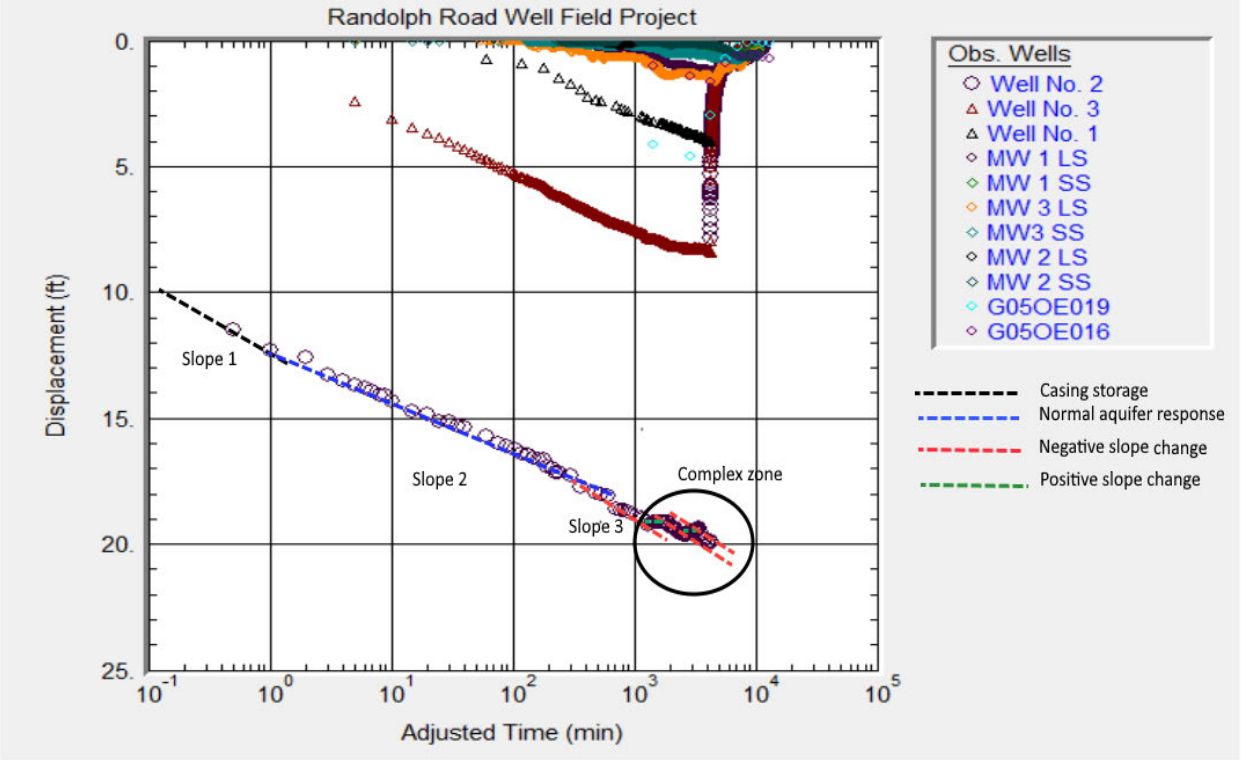


**Figure 40: Slope Changes observed during the pumping test.**

(Source: Friesen Drillers Pumping Test Data, 2022)

## 13.2 GROUNDWATER GEOCHEMISTRY

### 13.2.1 Field Parameters

During the pumping test, field measurement of basic groundwater quality was measured at hourly intervals from the discharge of Well No. 2 (pump well). The parameters measures included electrical conductivity (EC), pH, and turbidity. The plot of the field measurements is shown as Figure 41. A summary of the measured field parameters is shown in Table 10.

EC, typically measured in microSiemens per centimeter or milliSiemens per centimeter (uS/cm or mS/cm) and sometimes in micromhos per centimeter or millimhos per centimeter (umhos/cm or mmhos/cm), is a measure of the ability of water to pass electrical current (Freeze and Cherry, 1979). The EC of water increases with the amount dissolved salts and conducive inorganic chemical present in the water. As a result, EC increases with increased salinity. Organic compounds like oil do not conduct electrical current very well and therefore have a low EC when in water. EC is also affected by temperature. EC typically rises with temperature (EPA, 2012).

Measured EC for the duration of the pumping test was relatively stable and ranged between 618 to 812 umhos/cm.

The pH, values ranging from 0 to 14 pH units, measures the acidity/basicity of groundwater. The pH of water determines the solubility and biological availability of chemical constituents to react with groundwater (Freeze and Cherry, 1979). The measured pH during the pumping test was measured between 8.9 to 9.7 units. The operational guideline for allowable pH in drinking water is between 7.5 to 10.0 (Health Canada, 2022).

Turbidity is a measure of water clarity. Groundwater from a fractured rock aquifer typically includes some amount of turbidity from suspended particles. The particles can be derived from sediments deposited within the fracture zones and from the rock formation itself. The turbidity measurements during the current pumping test fluctuated between a high of 5.2 NTU (Hour 2) and a low of 0.1 NTU measured in several instances past the 10 hour mark. In general, while there were some spikes in measurement, the turbidity trend was higher at the beginning of the test and became gradually lower after longer pumping durations. It is common for turbidity values to fluctuate in constructed wells, particularly with changes to the pumping scheme. Since the wells at the Randolph Well Field have not been pumped prior to these investigations, some fluctuations in the turbidity are expected. Often, these conditions tend to stabilize with consistent pumping over time.

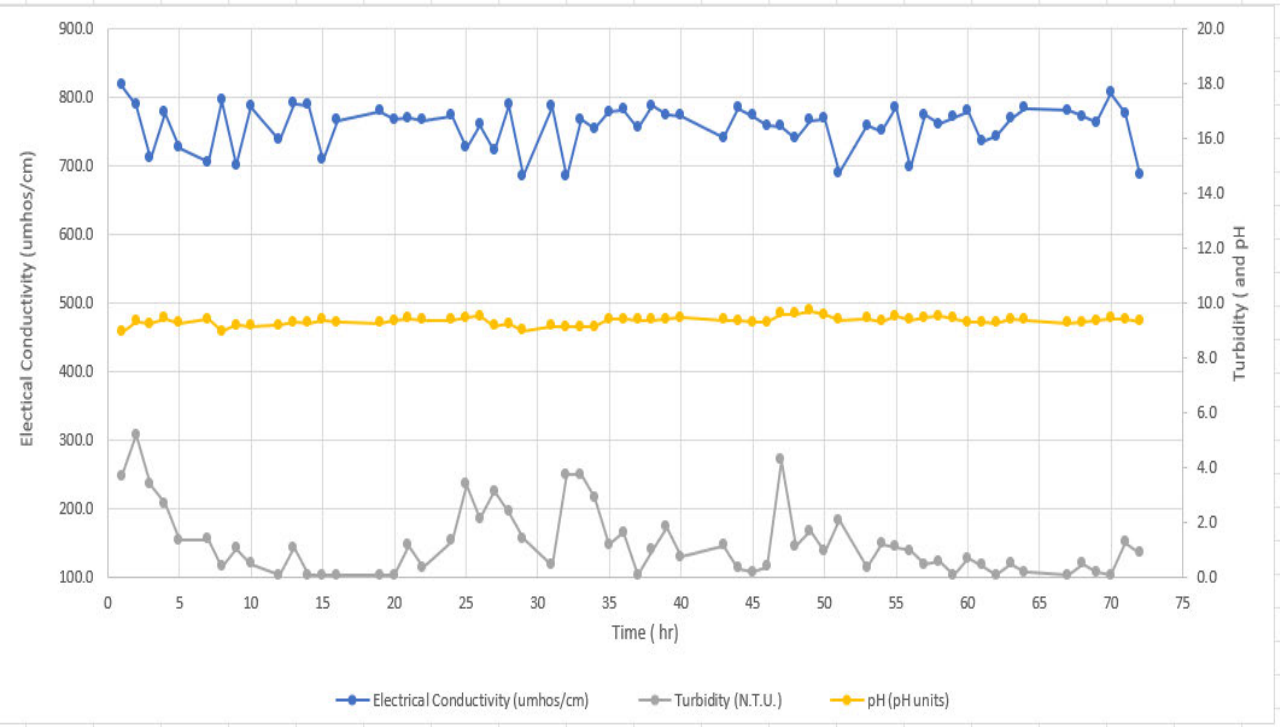


**Figure 41: Field Parameters measured during the 72 hour test**

(Source: Friesen Drillers, 2022)

Table 10 : Groundwater Quality Observed During 72 Hour Pumping

| Table10<br>Groundwater Quality Observed During Pumping<br>Proposed Municipality of Ritchot Water Supply Alteration<br>Randolph Road Well Field - SE 8-7-5 EPM | | | |
|---|---|---|---|
| **Pumping Time** | **Electrical Conductivity** | **pH** | **Turbidity** |
| 1 hour | 816 umhos/cm | 8.92 pH units | 3.69 N.T.U |
| 7 hours | 704 umhos/cm | 9.4 pH units | 1.39 N.T.U |
| 12 hours | 737 umhos/cm | 9.17 pH units | 0.1 N.T.U |
| 19 hours | 779 umhos/cm | 9.27 pH units | 0.1 N.T.U |
| 24 hours | 772 umhos/cm | 9.37 pH units | 1.34 N.T.U |
| 31 hours | 785 umhos/cm | 9.14 pH units | 0.45 N.T.U |
| 36 hours | 781 umhos/cm | 9.39 pH units | 1.65 N.T.U |
| 43 hours | 740 umhos/cm | 9.36 pH units | 1.18 N.T.U |
| 54 hours | 750 umhos/cm | 9.31 pH units | 1.24 N.T.U |
| 60 hours | 779 umhos/cm | 9.29 pH units | 0.69 N.T.U |
| 67 hours | 780 umhos/cm | 9.27 pH units | 0.1 N.T.U |
| 72 hours | 687 umhos/cm | 9.32 pH units | 0.88 N.T.U |

(Source: Friesen Drillers, 2022)

### 13.2.2 Routine Geochemistry

A total of five samples (four samples for routine geochemistry and one sample for MB-Ch-PWS) sets were collected from Well No. 2, during the 72-hour test, in laboratory supplied sampling bottles and were delivered to an accredited laboratory for analysis. A sample was also collected from Well No. 1 during the short-term capacity test. The samples were kept cool using ice packs and coolers prior to delivery to the analytical laboratory. The samples were analyzed by ALS Laboratories in Winnipeg (L2721317, L2725315 and L2721308). The stable environmental isotope analyses were conducted by EIL Laboratory at the University of Waterloo, Ontario. The laboratory analytical results are attached in Appendix I. The major ion results are shown in Table 11. A tri-linear plot is shown in Figure 42, on the following page.

**Table 11 – Groundwater Geochemistry Results – Long Term Pump Test**

| Table 11<br>Groundwater Analysis Results<br>Proposed Municipality of Ritchot Water Supply Alteration<br>Randolph Road Well Field - SE 8-7-5 EPM | | | | | |
|---|---|---|---|---|---|
| **Sample ID** | **TDS (mg/L)** | **Calcium (mg/L)** | **Chloride (mg/L)** | **Nitrate (as N) (mg/L)** | **Iron (mg/L)** |
| Well No. 2 - 1 hour | 392 | 44.6 | 40.4 | <0.020 | 0.298 |
| Well No. 2 - 24 hours | 391 | 45.0 | 39.5 | <0.020 | 0.322 |
| Well No. 2 - 48 hours | 391 | 45.3 | 39.3 | <0.020 | 0.393 |
| Well No. 2 - 72 hours | 388 | 45.1 | 39.2 | <0.020 | 0.507 |
| Well No. 2 - 72 hrs (MB-CH-PWS) | 392 | 44.9 | 39.2 | <0.0050 | 0.537 |
| Well No. 1 | 376 | 43.7 | 38.4 | <0.020 | 0.420 |

(Source: ALS L2725315, L2721308, and L2721317, 2022)

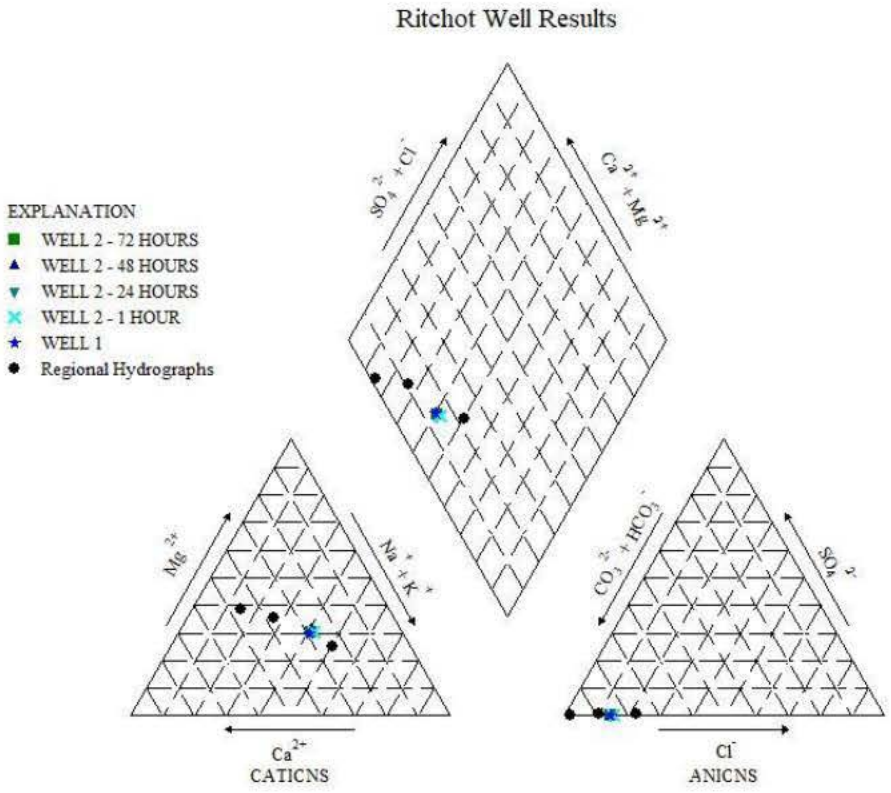


**Figure 42: Trilinear Plot - Randolph Well Field**

(Source: ALS L2725315, L2721308, and L2721317, 2022)

Overall, the samples plot as a calcium/bicarbonate type groundwater. The ion concentrations remained stable during the course of the pumping test as evidenced by the overlapping plots. The water quality was expected and plotted closely with nearby provincial monitoring station in the carbonate.

The concentration of total dissolved solids (TDS) in groundwater, typically reported in mg/L, is a measure of the major ions in groundwater. Over 90% of the measured TDS is attributed to the ions of sodium, magnesium, calcium, chlorides, bicarbonate and sulphate (also sulfate) (Freeze and Cherry, 1979). Based on taste, the maximum aesthetic objective for TDS is 500 mg/L and lower TDS concentrations are preferred (Health Canada, 2022). The TDS concentrations from the samples ranged from 372 mg/L to 392 mg/L which is lower than the aesthetic objective of 500 mg/L.

There are no adverse health effects associated with calcium and thus, calcium does not have a concentration limit in drinking water standards (Health Canada, 2022). However, calcium is one of the major constituents of TDS.

The total iron content was between 0.293 and 0.537 mg/L and is generally above the aesthetic objective of 0.3 mg/L (Health Canada, 2022). While there are no adverse health effects associated with high iron, higher iron is generally associated with staining, bad taste and could promote mineral encrustations. The calculated hardness was also over 180 mg/L and is considered very hard. According to Health Canada (2022), water hardness is not of direct public health concern.

Since the system has been in operation for over twenty years, it is highly likely that the water quality at the site has been considered in the system design as high concentrations of iron and very hard water could cause encrustation problems over time.

There were no detectable nitrates in the groundwater samples which was expected.

Barium, while detected in all samples, ranged from 0.385 to 0.505 mg/L and is below the maximum allowable concentration of 2.0 mg/L set out by Health Canada (2022) for drinking water Standards.

Fluoride concentrations ranged between 0.582 to 0.618 mg/L and was below the maximum allowable concentration of 1.5 mg/L as set out by Health Canada (2022) for drinking water Standards.

### 13.2.3 Stable Environmental Isotopes

Samples for stable environmental isotopes of oxygen$^{18}$ ($^{18}$O) and deuterium ($^{2}$H) were sent to the Environmental Isotope Lab in the University of Waterloo for analysis. The testing results for the stable environmental isotope results collected during the course of the current investigations are attached in Appendix I.

The ratios of the main isotopes that comprise the water molecule ($^{18}$O/$^{16}$O) and $^{2}$H/$^{1}$H are important for hydrogeological investigations (Freeze and Cherry, 1979). The units are presented in delta (δ) units as parts per thousand or ‰ (Freeze and Cherry, 1979) relative to standard mean oceanic water (SMOW). The two isotopes of water have different freezing and vapour points, which leads to different concentrations as a result of freezing, condensation, melting, and evaporation (Freeze and Cherry, 1979). As water evaporates from the ocean, there is a decline in the $^{18}$O concentration by a specific amount. As the vapor condenses, the precipitation has a higher $^{18}$O concentration. This process continues as the vapor moves inland and undergoes many cycles of condensation and evaporation. This fact makes deuterium and oxygen 18 very useful for hydrogeological investigations, as the origin and mixing of different waters can be determined. In order to determine the changes from local precipitation, deuterium and oxygen 18 results are plotted to determine the local meteoric water line, which would be expected to be the typical concentrations in recent precipitation events in the area.

Within Manitoba, glacial water (~ 10,000 years ago), typically shows oxygen$^{18}$ concentrations of -19 to -23 δ (‰ V –SMOW). Waters that are mixing with older glacial waters typically indicate about -17 to -19 δ (‰ V –SMOW), while recent water is -14 to -16 (‰ V –SMOW) (Freeze and Cherry, 1979).

The deuterium ($^{2}$H) and Oxygen$^{18}$ ($^{18}$O) were plotted against the local meteoric water line (Gimli Meteoric Water Line) in order to determine the water origin and apparent ages. This plot is shown on the following page as Figure 43.

The groundwater samples collected during the long-term pumping test of Well No. 2 reported oxygen$^{18}$ content of –13.66 to -14.2 ‰ (VSMOW), with a deuterium level between -103.03 to -104.21‰ (ALS L2731459). The samples generally plotted within the limits of the GMWL (dashed line). The results indicate very recent to recent water are indicative of modern meteoric groundwater source (Phipps et al., 2008).

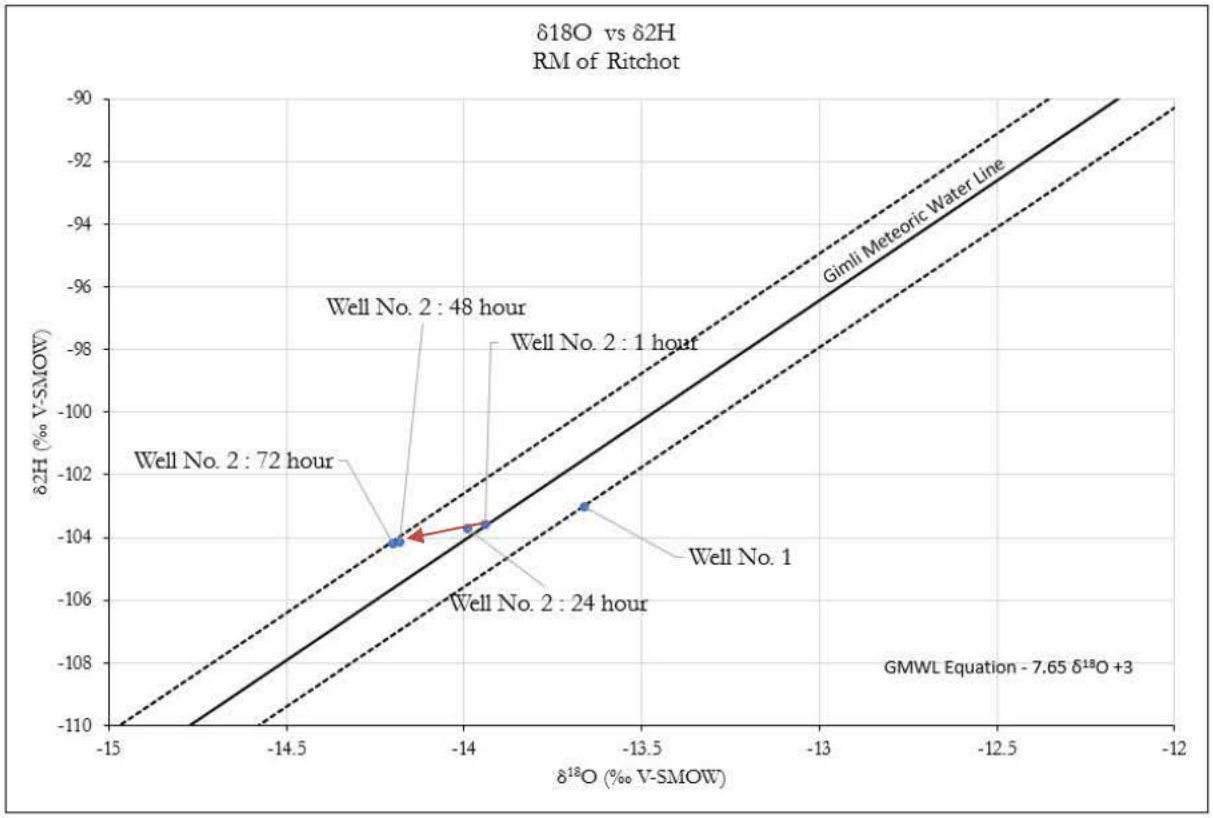


**Figure 43: Distribution of Oxygen 18 vs. Deuterium**

(Source - ALS L2725315, L2721308, and L2721317, 2022)

## 13.3 Well Interference

As per the conditions of the Groundwater Exploration Permit, the Rural Municipality of Ritchot, as the proponent of the water supply project, is responsible to correct any existing water supplies that are negatively impacted as a result of the requested water supply alteration for the Randolph Road Well Field. It should be noted that this responsibility is limited to issues related to the operation of the groundwater supply, such as increased drawdown caused by pumping. The proponent is not legally responsible for pre-existing plumbing issues or for problems that are not attributed to the new production wells. The proponent is responsible for resolving interference issues to the satisfaction of the Minister.

To the authors' knowledge, no well interference complaint was received from any nearby private domestic wells during the 72-hour pumping test. Long-term monitoring is recommended for the Well Field, especially during the first few years of mechanizing the supply wells. Discharge at the site has been ongoing since the 1980's and the Randolph Road Well Field has been in operation as a water supply source for the Municipality of Ritchot since 2002. The nearby private wells in the area appear to accommodate the operation of the well field.

The Municipality currently has a groundwater interference plan in place to provide a systematic guide on how well complaints are accommodated. A copy of the well interference plan is attached in Appendix J.

The Municipality of Ritchot may also need to adjust/lower some pump settings in the area to accommodate any well interference that could result from the mechanization of the Randolph Road Well Field.

# 14 DISCUSSIONS

## 14.1 LONG TERM HYDROGRAPH RESPONSE

The Municipality of Ritchot lies within the carbonate aquifer which is one of the largest regional aquifer systems in Manitoba. The regional transmissivity of the carbonate bedrock in the area is moderately high. Through reviewing the hydrograph data from the nearest provincial station, the precipitation records, and the water use records from the Municipality of Ritchot, previously shown in Figure 13, the following comments can be made:

- The operation of the Randolph Road Well Field for over 20 years has created a well-established drawdown cone in the area due to the depressurization of the aquifer by allowing the aquifer to freely discharge into discharge pipes/water lines using the relief wells, thereby lowering the groundwater levels. This has been the “state of nature” in the area since the early 1980’s.

- The aquifer is susceptible to seasonal and climatic variations. Water levels in the carbonate aquifer appear to decline very rapidly during prolonged dry periods. The aquifer appears to be very similar to an open reservoir and pipe analogy. When the water level in the reservoir falls, the potential in the pipe declines very rapidly. This means that during prolonged dry periods, static water levels in the area will respond very rapidly and decline accordingly.

- During periods of recharge, the aquifer also responds very quickly.

- The hydrograph records generally reflect the effect of seasonal and climatic fluctuations, with no long-term progressive drawdown that could not be explained through reviewing the precipitation records for the area. A local drawdown cone around the Randolph Road Well Field is present as a result of many years of operation. However, there is no unaccounted progressive long term drawdown present in the area.

## 14.2 AQUIFER SUSTAINABILITY

As discussed in the previous sections, the Sandilands area lying up gradient in Southeast Manitoba is a recharge area for the bedrock aquifer system lying to the west. This recharge area covers approximately 400 square miles. The following is an attempt to determine the long-term average groundwater sustainability for this area.

The only area known to the author where the aquifer recharge has been determined in Manitoba is the Upper Pine Creek Basin of the Assiniboine Delta Aquifer (Render, 1987). Render (1987) calculated that the average precipitation for the area during the time of evaluation was 482.82 mm (17.04 in). Render estimated that the average annual groundwater discharge from the basin over 17 years was 34.29 mm (1.35 in). This value was considered the sustainable yield of the aquifer in that area. Due to the importance of the determination for agricultural activities over the Assiniboine Delta Aquifer this work was reviewed by a committee chaired by R.N. Farvolden from the University of Waterloo.

While the Sandilands area is not a perfect replica of the Upper Pine Creek Basin, there are quite a few similarities. The author considered that if the Upper Pine Creek recharge value was adjusted for the current climatic precipitation average in the Sandilands area, it would produce a reasonable estimate of the Sandilands sustainability. The current climatic average for precipitation provided by Environment Canada (2022) from 1981 to 2010 shows an average annual value of precipitation of 575 mm (22.64 in) which was used to adjust the Upper Pine Creek recharge rate to an approximate rate for the Sandilands area.

If this value is used for the long-term average annual recharge, then the 400 square miles of the Sandilands would produce 1,666,814,197 cubic feet (47,198,921 cubic meters) of water per annum. This amount of water is considerably above the amount of water flowing westward through the carbonate and Winnipeg Sandstone aquifers. This, from the viewpoint of those aquifers, means that if there is a decline in water level in the aquifer due to an addition in withdrawals, the recharge area can likely supply the requested allocation.

## 14.3 PREDICTION OF LONG – TERM REGIONAL EFFECTS

In order to conservatively determine the long-term effects of operating the Municipality of Ritchot Randolph Road Well Field, the expected drawdown was calculated at a distance using the Theis (1935) equation and the estimated aquifer parameters.

Since the Randolph Road Well Field has been in operation for more than 40 years, the impacts from the current discharge from the well could now be considered as the “state of nature” on the aquifer. Water use records from 2007 to 2021 indicate that the Randolph Road Well Field has been discharging an average of 188.78 U.S.G.P.M. (11.90 L/s) or approximately 375.646 cubic decameters (304.54-acre feet) annually. The well field has been a form of water level control in

the carbonate aquifer since the 1980's and third-party wells that are present in the area have been able to operate with the current municipal water use in the area for more than 20 years.

Figure 44, shown below, illustrates the existing drawdown cone present in the Randolph Well Field wells through freely discharging water over the past few decades.

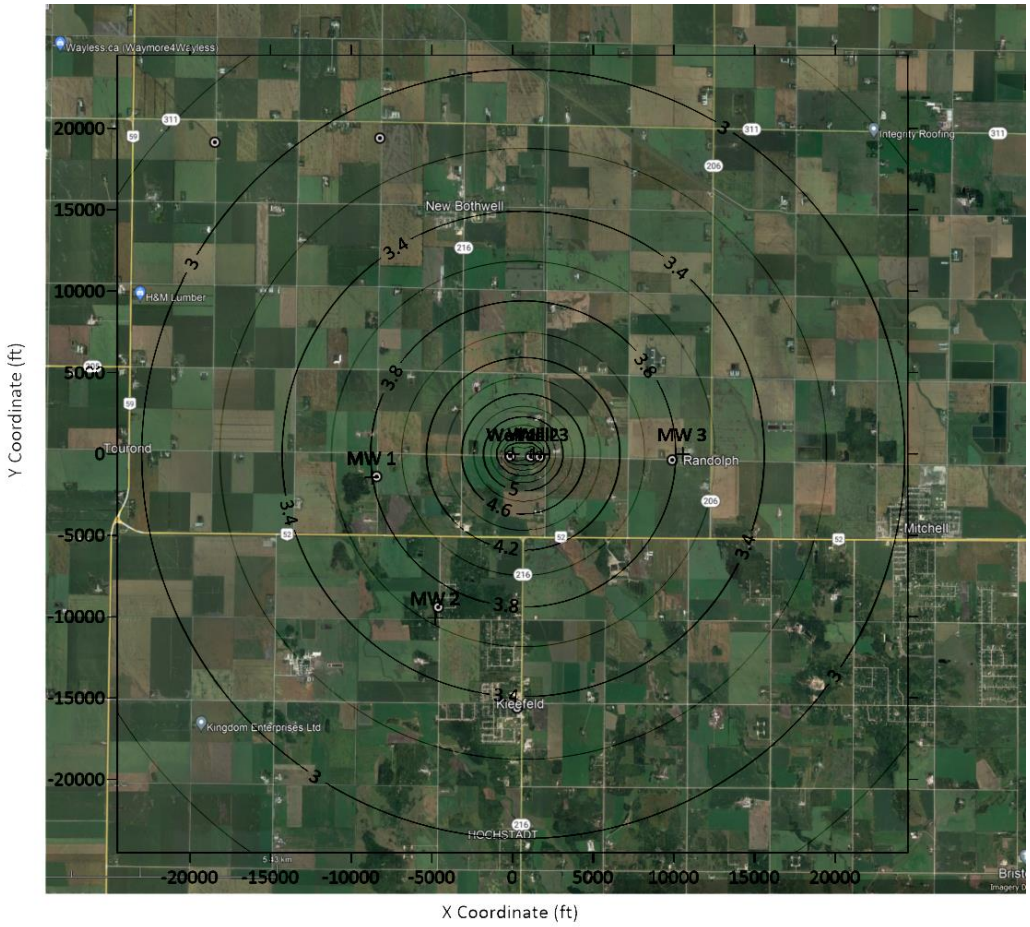


**Figure 44: Existing Drawdown created from continuous discharge of an average of 188.8 U.S.G.P.M. for over 20 years.**

(Drawdown cone (in feet) estimated from using Theis (1935) analysis, Aqtesolv Professional V. 4.5 and plotted using Surfer)

Based on the continuous pumping rate of 396.26 U.S.G.P.M. (25 L/s), the additional drawdown that will occur from mechanizing the Randolph Road Well Field was estimated by deducting the existing drawdown present in the area from the total estimated drawdown. The aquifer response from pumping the 396.26 U.S.G.P.M. (25 L/s) in the area would be similar to pumping an average of 207.8 U.S.G.P.M. from the Randolph Road Well Field. It should also be noted that the current water use licence does for the site does not have an upper limit to the amount of freely discharging water from the Randolph Road Well Field and that the requested additional allocation would allow the Municipality to support 10 to 20 years of growth. The estimated additional drawdown that will

be created by continuously operating the Randolph Road Well Field at 396.26 U.S.G.P.M. (25 L/s) for one year is shown in Figure 45. The estimated drawdown is shown in Table 12.

**Figure 45: Additional drawdown expected from operating the Well Field at 396.25 U.S.G.P.M. for 1 year**

(Drawdown cone (in feet) estimated from using Theis (1935) analysis, Aqtesolv Professional V. 4.5 and plotted using Surfer)

**Table 12 - Calculated Drawdown After One Year of Operations**

| Table 12<br>Calculated Drawdown – One Year Pumping at 25L/s (396.26 U.S.G.P.M.)<br>(639.16 acre feet/year)<br>Proposed Municipality of Ritchot Water Supply Alteration<br>Randolph Road Well Field - SE 8-7-5 EPM | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Well** | **250 feet** | **500 feet** | **1,000 feet** | **2,640 feet (0.5 mile)** | **3,960 feet (0.75 mile)** | **1 mile** | **2 miles** | **4 miles** |
| **Total estimated drawdown (from pumping 396.26 U.S.G.P.M.)** | | | | | | | | |
| 22.3 ft. | 12.33 ft | 10.97 ft. | 9.705 ft. | 7.96 ft. | 7.20 ft. | 6.67 ft. | 5.41 ft. | 4.14 ft. |
| **Assumed existing drawdown in the area ( assuming constant discharge rate of 188.8 U.S.G.P.M.)** | | | | | | | | |
| 10.62 ft. | 5.83 ft | 5.23 ft | 4.62 ft. | 3.78 ft. | 3.43 ft. | 3.18 ft. | 2.58 ft. | 1.97 ft |
| **Additional Drawdown (Total-Existing) – Similar aquifer response to continuous pumping at 208.5 U.S.G.P.M.** | | | | | | | | |
| 11.68 ft | 6.5 ft | 5.74 ft | 5.085 ft | 4.18 ft | 3.77 ft | 3.49 ft | 2.83 ft | 2.17 ft. |
| All calculations following the Theis (1935) equation and assumptions | | | | | | | | |

(Drawdown cone estimated using Theis (1935) analysis, Aqtesolv Professional V. 4.5)

In considering the average recorded discharge from the site since 2007, the effects of pumping the aquifer at the rate of 396.26 U.S.G.P.M, would create an effect similar to pumping 208.5 U.S.G.P.M. at the site. The additional drawdown at a radial distance of 2 miles from the supply well was determined to be approximately 2.83 feet after pumping one year continuously at the additional rate of 208.5 U.S.G.P.M. The effect of mechanizing the Randolph Road Well Field and continuously pumping at the rate of the 396.26 U.S.G.P.M, should be less than 3 feet at two miles from the site. Further, it is anticipated that the normal daily pumping operations are generally less than 20 hours per day.

The area is sparsely populated, and to a large extent, the aquifer is not overly utilized by private wells. To the author's knowledge, a sustainable yield for the aquifer in this area has not been determined, and there are few studies present which deal with regional groundwater yields in the area. In reviewing the local static water levels, it is noted that static water levels fluctuated close to 10 feet in the area.

It should be noted that the estimated drawdown is without considering natural gradients and the effects of other unknown pumping wells that may be present. The hydrograph record also does not depict these conditions. During the 72-hour pumping test, several external pumping effects were noted. However, the effects were minimal and were generally less than 1.0 feet near the Randolph Road Well Field site. Due to the moderately high regional transmissivity, the additional drawdown cone in the area is expected to be shallow and extend over a wider range.

## 14.4 Recalibration of Peak Demand Flow Rates

In May of 2023, the maximum peak demand flow rate for supporting the growth of the Municipality in the next 20 years was reviewed by the MWSB. Based on the review, MSWB estimated a new total peak demand of 1,188.78 U.S.G.P.M (75 L/s ) (N. Wittmeier, personal communication, May 2023) for the Municipality of Ritchot. This assessment was supported by an updated raw water demand estimation completed by WSP in September of 2023, using the most recent population data (Statistics Canada, 2021). The raw water demand estimate completed by WSP (2023) is attached as Appendix K.

The peak demand estimation included water supplies from the PR 305 Well Field and the Randolph Road Well Field. Using the peak demand requirement calculated by MWSB/WSP, and the licensed maximum diversion rate of 554.76 U.S.G.P.M. ( 35 L/s) from the PR 305 Well Field, the peak flow rate required for the Randolph Well Field was estimated to be about 634.02 U.S.G.P.M. (~ 40 L/s). It should be noted that the peak demands are not intended to be drawn continuously and that the annual allocation request is not intended to change with the recalculation of the peak demand flow rate.

A comparison of drawdowns created after one full day of operations at 396.26 U.S.G.P.M. (25 L/s) and 634.02 U.S.G.P.M. (~ 40 L/s) using the used the Theis (1935) analysis is shown in Figure

46. The additional drawdown resulting from operating one full day at 634.02 U.S.G.P.M. compared to operating at 396.26 U.S.G.P.M. is shown in Figure 47.

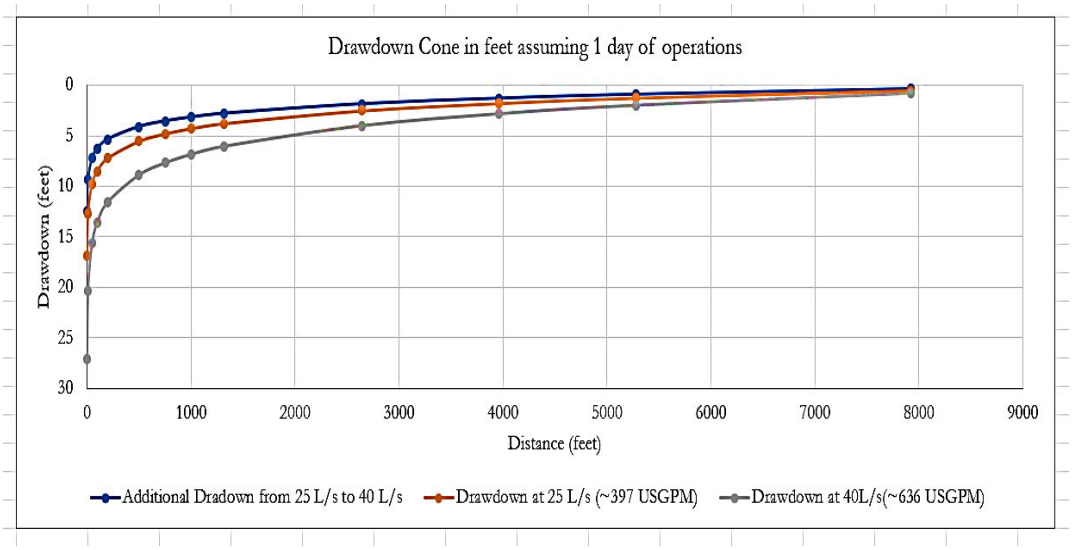


**Figure 46: Comparison of Drawdown at Distance Created at Different Pumping Rates**

(Drawdown cone estimated using Theis (1935) analysis)

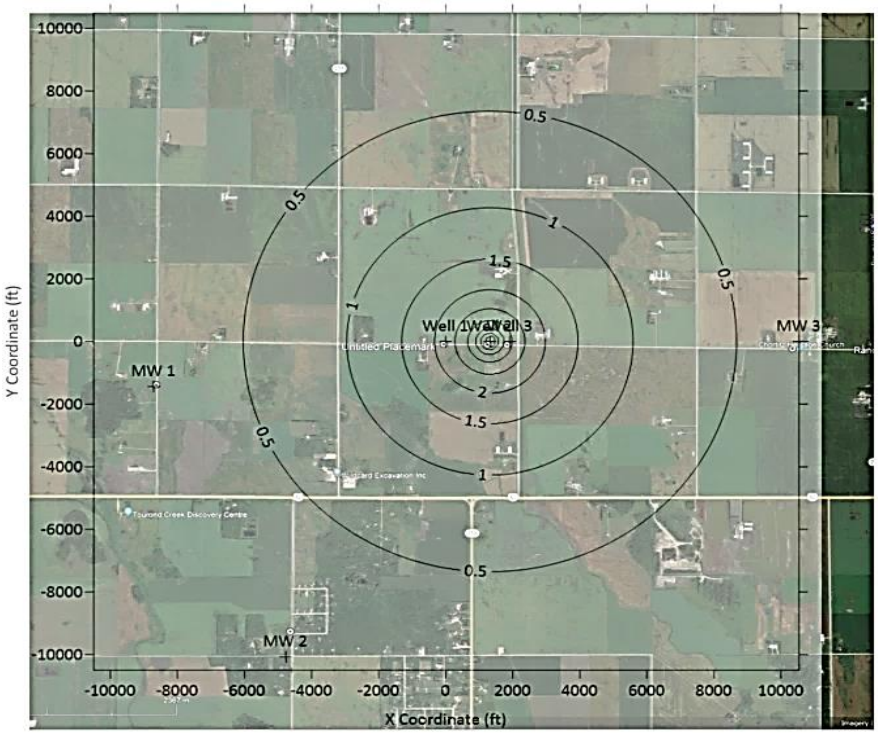


**Figure 47: Additional drawdown created when operating at peak flow rates (634.02 U.S.G.P.M.) from 396.26 U.S.G.P.M., after 24 hours of operation**

Based on the estimation, the additional instantaneous demand would result in an additional 1.0 feet of drawdown at 1 mile from the site and an addition 0.5 feet of drawdown at 1.5 miles from the site after 24 hours of continuous operation.

## 14.5 WELL FIELD DEVELOPMENT PLAN

The Randolph Road Well Field appears to be able to support pumping a maximum instantaneous flow rate of 634.02 U.S.G.P.M., with an average flow rate of 396.26 USGPM. This amounts to an annual allocation of 788.39 cubic meters (639.16 acre feet). During peak demands, the site will require both Well 1 and Well 2 to pump simultaneously, leaving no redundancy for the site.

In consideration of the wells in the area, a gradual increase in pumping is recommended to allow for the gradual expansion of the drawdown cones.

The following development plan is suggested for the Randolph Road Well Field:

- First five years development – Well Field discharge limited to 447.412-acre feet, annually. This would be about 70% of their total requested allocation. This reduced allocation should meet the Municipality of Ritchot's needs for the next 5 years and would allow the drawdown cone to develop slowly in the area. The peak demand for the site should be limited to 634.02 U.S.G.P.M. This will require both Well No. 1 and Well No. 2 to operate simultaneously during peak demand. Average Well Field operation should be limited to operating Well No. 1 and Well No. 2 on a duty standby basis. In order to provide back-up water supply in the future, the existing wells may either be over drilled into larger diameter 12 inch wells or additional wells may need to be installed at the site. Monitoring should also be completed.

- Five years and beyond – Pumping to full capacity, and up to 788.39 $dam^3$ (639.16 acre feet) of pumping, annually with a peak flow rate of 634.02 U.S.G.P.M.

- Additional monitoring is needed to observe how the drawdown cone develops in this area. It is recommended that some of the temporary monitoring stations drilled during the investigations be instrumented and be kept as permanent monitoring stations in the area. An additional monitoring well should be installed to the west of Well 1 to monitor groundwater levels in the carbonate aquifer between the well field and the nearest third-party user west of the site.

# 15 INTEGRATED WATER SUPPLY AND WATERSHED PLANNING STUDY

A water supply investigation and development of this size requires careful planning and assessment. Although it is assumed that groundwater supplies are the best option, an integrated water supply and watershed planning study is an important tool in the evaluation process.

An integrated planning study for water supply would identify future and prospective water supply sources, and the relative availability. This would document and address items such as river supplies, allocations, and other water supply alternatives. This is important for future water supply licensing and environment act licensing.

An integrated water supply and watershed planning study is recommended for the area.

# 16 WELL HOOK UP AND MECHANICAL CONSIDERATIONS

The following recommendations should be followed with respect to the mechanical connections to Well No. 1 and Well No. 2:

- The wells should be equipped with a center hung, full spool type pitless unit for ease of future servicing. Due to the higher water levels in the area, provisions should be made to properly vent the wells during winter periods. A hydrogeologist should assist in this design.

- The contract engineer should review the material for the pitless unit construction with the Municipality prior to specifying the product, although stainless steel is generally recommended. The pitless units should be installed so that no diameter restrictions are placed within the well at the pitless unit/casing connection. The pitless units should be installed concentric with the well casing with proper hold down assemblies.

- The submersible pump intake should be installed within the well casing. The deepest recommended pump setting is 85 feet below grade.

- At its current state, the maximum total pumping rate for the Randolph Road Well Field is limited to 634.02 U.S.G.P.M. Due to the diameter restrictions, both Well No. 1 And Well No. 2 will be required to pump simultaneously to provide the peak water demand. It is expected that normal operations will only require one well to pump at a time. In order to provide back-up water supply in the future, the existing wells may either be overdrilled into larger diameter 12 inch wells or additional wells may need to be installed at the site.

- The well field design and layout should allow for truck access to the wells in the future. The sites should also have drainage away from the well heads. The wells should be protected from vehicular impact.

- The entire system design should take into account the local water quality. Water quality could get slightly worse with prolonged pumping.

- Proper records, including daily temperature and pressure readings, along with weekly measurements of water levels in the wells should be recorded by the operators.

It is important to note that Friesen Drillers Limited did not undertake any design or review of the mechanical engineering design of the piping/delivery system. It should be noted that all piping, selection of submersible pumps, and connections to the wells were beyond the scope of this hydrogeological assessment.

# 17 RECOMMENDATIONS

The following recommendations are provided, based on our investigation for the proposed additional groundwater allocation for the Municipality of Ritchot:

- Under normal seasonal and climatic conditions, the Randolph Road Well Field can provide the peak demand flow rate of 634.02 U.S.G.P.M (40 L/s), with a total annual allocation of 639.16-acre feet.

- The combined instantaneous flow rate from both the Randolph Road Well Field and the PR 305 Well Field should be limited to 1,188.78 U.S.G.P.M (75 L/s).

- The Municipality should proceed with an application for a Water Rights Licence and an Environmental Act Licence Notice of Alteration application.

- The increased peak flow rate demand necessitates back-up water supply for the site. This could be attained by either over drilling Well No. 1 and Well No. 2 into larger diameter, 12 inch wells or installation and testing of additional back-up wells at the site. Further testing and monitoring will also be required.

- The hydraulic conditions on the site indicate moderately high transmissive conditions of 50,000 U.S.G./day/ft.

- The specific capacity of both wells is about 20 U.S.G.P.M./ft. The specific capacity may change over time which can impact overall well yield. It is recommended to redevelop the well within 5 years or sooner to maintain well efficiency.

- Water levels should be monitored closely under operating conditions to ensure that air is not entrained in the system.

- An additional monitoring station should be planned to further delineate the drawdown created by the additional pumping.

- An annual Groundwater Monitoring Program should be implemented. The program should be designed and supervised by a hydrogeologist/ hydrogeological engineer registered to practice in Manitoba. The program should include a review of transducer data from the monitoring wells and of regional hydrograph data from the provincial observation network. In addition, groundwater samples should be collected from the monitoring wells and analyzed for routine geochemical parameters and stable environmental isotopes of oxygen-18 and deuterium. The results of the groundwater monitoring program results should be publicly reported.

- The Municipality should develop an Aquifer/Well Head Protection Program for all municipal wells and develop a contingency plan for the event that the aquifer becomes impacted or unusable in some manner.

- The Municipality should implement the current Well Interference Plan both Municipal Well Fields (Randolph Road Well Field and PR 305 Well Field) to resolve any future well interference complaints. It should be noted that an effective Well Interference Plan typically relies on data produced from a Groundwater Monitoring Program. The Well Interference Plan should also be reviewed and modified as needed.

- In the event of considerably lower regional static water levels in the aquifer, water levels in the production wells should be monitored daily. It is recommended that each production well be equipped with automatic data recording pressure transducers to assist the Municipality in monitoring pumping water levels.

- The wells will require regular maintenance. The pump and motor assembly should be removed and inspected at least once every 5 years. Well redeveloping may be required from time to time to maintain well efficiency.

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# 19 LIMITATIONS AND DISCLAIMERS

## 19.1 LIMITATIONS

The scope of this report is limited to the matters expressly covered and is intended solely for the client to whom it is addressed. Friesen Drillers Limited makes no warranties, expressed or implied, including without limitation, as to the marketability of the site, or fitness to a particular use. The assessment was conducted using standard engineering and scientific judgment, principles, and practices, within a practical scope and budget. It is based partially on the observations of the assessor during the site visit in conjunction with archival information obtained from a number of sources, which is assumed to be correct. Except as provided, Friesen Drillers Limited has made no independent investigations to verify the accuracy or completeness of the information obtained from secondary sources or personal interviews. Generally, the findings, conclusions, and recommendations are based on a limited amount of data (e.g. number of boreholes drilled or water quality samples submitted for laboratory analysis) interpolated between sampling points and the actual conditions on the site may vary from that described above. Any findings regarding the site conditions different from those described above upon which this report was based will consequently change Friesen Drillers Limited's conclusions and recommendations.

## 19.2 DISCLAIMER

This Friesen Drillers Limited report has been prepared in response to the specific requests for services from the client to whom it is addressed. The content of this document is not intended to be relied upon by any person, firm or corporation, other than the client of Friesen Drillers Limited, to who it is addressed. Friesen Drillers Limited denies any liability whatsoever to other parties who may obtain access to this document by them, without express prior written authority of Friesen Drillers Limited and the client who has commissioned this document.

Friesen
DRILLERS

# Appendix A

# Landmark Planning Inc.
# Public Consultation

# RURAL MUNICIPALITY OF RITCHOT

## WATER SUPPLY PROJECT

## PUBLIC ENGAGEMENT SUMMARY

LANDMARK PLANNING & DESIGN INC.

MARCH 2023

Landmark
Planning & Design Inc.

RITCHOT WATER SUPPLY PROJECT

# PUBLIC AND STAKEHOLDER ENGAGEMENT SUMMARY

**PREPARED FOR:**
THE RURAL MUNICIPALITY OF RITCHOT
THE MANITOBA WATER SERVICES BOARD
AND FRIESEN DRILLERS

**PREPARED BY:**
LANDMARK PLANNING AND DESIGN INC.

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APPENDIX E – ROUND TWO STAKEHOLDER MEETING MINUTES

APPENDIX F – ROUND THREE STAKEHOLDER MEETING MINUTES

# 1 INTRODUCTION

In 2020, the Rural Municipality of Ritchot (RM of Ritchot) initiated a process to identify options for supplementing their current water supply. The RM of Ritchot is working with the Manitoba Water Services Board (MWSB), Friesen Drillers, and Landmark Planning & Design (Landmark) to amend their water rights license to increase their water supply.

Landmark undertook a comprehensive engagement process with key stakeholders and members of the general public over three formal rounds of public engagement, supplemented by a Well Inventory Program, regular project updates, and by inviting members of the public to attend pump tests and conduct site visits. This report provides an overview of the work undertaken to date, a summary of the engagement process, and identifies next steps in the planning process.

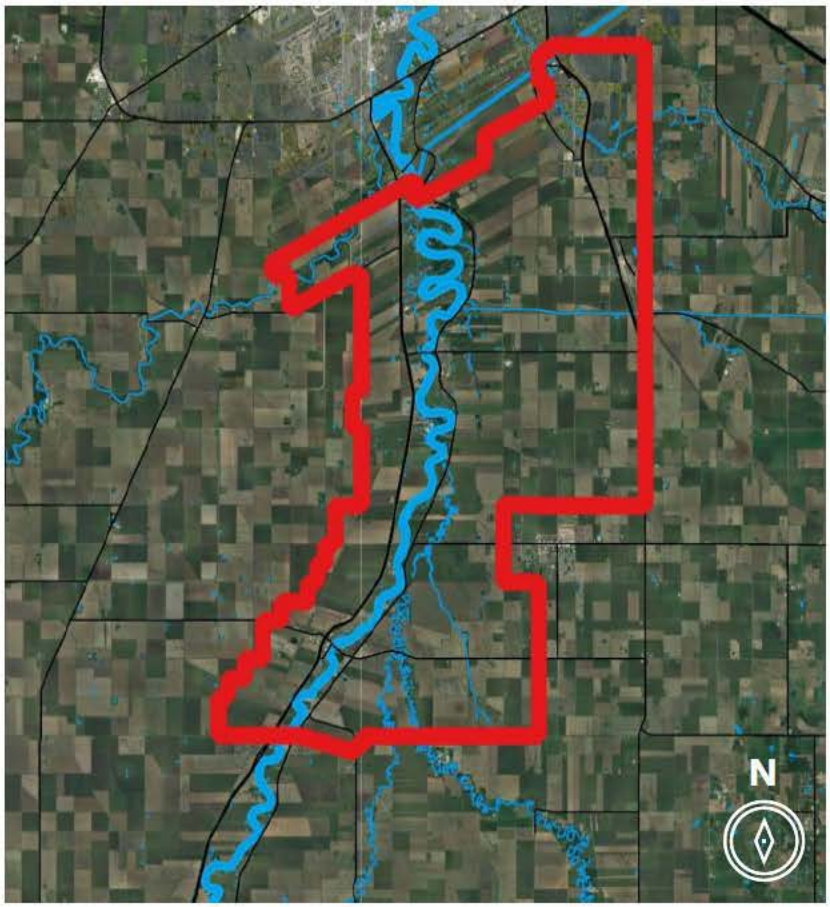



*Figure 1: RM of Ritchot*

# 2 PROJECT BACKGROUND

Stakeholders were provided with an extensive overview of the Ritchot Water Supply Project, including the project intent, background information, and guiding principles. The information contained within this Section of the report was provided to stakeholders at the outset of the project and was made available to read offline (download). Additional information that was shared can be found in the Appendices of this report.

The RM of Ritchot's existing water supply has served their needs for many decades. Though the RM of Ritchot is not experiencing a shortage in water supply, planning for the future means Ritchot should consider potential sources of additional water supply to serve the RM over the coming decades. Any new well or additional water supply requests would require an amendment to the existing Water Rights License and Environmental Act License.

Considerations relevant to supplementing water supply for the RM of Ritchot include:

- Rapid local population growth fueling domestic supply needs;
- Existing businesses requiring a strong, reliable water supply;
- New economic investment in industrial and commercial operations; and
- A steady rise in local construction and development.

As a result of these factors, the RM will need to match amenities and services with their current and future needs.

In 2021, the RM of Ritchot's population reached 7,469 people, an increase of 11.8% from their 2016 population. From 2001 to 2016, the population grew 22% (1,201 people). In comparison, the population growth in Manitoba over the same period was 5.8%, and the national average was 5.0%. If this rate of population growth continues, water supply may become a more pressing concern for the region, particularly as climate change continues to alter global water supply.

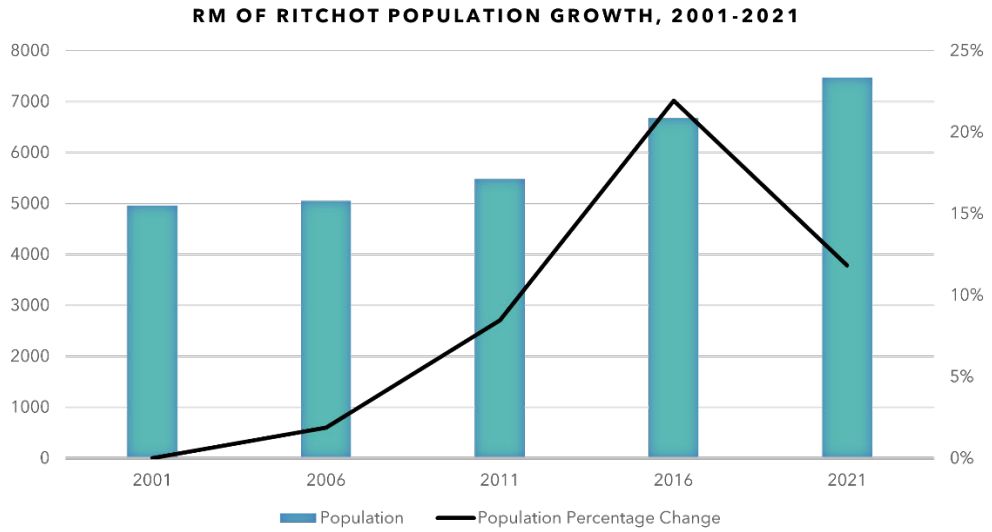



*Figure 2: RM of Ritchot Population Growth*

In 2020, the three most common Ritchot businesses by industry were: 1) Construction; 2) Agriculture; and 3) Real Estate. Many industries count on a reliable water supply in order to contribute to the local economy. Construction and agriculture in particular are highly water intensive. The RM of Ritchot has experienced a steady annual increase in building permits issued since 2013. In 2017, the municipality approved a total of 160 building permits, a rise of 17% from 2016. Despite the implementation of ongoing conservation measures (including a water conservation policy that restricts lawn watering to even/odd calendar days depending on address), increased growth of all types requires a dependable plan for water supply.

## 2.1 Existing Wells

The RM of Ritchot currently has two well fields. The Randolph Road well field is located on SE 8-7-5 EPM. The PR 305 well field is located on NE 12-7-3 EPM. Water is piped from these locations to the RM of Ritchot Water Treatment Plant and from there to users throughout the RM. There are no pumps in the existing wells at the Randolph Road well field site. There are well pumps in the PR 305 well field.

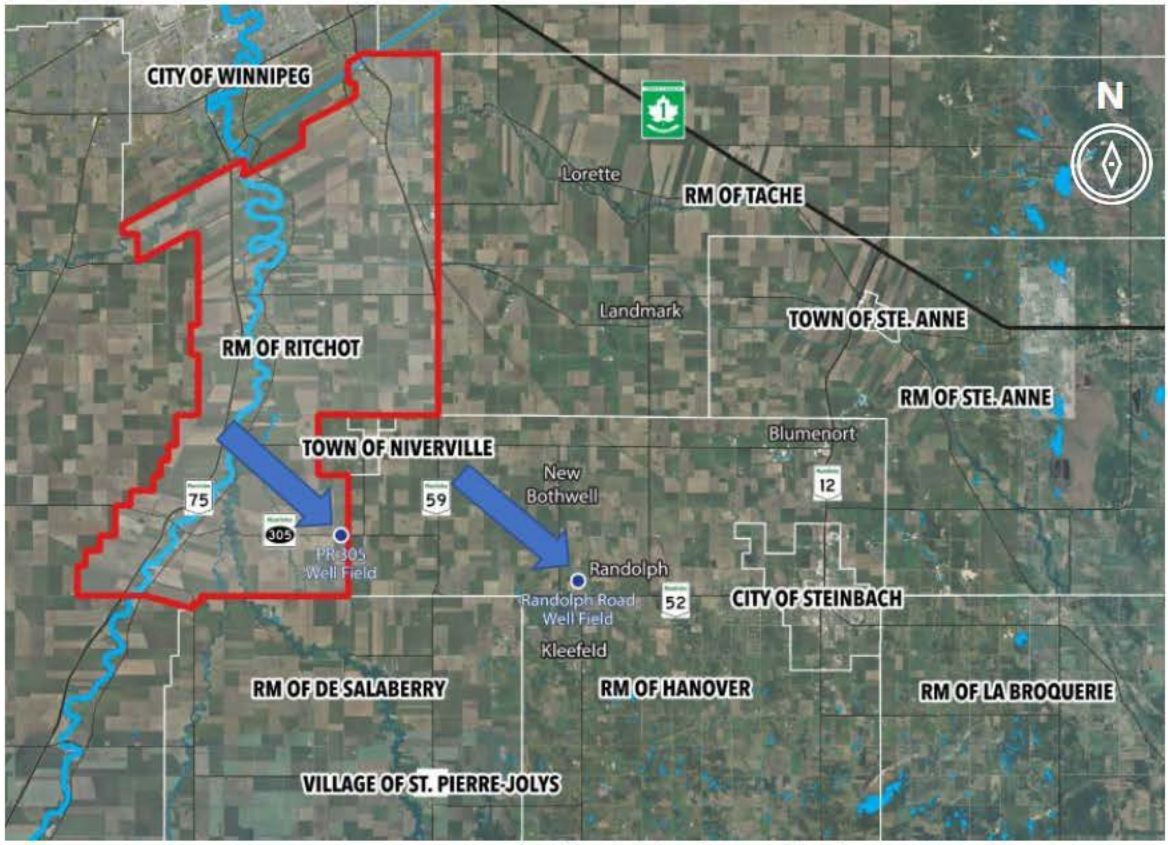



*Figure 3: Location of Well Fields for the RM of Ritchot*

The Randolph Road well field was originally established to relieve groundwater pressure to prevent 'hydraulic rupture' of a major drainage canal passing through the RM of Hanover. The flowing groundwater was allowed to freely flow to the Red River, where it was discharged unused. Rather than letting it go to waste, the RM of Ritchot was granted permission to collect the water via pipes and use it for their own consumption.

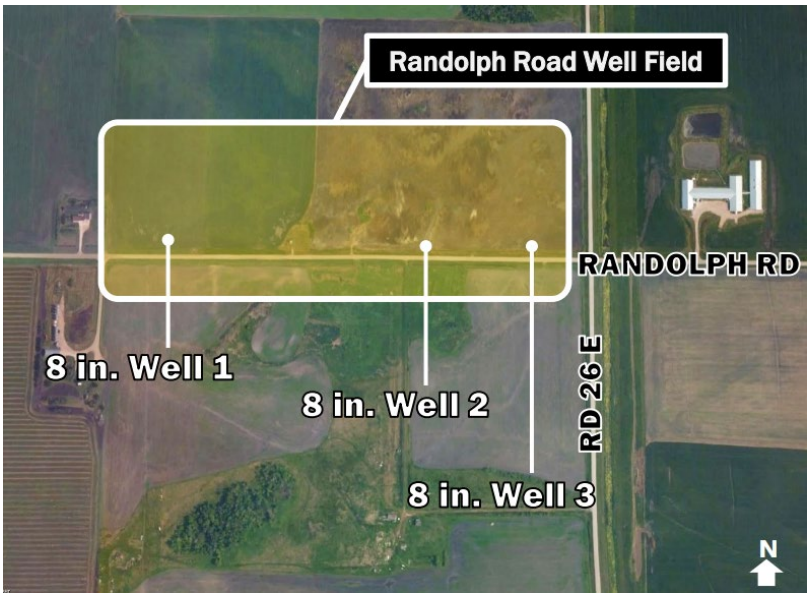



*Figure 4: Randolph Road Well Field*

The PR 305 well field was installed to supplement the decreasing water supplies from the gradual lowering of the local groundwater pressure.

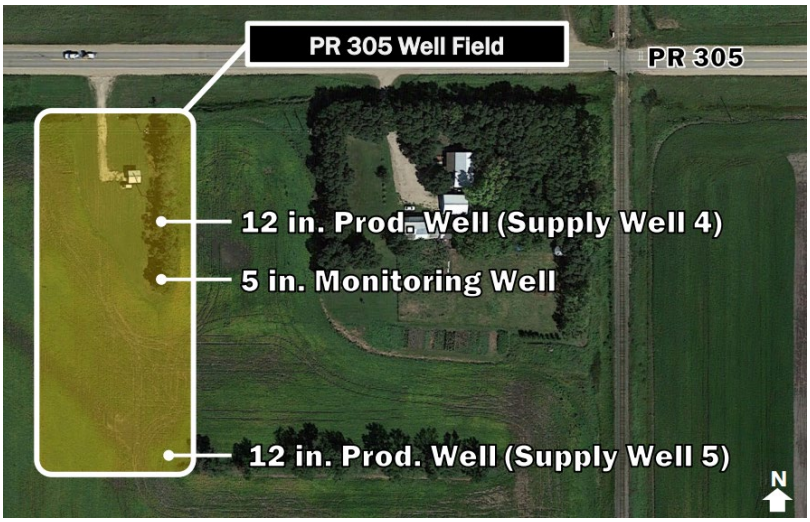



*Figure 5: PR 305 Well Field*

## 2.2 Hydrogeology

There are two natural aquifers below the ground surface near the RM of Ritchot, the Carbonate Aquifer and a Sandstone Aquifer. Groundwater in each aquifer is increasingly saline west of the subject site and fresher east of the subject site. Most of the RM of Ritchot is located in the saline portion of these aquifers, with some exceptions. For an extensive description of the local and regional hydrogeology, see Friesen Drillers' *'Municipal Groundwater Supply Investigations'* report.

## 2.3 Study Area

Figure 6 illustrates the study area the project team has used to form the context for testing of the existing wells.

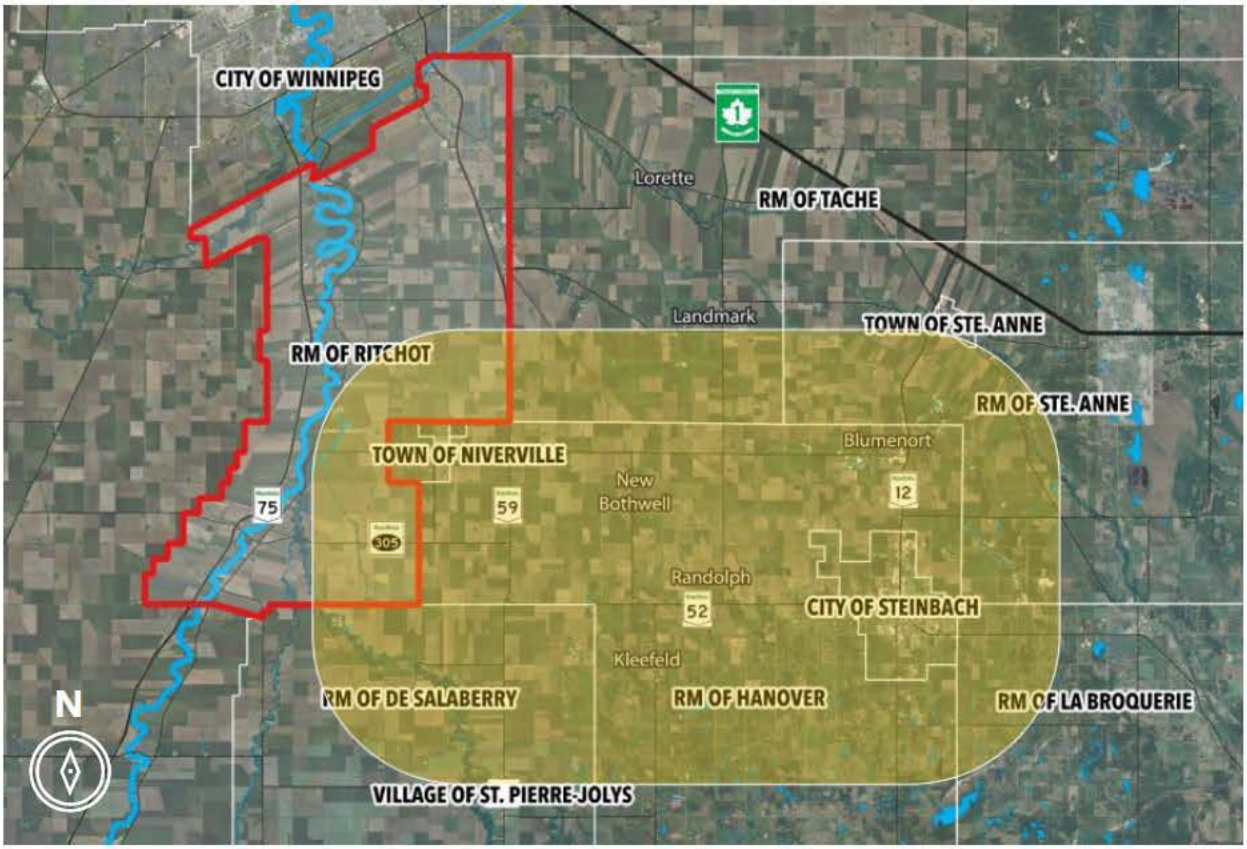



*Figure 6: Ritchot Water Supply Project Study Area*

# 3 STAKEHOLDER ENGAGEMENT PROCESS

Landmark held a comprehensive stakeholder engagement process throughout the duration of the Ritchot Water Supply Project. This process included a target area represented by a two-mile square area around the Randolph Road municipal well field site and was designed to engage landowners, residents, and industrial/manufacturing operators to better understand existing water supply and quality, and to assess any potential impacts of the project on local interests.

The project team reached out to a number of local stakeholders including:

- Council and CAO for the RM of Ritchot and RM of Hanover;
- RM of Hanover Public Works department representatives;
- Private landowners or businesses with wells in the target study area; and
- Local farmers, livestock operations, and farming operations
- Other landowners.

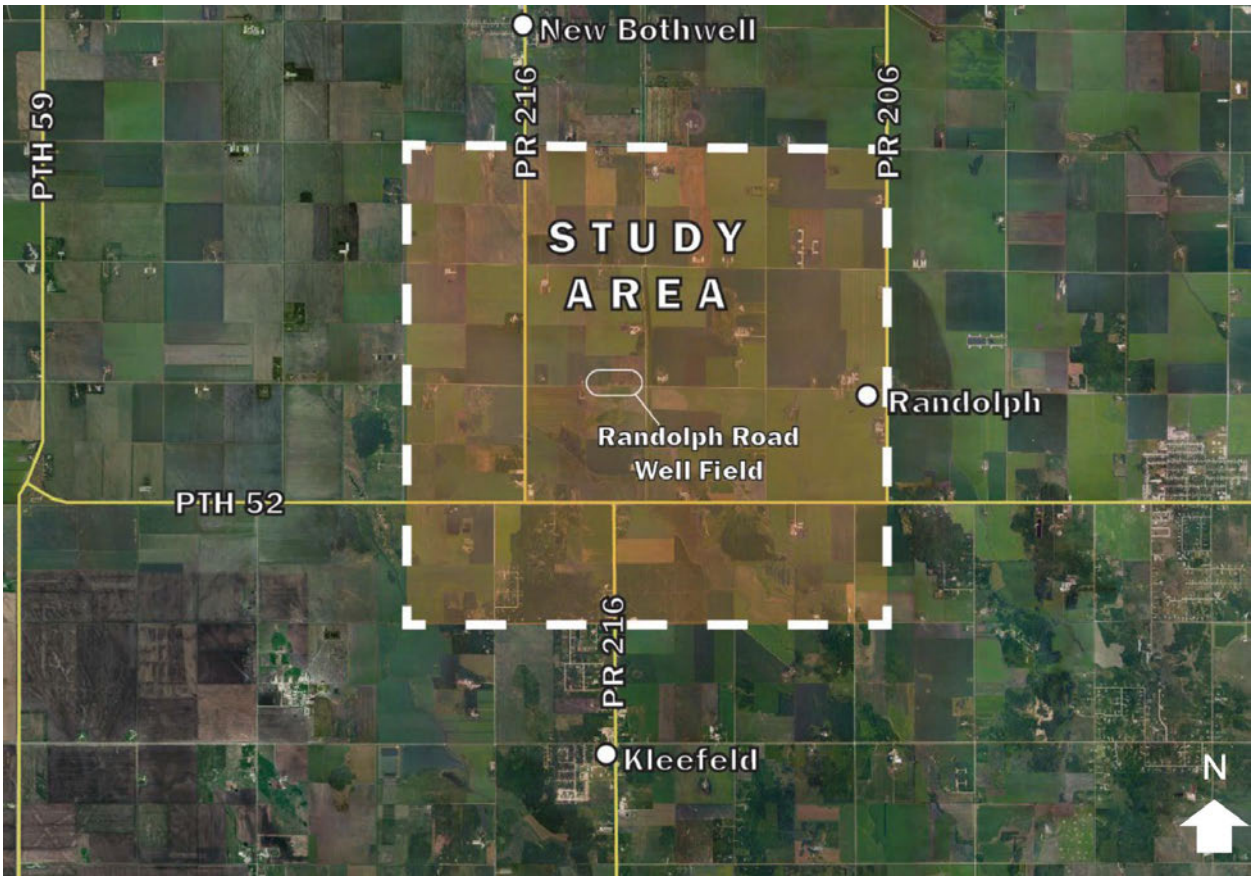



*Figure 7: Target Study Area*

## 3.1 TARGETED STAKEHOLDER MEETINGS

The project team identified all landowners within a two-mile block surrounding the Randolph Road Well Field Site and invited them to participate in three rounds of stakeholder engagement held in December 2021, April 2022, and September 2022. The objective of the targeted stakeholder meetings was to share project information, receive feedback, and respond to any comments, questions, or concerns.

Landowners, residents, business owners, and commercial/industrial operators within the study area received direct invitation via notification letter, email, and/or registered letter to attend group stakeholder meetings. Two sessions were offered for both rounds one and three of stakeholder meetings. Due to variability in weather (Spring melt), considerations for road restrictions and their implications for the installation of monitoring wells, as well as scheduling conflicts, only one session was offered for the second round of engagement. Attendance for each session is outlined in Table 1 below:

| | December 9th 2021 | | April 26th 2022 | September 27th 2022 | |
|---|---|---|---|---|---|
| Session | 4:00 – 5:30 PM | 7:00 – 8:30 PM | 7:00 – 8:30 PM | 4:00 – 5:30 PM | 7:00 – 8:30 PM |
| RSVPs | 10 | 10 | 13 | 4 | 10 |
| Attendance | 13 | 5 | 15 | 2 | 8 |
| **Total** | **18** | | **15** | **10** | |

*Table 1: Stakeholder Meeting Attendees*

### 3.1.1 Round One

The objective of the first round of engagement was to introduce the project team, outline the planning process, receive feedback, and discuss anticipated next steps.

Due to COVID-19 considerations, meetings were held remotely via Zoom. The first round of engagement was held on December 9th, 2021 in two identical sessions at 4:00pm and 7:00pm. Prior to the meetings, 20 individuals responded to indicate their attendance, and 18 individuals attended.

Stakeholders present at these meetings raised a variety of questions and comments about current well output, the process for identifying potential well sites, and risks to the current water supply. A summary of these comments and concerns is outlined below (edited for clarity):

- If our wells were affected by an eventual project, whose responsibility would it be to rectify the issue?
- What is the level of confidence of sustainability based on the [predetermined pump test] period of time?
- How has the drought impacted water supply in the area?
- Have artesian wells stopped flowing?
- Are different types of wells affected in different ways?
- Is there a chance of saline migration?
- How much water is the RM of Ritchot looking for?

The project team provided responses to the above comments during the meetings and if a response was not readily available followed up with stakeholders in the following days. See Appendix D for project team responses to the above-noted comments.

### 3.1.2 Well Inventory Program

Landowners within the study area for the Water Supply Project were invited to participate in a Well Inventory Program. This Program was designed to help evaluate the quantity and quality of existing wells in the study area and assist in forecasting any possible effects of potential new wells, or the installation of pumps into the Randolph Road well field. This program formed an important part of the overall study to help ensure that any changes to the current water supply would not have a negative effect on existing wells.

The inventory process was undertaken from January 2022 to May 2022. Appointments were made available via Zoom, FaceTime, and phone call, and evening timeslots were made available.

The project team was able to collect information regarding well history, water quality, and well performance.

All landowners, residents, and commercial operations within the study area were invited to participate in the Well Inventory Program by mailed notification letter, verbally in stakeholder engagement meetings, and via email. Two rounds of invitations were distributed, including in December of 2021 and in May of 2022.

In addition to the above efforts, all landowners within a one-mile block around the well site were invited to participate in the Well Inventory Program via two rounds of registered letters.

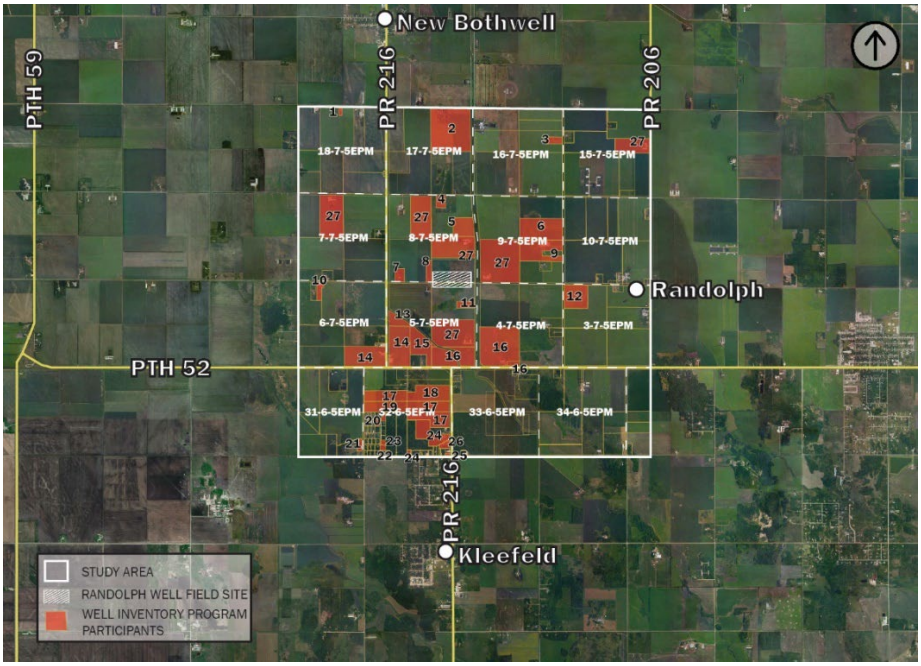



*Figure 8: Well Inventory Program Participants*

A total of 27 stakeholders participated in the Well Inventory Program, including both domestic and agricultural/industrial well users. A total of 41 wells were inventoried by the conclusion of the Program.

**Round Two**

The objective of the second round of engagement was to provide a project update, address questions and comments raised at the first set of meetings, discuss the preliminary results of the Well Inventory Program, and share important information regarding upcoming monitor well drilling.

The second round of engagement was held on April 26th, 2022 at 7:00pm. For the second round of engagement, landowners, residents, business owners, and commercial/industrial operators within the study area received direct invitation via notification letter, and participants from previous engagement were invited via email. Prior to the meeting, 13 individuals responded to indicate their attendance, and 15 individuals attended.

Stakeholders in attendance provided questions and comments about water levels and pressure, trace minerals in the water supply, and potential interference with agricultural activities. A summary of these comments and concerns is outlined below (edited for clarity):

- There were issues with trace minerals in the water when municipal wells were drilled previously.
- Will the data account for 'dry' years?
- Have noticed a fair amount of ground shifting in the area.
- Will this project impede current landowners and water users from expanding their own operations in the future?
- Will new restrictions be imposed on existing landowners?
- Is the groundwater close to the surface?
- How might existing water quality be impacted? Would it be remedied?
- What happens if the project moves forward, but in twenty years we run out of water?
- How many gallons per minute would be pumped?

The project team provided responses to the above comments during the meetings and if a response was not readily available followed up with stakeholders in the following days. See Appendix E for project team responses to the above-noted comments.

### 3.1.3 Monitor Well Drilling

Following the Well Inventory Program, Friesen Drillers conducted a preliminary inspection and draw down test, which included an assessment of the existing municipal wells for functionality. Stakeholders were notified about the monitor well drilling at the second round of stakeholder meetings, via notification letter, and via email.

### 3.1.4 Pump Test

Stakeholders were invited to view a pump test at the Randolph Road well field site on July 25th, 2022 via notification letter and email. Members of the project team were available on site to address any questions or comments.

Approximately 12 stakeholders attended the pump test.

*Figure 9: Pump Test*

*Figure 10: Pump Test*

### 3.1.5 Round Three

The objective of the third round of engagement was to provide a project update, address questions and comments raised at previous meetings, share the results of the pump test, and provide a detailed overview of next steps in the planning process.

The third round of engagement was held on September 17th, 2022 in two identical sessions at 4:00PM and 7:00PM. For the third round of engagement, landowners, residents, business owners, and commercial/industrial operators within the study area received direct invitation via notification letter, and participants from previous engagement were invited via email. Prior to the meeting, 14 individuals responded to indicate their attendance, and 10 individuals attended.

Stakeholders in attendance provided questions and comments about water levels and pressure, specifics of the licensing application process, and potential long-term impacts. A summary of these comments and concerns is outlined below (edited for clarity):

- How do [development applications in the surrounding region] impact this application?
- Will have an animal nutritionist on board when pumps are installed to monitor health of our cattle/livestock.
- What was the rate of pumping during the 72-hour pump test?
- If the graduated license allows for 70% usage, would it still run at 25 litres per second or would it vary?
- What happens to people with artesian pressure wells in the area?
- If we lose water pressure, will we be protected by the Groundwater Interference Program?
- I like that what you're proposing is sustainable and will only slightly create a drawdown and then remain consistent.
- Hopeful that this will be okay for the area and landowners.
- We like that you have a response plan in place and would like to see that honoured.

The project team provided responses to the above comments during the meetings and if a response was not readily available followed up with stakeholders in the following days. See Appendix F for project team responses to the above-noted comments.

To address any outstanding concerns following the third round of meetings, Friesen Drillers offered to meet with landowners one-on-one to inspect their current well infrastructure. Friesen Drillers conducted a total of three personal site visits to assess the condition of landowner wells and attempt to address remaining concerns. At the time of writing this report, there are two landowners in the study area whose concerns may not have been resolved.

## 3.2 REGULAR PROJECT UPDATES

The project team provided regular project updates throughout the project.

### 3.2.1 Internal Project Update Meetings

Regular project updates were provided to both the RM of Ritchot and RM of Hanover Councils and their Administration at key milestones, including prior to stakeholder engagement meetings and prior to the pump test.

Each Council and their Administration continue to be engaged as the project moves forward towards a license application being submitted.

### 3.2.2 Online Comment Sheet

An online comment sheet was made available to stakeholders to provide follow-up questions, comments, or concerns following each round of stakeholder meetings. Participants were provided an opportunity to share additional feedback, register to participate in the Well Inventory Program, and provide their contact information to be added to the project's master stakeholder list to receive regular project updates.

### 3.2.3 Stakeholder Follow Ups

The project team was readily available to answer incoming inquiry and address potential concerns from stakeholders throughout the entirety of the project. Stakeholder follow ups occurred regularly via phone call, email, and Zoom meetings.

### 3.2.4 Project Webpage

All project materials, including stakeholder presentations and a link to the online comment sheets, were made available via project webpage on Landmark's website.

# 4 SUMMARY AND NEXT STEPS

The project team prepared a hydrogeologic report with the results of the and prepared an environmental assessment report with specified requirements of the *Environment Act*. The project team will proceed with submitting a license application to secure additional water supply for the RM of Ritchot. Stakeholders will continue to be engaged throughout the duration of the project at key stages going forward.

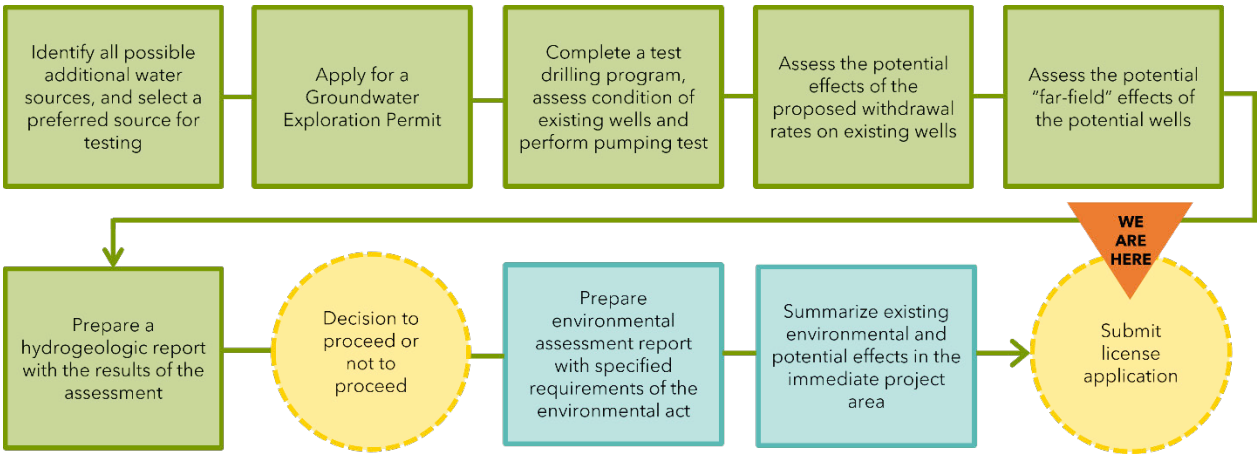



*Figure 11: Next Steps Timeline*

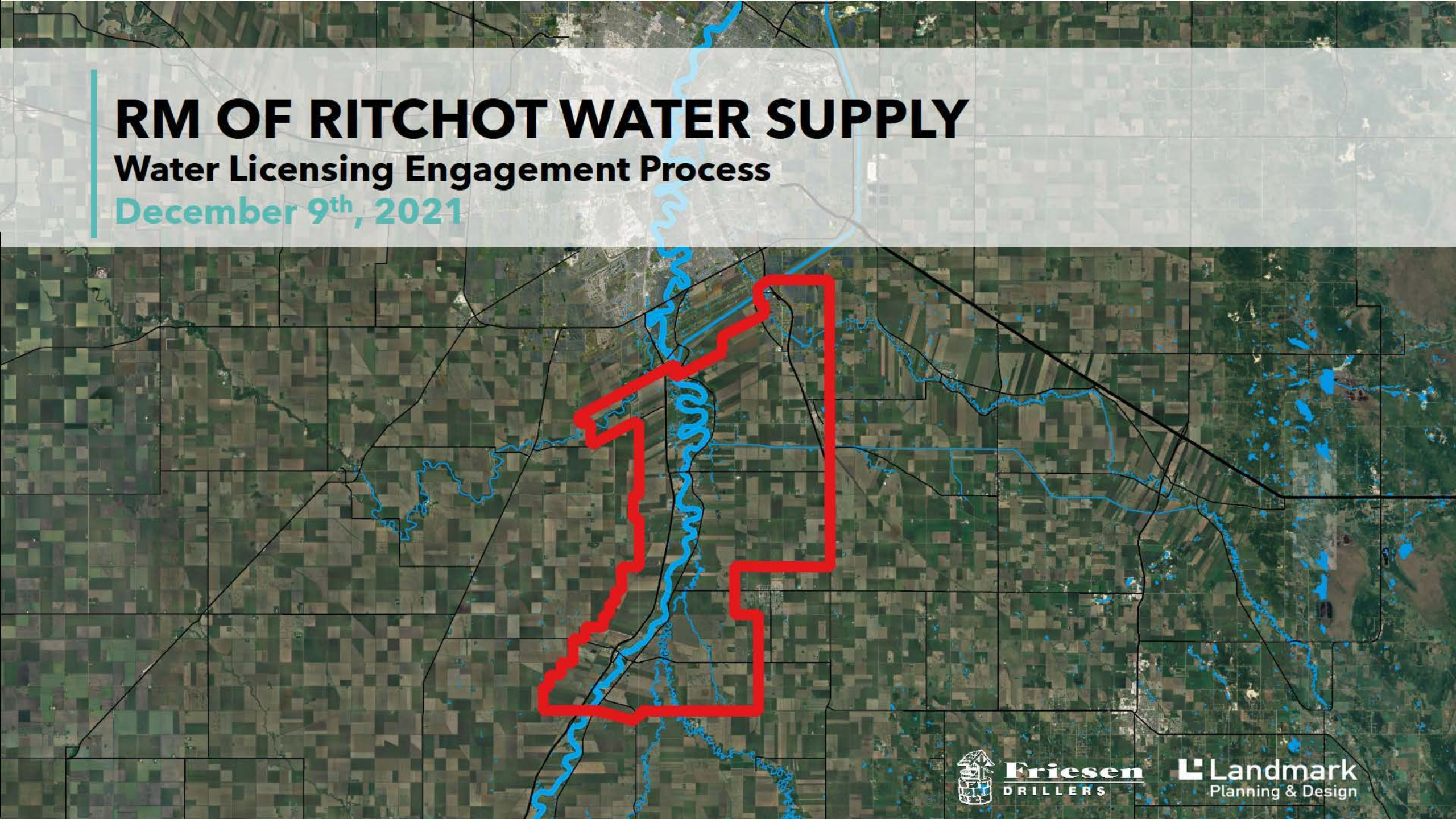
## APPENDIX A

# ROUND ONE STAKEHOLDER PRESENTATION

# RM OF RITCHOT WATER SUPPLY

## Water Licensing Engagement Process

December 9th, 2021



Friesen DRILLERS

Landmark Planning & Design

# BACKGROUND

- The existing water supplies for the RM of Ritchot have served the needs of the RM for many decades
- Planning for the future means the RM should look at additional water supply needs to serve the RM over the coming decades, while continuing to work at measures for conserving more water
- Landmark Planning & Design is working with Friesen Drillers, the RM of Ritchot and the Manitoba Water Services Board (MWSB) to increase the water supply
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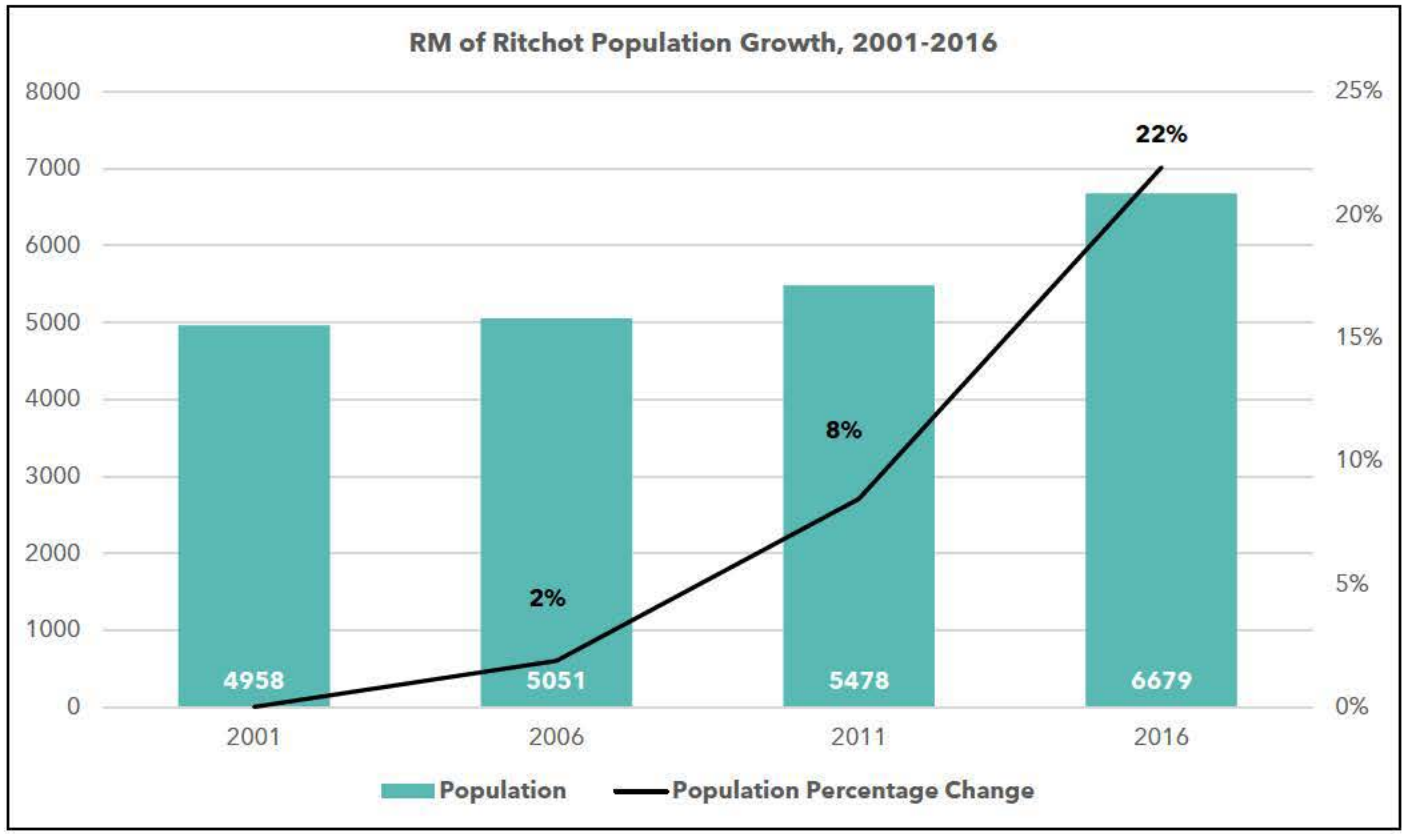


Source: Statistics Canada, 2016 Census



Friesen DRILLERS Landmark Planning & Design

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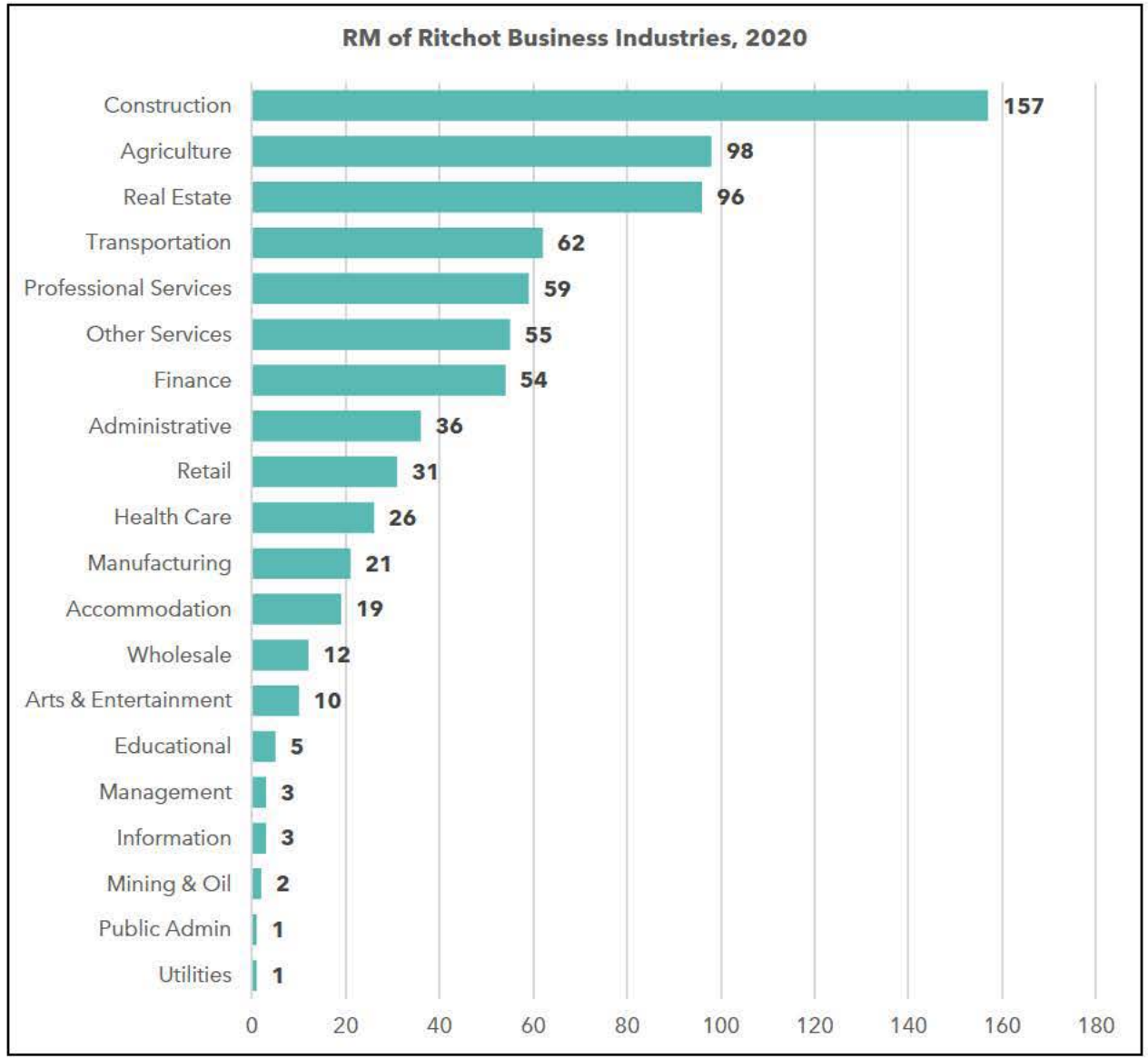


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Landmark Planning & Design

# BACKGROUND

- The RM of Ritchot has experienced a steady annual increase in building permits issued since 2013
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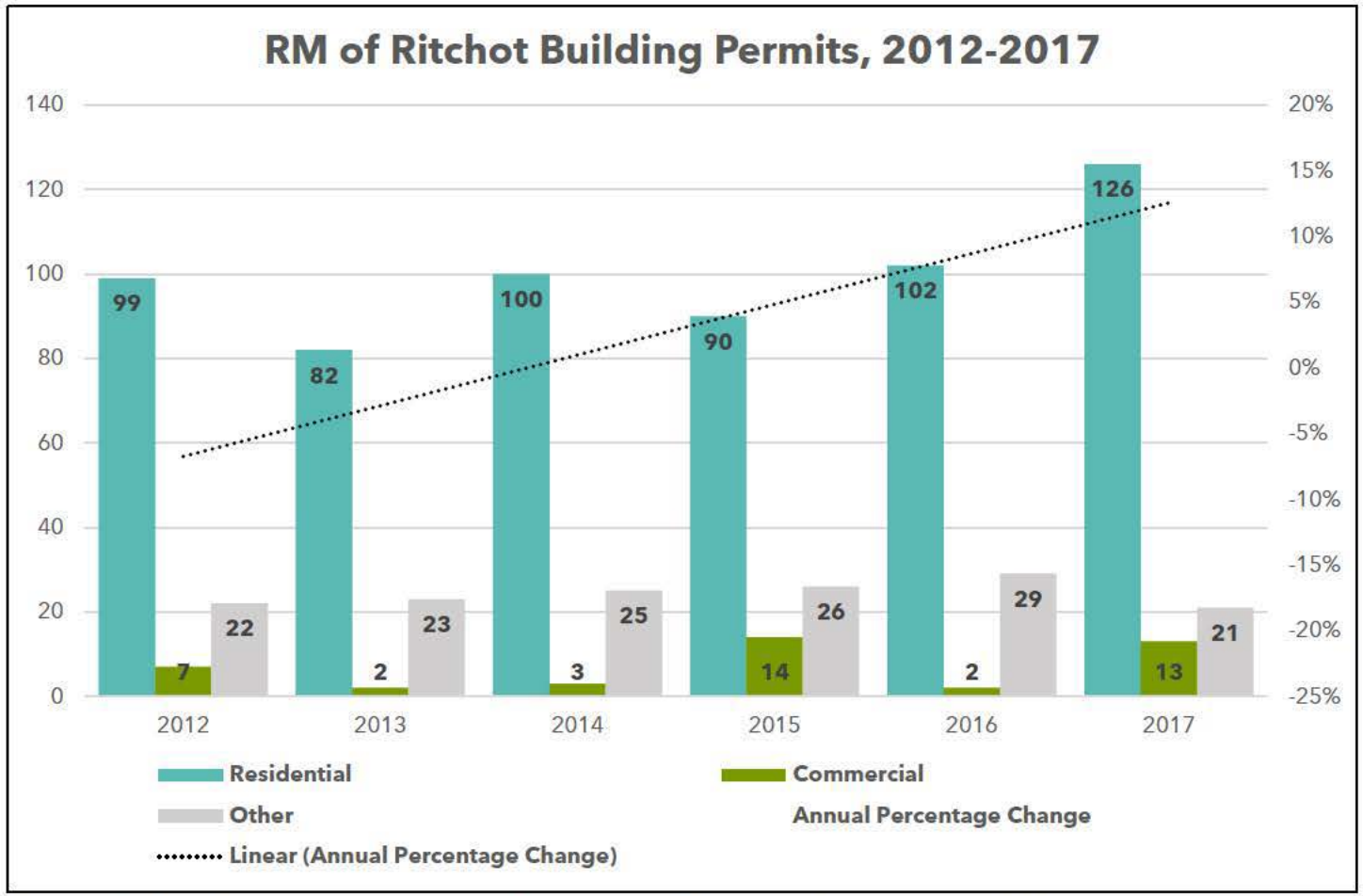


Source: RM of Ritchot, Invest in the Municipality of Ritchot, MB, Canada: 2018 Community Profile



Friesen DRILLERS Landmark Planning & Design

# RITCHOT SUPPLY WELLS

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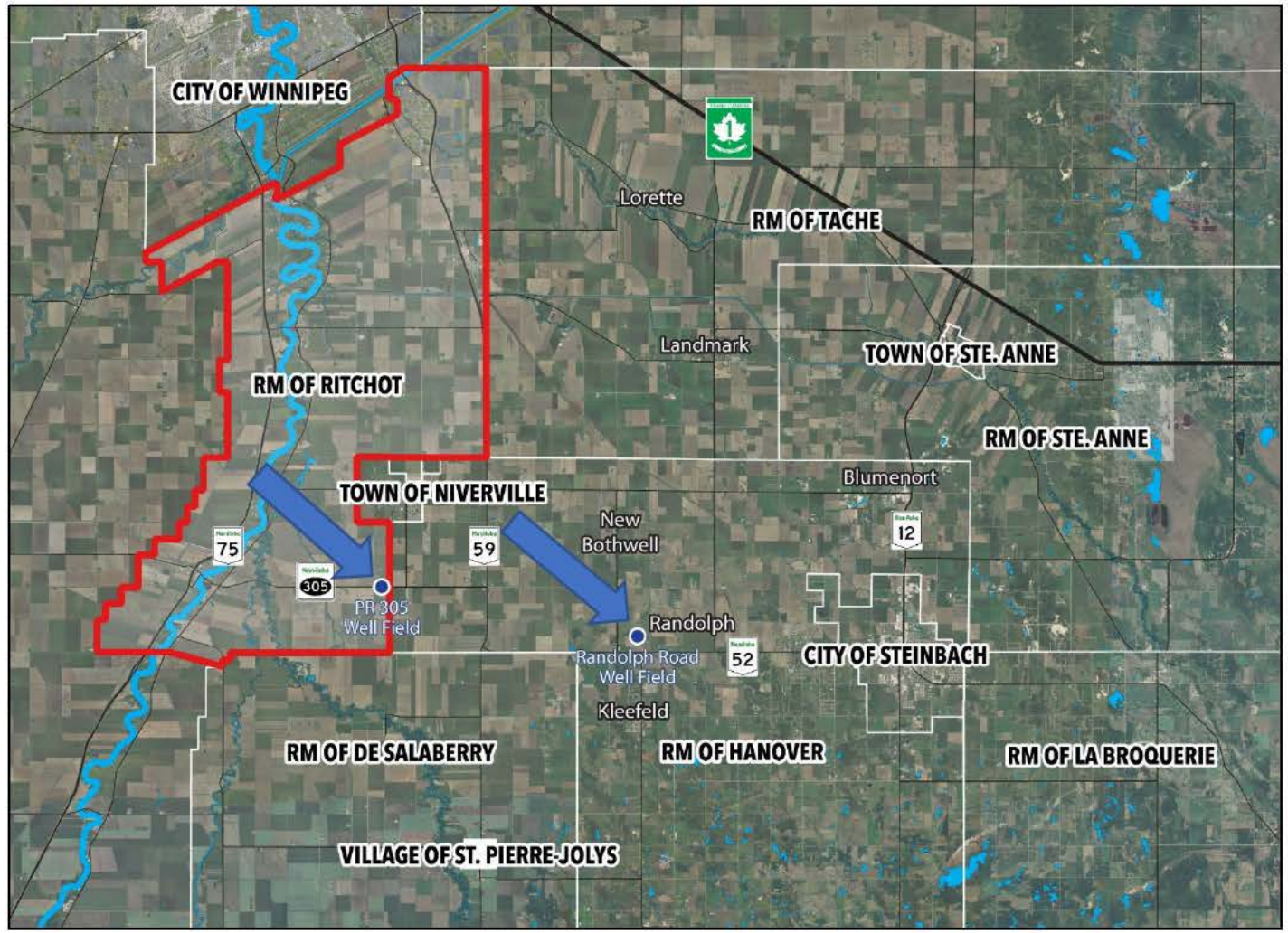




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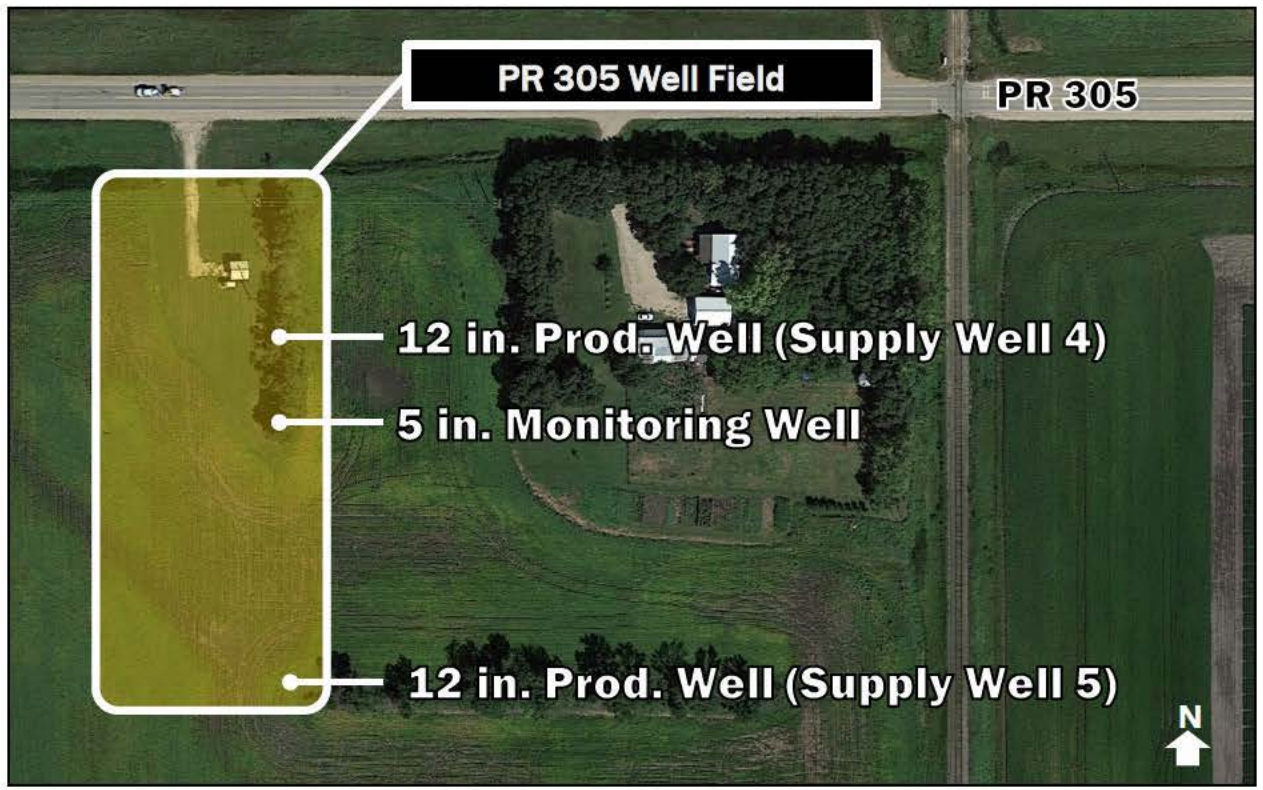
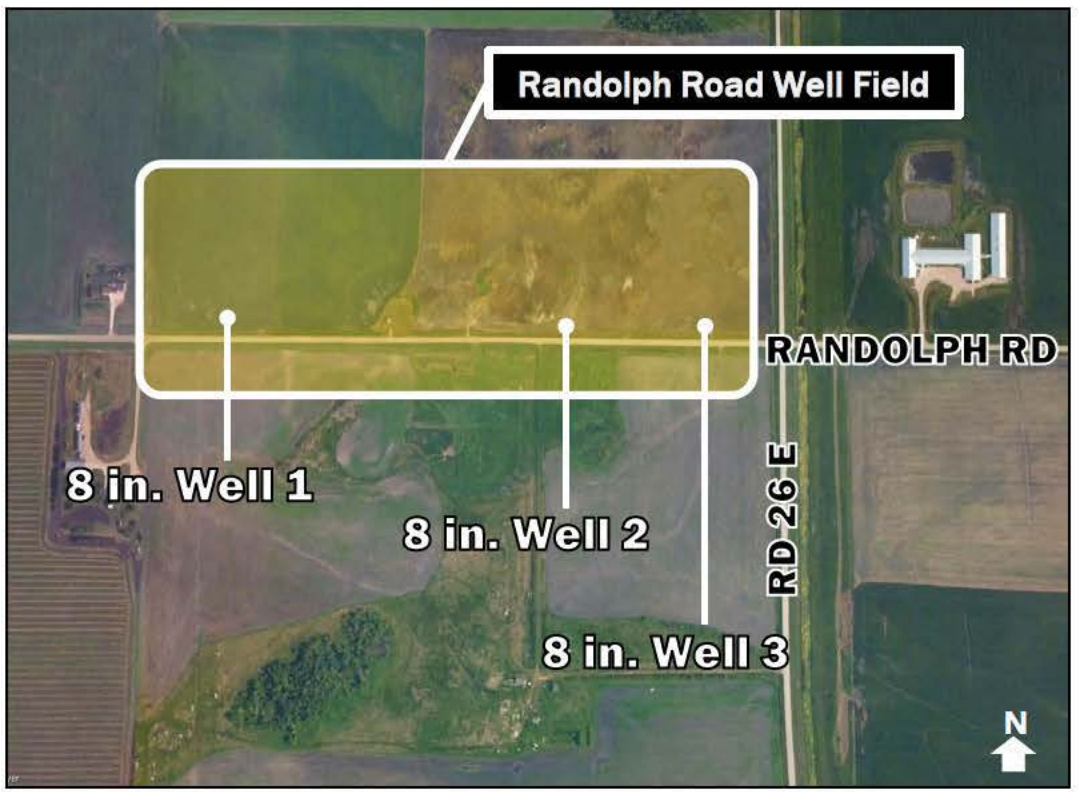
# EXISTING WELL FIELDS

- This slide illustrates the layout of the PR 305 and Randolph Road well fields



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# WELL FIELD HISTORY

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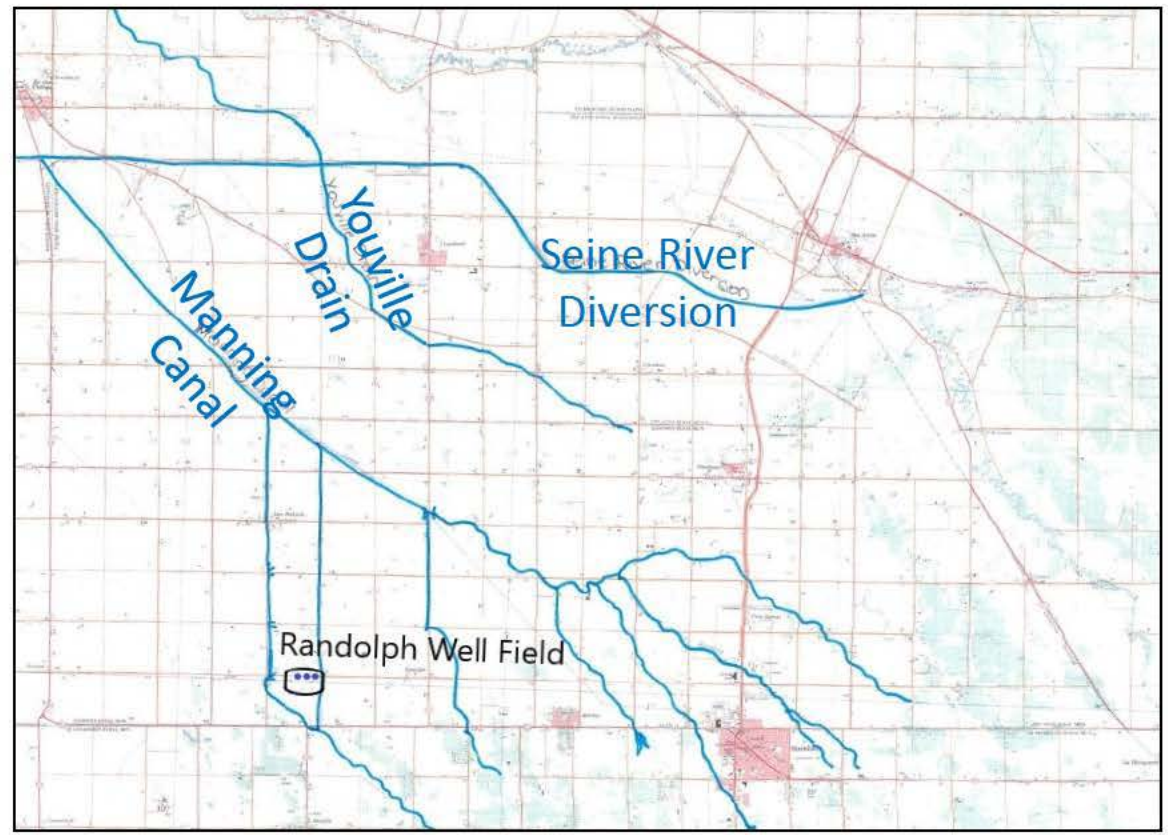




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# HYDROGEOLOGY

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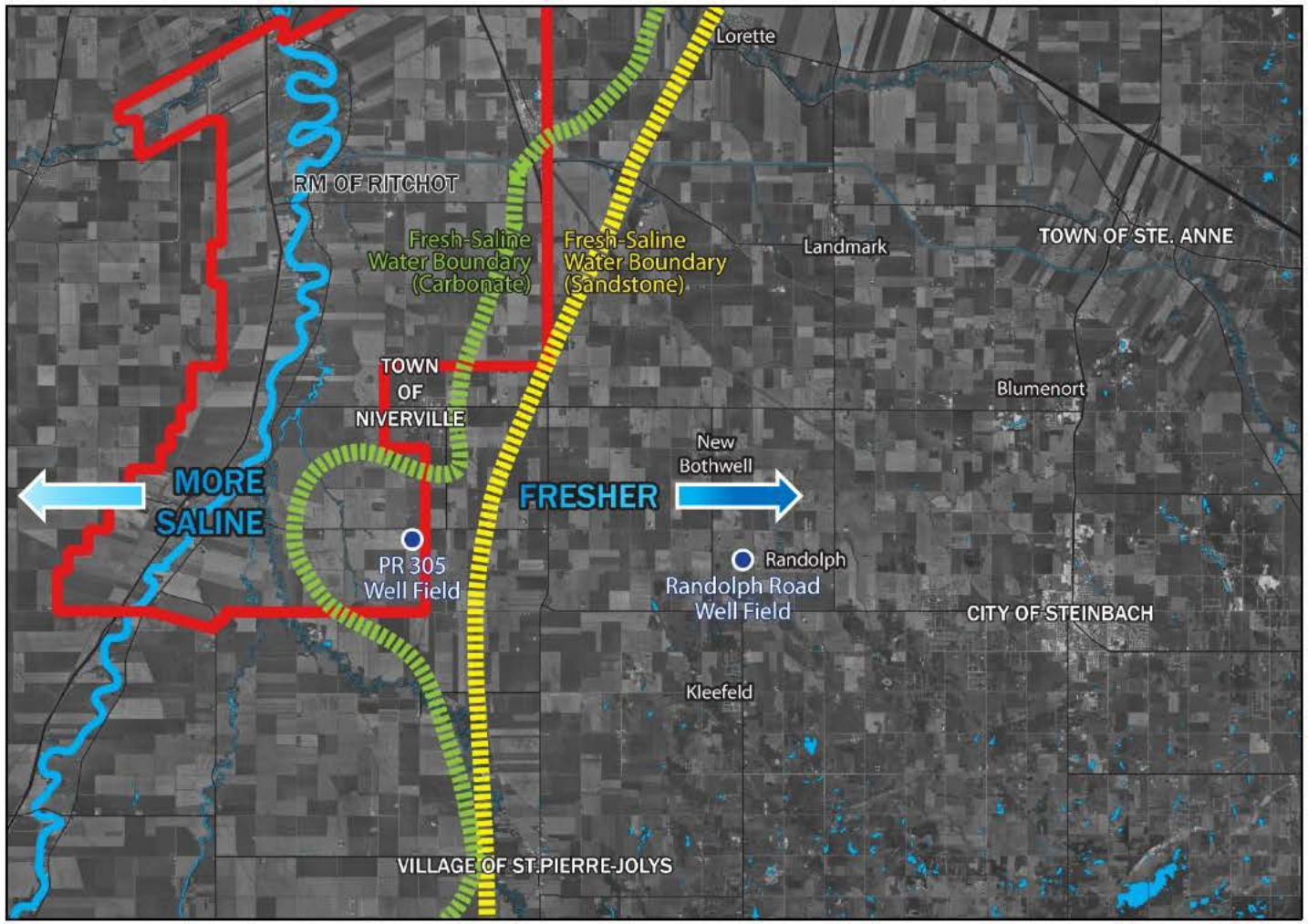




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# PRESSURE RELIEF WELLS

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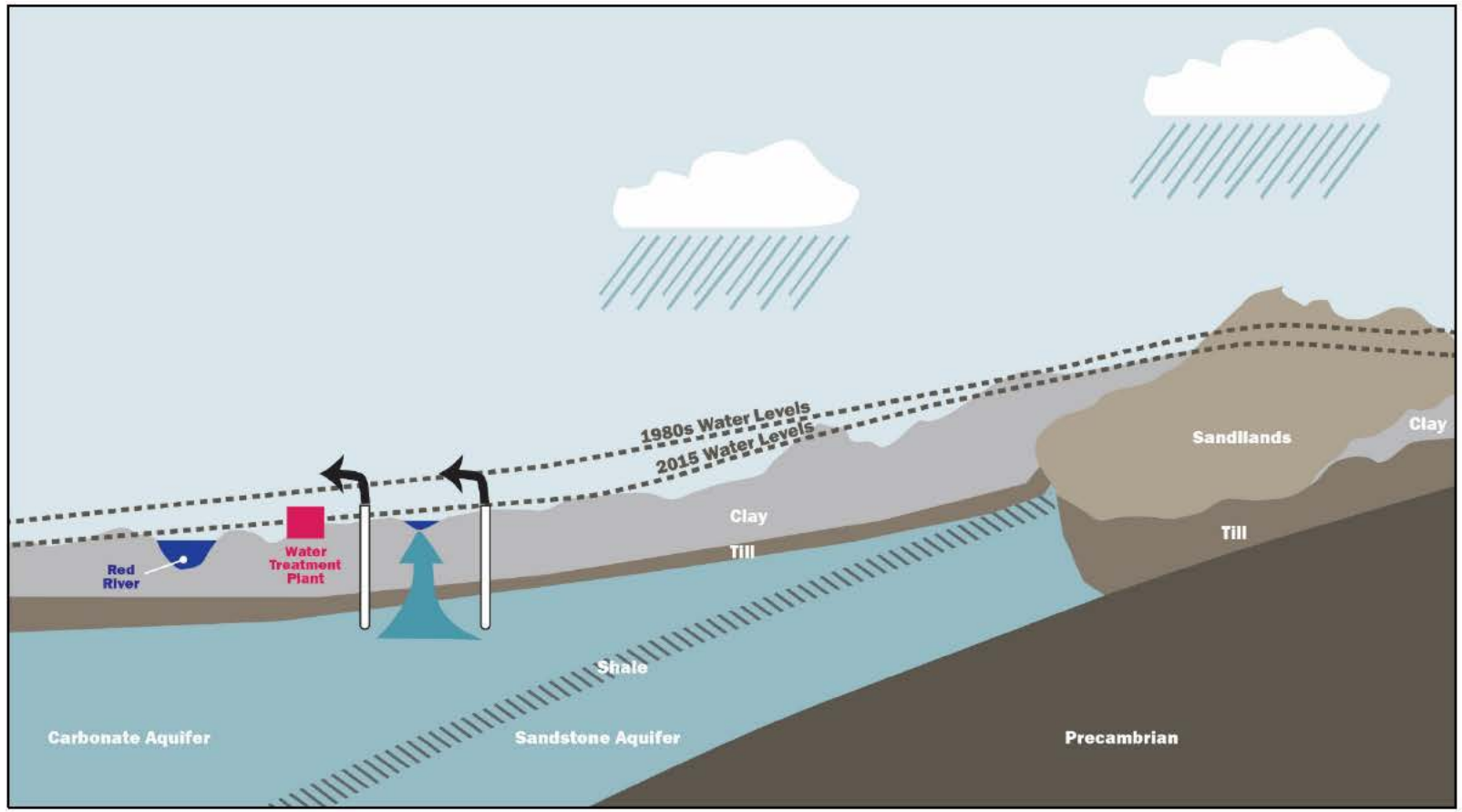




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# TARGET STUDY AREA

- This slide illustrates the approximate study area the project team would like to study to identify any additional groundwater supply options
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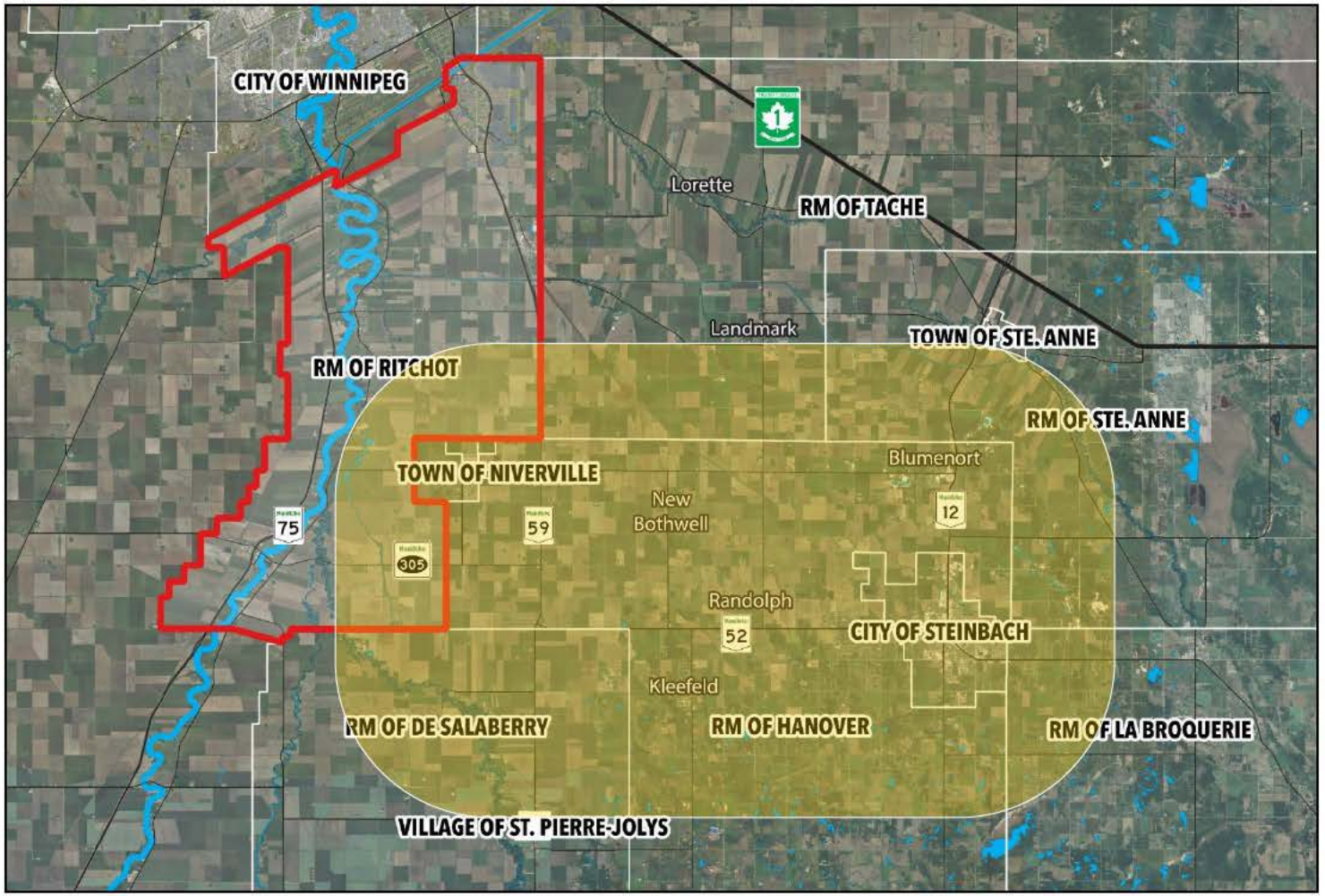
- Many municipalities are serviced by water that originates in areas outside of the RM area



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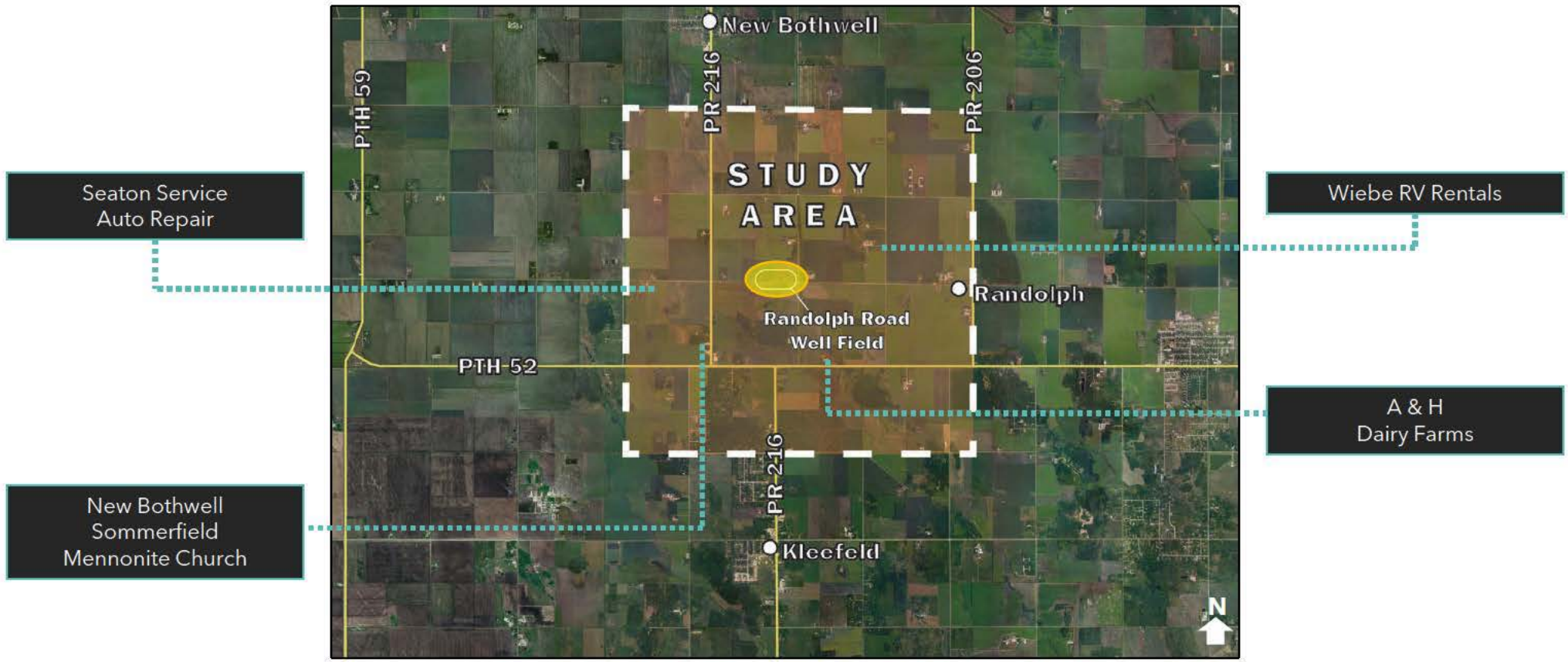
# LOCAL STUDY AREA

- This slide illustrates the study area around the Randolph Road well fields






Friesen DRILLERS
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# STAKEHOLDERS

A number of stakeholders may be interested or potentially affected by a change to the water supply. The study team will be reaching out to the following groups:

- Council and CAO for the RM of Ritchot, Town of Niverville, RM of Hanover, and any other relevant Local Urban District representatives
- Private landowners or businesses with wells in the target study area
- Local farmers, livestock operations, and farming operations
- Public Works department/representatives of each area
- Local emergency services, e.g. fire departments
- Macdonald-Ritchot Planning District
- Government departments/agencies including Sustainable Development: Water Stewardship Division, Manitoba Municipal Government, and the local Watershed District(s)
- Interest groups and organizations, e.g. Keystone Agricultural Producers
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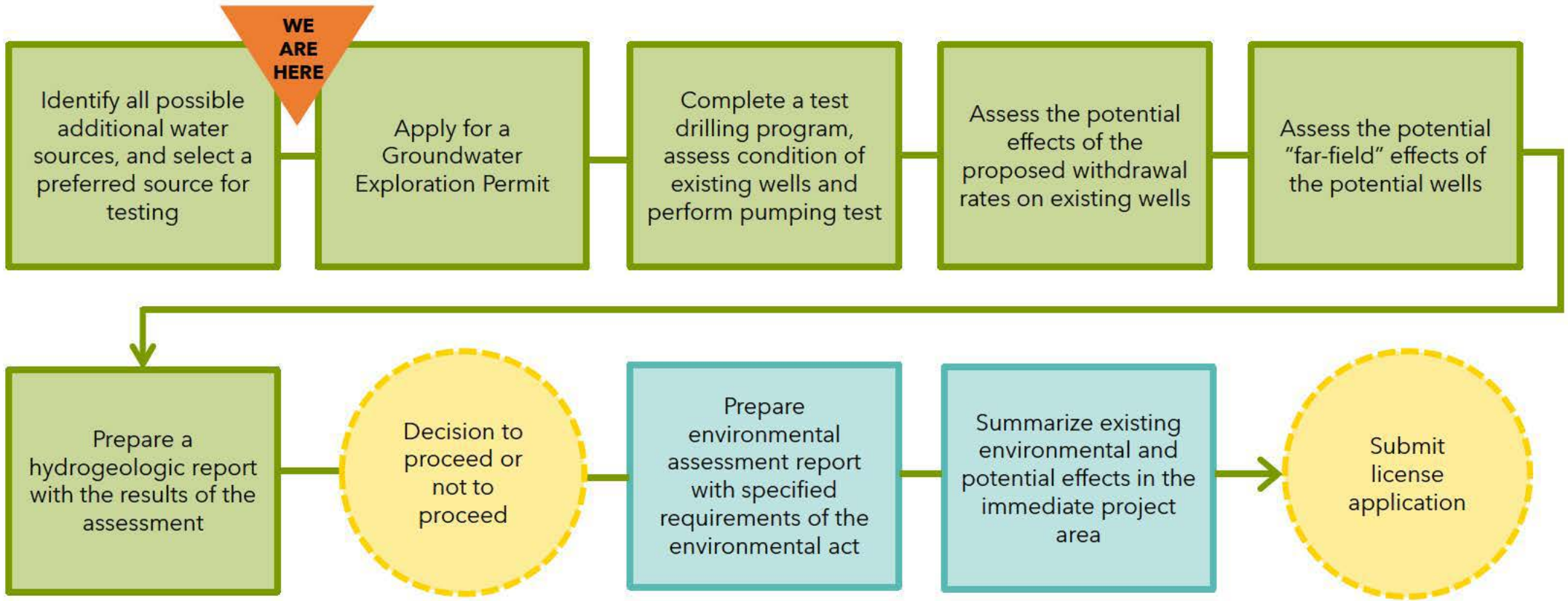
# PROJECT PROCESS

- The following steps outline the components of the water supply investigation.
- Once the technical investigations are complete, a decision would need to be made as to whether to proceed or not.



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# APPLICABLE MANITOBA ACTS & REGULATIONS

- A water supply system project is regulated by the following Manitoba acts and regulations:
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  - The Environment Act
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- The licensing approval process will be outlined in more detail in later stages of the project

# WELL INVENTORY PROGRAM

- As a landowner within the study area for the RM of Ritchot Water Supply Project, you are invited to participate in a Well Inventory Program to help us evaluate the quantity and quality of existing wells in the study area and further assist in forecasting any possible effect of potential new wells
- This program will form an important part of the overall study to help ensure that any changes to the current water supply will not have a negative effect on existing wells
- There is no cost to participate and the results may be of value to you
- The inventory process will occur from now until January 28th, 2022 and will involve an appointment with one of our study team members who would undertake the following activities:
  - Ask basic questions about existing well history and any other details as available;
  - Request pictures of the well site and infrastructure; and
  - Other activities as they arise.

# WELL INVENTORY PROGRAM

To participate in the Well Inventory Program, or to discuss this process further, please sign up via the link below or contact us via telephone at 204-453-8008 or email at RSVP@landmarkplanning.ca.

**https://www.surveymonkey.com/r/RitchotWaterSupply**

# NEXT STEPS

- Continue meeting with stakeholders to introduce the project process
- Find out about any concerns and try to address them before starting any field testing
- Prepare a well inventory
- Conduct field testing in order to confirm a target resource
- Report back to all stakeholders

## CONTACT INFORMATION

**Donovan Toews, RPP, MCIP**

Landmark Planning & Design

T: 204.453.8008

E: dtoews@landmarkplanning.ca



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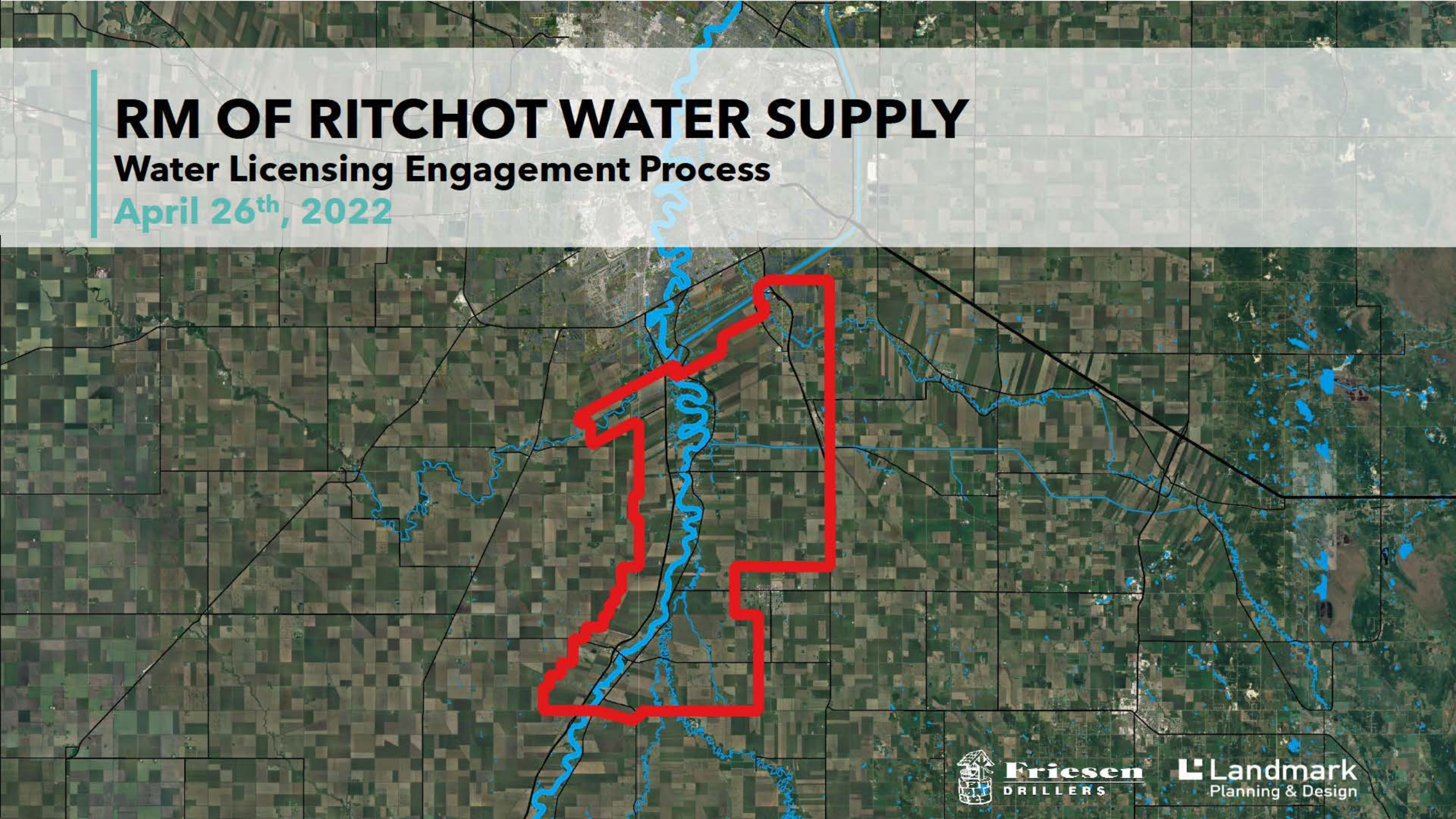
## APPENDIX B

# ROUND TWO STAKEHOLDER PRESENTATION

# RM OF RITCHOT WATER SUPPLY

## Water Licensing Engagement Process

**April 26th, 2022**



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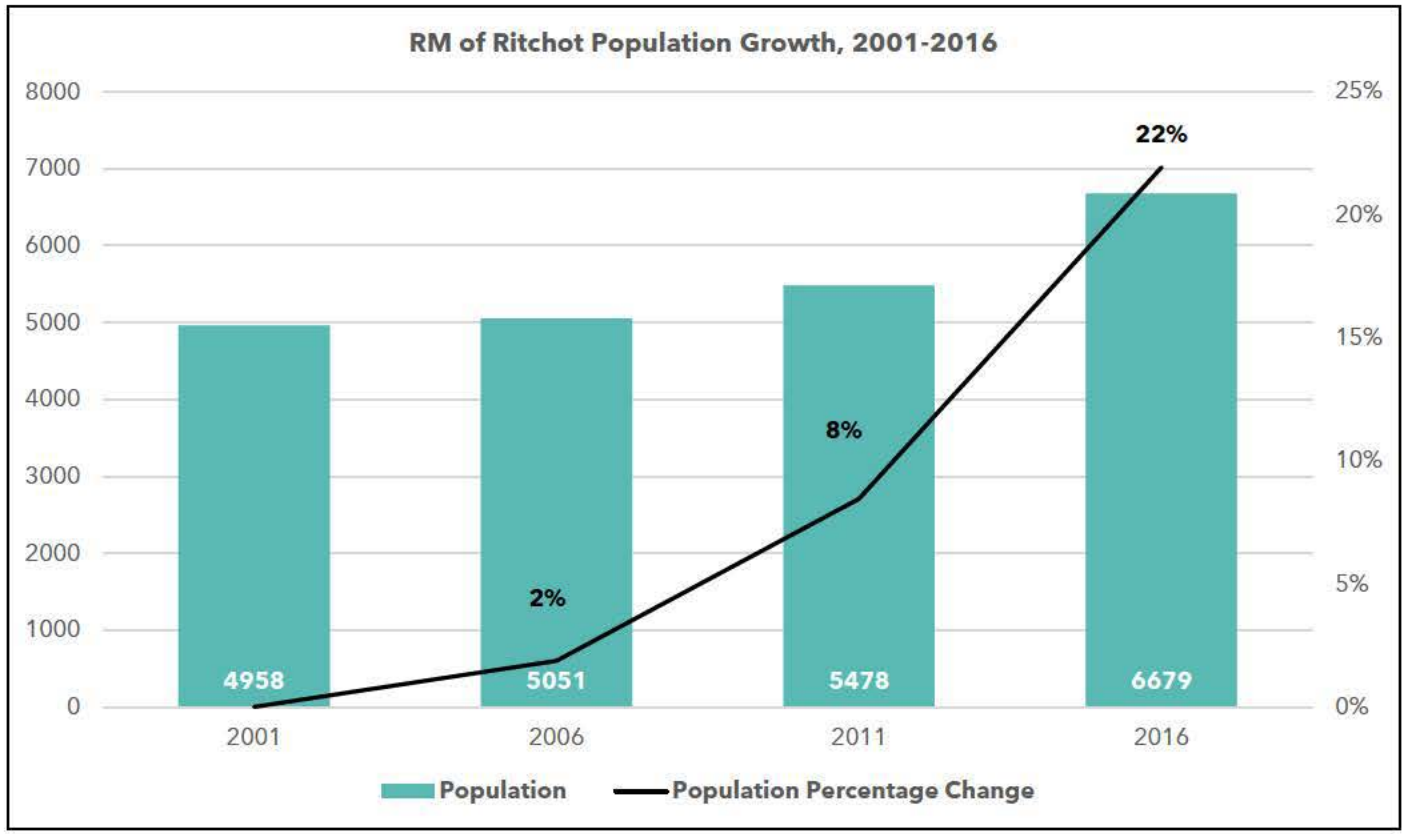


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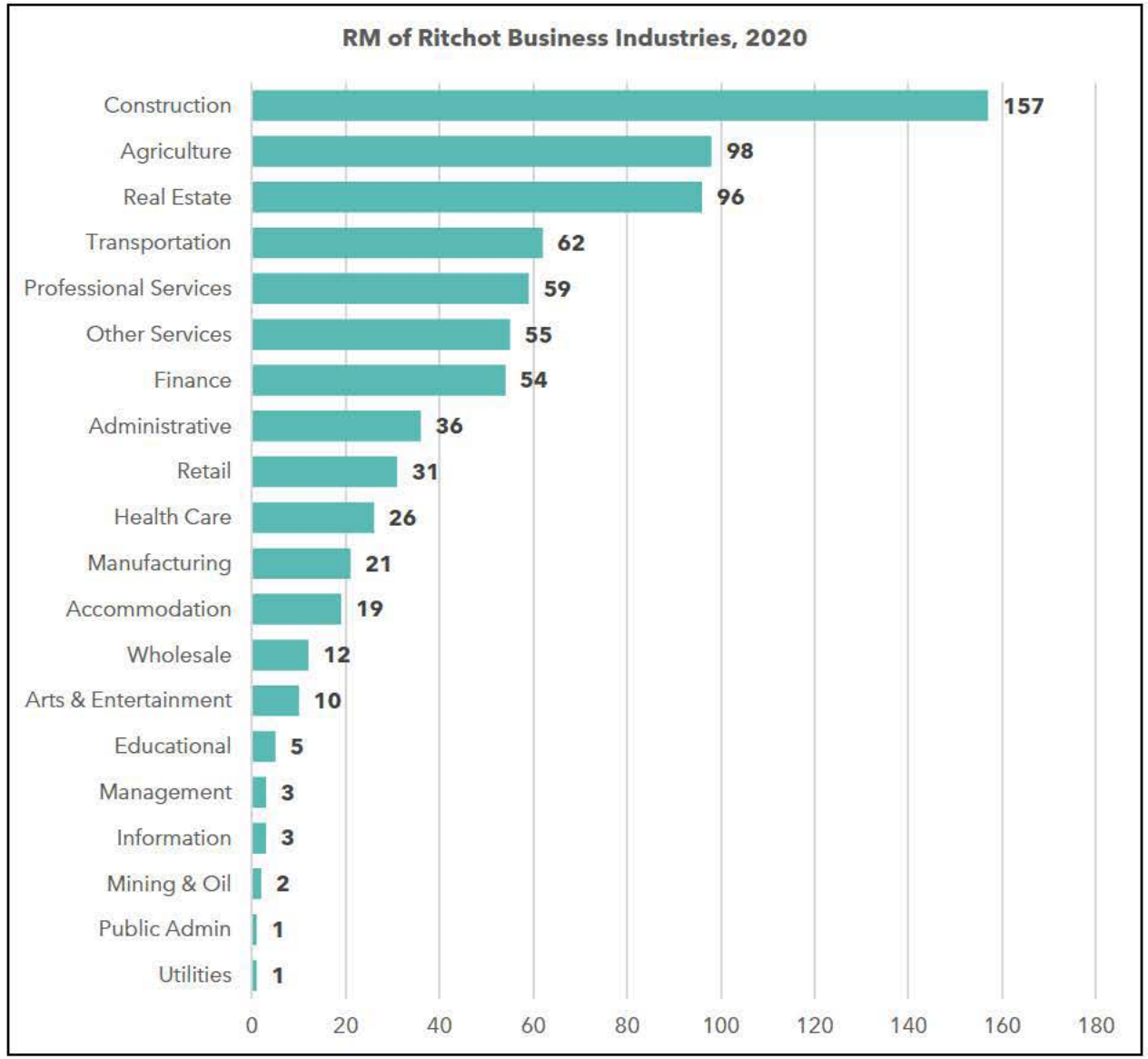


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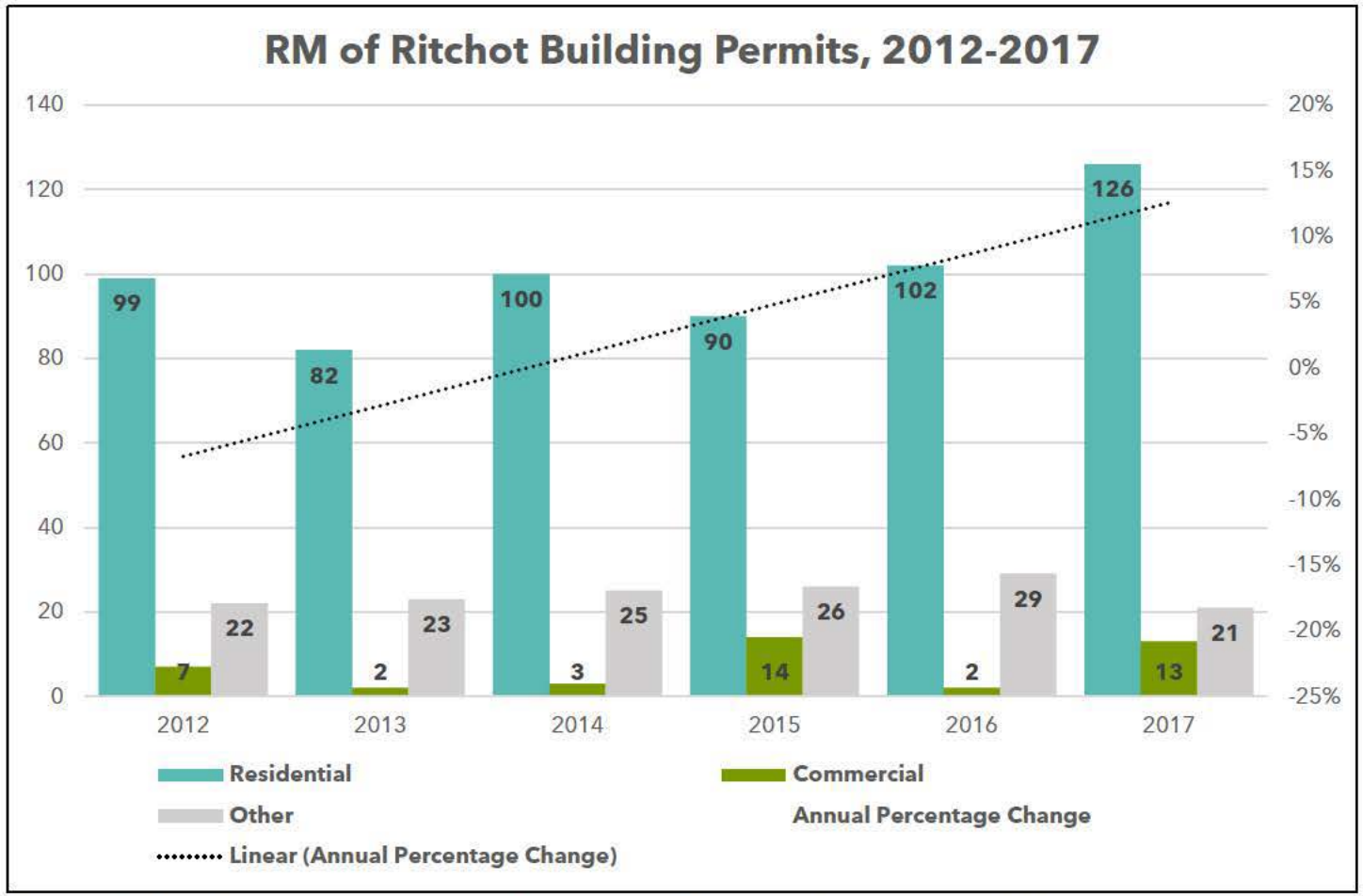


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Friesen DRILLERS Landmark Planning & Design

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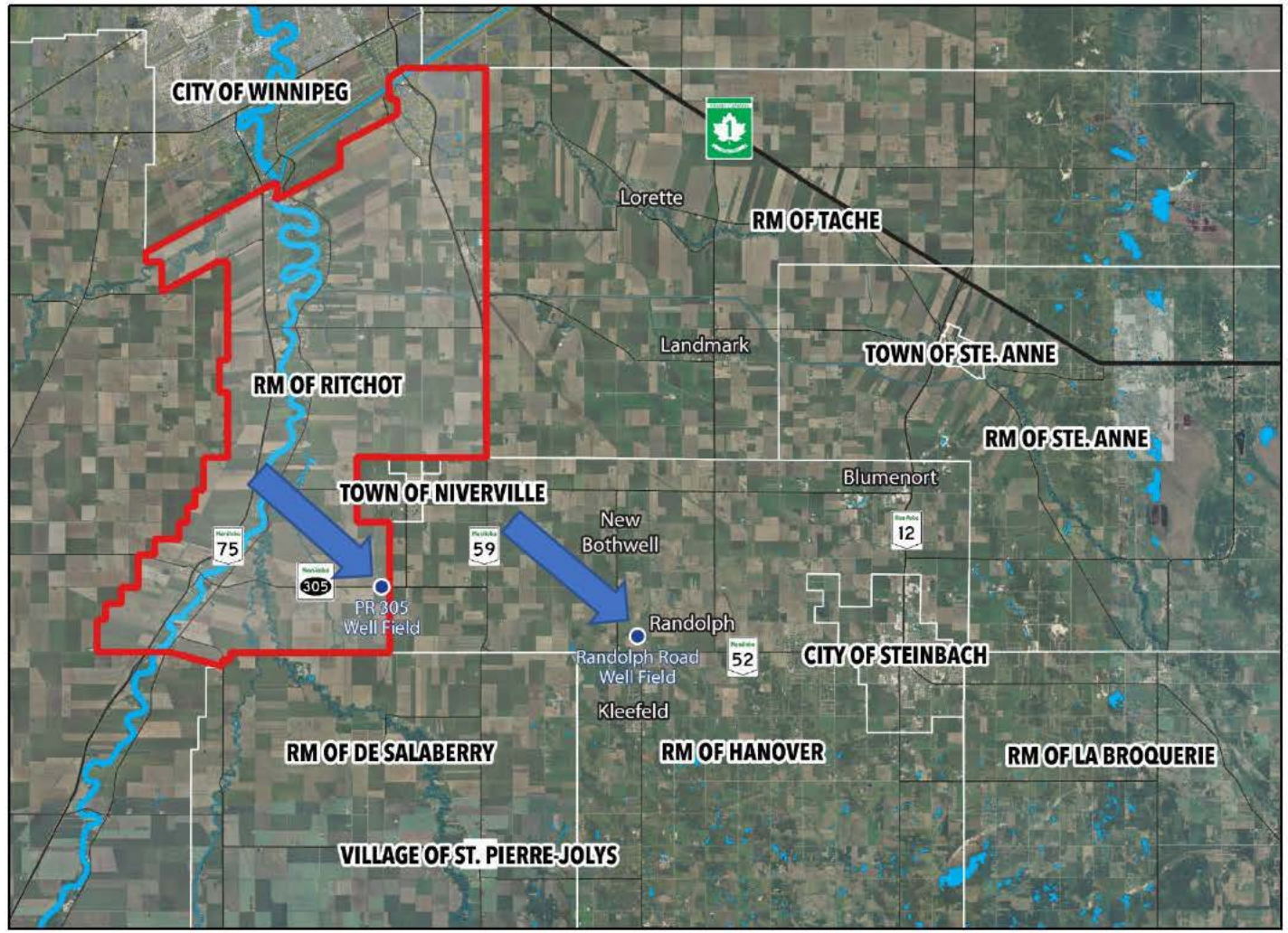




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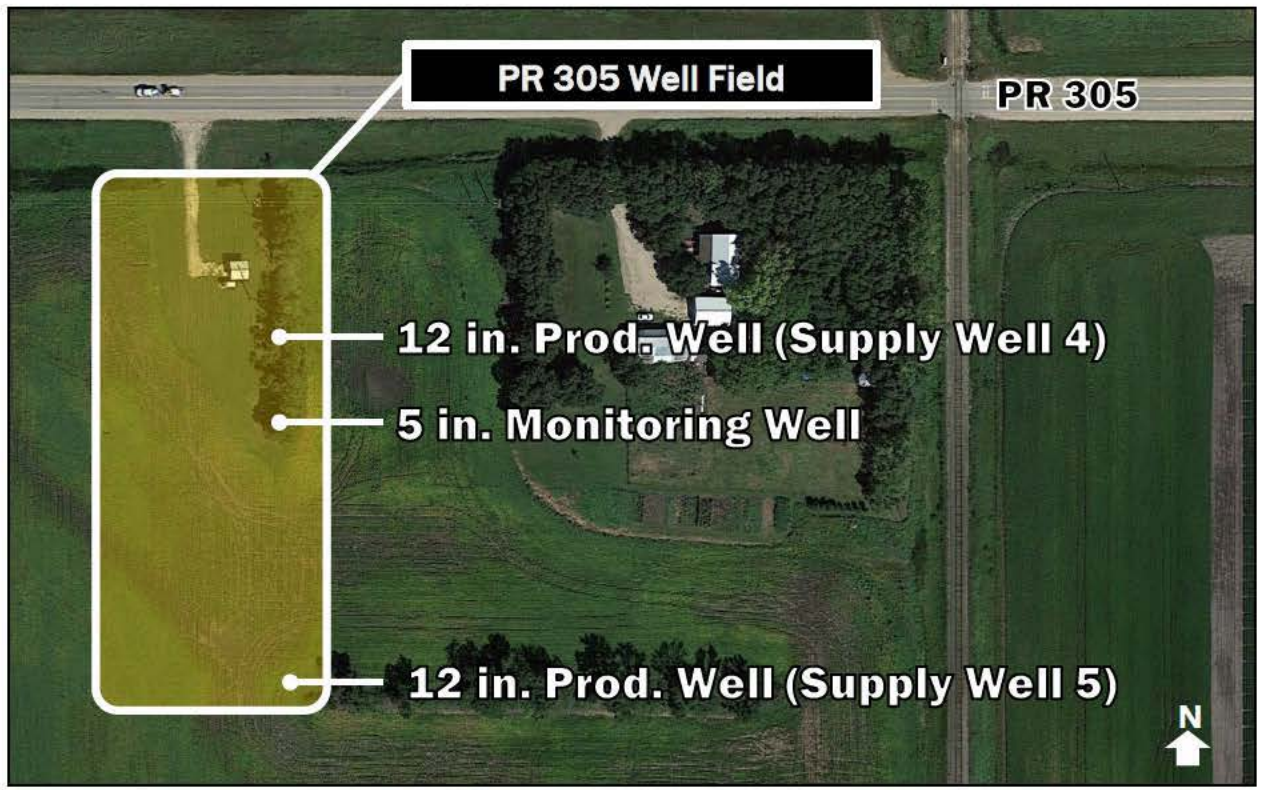


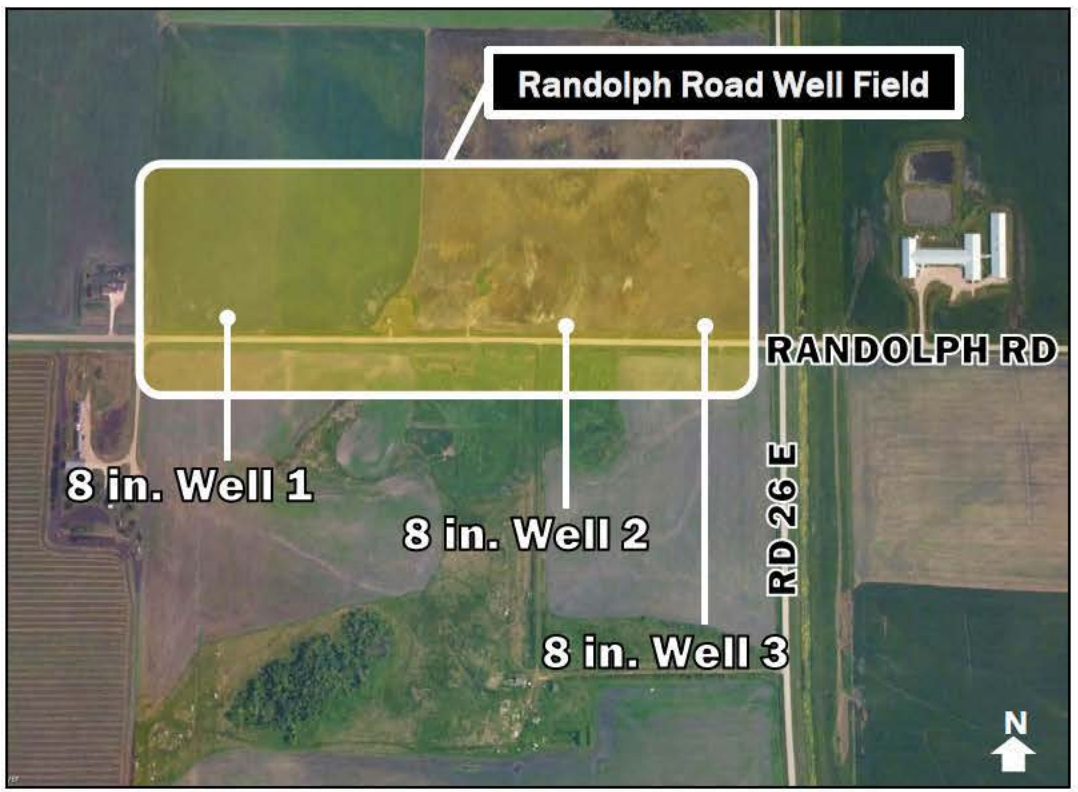




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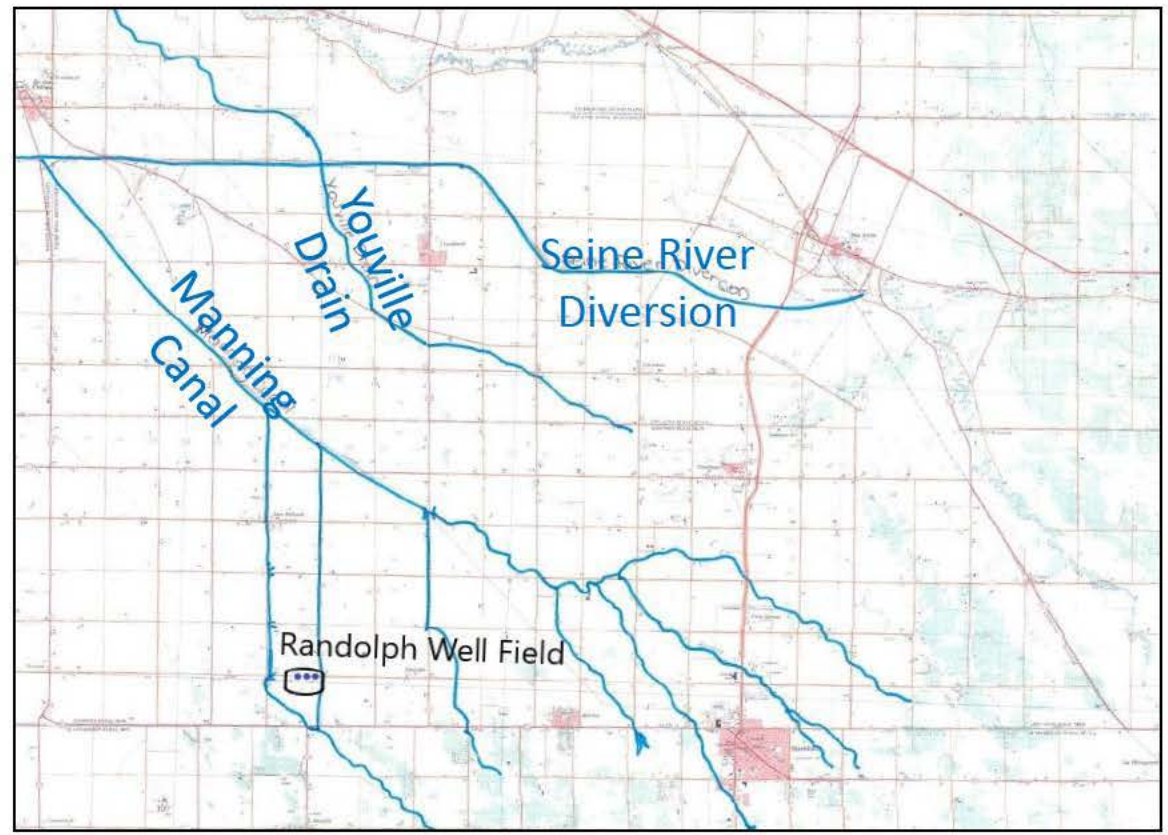




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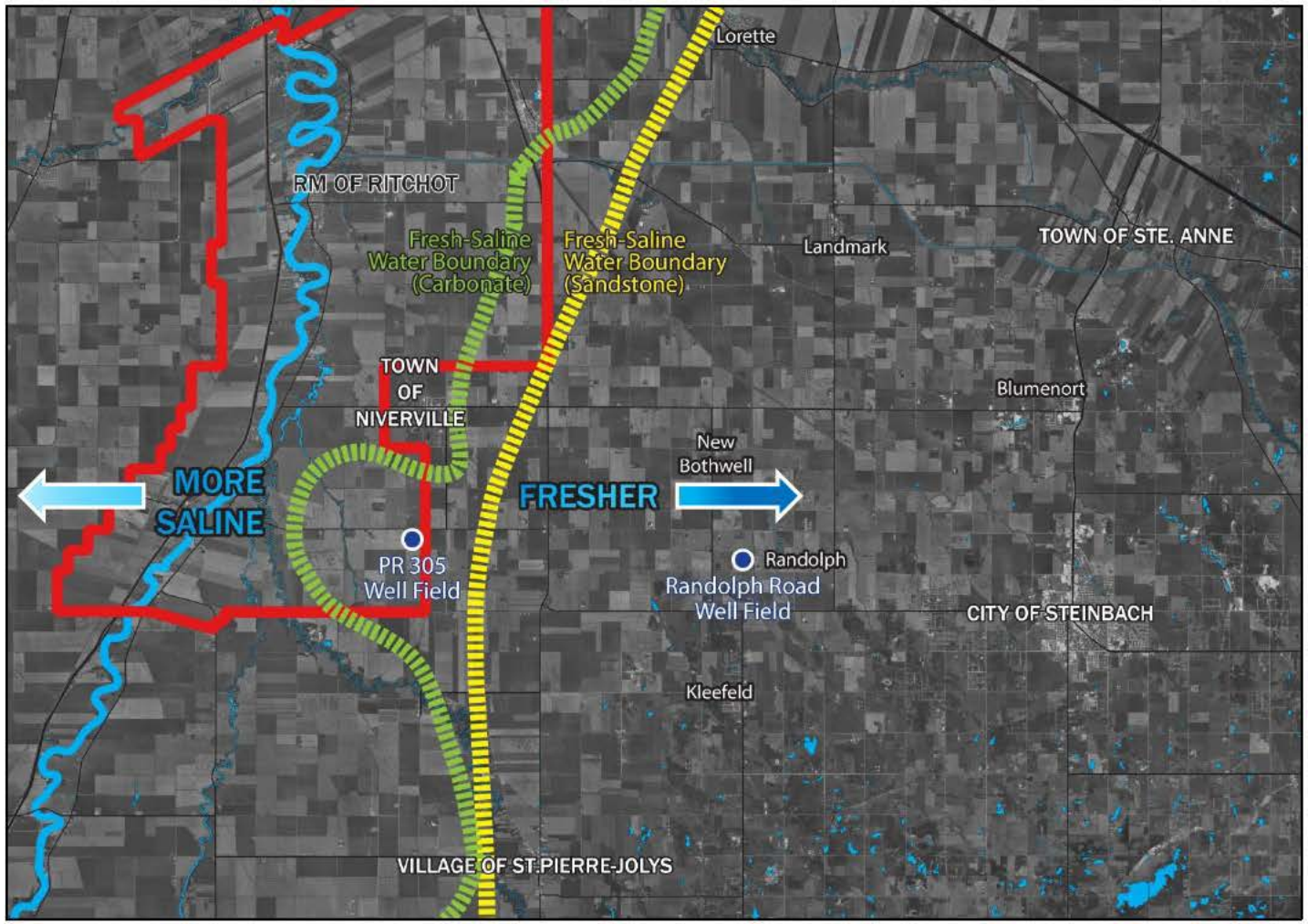




Friesen DRILLERS
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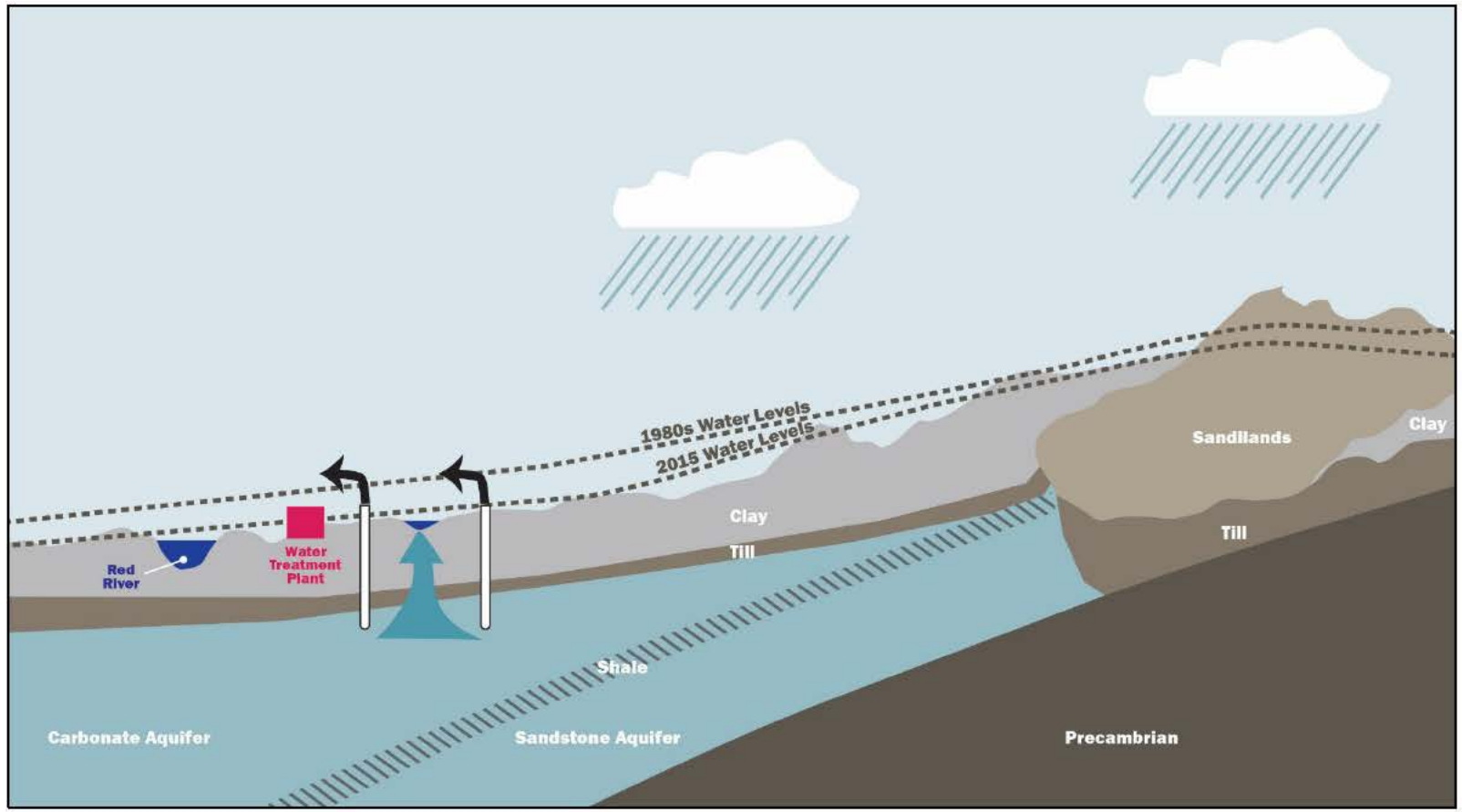




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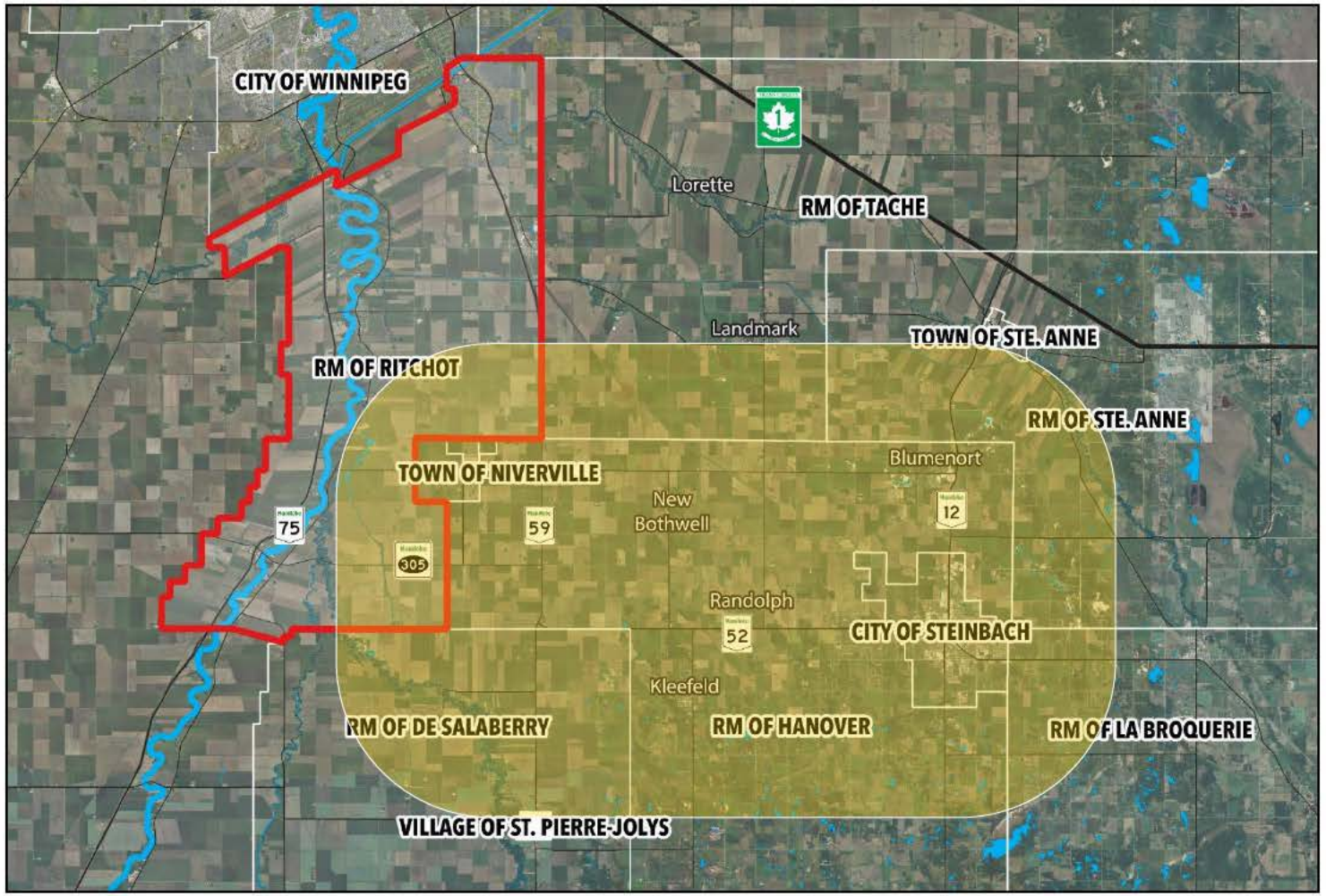




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Landmark Planning & Design

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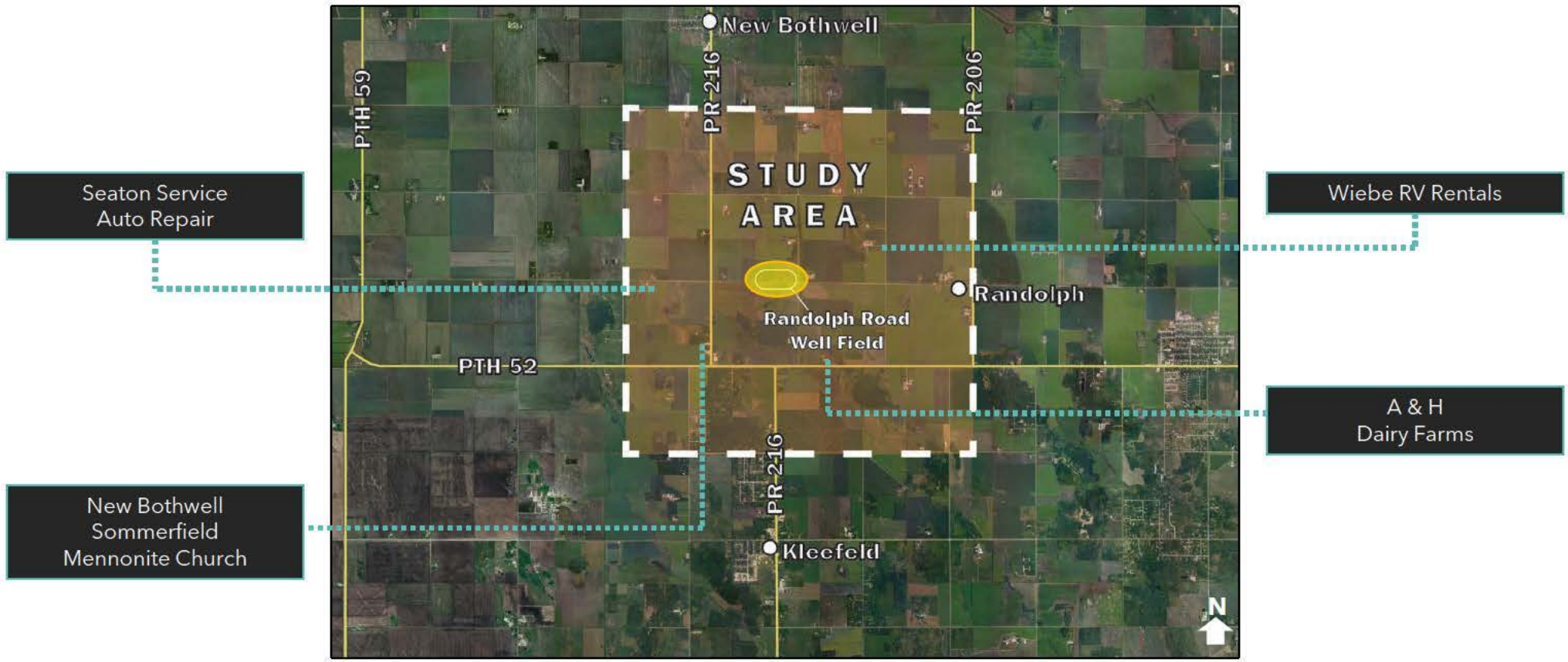




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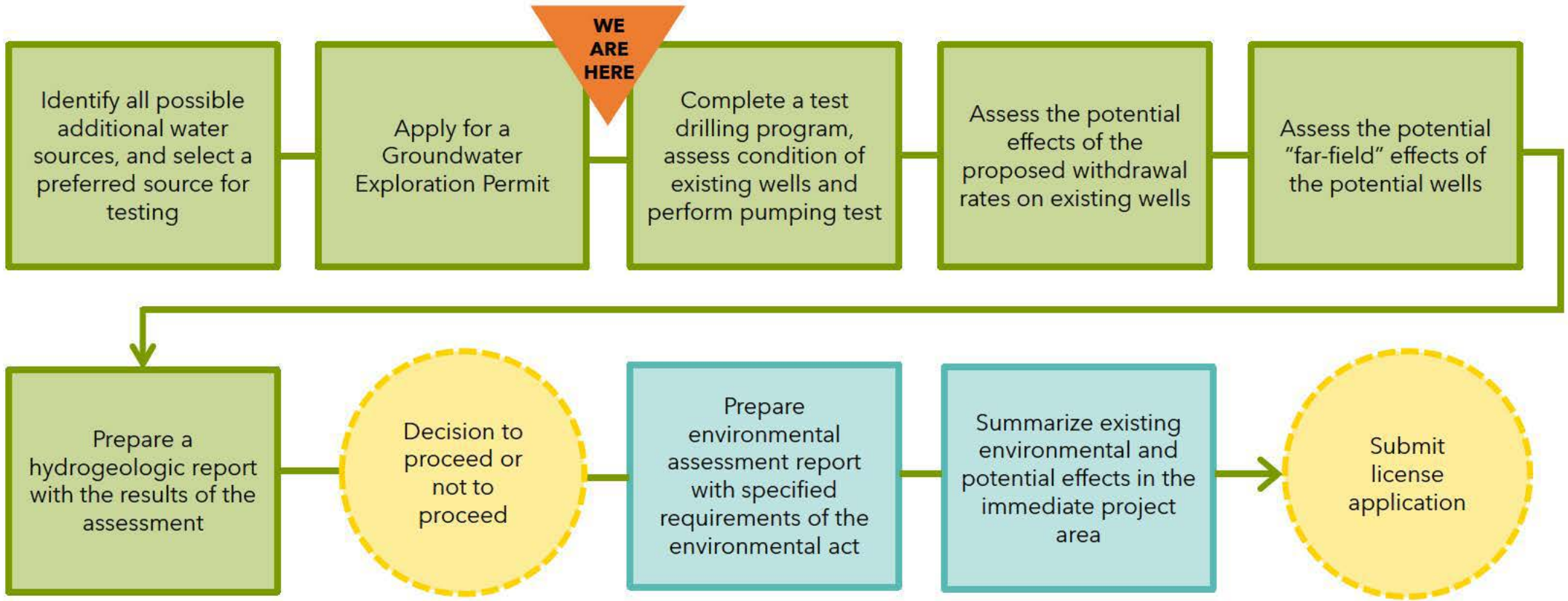




Friesen DRILLERS Landmark Planning & Design

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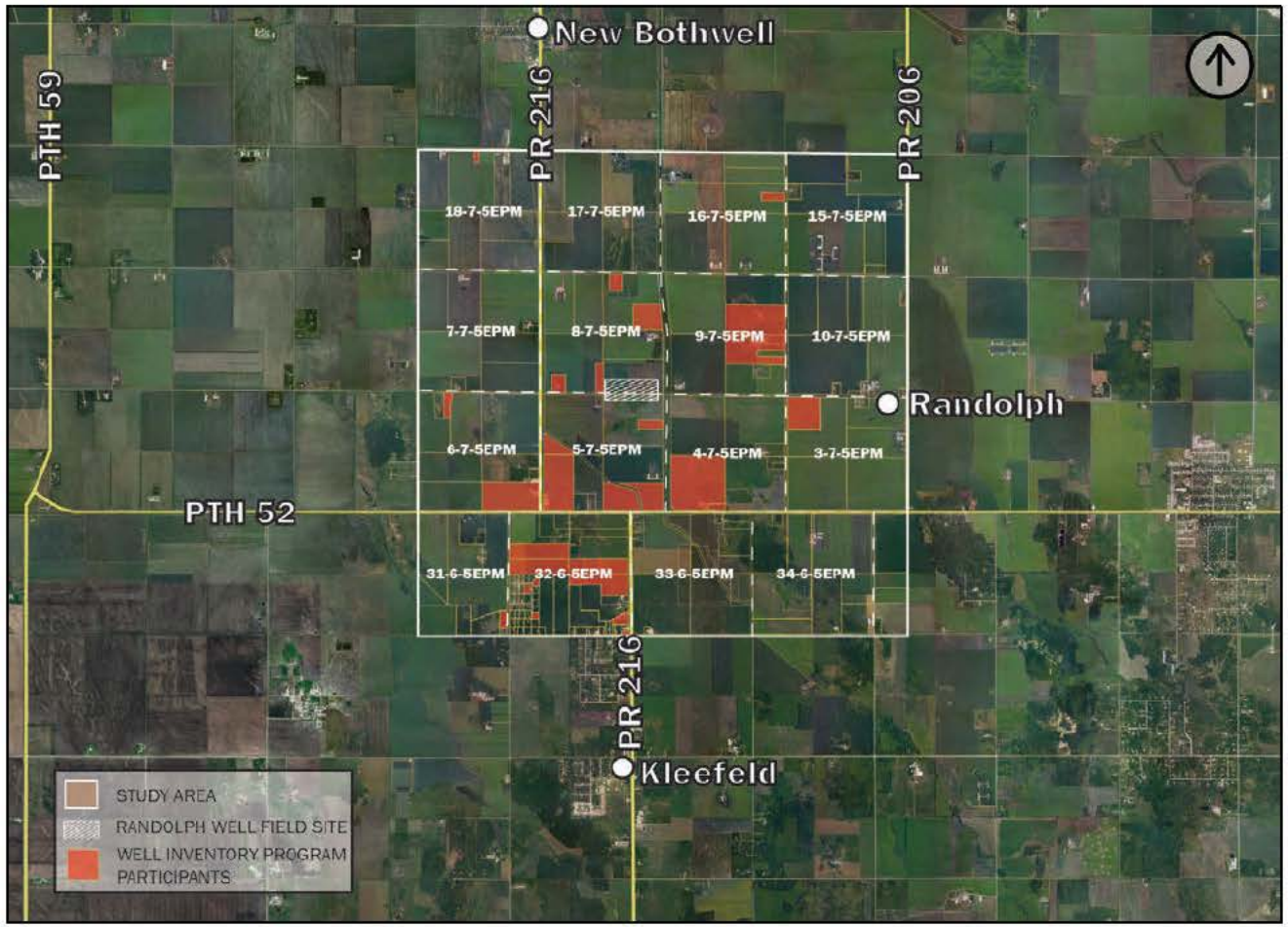
- This program will form an important part of the overall study to help ensure that any changes to the current water supply will not have a negative effect on existing wells
- The inventory process has been underway since January 2022
- The Project Team was able to collect information regarding well history, water quality, and well performance
    - 21 landowners participated
    - 30 wells inventoried
    - A mix of domestic and agricultural wells

# WELL INVENTORY PROGRAM

- This map illustrates the private well sites that have been inventoried within the local study area
- Private well sites can be seen in orange






Friesen DRILLERS
Landmark Planning & Design

# WELL INVENTORY PROGRAM

The final date to participate in the Well Inventory Program is May 6th, 2022.

There is no cost to participate and the results may be of value to you.

The appointment will include an appointment via telephone or Zoom with a member of our Project Team who will ask basic questions about your well, water quality and quantities, and collect any other details you can share with us.

Please sign up via the link below or contact Brennan via telephone at 204-453-8008 or email at RSVP@landmarkplanning.ca to schedule a Well Inventory Appointment.

**https://www.surveymonkey.com/r/RitchotWaterSupply**



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# UPCOMING MONITOR WELL DRILLING

- Friesen Drillers will be conducting a preliminary inspection and draw down test, which will include:
    - An assessment of the existing municipal wells for functionality
- Following preliminary testing, Friesen will be drilling monitoring wells at three sites within the study area:
    - Monitoring wells will be placed in both the sandstone and limestone aquifers
    - Drilling will occur for a duration of 1-2 weeks in mid-May

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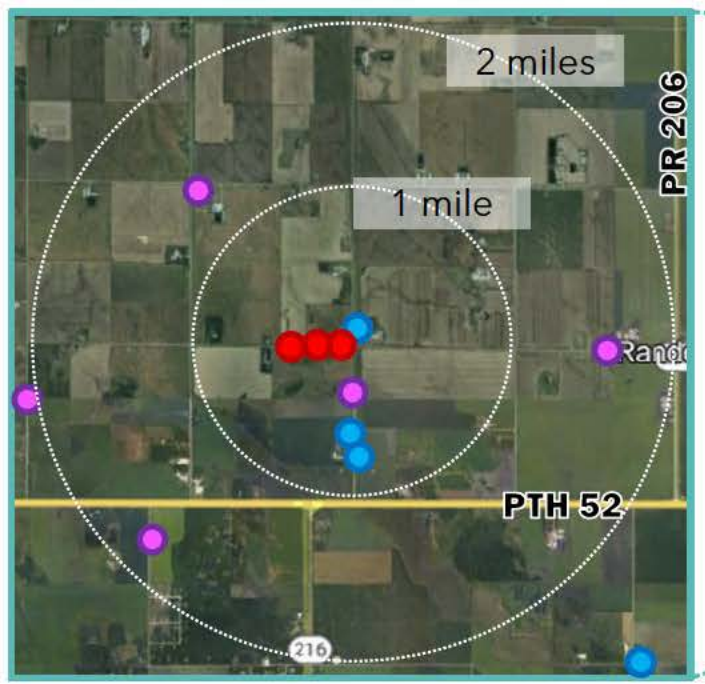
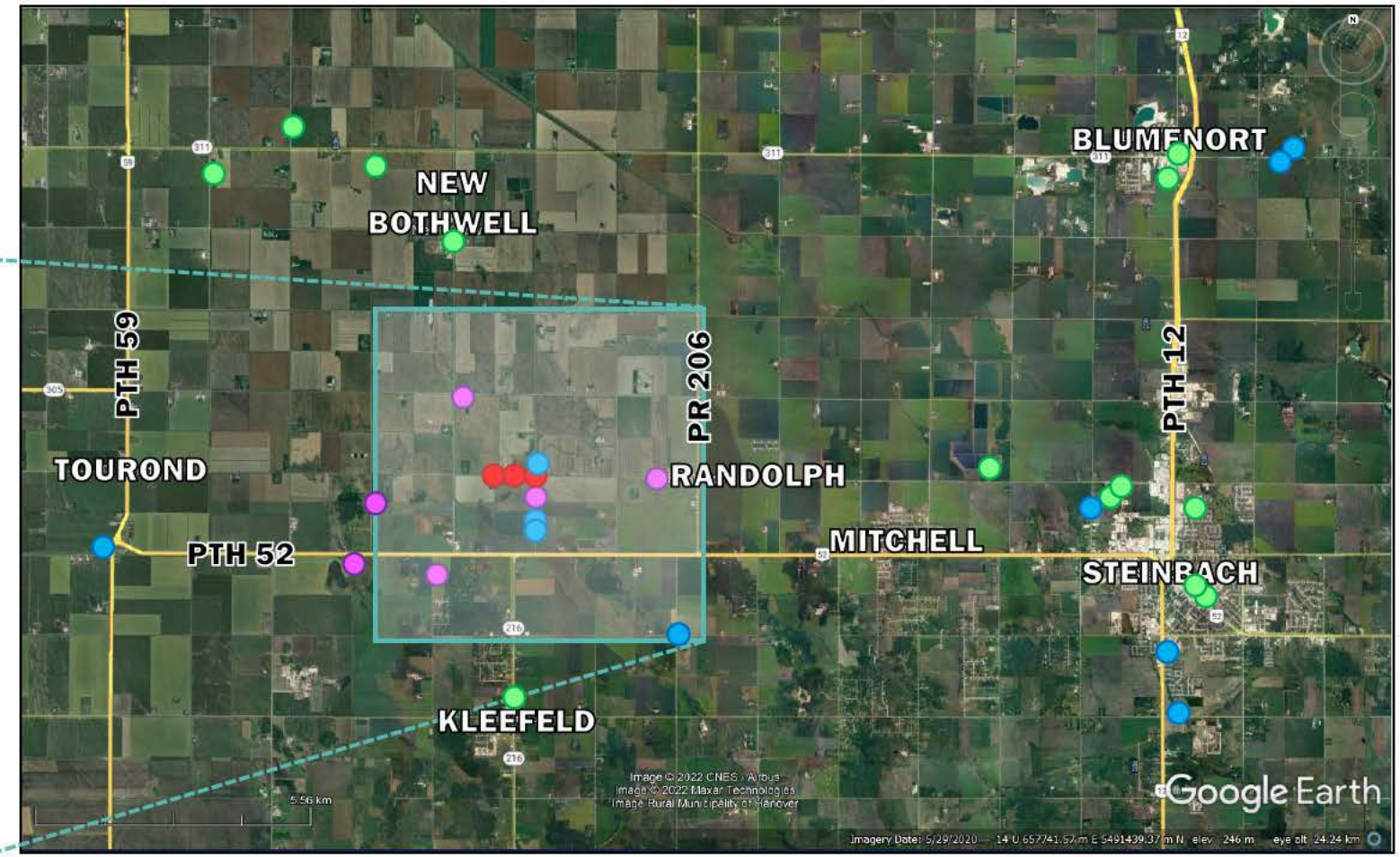
# UPCOMING MONITOR WELL DRILLING

- Existing Wells (RM Ritchot)
- Provincial Monitoring Network
- Tentative Monitoring Wells (to be drilled)
- Existing Monitoring Wells



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# NEXT STEPS

- Continue to meet with stakeholders to discuss project process and address any questions and comments
- Speak with well owners about adding additional monitoring devices
- Conduct pump tests
  - Anticipated in June 2022
  - Continue working with the RM of Ritchot to develop a drainage plan for the pump tests
- Share results with stakeholders

# THANK YOU

To participate in the Well Inventory Program, ask questions or share comments about next steps, or to discuss this process further, please contact us:

**https://www.surveymonkey.com/r/RitchotWaterSupply**

**Donovan Toews or Brennan Johnson**

Landmark Planning & Design

T: 204.453.8008

E: rsvp@landmarkplanning.ca



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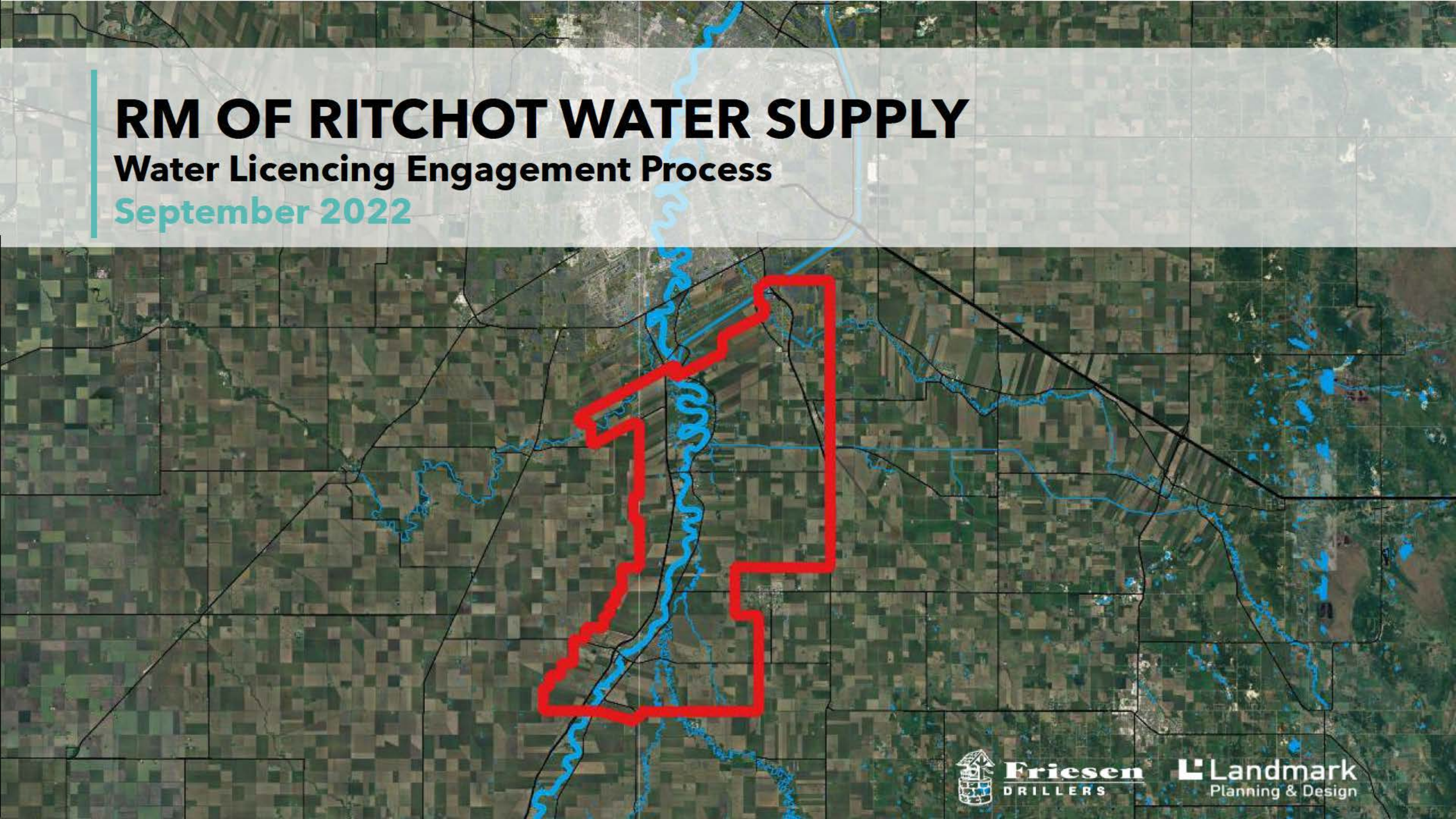
## APPENDIX C

# ROUND THREE STAKEHOLDER PRESENTATION

# RM OF RITCHOT WATER SUPPLY

## Water Licencing Engagement Process

**September 2022**



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# OVERVIEW

- Stakeholder Engagement Process
- Background Information
- Hydrogeology
- Well Field History
- Historic Water Use
- Well Inventory Program
- Pump Test Results
- Planning Process
- Next Steps
- Discussion

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# BACKGROUND

- The existing water supplies for the RM of Ritchot have served the needs of the RM for many decades
- Planning for the future means the RM should look at additional water supply needs to serve the RM over the coming decades, while continuing to work at measures for conserving more water
- Landmark Planning & Design is working with Friesen Drillers, the RM of Ritchot and the Manitoba Water Services Board (MWSB) to increase the water supply
- A new well or additional water supply requests will require amending the existing Water Rights Licence and Environmental Act Licence

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# STAKEHOLDERS

A number of stakeholders may be interested or potentially affected by a change to the water supply. The study team will be reaching out to the following groups:

- Council and CAO for the RM of Ritchot, Town of Niverville, RM of Hanover, and any other relevant Local Urban District representatives
- Private landowners or businesses with wells in the target study area
- Local farmers, livestock operations, and farming operations
- Public Works department/representatives of each area
- Local emergency services, e.g. fire departments
- Macdonald-Ritchot Planning District
- Government departments/agencies including Sustainable Development: Water Stewardship Division, Manitoba Municipal Government, and the local Watershed District(s)
- Interest groups and organizations, e.g. Keystone Agricultural Producers
- Local developers
- Others

# STAKEHOLDER ENGAGEMENT PROCESS

The project team undertook a thorough stakeholder engagement process with residents, business owners, and landowners within the project study area

**DEC 2021**
- Stakeholder Meetings outline the planning process

**JAN-MAY 2022**
- Well Inventory Program to evaluate existing wells and forecast any possible effects of new wells/pumps

**APRIL 2022**
- Stakeholder Meetings to share information about planned monitor well drilling

**MAY 2022**
- Notification of monitoring well drilling timing, and occurrence

**JUNE/JULY 2022**
- Invitation to see pump tests

**SEPT 2022**
- Stakeholder Meetings to share pump test results



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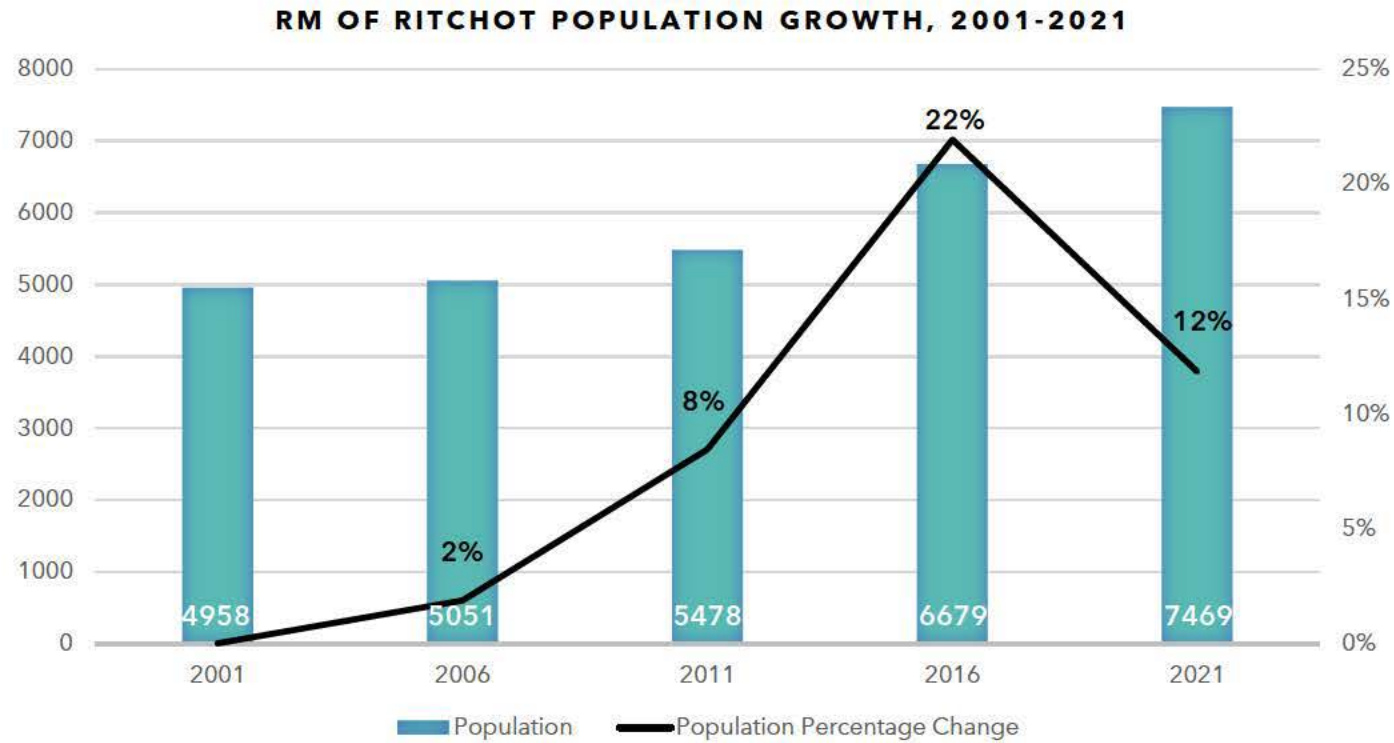
# BACKGROUND

- The statistics on the following slides illustrate considerations relevant to a water supply for the RM of Ritchot:
  - Rapid local population growth fuelling domestic supply needs
  - Existing businesses require a strong, reliable water supply
  - New economic investment in industrial and commercial operations
  - A steady rise in local construction and development
- As a result of these factors, the RM will be challenged to match amenities and services with their current and future needs
- The RM will need to consider looking for an alternative water supply as one of its priorities in order to sustain the viability of the community

# BACKGROUND

- The RM of Ritchot population reached 7,469 people in 2021, an increase of 11.8% from 2016
    - In comparison, the population growth in Manitoba over the same period was only 5%, and the national average was only 5.2%
- From 2001 to 2021, the RM of Ritchot grew by 34% (2,511 people)
    - In comparison, the population growth in Manitoba over the same period was only 17%




Source: Statistics Canada, 2021 Census



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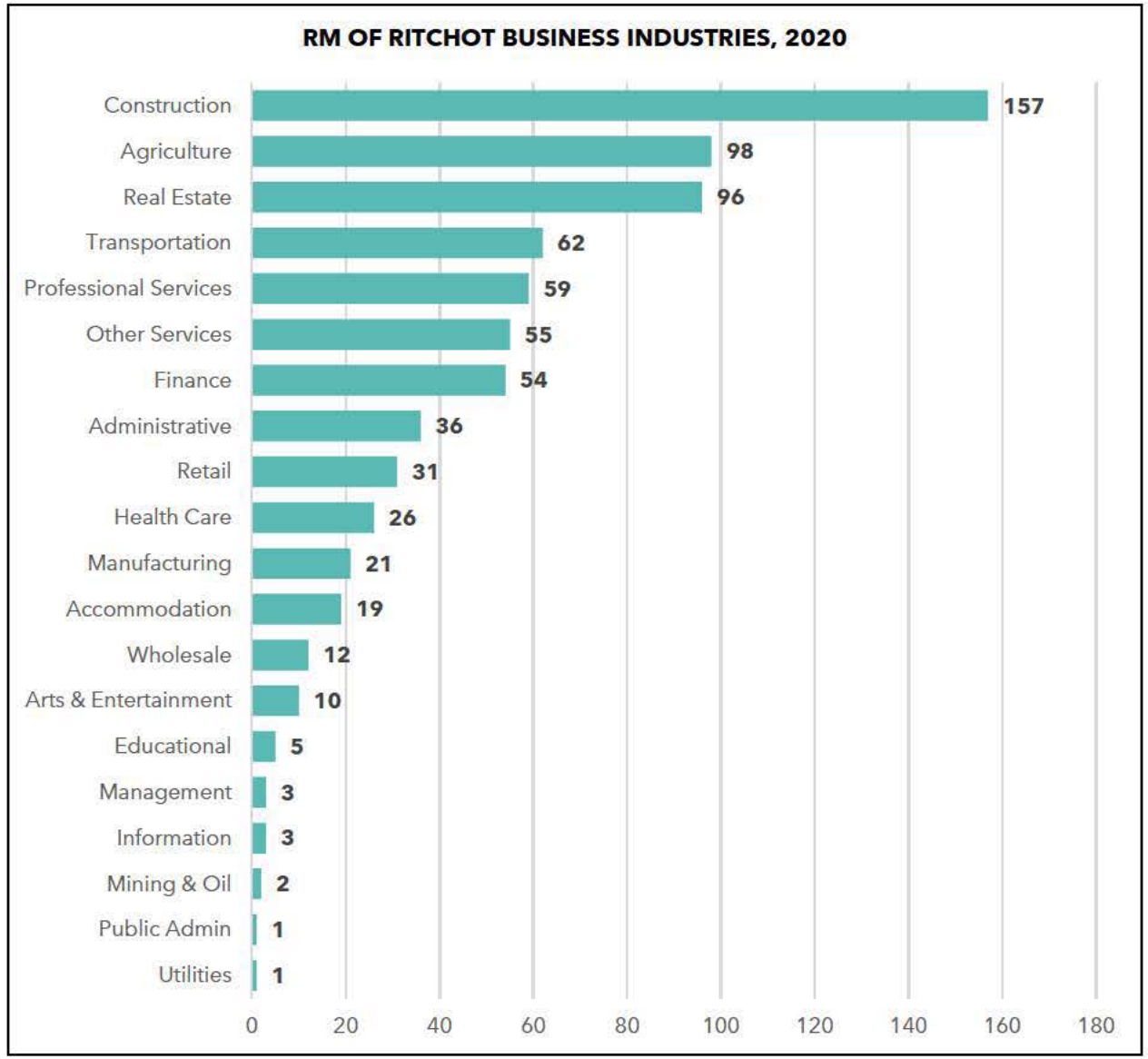
# BACKGROUND

- The three most common businesses by industry 2020 were Construction, Agriculture and Real Estate
- Most of these businesses rely on a reliable water supply in order to continue to fuel the local economy




Source: Statistics Canada



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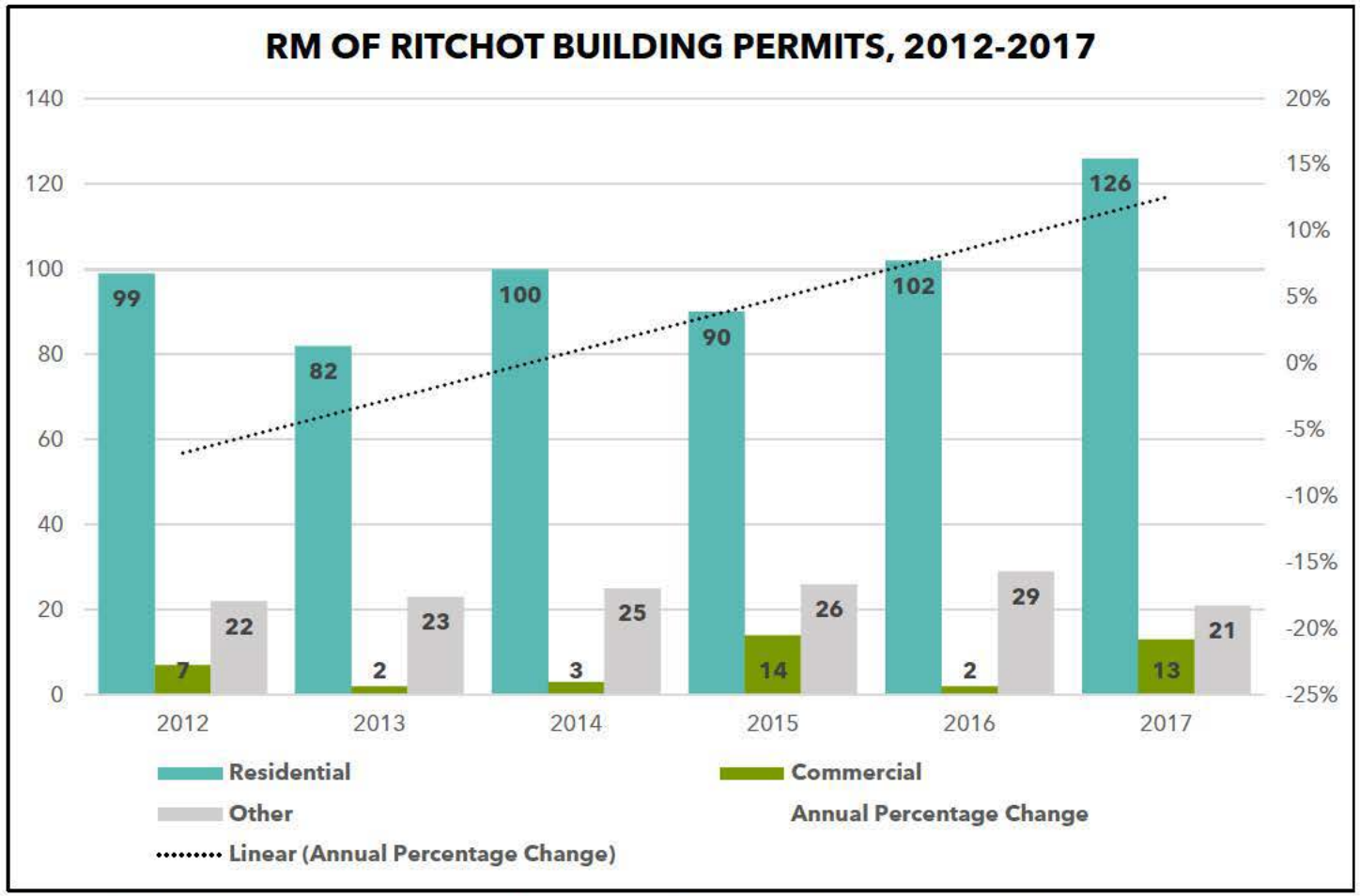
# BACKGROUND

- The RM of Ritchot has experienced a steady annual increase in building permits issued since 2013
- In 2017, the municipality approved a total of 160 building permits, a rise of 17% from 2016
- Increased growth of all types, require a dependable plan for water supply




Source: RM of Ritchot, Invest in the Municipality of Ritchot, MB, Canada: 2018 Community Profile



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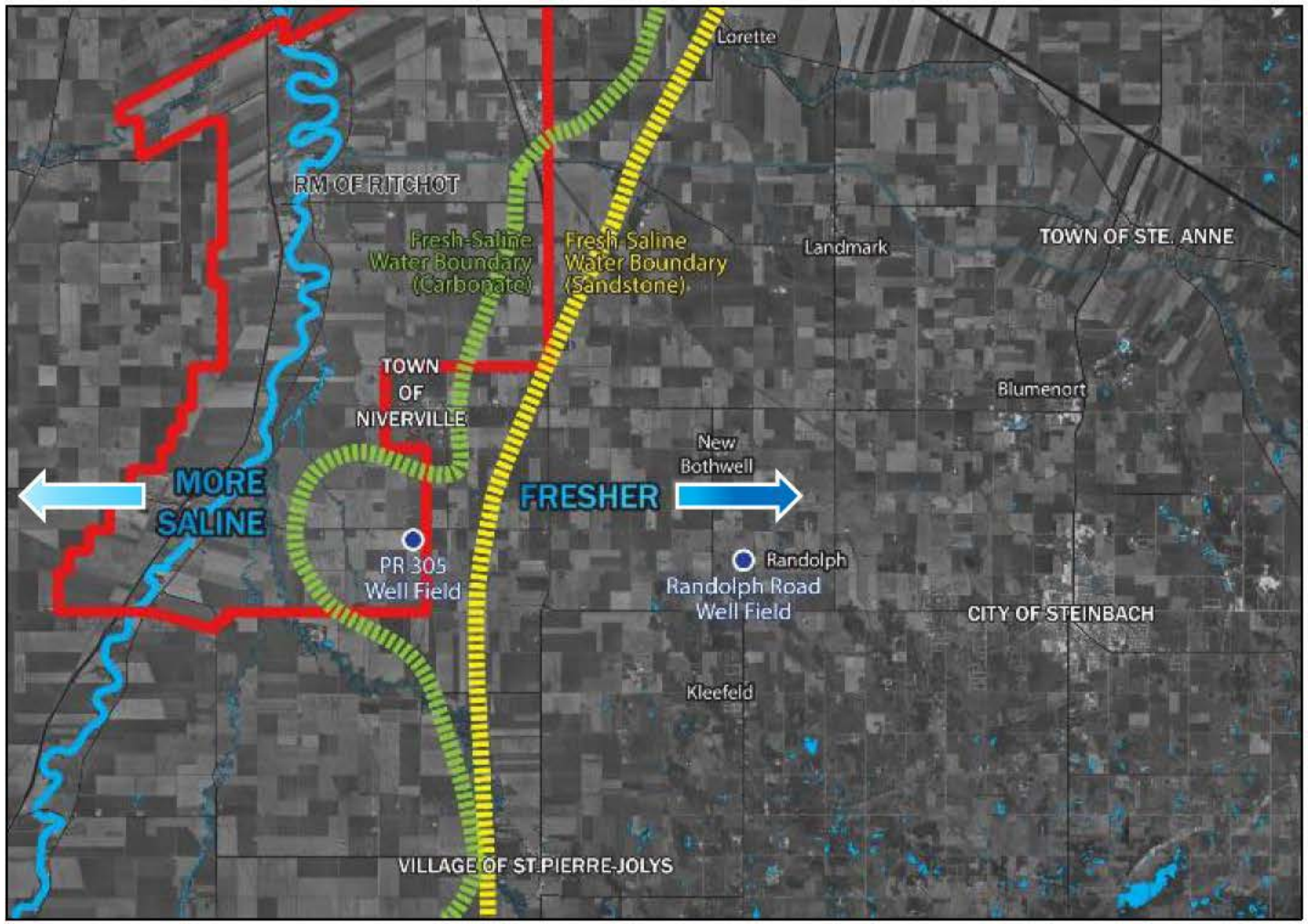
# HYDROGEOLOGY

- This slide illustrates the approximate boundaries between fresh water and saline (salt) water in the two aquifer layers below the surface
- Groundwater from formations east of the boundaries are fresh water, while those west of the boundaries are brackish water
- Groundwater in both aquifers within the RM of Ritchot are generally saline, with minor exceptions



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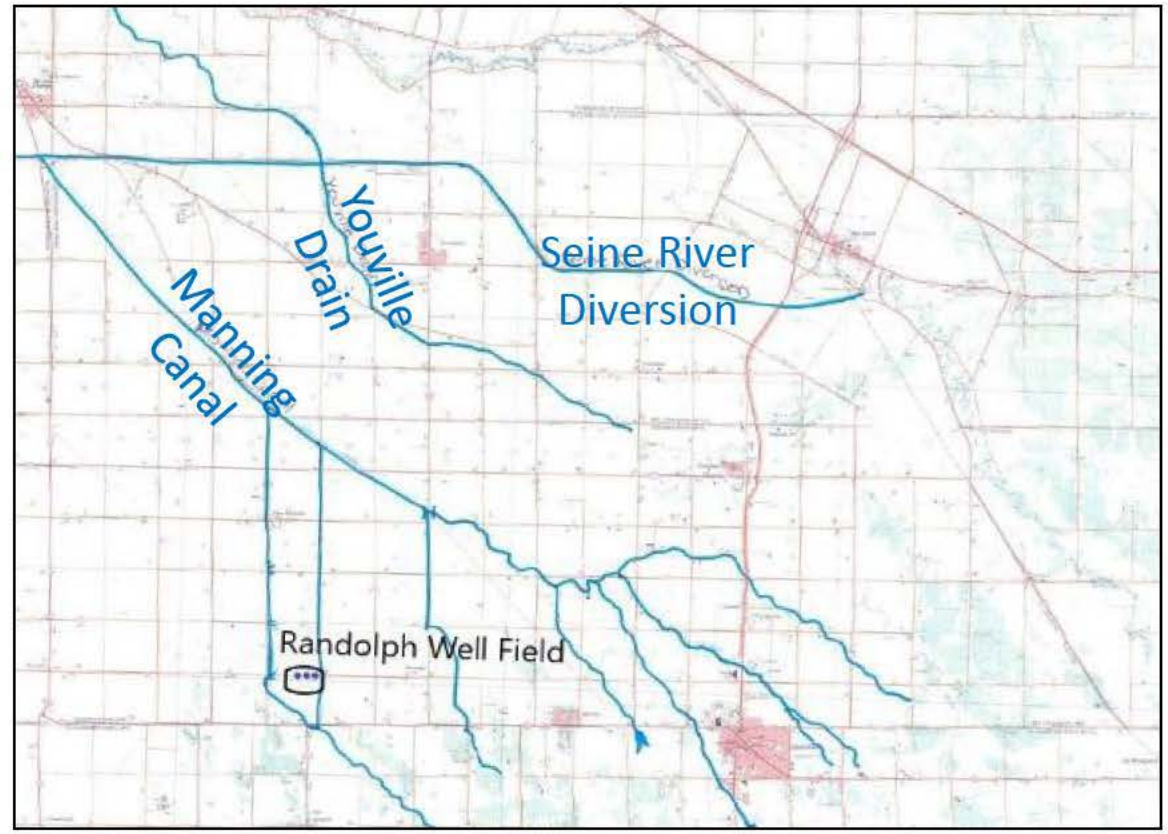
# WELL FIELD HISTORY

- The Randolph Road well field was originally established to relieve groundwater pressure to prevent 'hydraulic rupture' of a major drainage canal passing through the RM of Hanover
- The flowing groundwater was allowed to freely flow to the Red River, where it was discharged unused
- Rather than letting it go to waste, the RM of Ritchot was allowed to collect the water, pump it and use it
- The PR 305 well field was installed to supplement the decreasing water supplies from the gradual lowering of the local groundwater pressure



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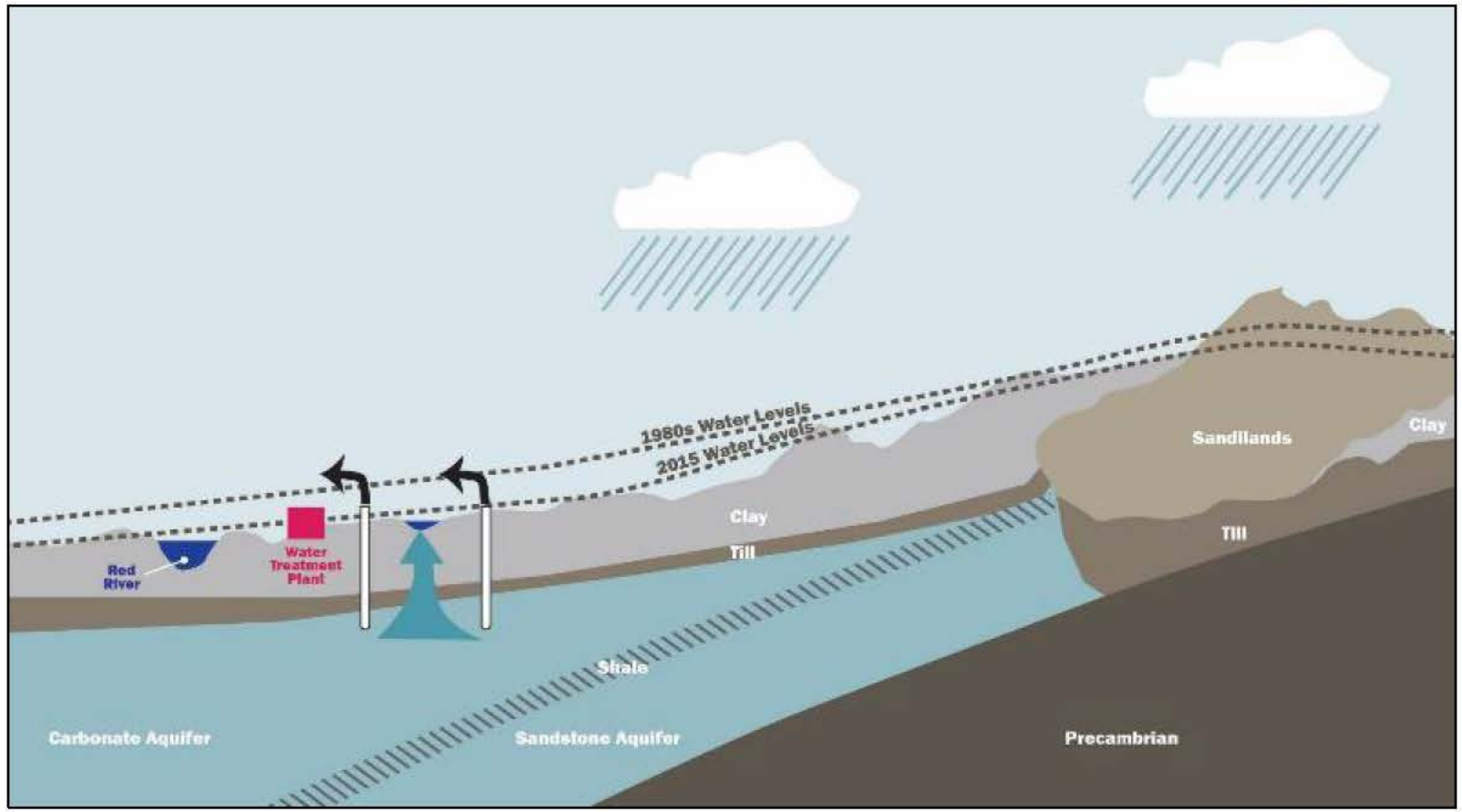
# PRESSURE RELIEF WELLS

- This slide illustrates how the relief wells work at the Randolph well site
- Natural water pressure from the carbonate aquifer was causing groundwater to flow into the canal, damaging the canal
- The relief wells allowed the local water pressure to be reduced to protect the canal
- The groundwater pressure has been reduced over time



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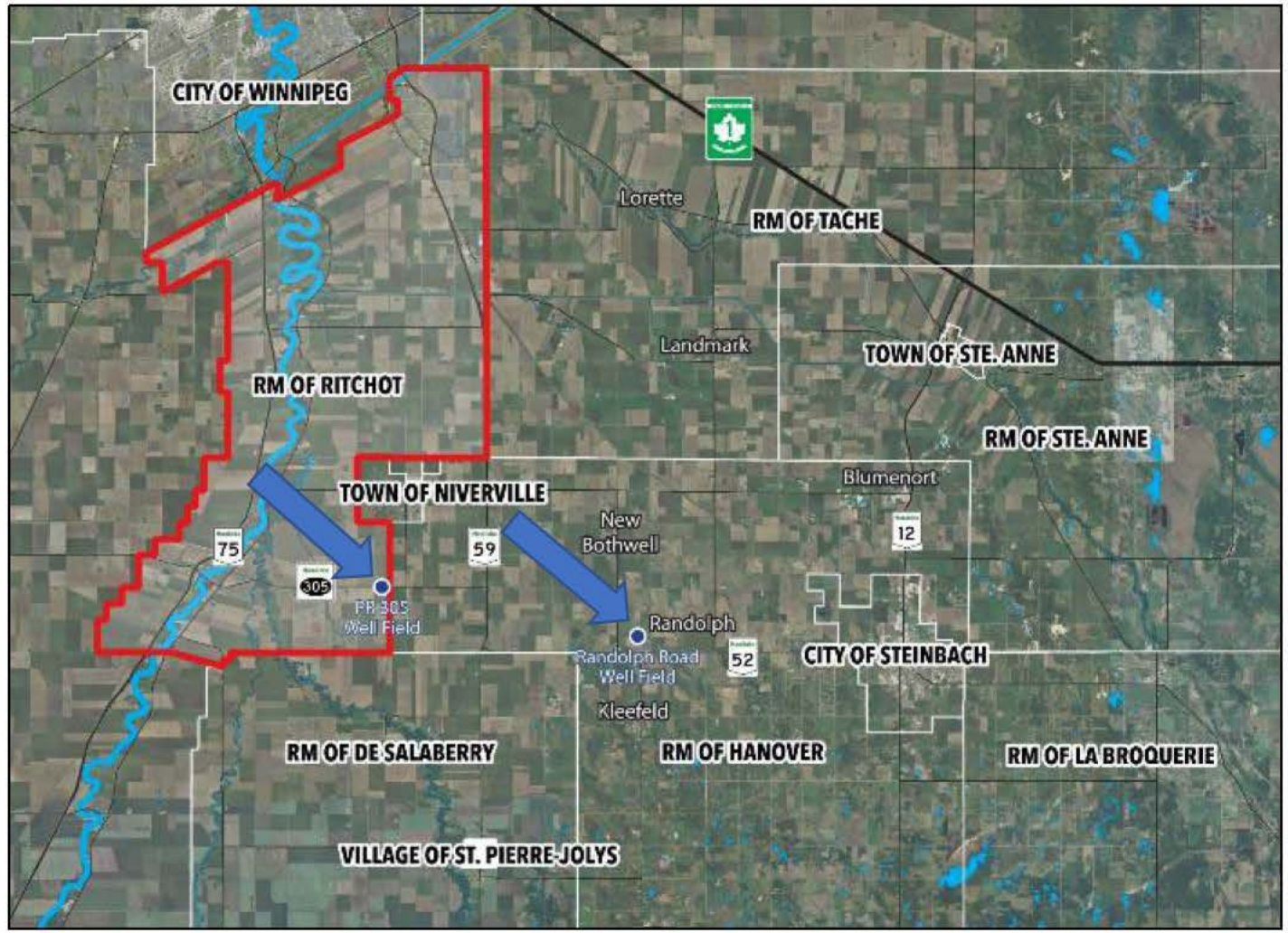
# RITCHOT SUPPLY WELLS

- The RM of Ritchot currently has two well fields
- The Randolph Road well field is located on SE 8-7-5 EPM
- The PR 305 well field is located on NE 12-7-3 EPM
- Water is piped from these locations to the RM of Ritchot Water Treatment Plant and from there to users throughout the RM
- There are no pumps in the existing wells (located in the Randolph Road well field). There are well pumps in the PR 305 well field.



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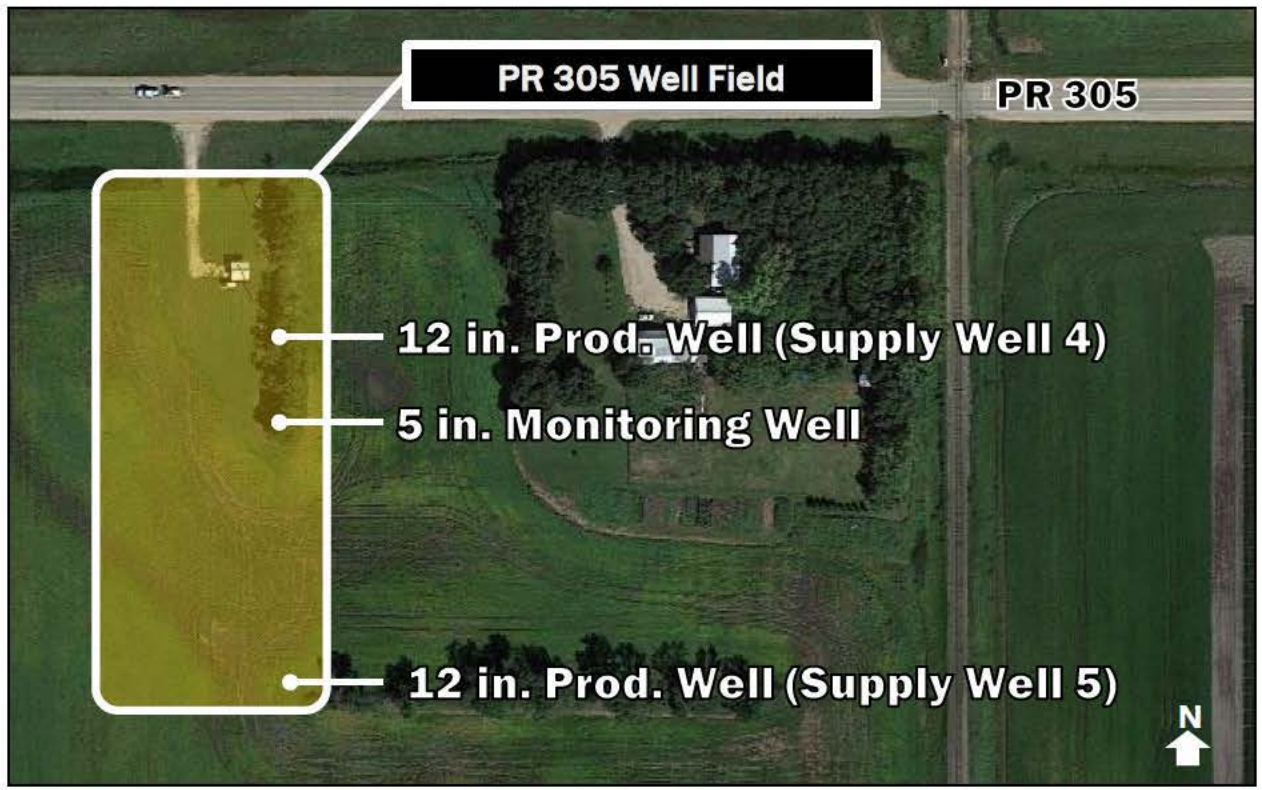
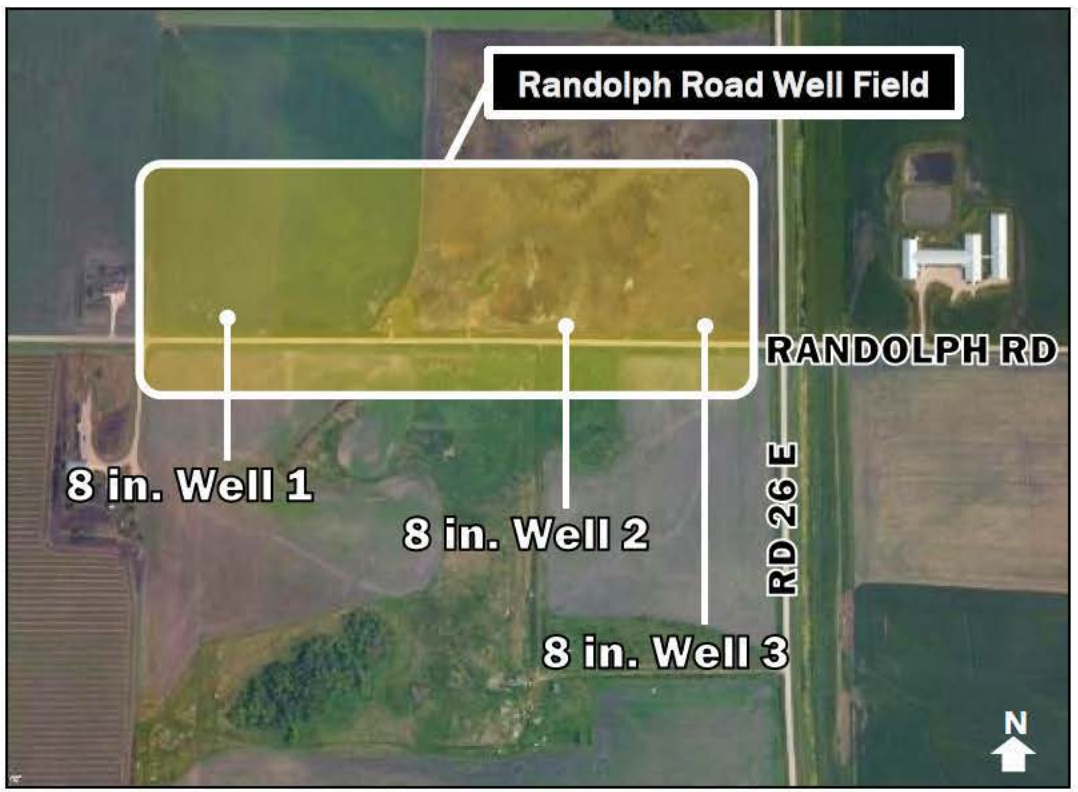
# EXISTING WELL FIELDS

- This slide illustrates the layout of the PR 305 and Randolph Road well fields



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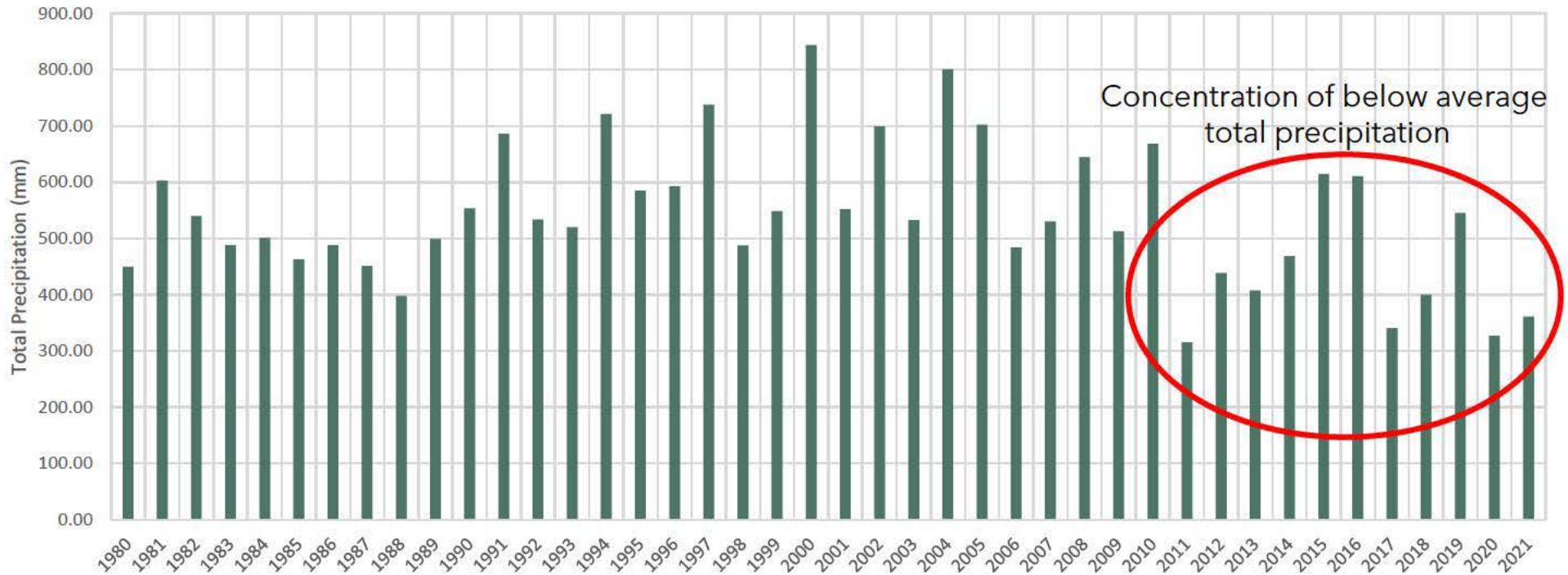
# HISTORIC PRECIPITATION CHANGES
## in Southeastern Manitoba

- This slide illustrates historic precipitation changes in Southeastern Manitoba since 1980
  - Since 2011, there has been a significant concentration of below average precipitation



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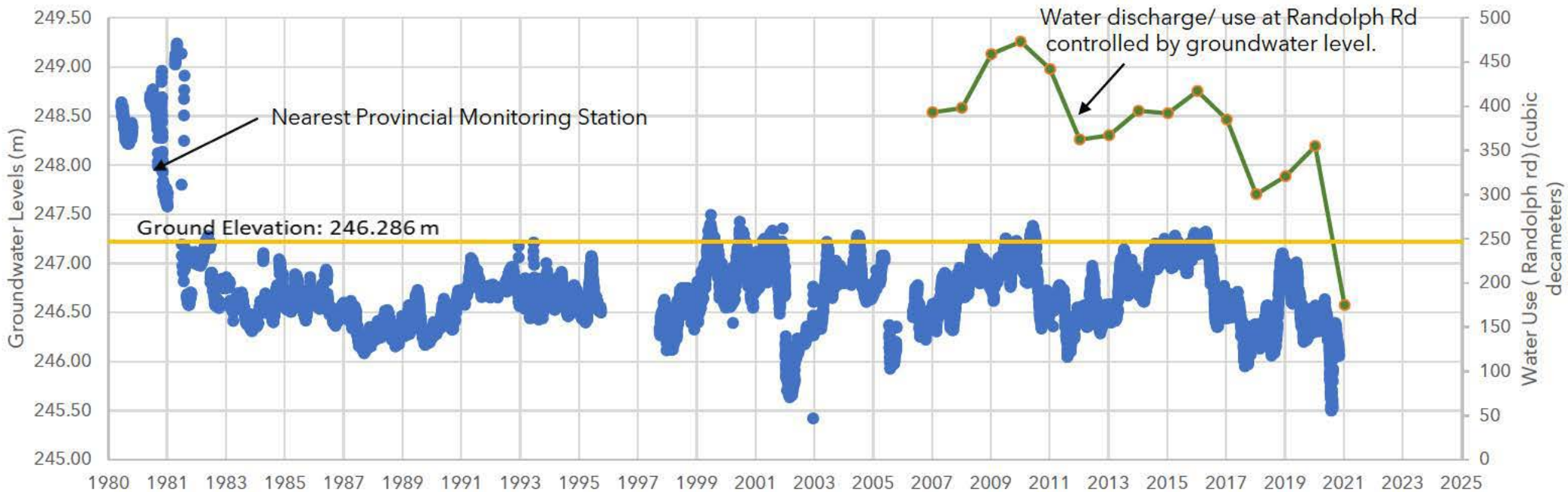
# HISTORIC GROUNDWATER CHANGES
## near the Randolph Road Well Field

- Groundwater levels have been variable over the years as they are driven by climatic conditions
  - This variation is normal, but makes it more difficult to service a municipality
  - There are no long-term problems or declining water levels in the area






Average Precipitation (1980-2021): 539.32 mm

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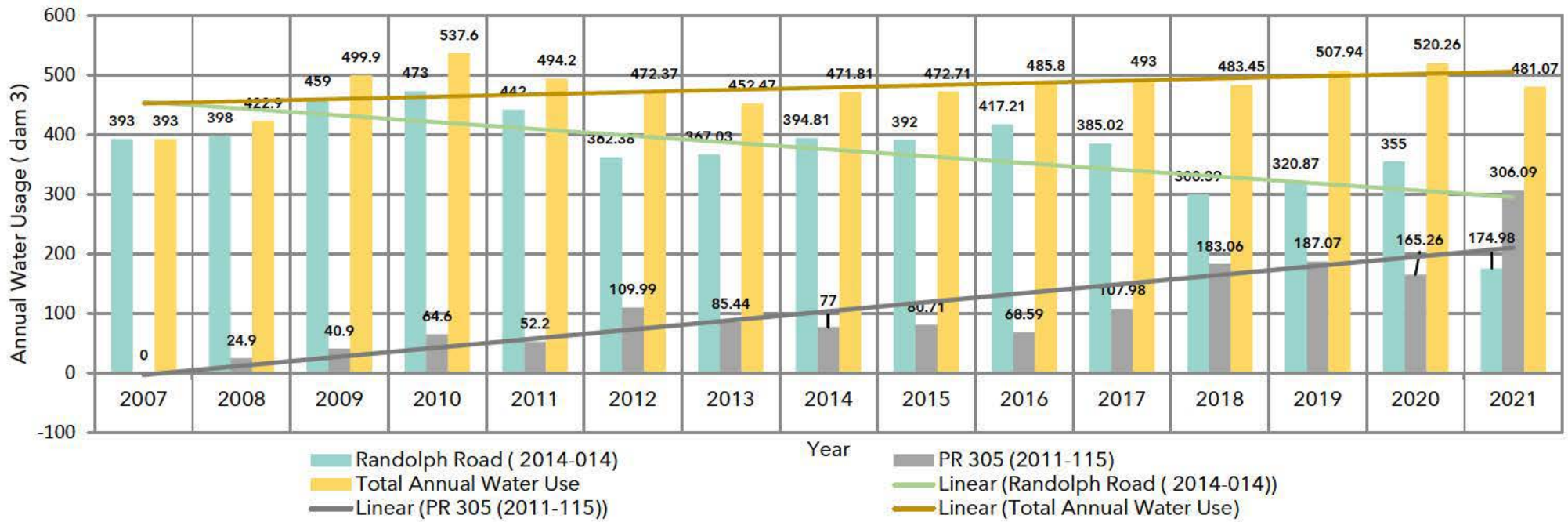
# HISTORIC WATER USE

- Water use has increased only modestly over the past 15 years (yellow line)
- Reliance on the Randolph Well site has decreased (green) while reliance on the PR 305 Well Site has increased (grey)



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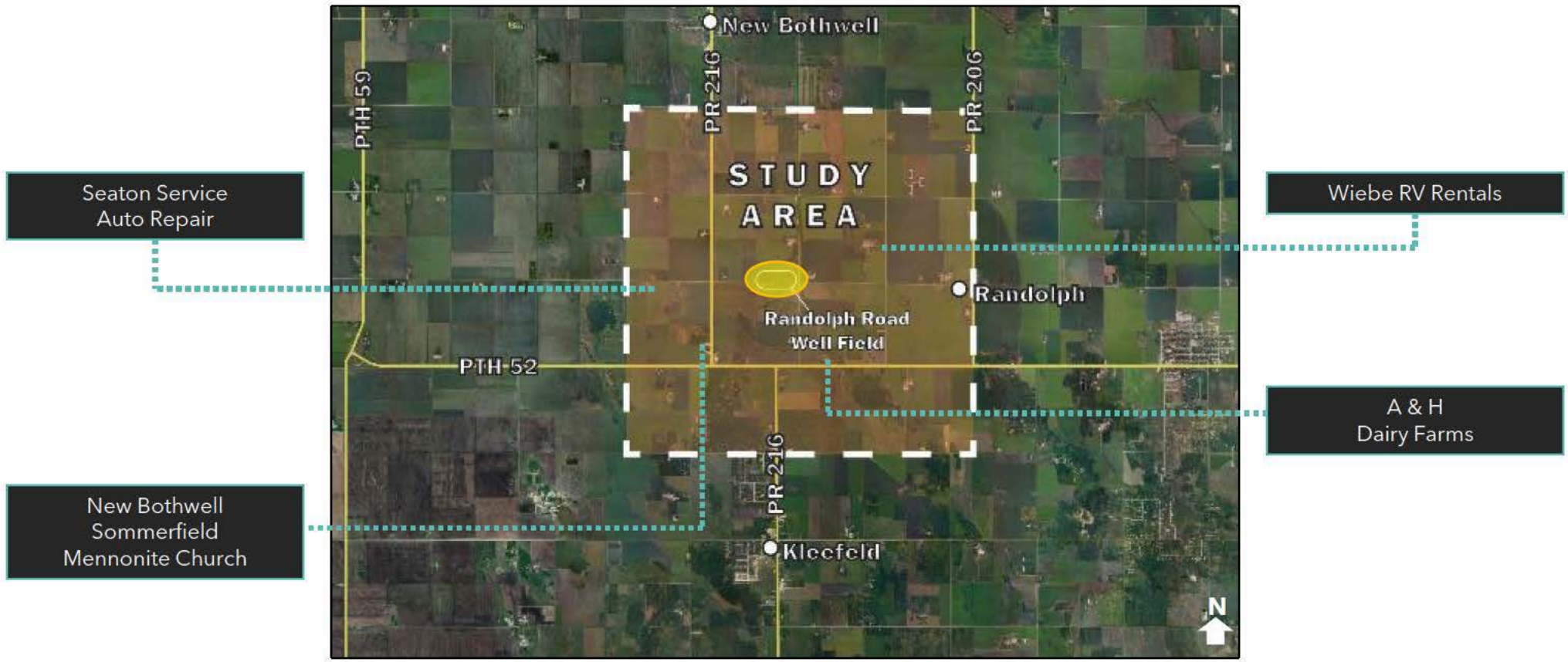
# LOCAL STUDY AREA

- This slide illustrates the study area around the Randolph Road well fields



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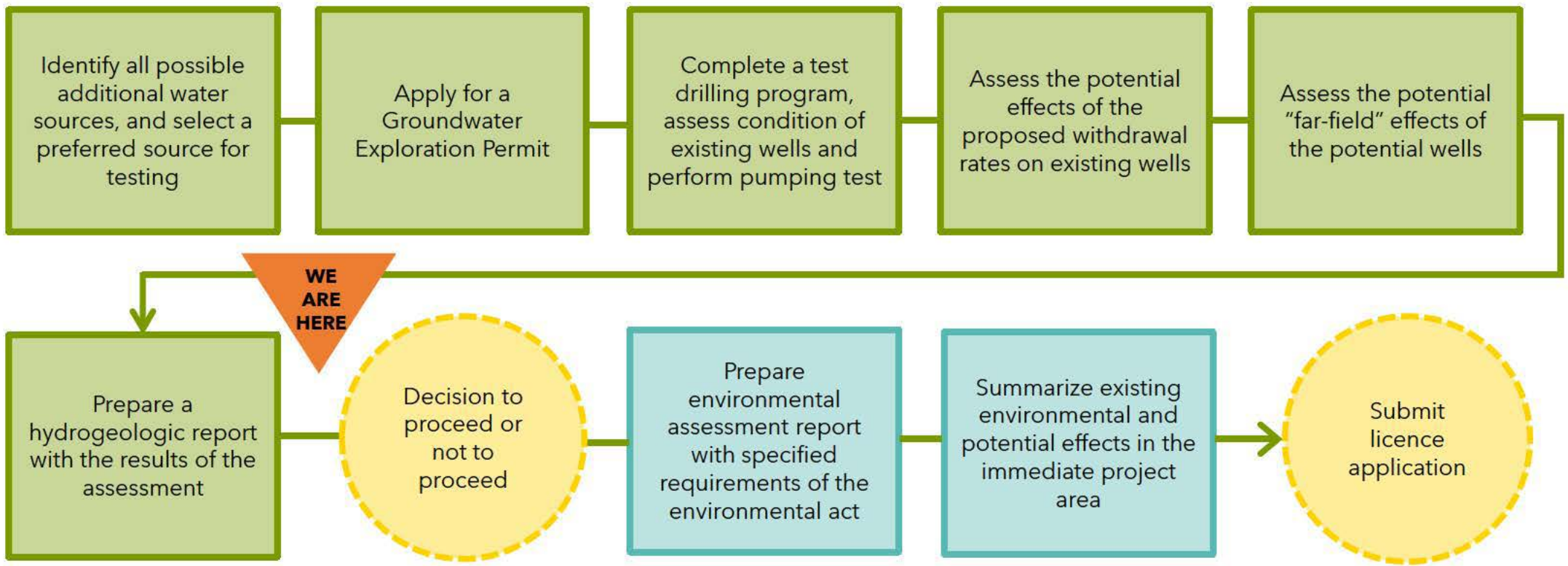
# APPLICABLE MANITOBA ACTS & REGULATIONS

- A water supply system project is regulated by the following Manitoba acts and regulations:
  - The Public Health Act
  - The Drinking Water Safety Act
  - The Water Rights Act
  - The Drinking Water Safety Regulation
  - The Environment Act
    - Licensing Procedures Regulation
    - Classes of Development Regulations
- The licensing approval process will be outlined in more detail in later stages of the project

# PROJECT PROCESS

- The following steps outline the components of the water supply investigation
- As the technical investigations are nearing completion, a decision will need to be made as to whether to proceed, or not



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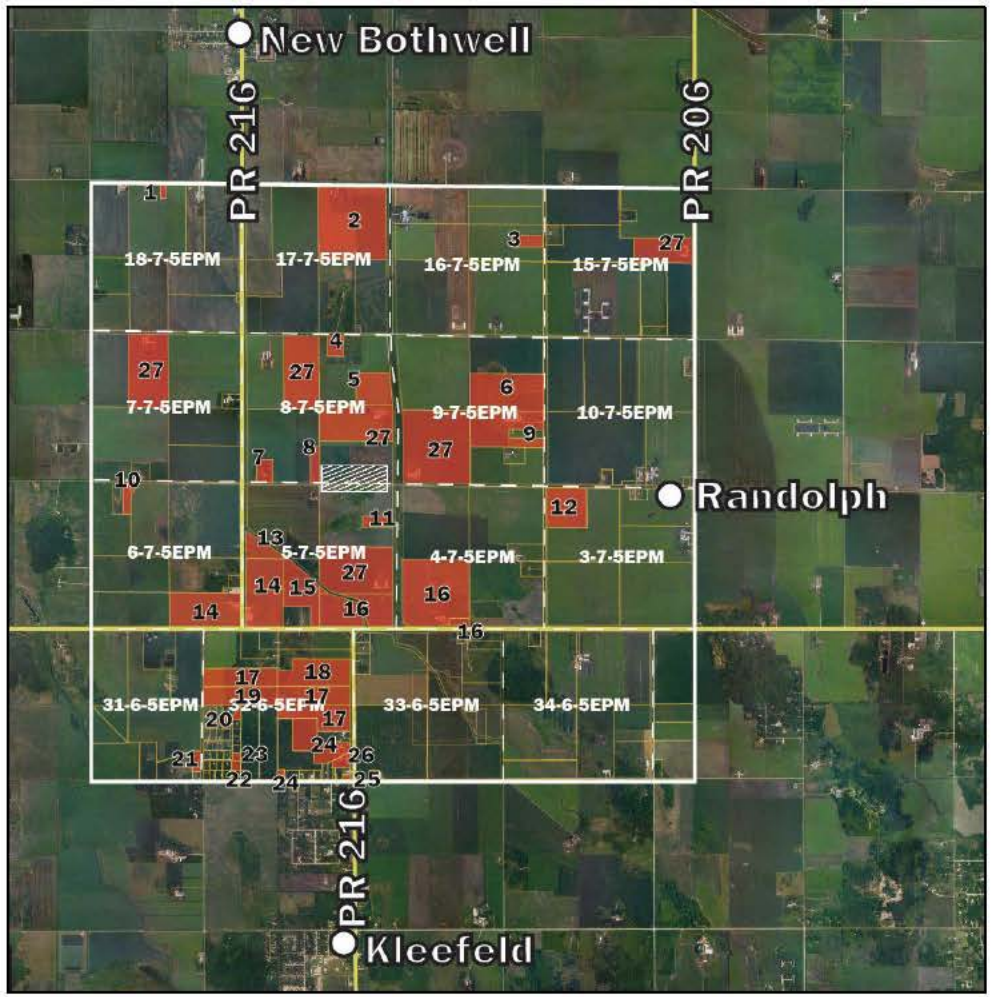
# WELL INVENTORY PROGRAM

- Landowners participated in a voluntary Well Inventory Program to help evaluate existing wells in the study area and to help forecast any possible effects of new wells/pumps
- The inventory process took place from January to May, 2022
- The Project Team was able to collect information regarding well history, water quality, and well performance:
  - 27 landowners participated
  - 41 wells inventoried
  - A mix of domestic and agricultural wells



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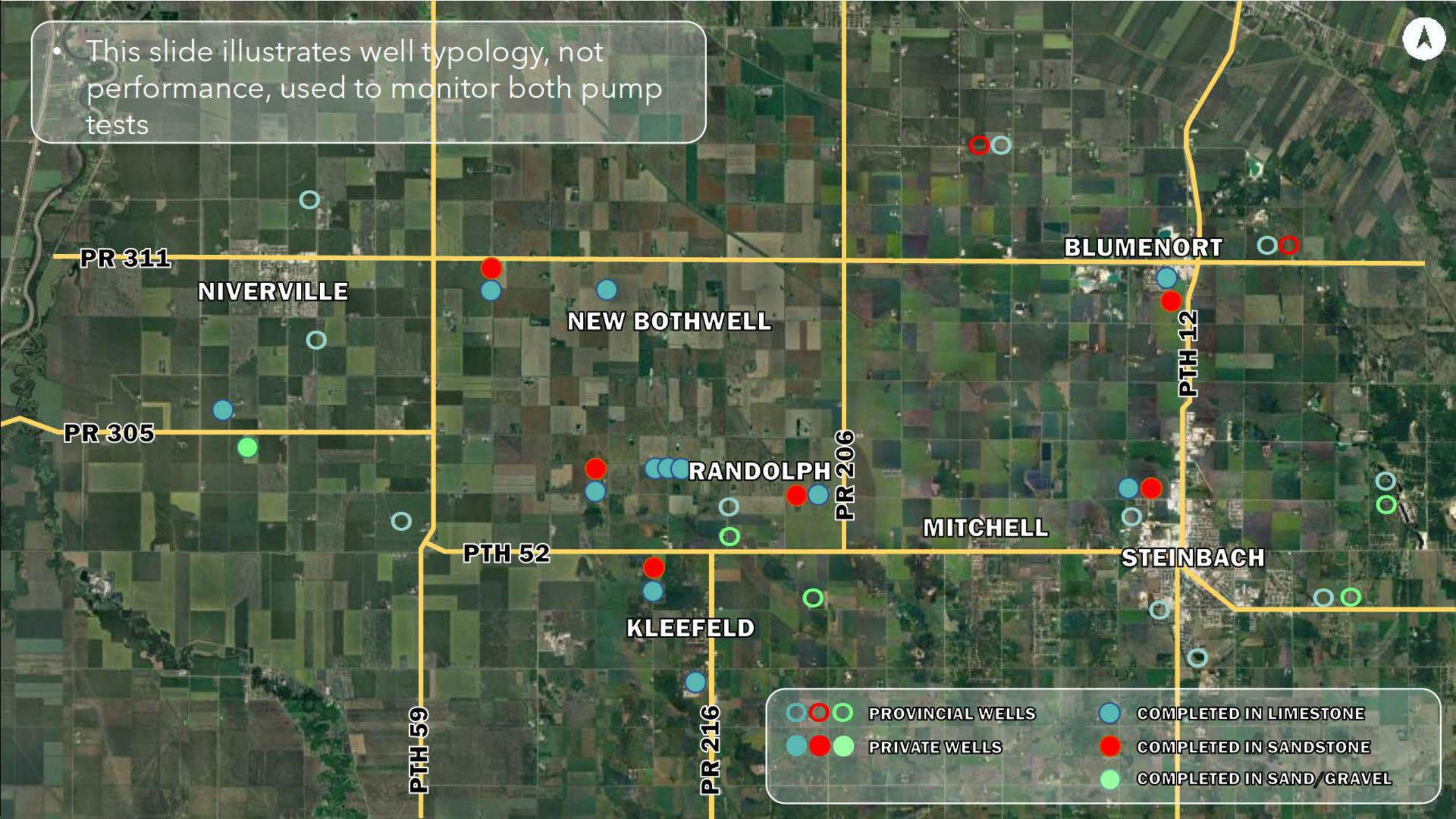
# MONITOR WELL DRILLING

- Friesen Drillers conducted a preliminary inspection and draw down test to assess the existing municipal wells for functionality
- Following preliminary testing, Friesen Drillers drilled new monitoring wells at three sites within the study area:
  - Monitoring wells were placed in both the sandstone and limestone aquifers
  - More than 40 wells were monitored throughout the duration of the testing


This slide illustrates well typology, not performance, used to monitor both pump tests
PR 311
NIVERVILLE
NEW BOTHWELL
BLUMENORT
PTH 12
PR 305
RANDOLPH
PR 206
MITCHELL
PTH 52
STEINBACH
KLEEFELD
PTH 59
PR 216
PROVINCIAL WELLS
PRIVATE WELLS
COMPLETED IN LIMESTONE
COMPLETED IN SANDSTONE
COMPLETED IN SAND/GRAVEL

# PUMP TEST

- Friesen Drillers conducted two pump tests (72hr and 4hr) at the Randolph Road municipal well field site to study the aquifers response to the stress of pumping water

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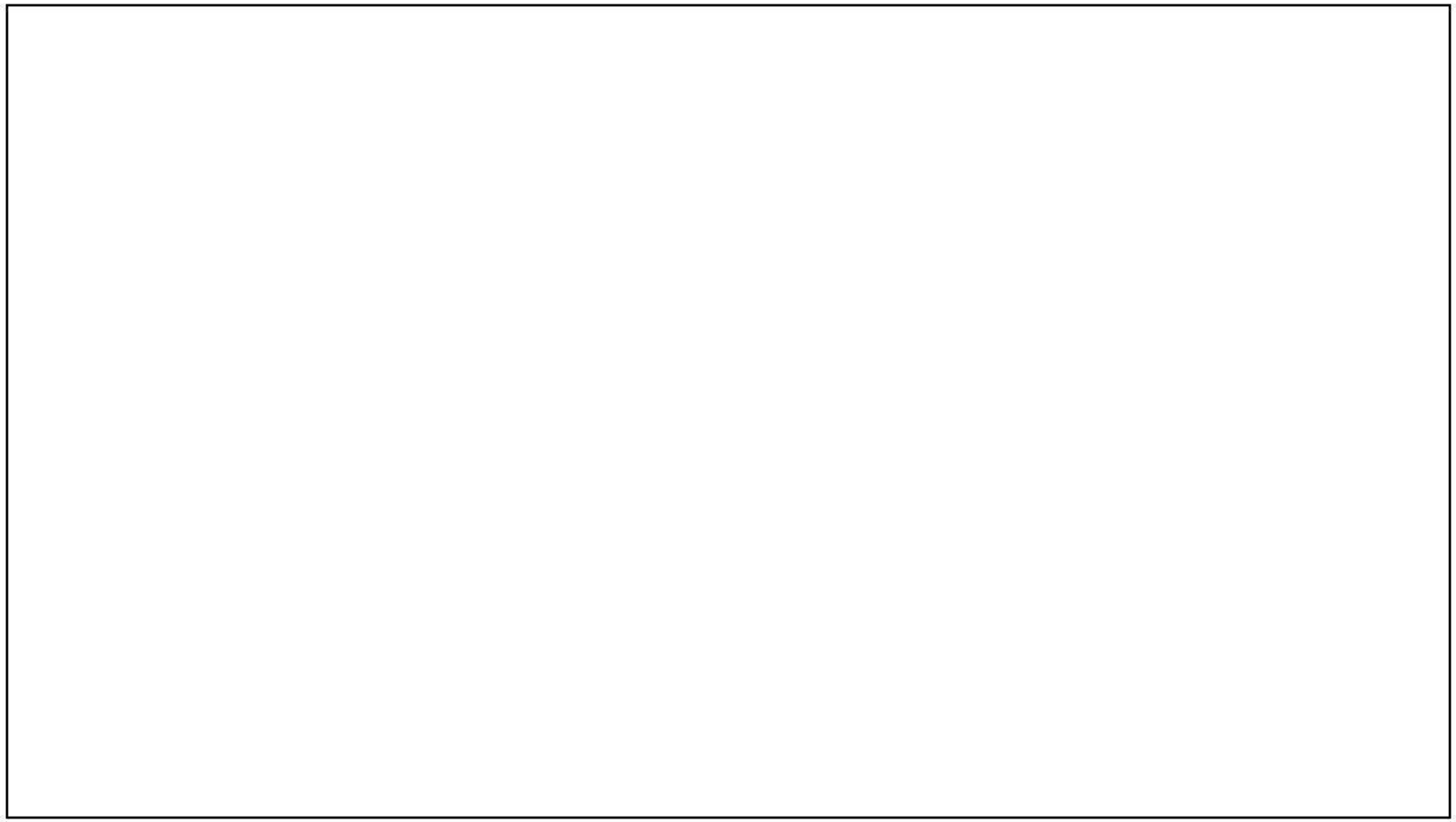
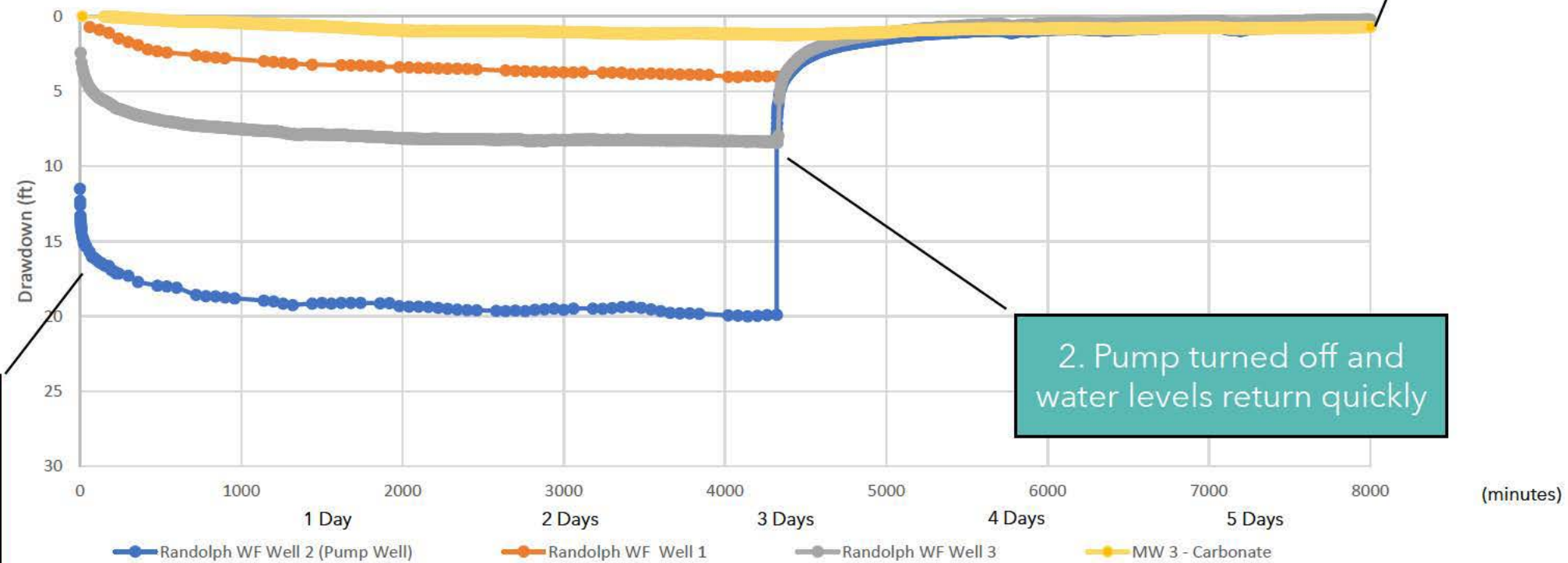
# PUMP TEST



# AQUIFER RESPONSE

3. Water levels return to original after 72hrs




2. Pump turned off and water levels return quickly

1. Pump turned on and water levels decline as expected



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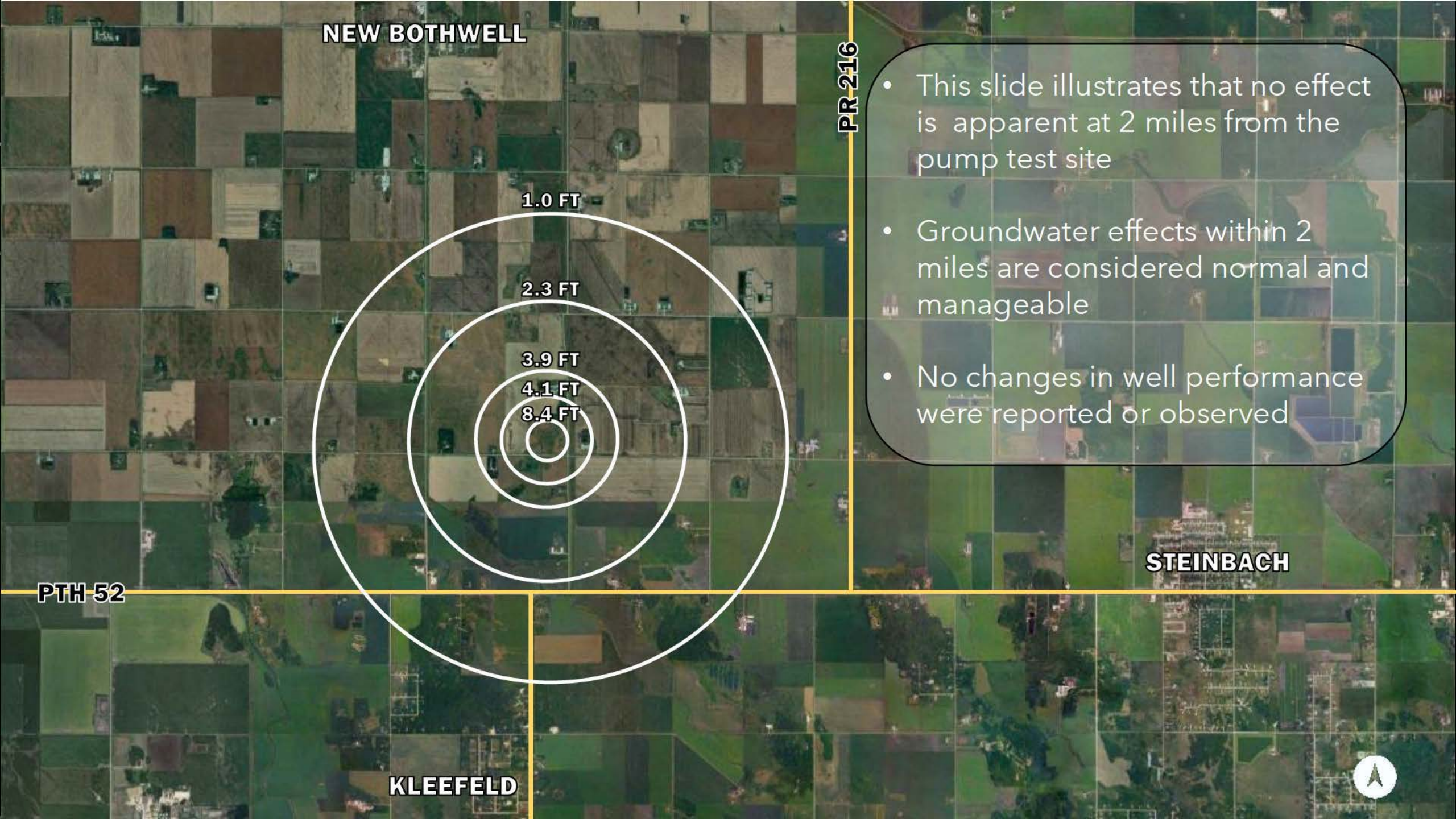
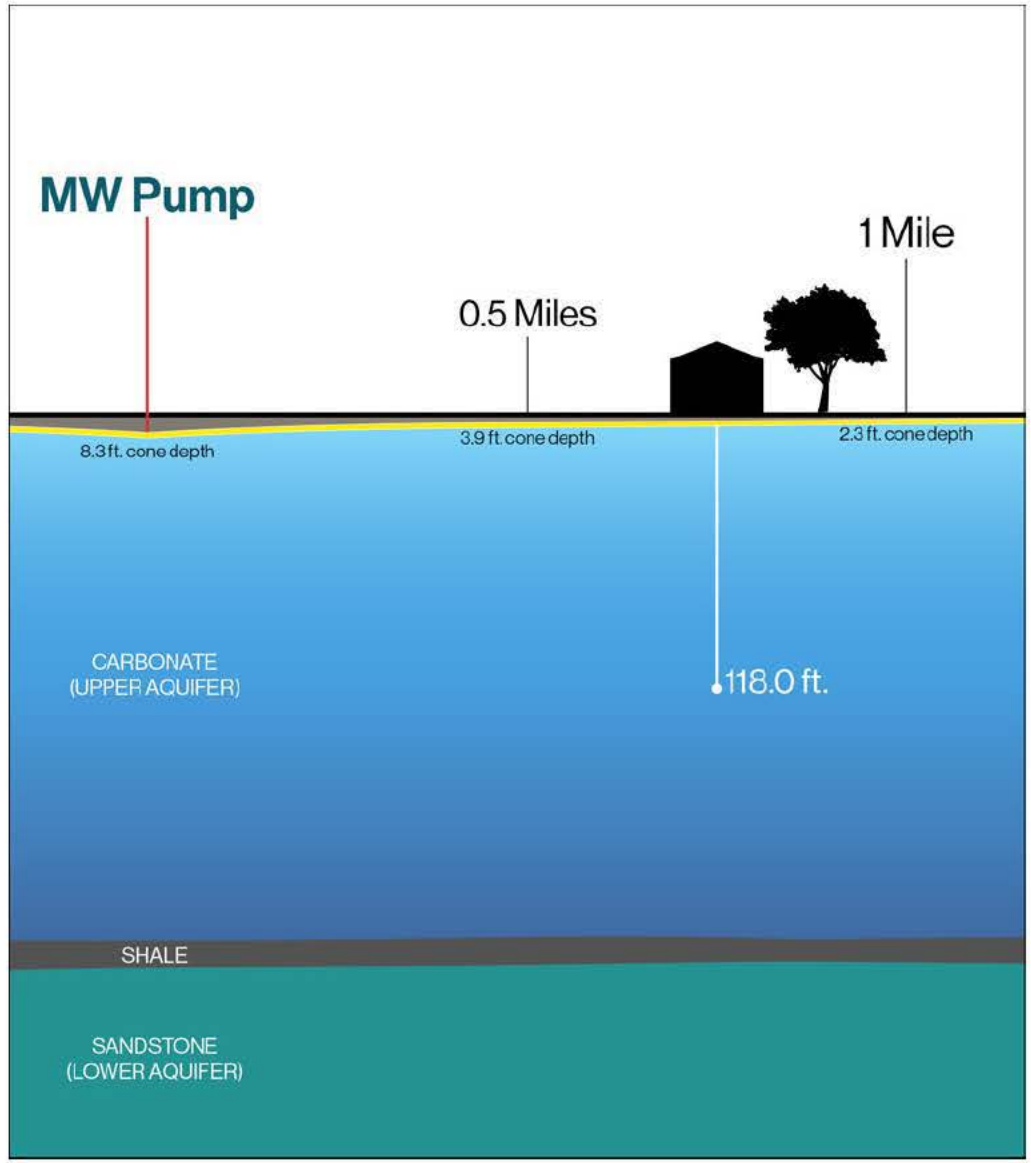



- This slide illustrates that no effect is apparent at 2 miles from the pump test site
- Groundwater effects within 2 miles are considered normal and manageable
- No changes in well performance were reported or observed



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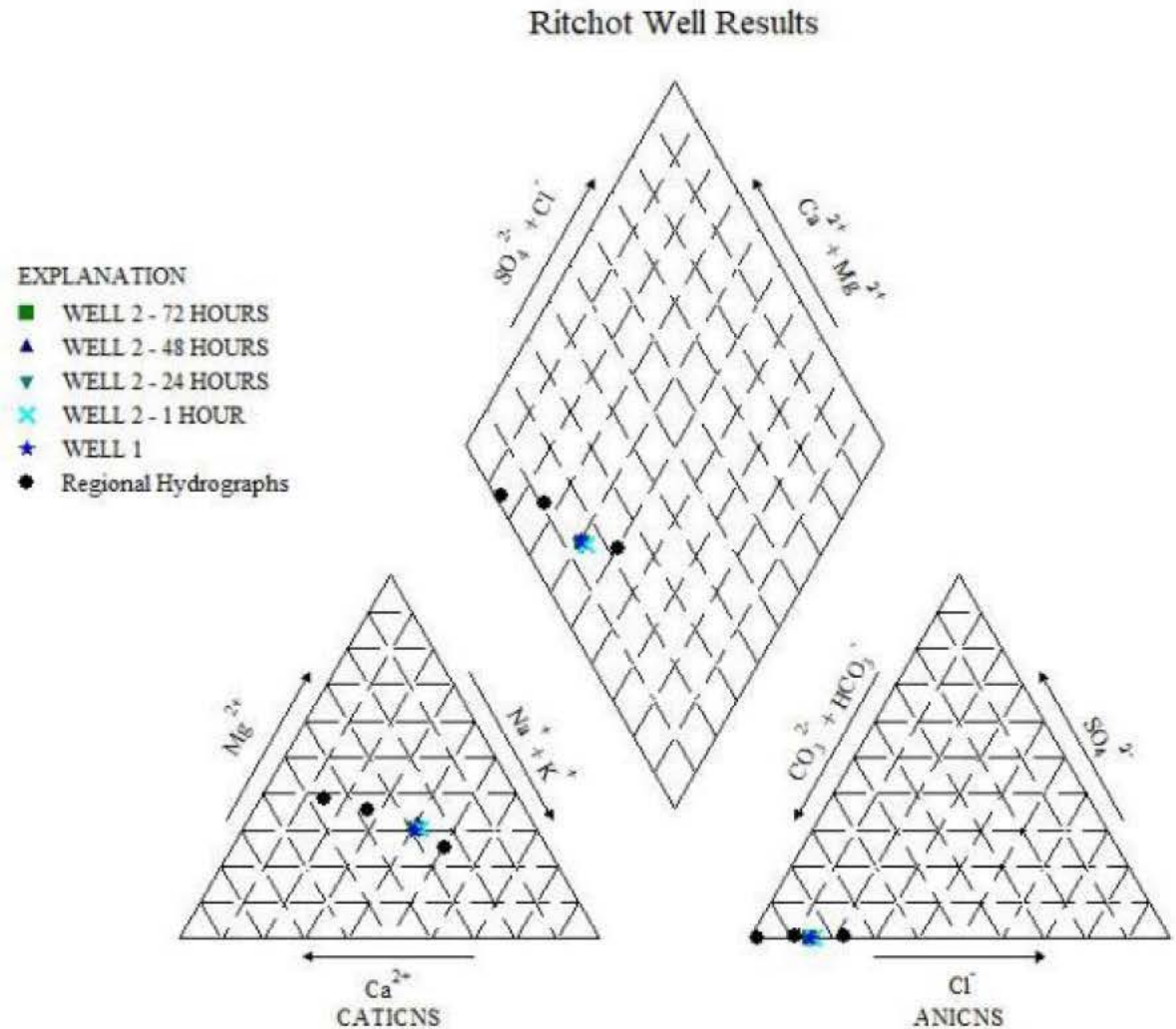
# PUMP TEST RESULTS

- The water quality in this area has been consistent for the last 40+ years
- The project team did not anticipate any impacts to water quality
- The pump test confirmed this assumption



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# PUMP TEST RESULTS

Historical records indicate that the Randolph Road Well field is already supplying a significant amount of water for the RM of Ritchot without any pumps installed.

During wetter periods, there is more discharge from the well field. During drier periods, there is less discharge from the well field.

- Installing pumps into this well field would ensure a consistent supply for the RM of Ritchot.

# PROPOSED CHANGES

Each existing well field has its own licence. The intent is to apply to change the Licence for the Randolph Road Well Field only.

- **PR 305 Well Field**
  - Current maximum pumping rate of 0.0350 cm/s (1.23 cfs)
  - Allows for the diversion of up to 639acre-feet of groundwater annually

- **Randolph Road Well Field**
  - Original Licence issued in 1993; RM must accept all of the water flowing from the wells
  - RM was not permitted to install pumps in these wells to increase water flow
  - Proposal to install pumps at this site at 25 litres per second

# GRADUATED LICENCING PLAN

- Available records (2007-2021) show that the Randolph Road Well Field site is discharging an average of 375 cubic decameters (304 acre-feet) annually at an average rate of +/-12 litres per second (or +/-190 gallons per minute)
- The Well Field is able to support pumping to a total of 25 litres per second continuously, with a total allocation of +/-788 cubic metres (+/-639 acre-feet)
- To ensure this support, the Project Team intends to apply for a 20-year Licence that would enforce a staged approach:
  - 70% of total allocation for the next 5 years (+/-447 acre-feet)
  - 100% of total allocation after 5 years (+/- 639 acre-feet)

# GROUNDWATER INTERFERENCE PROGRAM

- The Project Team will outline a Groundwater Interference Program in the Licence Application to establish a procedure to deal with any potential complaints of groundwater interference regarding a private well
    - It is up to the Regulator if the Program is required or not
- Groundwater interference is defined as a decrease in residential well performance due to factors such as the pumping of production or monitoring wells that causes a decrease in well capacity such that the supply of water to the well is temporarily or permanently interrupted
- There is an existing Groundwater Interference Program on the PR 305 wells
    - We plan on adopting this Groundwater Interference Program RM-wide

# GROUNDWATER INTERFERENCE PROGRAM

Below is a typical Response Plan to a Groundwater Interference Complaint:

- **Preliminary Well Assessment**
  - Municipal staff will undertake a preliminary well assessment immediately (<5 hours) after receiving the complaint
  - If interference has occurred, the municipality will immediately provide a resident with potable water and initiate an investigation to determine the cause of the interference
- **Secondary Well Assessment**
  - In the event that a bona fide groundwater interference may have occurred, the municipality shall continue to deliver water to the resident at no cost, or institute mitigation measures such as lowering the well pump or repairing/replacing the well

# NEXT STEPS

- Finalize environmental assessment report detailing the outcome of the pump test
- Adopt a Groundwater Interference Program
- Prepare an application for a Water Rights Licence increase to allow for the RM of Ritchot to install pumps within the Randolph Road Well Field

# THANK YOU

We would like to thank you again for attending today's stakeholder meeting. If you have any follow up comments/questions, or to discuss this process further, please contact us:

**https://www.surveymonkey.com/r/RitchotWaterSupply**

**Donovan Toews or Brennan Johnson**

Landmark Planning & Design

T: 204.453.8008

E: rsvp@landmarkplanning.ca



Friesen DRILLERS

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## APPENDIX D

# ROUND ONE STAKEHOLDER MEETING MINUTES

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# APPENDIX D

## Rural Municipality of Ritchot Water Supply Project

### Round One Stakeholder Meetings – Combined Minutes

December 9th, 2021 at 4:00PM and 7:00PM

18 Attendees

## WELL FIELD HISTORY

**Can you provide more information regarding the installation of these wells as pressure relief wells?**

Observation wells were drilled in the area in 1960s and the pressurizing wells were installed around the same time. In 1993, the RM of Ritchot acquired a license to divert excess water being discarded into the Red River to their municipality.

**Is the water supply in this area the same as Niverville's?**

Water in this region comes from the same aquifer.

## RESPONSIBILITY

**If our wells were affected by an eventual project, whose responsibility would it be to rectify the issue?**

The project team asked stakeholders to identify any issues or concerns regarding water supplies and quantities in the region.

The due diligence period and data collected during testing before any application is made to secure additional water rights will provide a high level of confidence that water supply is at a sustainable level.

If a license were granted, a condition of a Groundwater Interference Program would assign any responsibility to the RM of Ritchot to rectify problems caused that were a proven result of this project.

## CONFIDENCE

**What is the level of confidence of sustainability based on the [predetermined pump test] period of time?**

The level of confidence is high. Test results will be compared against historical records over the last several decades to fully understand the behaviour of the aquifer.

Monitoring equipment will be put into wells prior to and following any test pumping which will also allow the project team to monitor how the aquifer recovers from the stress of pumping.

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Winnipeg, Manitoba R3B 0G5
T: 204.453.8008
E: RSVP@landmarkplanning.ca

**Is there a point in time where the Province or other entities will stop looking to this area to provide them water?**

Eventually there will be a point when the science and data says there is no additional supply when communities in this area are needing more water. Until such a time as a test shows overlapping requirements are not sustainable, the data will indicate if it is okay to proceed.

**Is there a chance of saline migration?**

The boundary of saline water to the west has not moved in 14 years. This will continue to be monitored if the project moves forward.

## DROUGHT YEARS

**How has the drought impacted water supply in the area?**

Groundwater in Manitoba is in the carbonate aquifer, which is quite drought resilient. On average this aquifer fluctuates 10 to 15 feet each year, and this year (2021) there is an additional three feet of fluctuation. There is still a lot of drawdown available.

**Have artesian wells stopped flowing?**

Artesian pressure and conditions is an effect of topography and various other considerations. In Manitoba, there are several places with flowing conditions.

The static groundwater levels change throughout the year – for example, January has a lower water level. Winter recharge occurs when the snow melts towards March/April when groundwater levels rise, and they slowly decline again through Summer into Winter.

The aquifer is very responsive to precipitation recharge, and therefore in years where we see a lot of precipitation you will likely see flowing conditions.

**Are different types of wells affected in different ways?**

People who rely on artesian wells do not have any pumps installed to provide water when there aren't flowing conditions. People who do have a pump have either a submersible pump or a suction pump.

The Randolph Road Well Field sites currently do not have pumps installed.

## PROJECT

**How much water is the RM of Ritchot looking for?**

Available data and due diligence by Friesen Drillers through this study will demonstrate what amount the Randolph Road Well Field can yield sustainably, and will be used to determine how much water may be able to be pumped to the RM of Ritchot.

**Will project materials be shared with us?**

Project materials will be made available on the Landmark Planning website [www.landmarkplanning.ca].

298 Waterfront Drive
Winnipeg, Manitoba R3B 0G5
T: 204.453.8008
E: RSVP@landmarkplanning.ca

## APPENDIX E

# ROUND TWO STAKEHOLDER MEETING MINUTES

Landmark
Planning & Design Inc.

# APPENDIX E

## Rural Municipality of Ritchot Water Supply Project

### Round Two Stakeholder Meeting – Minutes

April 26th, 2022 at 7:00PM

15 Attendees

## TYPICAL WATER LEVELS

**What are the typical water levels in the area?**

Even at its lowest point (which was during Summer 2021), groundwater within the carbonate aquifer was still within five feet of the surface and within four and one half feet from grade directly across the street form the Randolph Road well field.

**Is the groundwater close to the surface?**

It is very close to the surface. Groundwater levels within 10 feet of grade are deemed flowing wells.

## DROUGHT EVENTS

**Will the data account for dry years?**

There is data available for several decades that will be used to inform the research and we are not only considering one point in time (the present). This data will accommodate for dry years as well, and all information will be presented factually in an environmental report.

Our interest is ensuring there is long term viability if this project moves forward.

Over the last 10 years there have been many instances of below average precipitation throughout all of southern Manitoba – but it is not an indication of the aquifer not being able to perform. The carbonate aquifer is highly reactive to precipitation levels.

**Comment regarding shifting in the ground in this area, particularly during thawing seasons.**

There is a lot of clay in the area, and when it dries out it clumps. When you have that effect in the soils on your property, there is a tendency for your foundation to shift.

## FUTURE IMPACTS

**Will this project impede current landowners and water users from expanding their own operations in the future?**

There are hundreds of existing wells in the area, and we are not introducing new wells, we are only proposing to pump water from existing wells. The results of this study, as well as the data collected during monitoring, will indicate whether there will be any potential impacts to existing water supply.

298 Waterfront Drive
Winnipeg, Manitoba R3B 0G5
T: 204.453.8008
E: RSVP@landmarkplanning.ca

In terms of future use, nobody is able to reserve future supply. If there is a need, that need is met (through a license). If the study determines this project is not sustainable or will have a negative impact on others, it will not move forward.

**What happens if the project moves forward, but 20 years later we run out of water?**

Our testing regime will be based on sustainability versus a fixed term. If something were to go wrong and your well was impacted as a result of this process, your water rights are protected and the RM of Ritchot would be responsible to correct your problem.

If there is a problem in 20 or 30 years from now, we probably all will have a problem and we will need to find somewhere to get additional water.

## WATER QUALITY

**How might existing water quality be impacted?**

Monitoring will be done before, during, and after testing to monitor any changes in water level and water quality. If the project moves forward, both levels and quality will continue to be monitored annually.

Routine tests will monitor metals, pH changes, and total dissolved solids.

## PROJECT

**How many gallons per minute would be pumped [for this project]?**

The research and data will tell the RM of Ritchot what amount would be sustainable. Their target is 475 gallons per minute, however we will need to do an assessment of the existing wells to see if they are pump worthy or if maintenance is required. Following additional due diligence we will set target pumping rates.

**Will pumps be placed in all three [Randolph Road wells], or only in one?**

All three wells will be tested and monitored during the assessment, and pumps would be placed in the one or two best wells.

298 Waterfront Drive
Winnipeg, Manitoba R3B 0G5
T: 204.453.8008
E: RSVP@landmarkplanning.ca

## APPENDIX F

# ROUND THREE STAKEHOLDER MEETING MINUTES

Landmark
Planning & Design Inc.

## APPENDIX F

## Rural Municipality of Ritchot Water Supply Project

### Round Three Stakeholder Meetings – Combined Minutes

September 17th, 2022 at 4:00 and 7:00PM

10 Attendees

## REGIONAL USE

**How do development projects in the region impact this project?**

This project is required for new growth, but this project is not tied to any existing or proposed development in the area.

**Comment that quarry operation in the area is using a lot of water.**

A quarry operation would have a water rights license. If they are pumping at a higher rate, they likely would have been required to conduct studies, however we cannot comment on the operation.

## PUMP TEST

**What was the rate of pumping during the 72-hour pump test?**

The rate was 25 litres per second.

## IMPLEMENTATION

**Comment that stakeholders will monitor their own activity if the project moves forward.**

We encourage you to continue to monitor your existing water supply and quality. The Province will continue to collect data and monitor water supply and quality as well.

**If a graduated license allows for 70% of the allocation, would it still run at 25 litres per second or would it vary?**

The rate would be based on demand to a maximum of 25 litres per second, however the total amount of water being pumped would vary.

**Comments from a few landowners with specific concerns regarding their existing well infrastructure and water supply.**

The Project Team collected contact information and arranged one-on-one meetings with landowners and Friesen Drillers to assess the conditions of their wells to anticipate any potential future impacts.

298 Waterfront Drive
Winnipeg, Manitoba R3B 0G5
T: 204.453.8008
E: RSVP@landmarkplanning.ca

## PROCESS

**What happens to people with artesian pressure wells in the area – if we lose pressure, will we be protected by the Groundwater Interference Program?**

If an inspection determined that any problem you were experiencing was a direct result of this project, you would be protected.

**Is there a way to oppose this licence application?**

We can provide contact information to the Regulators at the Province. We would prefer to have a discussion and continue to mitigate your concerns.

**Comment that stakeholders would like to see the Groundwater Interference Program honoured.**

We will make our recommendation to have that response plan in place.

**Comments that landowners like what is being proposed and that it will only create a slight drawdown and then remain consistent.**

298 Waterfront Drive
Winnipeg, Manitoba R3B 0G5
T: 204.453.8008
E: RSVP@landmarkplanning.ca

Friesen
DRILLERS

# Appendix B

# Water Rights and Environment Act Licences Municipality of Ritchot

MG-14854 (English)

# Licence to Use Water for Municipal Purposes

Manitoba
Conservation and Water Stewardship
200 Saulteaux Cresc.
Winnipeg, Manitoba
R3J 3W3

Issued in accordance with the provisions of
**The Water Rights Act** and regulations made thereunder.

Licence No.: **2014-014**
(Original Lic. No.: 93-16)
U.T.M.: Zone 14 654248 E
5490387 N

Subject to the terms and conditions contained in this Licence, the Minister of Conservation and Water Stewardship authorizes:

**The Rural Municipality of Hanover**

of the **Rural Municipality of Ritchot** in the Province of Manitoba (the "LICENSEE") to construct, operate, establish and maintain a project consisting of water well(s), pump(s), transmittal pipeline(s) and other works specific to the type of use (the "WORKS") and divert water from a **fractured limestone** aquifer located on the following land:

**The Government Road Allowance Lying South of the Southeast Quarter of Section 8 in Township 7 and Range 5, East of the Principal Meridian, in Manitoba.**

as more particularly located and shown on the attached Exhibit "A" for **municipal** purposes on the following lands:

**The Government Road Allowance Lying South of the Southeast Quarter of Section 8 in Township 7 and Range 5, East of the Principal Meridian, in Manitoba.**

This licence is issued upon the express condition that it shall be subject to the provisions of The Water Rights Act and Regulation and all amendments thereto and, without limiting the generality of the aforesaid, to the following terms and conditions, namely:

1. The water shall be used solely for **municipal** purposes.

2. The WORKS shall be operated in accordance with the terms herein contained.

3. The LICENSEE does hereby remise, release and forever discharge Her Majesty the Queen in Right of the Province of Manitoba, of and from all manner of action, causes of action, claims and demands whatsoever which against Her Majesty the LICENSEE ever had, now has or may hereafter have, resulting from the use of water for **municipal** purposes.

4. In the event that the rights of others are infringed upon and/or damage to the property of others is sustained as a result of the operation or maintenance of the WORKS and the rights herein granted, the LICENSEE shall be solely responsible and shall save harmless and fully indemnify Her Majesty the Queen in Right of the Province of Manitoba, from and against any liability to which Her Majesty may become liable by virtue of the issue of this Licence and anything done pursuant hereto.

5. This Licence is not assignable or transferable by the LICENSEE and when no longer required by the LICENSEE this Licence shall be returned to Manitoba Conservation and Water Stewardship for cancellation on behalf of the Minister.

6. Upon the execution of this Licence the LICENSEE hereby grants the Minister or the Minister's agents the right of ingress and egress to and from the lands on which the WORKS are located for the purpose of inspection of the WORKS and the LICENSEE shall at all times comply with such directions and/or orders that may be given by the Minister or the Minister's agents in writing from time to time with regard to the operation and maintenance of the WORKS.

7. This Licence may be amended, suspended or cancelled by the Minister in accordance with The Water Rights Act by letter addressed to the LICENSEE at **352 Main Street, St. Adolphe, MB, R5A 1B9, Canada** and thereafter this Licence shall be determined to be at an end.

8. Notwithstanding anything preceding in this Licence, the LICENSEE must have legal control, by ownership or by rental, lease, or other agreement, of the lands on which the WORKS shall be placed and the water shall be used.

9. The term of this Licence shall be **ten (10) years** and this Licence shall become effective only on the date of execution hereof by a person so authorized in Manitoba Conservation and Water Stewardship. The LICENSEE may apply for renewal of this Licence not more than 365 days and not less than 90 days prior to the expiry date.

10. This Licence expires automatically upon the loss of the legal control of any of the lands on which the WORKS are located or on which water is used, unless the Licence is transferred or amended by the Minister upon application for Licence transfer or amendment.

11. The LICENSEE shall keep records of daily and annual water use and shall provide a copy of such records to Manitoba Conservation and Water Stewardship not later than February 1st of the following year.

12. A flow meter must be installed, positioned to accurately measure instantaneous pumping rate and accumulative withdrawals from the water source.

13. The LICENSEE does hereby agree to correct, to the satisfaction of the Minister, any water supply problems to wells or other forms of supply, which were constructed and operating prior to the date of the original application for the project and which are partly or wholly attributable, in the opinion of the Minister, to the diversion of water as authorized by this Licence.

14. The LICENSEE shall hold and maintain all other regulatory approvals that may be required and shall comply with all other regulatory requirements for the construction, operation, or maintenance of the WORKS or to divert or use water as provided by this Licence.

15. Under this licence, the LICENSEE is prohibited from installing pumps in the said three (3) wells in order to increase water supply.

16. The LICENSEE must accept all the water flowing from the wells except as may be prescribed by separate agreements between the Province and the Rural Municipality of Ritchot.

17. The ownership of the wells will be retained by the Province who will be responsible for operation of any valves which regulate the free flow from the wells to the pipeline.

18. The Licence does not assure the RM of Ritchot of any specific minimum flow to the pipeline as it is understood this flow may decrease naturally with time.

In witness whereof I the undersigned hereby agree to accept the aforesaid Licence on the terms and conditions set forth therein and hereby set my hand and seal this 11th day of April A.D. 2014.

SIGNED, SEALED AND DELIVERED
in the presence of

[redacted] } [redacted] (Seal)
Witness Licensee

Canada, PROVINCE OF MANITOBA To Wit:

I, Jocelyne Potvin of the town
of Ste-Agathe in the Province of Manitoba, MAKE OATH AND SAY:

1. That I was personally present and did see Florence May, the within named party, execute the within Instrument.
2. That I know the said Florence May and am satisfied that he/she is of the full age of eighteen years.
3. That the said Instrument was executed at ~~Florence May~~ J.P. 352 Main Street, St. Adolphe, Manitoba aforesaid and that I am subscribing witness thereto.

SWORN BEFORE me at the Rural Municipality of Ritchot ~~352 Main Street, St. Adolphe, Manitoba~~ J.P.
in the Province of Manitoba this 11th day of April A.D. 2014.

[redacted] } [redacted]
A COMMISSIONER FOR OATHS Witness
in and for the Province of Manitoba

My Commission expires May 11, 2015

Issued at the City of Winnipeg, in the Province of Manitoba, this 22nd day of April A.D. 2014.

[redacted]
The Honourable the Minister of Conservation and Water Stewardship

Location of Project Wells
on the Gov't. Rd. Allowance Lying South
of the SE 8-7-5 EPM, in the RM of Hanover,
for RM of Ritchot (Municipal Purposes)

EXHIBIT "A"

THIS PLAN IS AN INTEGRAL PART OF
LICENCE NO. ___2014-014___
ISSUED UNDER THE WATER RIGHTS ACT

0 75 150 300 Meters

# Licence to Use Water for Municipal Purposes

Manitoba
Sustainable Development
200 Saulteaux Cresc.
Winnipeg, Manitoba
R3J 3W3

Issued in accordance with the provisions
**The Water Rights Act** and regulations made thereunder.

| | |
|---|---|
| Project: | Supplementary Well |
| Licence No.: | **2019-123** |
| (Previous Lic. No.: | 2011-115) |
| U.T.M.: | 640921 E 5491552 N |

Subject to the terms and conditions contained in this Licence, the Minister of Sustainable Development authorizes:

**The Rural Municipality of Ritchot**

in the **Rural Municipality of Ritchot** in the Province of Manitoba (the "LICENSEE") to construct, operate, establish and maintain a project consisting of water well(s), pump(s), transmittal pipeline(s) and other works specific to the type of use (the "WORKS") and divert water from a **Sand and gravel** aquifer located on the following land:

**NE 12-7-3 EPM**

as more particularly located and shown on the attached Exhibit "A" for **Municipal** purposes on the following lands:

**The Rural Municipality of Ritchot and Service Area**

This licence is issued upon the express condition that it shall be subject to the provisions of The Water Rights Act and Regulation and all amendments thereto and, without limiting the generality of the aforesaid, to the following terms and conditions, namely:

1. The water shall be used solely for **Municipal** purposes.

2. The WORKS shall be operated in accordance with the terms herein contained.

3. a) The maximum rate at which water may be diverted pursuant hereto shall not exceed **0.0350 cubic metres per second (1.23 cubic feet per second)**.

   b) The total quantity of water diverted in any one year shall not exceed **789.00 cubic decametres (639.65 acre feet)**.

4. Water shall not be diverted during any period when the water level in the aquifer is below the casing of any project well.

5. The LICENSEE does hereby remise, release and forever discharge Her Majesty the Queen in Right of the Province of Manitoba, of and from all manner of action, causes of action, claims and demands whatsoever which against Her Majesty the LICENSEE ever had, now has or may hereafter have, resulting from the use of water for **Municipal** purposes.

6. In the event that the rights of others are infringed upon and/or damage to the property of others is sustained as a result of the operation or maintenance of the WORKS and the rights herein granted, the LICENSEE shall be solely responsible and shall save harmless and fully indemnify Her Majesty the Queen in Right of the Province of Manitoba, from and against any liability to which Her Majesty may become liable by virtue of the issue of this Licence and anything done pursuant hereto.

7. This Licence is not assignable or transferable by the LICENSEE and when no longer required by the LICENSEE this Licence shall be returned to the Water Use Licensing Section for cancellation on behalf of the Minister.

8. Upon the execution of this Licence the LICENSEE hereby grants the Minister or the Minister's agents the right of ingress and egress to and from the lands on which the WORKS are located for the purpose of inspection of the WORKS and the LICENSEE shall at all times comply with such directions and/or orders that may be given by the Minister or the Minister's agents in writing from time to time with regard to the operation and maintenance of the WORKS.

9. This Licence may be amended, suspended or cancelled by the Minister in accordance with The Water Rights Act by letter addressed to the LICENSEE at **352 Main Street, St. Adolphe, MB, R5A 1B9, Canada** and thereafter this Licence shall be determined to be at an end.

10. Notwithstanding anything preceding in this Licence, the LICENSEE must have legal control, by ownership or by rental,

lease, or other agreement, of the lands on which the WORKS shall be placed and the water shall be used.

11. The term of this Licence shall be until April 20, 2032 and this Licence shall become effective only on the date of execution hereof by a person so authorized in the Department of Sustainable Development. The LICENSEE may apply for renewal of this Licence not more than 365 days and not less than 90 days prior to the expiry date.

12. This Licence expires automatically upon the loss of the legal control of any of the lands on which the WORKS are located or on which water is used, unless the Licence is transferred or amended by the Minister upon application for Licence transfer or amendment.

13. The LICENSEE shall keep records of daily and annual water use and shall provide a copy of such records to the Water Use Licensing Section not later than February 1st of the following year.

14. A flow meter must be installed, positioned to accurately measure instantaneous pumping rate and accumulative withdrawals from the water source.

15. The LICENSEE does hereby agree to correct, to the satisfaction of the Minister, any water supply problems to wells or other forms of supply, which were constructed and operating prior to the date of the original application for the project and which are partly or wholly attributable, in the opinion of the Minister, to the diversion of water as authorized by this Licence.

16. The LICENSEE shall hold and maintain all other regulatory approvals that may be required and shall comply with all other regulatory requirements for the construction, operation, or maintenance of the WORKS or to divert or use water as provided by this Licence.

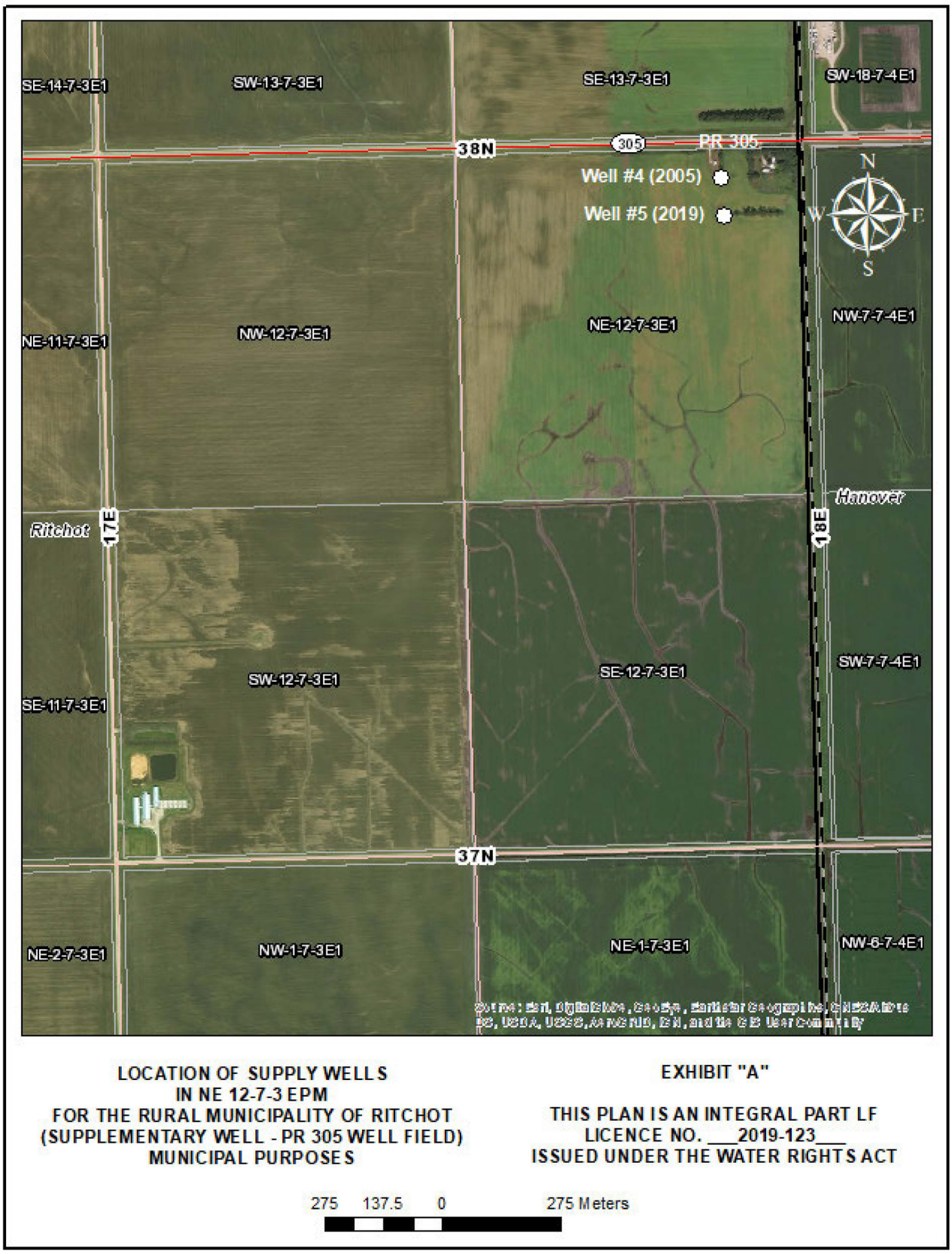
**FOR OFFICE USE ONLY**

Issued at the City of Winnipeg, in the Province of Manitoba, this 30th day of December A.D. 20 19.

Perry Stonehouse [redacted]

Print Name Signature

Signed by the Honourable Minister of Sustainable Development (or her/his designate)




LOCATION OF SUPPLY WELLS
IN NE 12-7-3 EPM
FOR THE RURAL MUNICIPALITY OF RITCHOT
(SUPPLEMENTARY WELL - PR 305 WELL FIELD)
MUNICIPAL PURPOSES

EXHIBIT "A"

THIS PLAN IS AN INTEGRAL PART LF
LICENCE NO. ___2019-123___
ISSUED UNDER THE WATER RIGHTS ACT

275 137.5 0 275 Meters

Manitoba
**Conservation and Climate**
Environmental Stewardship Division
Environmental Approvals Branch
1007 Century Street, Winnipeg, Manitoba R3H 0W4
T 204 945-8321 F 204 945-5229
www.gov.mb.ca/sd

**CLIENT FILE NO.: 4463.00**

November 21, 2019

Mr. Mitch Duval
Chief Administrative Officer
Rural Municipality of Ritchot
352 Rue Main
St. Adolphe MB R5A 1B9
cao@ritchot.com

Dear Mr. Duval:

**Re: Rural Municipality of Ritchot – Supplemental Municipal Groundwater Supply**

This is in response to a Notice of Alteration filed on your behalf by the Manitoba Water Services Board on August 30, 2019 concerning the addition of another well in the municipality's Provincial Road 305 well field.

As the environmental effects of the proposed alteration in the water supply system are insignificant, the alteration can be approved pursuant to Clause 14(2) of The Environment Act. Approval to implement the alteration is provided in the enclosed Environment Act Licence No. 2415 R. This licence also incorporates relevant provisions of previously issued Environment Act licences for components of the water supply system, and rescinds these licences.

For further information on the administration and application of the Licence, please feel free to contact Nada Suresh, Environment Officer, at 204-945-8214 or Nada.Suresh@gov.mb.ca.

Sincerely,

[redacted]

Siobhan Burland Ross, M. Eng., P. Eng.
Director
The Environment Act

c. Shannon Kohler/Yvonne Hawryliuk/Nada Suresh, Environmental Compliance and Enforcement
Andrew March, Manitoba Water Services Board / Paulynn Estrella-Legal, Friesen Drillers Ltd.
Public Registries

**NOTE: Confirmation of receipt of this Licence No. 2415 R (by the Licencee only) is required by the Director of Environmental Approvals. Please acknowledge receipt by signing in the space below and email a copy of this letter to Bruce.Webb@gov.mb.ca by December 5, 2019.**

**On behalf of Rural Municipality of Ritchot** **Date**

THE ENVIRONMENT ACT
LOI SUR L'ENVIRONNEMENT

Manitoba

# LICENCE

**Licence No. / Licence n°:** **2415 R**
**Issue Date / Date de délivrance:** **September 14, 1999**
**Revised:** **November 21, 2019**

**In accordance with The Environment Act (C.C.S.M. c. E125)**
**Conformément à la Loi sur l'environnement (C.P.L.M. c. E125)**

**Pursuant to Sections 11(1) and 14(2) / Conformément au Paragraphes 11(1) et 14(2)**

**THIS LICENCE IS ISSUED TO: / CETTE LICENCE EST DONNÉÉ À:**

**RURAL MUNICIPALITY OF RITCHOT; "the Licencee"**

for the construction and operation of the Development being a water supply system for municipal purposes in the Rural Municipality of Ritchot in accordance with proposals filed on March 27, 1992, January 24, 1997, and August 5, 1999, and a Notice of Alteration dated August 1, 2019, and subject to the following specifications, limits, terms and conditions:

## DEFINITIONS

In this Licence,

**"approved"** means approved by the Director or an assigned Environment Officer in writing;

**"Director"** means an employee so designated pursuant to The Environment Act;

**"Environment Officer"** means an employee so designated pursuant to The Environment Act; and

## GENERAL TERMS AND CONDITIONS

This Section of the Licence contains requirements intended to provide guidance to the Licencee in implementing practices to ensure that the environment is maintained in such a manner as to sustain a high quality of life, including social and economic development, recreation and leisure for present and future Manitobans.

1. The Development includes the following components:
   a) three supply wells in SE 8-7-5E (Randolph Road Well Field) in the carbonate aquifer;
   b) two supply wells in NE 12-7-3E (Provincial Road 305 Well Field) in a sand and gravel aquifer;
   c) a raw water pipeline connecting all wells with a water treatment plant and reservoir east of Ste. Agathe adjacent to Provincial Road 305;
   d) pipelines from the water treatment plant to communities within the Rural Municipality of Ritchot; and
   e) distribution systems serving the communities of Grand Pointe, Ile des Chenes, St. Adolphe, Ste. Agathe, and adjacent rural residential areas.

2. The Licencee shall at all times maintain a copy of this licence at the Development or at the premises from which the Development's operations are managed.

3. In addition to any of the limits, terms and conditions specified in this Licence, the Licencee shall, upon the request of the Director:
   a) sample, monitor, analyze or investigate specific areas of concern regarding any segment, component or aspect of pollutant storage, containment, treatment, handling, disposal or emission systems, for such pollutants, ambient quality, aquatic toxicity, leachate characteristics and discharge or emission rates, and for such duration and at such frequencies as may be specified;
   b) determine the environmental impact associated with the release of any pollutant from the Development;
   c) conduct specific investigations in response to the data gathered during environmental monitoring programs; or
   d) provide the Director, within such time as may be specified, with such reports, drawings, specifications, analytical data, descriptions of sampling and analytical procedures being used, bioassay data, flow rate measurements and such other information as may from time to time be requested.

4. The Licencee shall submit all information required to be provided to the Director or Environment Officer under this Licence, in written and electronic format, in such form (including number of copies) and of such content as may be required by the Director or Environment Officer, and each submission shall be clearly labeled with the Licence Number and Client File Number associated with this Licence.

5. The Licencee shall construct and operate the water supply system in accordance with Manitoba Regulations under The Public Health Act, The Drinking Water Safety Act, and all operating requirements as recommended by Manitoba Conservation and Climate.

6. The Licencee shall collect and dispose of all used oil products and other regulated hazardous wastes generated by the machinery used in the construction and operation of the Development in accordance with applicable Manitoba Conservation and Climate and legislation requirements.

7. The Licencee shall not permit the interconnection of a private water supply system with the Development.

8. The Licencee shall maintain the water supply wells associated with the Development to prevent the contamination of groundwater by surface water:
   a) entering the well casings through the top of the casings; and
   b) entering the well casings through the sides of the casings.

## SPECIFICATIONS, LIMITS, TERMS AND CONDITIONS

### Construction - General

9. The Licencee shall notify the assigned Environment Officer not less than two weeks prior to beginning construction of the Development. The notification shall include the intended starting date of construction and the name of the contractor responsible for the construction.

10. The Licencee shall, prior to the construction of the Development, obtain a Permit to Construct or Alter a Public Water System from the Office of Drinking Water of Manitoba Conservation and Climate.

11. The Licencee shall dispose of non-reusable construction debris from the Development at a waste disposal ground operating under the authority of a permit issued pursuant to Manitoba Regulation 37/2016 respecting Waste Management Facilities, or any future amendment thereof, or a Licence issued pursuant to The Environment Act.

12. The Licencee shall comply with the requirements of The Heritage Resources Act, and suspend construction and immediately notify the Historic Resources Branch if heritage resources are encountered during the construction of the Development.

13. The Licencee shall locate fuel storage and equipment servicing areas established for the construction and operation of the Development a minimum distance of 100 metres from any waterbody and 30 metres from any well, and shall comply with the requirements of Manitoba Regulation 188/2001 respecting Storage and Handling of Petroleum Products and Allied Products, or any future amendment thereof.

14. The Licencee shall, during construction and maintenance of the Development, operate, maintain and store all materials and equipment in a manner that prevents any deleterious substances (fuel, oil, grease, hydraulic fluids, coolant, paint, uncured concrete and concrete wash water, etc.) from entering watercourses or any well, and have an emergency spill kit for in-water use available on site during construction.

15. The Licencee shall, in the case of physical or mechanical equipment breakdown or process upset where such breakdown or process upset results or may result in the release of a pollutant in an amount or concentration, or at a level or rate of release, that causes or may cause a significant adverse effect, immediately report the event by calling the 24-hour environmental accident reporting line at 204-944-4888 (toll-free 1-855-944-4888). The report shall indicate the nature of the event, the time and estimated duration of the event and the reason for the event.

16. The Licencee shall, following the reporting of an event pursuant to Clause 15,
    a) identify the repairs required to the mechanical equipment;
    b) undertake all repairs to minimize unauthorized discharges of a pollutant;
    c) complete the repairs in accordance with any written instructions of the Director and/or the Environment Officer; and
    d) submit a report to the Director about the causes of breakdown and measures taken, within one week of the repairs being done.

17. The Licencee shall, during construction and maintenance of the Development, prevent the introduction and spread of foreign aquatic and terrestrial biota by cleaning equipment prior to its delivery to the site of the Development and complying with the requirements of Manitoba Regulation 173/2015 respecting Aquatic Invasive Species, or any future amendment thereof.

18. The Licencee shall revegetate soil exposed during the construction of the Development with native or introduced grasses or legumes. Native species shall be used to revegetate areas where native species existed prior to construction.

**Construction – Pipelines**

19. The Licencee shall, prior to constructing components of the Development on or adjacent to highway rights-of-way, obtain all necessary approvals from Manitoba Infrastructure.

20. The Licencee shall not release chlorinated water from pipeline testing and startup activities associated with the Development to a surface water body until total residual chlorine concentrations are equal to or less than 0.02 milligrams per litre. Releases of chlorinated water at higher concentrations may be made to vegetated land or dry waterways, provided that total residual chlorine concentrations have decayed to 0.02 milligrams per litre or less before the released water reaches any body of surface water.

21. The Licencee shall construct waterway crossings on flowing waterways by augering, tunneling or boring. Open cut crossings on flowing waterways shall not be made unless prior consultation with Manitoba Conservation and Climate and Department of Fisheries and Oceans staff has occurred and the prior written approval of the Director has been obtained. Dry or non-flowing (i.e. hydraulically unconnected to downstream flowing water) natural and artificial waterways may

be crossed with open cut techniques where approval has been obtained where necessary from the authority responsible for the channel.

22. The Licencee shall complete augered, tunneled or bored waterway crossings in accordance with the September, 2004 publication "Planning Horizontal Directional Drilling for Pipeline Construction", published by the Canadian Association of Petroleum Producers, and notify the Environment Officer if a frac out occurs.

23. The Licencee shall, where conditions allow, excavate endpoints for directional drilling operations a minimum of 30 m from the high water mark of third and higher order waterways, and a minimum of 15 m from the high water mark of first and second order waterways.

24. The Licencee shall construct open cut stream crossings associated with the Development in accordance with the methodologies described in the October, 2005 publication "Pipeline Associated Watercourse Crossings Third Edition", published by the Canadian Pipeline Water Crossing Committee, and the May, 1996 publication "Manitoba Stream Crossing Guidelines for the Protection of Fish and Fish Habitat", published by the Department of Fisheries and Oceans and Manitoba Natural Resources.

25. The Licencee shall, where open cut stream crossing techniques are used on intermittent waterways and artificial drainage channels, not construct open cut crossings associated with the Development between March 15 and June 15 of any year.

26. The Licencee shall, where open cut stream crossing techniques are used on intermittent waterways and artificial drainage channels, minimize disturbance to riparian areas and restore the bottom and banks of the waterways to their original elevations and shapes.

27. The Licencee shall not alter local drainage patterns by the construction of the Development.

**Decommissioning of Existing Wells**

28. The Licencee shall decommission municipal and private wells made redundant by the Development in accordance with the requirements of Manitoba Regulation 215/2015 respecting Well Standards, or any future amendment thereof.

**Operation**

29. The Licencee shall obtain and maintain classification of the Development pursuant to Manitoba Regulation 77/2003 respecting Water and Wastewater

Facility Operators, or any future amendment thereof and maintain compliance with all requirements of the regulation including, but not limited to, the preparation and maintenance of a Table of Organization, Emergency Response Plan and Standard Operating Procedures.

30. The Licencee shall carry out the operation of the Development with individuals properly certified to do so pursuant to Manitoba Regulation 77/2003 respecting Water and Wastewater Facility Operators, or any future amendment thereof.

31. The Licencee shall operate the Development with respect to the volume and rate of water diverted in accordance with Water Rights licences issued pursuant to The Water Rights Act.

32. The Licencee shall develop, maintain and implement a wellhead protection plan for the wells of the Development that addresses disruption and contamination due to natural disasters, spills of contaminants and vandalism.

33. The Licencee shall develop and implement a groundwater level monitoring program for the Development. The program shall address monitoring well locations, monitoring frequency and equipment to be used in monitoring.

## REVIEW AND REVOCATION

A. Environment Act Licence Nos. 1572, 2251 and 2415 are hereby rescinded.

B. If, in the opinion of the Director, the Licencee has exceeded or is exceeding or has or is failing to meet the specifications, limits, terms, or conditions set out in this Licence, the Director may, temporarily or permanently, revoke this Licence.

C. If, in the opinion of the Director, new evidence warrants a change in the specifications, limits, terms or conditions of this Licence, the Director may require the filing of a new proposal pursuant to Section 11 of The Environment Act.

[redacted]
Siobhan Burland Ross, P. Eng.
Director
The Environment Act

**Client File No.:** **3452.00 (raw water pipeline)**
**4229.00 (Red River pipeline crossing)**
**4463.00 (distribution pipelines)**

Friesen DRILLERS

# Appendix C

# Groundwater Exploration Permit Application and Authorization

Friesen
DRILLERS

April 26, 2022

Ms. Kylene Wiseman, P. Geo.
Drainage and Water Rights Licensing Branch
Manitoba Environment, Climate and Parks
Box 16 - 200 Saulteaux Crescent
Winnipeg, MB R3J 3W3

Dear Kylene,

Subject **Hydrogeological Assessment for Municipal Groundwater Supply – Rural Municipality (RM) of Ritchot**
**Section 1 and Section 12 of Township 7 – Range 4 EPM,**
**Sections 3 to 6, Sections 7 to 10, and Sections 15 to 18 of Township 7 – Range 5 EPM,**
**Sections 31 to 34 of Township 6 – Range 5 EPM - RM of Hanover, Manitoba**
**Manitoba Water Services Board Project - Municipal Groundwater Supply Project for the RM of Ritchot**

Friesen Drillers Ltd. has been retained by the Manitoba Water Services Board (MWSB) and the RM of Ritchot to provide hydrogeological engineering services in association with the design, monitoring well drilling, testing, and reporting to expand the supply capacity of the existing groundwater supply well field located in SE 8-7-5 EPM (Randolph Road well field). The water supply upgrades are proposed to provide a more reliable water supply source for the RM and to support the long term development and growth of the RM.

The RM of Ritchot water supply is currently sourced from SE 8-7-5 EPM (Randolph Road) well field and NE 12-7-3 EPM (PR 305) supplementary well field. Both well field sites are operating under Water Rights Licence # 2014-014 and Water Rights Licence # 2019-123, respectively. The water supply upgrades completed at the PR 305 well field in 2018/2019 has increased the allocation of the well field from 18 L/s to 35 L/s. However, the rapidly growing RM still needs an additional 25 L/s to 30 L/s of steady groundwater supply to support the water demands of the RM in the next 20 years and to provide some system redundancy.

The Randolph Road wells were originally installed to depressurize the carbonate aquifer and prevent basal hydraulic rupture of a major drainage canal in the area. This canal ultimately joins the Manning Canal. The groundwater free flowed from the relief wells into an underground pipeline directed into the Red River for many years.

Sometime afterwards, the RM of Ritchot expressed interest in utilizing the water supply for municipal purposes within the RM. The RM of Ritchot was originally awarded a groundwater use licence in 1993 to utilize the groundwater discharge from the pressure relief wells (Original Licence #93-16). As part of the licence agreement, the RM of Ritchot was prohibited from installing pumps in the relief wells as none of the wells were originally intended to be mechanized. The original relief wells were subsequently replaced by three 8-inch PVC cased wells in 2002 and the licence was last renewed in 2014 (Water Rights Licence # 2014-014). The site location is shown as Figure 1, on the following page.

Over the last 40 years or so, the potentiometric surface in the carbonate aquifer has gradually lowered to the new level due to the discharge from the relief wells. As the wells flowed over the years, the flow rates from the wells have also diminished, in addition to the lowering of the potentiometric surface in the area. The Randolph Road well field wells also ceased flowing for some time during the summer of 2021 due to prolonged below average precipitation in the recent years. This has also been observed in many flowing well areas in the southeast.

Friesen Drillers proposes to test the existing wells in the Randolph Road well field to provide a more consistent groundwater supply for the RM. As part of the project, Friesen Drillers retained the services of Landmark Planning to undertake the public consultation aspects. Preliminary stakeholder and landowner meetings have been held for the project and additional public engagements are planned prior to commencing the field work.

Friesen Drillers also proposes to drill up to 5 additional nested monitoring wells in the sandstone and limestone aquifer in the area. The proposed monitoring wells would be drilled in crown held lands, and within the provincially controlled right of ways under our program with Manitoba Water Services Board.

A well inventory within 2 mile radius of the Randolph well field site is planned. Following preliminary assessment on the existing wells, a long term ( 72 hour ) pumping test with recovery is planned for the site. During the testing, we are proposing to monitor up to 30 observations wells in the area. The monitoring well network will monitor the effect in the carbonate aquifer and in the Winnipeg Formation Sandstone aquifer. Water quality samples will be collected and sent to an accredited laboratory for routine and environmental isotopic analysis.

Figure 1: Randolph Road well field site showing 2 mile rad. (in yellow) (modified from Google Earth, 2022)

A large scale report detailing the results will be provided after the completion of testing, second public open house and public/landowner meetings. Meetings with stakeholders and municipalities will also be held to discuss the results of the investigations.

Should you require anything further or request additional details, please call us at (204)-326-2485.

Sincerely,

Friesen Drillers Ltd.

[redacted]

J. [redacted] Sc. (Mn.E), P.Eng.
H

**Land descriptions**

| | |
|---|---|
| Randolph Road well field: | Southeast ¼ of Section 8 Township 7 Range 5 EPM |
| Sections within 2 miles of the Randolph Road well field: | 1, 2 of Township 7 – Range 4 EPM<br>3, 4, 5, 6, 7, 8, 9, 10, 15, 16, 17, 18 of Township 7 – Range 5 EPM,<br>31, 32, 33, 34 of Township 6 – Range 5 EPM |

**GROUNDWATER EXPLORATION PERMIT**

Manitoba

Issued in accordance with the provisions

**The Water Rights Act** and regulations made thereunder.

Subject to the terms and conditions contained in this Groundwater Exploration Permit, the Minister charged with administration of The Water Rights Act authorizes:

**Rural Municipality of Ritchot**

In the province of Manitoba, to explore for groundwater; as well as construct water well(s), install pump(s) and transmittal pipeline(s) (the "WORKS") for **Municipal** purposes on the following land:

**SE 8-7-5 EPM, Sections 1 & 12 Township 7, Range 4 EPM, Sections 3-6, 7-10, and 15-18, Township 7, Range 5 EPM and Sections 31-34 Township 6, Range 5 EPM**

This Groundwater Exploration Permit does not authorize diversion and use of water for **Municipal** purposes.

The WORKS shall be constructed in accordance with the terms and conditions described as follows:

1. This Permit expires within twenty-four (24) months of the date of issuance. Failure to construct all of the necessary WORKS and use water for **Municipal** purposes prior to the permit expiry date may result in cancellation of the application for a Water Rights Licence.

2. This Permit is not transferable or assignable to any other party.

3. The Permittee must have legal access to all lands occupied by the project.

4. The Permittee must hold and maintain all regulatory approvals and requirements for the construction of the WORKS as provided by this Permit.

5. Prior to undertaking any work or construction of any WORKS authorized by this Permit, the Permittee must retain the services of a hydrogeologist registered with Engineers Geoscientists Manitoba, who is required to:
   a. Plan and supervise the drilling of boreholes, test well(s), production well(s), observation well(s) and well pump testing.
   b. Conduct a constant rate pumping test on the proposed production well(s) in accordance with Form H. (https://www.gov.mb.ca/sd/pubs/water/form_h_july.pdf)
   c. Conduct a recovery test for a period equal to pump test or 90% recovery, whichever comes first.
   d. Conduct an inventory of private, agricultural and commercial wells within a one mile radius of the project well(s) site. The inventory may be expanded based on the assessment of the expected area of water level draw-down impact resulting from future pumping.
   e. Install a lockable and permanent two-inch observation well with the location to be determined by the Hydrogeologist if the supply well(s) will be less than 800 m from any existing wells.
   f. Prepare and submit to the Water Use Licensing Section a technical report on the drilling of boreholes and test wells, pump testing of wells, well inventory and water quality sampling. The report must contain: well driller's report for test well(s) production well(s) and observation well(s); a location plan of the well(s) on the property and/or GPS locations of the well(s); an analysis of aquifer pumping tests; and calculations of transmissivity. The report must also indicate if any local wells are expected to be adversely affected by the proposed use of water and where these wells are located. A digital copy of the report must be submitted.

6. The Permittee must cease pumping immediately if any local water supplies are negatively impacted as a result of the pumping tests. The Permittee is also responsible to correct any water supply problems or provide a temporary water supply to anyone whose water supplies are negatively impacted as a result of the tests.

7. The Permittee shall assume any liability that may result from the construction of the WORKS.

8. The Province of Manitoba shall hereby be released from any liability or claims for damages that may result from the construction of the WORKS.

9. The Minister or Minister's agents have the right of unrestricted access for the purpose of inspection of any WORKS constructed under this Permit.

10. The issuance of this Permit does not imply that the Department will extend or renew the Permit in subsequent years.

11. A water use monitoring device must be installed on the pipeline from the supply well(s), positioned to accurately measure instantaneous pumping rate and accumulative withdrawals.

**FOR OFFICE USE ONLY**

Issued at the City of Winnipeg, in the Province of Manitoba, this 29th day of April A.D. 2022.

Kylene Wiseman

Print Name

Signature [redacted]

Signed by he Minister charged wi h the administration of The Water Rights Act (or her/his designate)

# Appendix D

# Well Inventory

Desktop Well Inventory Table – 2 -Mile Radius
(GWDRILL, 2019)

Site Specific Well Inventory
(Landmark Planning, 2022)

Content removed due to the sensitive and confidential nature of the information contained in this Appendix.

As per requirements for the licence application process, a copy of this Appendix was provided to Manitoba Environment and Climate - Drainage and Water Rights Licensing Branch

Friesen
DRILLERS

# Appendix E

# Borehole Logs

Friesen
DRILLERS

# Existing Well Logs

(GWDRILL, 2019)

Friesen DRILLERS

Location: SE8-7-5E

Well_PID: 120804
Owner: RM OF RITCHOT
Driller: Friesen Drillers Ltd.
Well Name: WELL NO. 1
Well Use: PRODUCTION
Water Use: Municipal
UTMX: 653665
UTMY: 5490378
Accuracy XY: 1 EXACT [<5M] [GPS]
UTMZ:
Accuracy Z: UNKNOWN
Date Completed: 2002 Nov 29

WELL LOG

| From (ft.) | To (ft.) | Log |
|---|---|---|
| 0 | 47.0 | CLAY |
| 47.0 | 87.0 | HARD GREY CLAY |
| 87.0 | 91.0 | BROWN TILL |
| 91.0 | 140.0 | LIMESTONE |

WELL CONSTRUCTION

| From (ft.) | To (ft.) | Casing Type | Inside Dia.(in) | Outside Dia.(in) | Slot Size(in) | Type | Material |
|---|---|---|---|---|---|---|---|
| 0 | 92.0 | CASING | 8.50 | | | INSERT | PVC |
| 92.0 | 140.0 | OPEN HOLE | 6.25 | | | | |
| 0 | 92.0 | CASING GROUT | 8.50 | 12.30 | | | CEMENT |

Top of Casing: 2.600 ft. above ground

Friesen DRILLERS

PUMPING TEST

Date: 2002 Dec 02
Pumping Rate: 278.997 Imp. gallons/minute
Water level before pumping: 2.6 ft. above ground
Pumping level at end of test: 13.8 ft. below ground
Test duration: ??? hours, ?? minutes
Water temperature: ?? degrees F

REMARKS

RITCHOT REGIONAL PUBLIC WATER SYSTEM - PUBLIC WATER SYSTEM WELL (COMMUNITY CODE 178.50). WELL NO. 1. (WEST WELL) WAS DRILLED TO REPLACE RW-6. WELL WATER IS PIPED TO STE. AGATHE WATER TREATMENT PLANT. WELL INVENTORY/GPS COMPLETED BY WRB IN JUNE 2006.

---

Location: SE8-7-5E

Well_PID: 120805
Owner: RM OF RITCHOT
Driller: Friesen Drillers Ltd.
Well Name: WELL NO. 2
Well Use: PRODUCTION
Water Use: Municipal
UTMX: 654071
UTMY: 5490386
Accuracy XY: 1 EXACT [<5M] [GPS]
UTMZ:
Accuracy Z: UNKNOWN
Date Completed: 2002 Nov 27

WELL LOG

Friesen DRILLERS

| From (ft.) | To (ft.) | Log |
|---|---|---|
| 0 | 21.0 | CLAY |
| 21.0 | 38.0 | TILL |
| 38.0 | 69.0 | SAND |
| 69.0 | 93.0 | TILL |
| 93.0 | 140.0 | LIMESTONE |

WELL CONSTRUCTION

| From (ft.) | To (ft.) | Casing Type | Inside Dia.(in) | Outside Dia.(in) | Slot Size(in) | Type | Material |
|---|---|---|---|---|---|---|---|
| 0 | 94.0 | CASING | 8.50 | | | INSERT | PVC |
| 94.0 | 140.0 | OPEN HOLE | 6.30 | | | | |
| 0 | 94.0 | CASING GROUT | 8.50 | 12.30 | | | CEMENT |

Top of Casing: 2.600 ft. above ground

PUMPING TEST

Date: 2002 Dec 02
Pumping Rate: 278.997 Imp. gallons/minute
Water level before pumping: 2.2 ft. below ground
Pumping level at end of test: 15.5 ft. below ground
Test duration: ??? hours, ?? minutes
Water temperature: ?? degrees F

REMARKS

RITCHOT REGIONAL PUBLIC WATER SYSTEM - PUBLIC WATER SYSTEM WELL (COMMUNITY CODE 178.50). WELL NO. 2 (MIDDLE WELL) WAS DRILLED TO REPLACE RW-5. WELL WATER IS PIPED TO STE. AGATHE WATER TREATMENT PLANT. SITE WAS CHECKED WITH 5-INCH TEST WELL, PUMPED 100 IGPM WITH 3

FT DRAWDOWN. CASING SET INTO SOCKET. WELL INVENTORY/GPS COMPLETED BY
WRB IN JUNE 2006.

---

Location: SE8-7-5E

Well_PID: 120803
Owner: RM OF RITCHOT
Driller: Friesen Drillers Ltd.
Well Name: WELL NO. 3
Well Use: PRODUCTION
Water Use: Municipal
UTMX: 654248
UTMY: 5490387
Accuracy XY: 1 EXACT [<5M] [GPS]
UTMZ:
Accuracy Z: UNKNOWN
Date Completed: 2002 Nov 22

WELL LOG

| From (ft.) | To (ft.) | Log |
|---|---|---|
| 0 | 32.0 | CLAY |
| 32.0 | 79.0 | SAND AND GRAVEL |
| 79.0 | 93.0 | HARD GREY CLAY |
| 93.0 | 140.0 | LIMESTONE |

WELL CONSTRUCTION

| From (ft.) | To (ft.) | Casing Type | Inside Dia.(in) | Outside Dia.(in) | Slot Size(in) | Type | Material |
|---|---|---|---|---|---|---|---|
| 0 | 94.0 | CASING | | 8.50 | | INSERT | PVC |

Friesen DRILLERS

| | | | | | |
|---|---|---|---|---|---|
| 94.0 | 140.0 | OPEN HOLE | | 6.25 | |
| 0 | 94.0 | CASING GROUT | 8.50 | 12.30 | CEMENT |

Top of Casing: 2.000 ft. above ground

PUMPING TEST

Date: 2002 Nov 22
Pumping Rate: 35.000 Imp. gallons/minute
Water level before pumping: ?? ft. below ground
Pumping level at end of test: ?? ft. below ground
Test duration: ??? hours, ?? minutes
Water temperature: ?? degrees F

REMARKS

RITCHOT REGIONAL PUBLIC WATER SYSTEM - PUBLIC WATER SYSTEM WELL (COMMUNITY CODE 178.50). WELL NO. 3 (EAST WELL) WAS DRILLED TO REPLACE RW-7. WELL WATER PIPED TO STE. AGATHE WATER TREATMENT PLANT. CASING SET INTO SOCKET. WELL INVENTORY/GPS COMPLETED BY WRB IN JUNE 2006.

# Well Construction Report

Manitoba

Sheet 1 of 1 — **For PDF submission: Report must be printed on legal size paper (8.5 x 14 inches) and be signed in ink.** — Form No. WELLCON-V01-PDF

**Owner Name:** RM of Ritchot (First / Last)
Mailing Address: 352 Main St
Town/City: Saint Adolphe
Postal Code: R5A 1B9 Phone:
Email:

**Well Name:** (if applicable) MW1
Well Identification Tag Number: 7647
Location of Tag: ☒ Attached to casing stick-up
☐ Other (specify)

**Well Location:** (see note 3; attach sketch if necessary)
Civic Address: Willow Ridge Rd
(if different than mailing address)
Quarter: NE Section: 1 Township: 7 Range: 4 ☒E ☐W
Parish: Type & Lot No.:

**GPS:** (see note 4), Accuracy +/- 9 ☒ feet ☐ metres
Latitude (decimal degrees) 49.54267
Longitude (decimal degrees) 96.91229

**Rockwood Sensitive Area:** ☐ Yes - Permit No. ☒ No

**Test Hole** (see note 5) - Sealed ☐ Yes ☐ No **or**
**Well Use:** ☐ test well - Sealed ☐ Yes ☐ No
☐ production/source ☐ recharge/return
☒ monitoring ☐ dewatering ☐ geotechnical
☐ other (specify)

**Method of Construction:**
☐ auger ☐ bored ☐ backhoe/dug
☒ rotary (mud) ☐ rotary (air)
☐ dual rotary ☐ driven ☐ jetted
☐ other (specify)

**Water Use:** (Check all that apply)
☐ domestic ☒ public/semi-public ☐ irrigation
☐ commercial/industrial ☐ livestock/poultry
☐ earth energy (heating/cooling)
☐ other (specify)

**Lithologic Description:** (see notes 6 and 7) - Measure From/To depths from ground surface. Attach another sheet if needed.

| From (ft) | To (ft) | Colour | Material Description (use recommended names on guide) | Observations |
|---|---|---|---|---|
| 0 | 10 | | Sand | Soft, Fine |
| 10 | 17 | Grey | Till | |
| 17 | 91 | Grey | Clay | |
| 91 | 100 | Brown | Till | |
| 100 | 331 | | Limestone | |
| 331 | 337 | Red | Shale | |
| 337 | 370 | | Sandstone | |
| 370 | | | | |
| 0 | | | | |
| 0 | | | | |

**Well Construction:** (see note 8) - Measure From/To depths from ground surface. Attach another sheet if needed.

| From (ft) | To (ft) | Borehole | Casing | Liner | Open Hole | Well Screen | Surface Seal | Annular Fill | Filter Pack | ID (inches) | OD (inches) | Type of Material (ex: casing and screen material, screen type and slot size, use of shale traps, packers, screen blanks or tail pipes, and type and size of surface seal/annular fill/filter pack material) | Method of Placement (ex: poured, tremie) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 101 | X | | | | | | | | | 7 7/8 | | |
| 0 | 101 | | X | | | | | | | 5 | 5½ | Insert Glued PVC | |
| 101 | 370 | | | | X | | | | | | 4¾ | | |
| 337 | 357 | | | | | X | | | | 2 | 2½ | Threaded PVC - 10 Slot | |
| 0 | 337 | | | X | | | | | | 2 | 2½ | Threaded PVC | |
| 0 | 101 | | | | | | X | | | | | Cement | Tremie |
| | | | | | | | | | | | | Shale Traps at 331 Feet and 337 Feet | |
| | | | | | | | | | | | | | |

**Well Completion:** Day 28 Month June Year 20 22
Top of casing 24 inches ☒ags ☐ bgs; Well vented: ☒ Yes ☐ No
Well disinfected: ☒ Yes ☐ No; Well cover installed: ☒ Yes ☐ No
Pitless adapter/unit installed at ____ feet bgs; ☒Not installed

**Source of Drilling Water:** ☒ Groundwater ☐ Surface water
Water contains a minimum of 10 mg/L free chlorine: ☒ Yes ☐ No
Name/Location of water source: Friesen Drillers Ltd.

**Drilling Additives Used:** ☒ Yes (list type & quantity) Bags Wyo-Ben Extra High Yield Bentonite ☐ No

**Well Yield Test** (see note 9),
Date of Test: Day ____ Month ____ Year 20 ____
☒ Same as date of well completion
**Static Water Level Before Test** (L/S) 3 feet ☐ bgs ☒ ags
Method of Test: ☒pumping ☐air lift ☐bailing ☐recovery
☐ other (specify)
Water level at end of test 52.05 feet ☒ bgs ☐ ags
Length of test 1 hours ____ minutes
Estimated rate of discharge 17.5 ☒ GPM ☐ USGPM

**Well Development:** ☒ air lifting ☐ surging ☐ pumping ☐ jetting
☐ bailing ☐ hydrofracturing ☐ other (specify)
**Water Quality Characteristics:** ☒ fresh ☐ salty ☐ clear ☐ cloudy
☐ sediment ☐ odour (specify)

**Flowing Artesian Well** ☒ No ☐ Yes - If yes, estimated rate of artesian flow ____ ☐IGPM ☐ USGPM Annular space cemented: ☐ Yes ☐ No
Flow control device installed: ☐ Yes ☐ No
Does water leak from around the outside of the casing: ☐ Yes ☒ No

**Recommended Pumping Rate:** ____ ☒IGPM ☐ USGPM with pump intake at ____ feet bgs;
Will your company be installing a pump?: ☐ Yes ☒ No

**Remarks** (see note 10)

**Well Drilling Contractor:** Company Name Friesen Drillers Ltd Licence No. 607-22
Well Driller: Print Name Greg Harder / Stanley Flear Signature

**Declaration:** I certify that to the best of my knowledge the information provided herein is accurate and true and complies with The Groundwater and Water Well Act.

# Well Construction Report

Manitoba

Sheet 1 of 1 — **For PDF submission: Report must be printed on legal size paper (8.5 x 14 inches) and be signed in ink.** — Form No. WELLCON-V01-PDF

**Owner Name:** RM of Ritchot (First / Last)
Mailing Address: 352 Main St
Town/City: Saint Adolphe
Postal Code: R5A 1B9 Phone:
Email:

**Well Location:** (see note 3; attach sketch if necessary)
Civic Address: Rd. 25 E
(if different than mailing address)
Quarter: SE Section: 31 Township: 6 Range: 5 ☒ E ☐ W
Parish: Type & Lot No.:

**Well Name:** (if applicable) MW 2
Well Identification Tag Number: 7645
Location of Tag ☒ Attached to casing stick-up
☐ Other (specify)

**GPS:** (see note 4), Accuracy +/- 9 ☒ feet ☐ metres
Latitude (decimal degrees): 49.51961
Longitude (decimal degrees): 96.89491
**Rockwood Sensitive Area:** ☐ Yes - Permit No. ☒ No

**Test Hole** (see note 5) - Sealed ☐ Yes ☐ No **or**
**Well Use:** ☐ test well - Sealed ☐ Yes ☐ No
☐ production/source ☐ recharge/return
☒ monitoring ☐ dewatering ☐ geotechnical
☐ other (specify)

**Method of Construction:**
☐ auger ☐ bored ☐ backhoe/dug
☒ rotary (mud) ☐ rotary (air)
☐ dual rotary ☐ driven ☐ jetted
☐ other (specify)

**Water Use:** (Check all that apply)
☐ domestic ☒ public/semi-public ☐ irrigation
☐ commercial/industrial ☐ livestock/poultry
☐ earth energy (heating/cooling)
☐ other (specify)

**Lithologic Description:** (see notes 6 and 7) - Measure From/To depths from ground surface. Attach another sheet if needed.

| From (ft) | To (ft) | Colour | Material Description (use recommended names on guide) | Observations |
|---|---|---|---|---|
| 0 | 7 | Brown | Till | |
| 7 | 95 | Grey | Clay | |
| 95 | 105 | Brown | Till | |
| 105 | 353 | | Limestone | |
| 353 | 356 | Red | Shale | |
| 356 | 376 | | Sandstone | |
| 376 | | | | |
| 0 | | | | |
| 0 | | | | |
| 0 | | | | |

**Well Construction:** (see note 8) - Measure From/To depths from ground surface. Attach another sheet if needed.

| From (ft) | To (ft) | Borehole | Casing | Liner | Open Hole | Well Screen | Surface Seal | Annular Fill | Filter Pack | ID (inches) | OD (inches) | Type of Material (ex: casing and screen material, screen type and slot size, use of shale traps, packers, screen blanks or tail pipes, and type and size of surface seal/annular fill/filter pack material) | Method of Placement (ex: poured, tremie) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 106 | X | | | | | | | | | 7 7/8 | | |
| 0 | 106 | | X | | | | | | | 5 | 5½ | Insert Glued PVC | |
| 106 | 376 | | | | X | | | | | | 4¾ | | |
| 356 | 376 | | | | | X | | | | 2 | 2½ | Threaded PVC - 10 Slot | |
| 0 | 356 | | | X | | | | | | 2 | 2½ | Threaded PVC | |
| 0 | 106 | | | | | | X | X | | | | Cement | Tremie |
| | | | | | | | | | | | | Shale Traps at 353 Feet and 356 Feet | |
| | | | | | | | | | | | | | |

**Well Completion:** Day 29 Month June Year 20 22
Top of casing ____ inches ☒ ags ☐ bgs; Well vented: ☒ Yes ☐ No
Well disinfected: ☒ Yes ☐ No; Well cover installed: ☒ Yes ☐ No
Pitless adapter/unit installed at ____ feet bgs; ☒ Not installed

**Source of Drilling Water:** ☒ Groundwater ☐ Surface water
Water contains a minimum of 10 mg/L free chlorine: ☒ Yes ☐ No
Name/Location of water source: Friesen Drillers Ltd.

**Drilling Additives Used:** ☒ Yes (list type & quantity) Bags Wyo-Ben Extra High Yield Bentonite ☐ No

**Well Yield Test** (see note 9),
Date of Test: Day ____ Month ____ Year 20 ____
☒ Same as date of well completion
**Static Water Level Before Test** L/s 2 feet ☐ bgs ☒ ags
Method of Test: ☒ pumping ☐ air lift ☐ bailing ☐ recovery
☐ other (specify)
Water level at end of test 68.7 feet ☒ bgs ☐ ags
Length of test 1 hours ____ minutes
Estimated rate of discharge 10 ☒ GPM ☐ USGPM

**Well Development:** ☒ air lifting ☐ surging ☐ pumping ☐ jetting
☐ bailing ☐ hydrofracturing ☐ other (specify)
**Water Quality Characteristics:** ☒ fresh ☐ salty ☐ clear ☐ cloudy
☐ sediment ☐ odour (specify)

**Flowing Artesian Well** ☒ No ☐ Yes - If yes, estimated rate of artesian flow ____ ☐ IGPM ☐ USGPM Annular space cemented: ☐ Yes ☐ No
Flow control device installed: ☐ Yes ☐ No
Does water leak from around the outside of the casing: ☐ Yes ☒ No

**Recommended Pumping Rate:** N/A ☒ IGPM ☐ USGPM with pump intake at ____ feet bgs;
Will your company be installing a pump?: ☐ Yes ☒ No

**Remarks** (see note 10)

**Well Drilling Contractor:** Company Name Friesen Drillers Ltd Licence No. 607-22
Well Driller: Print Name Greg Harder / Stanley Flear Signature

**Declaration:** I certify that to the best of my knowledge the information provided herein is accurate and true and complies with The Groundwater and Water Well Act.

# Well Construction Report

Manitoba

Sheet 1 of 1 — **For PDF submission: Report must be printed on legal size paper (8.5 x 14 inches) and be signed in ink.** — Form No. WELLCON-V01-PDF

**Owner Name:** RM of Ritchot (First / Last)
Mailing Address: 352 Main St
Town/City: Saint Adolphe
Postal Code: R5A 1B9 Phone:
Email:

**Well Location:** (see note 3; attach sketch if necessary)
Civic Address: Randolph Road (if different than mailing address)
Quarter: SE Section: 10 Township: 7 Range: 5 ☒ E ☐ W
Parish: Type & Lot No.:

**Well Name:** (if applicable) MW3
Well Identification Tag Number: 7646
Location of Tag ☒ Attached to casing stick-up
☐ Other (specify)

**GPS:** (see note 4), Accuracy +/- 9 ☒ feet ☐ metres
Latitude (decimal degrees): 49.54603
Longitude (decimal degrees): 96.83133

**Rockwood Sensitive Area:** ☐ Yes - Permit No. ☒ No

**Test Hole** (see note 5) - Sealed ☐ Yes ☐ No **or**
**Well Use:** ☐ test well - Sealed ☐ Yes ☐ No
☐ production/source ☐ recharge/return
☒ monitoring ☐ dewatering ☐ geotechnical
☐ other (specify)

**Method of Construction:**
☐ auger ☐ bored ☐ backhoe/dug
☒ rotary (mud) ☐ rotary (air)
☐ dual rotary ☐ driven ☐ jetted
☐ other (specify)

**Water Use:** (Check all that apply)
☐ domestic ☒ public/semi-public ☐ irrigation
☐ commercial/industrial ☐ livestock/poultry
☐ earth energy (heating/cooling)
☐ other (specify)

**Lithologic Description:** (see notes 6 and 7) - Measure From/To depths from ground surface. Attach another sheet if needed.

| From (ft) | To (ft) | Colour | Material Description (use recommended names on guide) | Observations |
|---|---|---|---|---|
| 0 | 17 | Grey | Clay | |
| 17 | 90 | Grey | Till | |
| 90 | 97 | | Gravel | |
| 97 | 297 | | Limestone | |
| 297 | 301 | Red | Shale | |
| 301 | 330 | | Sandstone | |
| 330 | | | | |
| 0 | | | | |
| 0 | | | | |
| 0 | | | | |

**Well Construction:** (see note 8) - Measure From/To depths from ground surface. Attach another sheet if needed.

| From (ft) | To (ft) | Borehole | Casing | Liner | Open Hole | Well Screen | Surface Seal | Annular Fill | Filter Pack | ID (inches) | OD (inches) | Type of Material (ex: casing and screen material, screen type and slot size, use of shale traps, packers, screen blanks or tail pipes, and type and size of surface seal/annular fill/filter pack material) | Method of Placement (ex: poured, tremie) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 99 | X | | | | | | | | | 7 7/8 | | |
| 0 | 99 | | X | | | | | | | 5 | 5½ | Insert Glued PVC | |
| 99 | 330 | | | | X | | | | | | 4¾ | | |
| 306 | 326 | | | | | X | | | | 2 | 2½ | Threaded PVC - 10 Slot | |
| 0 | 306 | | | X | | | | | | 2 | 2½ | Threaded PVC | |
| 0 | 99 | | | | | | X | | | | | Cement | Tremie |
| | | | | | | | | | | | | Shale Traps at 297 Feet and 301 Feet | |
| | | | | | | | | | | | | | |

**Well Completion:** Day 27 Month June Year 20 22
Top of casing 24 inches ☒ ags ☐ bgs; Well vented: ☒ Yes ☐ No
Well disinfected: ☒ Yes ☐ No; Well cover installed: ☒ Yes ☐ No
Pitless adapter/unit installed at ____ feet bgs; ☒ Not installed

**Source of Drilling Water:** ☒ Groundwater ☐ Surface water
Water contains a minimum of 10 mg/L free chlorine: ☒ Yes ☐ No
Name/Location of water source: Friesen Drillers Ltd.

**Drilling Additives Used:** ☒ Yes (list type & quantity) Bags Wyo-Ben Extra High Yield Bentonite ☐ No

**Well Yield Test** (see note 9),
Date of Test: Day ____ Month ____ Year 20 ____
☒ Same as date of well completion
**Static Water Level Before Test** (L/S)0 feet ☒ bgs ☐ ags
Method of Test: ☒ pumping ☐ air lift ☐ bailing ☐ recovery
☐ other (specify)
Water level at end of test (L/S) 2.73 feet ☒ bgs ☐ ags
Length of test 1 hours ____ minutes
Estimated rate of discharge 80 ☒ GPM ☐ USGPM

**Well Development:** ☒ air lifting ☐ surging ☐ pumping ☐ jetting
☐ bailing ☐ hydrofracturing ☐ other (specify)
**Water Quality Characteristics:** ☒ fresh ☐ salty ☐ clear ☐ cloudy
☐ sediment ☐ odour (specify)

**Flowing Artesian Well** ☒ No ☐ Yes - If yes, estimated rate of artesian flow ____ ☐ IGPM ☐ USGPM Annular space cemented: ☐ Yes ☐ No
Flow control device installed: ☐ Yes ☐ No
Does water leak from around the outside of the casing: ☐ Yes ☒ No

**Recommended Pumping Rate:** 83.33 ☒ IGPM ☐ USGPM with pump intake at ____ feet bgs;
Will your company be installing a pump?: ☐ Yes ☒ No

**Remarks** (see note 10)

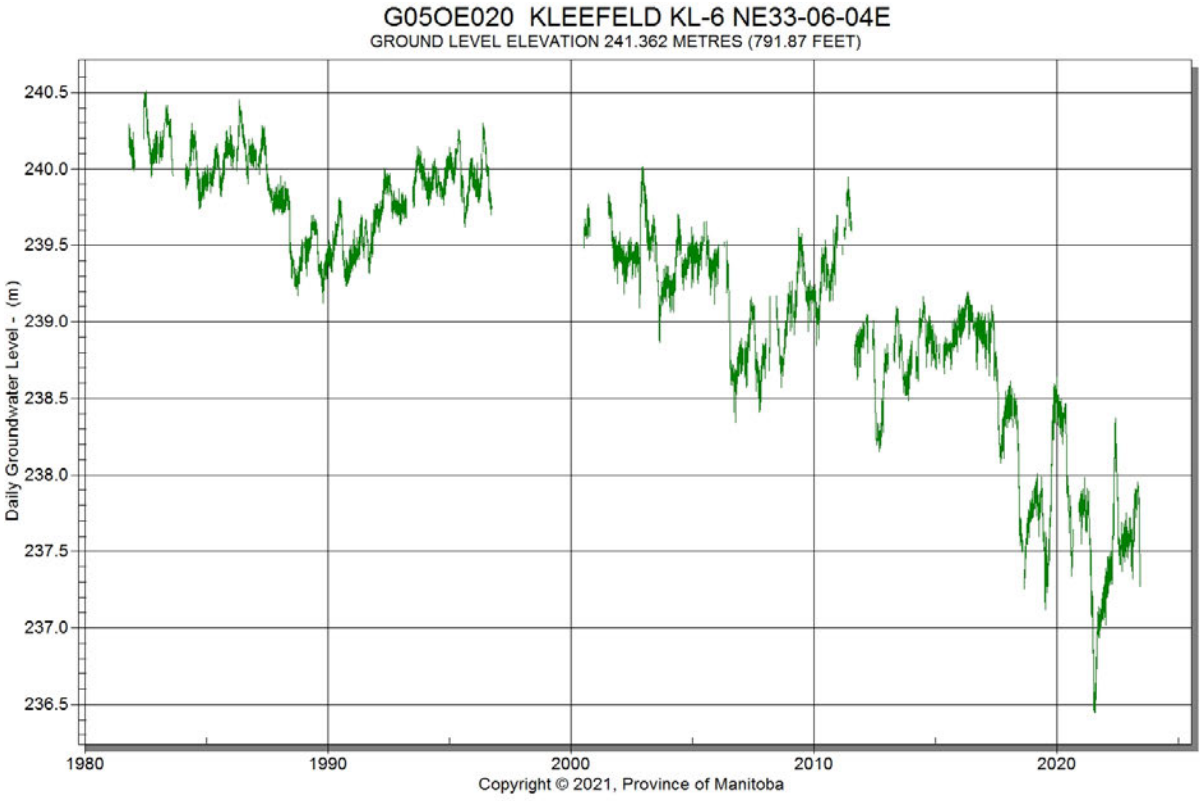
**Well Drilling Contractor:** Company Name: Friesen Drillers Ltd Licence No. 607-22
Well Driller: Print Name: Greg Harder / Stanley Flear Signature:

**Declaration:** I certify that to the best of my knowledge the information provided herein is accurate and true and complies with The Groundwater and Water Well Act.

Friesen
DRILLERS

# Appendix F

# Transducer Plots

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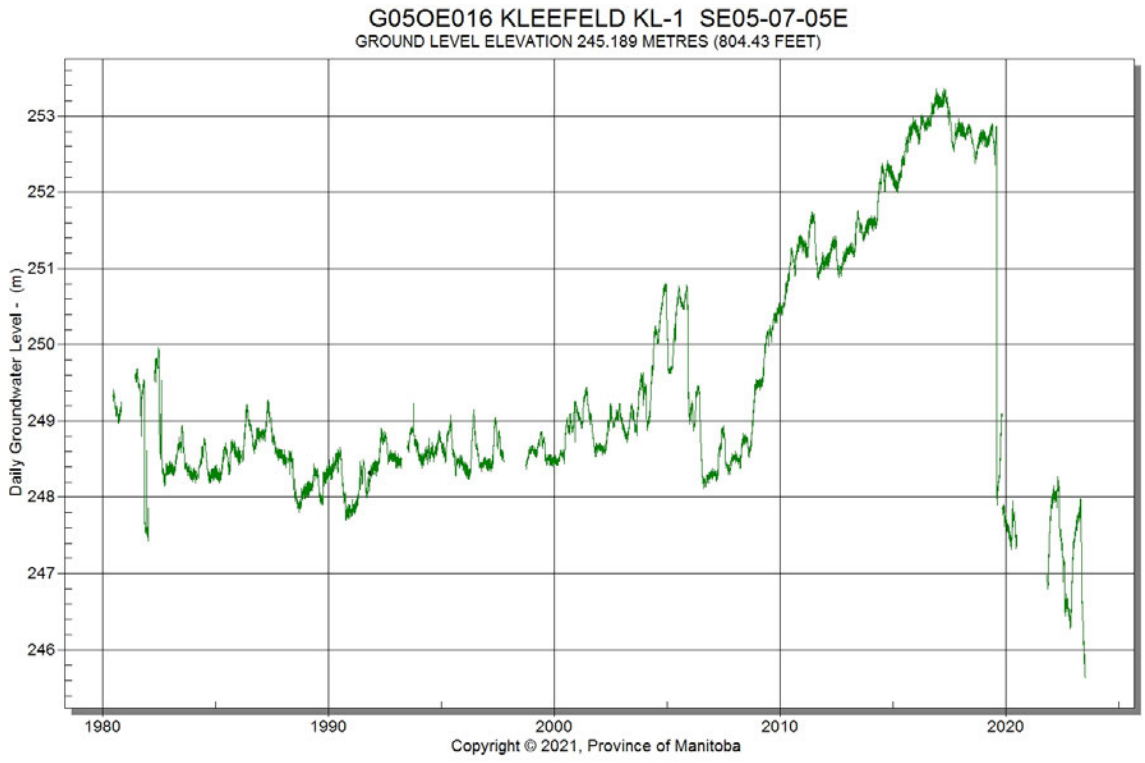


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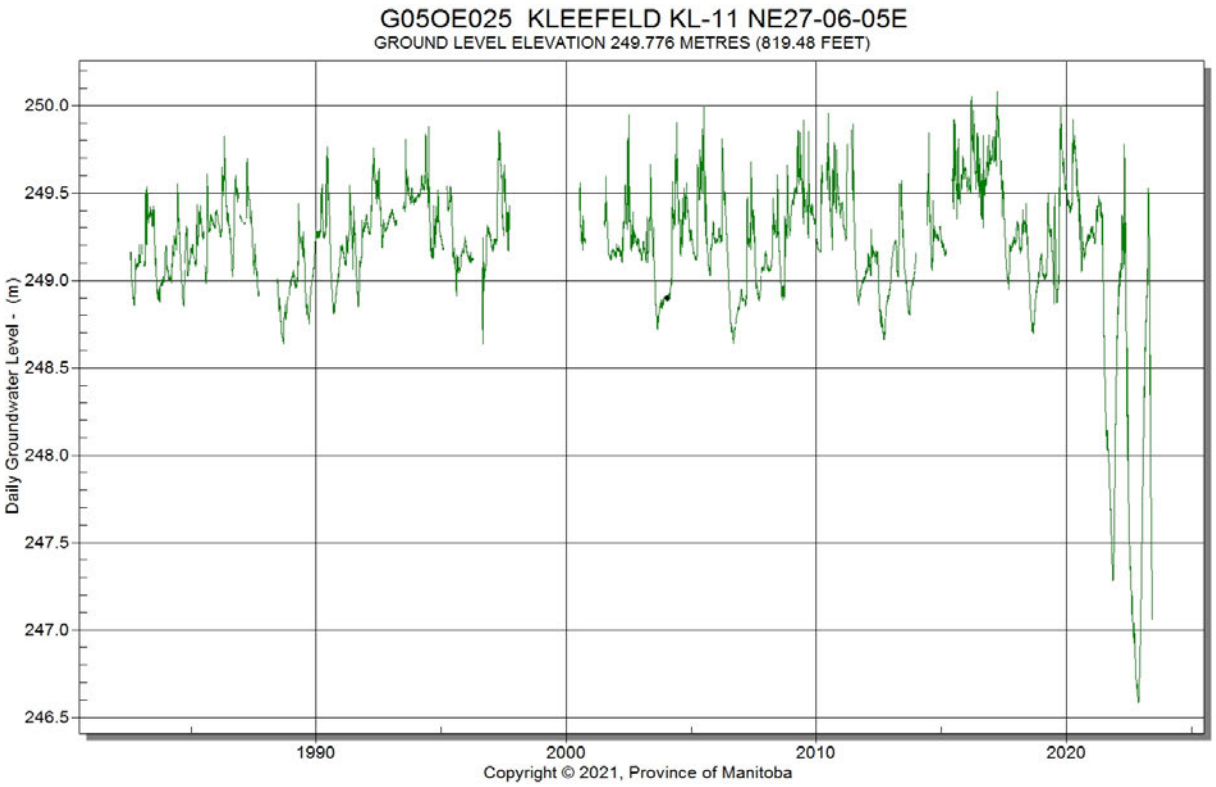


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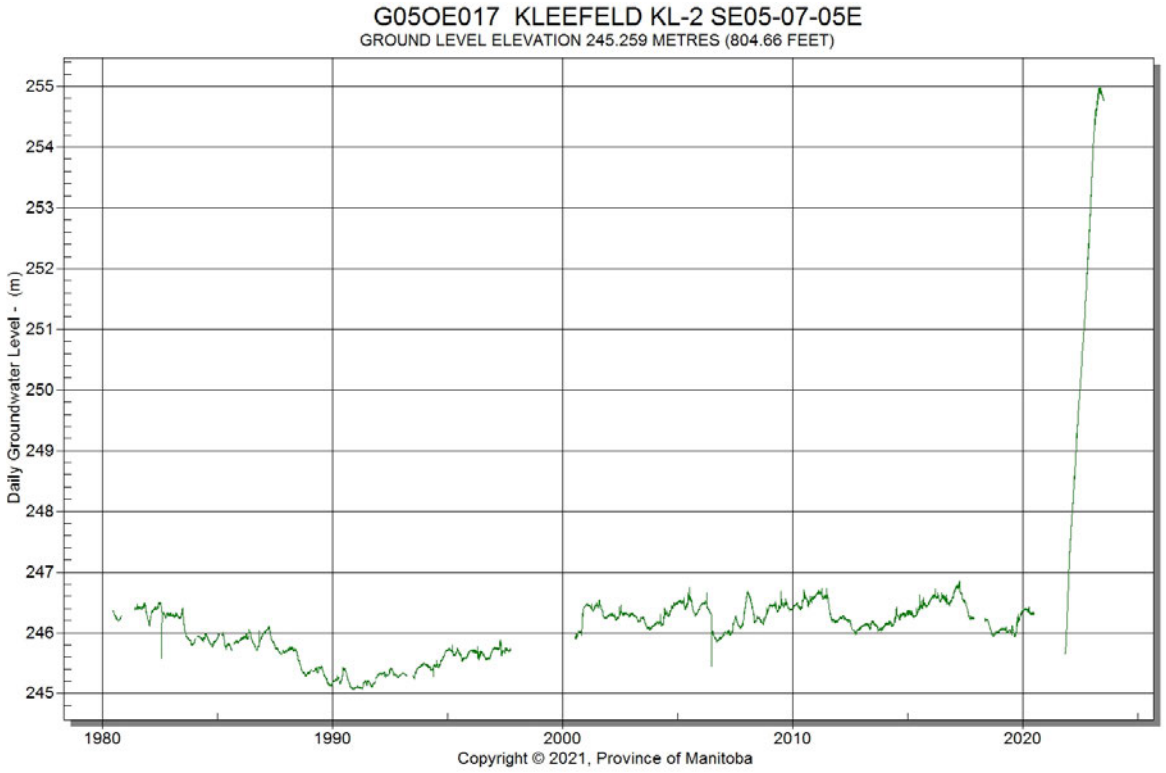


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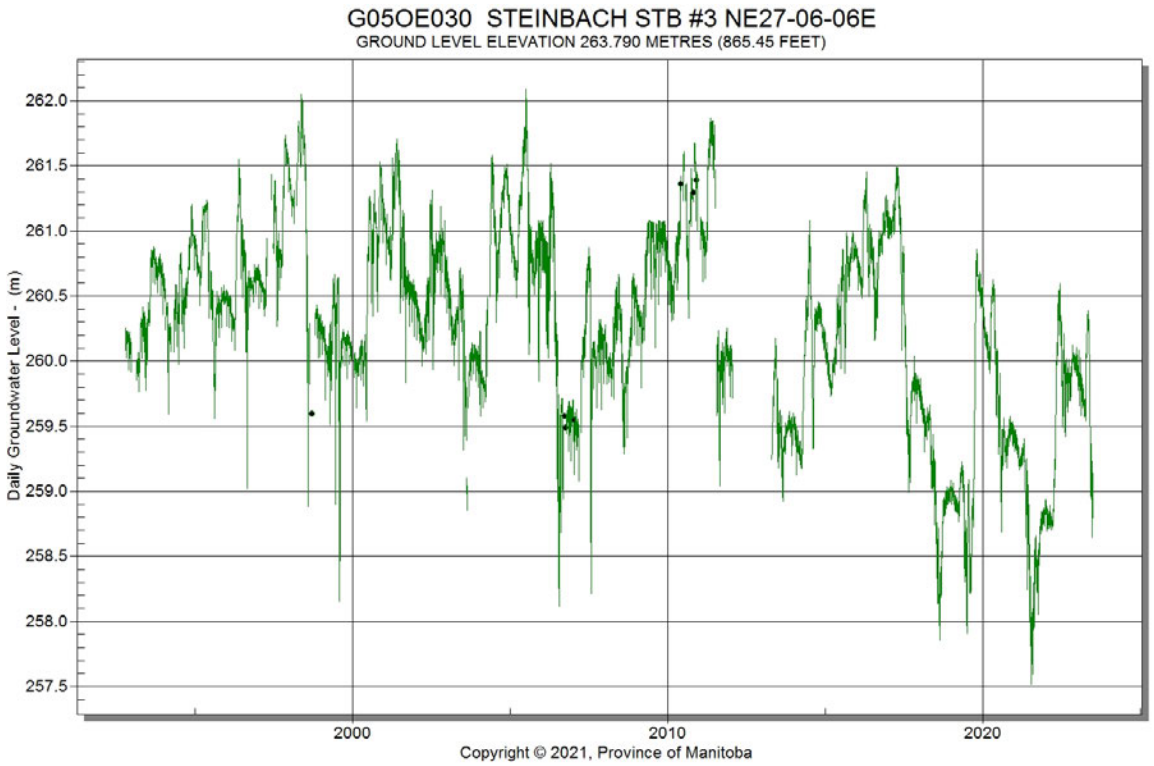


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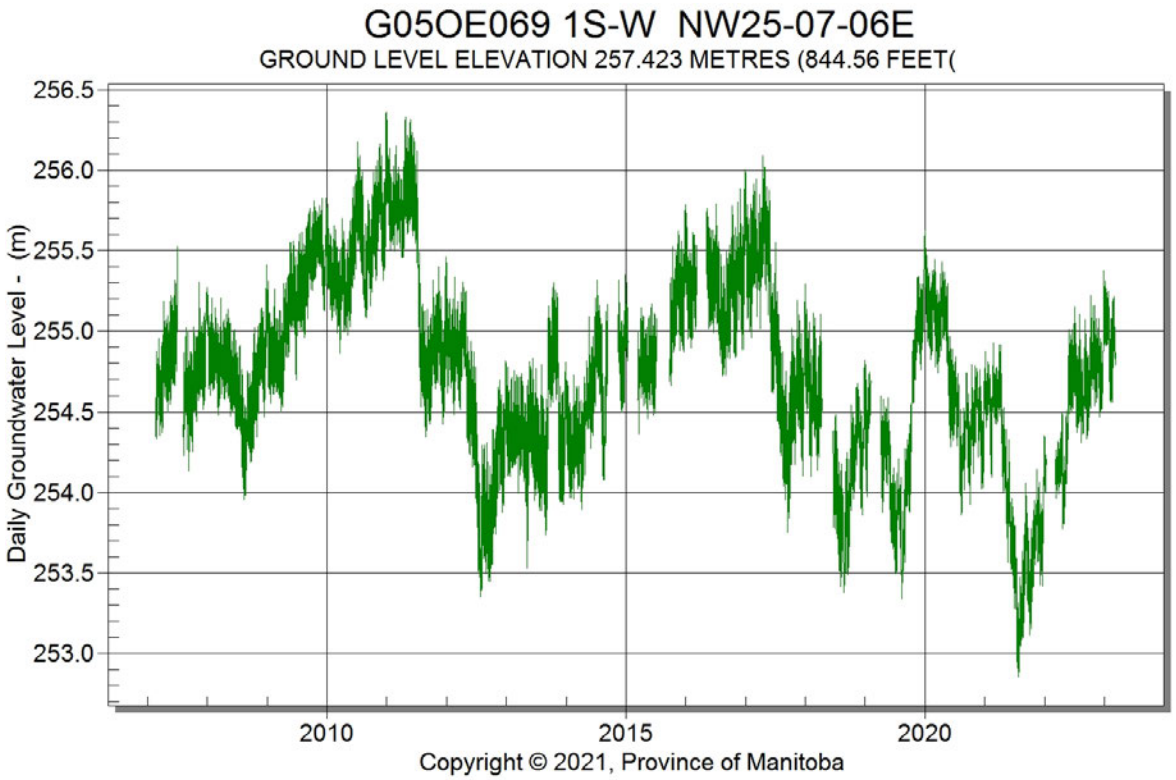


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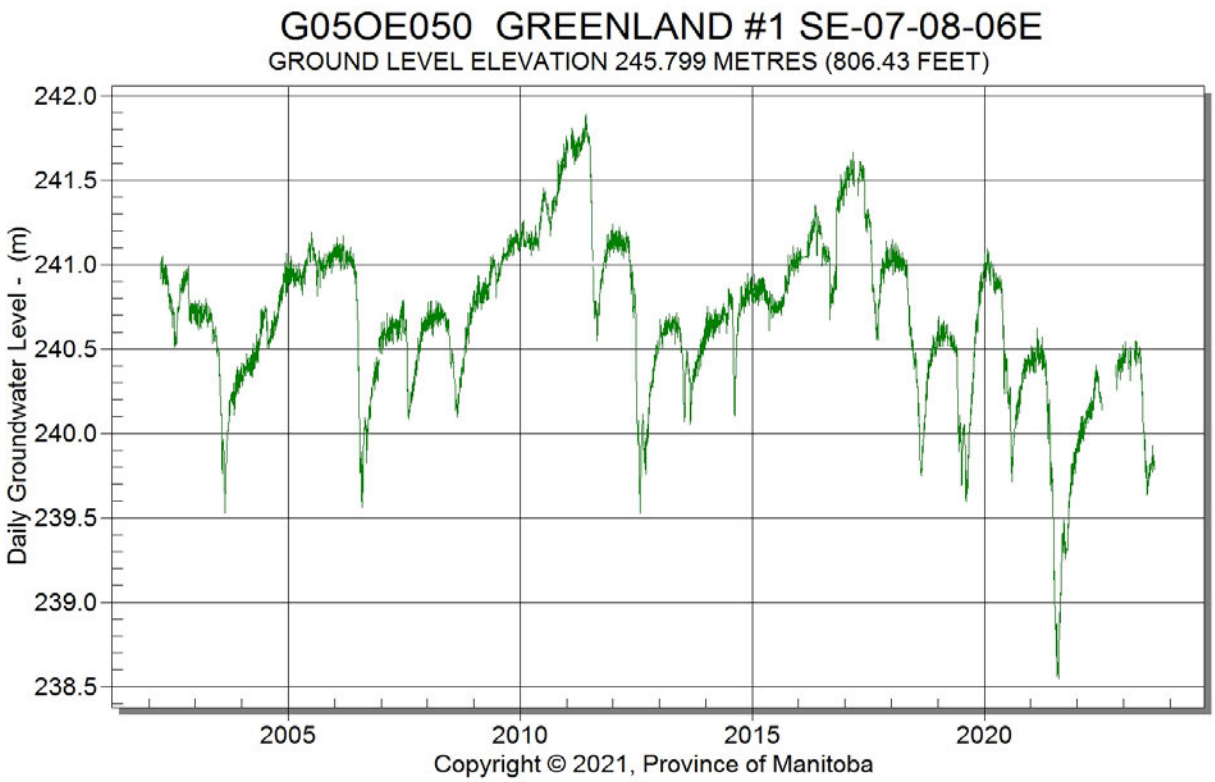


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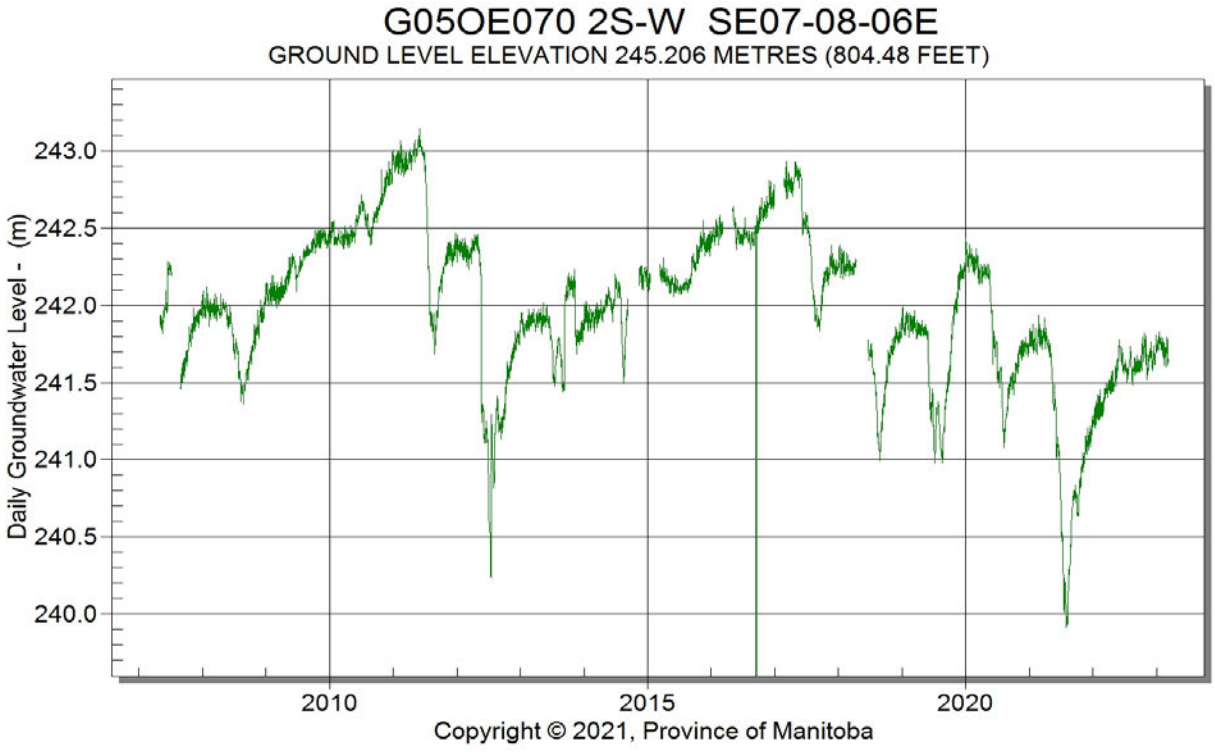


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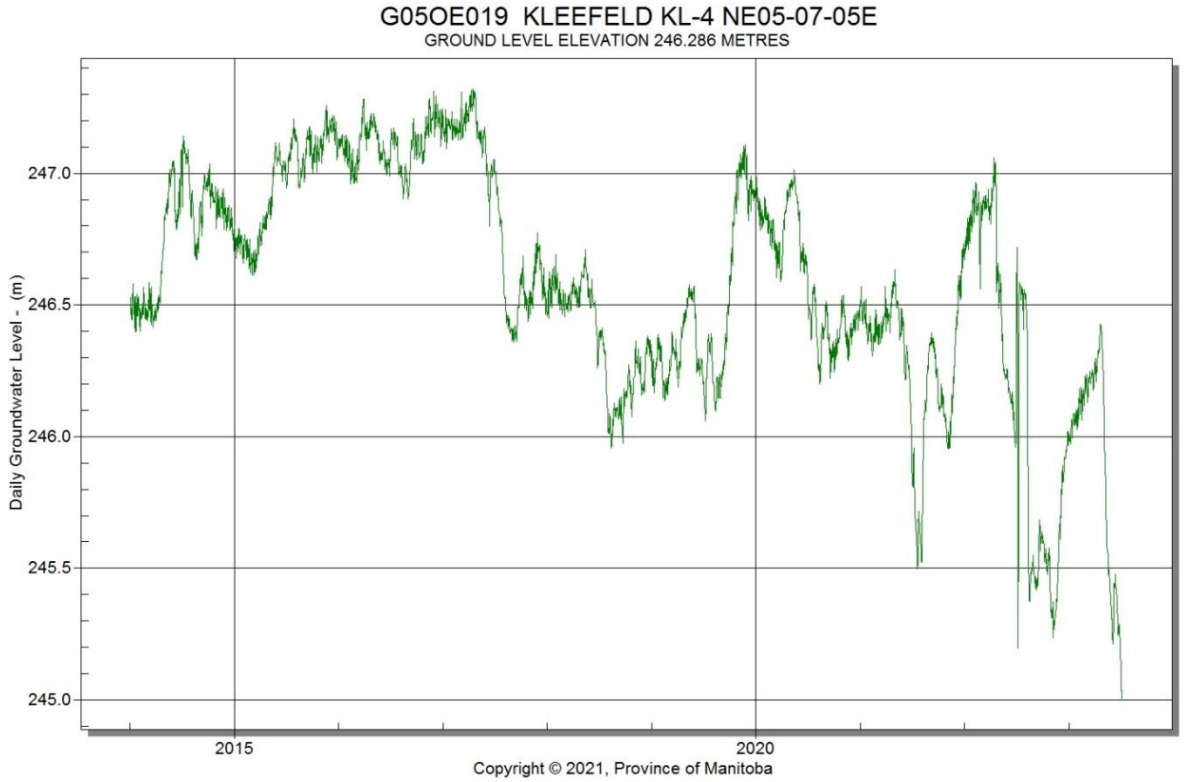


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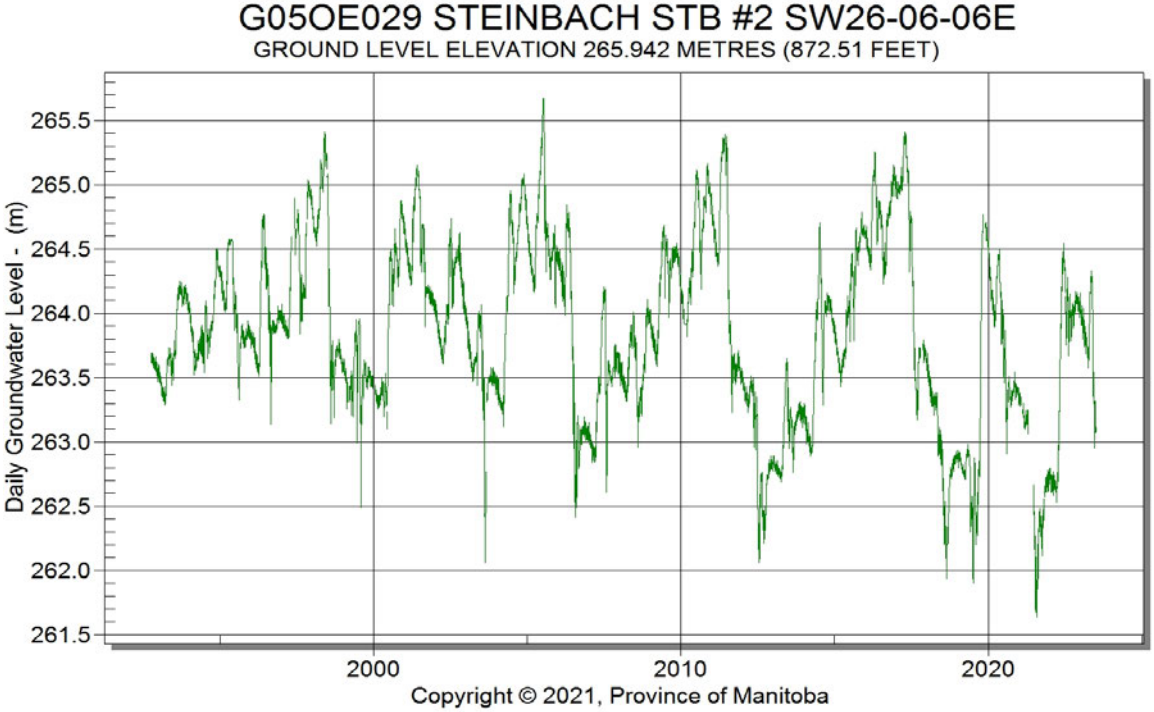


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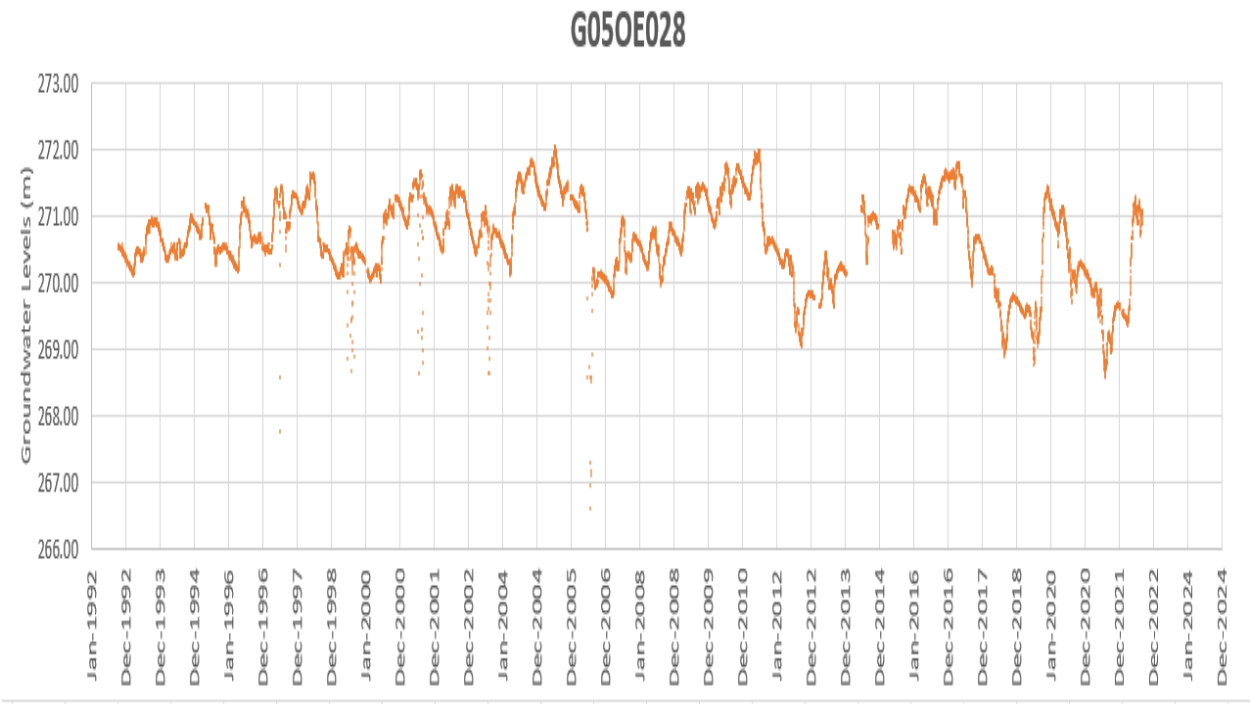


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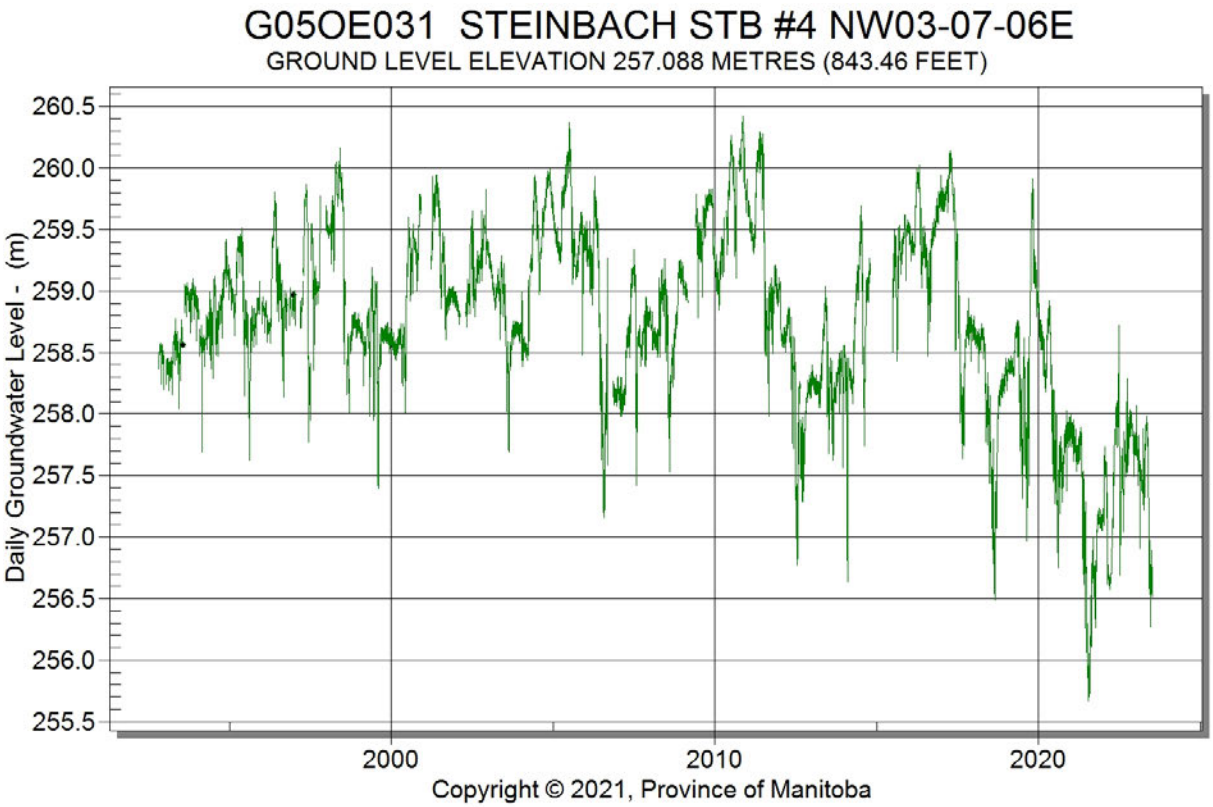


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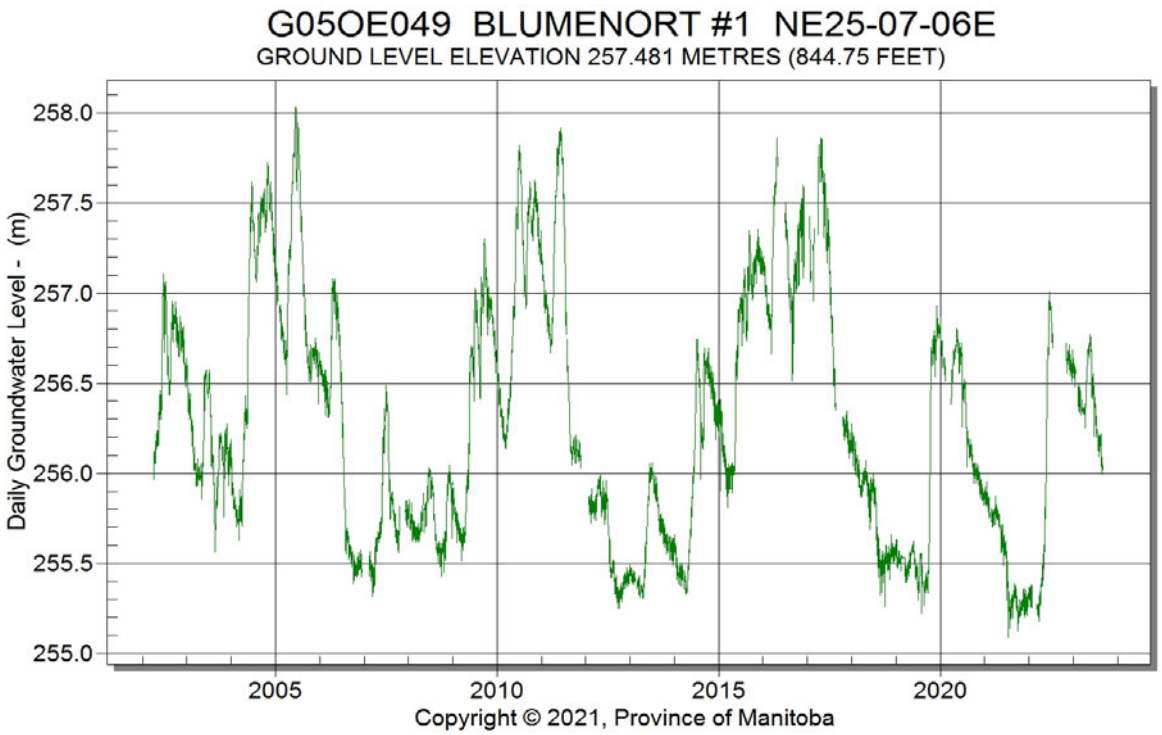


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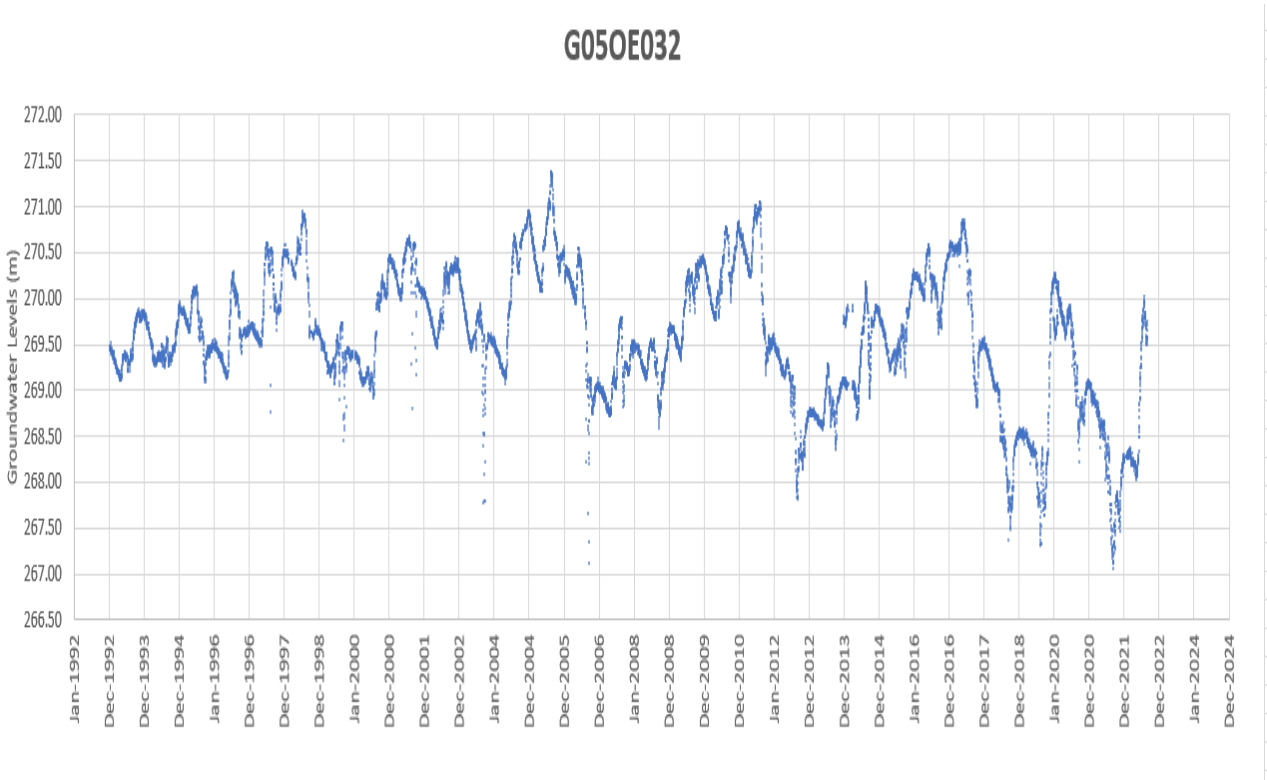


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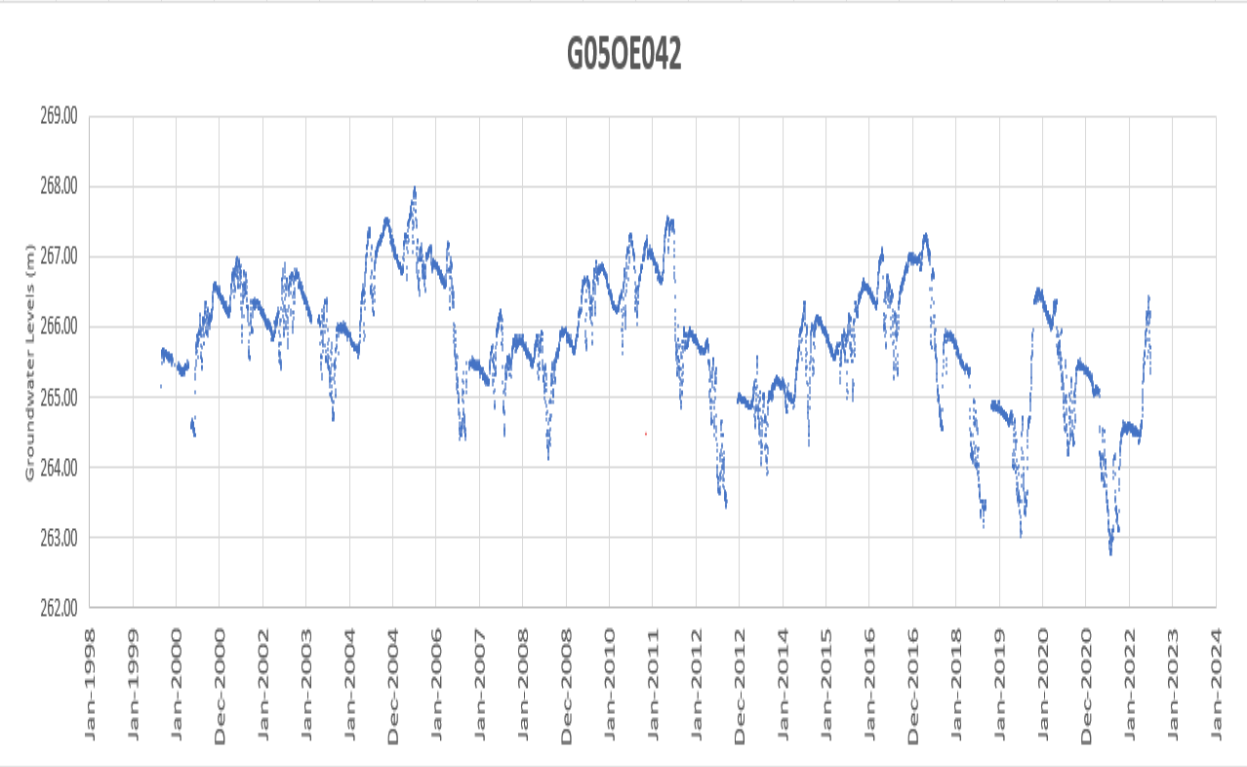


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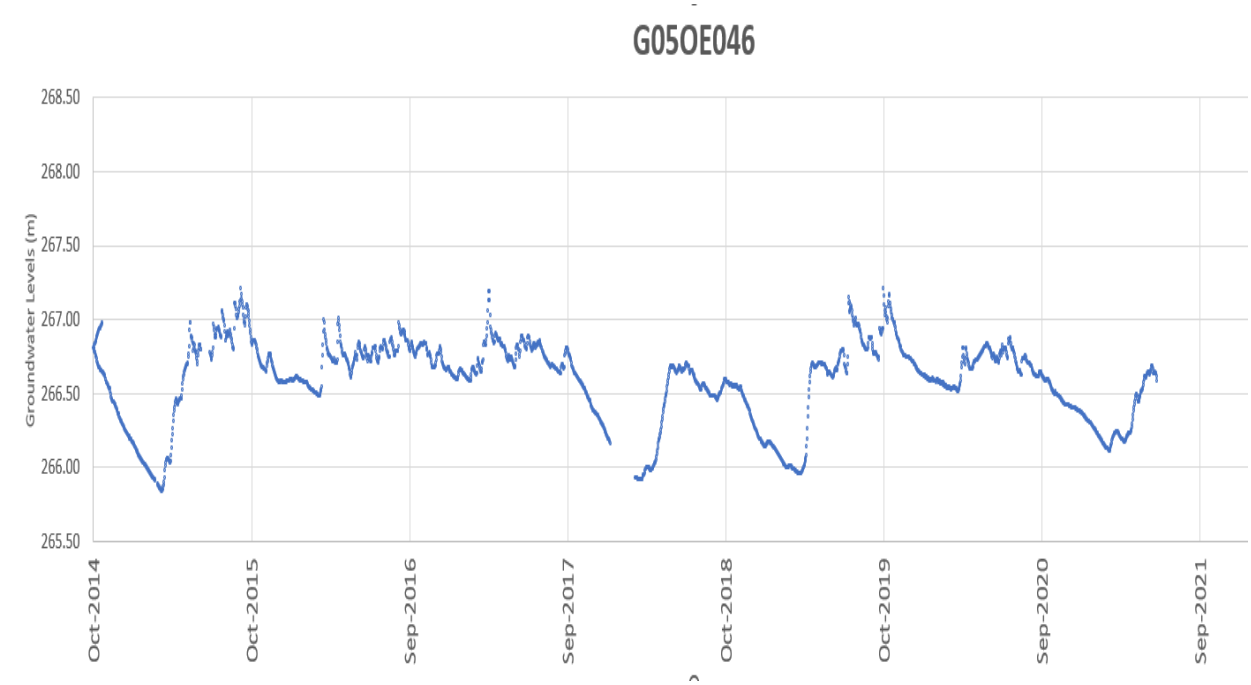


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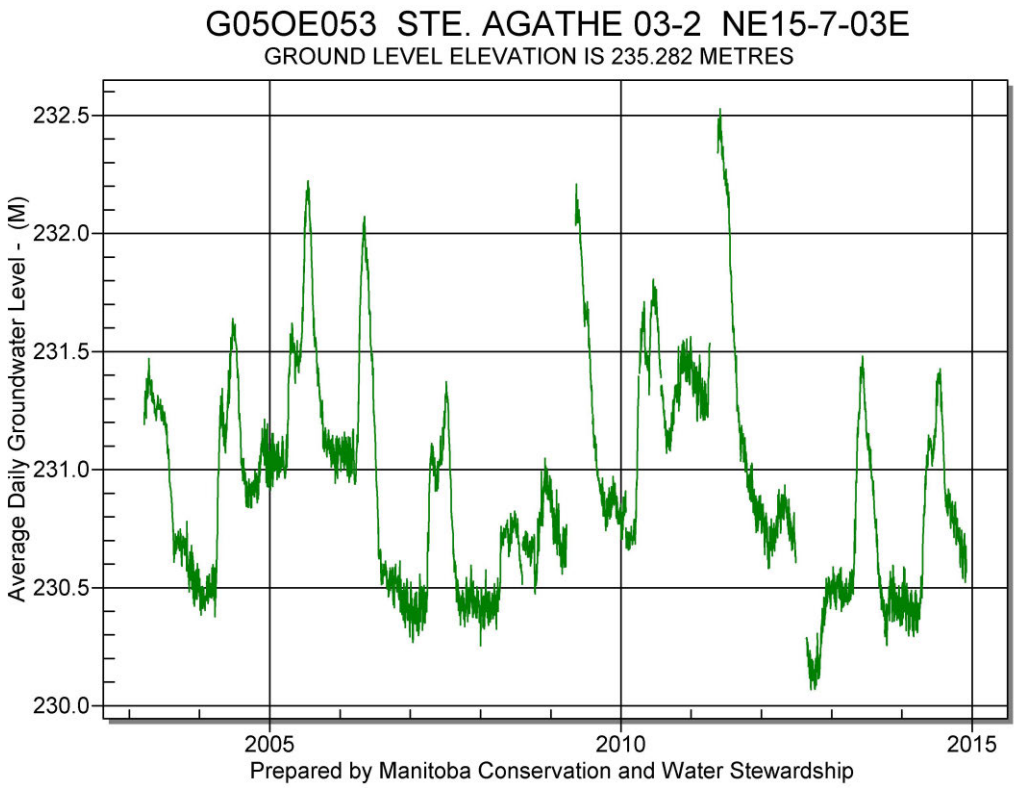


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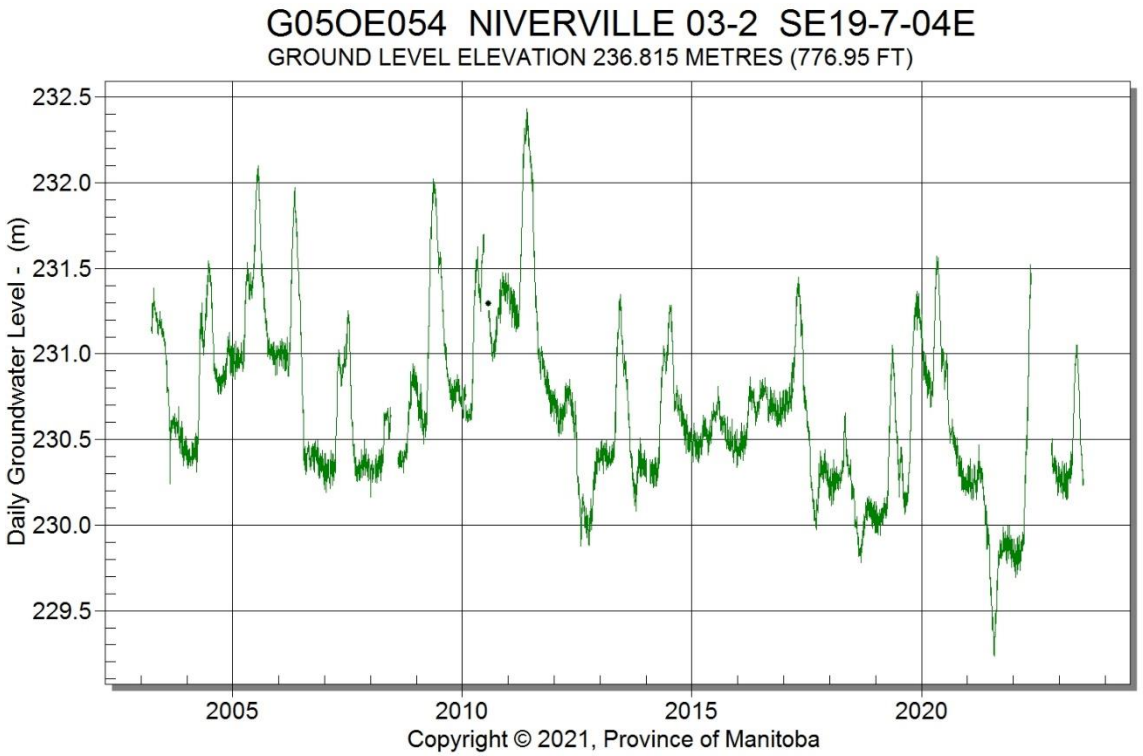


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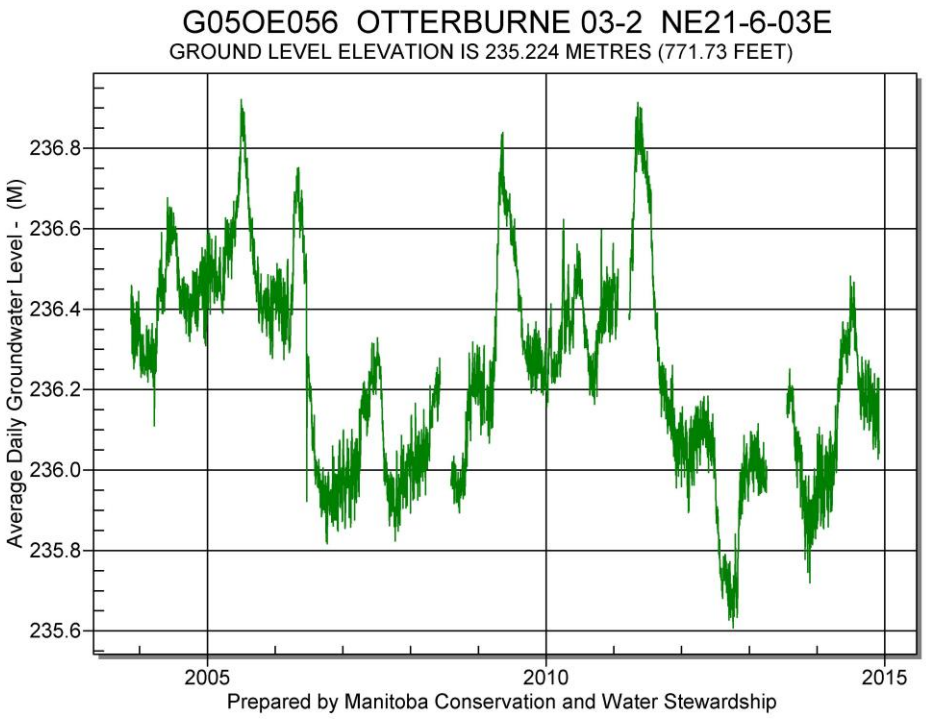


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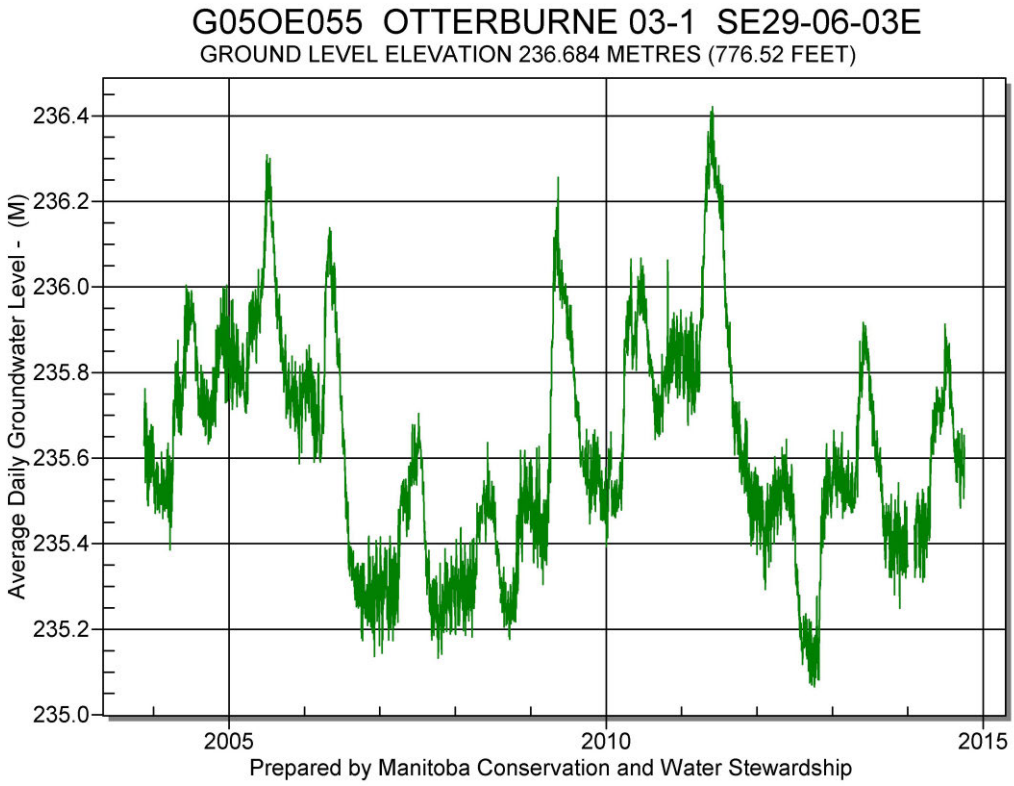


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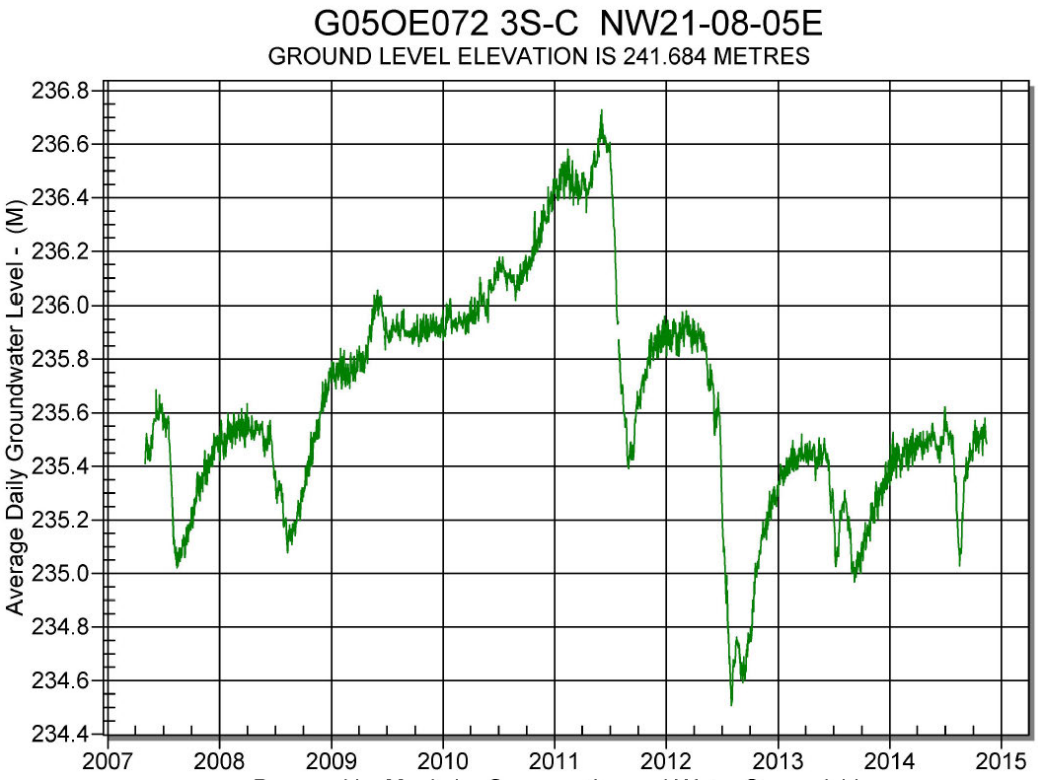


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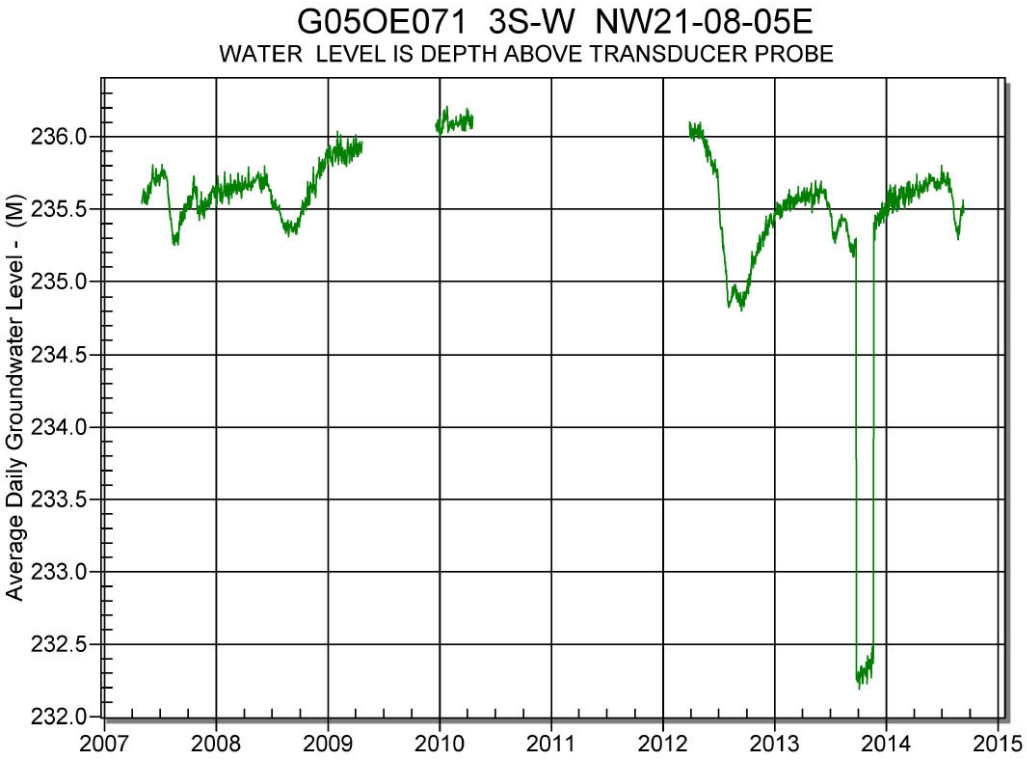


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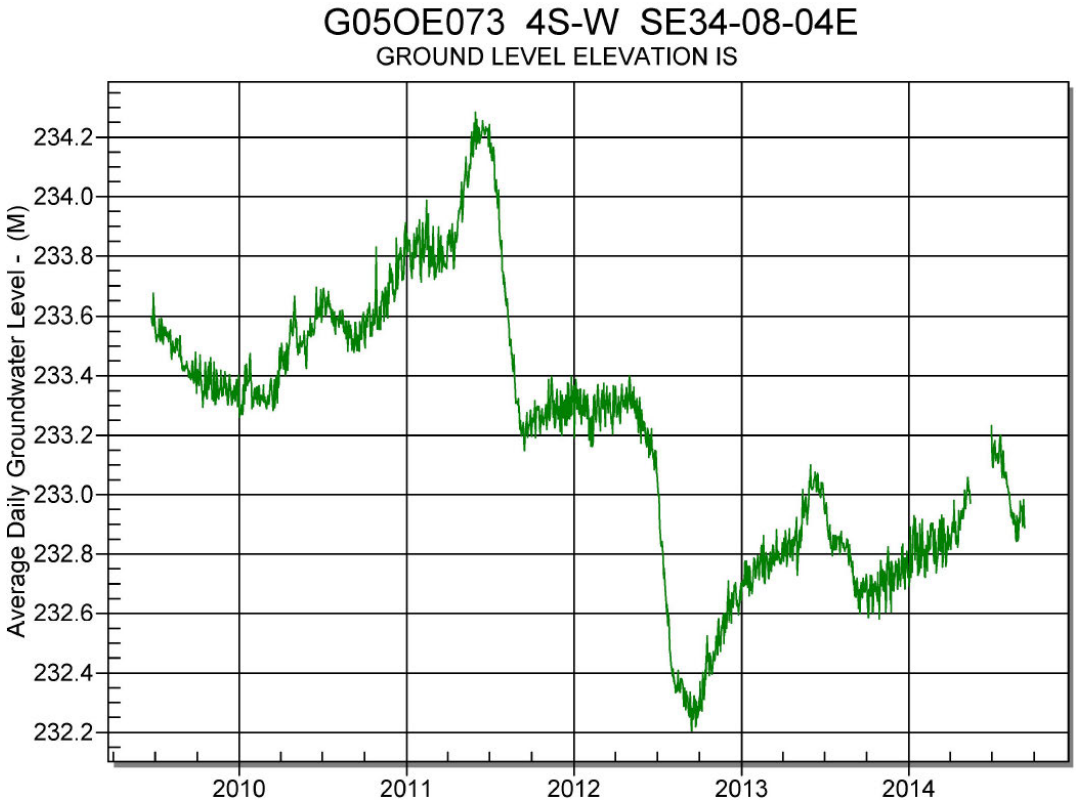


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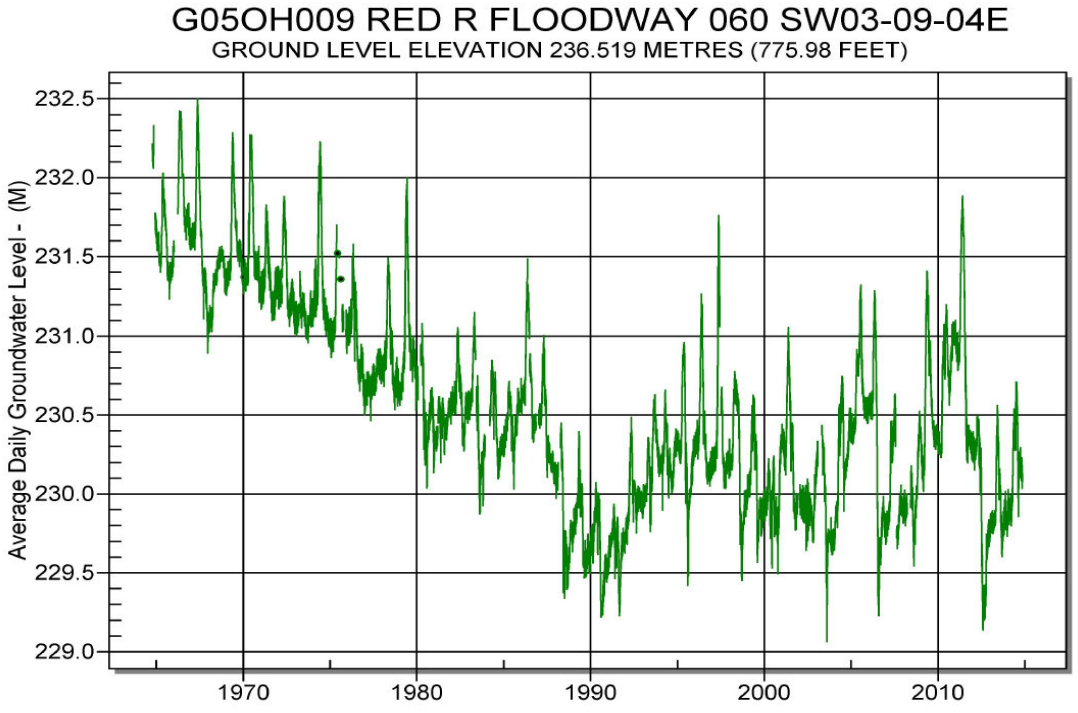


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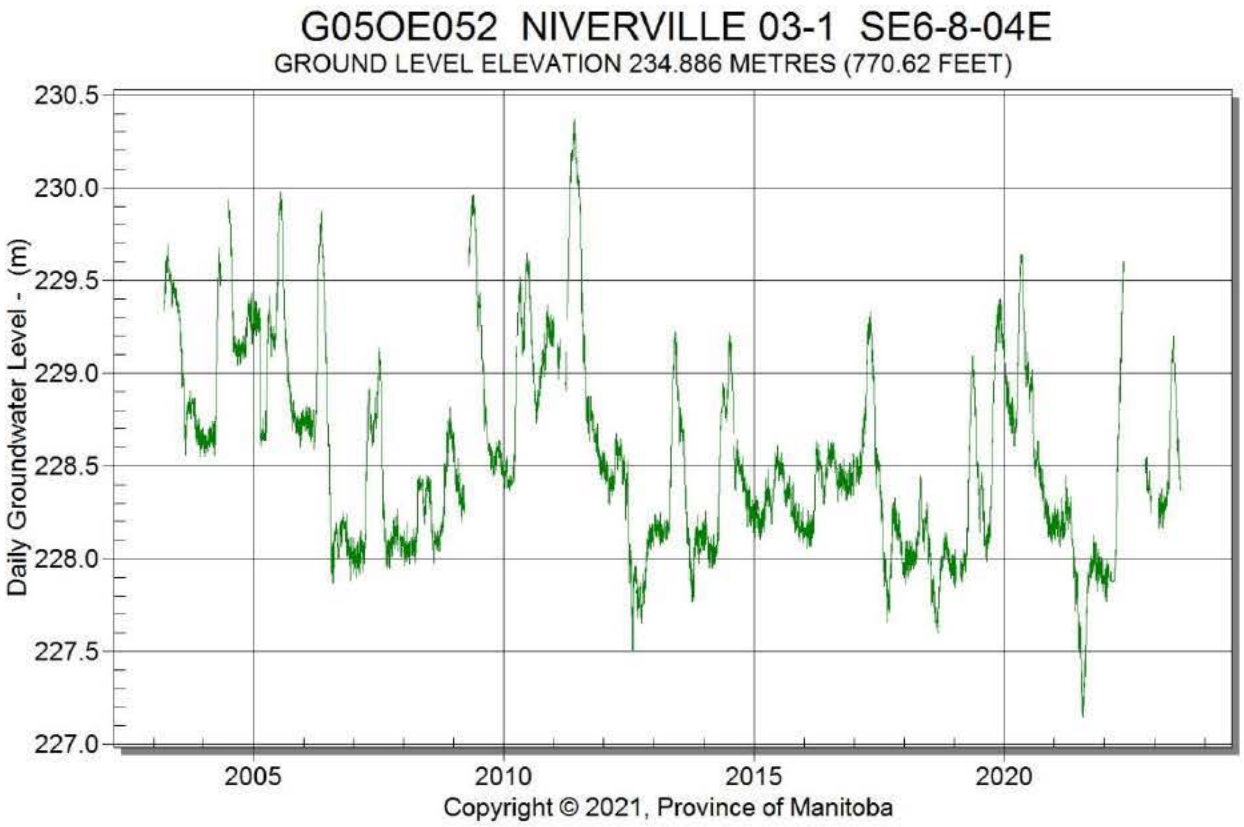


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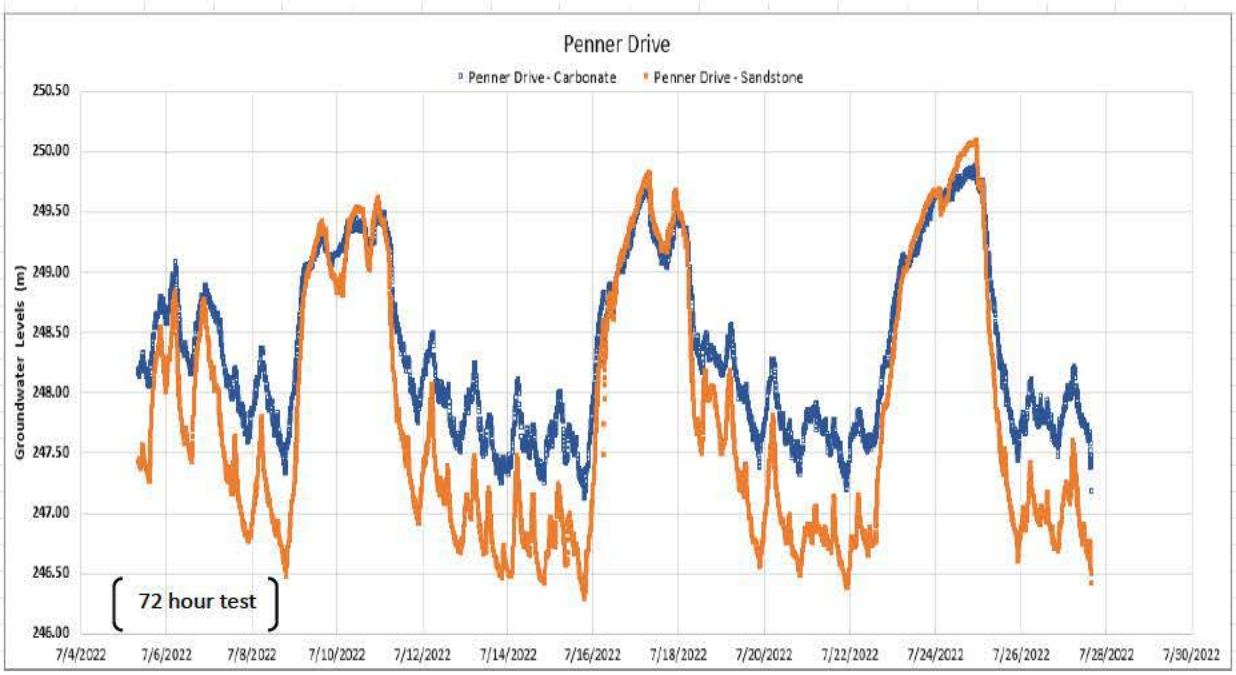


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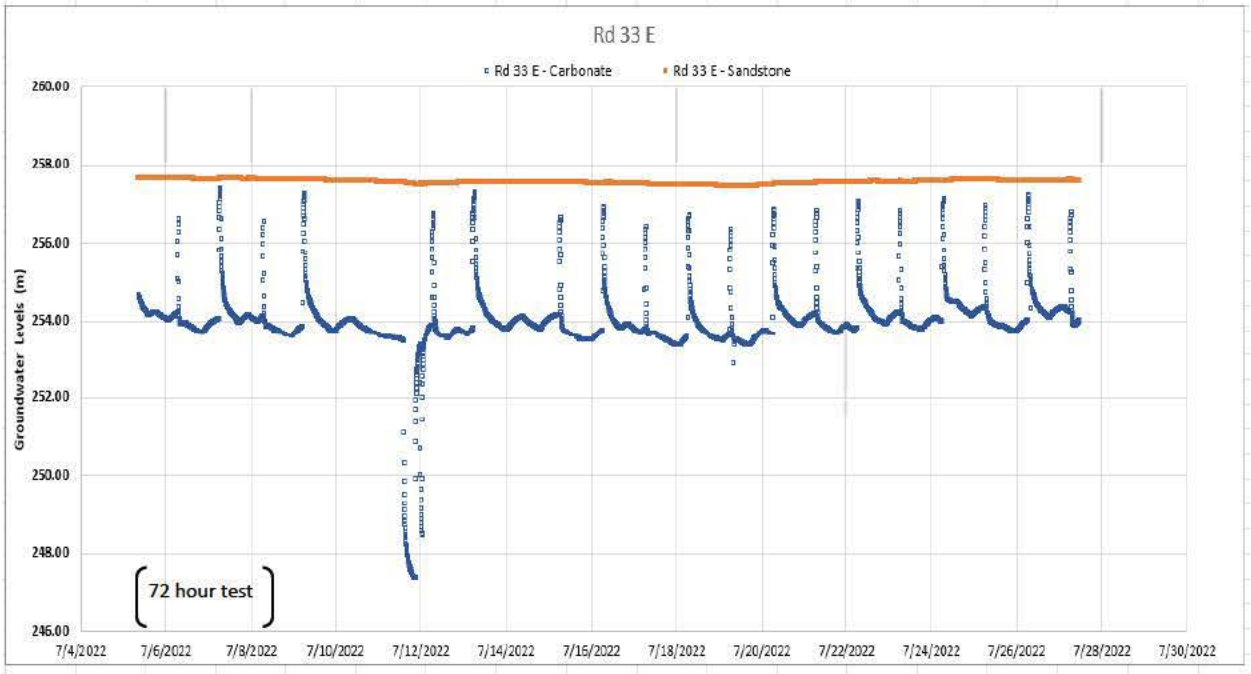


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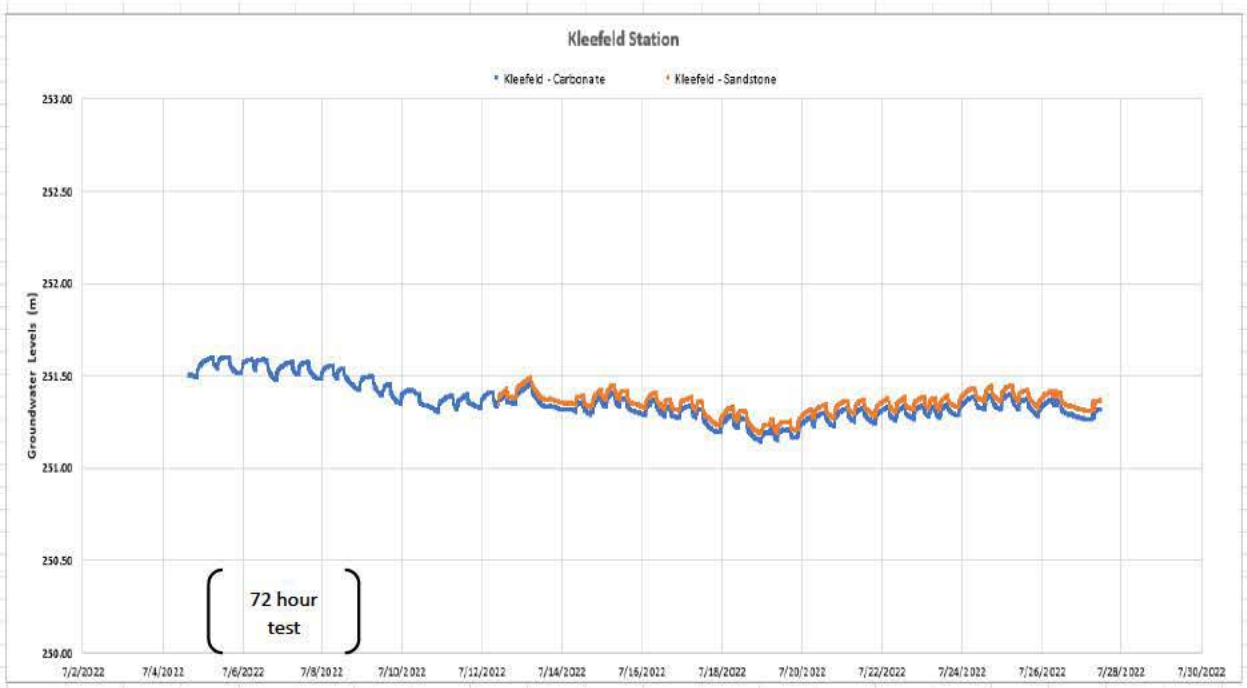


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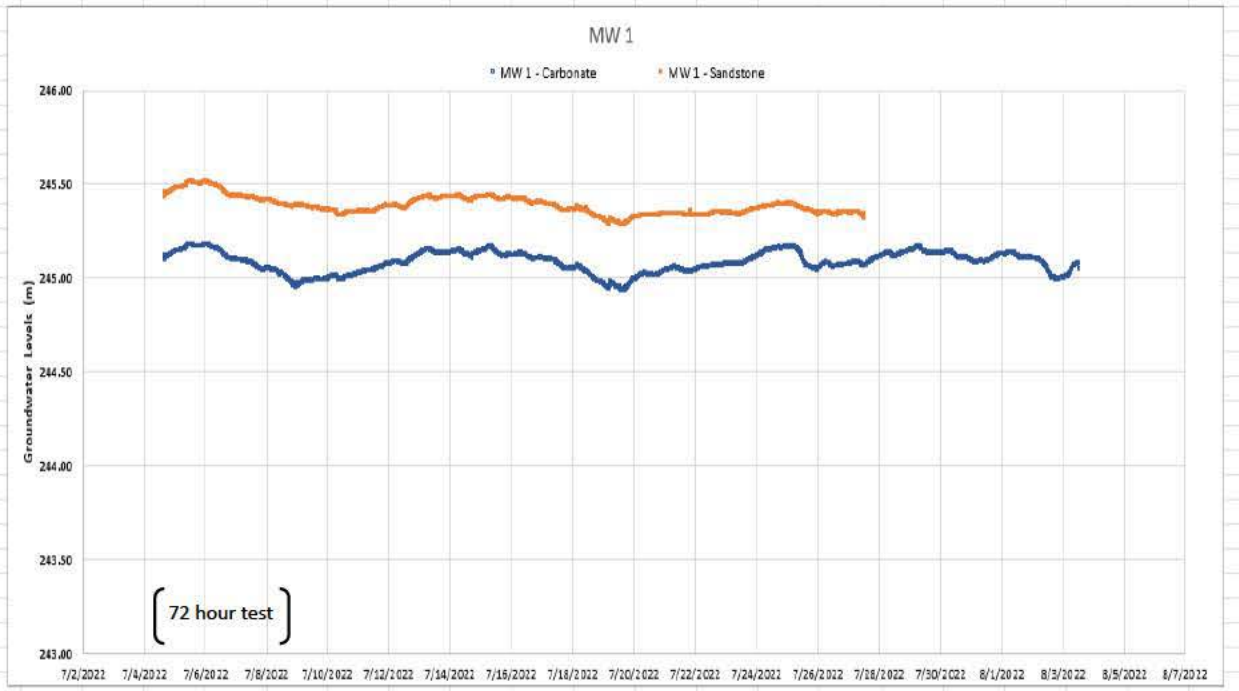


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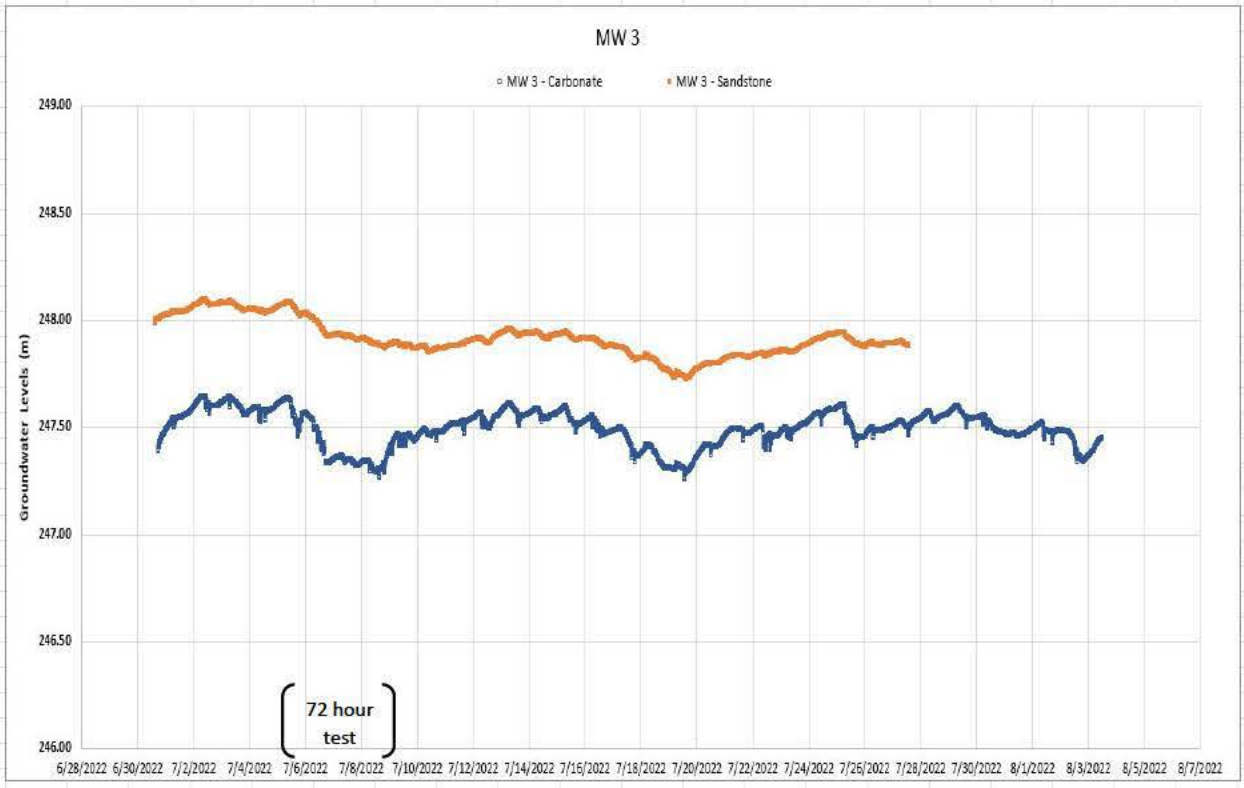

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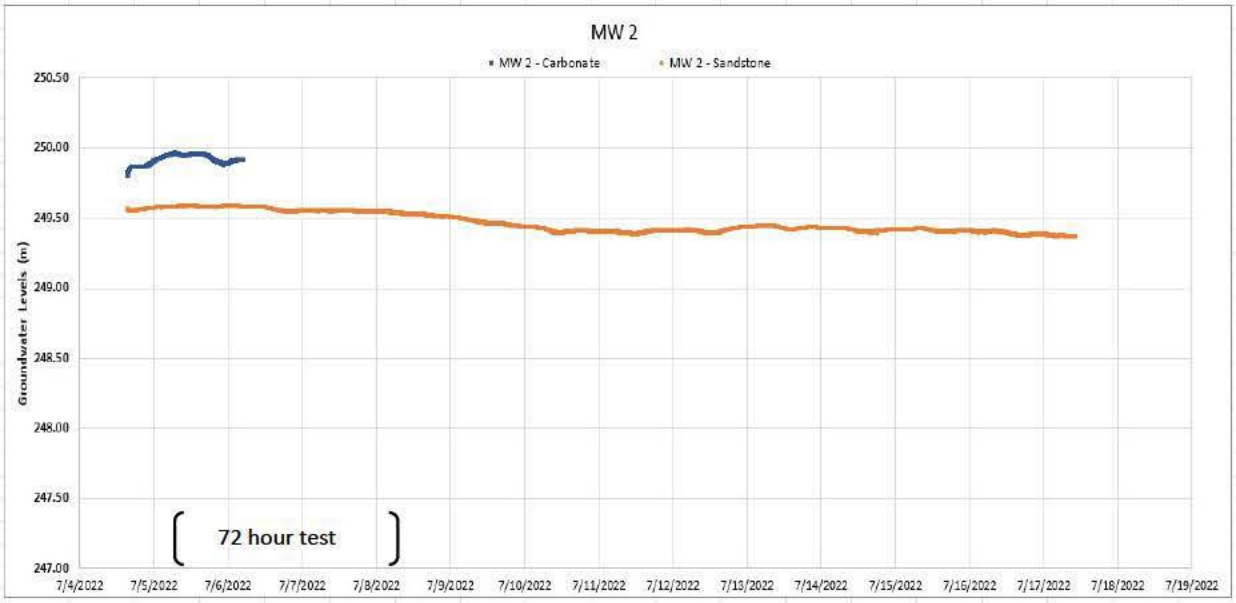


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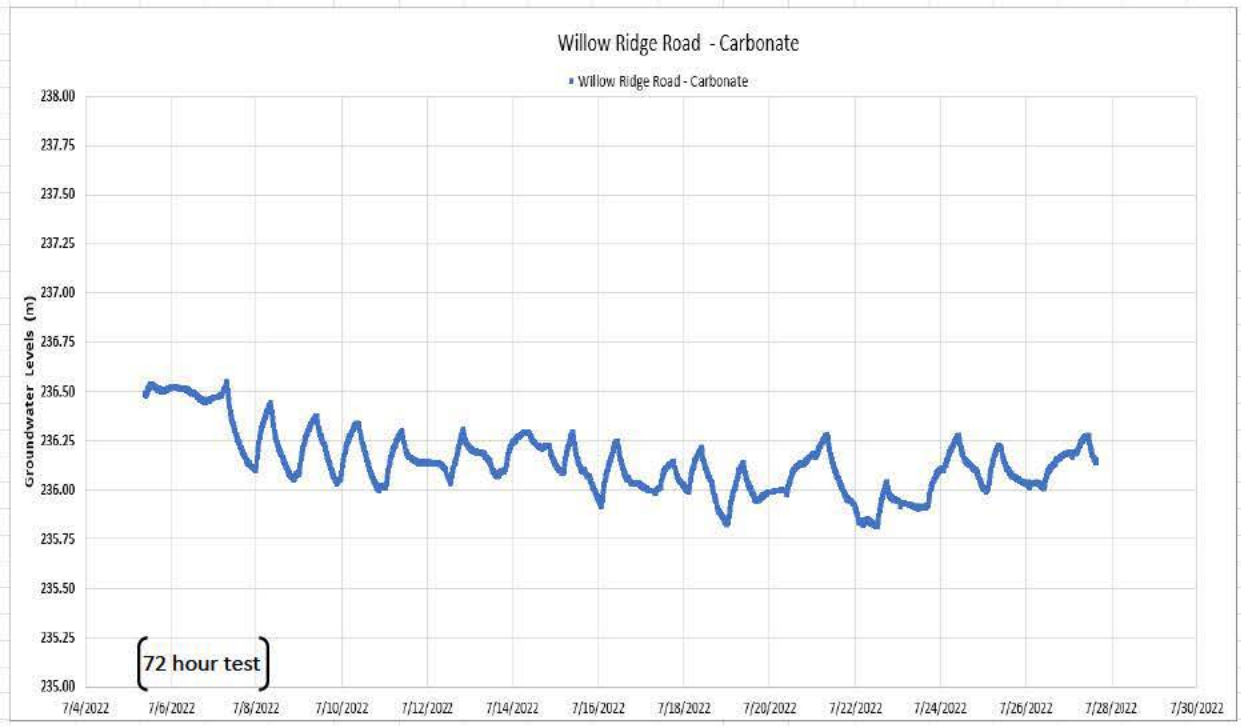


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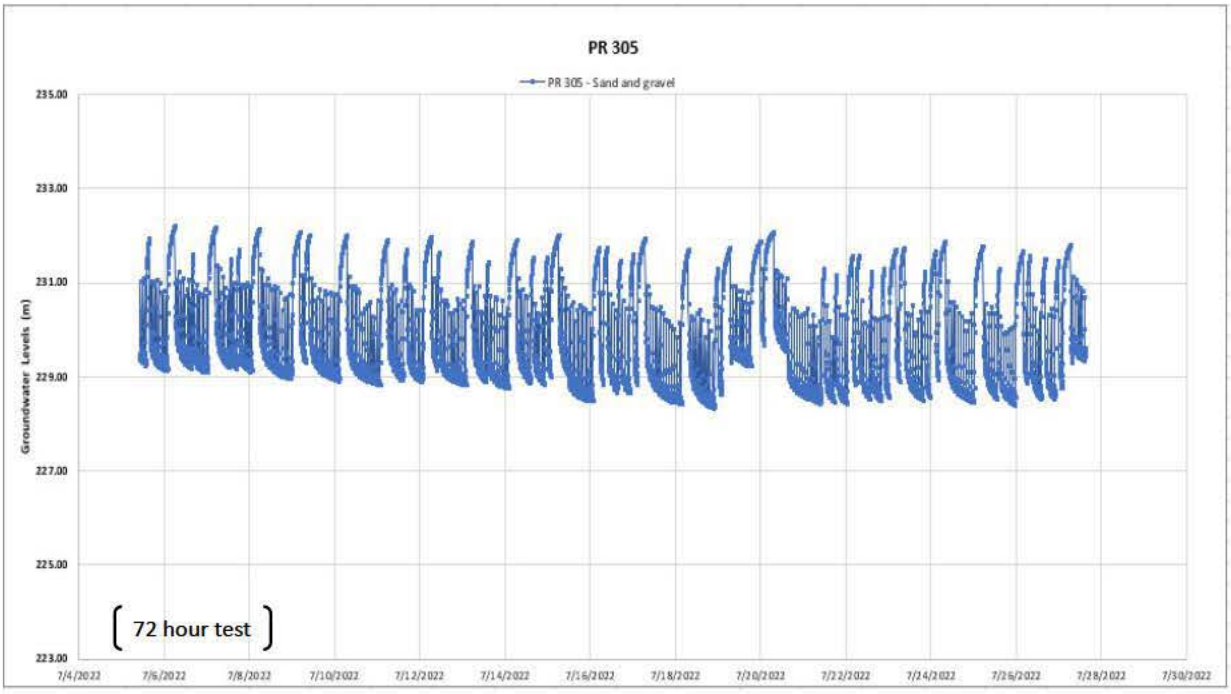


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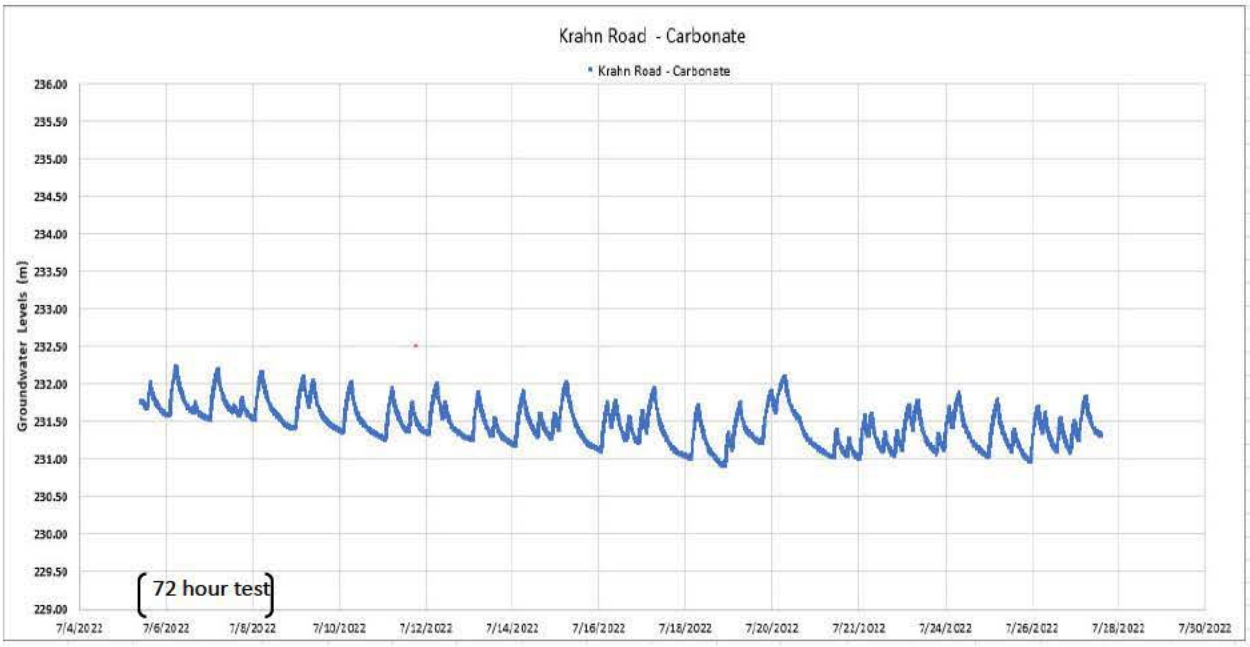


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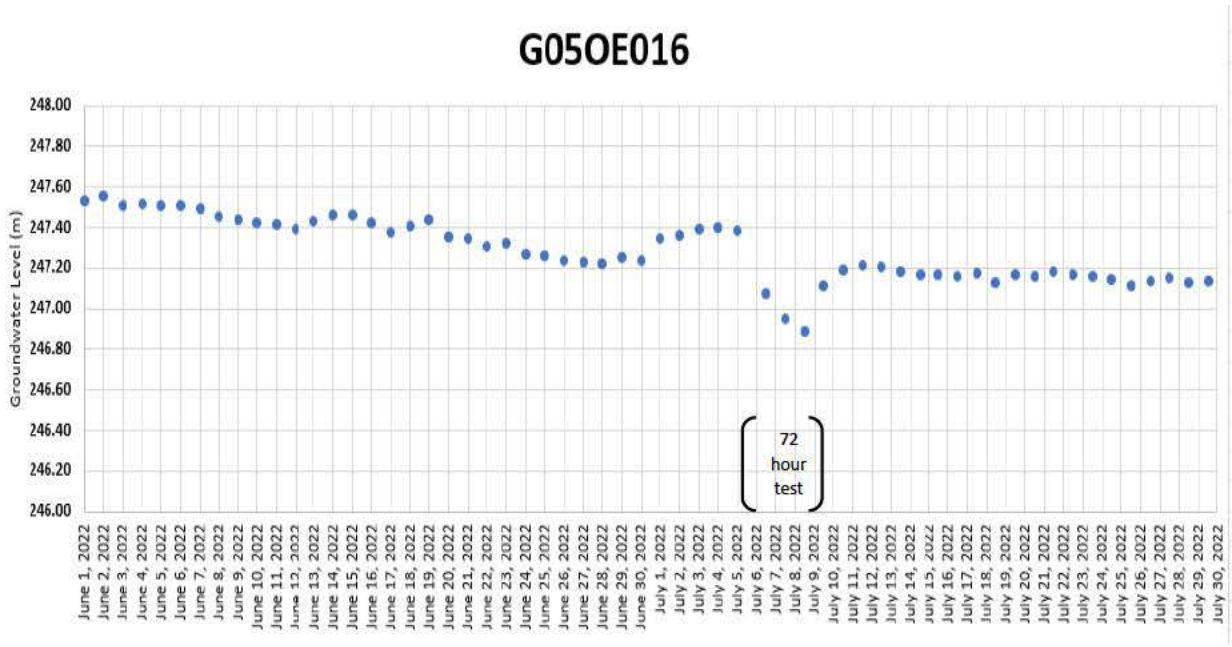


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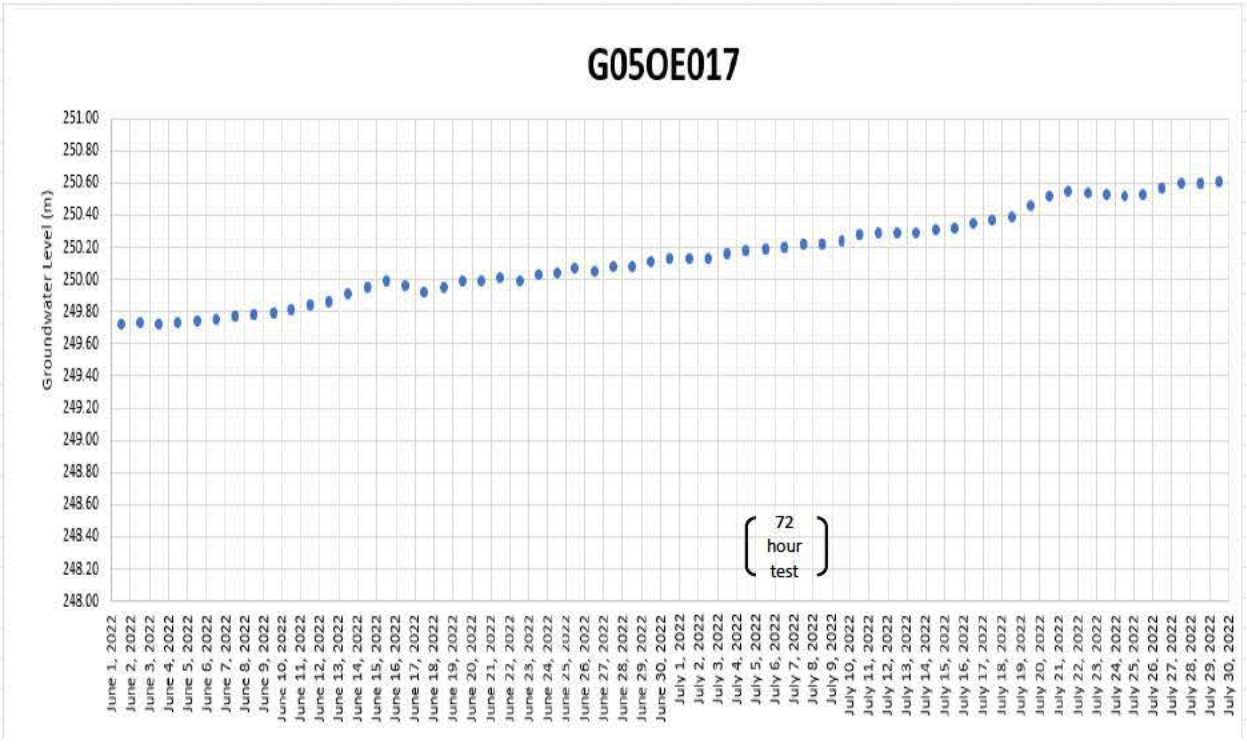


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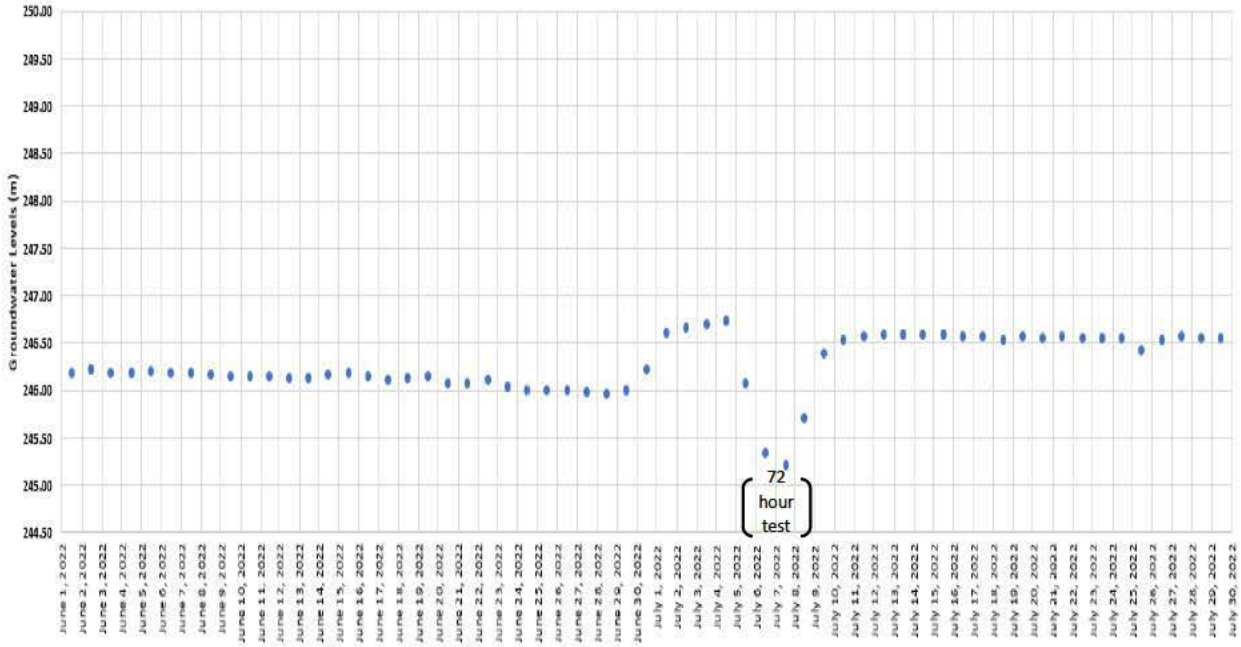
G05OE019

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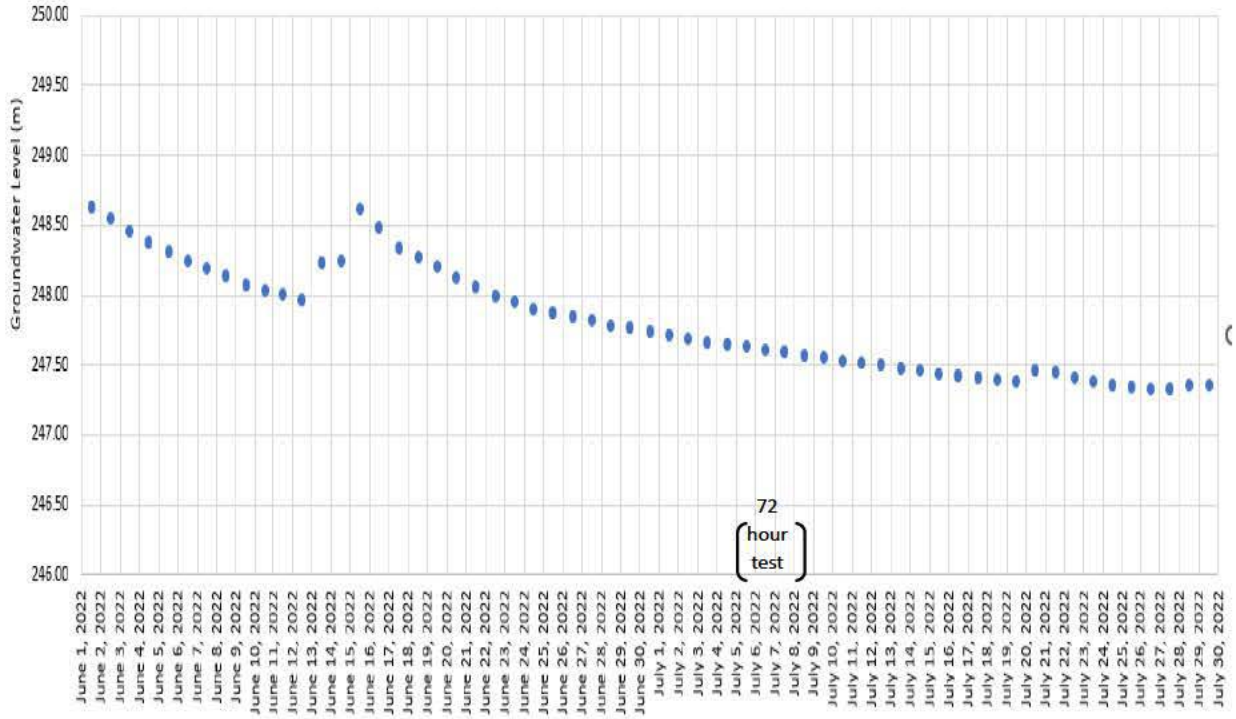


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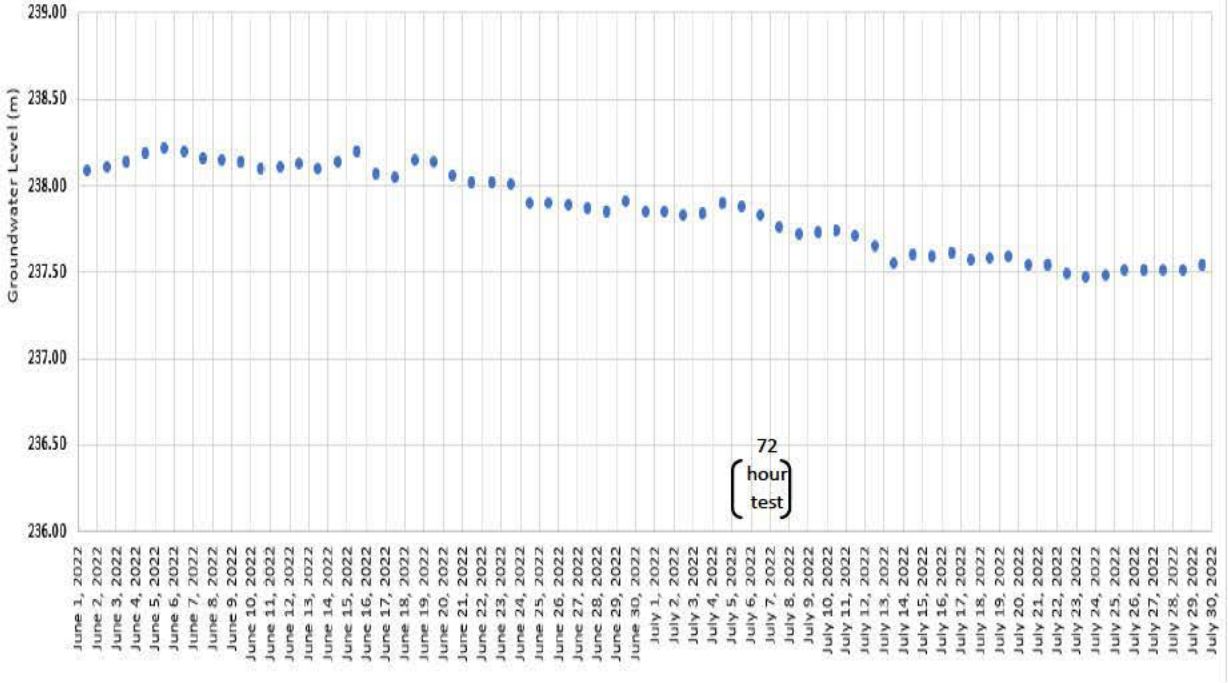


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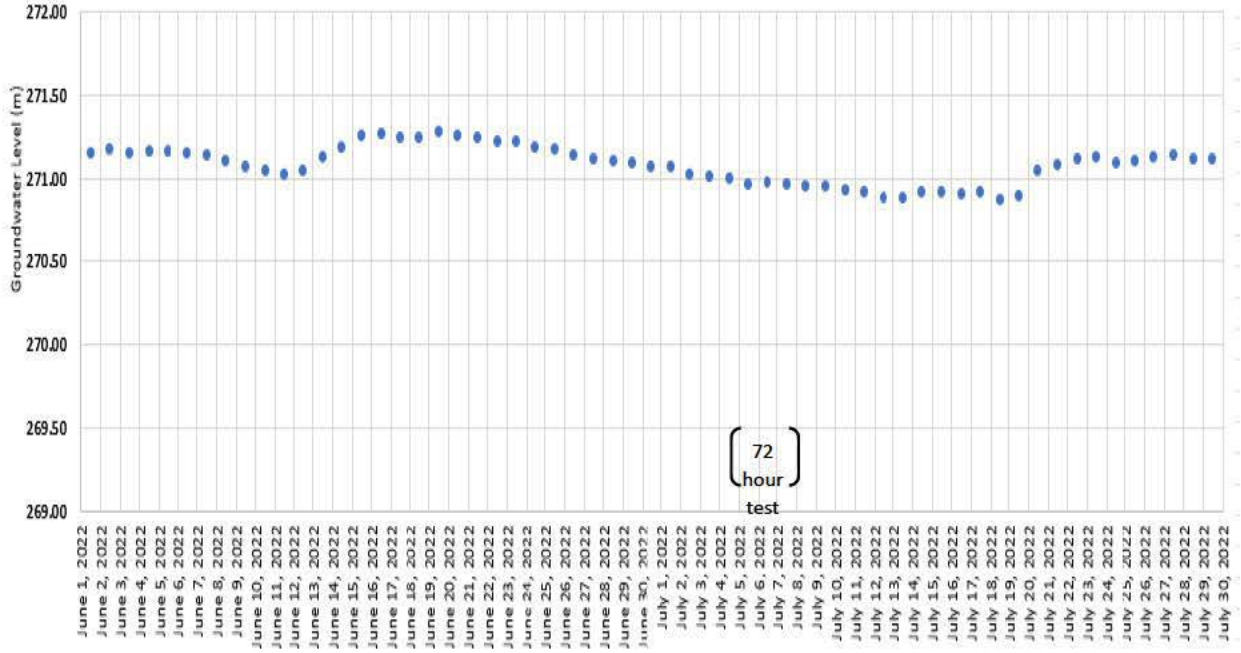


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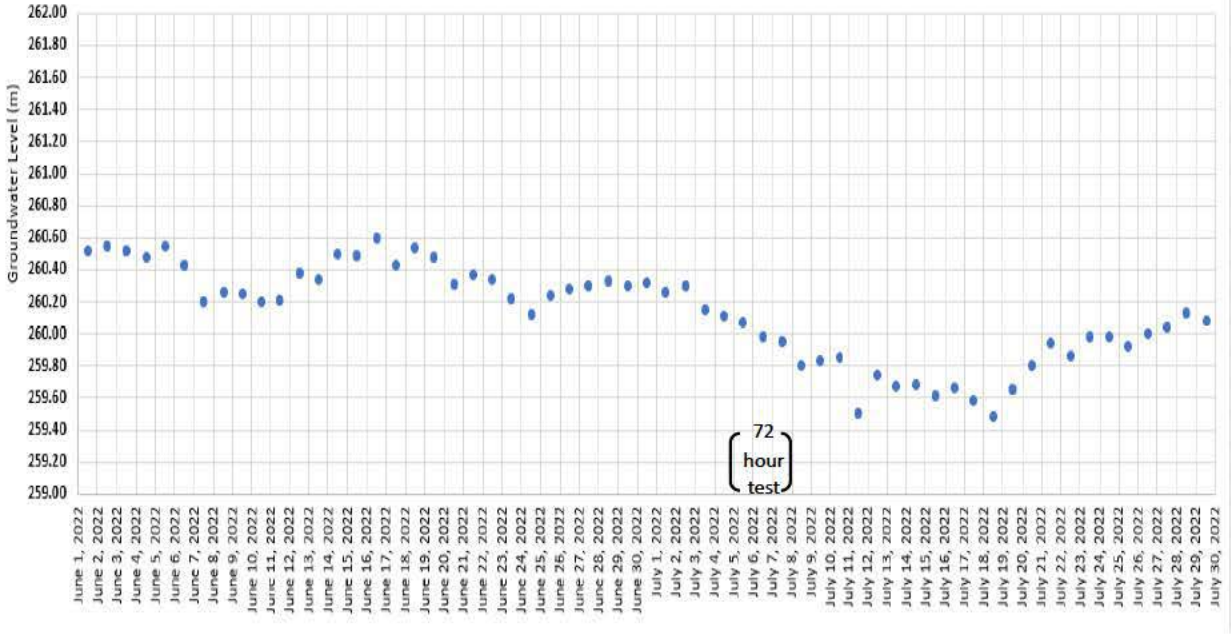
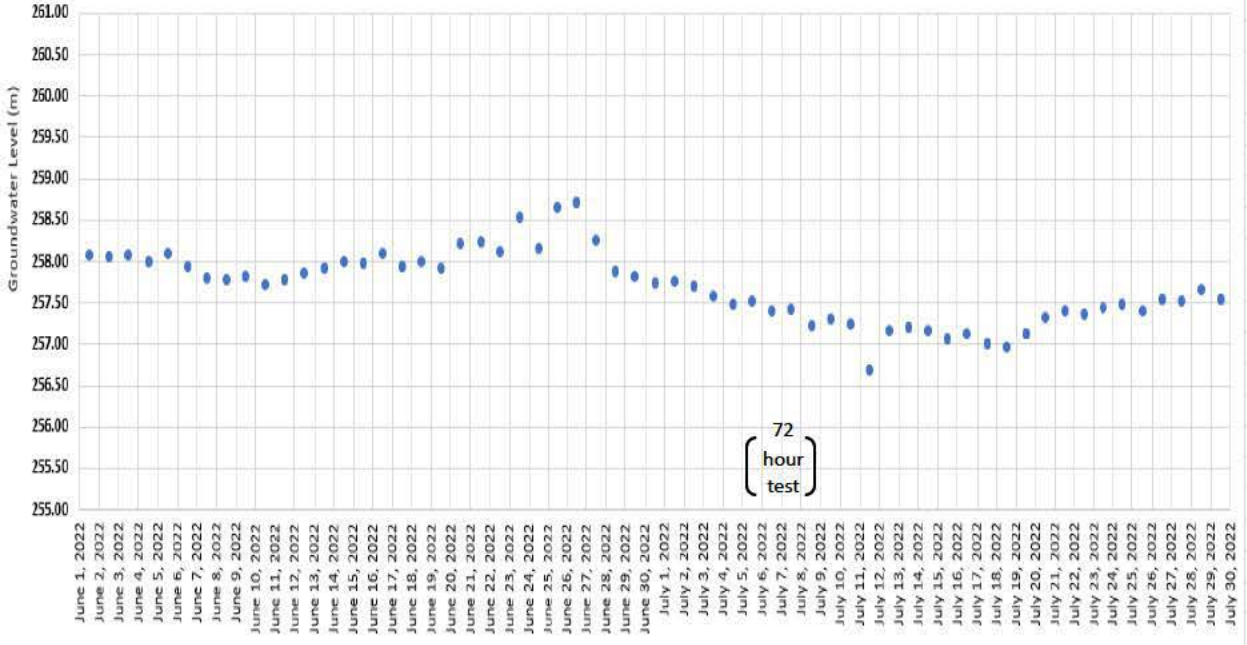


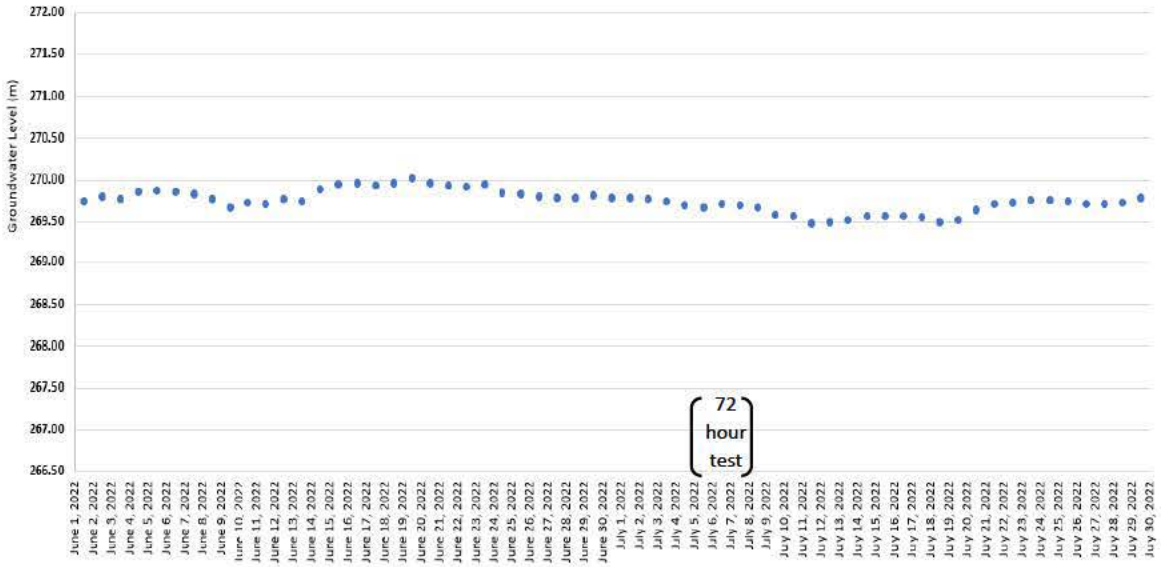

**(Data Source: MEC,2022)**

## G05OE031



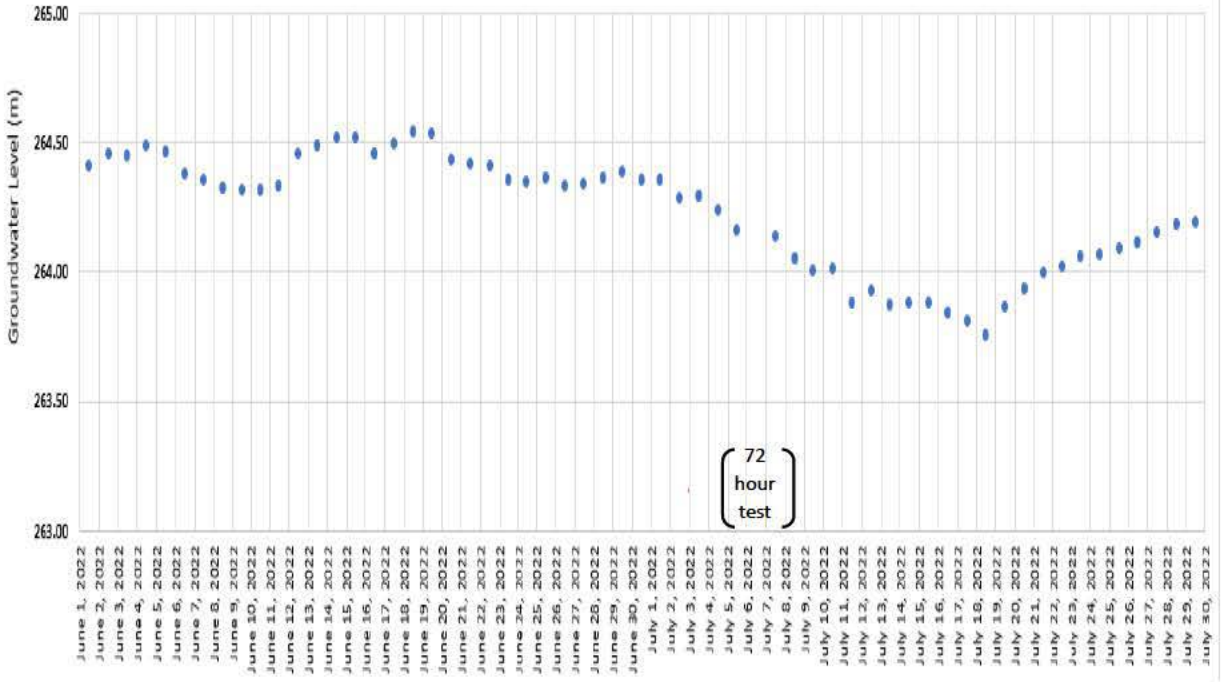

**(Data Source: MEC,2022)**

## G05OE032

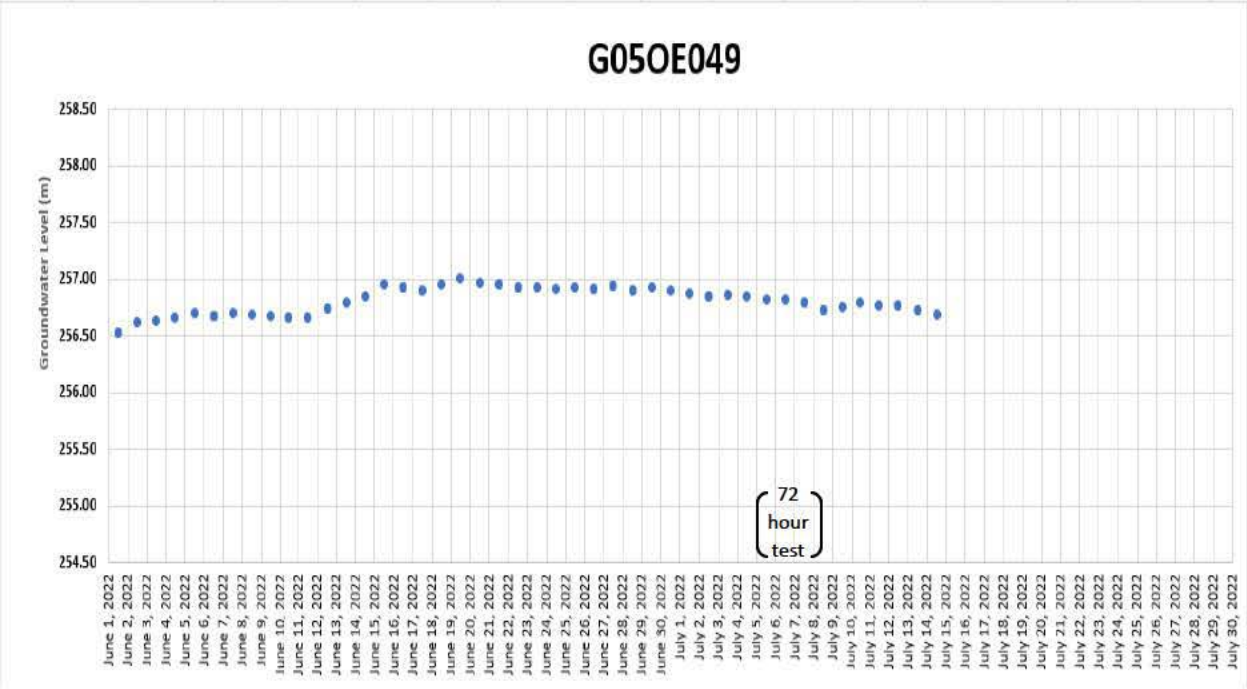



**(Data Source: MEC,2022)**

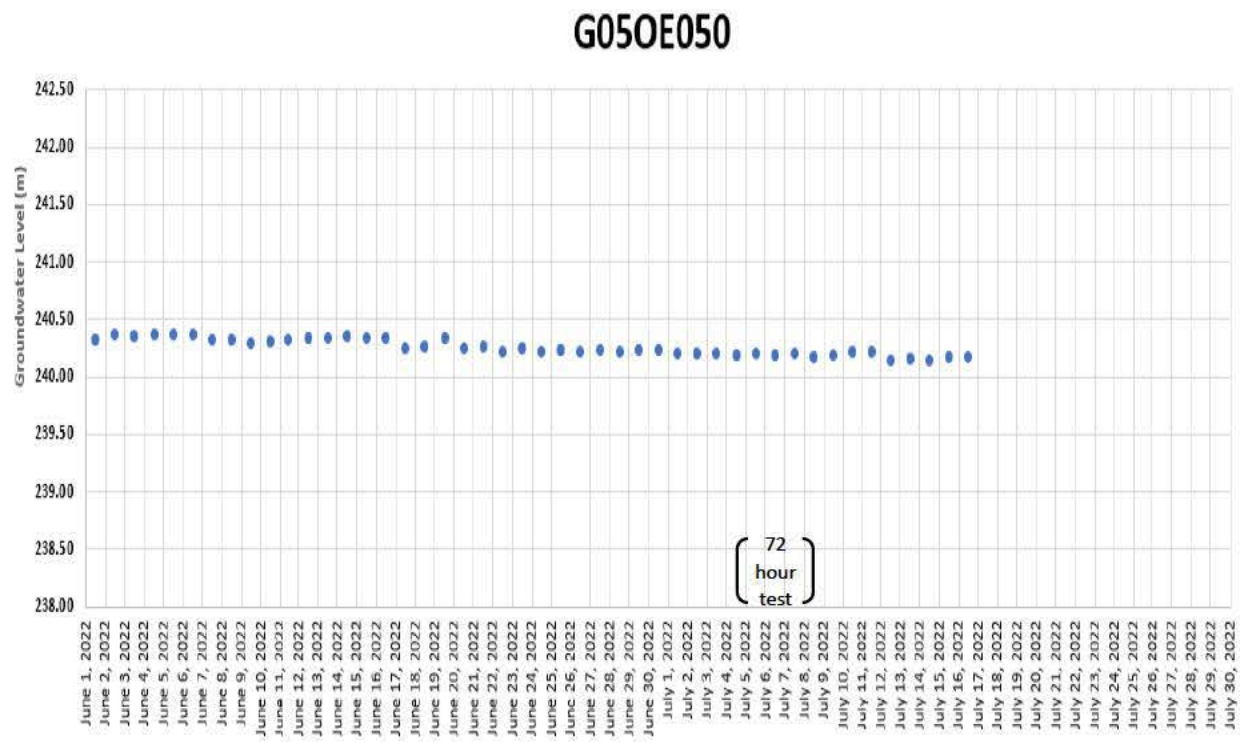
## G05OE029




**(Data Source: MEC,2023)**

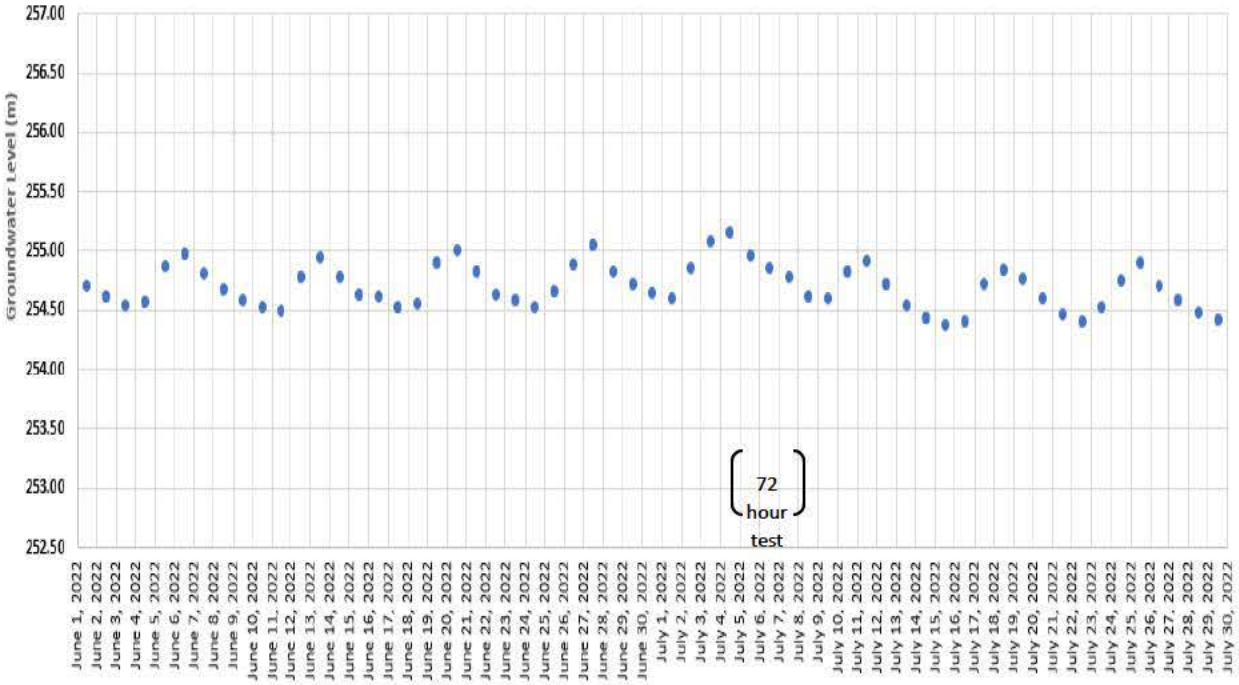



**(Data Source: MEC,2023)**



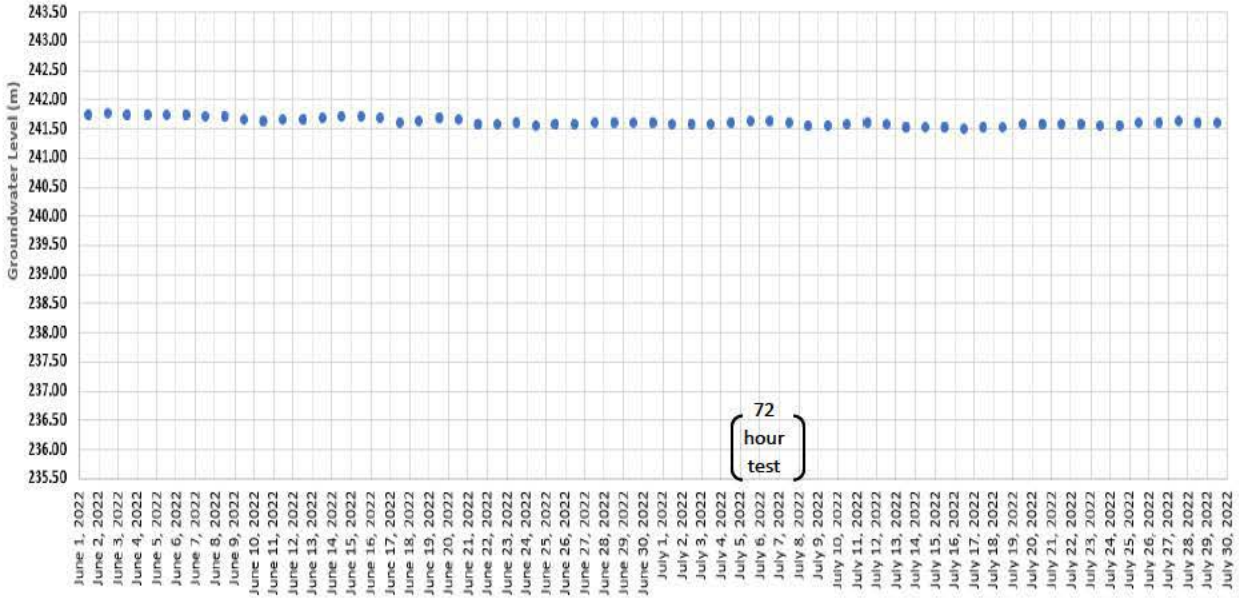

**(Data Source: MEC,2023)**

# G05OE069




**(Data Source: MEC,2023)**

# G05OE070




**(Data Source: MEC,2023)**

Friesen
DRILLERS

# Appendix G

# Geodetic Survey Data

LAWSON
CONSULTING · SURVEY · PIPELINE · UTILITY SERVICES

| | | | | |
|---|---|---|---|---|
| 1000 | 5492396 | 668471.6 | 269.873 | MB_Stein Base |
| 20922100 | 5489878 | 651029.3 | 244.668 | MW1-5" |
| 20922101 | 5489878 | 651029.3 | 244.164 | MW1-GND |
| 20922102 | 5489878 | 651029.2 | 244.75 | MW1-2" |
| 20922103 | 5487349 | 652350.8 | 248.677 | MW2-2" |
| 20922104 | 5487349 | 652350.9 | 248.628 | MW2-5" |
| 20922105 | 5487349 | 652350.9 | 248.053 | MW2-GND |
| 20922106 | 5485425 | 653987.2 | 250.302 | KLEEFELD-GND |
| 20922107 | 5485425 | 653987.1 | 250.813 | KLEEFELD-5" |
| 20922108 | 5485425 | 653987.1 | 250.878 | KLEEFELD-1" |
| 20922109 | 5490429 | 665696.2 | 256.016 | RD33E-GND |
| 20922110 | 5490429 | 665696.2 | 256.768 | RD33E-5" |
| 20922111 | 5490429 | 665696.2 | 256.684 | RD33E-2" |
| 20922112 | 5496577 | 650831.4 | 240.577 | WRR-GND |
| 20922113 | 5496577 | 650831.4 | 241.372 | WRR-5" |
| 20922114 | 5496376 | 647554.5 | 239.466 | HERITAGE LANE-GND |
| 20922115 | 5496376 | 647554.4 | 239.824 | HERITAGE LANE-2+5" |
| 20922116 | 5491984 | 640281.6 | 235.982 | KRAHN RD-GND |
| 20922117 | 5491984 | 640281.5 | 236.725 | KRAHN RD-5" |
| 20922118 | 5491625 | 640918.4 | 236.331 | PR305-GND |
| 20922119 | 5491625 | 640918.5 | 237.51 | PR305-5" |
| 20922120 | 5490378 | 653665.7 | 245.5 | WELL1-GND |
| 20922121 | 5490378 | 653665.9 | 246.003 | WELL1-8" |
| 20922122 | 5490386 | 654070.3 | 246.113 | WELL2-GND |
| 20922123 | 5490386 | 654070.2 | 246.587 | WELL2-8" |
| 20922124 | 5490388 | 654248.4 | 246.496 | WELL3-8" |
| 20922125 | 5490388 | 654248.6 | 245.788 | WELL3-GND |
| 20922126 | 5490423 | 656873.8 | 246.52 | MW3-GND |
| 20922127 | 5490423 | 656873.7 | 246.999 | MW3-5" |
| 20922128 | 5490423 | 656873.7 | 247.192 | MW3-2" |

Friesen
DRILLERS

# Appendix H

# Pumping Test Data

| WELL OWNER | Municipality of Ritchot | | | DATE | | July 5-8, 2022 | | |
|---|---|---|---|---|---|---|---|---|
| LOCATION | Randolph Well Field | | | STATIC LEVEL (ft) | | 1.52 | | |
| | | | | | | | | |
| | | | | | | | | |
| | ELAPSED | Pump Well | ELAPSED | | ELAPSED | | PUMPING | REMARKS |
| TIME | TIME (min) | Well 2 | TIME (min) | Well 1 | TIME (min) | Well 3 | RATE (gpm) | |
| 10 05 AM | 0 | 1.52 | 0 | 1.51 | 0 | 1.25 | | level from TOC |
| | 0.5 | 13.02 | 60 | 2.22 | 5 | 3.68 | | July 5th |
| | 1 | 13.83 | 120 | 2.4 | 10 | 4.328 | | |
| | 2 | 14.12 | 180 | 2.6 | 15 | 4.705 | | |
| | 3 | 14.81 | 240 | 2.98 | 20 | 4.939 | | |
| | 4 | 15.03 | 300 | 3.22 | 25 | 5.115 | | |
| | 5 | 15.21 | 360 | 3.42 | 30 | 5.3 | | |
| | 6 | 15.33 | 420 | 3.72 | 35 | 5.436 | | |
| | 7 | 15.44 | 480 | 3.83 | 40 | 5.562 | | |
| | 8 | 15.59 | 540 | 3.92 | 45 | 5.685 | | |
| | 9 | 15.61 | 720 | 4.1 | 50 | 5.795 | | |
| | 10 | 15.85 | 780 | 4.2 | 55 | 5.909 | | |
| | 15 | 16.22 | 840 | 4.25 | 60 | 5.987 | | |
| | 20 | 16.39 | 900 | 4.3 | 65 | 6.073 | | |
| | 25 | 16.67 | 1140 | 4.5 | 70 | 6.158 | 394 | |
| | 30 | 16.66 | 1200 | 4.55 | 75 | 6.229 | | |
| | 35 | 16.82 | 1260 | 4.6 | 80 | 6.271 | | |
| | 40 | 16.89 | 1320 | 4.68 | 85 | 6.346 | | |
| | 60 | 17.22 | 1440 | 4.73 | 90 | 6.399 | | |
| | 75 | 17.55 | 1620 | 4.77 | 95 | 6.454 | | |
| | 90 | 17.63 | 1680 | 4.78 | 100 | 6.506 | | |
| | 105 | 17.77 | 1740 | 4.78 | 105 | 6.559 | | |
| | 120 | 17.92 | 1800 | 4.82 | 110 | 6.62 | | |
| | 135 | 17.98 | 1860 | 4.85 | 115 | 6.671 | | |
| | 150 | 18.11 | 1980 | 4.89 | 120 | 6.685 | | |
| | 165 | 18.16 | 2040 | 4.92 | 125 | 6.723 | | |
| | 180 | 18.17 | 2100 | 4.95 | 130 | 6.747 | | |
| | 195 | 18.43 | 2160 | 4.95 | 135 | 6.78 | | |
| | 210 | 18.51 | 2220 | 4.98 | 140 | 6.816 | | |
| | 225 | 18.67 | 2280 | 4.99 | 145 | 6.845 | | |
| | 240 | 18.67 | 2340 | 5 | 150 | 6.876 | | |
| | 300 | 18.81 | 2400 | 5.02 | 155 | 6.888 | | |
| | 360 | 19.23 | 2460 | 5.05 | 160 | 6.916 | | |
| | 480 | 19.47 | 2640 | 5.12 | 165 | 6.939 | | |
| | 540 | 19.52 | 2700 | 5.15 | 170 | 6.969 | | |
| | 600 | 19.61 | 2760 | 5.16 | 175 | 7.002 | | |
| | 720 | 20.1 | 2820 | 5.19 | 180 | 7.036 | 390 | |
| | 780 | 20.17 | 2880 | 5.21 | 185 | 7.065 | | |
| | 840 | 20.19 | 2940 | 5.23 | 190 | 7.115 | | |
| | 900 | 20.26 | 3000 | 5.24 | 195 | 7.14 | | |
| | 960 | 20.32 | 3060 | 5.24 | 200 | 7.187 | | |
| | 1140 | 20.47 | 3120 | 5.23 | 205 | 7.213 | | |
| | 1200 | 20.52 | 3240 | 5.27 | 210 | 7.244 | | |
| | 1260 | 20.67 | 3300 | 5.27 | 215 | 7.292 | | |
| | 1320 | 20.77 | 3360 | 5.26 | 220 | 7.341 | | |
| 10 05 AM | 1440 | 20.67 | 3420 | 5.36 | 225 | 7.378 | | |
| | 1500 | 21.63 | 3480 | 5.34 | 230 | 7.392 | | |
| | 1560 | 20.67 | 3540 | 5.32 | 235 | 7.411 | | |
| | 1620 | 20.62 | 3600 | 5.35 | 240 | 7.413 | | |
| | 1680 | 20.62 | 3660 | 5.36 | 245 | 7.427 | | |
| | 1740 | 20.63 | 3720 | 5.38 | 250 | 7.453 | | |
| | 1860 | 20.65 | 3780 | 5.39 | 255 | 7.455 | 390 | |

| | ELAPSED | Pump Well | ELAPSED | | ELAPSED | | PUMPING | REMARKS |
|---|---|---|---|---|---|---|---|---|
| TIME | TIME (min) | Well 2 | TIME (min) | Well 1 | TIME (min) | Well 3 | RATE (gpm) | |
| | 1920 | 20.64 | 3840 | 5.4 | 260 | 7.476 | | |
| | 1980 | 20.84 | 3900 | 5.42 | 265 | 7.488 | | |
| | 2040 | 20.88 | 4020 | 5.54 | 270 | 7.521 | | |
| | 2100 | 20.87 | 4080 | 5.56 | 275 | 7.537 | | |
| | 2160 | 20.89 | 4140 | 5.48 | 280 | 7.551 | | |
| | 2220 | 20.95 | 4200 | 5.51 | 285 | 7.577 | | |
| | 2280 | 21.02 | 4260 | 5.52 | 290 | 7.589 | | |
| | 2340 | 21.07 | 4320 | 5.53 | 295 | 7.613 | | |
| | 2400 | 21.1 | | | 300 | 7.634 | | |
| | 2460 | 21.12 | | | 305 | 7.654 | | |
| | 2580 | 21.15 | | | 310 | 7.681 | | |
| | 2640 | 21.17 | | | 315 | 7.701 | | |
| | 2700 | 21.14 | | | 320 | 7.708 | | |
| | 2760 | 21.17 | | | 325 | 7.726 | | |
| | 2820 | 21.09 | | | 330 | 7.745 | | |
| 10 05 AM | 2880 | 21.05 | | | 335 | 7.753 | | |
| | 2940 | 21 | | | 340 | 7.787 | | |
| | 3000 | 21.09 | | | 345 | 7.805 | | |
| | 3060 | 21 | | | 350 | 7.811 | | |
| | 3180 | 21 | | | 355 | 7.825 | 392 | |
| | 3240 | 21.03 | | | 360 | 7.844 | | |
| | 3300 | 20.98 | | | 365 | 7.872 | | |
| | 3360 | 20.91 | | | 370 | 7.874 | | |
| | 3420 | 20.89 | | | 375 | 7.894 | | |
| | 3480 | 20.96 | | | 380 | 7.901 | | |
| | 3540 | 21.06 | | | 385 | 7.898 | | |
| | 3600 | 21.17 | | | 390 | 7.911 | | |
| | 3660 | 21.29 | | | 395 | 7.919 | | |
| | 3720 | 21.32 | | | 400 | 7.949 | | |
| | 3780 | 21.32 | | | 405 | 7.947 | | |
| | 3840 | 21.35 | | | 410 | 7.959 | 390 | |
| | 4020 | 21.45 | | | 415 | 7.971 | | |
| | 4080 | 21.48 | | | 420 | 7.989 | | |
| | 4140 | 21.52 | | | 425 | 8.002 | | |
| | 4200 | 21.49 | | | 430 | 8.005 | | |
| | 4260 | 21.44 | | | 435 | 8.027 | | July 8th |
| 10 05 AM | 4320 | 21.42 | | | 440 | 8.038 | 0 | end of pumping |
| | 4320.5 | 9.37 | | | 445 | 8.038 | | |
| | 4321 | 9.04 | | | 450 | 8.069 | | |
| | 4322 | 8.67 | | | 455 | 8.084 | | |
| | 4323 | 8.27 | | | 460 | 8.097 | | |
| | 4324 | 8.02 | | | 465 | 8.106 | | |
| | 4325 | 7.82 | | | 470 | 8.11 | | |
| | 4326 | 7.67 | | | 475 | 8.121 | | |
| | 4327 | 7.55 | | | 480 | 8.126 | | |
| | 4328 | 7.47 | | | 485 | 8.148 | | |
| | 4329 | 7.36 | | | 490 | 8.15 | | |
| | 4330 | 7.2876 | | | 495 | 8.161 | | |
| | 4335 | 6.8322 | | | 500 | 8.169 | | |
| | 4340 | 6.5543 | | | 505 | 8.2 | | |
| | 4345 | 6.3452 | | | 510 | 8.194 | | |
| | 4350 | 6.1811 | | | 515 | 8.212 | | |
| | 4355 | 6.0444 | | | 520 | 8.209 | | |
| | 4360 | 5.926 | | | 525 | 8.225 | | |
| | 4365 | 5.8207 | | | 530 | 8.238 | | |
| | 4370 | 5.7276 | | | 535 | 8.237 | | |

| | ELAPSED | Pump Well | ELAPSED | | ELAPSED | | PUMPING | REMARKS |
|---|---|---|---|---|---|---|---|---|
| TIME | TIME (min) | Well 2 | TIME (min) | Well 1 | TIME (min) | Well 3 | RATE (gpm) | |
| | 4375 | 5.6502 | | | 540 | 8.241 | | |
| | 4380 | 5.5689 | | | 545 | 8.259 | | |
| | 4385 | 5.4967 | | | 550 | 8.27 | | |
| | 4390 | 5.4212 | | | 555 | 8.275 | | |
| | 4395 | 5.3526 | | | 560 | 8.283 | | |
| | 4400 | 5.2839 | | | 565 | 8.299 | | |
| | 4405 | 5.219 | | | 570 | 8.298 | | |
| | 4410 | 5.1652 | | | 575 | 8.299 | | |
| | 4415 | 5.09 | | | 580 | 8.303 | | |
| | 4420 | 5.0529 | | | 585 | 8.325 | | |
| | 4425 | 5.0129 | | | 590 | 8.328 | | |
| | 4430 | 4.9494 | | | 595 | 8.327 | | |
| | 4435 | 4.8883 | | | 600 | 8.343 | | |
| | 4440 | 4.8286 | | | 605 | 8.349 | | |
| | 4445 | 4.7755 | | | 610 | 8.367 | | |
| | 4450 | 4.7262 | | | 615 | 8.377 | | |
| | 4455 | 4.6809 | | | 620 | 8.402 | | |
| | 4460 | 4.6333 | | | 625 | 8.413 | | |
| | 4465 | 4.5974 | | | 630 | 8.414 | | |
| | 4470 | 4.5572 | | | 635 | 8.428 | | |
| | 4475 | 4.5141 | | | 640 | 8.433 | | |
| | 4480 | 4.4777 | | | 645 | 8.44 | | |
| | 4485 | 4.441 | | | 650 | 8.439 | | |
| | 4490 | 4.4053 | | | 655 | 8.439 | | |
| | 4495 | 4.3725 | | | 660 | 8.456 | | |
| | 4500 | 4.3401 | | | 665 | 8.462 | | |
| | 4505 | 4.3064 | | | 670 | 8.463 | | |
| | 4510 | 4.2794 | | | 675 | 8.48 | | |
| | 4515 | 4.2514 | | | 680 | 8.497 | | |
| | 4520 | 4.2227 | | | 685 | 8.483 | | |
| | 4525 | 4.1956 | | | 690 | 8.502 | | |
| | 4530 | 4.1707 | | | 695 | 8.509 | | |
| | 4535 | 4.1445 | | | 700 | 8.508 | | |
| | 4540 | 4.1205 | | | 705 | 8.509 | | |
| | 4545 | 4.0947 | | | 710 | 8.518 | | |
| | 4550 | 4.074 | | | 715 | 8.529 | | |
| | 4555 | 4.0466 | | | 720 | 8.539 | | |
| | 4560 | 4.0183 | | | 725 | 8.54 | | |
| | 4565 | 3.9842 | | | 730 | 8.544 | | |
| | 4570 | 3.9579 | | | 735 | 8.537 | | |
| | 4575 | 3.9259 | | | 740 | 8.546 | | |
| | 4580 | 3.922 | | | 745 | 8.561 | | |
| | 4585 | 3.8999 | | | 750 | 8.562 | | |
| | 4590 | 3.8826 | | | 755 | 8.552 | | |
| | 4595 | 3.8645 | | | 760 | 8.564 | | |
| | 4600 | 3.8448 | | | 765 | 8.566 | | |
| | 4605 | 3.8244 | | | 770 | 8.572 | | |
| | 4610 | 3.8086 | | | 775 | 8.582 | | |
| | 4615 | 3.7893 | | | 780 | 8.575 | | |
| | 4620 | 3.7708 | | | 785 | 8.586 | | |
| | 4625 | 3.7552 | | | 790 | 8.586 | | |
| | 4630 | 3.7388 | | | 795 | 8.584 | | |
| | 4635 | 3.7217 | | | 800 | 8.589 | | |
| | 4640 | 3.7061 | | | 805 | 8.615 | | |
| | 4645 | 3.6891 | | | 810 | 8.593 | | |
| | 4650 | 3.676 | | | 815 | 8.595 | | |

| | ELAPSED | Pump Well | ELAPSED | | ELAPSED | | PUMPING | REMARKS |
|---|---|---|---|---|---|---|---|---|
| TIME | TIME (min) | Well 2 | TIME (min) | Well 1 | TIME (min) | Well 3 | RATE (gpm) | |
| | 4655 | 3.6608 | | | 820 | 8.61 | | |
| | 4660 | 3.6515 | | | 825 | 8.611 | | |
| | 4665 | 3.6363 | | | 830 | 8.619 | | |
| | 4670 | 3.6193 | | | 835 | 8.619 | | |
| | 4675 | 3.6037 | | | 840 | 8.628 | | |
| | 4680 | 3.59 | | | 845 | 8.628 | | |
| | 4685 | 3.5751 | | | 850 | 8.628 | | |
| | 4690 | 3.5594 | | | 855 | 8.642 | | |
| | 4695 | 3.5462 | | | 860 | 8.649 | | |
| | 4700 | 3.5333 | | | 865 | 8.647 | | |
| | 4705 | 3.5206 | | | 870 | 8.646 | | |
| | 4710 | 3.5108 | | | 875 | 8.662 | | |
| | 4715 | 3.4968 | | | 880 | 8.651 | | |
| | 4720 | 3.49 | | | 885 | 8.654 | | |
| | 4725 | 3.4773 | | | 890 | 8.671 | | |
| | 4730 | 3.4654 | | | 895 | 8.669 | | |
| | 4735 | 3.4514 | | | 900 | 8.678 | | |
| | 4740 | 3.4423 | | | 905 | 8.683 | | |
| | 4745 | 3.4312 | | | 910 | 8.684 | | |
| | 4750 | 3.4225 | | | 915 | 8.691 | | |
| | 4755 | 3.4111 | | | 920 | 8.691 | | |
| | 4760 | 3.4015 | | | 925 | 8.693 | | |
| | 4765 | 3.3943 | | | 930 | 8.702 | | |
| | 4770 | 3.3834 | | | 935 | 8.711 | | |
| | 4775 | 3.3749 | | | 940 | 8.717 | | |
| | 4780 | 3.3645 | | | 945 | 8.731 | | |
| | 4785 | 3.3536 | | | 950 | 8.728 | | |
| | 4790 | 3.3481 | | | 955 | 8.725 | | |
| | 4795 | 3.3383 | | | 960 | 8.752 | | |
| | 4800 | 3.3265 | | | 965 | 8.751 | | |
| | 4805 | 3.3177 | | | 970 | 8.742 | | |
| | 4810 | 3.3086 | | | 975 | 8.746 | | |
| | 4815 | 3.3002 | | | 980 | 8.758 | | |
| | 4820 | 3.2908 | | | 985 | 8.762 | | |
| | 4825 | 3.2804 | | | 990 | 8.762 | | |
| | 4830 | 3.2709 | | | 995 | 8.766 | | |
| | 4835 | 3.2629 | | | 1000 | 8.771 | | |
| | 4840 | 3.2557 | | | 1005 | 8.771 | | |
| | 4845 | 3.2464 | | | 1010 | 8.784 | | |
| | 4850 | 3.2377 | | | 1015 | 8.773 | | |
| | 4855 | 3.2308 | | | 1020 | 8.775 | | |
| | 4860 | 3.2179 | | | 1025 | 8.791 | | |
| | 4865 | 3.2131 | | | 1030 | 8.801 | | |
| | 4870 | 3.2055 | | | 1035 | 8.803 | | |
| | 4875 | 3.1937 | | | 1040 | 8.808 | | |
| | 4880 | 3.1877 | | | 1045 | 8.81 | | |
| | 4885 | 3.1819 | | | 1050 | 8.824 | | |
| | 4890 | 3.1718 | | | 1055 | 8.82 | | |
| | 4895 | 3.1651 | | | 1060 | 8.818 | | |
| | 4900 | 3.157 | | | 1065 | 8.821 | | |
| | 4905 | 3.1464 | | | 1070 | 8.84 | | |
| | 4910 | 3.1415 | | | 1075 | 8.835 | | |
| | 4915 | 3.1348 | | | 1080 | 8.845 | | |
| | 4920 | 3.1261 | | | 1085 | 8.859 | | |
| | 4925 | 3.1188 | | | 1090 | 8.863 | | |
| | 4930 | 3.1121 | | | 1095 | 8.861 | | |

| | ELAPSED | Pump Well | ELAPSED | | ELAPSED | | PUMPING | REMARKS |
|---|---|---|---|---|---|---|---|---|
| TIME | TIME (min) | Well 2 | TIME (min) | Well 1 | TIME (min) | Well 3 | RATE (gpm) | |
| | 4935 | 3.1066 | | | 1100 | 8.871 | | |
| | 4940 | 3.1005 | | | 1105 | 8.865 | | |
| | 4945 | 3.0937 | | | 1110 | 8.862 | | |
| | 4950 | 3.0877 | | | 1115 | 8.864 | | |
| | 4955 | 3.0796 | | | 1120 | 8.861 | | |
| | 4960 | 3.0719 | | | 1125 | 8.867 | | |
| | 4965 | 3.0653 | | | 1130 | 8.873 | | |
| | 4970 | 3.0572 | | | 1135 | 8.869 | | |
| | 4975 | 3.0514 | | | 1140 | 8.88 | | |
| | 4980 | 3.0459 | | | 1145 | 8.873 | | |
| | 4985 | 3.038 | | | 1150 | 8.89 | | |
| | 4990 | 3.0273 | | | 1155 | 8.88 | | |
| | 4995 | 3.0237 | | | 1160 | 8.883 | | |
| | 5000 | 3.011 | | | 1165 | 8.883 | | |
| | 5005 | 3.0036 | | | 1170 | 8.885 | | |
| | 5010 | 2.9925 | | | 1175 | 8.891 | | |
| | 5015 | 2.9888 | | | 1180 | 8.893 | | |
| | 5020 | 2.9792 | | | 1185 | 8.903 | | |
| | 5025 | 2.9729 | | | 1190 | 8.901 | | |
| | 5030 | 2.9628 | | | 1195 | 8.909 | | |
| | 5035 | 2.9565 | | | 1200 | 8.907 | | |
| | 5040 | 2.949 | | | 1205 | 8.914 | | |
| | 5045 | 2.9436 | | | 1210 | 8.91 | | |
| | 5050 | 2.9394 | | | 1215 | 8.914 | | |
| | 5055 | 2.9299 | | | 1220 | 8.926 | | |
| | 5060 | 2.9258 | | | 1225 | 8.925 | | |
| | 5065 | 2.9164 | | | 1230 | 8.93 | | |
| | 5070 | 2.912 | | | 1235 | 8.937 | | |
| | 5075 | 2.9061 | | | 1240 | 8.945 | | |
| | 5080 | 2.8983 | | | 1245 | 8.962 | | |
| | 5085 | 2.8907 | | | 1250 | 8.977 | | |
| | 5090 | 2.885 | | | 1255 | 8.991 | | |
| | 5095 | 2.8823 | | | 1260 | 9.003 | | |
| | 5100 | 2.8725 | | | 1265 | 9.019 | | |
| | 5105 | 2.8658 | | | 1270 | 9.023 | | |
| | 5110 | 2.8619 | | | 1275 | 9.035 | | |
| | 5115 | 2.8555 | | | 1280 | 9.04 | | |
| | 5120 | 2.8499 | | | 1285 | 9.059 | | |
| | 5125 | 2.8461 | | | 1290 | 9.065 | | |
| | 5130 | 2.8423 | | | 1295 | 9.07 | | |
| | 5135 | 2.8361 | | | 1300 | 9.074 | | |
| | 5140 | 2.8323 | | | 1305 | 9.089 | | |
| | 5145 | 2.8251 | | | 1310 | 9.094 | | |
| | 5150 | 2.8199 | | | 1315 | 9.093 | | |
| | 5155 | 2.8159 | | | 1320 | 9.11 | | |
| | 5160 | 2.8071 | | | 1325 | 9.116 | | |
| | 5165 | 2.8024 | | | 1330 | 9.1 | | |
| | 5170 | 2.7951 | | | 1335 | 9.099 | | |
| | 5175 | 2.7913 | | | 1340 | 9.119 | | |
| | 5180 | 2.7824 | | | 1345 | 9.148 | | |
| | 5185 | 2.7759 | | | 1350 | 9.154 | | |
| | 5190 | 2.7755 | | | 1355 | 9.164 | | |
| | 5195 | 2.7642 | | | 1360 | 9.144 | | |
| | 5200 | 2.7612 | | | 1365 | 9.147 | | |
| | 5205 | 2.7515 | | | 1370 | 9.142 | | |
| | 5210 | 2.7483 | | | 1375 | 9.116 | | |

| | ELAPSED | Pump Well | ELAPSED | | ELAPSED | | PUMPING | REMARKS |
|---|---|---|---|---|---|---|---|---|
| TIME | TIME (min) | Well 2 | TIME (min) | Well 1 | TIME (min) | Well 3 | RATE (gpm) | |
| | 5215 | 2.7411 | | | 1380 | 9.116 | | |
| | 5220 | 2.7391 | | | 1385 | 9.106 | | |
| | 5225 | 2.7319 | | | 1390 | 9.105 | | |
| | 5230 | 2.7278 | | | 1395 | 9.095 | | |
| | 5235 | 2.722 | | | 1400 | 9.099 | | |
| | 5240 | 2.7201 | | | 1405 | 9.106 | | |
| | 5245 | 2.7138 | | | 1410 | 9.088 | | |
| | 5250 | 2.7098 | | | 1415 | 9.104 | | |
| | 5255 | 2.708 | | | 1420 | 9.118 | | |
| | 5260 | 2.7027 | | | 1425 | 9.115 | | |
| | 5265 | 2.7018 | | | 1430 | 9.117 | | |
| | 5270 | 2.6984 | | | 1435 | 9.099 | | |
| | 5275 | 2.694 | | | 1440 | 9.108 | | |
| | 5280 | 2.6911 | | | 1445 | 9.117 | | |
| | 5285 | 2.6871 | | | 1450 | 9.107 | | |
| | 5290 | 2.6823 | | | 1455 | 9.11 | | |
| | 5295 | 2.6783 | | | 1460 | 9.11 | | |
| | 5300 | 2.6731 | | | 1465 | 9.115 | | |
| | 5305 | 2.6694 | | | 1470 | 9.121 | | |
| | 5310 | 2.6642 | | | 1475 | 9.116 | | |
| | 5315 | 2.6651 | | | 1480 | 9.119 | | |
| | 5320 | 2.6647 | | | 1485 | 9.123 | | |
| | 5325 | 2.6636 | | | 1490 | 9.124 | | |
| | 5330 | 2.6592 | | | 1495 | 9.127 | | |
| | 5335 | 2.6546 | | | 1500 | 9.128 | | |
| | 5340 | 2.6524 | | | 1505 | 9.119 | | |
| | 5345 | 2.6492 | | | 1510 | 9.116 | | |
| | 5350 | 2.6454 | | | 1515 | 9.143 | | |
| | 5355 | 2.6354 | | | 1520 | 9.144 | | |
| | 5360 | 2.6308 | | | 1525 | 9.16 | | |
| | 5365 | 2.6259 | | | 1530 | 9.155 | | |
| | 5370 | 2.6202 | | | 1535 | 9.146 | | |
| | 5375 | 2.6172 | | | 1540 | 9.15 | | |
| | 5380 | 2.6158 | | | 1545 | 9.155 | | |
| | 5385 | 2.6126 | | | 1550 | 9.16 | | |
| | 5390 | 2.6115 | | | 1555 | 9.155 | | |
| | 5395 | 2.6063 | | | 1560 | 9.16 | | |
| | 5400 | 2.6035 | | | 1565 | 9.172 | | |
| | 5405 | 2.6033 | | | 1570 | 9.157 | | |
| | 5410 | 2.6045 | | | 1575 | 9.155 | | |
| | 5415 | 2.6005 | | | 1580 | 9.147 | | |
| | 5420 | 2.5982 | | | 1585 | 9.153 | | |
| | 5425 | 2.5945 | | | 1590 | 9.143 | | |
| | 5430 | 2.5914 | | | 1595 | 9.145 | | |
| | 5435 | 2.5911 | | | 1600 | 9.149 | | |
| | 5440 | 2.5842 | | | 1605 | 9.133 | | |
| | 5445 | 2.5813 | | | 1610 | 9.132 | | |
| | 5450 | 2.5799 | | | 1615 | 9.143 | | |
| | 5455 | 2.574 | | | 1620 | 9.142 | | |
| | 5460 | 2.568 | | | 1625 | 9.142 | | |
| | 5465 | 2.5653 | | | 1630 | 9.148 | | |
| | 5470 | 2.5615 | | | 1635 | 9.151 | | |
| | 5475 | 2.5548 | | | 1640 | 9.146 | | |
| | 5480 | 2.5555 | | | 1645 | 9.148 | | |
| | 5485 | 2.552 | | | 1650 | 9.141 | | |
| | 5490 | 2.5471 | | | 1655 | 9.157 | | |

| | ELAPSED | Pump Well | ELAPSED | | ELAPSED | | PUMPING | REMARKS |
|---|---|---|---|---|---|---|---|---|
| TIME | TIME (min) | Well 2 | TIME (min) | Well 1 | TIME (min) | Well 3 | RATE (gpm) | |
| | 5495 | 2.5466 | | | 1660 | 9.184 | | |
| | 5500 | 2.5442 | | | 1665 | 9.216 | | |
| | 5505 | 2.5379 | | | 1670 | 9.229 | | |
| | 5510 | 2.5357 | | | 1675 | 9.228 | | |
| | 5515 | 2.5304 | | | 1680 | 9.223 | | |
| | 5520 | 2.5257 | | | 1685 | 9.214 | | |
| | 5525 | 2.5249 | | | 1690 | 9.211 | | |
| | 5530 | 2.5223 | | | 1695 | 9.212 | | |
| | 5535 | 2.522 | | | 1700 | 9.215 | | |
| | 5540 | 2.5212 | | | 1705 | 9.217 | | |
| | 5545 | 2.5192 | | | 1710 | 9.219 | | |
| | 5550 | 2.5184 | | | 1715 | 9.223 | | |
| | 5555 | 2.5132 | | | 1720 | 9.224 | | |
| | 5560 | 2.5109 | | | 1725 | 9.231 | | |
| | 5565 | 2.5087 | | | 1730 | 9.232 | | |
| | 5570 | 2.5024 | | | 1735 | 9.224 | | |
| | 5575 | 2.4966 | | | 1740 | 9.233 | | |
| | 5580 | 2.4971 | | | 1745 | 9.232 | | |
| | 5585 | 2.4921 | | | 1750 | 9.233 | | |
| | 5590 | 2.4911 | | | 1755 | 9.237 | | |
| | 5595 | 2.4881 | | | 1760 | 9.245 | | |
| | 5600 | 2.4824 | | | 1765 | 9.248 | | |
| | 5605 | 2.4807 | | | 1770 | 9.256 | | |
| | 5610 | 2.4815 | | | 1775 | 9.261 | | |
| | 5615 | 2.4797 | | | 1780 | 9.265 | | |
| | 5620 | 2.4751 | | | 1785 | 9.259 | | |
| | 5625 | 2.4778 | | | 1790 | 9.261 | | |
| | 5630 | 2.4746 | | | 1795 | 9.253 | | |
| | 5635 | 2.4671 | | | 1800 | 9.27 | | |
| | 5640 | 2.4641 | | | 1805 | 9.264 | | |
| | 5645 | 2.4662 | | | 1810 | 9.275 | | |
| | 5650 | 2.4658 | | | 1815 | 9.273 | | |
| | 5655 | 2.4649 | | | 1820 | 9.281 | | |
| | 5660 | 2.4688 | | | 1825 | 9.293 | | |
| | 5665 | 2.4721 | | | 1830 | 9.299 | | |
| | 5670 | 2.4688 | | | 1835 | 9.294 | | |
| | 5675 | 2.4578 | | | 1840 | 9.293 | | |
| | 5680 | 2.4613 | | | 1845 | 9.299 | | |
| | 5685 | 2.4621 | | | 1850 | 9.304 | | |
| | 5690 | 2.4601 | | | 1855 | 9.296 | | |
| | 5695 | 2.4605 | | | 1860 | 9.298 | | |
| | 5700 | 2.4596 | | | 1865 | 9.306 | | |
| | 5705 | 2.4595 | | | 1870 | 9.306 | | |
| | 5710 | 2.4641 | | | 1875 | 9.298 | | |
| | 5715 | 2.4647 | | | 1880 | 9.308 | | |
| | 5720 | 2.4758 | | | 1885 | 9.311 | | |
| | 5725 | 2.5004 | | | 1890 | 9.308 | | |
| | 5730 | 2.5129 | | | 1895 | 9.316 | | |
| | 5735 | 2.5314 | | | 1900 | 9.316 | | |
| | 5740 | 2.5377 | | | 1905 | 9.311 | | |
| | 5745 | 2.5513 | | | 1910 | 9.333 | | |
| | 5750 | 2.5646 | | | 1915 | 9.327 | | |
| | 5755 | 2.5759 | | | 1920 | 9.325 | | |
| | 5760 | 2.5922 | | | 1925 | 9.33 | | |
| | 5765 | 2.6068 | | | 1930 | 9.339 | | |
| | 5770 | 2.6138 | | | 1935 | 9.333 | | |

| | ELAPSED | Pump Well | ELAPSED | | ELAPSED | | PUMPING | REMARKS |
|---|---|---|---|---|---|---|---|---|
| TIME | TIME (min) | Well 2 | TIME (min) | Well 1 | TIME (min) | Well 3 | RATE (gpm) | |
| | 5775 | 2.6217 | | | 1940 | 9.345 | | |
| | 5780 | 2.6293 | | | 1945 | 9.35 | | |
| | 5785 | 2.6206 | | | 1950 | 9.356 | | |
| | 5790 | 2.6036 | | | 1955 | 9.361 | | |
| | 5795 | 2.5818 | | | 1960 | 9.354 | | |
| | 5800 | 2.5669 | | | 1965 | 9.373 | | |
| | 5805 | 2.554 | | | 1970 | 9.37 | | |
| | 5810 | 2.5433 | | | 1975 | 9.371 | | |
| | 5815 | 2.5351 | | | 1980 | 9.374 | | |
| | 5820 | 2.5283 | | | 1985 | 9.389 | | |
| | 5825 | 2.5215 | | | 1990 | 9.379 | | |
| | 5830 | 2.5184 | | | 1995 | 9.389 | | |
| | 5835 | 2.5104 | | | 2000 | 9.386 | | |
| | 5840 | 2.5042 | | | 2005 | 9.387 | | |
| | 5845 | 2.4972 | | | 2010 | 9.383 | | |
| | 5850 | 2.4933 | | | 2015 | 9.371 | | |
| | 5855 | 2.4905 | | | 2020 | 9.395 | | |
| | 5860 | 2.4962 | | | 2025 | 9.399 | | |
| | 5865 | 2.5139 | | | 2030 | 9.394 | | |
| | 5870 | 2.5238 | | | 2035 | 9.393 | | |
| | 5875 | 2.527 | | | 2040 | 9.395 | | |
| | 5880 | 2.5261 | | | 2045 | 9.395 | | |
| | 5885 | 2.5297 | | | 2050 | 9.389 | | |
| | 5890 | 2.5192 | | | 2055 | 9.395 | | |
| | 5895 | 2.5103 | | | 2060 | 9.398 | | |
| | 5900 | 2.5008 | | | 2065 | 9.403 | | |
| | 5905 | 2.4934 | | | 2070 | 9.398 | | |
| | 5910 | 2.4882 | | | 2075 | 9.39 | | |
| | 5915 | 2.4797 | | | 2080 | 9.399 | | |
| | 5920 | 2.476 | | | 2085 | 9.41 | | |
| | 5925 | 2.468 | | | 2090 | 9.411 | | |
| | 5930 | 2.471 | | | 2095 | 9.418 | | |
| | 5935 | 2.4654 | | | 2100 | 9.409 | | |
| | 5940 | 2.4634 | | | 2105 | 9.418 | | |
| | 5945 | 2.4584 | | | 2110 | 9.411 | | |
| | 5950 | 2.4552 | | | 2115 | 9.416 | | |
| | 5955 | 2.4473 | | | 2120 | 9.417 | | |
| | 5960 | 2.4447 | | | 2125 | 9.419 | | |
| | 5965 | 2.4391 | | | 2130 | 9.416 | | |
| | 5970 | 2.4401 | | | 2135 | 9.415 | | |
| | 5975 | 2.432 | | | 2140 | 9.426 | | |
| | 5980 | 2.4327 | | | 2145 | 9.426 | | |
| | 5985 | 2.4266 | | | 2150 | 9.415 | | |
| | 5990 | 2.4219 | | | 2155 | 9.429 | | |
| | 5995 | 2.4144 | | | 2160 | 9.432 | | |
| | 6000 | 2.4103 | | | 2165 | 9.422 | | |
| | 6005 | 2.4066 | | | 2170 | 9.434 | | |
| | 6010 | 2.407 | | | 2175 | 9.422 | | |
| | 6015 | 2.4036 | | | 2180 | 9.41 | | |
| | 6020 | 2.4017 | | | 2185 | 9.411 | | |
| | 6025 | 2.4012 | | | 2190 | 9.409 | | |
| | 6030 | 2.3959 | | | 2195 | 9.415 | | |
| | 6035 | 2.3931 | | | 2200 | 9.409 | | |
| | 6040 | 2.3925 | | | 2205 | 9.406 | | |
| | 6045 | 2.3908 | | | 2210 | 9.412 | | |
| | 6050 | 2.3906 | | | 2215 | 9.408 | | |

| | ELAPSED | Pump Well | ELAPSED | | ELAPSED | | PUMPING | REMARKS |
|---|---|---|---|---|---|---|---|---|
| TIME | TIME (min) | Well 2 | TIME (min) | Well 1 | TIME (min) | Well 3 | RATE (gpm) | |
| | 6055 | 2.3907 | | | 2220 | 9.414 | | |
| | 6060 | 2.3901 | | | 2225 | 9.419 | | |
| | 6065 | 2.3887 | | | 2230 | 9.428 | | |
| | 6070 | 2.3873 | | | 2235 | 9.434 | | |
| | 6075 | 2.3842 | | | 2240 | 9.423 | | |
| | 6080 | 2.3849 | | | 2245 | 9.425 | | |
| | 6085 | 2.3799 | | | 2250 | 9.434 | | |
| | 6090 | 2.3828 | | | 2255 | 9.434 | | |
| | 6095 | 2.3804 | | | 2260 | 9.438 | | |
| | 6100 | 2.379 | | | 2265 | 9.436 | | |
| | 6105 | 2.3816 | | | 2270 | 9.437 | | |
| | 6110 | 2.3807 | | | 2275 | 9.445 | | |
| | 6115 | 2.3782 | | | 2280 | 9.44 | | |
| | 6120 | 2.3741 | | | 2285 | 9.441 | | |
| | 6125 | 2.3697 | | | 2290 | 9.429 | | |
| | 6130 | 2.3692 | | | 2295 | 9.442 | | |
| | 6135 | 2.3637 | | | 2300 | 9.427 | | |
| | 6140 | 2.3638 | | | 2305 | 9.427 | | |
| | 6145 | 2.3629 | | | 2310 | 9.424 | | |
| | 6150 | 2.3605 | | | 2315 | 9.436 | | |
| | 6155 | 2.36 | | | 2320 | 9.431 | | |
| | 6160 | 2.3581 | | | 2325 | 9.424 | | |
| | 6165 | 2.3566 | | | 2330 | 9.433 | | |
| | 6170 | 2.3555 | | | 2335 | 9.429 | | |
| | 6175 | 2.3549 | | | 2340 | 9.424 | | |
| | 6180 | 2.3546 | | | 2345 | 9.429 | | |
| | 6185 | 2.3582 | | | 2350 | 9.433 | | |
| | 6190 | 2.3604 | | | 2355 | 9.429 | | |
| | 6195 | 2.3644 | | | 2360 | 9.446 | | |
| | 6200 | 2.3687 | | | 2365 | 9.437 | | |
| | 6205 | 2.3735 | | | 2370 | 9.433 | | |
| | 6210 | 2.3781 | | | 2375 | 9.435 | | |
| | 6215 | 2.3794 | | | 2380 | 9.441 | | |
| | 6220 | 2.3845 | | | 2385 | 9.434 | | |
| | 6225 | 2.3843 | | | 2390 | 9.438 | | |
| | 6230 | 2.3886 | | | 2395 | 9.437 | | |
| | 6235 | 2.393 | | | 2400 | 9.428 | | |
| | 6240 | 2.3963 | | | 2405 | 9.424 | | |
| | 6245 | 2.4018 | | | 2410 | 9.44 | | |
| | 6250 | 2.4053 | | | 2415 | 9.438 | | |
| | 6255 | 2.412 | | | 2420 | 9.434 | | |
| | 6260 | 2.4124 | | | 2425 | 9.436 | | |
| | 6265 | 2.4158 | | | 2430 | 9.435 | | |
| | 6270 | 2.4226 | | | 2435 | 9.443 | | |
| | 6275 | 2.422 | | | 2440 | 9.434 | | |
| | 6280 | 2.4262 | | | 2445 | 9.445 | | |
| | 6285 | 2.4291 | | | 2450 | 9.43 | | |
| | 6290 | 2.433 | | | 2455 | 9.439 | | |
| | 6295 | 2.4361 | | | 2460 | 9.438 | | |
| | 6300 | 2.4394 | | | 2465 | 9.436 | | |
| | 6305 | 2.4412 | | | 2470 | 9.429 | | |
| | 6310 | 2.4462 | | | 2475 | 9.432 | | |
| | 6315 | 2.4491 | | | 2480 | 9.44 | | |
| | 6320 | 2.455 | | | 2485 | 9.438 | | |
| | 6325 | 2.4557 | | | 2490 | 9.448 | | |
| | 6330 | 2.4557 | | | 2495 | 9.442 | | |

| | ELAPSED | Pump Well | ELAPSED | | ELAPSED | | PUMPING | REMARKS |
|---|---|---|---|---|---|---|---|---|
| TIME | TIME (min) | Well 2 | TIME (min) | Well 1 | TIME (min) | Well 3 | RATE (gpm) | |
| | 6335 | 2.4593 | | | 2500 | 9.441 | | |
| | 6340 | 2.4605 | | | 2505 | 9.44 | | |
| | 6345 | 2.459 | | | 2510 | 9.446 | | |
| | 6350 | 2.4652 | | | 2515 | 9.464 | | |
| | 6355 | 2.4652 | | | 2520 | 9.457 | | |
| | 6360 | 2.465 | | | 2525 | 9.449 | | |
| | 6365 | 2.4636 | | | 2530 | 9.452 | | |
| | 6370 | 2.4668 | | | 2535 | 9.455 | | |
| | 6375 | 2.4644 | | | 2540 | 9.449 | | |
| | 6380 | 2.4623 | | | 2545 | 9.46 | | |
| | 6385 | 2.4603 | | | 2550 | 9.464 | | |
| | 6390 | 2.4588 | | | 2555 | 9.471 | | |
| | 6395 | 2.455 | | | 2560 | 9.461 | | |
| | 6400 | 2.4523 | | | 2565 | 9.473 | | |
| | 6405 | 2.4498 | | | 2570 | 9.467 | | |
| | 6410 | 2.4441 | | | 2575 | 9.482 | | |
| | 6415 | 2.443 | | | 2580 | 9.477 | | |
| | 6420 | 2.4439 | | | 2585 | 9.472 | | |
| | 6425 | 2.4434 | | | 2590 | 9.484 | | |
| | 6430 | 2.4402 | | | 2595 | 9.478 | | |
| | 6435 | 2.4396 | | | 2600 | 9.469 | | |
| | 6440 | 2.4329 | | | 2605 | 9.467 | | |
| | 6445 | 2.4332 | | | 2610 | 9.478 | | |
| | 6450 | 2.4283 | | | 2615 | 9.466 | | |
| | 6455 | 2.428 | | | 2620 | 9.464 | | |
| | 6460 | 2.4217 | | | 2625 | 9.46 | | |
| | 6465 | 2.4189 | | | 2630 | 9.463 | | |
| | 6470 | 2.416 | | | 2635 | 9.46 | | |
| | 6475 | 2.4141 | | | 2640 | 9.456 | | |
| | 6480 | 2.4112 | | | 2645 | 9.469 | | |
| | 6485 | 2.4071 | | | 2650 | 9.464 | | |
| | 6490 | 2.4049 | | | 2655 | 9.459 | | |
| | 6495 | 2.4015 | | | 2660 | 9.457 | | |
| | 6500 | 2.3999 | | | 2665 | 9.455 | | |
| | 6505 | 2.3975 | | | 2670 | 9.456 | | |
| | 6510 | 2.392 | | | 2675 | 9.456 | | |
| | 6515 | 2.3914 | | | 2680 | 9.452 | | |
| | 6520 | 2.3882 | | | 2685 | 9.45 | | |
| | 6525 | 2.3844 | | | 2690 | 9.462 | | |
| | 6530 | 2.3817 | | | 2695 | 9.458 | | |
| | 6535 | 2.3776 | | | 2700 | 9.464 | | |
| | 6540 | 2.3742 | | | 2705 | 9.465 | | |
| | 6545 | 2.3746 | | | 2710 | 9.461 | | |
| | 6550 | 2.3716 | | | 2715 | 9.443 | | |
| | 6555 | 2.371 | | | 2720 | 9.433 | | |
| | 6560 | 2.3709 | | | 2725 | 9.463 | | |
| | 6565 | 2.3667 | | | 2730 | 9.457 | | |
| | 6570 | 2.3604 | | | 2735 | 9.473 | | |
| | 6575 | 2.3586 | | | 2740 | 9.469 | | |
| | 6580 | 2.3601 | | | 2745 | 9.484 | | |
| | 6585 | 2.3551 | | | 2750 | 9.496 | | |
| | 6590 | 2.351 | | | 2755 | 9.516 | | |
| | 6595 | 2.3549 | | | 2760 | 9.525 | | |
| | 6600 | 2.3504 | | | 2765 | 9.539 | | |
| | 6605 | 2.3473 | | | 2770 | 9.534 | | |
| | 6610 | 2.3473 | | | 2775 | 9.538 | | |

| | ELAPSED | Pump Well | ELAPSED | | ELAPSED | | PUMPING | REMARKS |
|---|---|---|---|---|---|---|---|---|
| TIME | TIME (min) | Well 2 | TIME (min) | Well 1 | TIME (min) | Well 3 | RATE (gpm) | |
| | 6615 | 2.346 | | | 2780 | 9.551 | | |
| | 6620 | 2.3413 | | | 2785 | 9.555 | | |
| | 6625 | 2.3404 | | | 2790 | 9.563 | | |
| | 6630 | 2.3359 | | | 2795 | 9.55 | | |
| | 6635 | 2.3391 | | | 2800 | 9.542 | | |
| | 6640 | 2.3377 | | | 2805 | 9.54 | | |
| | 6645 | 2.3347 | | | 2810 | 9.544 | | |
| | 6650 | 2.3313 | | | 2815 | 9.549 | | |
| | 6655 | 2.3293 | | | 2820 | 9.54 | | |
| | 6660 | 2.3273 | | | 2825 | 9.539 | | |
| | 6665 | 2.3235 | | | 2830 | 9.531 | | |
| | 6670 | 2.3242 | | | 2835 | 9.529 | | |
| | 6675 | 2.318 | | | 2840 | 9.529 | | |
| | 6680 | 2.3151 | | | 2845 | 9.51 | | |
| | 6685 | 2.3104 | | | 2850 | 9.516 | | |
| | 6690 | 2.3094 | | | 2855 | 9.529 | | |
| | 6695 | 2.3062 | | | 2860 | 9.539 | | |
| | 6700 | 2.3056 | | | 2865 | 9.543 | | |
| | 6705 | 2.305 | | | 2870 | 9.562 | | |
| | 6710 | 2.305 | | | 2875 | 9.553 | | |
| | 6715 | 2.3015 | | | 2880 | 9.569 | | |
| | 6720 | 2.2947 | | | 2885 | 9.551 | | |
| | 6725 | 2.2944 | | | 2890 | 9.539 | | |
| | 6730 | 2.2918 | | | 2895 | 9.523 | | |
| | 6735 | 2.2901 | | | 2900 | 9.526 | | |
| | 6740 | 2.2905 | | | 2905 | 9.512 | | |
| | 6745 | 2.2872 | | | 2910 | 9.505 | | |
| | 6750 | 2.2862 | | | 2915 | 9.502 | | |
| | 6755 | 2.2843 | | | 2920 | 9.495 | | |
| | 6760 | 2.2832 | | | 2925 | 9.495 | | |
| | 6765 | 2.2797 | | | 2930 | 9.494 | | |
| | 6770 | 2.2789 | | | 2935 | 9.476 | | |
| | 6775 | 2.2803 | | | 2940 | 9.479 | | |
| | 6780 | 2.2784 | | | 2945 | 9.498 | | |
| | 6785 | 2.2813 | | | 2950 | 9.498 | | |
| | 6790 | 2.2764 | | | 2955 | 9.503 | | |
| | 6795 | 2.2767 | | | 2960 | 9.507 | | |
| | 6800 | 2.276 | | | 2965 | 9.504 | | |
| | 6805 | 2.2785 | | | 2970 | 9.5 | | |
| | 6810 | 2.2737 | | | 2975 | 9.494 | | |
| | 6815 | 2.271 | | | 2980 | 9.503 | | |
| | 6820 | 2.2711 | | | 2985 | 9.5 | | |
| | 6825 | 2.2755 | | | 2990 | 9.493 | | |
| | 6830 | 2.2704 | | | 2995 | 9.479 | | |
| | 6835 | 2.2666 | | | 3000 | 9.485 | | |
| | 6840 | 2.2656 | | | 3005 | 9.513 | | |
| | 6845 | 2.2614 | | | 3010 | 9.522 | | |
| | 6850 | 2.2603 | | | 3015 | 9.523 | | |
| | 6855 | 2.2607 | | | 3020 | 9.502 | | |
| | 6860 | 2.2572 | | | 3025 | 9.513 | | |
| | 6865 | 2.2535 | | | 3030 | 9.507 | | |
| | 6870 | 2.2584 | | | 3035 | 9.492 | | |
| | 6875 | 2.2602 | | | 3040 | 9.491 | | |
| | 6880 | 2.2611 | | | 3045 | 9.487 | | |
| | 6885 | 2.2606 | | | 3050 | 9.486 | | |
| | 6890 | 2.2518 | | | 3055 | 9.48 | | |

| | ELAPSED | Pump Well | ELAPSED | | ELAPSED | | PUMPING | REMARKS |
|---|---|---|---|---|---|---|---|---|
| TIME | TIME (min) | Well 2 | TIME (min) | Well 1 | TIME (min) | Well 3 | RATE (gpm) | |
| | 6895 | 2.253 | | | 3060 | 9.478 | | |
| | 6900 | 2.2547 | | | 3065 | 9.475 | | |
| | 6905 | 2.2516 | | | 3070 | 9.475 | | |
| | 6910 | 2.2503 | | | 3075 | 9.472 | | |
| | 6915 | 2.2488 | | | 3080 | 9.468 | | |
| | 6920 | 2.2483 | | | 3085 | 9.47 | | |
| | 6925 | 2.2461 | | | 3090 | 9.465 | | |
| | 6930 | 2.2451 | | | 3095 | 9.473 | | |
| | 6935 | 2.2381 | | | 3100 | 9.469 | | |
| | 6940 | 2.2334 | | | 3105 | 9.467 | | |
| | 6945 | 2.2345 | | | 3110 | 9.47 | | |
| | 6950 | 2.2316 | | | 3115 | 9.466 | | |
| | 6955 | 2.234 | | | 3120 | 9.469 | | |
| | 6960 | 2.2331 | | | 3125 | 9.469 | | |
| | 6965 | 2.231 | | | 3130 | 9.466 | | |
| | 6970 | 2.2318 | | | 3135 | 9.461 | | |
| | 6975 | 2.2311 | | | 3140 | 9.469 | | |
| | 6980 | 2.2289 | | | 3145 | 9.465 | | |
| | 6985 | 2.232 | | | 3150 | 9.466 | | |
| | 6990 | 2.2344 | | | 3155 | 9.452 | | |
| | 6995 | 2.2305 | | | 3160 | 9.47 | | |
| | 7000 | 2.2354 | | | 3165 | 9.46 | | |
| | 7005 | 2.2378 | | | 3170 | 9.461 | | |
| | 7010 | 2.2398 | | | 3175 | 9.456 | | |
| | 7015 | 2.2421 | | | 3180 | 9.463 | | |
| | 7020 | 2.2403 | | | 3185 | 9.461 | | |
| | 7025 | 2.2354 | | | 3190 | 9.472 | | |
| | 7030 | 2.2284 | | | 3195 | 9.482 | | |
| | 7035 | 2.224 | | | 3200 | 9.476 | | |
| | 7040 | 2.2153 | | | 3205 | 9.48 | | |
| | 7045 | 2.2174 | | | 3210 | 9.478 | | |
| | 7050 | 2.2281 | | | 3215 | 9.486 | | |
| | 7055 | 2.2392 | | | 3220 | 9.486 | | |
| | 7060 | 2.2444 | | | 3225 | 9.492 | | |
| | 7065 | 2.2473 | | | 3230 | 9.489 | | |
| | 7070 | 2.2503 | | | 3235 | 9.496 | | |
| | 7075 | 2.2562 | | | 3240 | 9.509 | | |
| | 7080 | 2.2614 | | | 3245 | 9.483 | | |
| | 7085 | 2.2874 | | | 3250 | 9.483 | | |
| | 7090 | 2.3065 | | | 3255 | 9.485 | | |
| | 7095 | 2.33 | | | 3260 | 9.478 | | |
| | 7100 | 2.3432 | | | 3265 | 9.475 | | |
| | 7105 | 2.3563 | | | 3270 | 9.477 | | |
| | 7110 | 2.3741 | | | 3275 | 9.491 | | |
| | 7115 | 2.386 | | | 3280 | 9.485 | | |
| | 7120 | 2.3943 | | | 3285 | 9.48 | | |
| | 7125 | 2.4008 | | | 3290 | 9.486 | | |
| | 7130 | 2.4062 | | | 3295 | 9.487 | | |
| | 7135 | 2.4145 | | | 3300 | 9.482 | | |
| | 7140 | 2.42 | | | 3305 | 9.489 | | |
| | 7145 | 2.406 | | | 3310 | 9.487 | | |
| | 7150 | 2.4057 | | | 3315 | 9.493 | | |
| | 7155 | 2.4014 | | | 3320 | 9.488 | | |
| | 7160 | 2.4094 | | | 3325 | 9.489 | | |
| | 7165 | 2.4188 | | | 3330 | 9.482 | | |
| | 7170 | 2.4244 | | | 3335 | 9.487 | | |

Friesen DRILLERS

# Appendix I

# Analytical Laboratory Data (L2721308, L2721317 and L27225315)

Friesen Drillers Ltd
ATTN: PAULYNN ESTRELLA
307 PTH 12 N
Steinbach MB R5G 1L9

Date Received: 11-JUL-22
Report Date: 28-JUL-22 10:18 (MT)
Version: FINAL

Client Phone: 204-326-2485

# Certificate of Analysis

Lab Work Order #: L2721308
Project P.O. #: RANDOLPH WELL FIELD
Job Reference: RM OF RITCHOT
C of C Numbers:
Legal Site Desc:

[redacted]
Hua Wo
Chemistry Laboratory Manager

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# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2721308-1 WELL 2-72 HOURS | | | | | | | |
| Sampled By: CLIENT on 08-JUL-22 @ 22:00 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **MB Chemistry for PWS** | | | | | | | |
| **Alkalinity, Bicarbonate** | | | | | | | |
| Bicarbonate (HCO3) | 399 | | 1.2 | mg/L | | 15-JUL-22 | |
| **Alkalinity, Carbonate** | | | | | | | |
| Carbonate (CO3) | <0.60 | | 0.60 | mg/L | | 15-JUL-22 | |
| **Alkalinity, Hydroxide** | | | | | | | |
| Hydroxide (OH) | <0.34 | | 0.34 | mg/L | | 15-JUL-22 | |
| **Alkalinity, Total (as CaCO3)** | | | | | | | |
| Alkalinity, Total (as CaCO3) | 327 | | 1.0 | mg/L | | 14-JUL-22 | R5822357 |
| **Ammonia by colour** | | | | | | | |
| Ammonia, Total (as N) | 0.94 | | 0.10 | mg/L | | 18-JUL-22 | R5827665 |
| **Bromide in Water by IC (Low Level)** | | | | | | | |
| Bromide (Br) | 0.069 | | 0.010 | mg/L | | 11-JUL-22 | R5822060 |
| **Chloride in Water by IC (Low Level)** | | | | | | | |
| Chloride (Cl) | 39.2 | | 0.10 | mg/L | | 11-JUL-22 | R5822060 |
| **Colour, True** | | | | | | | |
| Colour, True | <5.0 | | 5.0 | CU | | 11-JUL-22 | R5821503 |
| **Conductivity** | | | | | | | |
| Conductivity | 688 | | 1.0 | umhos/cm | | 14-JUL-22 | R5822357 |
| **Dissolved Organic Carbon by Combustion** | | | | | | | |
| Dissolved Organic Carbon | 1.92 | | 0.50 | mg/L | | 27-JUL-22 | R5829339 |
| **Fluoride in Water by IC** | | | | | | | |
| Fluoride (F) | 0.595 | | 0.020 | mg/L | | 11-JUL-22 | R5822060 |
| **Hardness Calculated** | | | | | | | |
| Hardness (as CaCO3) | 231 | HTC | 0.20 | mg/L | | 15-JUL-22 | |
| **Langelier Index 4C** | | | | | | | |
| Langelier Index (4 C) | 0.64 | | | | | 22-JUL-22 | |
| **Langelier Index 60C** | | | | | | | |
| Langelier Index (60 C) | 1.4 | | | | | 22-JUL-22 | |
| **Nitrate in Water by IC (Low Level)** | | | | | | | |
| Nitrate (as N) | <0.0050 | | 0.0050 | mg/L | | 11-JUL-22 | R5822060 |
| **Nitrite in Water by IC (Low Level)** | | | | | | | |
| Nitrite (as N) | <0.0010 | | 0.0010 | mg/L | | 11-JUL-22 | R5822060 |
| **Sulfate in Water by IC** | | | | | | | |
| Sulfate (SO4) | <0.30 | | 0.30 | mg/L | | 11-JUL-22 | R5822060 |
| **Total Dissolved Solids (TDS)** | | | | | | | |
| Total Dissolved Solids | 392 | | 20 | mg/L | | 13-JUL-22 | R5822214 |
| **Total Metals in Water by CRC ICPMS** | | | | | | | |
| Aluminum (Al)-Total | <0.0030 | | 0.0030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Antimony (Sb)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Arsenic (As)-Total | 0.00015 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Barium (Ba)-Total | 0.395 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Beryllium (Be)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Bismuth (Bi)-Total | <0.000050 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Boron (B)-Total | 0.327 | | 0.010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cadmium (Cd)-Total | <0.0000050 | | 0.0000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Calcium (Ca)-Total | 44.9 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cesium (Cs)-Total | 0.000017 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Chromium (Cr)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cobalt (Co)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Copper (Cu)-Total | <0.00050 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Iron (Fe)-Total | 0.537 | | 0.010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Lead (Pb)-Total | <0.000050 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2721308-1 WELL 2-72 HOURS | | | | | | | |
| Sampled By: CLIENT on 08-JUL-22 @ 22:00 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Total Metals in Water by CRC ICPMS** | | | | | | | |
| Lithium (Li)-Total | 0.0323 | | 0.0010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Magnesium (Mg)-Total | 28.9 | | 0.0050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Manganese (Mn)-Total | 0.00580 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Molybdenum (Mo)-Total | 0.00103 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Nickel (Ni)-Total | <0.00050 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Potassium (K)-Total | 7.53 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Phosphorus (P)-Total | <0.050 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Rubidium (Rb)-Total | 0.00451 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Selenium (Se)-Total | <0.000050 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Silicon (Si)-Total | 6.36 | | 0.10 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Silver (Ag)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Sodium (Na)-Total | 69.6 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Strontium (Sr)-Total | 0.476 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tellurium (Te)-Total | <0.00020 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Thallium (Tl)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Thorium (Th)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tin (Sn)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Titanium (Ti)-Total | <0.00030 | | 0.00030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tungsten (W)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Uranium (U)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Vanadium (V)-Total | <0.00050 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Zinc (Zn)-Total | <0.0030 | | 0.0030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Zirconium (Zr)-Total | <0.00020 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| **Total Organic Carbon by Combustion** | | | | | | | |
| Total Organic Carbon | 2.95 | | 0.50 | mg/L | | 24-JUL-22 | R5828415 |
| **Turbidity** | | | | | | | |
| Turbidity | 2.30 | | 0.10 | NTU | | 11-JUL-22 | R5820259 |
| **UV Transmittance (Calculated)** | | | | | | | |
| Transmittance, UV (254 nm) | 86.1 | | 1.0 | %T/cm | | 12-JUL-22 | R5822505 |
| **pH** | | | | | | | |
| pH | 8.17 | | 0.10 | pH units | | 14-JUL-22 | R5822357 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## Sample Parameter Qualifier Key:

| Qualifier | Description |
|---|---|
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| ALK-CO3CO3-CALC-WP | Water | Alkalinity, Carbonate | CALCULATION |
| The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contr buted by carbonate is calculated and reported as mg CO3 2-/L. | | | |
| ALK-HCO3HCO3-CALC-WP | Water | Alkalinity, Bicarbonate | CALCULATION |
| The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contr buted by bicarbonate is calculated and reported as mg HCO3-/L | | | |
| ALK-OHOH-CALC-WP | Water | Alkalinity, Hydroxide | CALCULATION |
| The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contr buted by hydroxide is calculated and reported as mg OH-/L. | | | |
| ALK-TITR-WP | Water | Alkalinity, Total (as CaCO3) | APHA 2320B |
| The Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. Total alkalinity is determined by titration with a strong standard mineral acid to the successive HCO3- and H2CO3 endpoints indicated electrometrically. | | | |
| BR-L-IC-N-WP | Water | Bromide in Water by IC (Low Level) | EPA 300.1 (mod)-LR |
| Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection. | | | |
| C-DOC-HTC-WP | Water | Dissolved Organic Carbon by Combustion | APHA 5310 B-WP |
| Filtered (0.45 um) sample is acidified and purged to remove inorganic carbon, then injected into a heated reaction chamber where organic carbon is oxidized to CO2 which is then transported in the carrier gas stream and measured via a non-dispersive infrared analyzer. | | | |
| C-TOC-HTC-WP | Water | Total Organic Carbon by Combustion | APHA 5310 B-WP |
| Sample is acidified and purged to remove inorganic carbon, then injected into a heated reaction chamber where organic carbon is oxidized to CO2 which is then transported in the carrier gas stream and measured via a non-dispersive infrared analyzer. | | | |
| CL-L-IC-N-WP | Water | Chloride in Water by IC (Low Level) | EPA 300.1 (mod) |
| Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection. | | | |
| COLOUR-TRUE-WP | Water | Colour, True | APHA 2120C |
| True Colour is measured spectrophotometrically by comparison to platinum-cobalt standards using the single wavelength method (450 - 465 nm) after filtration of sample through a 0.45 um filter. Colour measurements can be highly pH dependent, and apply to the pH of the sample as received (at time of testing), without pH adjustment. Concurrent measurement of sample pH is recommended. | | | |
| EC-SCREEN-WP | Water | Conductivity Screen (Internal Use Only) | APHA 2510 |
| Qualitative analysis of conductivity where required during preparation of other test eg. IC, TDS, TSS, etc | | | |
| EC-WP | Water | Conductivity | APHA 2510B |
| Conductivity of an aqueous solution refers to its ability to carry an electric current. Conductance of a solution is measured between two spatially fixed and chemically inert electrodes. | | | |
| ETL-LANGELIER-4-WP | Water | Langelier Index 4C | Calculated |
| ETL-LANGELIER-60-WP | Water | Langelier Index 60C | Calculated |
| F-IC-N-WP | Water | Fluoride in Water by IC | EPA 300.1 (mod) |
| Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection. | | | |
| HARDNESS-CALC-WP | Water | Hardness Calculated | APHA 2340B |
| Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation. | | | |

# Reference Information

**Test Method References:**

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| IONBALANCE-CALC-WP | Water | Ion Balance Calculation | APHA 1030E |

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance (as % difference) cannot be calculated accurately for waters with very low electrical conductivity (EC), and is reported as "Low EC" where EC < 100 uS/cm (umhos/cm). Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

| | | | |
|---|---|---|---|
| MET-T-CCMS-WP | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020B (mod.) |

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

| | | | |
|---|---|---|---|
| NH3-COL-WP | Water | Ammonia by colour | APHA 4500 NH3 F |

Ammonia in water samples forms indophenol when reacted with hypochlorite and phenol. The intensity is amplified by the addition of sodium nitroprusside and measured colourmetrically.

| | | | |
|---|---|---|---|
| NO2-L-IC-N-WP | Water | Nitrite in Water by IC (Low Level) | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| | | | |
|---|---|---|---|
| NO3-L-IC-N-WP | Water | Nitrate in Water by IC (Low Level) | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| | | | |
|---|---|---|---|
| PH-WP | Water | pH | APHA 4500H |

The pH of a sample is the determination of the activity of the hydrogen ions by potentiometric measurement using a standard hydrogen electrode and a reference electrode.

| | | | |
|---|---|---|---|
| SO4-IC-N-WP | Water | Sulfate in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| | | | |
|---|---|---|---|
| TDS-WP | Water | Total Dissolved Solids (TDS) | APHA 2540 SOLIDS C,E |

A well-mixed sample is filtered through a glass fiber filter paper. The filtrate is then evaportaed to dryness in a pre-weighed vial and dried at 180 – 2C. The increase in vial weight represents the total dissolved solids.

| | | | |
|---|---|---|---|
| TURBIDITY-WP | Water | Turbidity | APHA 2130B (modified) |

Turbidity in aqueous matrices is determined by the nephelometric method.

| | | | |
|---|---|---|---|
| UV-%TRANS-WP | Water | UV Transmittance (Calculated) | APHA 5910B |

Test method is adapted from APHA Method 5910B. A sample is filtered through a 0.45 um polyethersulfone (PES) filter and its UV Absorbance is measured in a quartz cell at 254 nm. UV Transmittance is calculated from the UV Absorbance result and reported as UV Transmittance per cm. The analysis is carried out without pH adjustment.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WP | ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA |

**Chain of Custody Numbers:**

# Reference Information

**Test Method References:**

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*
*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report



Client: Friesen Drillers Ltd
307 PTH 12 N
Steinbach MB R5G 1L9
Contact: PAULYNN ESTRELLA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **ALK-TITR-WP** | **Water** | | | | | | | |
| **Batch R5822357** | | | | | | | | |
| **WG3749556-24 LCS** | | | | | | | | |
| Alkalinity, Total (as CaCO3) | | | 102.6 | | % | | 85-115 | 14-JUL-22 |
| **WG3749556-21 MB** | | | | | | | | |
| Alkalinity, Total (as CaCO3) | | | <1.0 | | mg/L | | 1 | 14-JUL-22 |
| **BR-L-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5822060** | | | | | | | | |
| **WG3748211-2 LCS** | | | | | | | | |
| Bromide (Br) | | | 101.5 | | % | | 85-115 | 11-JUL-22 |
| **WG3748211-1 MB** | | | | | | | | |
| Bromide (Br) | | | <0.010 | | mg/L | | 0.01 | 11-JUL-22 |
| **C-DOC-HTC-WP** | **Water** | | | | | | | |
| **Batch R5829339** | | | | | | | | |
| **WG3752695-6 LCS** | | | | | | | | |
| Dissolved Organic Carbon | | | 95.9 | | % | | 80-120 | 27-JUL-22 |
| **WG3752695-5 MB** | | | | | | | | |
| Dissolved Organic Carbon | | | <0.50 | | mg/L | | 0.5 | 27-JUL-22 |
| **C-TOC-HTC-WP** | **Water** | | | | | | | |
| **Batch R5828415** | | | | | | | | |
| **WG3752121-6 LCS** | | | | | | | | |
| Total Organic Carbon | | | 105.8 | | % | | 80-120 | 24-JUL-22 |
| **WG3752121-5 MB** | | | | | | | | |
| Total Organic Carbon | | | <0.50 | | mg/L | | 0.5 | 24-JUL-22 |
| **CL-L-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5822060** | | | | | | | | |
| **WG3748211-2 LCS** | | | | | | | | |
| Chloride (Cl) | | | 97.9 | | % | | 90-110 | 11-JUL-22 |
| **WG3748211-1 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.10 | | mg/L | | 0.1 | 11-JUL-22 |
| **COLOUR-TRUE-WP** | **Water** | | | | | | | |
| **Batch R5821503** | | | | | | | | |
| **WG3748579-2 LCS** | | | | | | | | |
| Colour, True | | | 106.1 | | % | | 85-115 | 11-JUL-22 |
| **WG3748579-1 MB** | | | | | | | | |
| Colour, True | | | <5.0 | | CU | | 5 | 11-JUL-22 |
| **EC-WP** | **Water** | | | | | | | |

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **EC-WP** | **Water** | | | | | | | |
| **Batch R5822357** | | | | | | | | |
| **WG3749556-23 LCS** | | | | | | | | |
| Conductivity | | | 98.7 | | % | | 90-110 | 14-JUL-22 |
| **WG3749556-21 MB** | | | | | | | | |
| Conductivity | | | <1.0 | | umhos/cm | | 1 | 14-JUL-22 |
| **F-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5822060** | | | | | | | | |
| **WG3748211-2 LCS** | | | | | | | | |
| Fluoride (F) | | | 102.4 | | % | | 90-110 | 11-JUL-22 |
| **WG3748211-1 MB** | | | | | | | | |
| Fluoride (F) | | | <0.020 | | mg/L | | 0.02 | 11-JUL-22 |
| **MET-T-CCMS-WP** | **Water** | | | | | | | |
| **Batch R5822448** | | | | | | | | |
| **WG3748866-2 LCS** | | | | | | | | |
| Aluminum (Al)-Total | | | 109.3 | | % | | 80-120 | 14-JUL-22 |
| Antimony (Sb)-Total | | | 103.6 | | % | | 80-120 | 14-JUL-22 |
| Arsenic (As)-Total | | | 98.5 | | % | | 80-120 | 14-JUL-22 |
| Barium (Ba)-Total | | | 102.7 | | % | | 80-120 | 14-JUL-22 |
| Beryllium (Be)-Total | | | 109.2 | | % | | 80-120 | 14-JUL-22 |
| Bismuth (Bi)-Total | | | 98.5 | | % | | 80-120 | 14-JUL-22 |
| Boron (B)-Total | | | 106.9 | | % | | 80-120 | 14-JUL-22 |
| Cadmium (Cd)-Total | | | 102.2 | | % | | 80-120 | 14-JUL-22 |
| Calcium (Ca)-Total | | | 101.5 | | % | | 80-120 | 14-JUL-22 |
| Cesium (Cs)-Total | | | 98.2 | | % | | 80-120 | 14-JUL-22 |
| Chromium (Cr)-Total | | | 101.4 | | % | | 80-120 | 14-JUL-22 |
| Cobalt (Co)-Total | | | 97.6 | | % | | 80-120 | 14-JUL-22 |
| Copper (Cu)-Total | | | 95.3 | | % | | 80-120 | 14-JUL-22 |
| Iron (Fe)-Total | | | 98.5 | | % | | 80-120 | 14-JUL-22 |
| Lead (Pb)-Total | | | 96.5 | | % | | 80-120 | 14-JUL-22 |
| Lithium (Li)-Total | | | 113.4 | | % | | 80-120 | 14-JUL-22 |
| Magnesium (Mg)-Total | | | 106.1 | | % | | 80-120 | 14-JUL-22 |
| Manganese (Mn)-Total | | | 102.0 | | % | | 80-120 | 14-JUL-22 |
| Molybdenum (Mo)-Total | | | 100.9 | | % | | 80-120 | 14-JUL-22 |
| Nickel (Ni)-Total | | | 96.6 | | % | | 80-120 | 14-JUL-22 |
| Potassium (K)-Total | | | 104.5 | | % | | 80-120 | 14-JUL-22 |
| Phosphorus (P)-Total | | | 114.5 | | % | | 80-120 | 14-JUL-22 |
| Rubidium (Rb)-Total | | | 98.4 | | % | | 80-120 | 14-JUL-22 |

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **MET-T-CCMS-WP** | **Water** | | | | | | | |
| **Batch R5822448** | | | | | | | | |
| **WG3748866-2 LCS** | | | | | | | | |
| Selenium (Se)-Total | | | 95.1 | | % | | 80-120 | 14-JUL-22 |
| Silicon (Si)-Total | | | 112.2 | | % | | 80-120 | 14-JUL-22 |
| Silver (Ag)-Total | | | 97.7 | | % | | 80-120 | 14-JUL-22 |
| Sodium (Na)-Total | | | 107.9 | | % | | 80-120 | 14-JUL-22 |
| Strontium (Sr)-Total | | | 101.3 | | % | | 80-120 | 14-JUL-22 |
| Tellurium (Te)-Total | | | 87.4 | | % | | 80-120 | 14-JUL-22 |
| Thallium (Tl)-Total | | | 99.7 | | % | | 80-120 | 14-JUL-22 |
| Thorium (Th)-Total | | | 93.0 | | % | | 80-120 | 14-JUL-22 |
| Tin (Sn)-Total | | | 98.7 | | % | | 80-120 | 14-JUL-22 |
| Titanium (Ti)-Total | | | 100.5 | | % | | 80-120 | 14-JUL-22 |
| Tungsten (W)-Total | | | 98.1 | | % | | 80-120 | 14-JUL-22 |
| Uranium (U)-Total | | | 93.4 | | % | | 80-120 | 14-JUL-22 |
| Vanadium (V)-Total | | | 103.6 | | % | | 80-120 | 14-JUL-22 |
| Zinc (Zn)-Total | | | 101.6 | | % | | 80-120 | 14-JUL-22 |
| Zirconium (Zr)-Total | | | 95.7 | | % | | 80-120 | 14-JUL-22 |
| **WG3748866-1 MB** | | | | | | | | |
| Aluminum (Al)-Total | | | <0.0030 | | mg/L | | 0.003 | 14-JUL-22 |
| Antimony (Sb)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Arsenic (As)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Barium (Ba)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Beryllium (Be)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Bismuth (Bi)-Total | | | <0.000050 | | mg/L | | 0.00005 | 14-JUL-22 |
| Boron (B)-Total | | | <0.010 | | mg/L | | 0.01 | 14-JUL-22 |
| Cadmium (Cd)-Total | | | <0.000005C | | mg/L | | 0.000005 | 14-JUL-22 |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 14-JUL-22 |
| Cesium (Cs)-Total | | | <0.000010 | | mg/L | | 0.00001 | 14-JUL-22 |
| Chromium (Cr)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Cobalt (Co)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Copper (Cu)-Total | | | <0.00050 | | mg/L | | 0.0005 | 14-JUL-22 |
| Iron (Fe)-Total | | | <0.010 | | mg/L | | 0.01 | 14-JUL-22 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 14-JUL-22 |
| Lithium (Li)-Total | | | <0.0010 | | mg/L | | 0.001 | 14-JUL-22 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 14-JUL-22 |
| Manganese (Mn)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **MET-T-CCMS-WP** | **Water** | | | | | | | |
| **Batch R5822448** | | | | | | | | |
| **WG3748866-1 MB** | | | | | | | | |
| Molybdenum (Mo)-Total | | | <0.000050 | | mg/L | | 0.00005 | 14-JUL-22 |
| Nickel (Ni)-Total | | | <0.00050 | | mg/L | | 0.0005 | 14-JUL-22 |
| Potassium (K)-Total | | | <0.050 | | mg/L | | 0.05 | 14-JUL-22 |
| Phosphorus (P)-Total | | | <0.030 | | mg/L | | 0.03 | 14-JUL-22 |
| Rubidium (Rb)-Total | | | <0.00020 | | mg/L | | 0.0002 | 14-JUL-22 |
| Selenium (Se)-Total | | | <0.000050 | | mg/L | | 0.00005 | 14-JUL-22 |
| Silicon (Si)-Total | | | <0.10 | | mg/L | | 0.1 | 14-JUL-22 |
| Silver (Ag)-Total | | | <0.000010 | | mg/L | | 0.00001 | 14-JUL-22 |
| Sodium (Na)-Total | | | <0.050 | | mg/L | | 0.05 | 14-JUL-22 |
| Strontium (Sr)-Total | | | <0.00020 | | mg/L | | 0.0002 | 14-JUL-22 |
| Tellurium (Te)-Total | | | <0.00020 | | mg/L | | 0.0002 | 14-JUL-22 |
| Thallium (Tl)-Total | | | <0.000010 | | mg/L | | 0.00001 | 14-JUL-22 |
| Thorium (Th)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Tin (Sn)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Titanium (Ti)-Total | | | <0.00030 | | mg/L | | 0.0003 | 14-JUL-22 |
| Tungsten (W)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Uranium (U)-Total | | | <0.000010 | | mg/L | | 0.00001 | 14-JUL-22 |
| Vanadium (V)-Total | | | <0.00050 | | mg/L | | 0.0005 | 14-JUL-22 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 14-JUL-22 |
| Zirconium (Zr)-Total | | | <0.00020 | | mg/L | | 0.0002 | 14-JUL-22 |
| **NH3-COL-WP** | **Water** | | | | | | | |
| **Batch R5827665** | | | | | | | | |
| **WG3750748-14 LCS** | | | | | | | | |
| Ammonia, Total (as N) | | | 100.5 | | % | | 85-115 | 18-JUL-22 |
| **WG3750748-13 MB** | | | | | | | | |
| Ammonia, Total (as N) | | | <0.010 | | mg/L | | 0.01 | 18-JUL-22 |
| **NO2-L-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5822060** | | | | | | | | |
| **WG3748211-2 LCS** | | | | | | | | |
| Nitrite (as N) | | | 99.9 | | % | | 90-110 | 11-JUL-22 |
| **WG3748211-1 MB** | | | | | | | | |
| Nitrite (as N) | | | <0.0010 | | mg/L | | 0.001 | 11-JUL-22 |
| **NO3-L-IC-N-WP** | **Water** | | | | | | | |

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-L-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5822060** | | | | | | | | |
| **WG3748211-2 LCS** | | | | | | | | |
| Nitrate (as N) | | | 98.4 | | % | | 90-110 | 11-JUL-22 |
| **WG3748211-1 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.0050 | | mg/L | | 0.005 | 11-JUL-22 |
| **PH-WP** | **Water** | | | | | | | |
| **Batch R5822357** | | | | | | | | |
| **WG3749556-22 LCS** | | | | | | | | |
| pH | | | 7.01 | | pH units | | 6.9-7.1 | 14-JUL-22 |
| **SO4-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5822060** | | | | | | | | |
| **WG3748211-2 LCS** | | | | | | | | |
| Sulfate (SO4) | | | 99.9 | | % | | 90-110 | 11-JUL-22 |
| **WG3748211-1 MB** | | | | | | | | |
| Sulfate (SO4) | | | <0.30 | | mg/L | | 0.3 | 11-JUL-22 |
| **TDS-WP** | **Water** | | | | | | | |
| **Batch R5822214** | | | | | | | | |
| **WG3748620-6 DUP** | | **L2721308-1** | | | | | | |
| Total Dissolved Solids | | 392 | 376 | | mg/L | 4.3 | 20 | 13-JUL-22 |
| **WG3748620-5 LCS** | | | | | | | | |
| Total Dissolved Solids | | | 97.1 | | % | | 85-115 | 13-JUL-22 |
| **WG3748620-4 MB** | | | | | | | | |
| Total Dissolved Solids | | | <4.0 | | mg/L | | 4 | 13-JUL-22 |
| **TURBIDITY-WP** | **Water** | | | | | | | |
| **Batch R5820259** | | | | | | | | |
| **WG3748190-2 LCS** | | | | | | | | |
| Turbidity | | | 99.96 | | % | | 85-115 | 11-JUL-22 |
| **WG3748190-1 MB** | | | | | | | | |
| Turbidity | | | <0.10 | | NTU | | 0.1 | 11-JUL-22 |
| **UV-%TRANS-WP** | **Water** | | | | | | | |
| **Batch R5822505** | | | | | | | | |
| **WG3749710-1 IRM** | | **BLANK** | | | | | | |
| Transmittance, UV (254 nm) | | | 100.0 | | % | | 99.5-100.5 | 12-JUL-22 |
| **WG3749710-2 LCS** | | | | | | | | |
| Transmittance, UV (254 nm) | | | 103.3 | | % | | 85-115 | 12-JUL-22 |

# Quality Control Report



**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

# Quality Control Report



**Hold Time Exceedances:**

| ALS Product Description | Sample ID | Sampling Date | Date Processed | Rec. HT | Actual HT | Units | Qualifier |
|---|---|---|---|---|---|---|---|
| **Physical Tests** | | | | | | | |
| UV Transmittance (Calculated) | | | | | | | |
| | 1 | 08-JUL-22 22:00 | 12-JUL-22 11:00 | 3 | 4 | days | EHTL |
| pH | | | | | | | |
| | 1 | 08-JUL-22 22:00 | 14-JUL-22 09:00 | 0.25 | 131 | hours | EHTR-FM |

**Legend & Qualifier Definitions:**

| | |
|---|---|
| EHTR-FM: | Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended. |
| EHTR: | Exceeded ALS recommended hold time prior to sample receipt. |
| EHTL: | Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry. |
| EHT: | Exceeded ALS recommended hold time prior to analysis. |
| Rec. HT: | ALS recommended hold time (see units). |

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L2721308 were received on 11-JUL-22 07:55.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

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The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

# Chain of Custody (COC) / Analytical Request Form

ALS Environmental

www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2721308-COFC

COC Number: 17 -

Page of

| Report To | Contact and company name below will appear on the final report |
|---|---|
| Company: | Friesen Drillers Ltd. |
| Contact: | Paulynn Estrella-Legal |
| Phone: | 204-326-2485 |
| | Company address below will appear on the final report |
| Street: | 307 PTH 12 N |
| City/Province: | Steinbach, MB |
| Postal Code: | R5G 1T8 |
| **Invoice To** | Same as Report To ☑ YES ☐ NO |
| | Copy of Invoice with Report ☑ YES ☐ NO |
| Company: | |
| Contact: | |

**Report Format / Distribution**

Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)

Quality Control (QC) Report with Report ☐ ☐ NO

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: jeff@friesendrillers.com

Email 2: paulynn@friesendrillers.com

Email 3: justin@friesendrillers.com

**Invoice Distribution**

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax:

Email 2:

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days):
- 4 day [P4-20%] ☐
- 3 day [P3-25%] ☐
- 2 day [P2-50%] ☐

EMERGENCY:
- 1 Business day [E1 - 100%] ☐
- Same Day, Weekend or Statutory holiday [E2 - 200% (Laboratory opening fees may apply)] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

| Project Information | | Oil and Gas Required Fields (client use) | |
|---|---|---|---|
| ALS Account # / Quote #: | | AFE/Cost Center: | PO#: |
| Job #: | RM of Ritchot | Major/Minor Code: | Routing Code: |
| PO / AFE: | Randolph Well Field | Requisitioner: | |
| LSD: | | Location: | |

**ALS Lab Work Order # (lab use only):**

**ALS Contact:** Judy **Sampler:** PE

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | MB-CH-PWS-WP | SAMPLES ON HOLD | Sample is hazardous (please provide further details) | NUMBER OF CONTAINERS |
|---|---|---|---|---|---|---|---|---|
| | Well 2 - 72 Hours | 8-Jul-22 | 22:00 | Water | R | | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System? ☐ ☐

Are samples for human consumption/ use? ☐ ☐

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

| INITIAL COOLER TEMPERATURES °C | | | | FINAL COOLER TEMPERATURES °C | | | |
|---|---|---|---|---|---|---|---|
| 14.5 | | | | | | | |

| SHIPMENT RELEASE (client use) | | | INITIAL SHIPMENT RECEPTION (lab use only) | | | FINAL SHIPMENT RECEPTION (lab use only) | | |
|---|---|---|---|---|---|---|---|---|
| Released by: | Date: | Time: | Received by: [redacted] | Date: JUL 11 2022 | Time: 7:55am | Received by: | Date: | Time: |

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

SEPT 2017 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Friesen Drillers Ltd
ATTN: PAULYNN ESTRELLA
307 PTH 12 N
Steinbach MB R5G 1L9

Date Received: 11-JUL-22
Report Date: 26-JUL-22 07:34 (MT)
Version: FINAL

Client Phone: 204-326-2485

# Certificate of Analysis

Lab Work Order #: L2721317
Project P.O. #: RANDOLPH WELL FIELD
Job Reference: RM OF RITCHOT
C of C Numbers:
Legal Site Desc:

[redacted]
Hua Wo
Chemistry Laboratory Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2721317-1 WELL 2 - 72 HOURS | | | | | | | |
| Sampled By: CLIENT on 08-JUL-22 @ 10:00 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Miscellaneous Parameters** | | | | | | | |
| Special Request | See Attached | | | | | 24-JUL-22 | R5812947 |
| **ROU4W total** | | | | | | | |
| **Alkalinity, Bicarbonate** | | | | | | | |
| Bicarbonate (HCO3) | 397 | | 1.2 | mg/L | | 15-JUL-22 | |
| **Alkalinity, Carbonate** | | | | | | | |
| Carbonate (CO3) | <0.60 | | 0.60 | mg/L | | 15-JUL-22 | |
| **Alkalinity, Hydroxide** | | | | | | | |
| Hydroxide (OH) | <0.34 | | 0.34 | mg/L | | 15-JUL-22 | |
| **Alkalinity, Total (as CaCO3)** | | | | | | | |
| Alkalinity, Total (as CaCO3) | 326 | | 1.0 | mg/L | | 14-JUL-22 | R5822357 |
| **Chloride in Water by IC** | | | | | | | |
| Chloride (Cl) | 39.2 | | 0.50 | mg/L | | 11-JUL-22 | R5822060 |
| **Conductivity** | | | | | | | |
| Conductivity | 682 | | 1.0 | umhos/cm | | 14-JUL-22 | R5822357 |
| **Fluoride in Water by IC** | | | | | | | |
| Fluoride (F) | 0.613 | | 0.020 | mg/L | | 11-JUL-22 | R5822060 |
| **Hardness Calculated** | | | | | | | |
| Hardness (as CaCO3) | 232 | HTC | 0.20 | mg/L | | 15-JUL-22 | |
| **Nitrate in Water by IC** | | | | | | | |
| Nitrate (as N) | <0.020 | | 0.020 | mg/L | | 11-JUL-22 | R5822060 |
| **Nitrate+Nitrite** | | | | | | | |
| Nitrate and Nitrite as N | <0.070 | | 0.070 | mg/L | | 14-JUL-22 | |
| **Nitrite in Water by IC** | | | | | | | |
| Nitrite (as N) | <0.010 | | 0.010 | mg/L | | 11-JUL-22 | R5822060 |
| **Sulfate in Water by IC** | | | | | | | |
| Sulfate (SO4) | <0.30 | | 0.30 | mg/L | | 11-JUL-22 | R5822060 |
| **TDS calculated** | | | | | | | |
| TDS (Calculated) | 388 | | 5.0 | mg/L | | 15-JUL-22 | |
| **Total Metals in Water by CRC ICPMS** | | | | | | | |
| Aluminum (Al)-Total | <0.0030 | | 0.0030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Antimony (Sb)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Arsenic (As)-Total | 0.00012 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Barium (Ba)-Total | 0.386 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Beryllium (Be)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Bismuth (Bi)-Total | <0.000050 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Boron (B)-Total | 0.330 | | 0.010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cadmium (Cd)-Total | <0.0000050 | | 0.0000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Calcium (Ca)-Total | 45.1 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cesium (Cs)-Total | 0.000016 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Chromium (Cr)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cobalt (Co)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Copper (Cu)-Total | <0.00050 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Iron (Fe)-Total | 0.507 | | 0.010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Lead (Pb)-Total | <0.000050 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Lithium (Li)-Total | 0.0323 | | 0.0010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Magnesium (Mg)-Total | 29.0 | | 0.0050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Manganese (Mn)-Total | 0.00585 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Molybdenum (Mo)-Total | 0.00114 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Nickel (Ni)-Total | <0.00050 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Potassium (K)-Total | 7.64 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Phosphorus (P)-Total | <0.030 | | 0.030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Rubidium (Rb)-Total | 0.00429 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2721317-1 WELL 2 - 72 HOURS | | | | | | | |
| Sampled By: CLIENT on 08-JUL-22 @ 10:00 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Total Metals in Water by CRC ICPMS** | | | | | | | |
| Selenium (Se)-Total | <0.000050 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Silicon (Si)-Total | 6.34 | | 0.10 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Silver (Ag)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Sodium (Na)-Total | 71.7 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Strontium (Sr)-Total | 0.482 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Sulfur (S)-Total | <0.50 | | 0.50 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tellurium (Te)-Total | <0.00020 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Thallium (Tl)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Thorium (Th)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tin (Sn)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Titanium (Ti)-Total | <0.00030 | | 0.00030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tungsten (W)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Uranium (U)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Vanadium (V)-Total | <0.00050 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Zinc (Zn)-Total | <0.0030 | | 0.0030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Zirconium (Zr)-Total | <0.00020 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| **Turbidity** | | | | | | | |
| Turbidity | 2.31 | | 0.10 | NTU | | 11-JUL-22 | R5820259 |
| **pH** | | | | | | | |
| pH | 8.23 | | 0.10 | pH units | | 14-JUL-22 | R5822357 |
| L2721317-2 WELL 2 - 48 HOURS | | | | | | | |
| Sampled By: CLIENT on 07-JUL-22 @ 10:00 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Miscellaneous Parameters** | | | | | | | |
| Special Request | See Attached | | | | | 24-JUL-22 | R5812947 |
| **ROU4W total** | | | | | | | |
| **Alkalinity, Bicarbonate** | | | | | | | |
| Bicarbonate (HCO3) | 399 | | 1.2 | mg/L | | 18-JUL-22 | |
| **Alkalinity, Carbonate** | | | | | | | |
| Carbonate (CO3) | <0.60 | | 0.60 | mg/L | | 18-JUL-22 | |
| **Alkalinity, Hydroxide** | | | | | | | |
| Hydroxide (OH) | <0.34 | | 0.34 | mg/L | | 18-JUL-22 | |
| **Alkalinity, Total (as CaCO3)** | | | | | | | |
| Alkalinity, Total (as CaCO3) | 327 | | 1.0 | mg/L | | 15-JUL-22 | R5822997 |
| **Chloride in Water by IC** | | | | | | | |
| Chloride (Cl) | 39.3 | | 0.50 | mg/L | | 11-JUL-22 | R5822060 |
| **Conductivity** | | | | | | | |
| Conductivity | 675 | | 1.0 | umhos/cm | | 15-JUL-22 | R5822997 |
| **Fluoride in Water by IC** | | | | | | | |
| Fluoride (F) | 0.599 | | 0.020 | mg/L | | 11-JUL-22 | R5822060 |
| **Hardness Calculated** | | | | | | | |
| Hardness (as CaCO3) | 238 | HTC | 0.20 | mg/L | | 15-JUL-22 | |
| **Nitrate in Water by IC** | | | | | | | |
| Nitrate (as N) | <0.020 | | 0.020 | mg/L | | 11-JUL-22 | R5822060 |
| **Nitrate+Nitrite** | | | | | | | |
| Nitrate and Nitrite as N | <0.070 | | 0.070 | mg/L | | 14-JUL-22 | |
| **Nitrite in Water by IC** | | | | | | | |
| Nitrite (as N) | <0.010 | | 0.010 | mg/L | | 11-JUL-22 | R5822060 |
| **Sulfate in Water by IC** | | | | | | | |
| Sulfate (SO4) | <0.30 | | 0.30 | mg/L | | 11-JUL-22 | R5822060 |
| **TDS calculated** | | | | | | | |
| TDS (Calculated) | 391 | | 5.0 | mg/L | | 18-JUL-22 | |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2721317-2 WELL 2 - 48 HOURS | | | | | | | |
| Sampled By: CLIENT on 07-JUL-22 @ 10:00 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Total Metals in Water by CRC ICPMS** | | | | | | | |
| Aluminum (Al)-Total | <0.0030 | | 0.0030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Antimony (Sb)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Arsenic (As)-Total | 0.00012 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Barium (Ba)-Total | 0.393 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Beryllium (Be)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Bismuth (Bi)-Total | <0.000050 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Boron (B)-Total | 0.337 | | 0.010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cadmium (Cd)-Total | <0.0000050 | | 0.0000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Calcium (Ca)-Total | 45.3 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cesium (Cs)-Total | 0.000016 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Chromium (Cr)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cobalt (Co)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Copper (Cu)-Total | 0.00098 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Iron (Fe)-Total | 0.393 | | 0.010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Lead (Pb)-Total | 0.000073 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Lithium (Li)-Total | 0.0347 | | 0.0010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Magnesium (Mg)-Total | 30.4 | | 0.0050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Manganese (Mn)-Total | 0.00586 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Molybdenum (Mo)-Total | 0.00105 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Nickel (Ni)-Total | <0.00050 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Potassium (K)-Total | 7.79 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Phosphorus (P)-Total | <0.030 | | 0.030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Rubidium (Rb)-Total | 0.00444 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Selenium (Se)-Total | <0.000050 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Silicon (Si)-Total | 6.59 | | 0.10 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Silver (Ag)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Sodium (Na)-Total | 72.3 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Strontium (Sr)-Total | 0.490 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Sulfur (S)-Total | <0.50 | | 0.50 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tellurium (Te)-Total | <0.00020 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Thallium (Tl)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Thorium (Th)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tin (Sn)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Titanium (Ti)-Total | <0.00030 | | 0.00030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tungsten (W)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Uranium (U)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Vanadium (V)-Total | <0.00050 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Zinc (Zn)-Total | 0.0036 | | 0.0030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Zirconium (Zr)-Total | <0.00020 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| **Turbidity** | | | | | | | |
| Turbidity | 2.87 | | 0.10 | NTU | | 11-JUL-22 | R5820259 |
| **pH** | | | | | | | |
| pH | 8.24 | | 0.10 | pH units | | 15-JUL-22 | R5822997 |
| L2721317-3 WELL 2 - 24 HOURS | | | | | | | |
| Sampled By: CLIENT on 06-JUL-22 @ 10:00 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Miscellaneous Parameters** | | | | | | | |
| Special Request | See Attached | | | | | 24-JUL-22 | R5812947 |
| **ROU4W total** | | | | | | | |
| **Alkalinity, Bicarbonate** | | | | | | | |
| Bicarbonate (HCO3) | 397 | | 1.2 | mg/L | | 18-JUL-22 | |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2721317-3 WELL 2 - 24 HOURS | | | | | | | |
| Sampled By: CLIENT on 06-JUL-22 @ 10:00 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Alkalinity, Carbonate** | | | | | | | |
| Carbonate (CO3) | <0.60 | | 0.60 | mg/L | | 18-JUL-22 | |
| **Alkalinity, Hydroxide** | | | | | | | |
| Hydroxide (OH) | <0.34 | | 0.34 | mg/L | | 18-JUL-22 | |
| **Alkalinity, Total (as CaCO3)** | | | | | | | |
| Alkalinity, Total (as CaCO3) | 326 | | 1.0 | mg/L | | 15-JUL-22 | R5822997 |
| **Chloride in Water by IC** | | | | | | | |
| Chloride (Cl) | 39.5 | | 0.50 | mg/L | | 11-JUL-22 | R5822060 |
| **Conductivity** | | | | | | | |
| Conductivity | 677 | | 1.0 | umhos/cm | | 15-JUL-22 | R5822997 |
| **Fluoride in Water by IC** | | | | | | | |
| Fluoride (F) | 0.597 | | 0.020 | mg/L | | 11-JUL-22 | R5822060 |
| **Hardness Calculated** | | | | | | | |
| Hardness (as CaCO3) | 235 | HTC | 0.20 | mg/L | | 15-JUL-22 | |
| **Nitrate in Water by IC** | | | | | | | |
| Nitrate (as N) | <0.020 | | 0.020 | mg/L | | 11-JUL-22 | R5822060 |
| **Nitrate+Nitrite** | | | | | | | |
| Nitrate and Nitrite as N | <0.070 | | 0.070 | mg/L | | 14-JUL-22 | |
| **Nitrite in Water by IC** | | | | | | | |
| Nitrite (as N) | <0.010 | | 0.010 | mg/L | | 11-JUL-22 | R5822060 |
| **Sulfate in Water by IC** | | | | | | | |
| Sulfate (SO4) | <0.30 | | 0.30 | mg/L | | 11-JUL-22 | R5822060 |
| **TDS calculated** | | | | | | | |
| TDS (Calculated) | 391 | | 5.0 | mg/L | | 18-JUL-22 | |
| **Total Metals in Water by CRC ICPMS** | | | | | | | |
| Aluminum (Al)-Total | 0.0036 | | 0.0030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Antimony (Sb)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Arsenic (As)-Total | 0.00011 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Barium (Ba)-Total | 0.390 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Beryllium (Be)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Bismuth (Bi)-Total | <0.000050 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Boron (B)-Total | 0.343 | | 0.010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cadmium (Cd)-Total | <0.0000050 | | 0.0000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Calcium (Ca)-Total | 45.0 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cesium (Cs)-Total | 0.000017 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Chromium (Cr)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cobalt (Co)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Copper (Cu)-Total | 0.00127 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Iron (Fe)-Total | 0.322 | | 0.010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Lead (Pb)-Total | 0.000088 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Lithium (Li)-Total | 0.0363 | | 0.0010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Magnesium (Mg)-Total | 29.9 | | 0.0050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Manganese (Mn)-Total | 0.00587 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Molybdenum (Mo)-Total | 0.00102 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Nickel (Ni)-Total | <0.00050 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Potassium (K)-Total | 7.88 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Phosphorus (P)-Total | <0.030 | | 0.030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Rubidium (Rb)-Total | 0.00431 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Selenium (Se)-Total | <0.000050 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Silicon (Si)-Total | 6.69 | | 0.10 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Silver (Ag)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Sodium (Na)-Total | 73.4 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Strontium (Sr)-Total | 0.492 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2721317-3 WELL 2 - 24 HOURS | | | | | | | |
| Sampled By: CLIENT on 06-JUL-22 @ 10:00 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Total Metals in Water by CRC ICPMS** | | | | | | | |
| Sulfur (S)-Total | <0.50 | | 0.50 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tellurium (Te)-Total | <0.00020 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Thallium (Tl)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Thorium (Th)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tin (Sn)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Titanium (Ti)-Total | <0.00030 | | 0.00030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tungsten (W)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Uranium (U)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Vanadium (V)-Total | <0.00050 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Zinc (Zn)-Total | 0.0053 | | 0.0030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Zirconium (Zr)-Total | <0.00020 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| **Turbidity** | | | | | | | |
| Turbidity | 2.39 | | 0.10 | NTU | | 11-JUL-22 | R5820259 |
| **pH** | | | | | | | |
| pH | 8.19 | | 0.10 | pH units | | 15-JUL-22 | R5822997 |
| L2721317-4 WELL 2 - 1 HOUR | | | | | | | |
| Sampled By: CLIENT on 05-JUL-22 @ 10:00 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Miscellaneous Parameters** | | | | | | | |
| Special Request | See Attached | | | | | 24-JUL-22 | R5812947 |
| **ROU4W total** | | | | | | | |
| **Alkalinity, Bicarbonate** | | | | | | | |
| Bicarbonate (HCO3) | 398 | | 1.2 | mg/L | | 18-JUL-22 | |
| **Alkalinity, Carbonate** | | | | | | | |
| Carbonate (CO3) | <0.60 | | 0.60 | mg/L | | 18-JUL-22 | |
| **Alkalinity, Hydroxide** | | | | | | | |
| Hydroxide (OH) | <0.34 | | 0.34 | mg/L | | 18-JUL-22 | |
| **Alkalinity, Total (as CaCO3)** | | | | | | | |
| Alkalinity, Total (as CaCO3) | 326 | | 1.0 | mg/L | | 15-JUL-22 | R5822997 |
| **Chloride in Water by IC** | | | | | | | |
| Chloride (Cl) | 40.4 | | 0.50 | mg/L | | 11-JUL-22 | R5822060 |
| **Conductivity** | | | | | | | |
| Conductivity | 673 | | 1.0 | umhos/cm | | 15-JUL-22 | R5822997 |
| **Fluoride in Water by IC** | | | | | | | |
| Fluoride (F) | 0.597 | | 0.020 | mg/L | | 11-JUL-22 | R5822060 |
| **Hardness Calculated** | | | | | | | |
| Hardness (as CaCO3) | 233 | HTC | 0.20 | mg/L | | 15-JUL-22 | |
| **Nitrate in Water by IC** | | | | | | | |
| Nitrate (as N) | <0.020 | | 0.020 | mg/L | | 11-JUL-22 | R5822060 |
| **Nitrate+Nitrite** | | | | | | | |
| Nitrate and Nitrite as N | <0.070 | | 0.070 | mg/L | | 14-JUL-22 | |
| **Nitrite in Water by IC** | | | | | | | |
| Nitrite (as N) | <0.010 | | 0.010 | mg/L | | 11-JUL-22 | R5822060 |
| **Sulfate in Water by IC** | | | | | | | |
| Sulfate (SO4) | <0.30 | | 0.30 | mg/L | | 11-JUL-22 | R5822060 |
| **TDS calculated** | | | | | | | |
| TDS (Calculated) | 392 | | 5.0 | mg/L | | 18-JUL-22 | |
| **Total Metals in Water by CRC ICPMS** | | | | | | | |
| Aluminum (Al)-Total | 0.0038 | | 0.0030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Antimony (Sb)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Arsenic (As)-Total | 0.00013 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Barium (Ba)-Total | 0.385 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2721317-4 WELL 2 - 1 HOUR | | | | | | | |
| Sampled By: CLIENT on 05-JUL-22 @ 10:00 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Total Metals in Water by CRC ICPMS** | | | | | | | |
| Beryllium (Be)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Bismuth (Bi)-Total | <0.000050 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Boron (B)-Total | 0.349 | | 0.010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cadmium (Cd)-Total | <0.0000050 | | 0.0000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Calcium (Ca)-Total | 44.6 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cesium (Cs)-Total | 0.000018 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Chromium (Cr)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Cobalt (Co)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Copper (Cu)-Total | 0.00183 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Iron (Fe)-Total | 0.298 | | 0.010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Lead (Pb)-Total | 0.000096 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Lithium (Li)-Total | 0.0356 | | 0.0010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Magnesium (Mg)-Total | 29.5 | | 0.0050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Manganese (Mn)-Total | 0.00580 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Molybdenum (Mo)-Total | 0.000942 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Nickel (Ni)-Total | <0.00050 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Potassium (K)-Total | 7.68 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Phosphorus (P)-Total | <0.030 | | 0.030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Rubidium (Rb)-Total | 0.00417 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Selenium (Se)-Total | <0.000050 | | 0.000050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Silicon (Si)-Total | 6.63 | | 0.10 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Silver (Ag)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Sodium (Na)-Total | 74.1 | | 0.050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Strontium (Sr)-Total | 0.489 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Sulfur (S)-Total | <0.50 | | 0.50 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tellurium (Te)-Total | <0.00020 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Thallium (Tl)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Thorium (Th)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tin (Sn)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Titanium (Ti)-Total | <0.00030 | | 0.00030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Tungsten (W)-Total | <0.00010 | | 0.00010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Uranium (U)-Total | <0.000010 | | 0.000010 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Vanadium (V)-Total | <0.00050 | | 0.00050 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Zinc (Zn)-Total | 0.0071 | | 0.0030 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| Zirconium (Zr)-Total | <0.00020 | | 0.00020 | mg/L | 13-JUL-22 | 14-JUL-22 | R5822448 |
| **Turbidity** | | | | | | | |
| Turbidity | 2.66 | | 0.10 | NTU | | 11-JUL-22 | R5820259 |
| **pH** | | | | | | | |
| pH | 8.30 | | 0.10 | pH units | | 15-JUL-22 | R5822997 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

**Sample Parameter Qualifier Key:**

| Qualifier | Description |
|---|---|
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

**Test Method References:**

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| ALK-CO3CO3-CALC-WP | Water | Alkalinity, Carbonate | CALCULATION |

The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contr buted by carbonate is calculated and reported as mg CO3 2-/L.

| | | | |
|---|---|---|---|
| ALK-HCO3HCO3-CALC-WP | Water | Alkalinity, Bicarbonate | CALCULATION |

The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contr buted by bicarbonate is calculated and reported as mg HCO3-/L

| | | | |
|---|---|---|---|
| ALK-OHOH-CALC-WP | Water | Alkalinity, Hydroxide | CALCULATION |

The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contr buted by hydroxide is calculated and reported as mg OH-/L.

| | | | |
|---|---|---|---|
| ALK-TITR-WP | Water | Alkalinity, Total (as CaCO3) | APHA 2320B |

The Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. Total alkalinity is determined by titration with a strong standard mineral acid to the successive HCO3- and H2CO3 endpoints indicated electrometrically.

| | | | |
|---|---|---|---|
| CL-IC-N-WP | Water | Chloride in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| | | | |
|---|---|---|---|
| EC-WP | Water | Conductivity | APHA 2510B |

Conductivity of an aqueous solution refers to its ability to carry an electric current. Conductance of a solution is measured between two spatially fixed and chemically inert electrodes.

| | | | |
|---|---|---|---|
| ETL-SOLIDS-CALC-WP | Water | TDS calculated | CALCULATION |
| F-IC-N-WP | Water | Fluoride in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| | | | |
|---|---|---|---|
| HARDNESS-CALC-WP | Water | Hardness Calculated | APHA 2340B |

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

| | | | |
|---|---|---|---|
| IONBALANCE-CALC-WP | Water | Ion Balance Calculation | APHA 1030E |

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance (as % difference) cannot be calculated accurately for waters with very low electrical conductivity (EC), and is reported as "Low EC" where EC < 100 uS/cm (umhos/cm). Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

| | | | |
|---|---|---|---|
| MET-T-CCMS-WP | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020B (mod.) |

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

| | | | |
|---|---|---|---|
| NO2+NO3-CALC-WP | Water | Nitrate+Nitrite | CALCULATION |
| NO2-IC-N-WP | Water | Nitrite in Water by IC | EPA 300.1 (mod) |

# Reference Information

**Test Method References:**

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection. | | | |
| NO3-IC-N-WP | Water | Nitrate in Water by IC | EPA 300.1 (mod) |
| Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection. | | | |
| PH-WP | Water | pH | APHA 4500H |
| The pH of a sample is the determination of the activity of the hydrogen ions by potentiometric measurement using a standard hydrogen electrode and a reference electrode. | | | |
| SO4-IC-N-WP | Water | Sulfate in Water by IC | EPA 300.1 (mod) |
| Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection. | | | |
| SPECIAL REQUEST-UW | Misc. | Special Request University of Waterloo | SEE SUBLET LAB RESULTS |
| TURBIDITY-WP | Water | Turbidity | APHA 2130B (modified) |
| Turbidity in aqueous matrices is determined by the nephelometric method. | | | |

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| UW | UNIVERSITY OF WATERLOO |
| WP | ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA |

**Chain of Custody Numbers:**

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*
*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report



Client: Friesen Drillers Ltd
307 PTH 12 N
Steinbach MB R5G 1L9
Contact: PAULYNN ESTRELLA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **ALK-TITR-WP** | **Water** | | | | | | | |
| **Batch R5822357** | | | | | | | | |
| **WG3749556-24 LCS** | | | | | | | | |
| Alkalinity, Total (as CaCO3) | | | 102.6 | | % | | 85-115 | 14-JUL-22 |
| **WG3749556-21 MB** | | | | | | | | |
| Alkalinity, Total (as CaCO3) | | | <1.0 | | mg/L | | 1 | 14-JUL-22 |
| **Batch R5822997** | | | | | | | | |
| **WG3750068-5 DUP** | | **L2721317-4** | | | | | | |
| Alkalinity, Total (as CaCO3) | | 326 | 325 | | mg/L | 0.2 | 20 | 15-JUL-22 |
| **WG3750068-4 LCS** | | | | | | | | |
| Alkalinity, Total (as CaCO3) | | | 100.2 | | % | | 85-115 | 15-JUL-22 |
| **WG3750068-1 MB** | | | | | | | | |
| Alkalinity, Total (as CaCO3) | | | <1.0 | | mg/L | | 1 | 15-JUL-22 |
| **CL-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5822060** | | | | | | | | |
| **WG3748211-3 DUP** | | **L2721317-1** | | | | | | |
| Chloride (Cl) | | 39.2 | 39.1 | | mg/L | 0.1 | 20 | 11-JUL-22 |
| **WG3748211-2 LCS** | | | | | | | | |
| Chloride (Cl) | | | 97.9 | | % | | 90-110 | 11-JUL-22 |
| **WG3748211-1 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 11-JUL-22 |
| **WG3748211-4 MS** | | **L2721317-1** | | | | | | |
| Chloride (Cl) | | | 103.3 | | % | | 75-125 | 11-JUL-22 |
| **EC-WP** | **Water** | | | | | | | |
| **Batch R5822357** | | | | | | | | |
| **WG3749556-23 LCS** | | | | | | | | |
| Conductivity | | | 98.7 | | % | | 90-110 | 14-JUL-22 |
| **WG3749556-21 MB** | | | | | | | | |
| Conductivity | | | <1.0 | | umhos/cm | | 1 | 14-JUL-22 |
| **Batch R5822997** | | | | | | | | |
| **WG3750068-5 DUP** | | **L2721317-4** | | | | | | |
| Conductivity | | 673 | 670 | | umhos/cm | 0.4 | 10 | 15-JUL-22 |
| **WG3750068-3 LCS** | | | | | | | | |
| Conductivity | | | 97.8 | | % | | 90-110 | 15-JUL-22 |
| **WG3750068-1 MB** | | | | | | | | |
| Conductivity | | | <1.0 | | umhos/cm | | 1 | 15-JUL-22 |
| **F-IC-N-WP** | **Water** | | | | | | | |

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **F-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5822060** | | | | | | | | |
| **WG3748211-3 DUP** | | **L2721317-1** | | | | | | |
| Fluoride (F) | | 0.613 | 0.602 | | mg/L | 1.8 | 20 | 11-JUL-22 |
| **WG3748211-2 LCS** | | | | | | | | |
| Fluoride (F) | | | 102.4 | | % | | 90-110 | 11-JUL-22 |
| **WG3748211-1 MB** | | | | | | | | |
| Fluoride (F) | | | <0.020 | | mg/L | | 0.02 | 11-JUL-22 |
| **WG3748211-4 MS** | | **L2721317-1** | | | | | | |
| Fluoride (F) | | | 101.5 | | % | | 75-125 | 11-JUL-22 |
| **MET-T-CCMS-WP** | **Water** | | | | | | | |
| **Batch R5822448** | | | | | | | | |
| **WG3748866-2 LCS** | | | | | | | | |
| Aluminum (Al)-Total | | | 109.3 | | % | | 80-120 | 14-JUL-22 |
| Antimony (Sb)-Total | | | 103.6 | | % | | 80-120 | 14-JUL-22 |
| Arsenic (As)-Total | | | 98.5 | | % | | 80-120 | 14-JUL-22 |
| Barium (Ba)-Total | | | 102.7 | | % | | 80-120 | 14-JUL-22 |
| Beryllium (Be)-Total | | | 109.2 | | % | | 80-120 | 14-JUL-22 |
| Bismuth (Bi)-Total | | | 98.5 | | % | | 80-120 | 14-JUL-22 |
| Boron (B)-Total | | | 106.9 | | % | | 80-120 | 14-JUL-22 |
| Cadmium (Cd)-Total | | | 102.2 | | % | | 80-120 | 14-JUL-22 |
| Calcium (Ca)-Total | | | 101.5 | | % | | 80-120 | 14-JUL-22 |
| Cesium (Cs)-Total | | | 98.2 | | % | | 80-120 | 14-JUL-22 |
| Chromium (Cr)-Total | | | 101.4 | | % | | 80-120 | 14-JUL-22 |
| Cobalt (Co)-Total | | | 97.6 | | % | | 80-120 | 14-JUL-22 |
| Copper (Cu)-Total | | | 95.3 | | % | | 80-120 | 14-JUL-22 |
| Iron (Fe)-Total | | | 98.5 | | % | | 80-120 | 14-JUL-22 |
| Lead (Pb)-Total | | | 96.5 | | % | | 80-120 | 14-JUL-22 |
| Lithium (Li)-Total | | | 113.4 | | % | | 80-120 | 14-JUL-22 |
| Magnesium (Mg)-Total | | | 106.1 | | % | | 80-120 | 14-JUL-22 |
| Manganese (Mn)-Total | | | 102.0 | | % | | 80-120 | 14-JUL-22 |
| Molybdenum (Mo)-Total | | | 100.9 | | % | | 80-120 | 14-JUL-22 |
| Nickel (Ni)-Total | | | 96.6 | | % | | 80-120 | 14-JUL-22 |
| Potassium (K)-Total | | | 104.5 | | % | | 80-120 | 14-JUL-22 |
| Phosphorus (P)-Total | | | 114.5 | | % | | 80-120 | 14-JUL-22 |
| Rubidium (Rb)-Total | | | 98.4 | | % | | 80-120 | 14-JUL-22 |
| Selenium (Se)-Total | | | 95.1 | | % | | 80-120 | 14-JUL-22 |
| Silicon (Si)-Total | | | 112.2 | | % | | 80-120 | 14-JUL-22 |

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **MET-T-CCMS-WP** | **Water** | | | | | | | |
| **Batch R5822448** | | | | | | | | |
| **WG3748866-2 LCS** | | | | | | | | |
| Silver (Ag)-Total | | | 97.7 | | % | | 80-120 | 14-JUL-22 |
| Sodium (Na)-Total | | | 107.9 | | % | | 80-120 | 14-JUL-22 |
| Strontium (Sr)-Total | | | 101.3 | | % | | 80-120 | 14-JUL-22 |
| Sulfur (S)-Total | | | 112.6 | | % | | 80-120 | 14-JUL-22 |
| Tellurium (Te)-Total | | | 87.4 | | % | | 80-120 | 14-JUL-22 |
| Thallium (Tl)-Total | | | 99.7 | | % | | 80-120 | 14-JUL-22 |
| Thorium (Th)-Total | | | 93.0 | | % | | 80-120 | 14-JUL-22 |
| Tin (Sn)-Total | | | 98.7 | | % | | 80-120 | 14-JUL-22 |
| Titanium (Ti)-Total | | | 100.5 | | % | | 80-120 | 14-JUL-22 |
| Tungsten (W)-Total | | | 98.1 | | % | | 80-120 | 14-JUL-22 |
| Uranium (U)-Total | | | 93.4 | | % | | 80-120 | 14-JUL-22 |
| Vanadium (V)-Total | | | 103.6 | | % | | 80-120 | 14-JUL-22 |
| Zinc (Zn)-Total | | | 101.6 | | % | | 80-120 | 14-JUL-22 |
| Zirconium (Zr)-Total | | | 95.7 | | % | | 80-120 | 14-JUL-22 |
| **WG3748866-1 MB** | | | | | | | | |
| Aluminum (Al)-Total | | | <0.0030 | | mg/L | | 0.003 | 14-JUL-22 |
| Antimony (Sb)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Arsenic (As)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Barium (Ba)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Beryllium (Be)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Bismuth (Bi)-Total | | | <0.000050 | | mg/L | | 0.00005 | 14-JUL-22 |
| Boron (B)-Total | | | <0.010 | | mg/L | | 0.01 | 14-JUL-22 |
| Cadmium (Cd)-Total | | | <0.0000050 | | mg/L | | 0.000005 | 14-JUL-22 |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 14-JUL-22 |
| Cesium (Cs)-Total | | | <0.000010 | | mg/L | | 0.00001 | 14-JUL-22 |
| Chromium (Cr)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Cobalt (Co)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Copper (Cu)-Total | | | <0.00050 | | mg/L | | 0.0005 | 14-JUL-22 |
| Iron (Fe)-Total | | | <0.010 | | mg/L | | 0.01 | 14-JUL-22 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 14-JUL-22 |
| Lithium (Li)-Total | | | <0.0010 | | mg/L | | 0.001 | 14-JUL-22 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 14-JUL-22 |
| Manganese (Mn)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Molybdenum (Mo)-Total | | | <0.000050 | | mg/L | | 0.00005 | 14-JUL-22 |

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **MET-T-CCMS-WP** | **Water** | | | | | | | |
| **Batch R5822448** | | | | | | | | |
| **WG3748866-1 MB** | | | | | | | | |
| Nickel (Ni)-Total | | | <0.00050 | | mg/L | | 0.0005 | 14-JUL-22 |
| Potassium (K)-Total | | | <0.050 | | mg/L | | 0.05 | 14-JUL-22 |
| Phosphorus (P)-Total | | | <0.030 | | mg/L | | 0.03 | 14-JUL-22 |
| Rubidium (Rb)-Total | | | <0.00020 | | mg/L | | 0.0002 | 14-JUL-22 |
| Selenium (Se)-Total | | | <0.000050 | | mg/L | | 0.00005 | 14-JUL-22 |
| Silicon (Si)-Total | | | <0.10 | | mg/L | | 0.1 | 14-JUL-22 |
| Silver (Ag)-Total | | | <0.000010 | | mg/L | | 0.00001 | 14-JUL-22 |
| Sodium (Na)-Total | | | <0.050 | | mg/L | | 0.05 | 14-JUL-22 |
| Strontium (Sr)-Total | | | <0.00020 | | mg/L | | 0.0002 | 14-JUL-22 |
| Sulfur (S)-Total | | | <0.50 | | mg/L | | 0.5 | 14-JUL-22 |
| Tellurium (Te)-Total | | | <0.00020 | | mg/L | | 0.0002 | 14-JUL-22 |
| Thallium (Tl)-Total | | | <0.000010 | | mg/L | | 0.00001 | 14-JUL-22 |
| Thorium (Th)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Tin (Sn)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Titanium (Ti)-Total | | | <0.00030 | | mg/L | | 0.0003 | 14-JUL-22 |
| Tungsten (W)-Total | | | <0.00010 | | mg/L | | 0.0001 | 14-JUL-22 |
| Uranium (U)-Total | | | <0.000010 | | mg/L | | 0.00001 | 14-JUL-22 |
| Vanadium (V)-Total | | | <0.00050 | | mg/L | | 0.0005 | 14-JUL-22 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 14-JUL-22 |
| Zirconium (Zr)-Total | | | <0.00020 | | mg/L | | 0.0002 | 14-JUL-22 |
| **NO2-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5822060** | | | | | | | | |
| **WG3748211-3 DUP** | | **L2721317-1** | | | | | | |
| Nitrite (as N) | | <0.010 | <0.010 | RPD-NA | mg/L | N/A | 20 | 11-JUL-22 |
| **WG3748211-2 LCS** | | | | | | | | |
| Nitrite (as N) | | | 99.9 | | % | | 90-110 | 11-JUL-22 |
| **WG3748211-1 MB** | | | | | | | | |
| Nitrite (as N) | | | <0.010 | | mg/L | | 0.01 | 11-JUL-22 |
| **WG3748211-4 MS** | | **L2721317-1** | | | | | | |
| Nitrite (as N) | | | 105.0 | | % | | 75-125 | 11-JUL-22 |
| **NO3-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5822060** | | | | | | | | |
| **WG3748211-3 DUP** | | **L2721317-1** | | | | | | |
| Nitrate (as N) | | <0.020 | <0.020 | RPD-NA | mg/L | N/A | 20 | 11-JUL-22 |
| **WG3748211-2 LCS** | | | | | | | | |

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5822060** | | | | | | | | |
| **WG3748211-2 LCS** | | | | | | | | |
| Nitrate (as N) | | | 98.4 | | % | | 90-110 | 11-JUL-22 |
| **WG3748211-1 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 11-JUL-22 |
| **WG3748211-4 MS** | | **L2721317-1** | | | | | | |
| Nitrate (as N) | | | 104.2 | | % | | 75-125 | 11-JUL-22 |
| **PH-WP** | **Water** | | | | | | | |
| **Batch R5822357** | | | | | | | | |
| **WG3749556-22 LCS** | | | | | | | | |
| pH | | | 7.01 | | pH units | | 6.9-7.1 | 14-JUL-22 |
| **Batch R5822997** | | | | | | | | |
| **WG3750068-5 DUP** | | **L2721317-4** | | | | | | |
| pH | | 8.30 | 8.29 | J | pH units | 0.01 | 0.2 | 15-JUL-22 |
| **WG3750068-2 LCS** | | | | | | | | |
| pH | | | 6.96 | | pH units | | 6.9-7.1 | 15-JUL-22 |
| **SO4-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5822060** | | | | | | | | |
| **WG3748211-3 DUP** | | **L2721317-1** | | | | | | |
| Sulfate (SO4) | | <0.30 | <0.30 | RPD-NA | mg/L | N/A | 20 | 11-JUL-22 |
| **WG3748211-2 LCS** | | | | | | | | |
| Sulfate (SO4) | | | 99.9 | | % | | 90-110 | 11-JUL-22 |
| **WG3748211-1 MB** | | | | | | | | |
| Sulfate (SO4) | | | <0.30 | | mg/L | | 0.3 | 11-JUL-22 |
| **WG3748211-4 MS** | | **L2721317-1** | | | | | | |
| Sulfate (SO4) | | | 103.3 | | % | | 75-125 | 11-JUL-22 |
| **TURBIDITY-WP** | **Water** | | | | | | | |
| **Batch R5820259** | | | | | | | | |
| **WG3748190-3 DUP** | | **L2721317-3** | | | | | | |
| Turbidity | | 2.39 | 2.40 | | NTU | 0.4 | 15 | 11-JUL-22 |
| **WG3748190-2 LCS** | | | | | | | | |
| Turbidity | | | 99.96 | | % | | 85-115 | 11-JUL-22 |
| **WG3748190-1 MB** | | | | | | | | |
| Turbidity | | | <0.10 | | NTU | | 0.1 | 11-JUL-22 |

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| J | Duplicate results and limits are expressed in terms of absolute difference. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

# Quality Control Report



**Hold Time Exceedances:**

| ALS Product Description | Sample ID | Sampling Date | Date Processed | Rec. HT | Actual HT | Units | Qualifier |
|---|---|---|---|---|---|---|---|
| **Physical Tests** | | | | | | | |
| Turbidity | | | | | | | |
| | 2 | 07-JUL-22 10:00 | 11-JUL-22 15:00 | 3 | 4 | days | EHTR |
| | 3 | 06-JUL-22 10:00 | 11-JUL-22 15:00 | 3 | 5 | days | EHTR |
| | 4 | 05-JUL-22 10:00 | 11-JUL-22 15:00 | 3 | 6 | days | EHTR |
| pH | | | | | | | |
| | 1 | 08-JUL-22 10:00 | 14-JUL-22 09:00 | 0.25 | 143 | hours | EHTR-FM |
| | 2 | 07-JUL-22 10:00 | 15-JUL-22 09:04 | 0.25 | 191 | hours | EHTR-FM |
| | 3 | 06-JUL-22 10:00 | 15-JUL-22 09:04 | 0.25 | 215 | hours | EHTR-FM |
| | 4 | 05-JUL-22 10:00 | 15-JUL-22 09:04 | 0.25 | 239 | hours | EHTR-FM |
| **Anions and Nutrients** | | | | | | | |
| Nitrate in Water by IC | | | | | | | |
| | 2 | 07-JUL-22 10:00 | 11-JUL-22 15:30 | 3 | 4 | days | EHTR |
| | 3 | 06-JUL-22 10:00 | 11-JUL-22 15:30 | 3 | 5 | days | EHTR |
| | 4 | 05-JUL-22 10:00 | 11-JUL-22 15:30 | 3 | 6 | days | EHTR |
| Nitrite in Water by IC | | | | | | | |
| | 2 | 07-JUL-22 10:00 | 11-JUL-22 15:30 | 3 | 4 | days | EHTR |
| | 3 | 06-JUL-22 10:00 | 11-JUL-22 15:30 | 3 | 5 | days | EHTR |
| | 4 | 05-JUL-22 10:00 | 11-JUL-22 15:30 | 3 | 6 | days | EHTR |

**Legend & Qualifier Definitions:**

| | |
|---|---|
| EHTR-FM: | Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended. |
| EHTR: | Exceeded ALS recommended hold time prior to sample receipt. |
| EHTL: | Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry. |
| EHT: | Exceeded ALS recommended hold time prior to analysis. |
| Rec. HT: | ALS recommended hold time (see units). |

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L2721317 were received on 11-JUL-22 07:55.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

---

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Client: Dalmaijer/ALS

PO: L2721317

ISO# 2022360
Location: A2
4 for 18O, 2H

Environmental Isotope Lab
2022-07-25


| # | Sample | Date | Lab# | $\delta^{18}O$ | Result | Repeat | $\delta^{2}H$ | Result | Repeat | | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $H_2O$ | VSMOW | ± 0.2‰ | $H_2O$ | VSMOW | ± 0.8‰ | | |
| 1 | L2721317-1 | 2022-07-08 | 484933 | X | -14.20 | -14.17 | X | -104.21 | -103.85 | 2x40ml | 8.23 |
| 2 | L2721317-2 | 2022-07-07 | 484934 | X | -14.18 | | X | -104.17 | | 2x40ml | 8.24 |
| 3 | L2721317-3 | 2022-07-06 | 484935 | X | -13.99 | -14.01 | X | -103.71 | -103.87 | 2x40ml | 8.19 |
| 4 | L2721317-4 | 2022-07-05 | 484936 | X | -13.94 | | X | -103.60 | | 2x40ml | 8.30 |

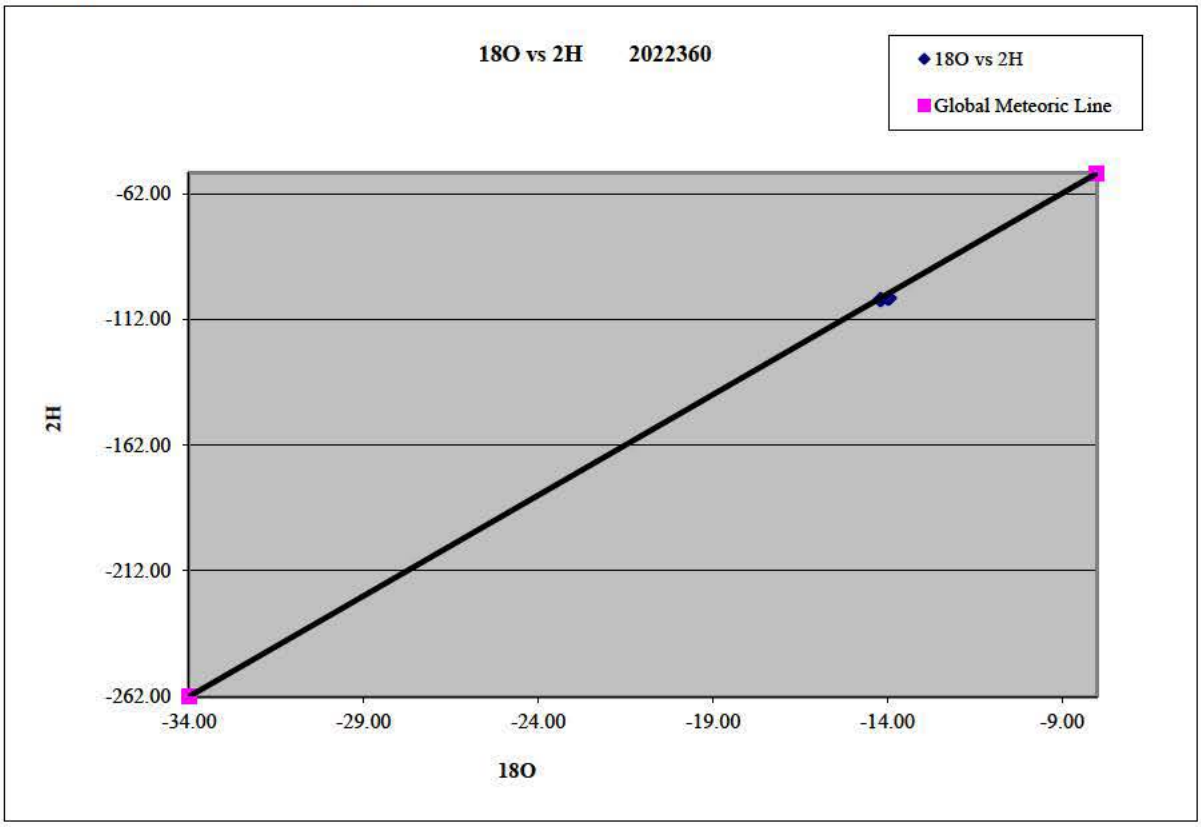
ENVIRONMENTAL ISOTOPE LABORATORY

| EC | AZD |
|---|---|
| uS/cm | |
| 682 | |
| 675 | |
| 677 | |
| 673 | |

Dalmaijer 2022360

| | | | |
|---|---|---|---|
| -14.20 | -14.17 | -104.21 | -103.85 |
| -14.18 | | -104.17 | |
| -13.99 | -14.01 | -103.71 | -103.87 |
| -13.94 | | -103.60 | |

| | |
|---|---|
| -8.00 | -54 |
| -34.00 | -262 |



# Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2721317-COFC

COC Number: 17 -

Page of

| Report To | Contact and company name below will appear on the final report |
|---|---|
| Company: | Friesen Drillers Ltd. |
| Contact: | Paulynn Estrella-Legal |
| Phone: | 204-326-2485 |
| | Company address below will appear on the final report |
| Street: | 307 PTH 12 N |
| City/Province: | Steinbach, MB |
| Postal Code: | R5G 1T8 |
| **Invoice To** | Same as Report To ☑ YES ☐ NO |
| | Copy of Invoice with Report ☑ YES ☐ NO |
| Company: | |
| Contact: | |

**Report Format / Distribution**

Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)
Quality Control (QC) Report with Report ☐ ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax jeff@friesendrillers.com
Email 2 paulynn@friesendrillers.com
Email 3 justin@friesendrillers.com

**Invoice Distribution**

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax
Email 2

**Project Information**

| | |
|---|---|
| ALS Account # / Quote #: | |
| Job #: | RM of Ritchot |
| PO / AFE: | Randolph Well Field |
| LSD: | |

**Oil and Gas Required Fields (client use)**

| | |
|---|---|
| AFE/Cost Center: | PO#: |
| Major/Minor Code: | Routing Code: |
| Requisitioner: | |
| Location: | |

**ALS Lab Work Order # (lab use only):**

**ALS Contact:** Judy **Sampler:** AF

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4-20%] ☐ | 3 day [P3-25%] ☐ | 2 day [P2-50%] ☐

EMERGENCY: 1 Business day [E1 - 100%] ☐ | Same Day, Weekend or Statutory holiday [E2 - 200%] (Laboratory opening fees may apply)] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | ROU4W + MET -WP | Oxygen 18 | Deuterium | SAMPLES ON HOLD | Sample is hazardous (please provide further details) | NUMBER OF CONTAINERS |
|---|---|---|---|---|---|---|---|---|---|---|
| | Well 2 - 72 Hours | 8-Jul-22 | 10:00 | Water | R | R | R | | | |
| | Well2 - 48 Hours | 7-Jul-22 | 10:00 | Water | R | R | R | | | |
| | Well 2 - 24 Hours | 6-Jul-22 | 10:00 | Water | R | R | R | | | |
| | Well 2 - 1 Hr | 5-Jul-22 | 10:00 | Water | R | R | R | | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System? ☐ ☐

Are samples for human consumption/ use? ☐ ☐

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

| INITIAL COOLER TEMPERATURES °C | | | | FINAL COOLER TEMPERATURES °C | | | |
|---|---|---|---|---|---|---|---|
| 14.5 | | | | | | | |

| SHIPMENT RELEASE (client use) | | | INITIAL SHIPMENT RECEPTION (lab use only) | | | FINAL SHIPMENT RECEPTION (lab use only) | | |
|---|---|---|---|---|---|---|---|---|
| Released by: | Date: | Time: | Received by: [redacted] | Date: JUL 11 2022 | Time: 7:55am | Received by: | Date: | Time: |

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

SEPT 2017 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Friesen Drillers Ltd
ATTN: JEFF BELL
307 PTH 12 N
Steinbach MB R5G 1L9

Date Received: 28-JUL-22
Report Date: 18-AUG-22 16:41 (MT)
Version: FINAL

Client Phone: 204-326-2485

# Certificate of Analysis

Lab Work Order #: L2725315
Project P.O. #: NOT SUBMITTED
Job Reference: RM OF RITCHOT
C of C Numbers:
Legal Site Desc:

[redacted]
Craig Biddell, B.Sc.Ag
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2725315-1 WELL 1 | | | | | | | |
| Sampled By: CLIENT on 25-JUL-22 @ 13:00 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Miscellaneous Parameters** | | | | | | | |
| Special Request | See Attached | | | | | 16-AUG-22 | R5812947 |
| **ROU4W total** | | | | | | | |
| **Alkalinity, Bicarbonate** | | | | | | | |
| Bicarbonate (HCO3) | 394 | | 1.2 | mg/L | | 04-AUG-22 | |
| **Alkalinity, Carbonate** | | | | | | | |
| Carbonate (CO3) | <0.60 | | 0.60 | mg/L | | 04-AUG-22 | |
| **Alkalinity, Hydroxide** | | | | | | | |
| Hydroxide (OH) | <0.34 | | 0.34 | mg/L | | 04-AUG-22 | |
| **Alkalinity, Total (as CaCO3)** | | | | | | | |
| Alkalinity, Total (as CaCO3) | 323 | | 1.0 | mg/L | | 03-AUG-22 | R5834956 |
| **Chloride in Water by IC** | | | | | | | |
| Chloride (Cl) | 38.4 | | 0.50 | mg/L | | 28-JUL-22 | R5831497 |
| **Conductivity** | | | | | | | |
| Conductivity | 686 | | 1.0 | umhos/cm | | 03-AUG-22 | R5834956 |
| **Fluoride in Water by IC** | | | | | | | |
| Fluoride (F) | 0.582 | | 0.020 | mg/L | | 28-JUL-22 | R5831497 |
| **Hardness Calculated** | | | | | | | |
| Hardness (as CaCO3) | 220 | HTC | 0.20 | mg/L | | 09-AUG-22 | |
| **Nitrate in Water by IC** | | | | | | | |
| Nitrate (as N) | <0.020 | | 0.020 | mg/L | | 28-JUL-22 | R5831497 |
| **Nitrate+Nitrite** | | | | | | | |
| Nitrate and Nitrite as N | <0.070 | | 0.070 | mg/L | | 30-JUL-22 | |
| **Nitrite in Water by IC** | | | | | | | |
| Nitrite (as N) | <0.010 | | 0.010 | mg/L | | 28-JUL-22 | R5831497 |
| **Sulfate in Water by IC** | | | | | | | |
| Sulfate (SO4) | <0.30 | | 0.30 | mg/L | | 28-JUL-22 | R5831497 |
| **TDS calculated** | | | | | | | |
| TDS (Calculated) | 376 | | 5.0 | mg/L | | 09-AUG-22 | |
| **Total Metals in Water by CRC ICPMS** | | | | | | | |
| Aluminum (Al)-Total | <0.0030 | | 0.0030 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Antimony (Sb)-Total | <0.00010 | | 0.00010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Arsenic (As)-Total | 0.00025 | | 0.00010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Barium (Ba)-Total | 0.505 | | 0.00010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Beryllium (Be)-Total | <0.00010 | | 0.00010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Bismuth (Bi)-Total | <0.000050 | | 0.000050 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Boron (B)-Total | 0.303 | | 0.010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Cadmium (Cd)-Total | <0.0000050 | | 0.0000050 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Calcium (Ca)-Total | 43.7 | | 0.050 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Cesium (Cs)-Total | 0.000018 | | 0.000010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Chromium (Cr)-Total | <0.00010 | | 0.00010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Cobalt (Co)-Total | <0.00010 | | 0.00010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Copper (Cu)-Total | <0.00050 | | 0.00050 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Iron (Fe)-Total | 0.420 | | 0.010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Lead (Pb)-Total | <0.000050 | | 0.000050 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Lithium (Li)-Total | 0.0269 | | 0.0010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Magnesium (Mg)-Total | 26.8 | | 0.0050 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Manganese (Mn)-Total | 0.00448 | | 0.00010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Molybdenum (Mo)-Total | 0.00115 | | 0.000050 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Nickel (Ni)-Total | <0.00050 | | 0.00050 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Potassium (K)-Total | 6.89 | | 0.050 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Phosphorus (P)-Total | <0.030 | | 0.030 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Rubidium (Rb)-Total | 0.00435 | | 0.00020 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2725315-1 WELL 1 | | | | | | | |
| Sampled By: CLIENT on 25-JUL-22 @ 13:00 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Total Metals in Water by CRC ICPMS** | | | | | | | |
| Selenium (Se)-Total | <0.000050 | | 0.000050 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Silicon (Si)-Total | 6.36 | | 0.10 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Silver (Ag)-Total | <0.000010 | | 0.000010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Sodium (Na)-Total | 66.6 | | 0.050 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Strontium (Sr)-Total | 0.487 | | 0.00020 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Sulfur (S)-Total | <0.50 | | 0.50 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Tellurium (Te)-Total | <0.00020 | | 0.00020 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Thallium (Tl)-Total | <0.000010 | | 0.000010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Thorium (Th)-Total | <0.00010 | | 0.00010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Tin (Sn)-Total | <0.00010 | | 0.00010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Titanium (Ti)-Total | <0.00030 | | 0.00030 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Tungsten (W)-Total | 0.00087 | | 0.00010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Uranium (U)-Total | <0.000010 | | 0.000010 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Vanadium (V)-Total | <0.00050 | | 0.00050 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Zinc (Zn)-Total | <0.0030 | | 0.0030 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| Zirconium (Zr)-Total | <0.00020 | | 0.00020 | mg/L | 29-JUL-22 | 02-AUG-22 | R5838837 |
| **Turbidity** | | | | | | | |
| Turbidity | 3.62 | | 0.10 | NTU | | 29-JUL-22 | R5832476 |
| **pH** | | | | | | | |
| pH | 8.22 | | 0.10 | pH units | | 03-AUG-22 | R5834956 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

**Sample Parameter Qualifier Key:**

| Qualifier | Description |
|---|---|
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

**Test Method References:**

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| ALK-CO3CO3-CALC-WP | Water | Alkalinity, Carbonate | CALCULATION |

The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contr buted by carbonate is calculated and reported as mg CO3 2-/L.

| | | | |
|---|---|---|---|
| ALK-HCO3HCO3-CALC-WP | Water | Alkalinity, Bicarbonate | CALCULATION |

The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contr buted by bicarbonate is calculated and reported as mg HCO3-/L

| | | | |
|---|---|---|---|
| ALK-OHOH-CALC-WP | Water | Alkalinity, Hydroxide | CALCULATION |

The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contr buted by hydroxide is calculated and reported as mg OH-/L.

| | | | |
|---|---|---|---|
| ALK-TITR-WP | Water | Alkalinity, Total (as CaCO3) | APHA 2320B |

The Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. Total alkalinity is determined by titration with a strong standard mineral acid to the successive HCO3- and H2CO3 endpoints indicated electrometrically.

| | | | |
|---|---|---|---|
| CL-IC-N-WP | Water | Chloride in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| | | | |
|---|---|---|---|
| EC-WP | Water | Conductivity | APHA 2510B |

Conductivity of an aqueous solution refers to its ability to carry an electric current. Conductance of a solution is measured between two spatially fixed and chemically inert electrodes.

| | | | |
|---|---|---|---|
| ETL-SOLIDS-CALC-WP | Water | TDS calculated | CALCULATION |
| F-IC-N-WP | Water | Fluoride in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| | | | |
|---|---|---|---|
| HARDNESS-CALC-WP | Water | Hardness Calculated | APHA 2340B |

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

| | | | |
|---|---|---|---|
| IONBALANCE-CALC-WP | Water | Ion Balance Calculation | APHA 1030E |

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance (as % difference) cannot be calculated accurately for waters with very low electrical conductivity (EC), and is reported as "Low EC" where EC < 100 uS/cm (umhos/cm). Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

| | | | |
|---|---|---|---|
| MET-T-CCMS-WP | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020B (mod.) |

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

| | | | |
|---|---|---|---|
| NO2+NO3-CALC-WP | Water | Nitrate+Nitrite | CALCULATION |
| NO2-IC-N-WP | Water | Nitrite in Water by IC | EPA 300.1 (mod) |

# Reference Information

**Test Method References:**

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection. | | | |
| NO3-IC-N-WP | Water | Nitrate in Water by IC | EPA 300.1 (mod) |
| Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection. | | | |
| PH-WP | Water | pH | APHA 4500H |
| The pH of a sample is the determination of the activity of the hydrogen ions by potentiometric measurement using a standard hydrogen electrode and a reference electrode. | | | |
| SO4-IC-N-WP | Water | Sulfate in Water by IC | EPA 300.1 (mod) |
| Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection. | | | |
| SPECIAL REQUEST-UW | Misc. | Special Request University of Waterloo | SEE SUBLET LAB RESULTS |
| TURBIDITY-WP | Water | Turbidity | APHA 2130B (modified) |
| Turbidity in aqueous matrices is determined by the nephelometric method. | | | |

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| UW | UNIVERSITY OF WATERLOO |
| WP | ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA |

**Chain of Custody Numbers:**

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*
*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L2725315 Report Date: 18-AUG-22 

Client: Friesen Drillers Ltd
307 PTH 12 N
Steinbach MB R5G 1L9
Contact: JEFF BELL

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **ALK-TITR-WP** | **Water** | | | | | | | |
| **Batch R5834956** | | | | | | | | |
| **WG3754560-14 LCS** | | | | | | | | |
| Alkalinity, Total (as CaCO3) | | | 100.2 | | % | | 85-115 | 03-AUG-22 |
| **WG3754560-11 MB** | | | | | | | | |
| Alkalinity, Total (as CaCO3) | | | <1.0 | | mg/L | | 1 | 03-AUG-22 |
| **CL-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5831497** | | | | | | | | |
| **WG3753232-2 LCS** | | | | | | | | |
| Chloride (Cl) | | | 98.3 | | % | | 90-110 | 28-JUL-22 |
| **WG3753232-1 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 28-JUL-22 |
| **EC-WP** | **Water** | | | | | | | |
| **Batch R5834956** | | | | | | | | |
| **WG3754560-13 LCS** | | | | | | | | |
| Conductivity | | | 98.7 | | % | | 90-110 | 03-AUG-22 |
| **WG3754560-11 MB** | | | | | | | | |
| Conductivity | | | <1.0 | | umhos/cm | | 1 | 03-AUG-22 |
| **F-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5831497** | | | | | | | | |
| **WG3753232-2 LCS** | | | | | | | | |
| Fluoride (F) | | | 102.4 | | % | | 90-110 | 28-JUL-22 |
| **WG3753232-1 MB** | | | | | | | | |
| Fluoride (F) | | | <0.020 | | mg/L | | 0.02 | 28-JUL-22 |
| **MET-T-CCMS-WP** | **Water** | | | | | | | |
| **Batch R5838837** | | | | | | | | |
| **WG3753395-2 LCS** | | | | | | | | |
| Aluminum (Al)-Total | | | 103.4 | | % | | 80-120 | 02-AUG-22 |
| Antimony (Sb)-Total | | | 104.0 | | % | | 80-120 | 02-AUG-22 |
| Arsenic (As)-Total | | | 104.5 | | % | | 80-120 | 02-AUG-22 |
| Barium (Ba)-Total | | | 110.2 | | % | | 80-120 | 02-AUG-22 |
| Beryllium (Be)-Total | | | 104.2 | | % | | 80-120 | 02-AUG-22 |
| Bismuth (Bi)-Total | | | 97.5 | | % | | 80-120 | 02-AUG-22 |
| Boron (B)-Total | | | 105.3 | | % | | 80-120 | 02-AUG-22 |
| Cadmium (Cd)-Total | | | 102.1 | | % | | 80-120 | 02-AUG-22 |
| Calcium (Ca)-Total | | | 99.0 | | % | | 80-120 | 02-AUG-22 |
| Cesium (Cs)-Total | | | 109.2 | | % | | 80-120 | 02-AUG-22 |
| Chromium (Cr)-Total | | | 96.1 | | % | | 80-120 | 02-AUG-22 |

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **MET-T-CCMS-WP** | **Water** | | | | | | | |
| **Batch R5838837** | | | | | | | | |
| **WG3753395-2 LCS** | | | | | | | | |
| Cobalt (Co)-Total | | | 97.6 | | % | | 80-120 | 02-AUG-22 |
| Copper (Cu)-Total | | | 95.3 | | % | | 80-120 | 02-AUG-22 |
| Iron (Fe)-Total | | | 90.2 | | % | | 80-120 | 02-AUG-22 |
| Lead (Pb)-Total | | | 101.3 | | % | | 80-120 | 02-AUG-22 |
| Lithium (Li)-Total | | | 98.0 | | % | | 80-120 | 02-AUG-22 |
| Magnesium (Mg)-Total | | | 97.9 | | % | | 80-120 | 02-AUG-22 |
| Manganese (Mn)-Total | | | 95.8 | | % | | 80-120 | 02-AUG-22 |
| Molybdenum (Mo)-Total | | | 103.4 | | % | | 80-120 | 02-AUG-22 |
| Nickel (Ni)-Total | | | 95.3 | | % | | 80-120 | 02-AUG-22 |
| Potassium (K)-Total | | | 103.2 | | % | | 80-120 | 02-AUG-22 |
| Phosphorus (P)-Total | | | 106.8 | | % | | 80-120 | 02-AUG-22 |
| Rubidium (Rb)-Total | | | 101.4 | | % | | 80-120 | 02-AUG-22 |
| Selenium (Se)-Total | | | 96.6 | | % | | 80-120 | 02-AUG-22 |
| Silicon (Si)-Total | | | 108.3 | | % | | 80-120 | 02-AUG-22 |
| Silver (Ag)-Total | | | 99.7 | | % | | 80-120 | 02-AUG-22 |
| Sodium (Na)-Total | | | 101.2 | | % | | 80-120 | 02-AUG-22 |
| Strontium (Sr)-Total | | | 103.2 | | % | | 80-120 | 02-AUG-22 |
| Sulfur (S)-Total | | | 109.5 | | % | | 80-120 | 02-AUG-22 |
| Tellurium (Te)-Total | | | 102.9 | | % | | 80-120 | 02-AUG-22 |
| Thallium (Tl)-Total | | | 100.9 | | % | | 80-120 | 02-AUG-22 |
| Thorium (Th)-Total | | | 97.5 | | % | | 80-120 | 02-AUG-22 |
| Tin (Sn)-Total | | | 104.0 | | % | | 80-120 | 02-AUG-22 |
| Titanium (Ti)-Total | | | 96.3 | | % | | 80-120 | 02-AUG-22 |
| Tungsten (W)-Total | | | 101.4 | | % | | 80-120 | 02-AUG-22 |
| Uranium (U)-Total | | | 94.2 | | % | | 80-120 | 02-AUG-22 |
| Vanadium (V)-Total | | | 99.4 | | % | | 80-120 | 02-AUG-22 |
| Zinc (Zn)-Total | | | 97.2 | | % | | 80-120 | 02-AUG-22 |
| Zirconium (Zr)-Total | | | 101.1 | | % | | 80-120 | 02-AUG-22 |
| **WG3753395-1 MB** | | | | | | | | |
| Aluminum (Al)-Total | | | <0.0030 | | mg/L | | 0.003 | 02-AUG-22 |
| Antimony (Sb)-Total | | | <0.00010 | | mg/L | | 0.0001 | 02-AUG-22 |
| Arsenic (As)-Total | | | <0.00010 | | mg/L | | 0.0001 | 02-AUG-22 |
| Barium (Ba)-Total | | | <0.00010 | | mg/L | | 0.0001 | 02-AUG-22 |
| Beryllium (Be)-Total | | | <0.00010 | | mg/L | | 0.0001 | 02-AUG-22 |

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **MET-T-CCMS-WP** | **Water** | | | | | | | |
| **Batch R5838837** | | | | | | | | |
| **WG3753395-1 MB** | | | | | | | | |
| Bismuth (Bi)-Total | | | <0.000050 | | mg/L | | 0.00005 | 02-AUG-22 |
| Boron (B)-Total | | | <0.010 | | mg/L | | 0.01 | 02-AUG-22 |
| Cadmium (Cd)-Total | | | <0.000005C | | mg/L | | 0.000005 | 02-AUG-22 |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 02-AUG-22 |
| Cesium (Cs)-Total | | | <0.000010 | | mg/L | | 0.00001 | 02-AUG-22 |
| Chromium (Cr)-Total | | | <0.00010 | | mg/L | | 0.0001 | 02-AUG-22 |
| Cobalt (Co)-Total | | | <0.00010 | | mg/L | | 0.0001 | 02-AUG-22 |
| Copper (Cu)-Total | | | <0.00050 | | mg/L | | 0.0005 | 02-AUG-22 |
| Iron (Fe)-Total | | | <0.010 | | mg/L | | 0.01 | 02-AUG-22 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 02-AUG-22 |
| Lithium (Li)-Total | | | <0.0010 | | mg/L | | 0.001 | 02-AUG-22 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 02-AUG-22 |
| Manganese (Mn)-Total | | | <0.00010 | | mg/L | | 0.0001 | 02-AUG-22 |
| Molybdenum (Mo)-Total | | | <0.000050 | | mg/L | | 0.00005 | 02-AUG-22 |
| Nickel (Ni)-Total | | | <0.00050 | | mg/L | | 0.0005 | 02-AUG-22 |
| Potassium (K)-Total | | | <0.050 | | mg/L | | 0.05 | 02-AUG-22 |
| Phosphorus (P)-Total | | | <0.030 | | mg/L | | 0.03 | 02-AUG-22 |
| Rubidium (Rb)-Total | | | <0.00020 | | mg/L | | 0.0002 | 02-AUG-22 |
| Selenium (Se)-Total | | | <0.000050 | | mg/L | | 0.00005 | 02-AUG-22 |
| Silicon (Si)-Total | | | <0.10 | | mg/L | | 0.1 | 02-AUG-22 |
| Silver (Ag)-Total | | | <0.000010 | | mg/L | | 0.00001 | 02-AUG-22 |
| Sodium (Na)-Total | | | <0.050 | | mg/L | | 0.05 | 02-AUG-22 |
| Strontium (Sr)-Total | | | <0.00020 | | mg/L | | 0.0002 | 02-AUG-22 |
| Sulfur (S)-Total | | | <0.50 | | mg/L | | 0.5 | 02-AUG-22 |
| Tellurium (Te)-Total | | | <0.00020 | | mg/L | | 0.0002 | 02-AUG-22 |
| Thallium (Tl)-Total | | | <0.000010 | | mg/L | | 0.00001 | 02-AUG-22 |
| Thorium (Th)-Total | | | <0.00010 | | mg/L | | 0.0001 | 02-AUG-22 |
| Tin (Sn)-Total | | | <0.00010 | | mg/L | | 0.0001 | 02-AUG-22 |
| Titanium (Ti)-Total | | | <0.00030 | | mg/L | | 0.0003 | 02-AUG-22 |
| Tungsten (W)-Total | | | <0.00010 | | mg/L | | 0.0001 | 02-AUG-22 |
| Uranium (U)-Total | | | <0.000010 | | mg/L | | 0.00001 | 02-AUG-22 |
| Vanadium (V)-Total | | | <0.00050 | | mg/L | | 0.0005 | 02-AUG-22 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 02-AUG-22 |
| Zirconium (Zr)-Total | | | <0.00020 | | mg/L | | 0.0002 | 02-AUG-22 |

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO2-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5831497** | | | | | | | | |
| **WG3753232-2 LCS** | | | | | | | | |
| Nitrite (as N) | | | 99.0 | | % | | 90-110 | 28-JUL-22 |
| **WG3753232-1 MB** | | | | | | | | |
| Nitrite (as N) | | | <0.010 | | mg/L | | 0.01 | 28-JUL-22 |
| **NO3-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5831497** | | | | | | | | |
| **WG3753232-2 LCS** | | | | | | | | |
| Nitrate (as N) | | | 99.7 | | % | | 90-110 | 28-JUL-22 |
| **WG3753232-1 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 28-JUL-22 |
| **PH-WP** | **Water** | | | | | | | |
| **Batch R5834956** | | | | | | | | |
| **WG3754560-12 LCS** | | | | | | | | |
| pH | | | 7.00 | | pH units | | 6.9-7.1 | 03-AUG-22 |
| **SO4-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5831497** | | | | | | | | |
| **WG3753232-2 LCS** | | | | | | | | |
| Sulfate (SO4) | | | 99.6 | | % | | 90-110 | 28-JUL-22 |
| **WG3753232-1 MB** | | | | | | | | |
| Sulfate (SO4) | | | <0.30 | | mg/L | | 0.3 | 28-JUL-22 |
| **TURBIDITY-WP** | **Water** | | | | | | | |
| **Batch R5832476** | | | | | | | | |
| **WG3753419-8 LCS** | | | | | | | | |
| Turbidity | | | 98.5 | | % | | 85-115 | 29-JUL-22 |
| **WG3753419-7 MB** | | | | | | | | |
| Turbidity | | | <0.10 | | NTU | | 0.1 | 29-JUL-22 |

# Quality Control Report



**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

# Quality Control Report



**Hold Time Exceedances:**

| ALS Product Description | Sample ID | Sampling Date | Date Processed | Rec. HT | Actual HT | Units | Qualifier |
|---|---|---|---|---|---|---|---|
| **Physical Tests** | | | | | | | |
| Turbidity | | | | | | | |
| | 1 | 25-JUL-22 13:00 | 29-JUL-22 09:00 | 3 | 4 | days | EHTL |
| pH | | | | | | | |
| | 1 | 25-JUL-22 13:00 | 03-AUG-22 10:42 | 0.25 | 214 | hours | EHTR-FM |

**Legend & Qualifier Definitions:**

| | |
|---|---|
| EHTR-FM: | Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended. |
| EHTR: | Exceeded ALS recommended hold time prior to sample receipt. |
| EHTL: | Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry. |
| EHT: | Exceeded ALS recommended hold time prior to analysis. |
| Rec. HT: | ALS recommended hold time (see units). |

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L2725315 were received on 28-JUL-22 09:56.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

---

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Client: Dalmaijer/ALS

PO: L2725315

ISO# 2022391
Location: A5
1 for 18O, 2H

Environmental Isotope Lab
2022-08-18

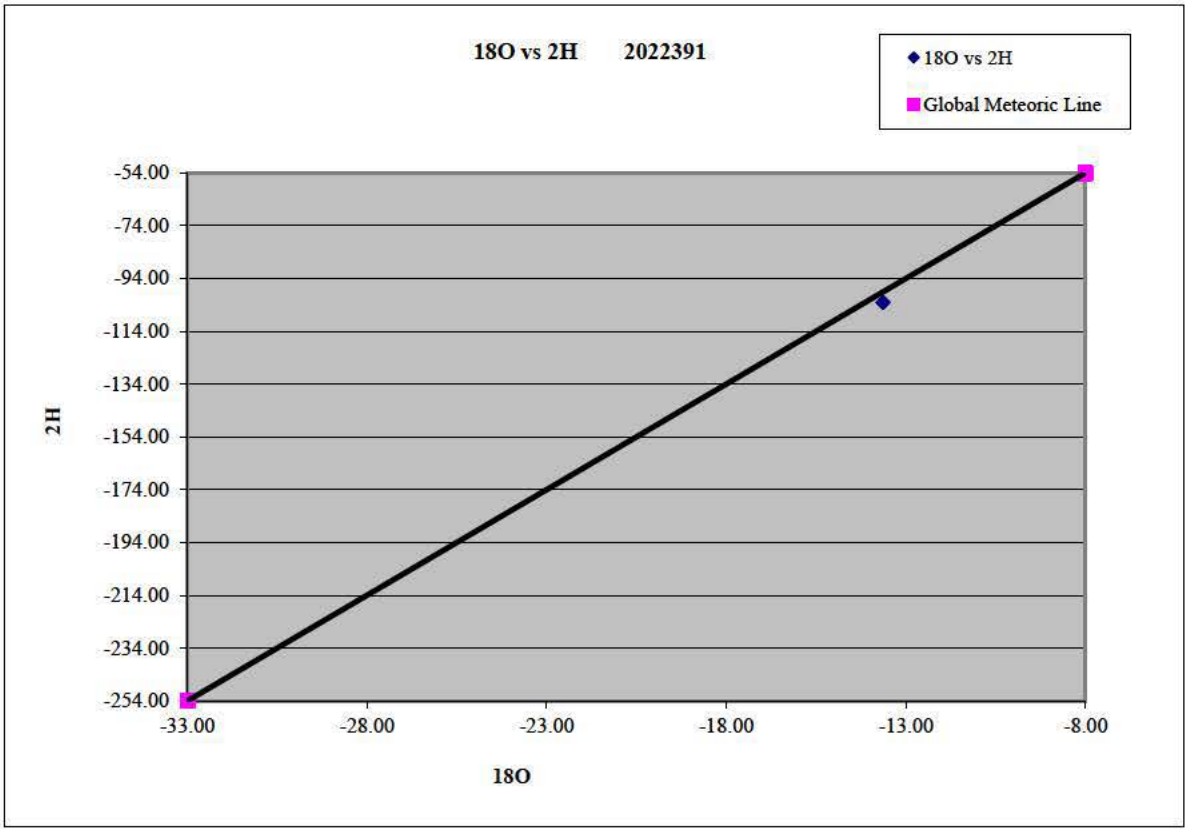

| # | Sample | Date | Lab# | $\delta^{18}O$ | Result | Repeat | $\delta^{2}H$ | Result | Repeat | | pH | EC | AZD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $H_2O$ | VSMOW ± 0.2‰ | | $H_2O$ | VSMOW ± 0.8‰ | | | | uS/cm | |
| 1 | L2725315-1 | 07-25-2022 | 485938 | X | -13.63 | -13.61 | X | -103.02 | -103.03 | 2x40ml | 8.22 | 686 | |

ENVIRONMENTAL ISOTOPE LABORATORY

Dalmaijer 2022391

| | | | |
|---|---|---|---|
| -13.63 | -13.61 | -103.02 | -103.03 |

| | |
|---|---|
| -8 | -54 |
| -33 | -254 |



# Chain of Custody (COC) / Analytical Request Form

ALS Environmental

www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2725315-COFC

COC Number: 17 -

Page of

| Report To | Contact and company name below will appear on the final report |
|---|---|
| Company: | Friesen Drillers Ltd. |
| Contact: | Jeff Bell, P. Eng. |
| Phone: | 204-326-2485 |
| | Company address below will appear on the final report |
| Street: | 307 PTH 12 N |
| City/Province: | Steinbach, MB |
| Postal Code: | R5G 1T8 |
| **Invoice To** | Same as Report To ☑ YES ☐ NO |
| | Copy of Invoice with Report ☑ YES ☐ NO |
| Company: | |
| Contact: | |

| Report Format / Distribution | |
|---|---|
| Select Report Format: | ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL) |
| Quality Control (QC) Report with Report | ☐ YES ☐ NO |
| ☐ Compare Results to Criteria on Report - provide details below if box checked | |
| Select Distribution: | ☑ EMAIL ☐ MAIL ☐ FAX |
| Email 1 or Fax | jeff@friesendrillers.com |
| Email 2 | paulynn@friesendrillers.com |
| Email 3 | justin@friesendrillers.com |
| **Invoice Distribution** | |
| Select Invoice Distribution: | ☑ EMAIL ☐ MAIL ☐ FAX |
| Email 1 or Fax | |
| Email 2 | |

| Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply) | |
|---|---|
| **Regular [R]** | ☑ Standard TAT if received by 3 pm - business days - no surcharges apply |
| PRIORITY (Business Days) | 4 day [P4-20%] ☐ |
| | 3 day [P3-25%] ☐ |
| | 2 day [P2-50%] ☐ |
| EMERGENCY | 1 Business day [E1 - 100%] ☐ |
| | Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐ |
| Date and Time Required for all E&P TATs: | |
| For tests that can not be performed according to the service level selected, you will be contacted. | |

| Project Information | | Oil and Gas Required Fields (client use) | |
|---|---|---|---|
| ALS Account # / Quote #: | | AFE/Cost Center: | PO# |
| Job #: | RM of Ritchot | Major/Minor Code: | Routing Code: |
| PO / AFE: | | Requisitioner: | |
| LSD: | | Location: | |
| **ALS Lab Work Order # (lab use only):** | | **ALS Contact:** Judy | **Sampler:** PF |

**Analysis Request**

indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | ROU4W+MET-WP | Oxygen 18 | Deuterium | SAMPLES ON HOLD | Sample is hazardous (please provide further details | NUMBER OF CONTAINERS |
|---|---|---|---|---|---|---|---|---|---|---|
| | Well 1 | 25-Jul-22 | 13:00 | Water | R | R | R | | | |

| Drinking Water (DW) Samples[1] (client use) | Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only) |
|---|---|
| Are samples taken from a Regulated DW System? ☐ YES ☐ NO | |
| Are samples for human consumption/ use? ☐ YES ☐ NO | |

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

| INITIAL COOLER TEMPERATURES °C | | | | FINAL COOLER TEMPERATURES °C | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

| SHIPMENT RELEASE (client use) | | | INITIAL SHIPMENT RECEPTION (lab use only) | | | FINAL SHIPMENT RECEPTION (lab use only) | | |
|---|---|---|---|---|---|---|---|---|
| Released by: | Date: | Time: | Received by: [redacted] 14.3°C | Date: 28/07/22 | Time: 9:50 | Received by: | Date: | Time: |

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

SEPT 2017 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Friesen
DRILLERS

# Appendix J

# Well Interference Plan

**Municipality of Ritchot**
**Regular Council Meeting**
**January 18, 2023**

**Groundwater Interference Complaint Response Policy**

Resolution Number: 20230026

BE IT RESOLVED that Council approves the following policy:

- Groundwater Interference Complaint Response Policy

For: Councillors S. Pelletier, J. Bodnarchuk, J. Lemoine, J. Boulanger
Against: None

**Carried**

Certified a true and correct copy of Resolution
passed by Council assembled in St. Adolphe, Manitoba.

[redacted]

Mitch Duval
Chief Administrative Officer

# RURAL MUNICIPALITY OF RITCHOT

# GROUNDWATER INTERFERENCE POLICY

## PURPOSE:

The purpose of the Groundwater Interference Complaint Response Policy is to establish a procedure to deal with complaints of groundwater interference regarding private wells.

The groundwater interference complaint response policy will be invoked if a resident makes a written groundwater interference complaint to the Rural Municipality of Ritchot (RM of Ritchot) on the form as set out in Schedule "A" attached to and forming part of this policy.

Any resident contacting Manitoba Environment, Climate and Parks regarding a well water interference complaint should first be referred to the RM of Ritchot.

## DEFINITIONS:

**"Groundwater Interference"** is defined as a decrease in residential well performance due to factors such as the pumping of the RM of Ritchot production well(s) that causes a decrease in well capacity such that the supply of water to the well is temporarily or permanently interrupted.

## PROCEDURE:

The procedures for responding to a groundwater interference complaint have been divided into two categories, as follows:

1. Preliminary Well Assessment; and

2. Secondary Well Assessment.

All complaints shall be in writing and shall be submitted on the Groundwater Interference Complaint Incident Report on the form as set out in Schedule "A" attached to and forming part of this policy. Upon receipt of a written complaint the preliminary well assessment will be completed by the Public Works Department as set out in Schedule "B". Depending on the results of the preliminary assessment, it may be necessary to have an approved private sector Investigating Contractor as listed in Schedule "C" attached to and forming part of this policy complete a more detailed secondary well assessment. The procedures for both types of assessment are detailed below.

1. **Preliminary Well Assessment**

a) The Public Works Department will undertake a well assessment within twenty-four (24) hours of receiving the interference complaint. The initial assessment and discussion with the well owner may conclude that no further action is required on the part of the RM of Ritchot.

b) In the event that the Public Works Department concludes that groundwater interference may have occurred, the following actions will be taken:

(i) Immediately offer or provide the resident with a reasonable amount of potable water: and,

(ii) Contact RM of Ritchot's Investigating Contractor to undertake an investigation to determine the cause of the complaint.

2. **Secondary Well Assessment**

a) In the event that the Investigating Contractor concludes that groundwater interference **did not** occur, the resident may be required to pay for the temporary water supply.

b) In the event that the Investigating Contractor concludes that a bona fide groundwater interference may have occurred, the Public Works Department will complete one of the following actions:

(i) With agreement of the affected resident, continue to deliver water to the resident at no cost; or

(ii) Institute mitigation measures such as lowering the well pump or repairing/replacing the well in order to accommodate the observed interference; or

(iii) Reduce the rate and amount of municipal water taking so as to alleviate the observed interference. This action may not immediately restore water to the private well and it may be necessary to continue action (i) above in the interim.

3. **Documentation**

The groundwater interference complaint incident report should be summarized and as a minimum, documents the following:

a) The location of the complaint (name, address, telephone number);

b) Investigation procedures and results; and

c) Any actions taken to restore water supply

## 4. Notification

Manitoba Environment, Climate and Parks - Drainage and Water Rights Licensing Branch must be notified of any bona fide well interference problem as follows:

The Public Works Department must notify Manitoba Environment, Climate and Parks - Drainage and Water Rights Licensing Branch, by phone and email immediately after the Investigating Contractor has confirmed that a well interference may have occurred.

a) The Groundwater Interference Complaint Incident Report documenting the well interference must be submitted to Manitoba Environment, Climate and Parks - Drainage and Water Rights Licensing Branch, no more than one (1) week after the interference was confirmed.

## 5. Appeal Process

a) Should the resident not agree with the results of the investigation of the well interference problem, the resident may, in writing, submit an appeal to Council for their consideration. Any appeal shall be submitted within fourteen (14) days after the date the report is received by the resident.

b) Upon receipt of an appeal, a Council hearing date will be set. The resident will be notified in writing of the hearing date. Council may:

(i) Require that another Contractor be requested to investigate the well interference problem and submit their findings to Council; or

(ii) Accept the report as submitted by the Investigating Contractor.

## 6. Updating the Groundwater Interference Complaint Response Policy

The groundwater interference complaint response policy should be regarded as a living document that is updated whenever there are changes in any of the contact information provided on the Groundwater Interference Complaint Information Sheet as listed in Schedule "D". As a minimum, the groundwater interference complaint response policy should be reviewed annually (Ideally by May 1st of every year) to ensure that the information is up to date.

**SCHEDULE "A"**
**RURAL MUNICIPALITY OF RITCHOT**
**GROUNDWATER INTERFERENCE COMPLAINT**
**BY PRIVATE OWNER**

| | |
|---|---|
| Name | |
| Address | |
| Phone Number | |
| Date | |
| Nature of Complaint | |
| Including: Description of problem and dates when the problem occurred. | |

## SCHEDULE "B"
## RURAL MUNICIPALITY OF RITCHOT
## GROUNDWATER INTERFERENCE COMPLAINT
## PUBLIC WORKS INCIDENT REPORT

| Contact Information | |
|---|---|
| Name | |
| Address | |
| Phone Number | |
| Date complaint registered | |
| **NATURE OF COMPLAINT** | |
| Including:<br>Description of problem and dates when the problem occurred | |

**SCHEDULE "C"**
**RURAL MUNICIPALITY OF RITCHOT**
**GROUNDWATER INTERFERENCE COMPLAINT**
**CONTRACTOR INCIDENT REPORT**

| PRELIMINARY WELL ASSESSMENT | |
|---|---|
| Assessment completed by | |
| Date Completed | |
| INVESTIGATION<br>Including investigation procedures, observations, and results. | |
| ACTIONS TAKEN<br>By owner or RM | |

| SECONDARY WELL ASSESSMENT | |
|---|---|
| Name of Company | |
| Contact Person | |
| Date Completed | |
| INVESTIGATION<br>Including investigation procedures, observations, and results. | |
| ACTIONS TAKEN<br>By owner, Investigator, or RM | |
| **COMPLAINT RESOLVED** | |
| Date Water Supply Temporarily Restored | |
| Date Water Supply Restored | |
| **NOTIFICATION : MANITOBA ENVIRONMENT, CLIMATE AND PARKS** | |
| Contact Person notified of bonna fide interference | |
| Date Contacted | |

## SCHEDULE "D"
## RURAL MUNICIPALITY OF RITCHOT
## GROUNDWATER INTERFERENCE COMPLAINT
## INFORMATION SHEET

**Rural Municipality of Ritchot**
Name and Address:

Municipality of Ritchot
352 Main Street
St. Adolphe, MB, R5A 1B9
Telephone: (204) 883-2293
Fax: (204) 883-2674
Email: info@ritchot.com

**The Manitoba Water Services Board**
Name and Address:

The Manitoba Water Services Board
Unit 1A – 2010 Currie Blvd.
Brandon, Manitoba
R7B 4E7
Phone: (204) 726-6076
Fax: (204) 726-7196
E-mail: mwsb@gov.mb.ca

**Manitoba Environment, Climate and Parks**
Name and Address:

Drainage and Water Rights Licensing
Box 16, 200 Saulteaux Crescent
Winnipeg MB R3J 3W3
Phone: 1-800-214-6497
E-mail: wateruse@gov.mb.ca

**Well Drillers**
Name and Address:

Friesen Drillers
307 – PTH #12
Steinbach, MB
Office: (204) 326-2485
Fax: (204) 326-2483
Email: jason@friesendrillers.com

**Hydrogeologist**
Name and Address:

Friesen Drillers
307 – PTH #12
Steinbach, MB
Office: (204) 326-2485
Fax: (204) 326-2483
Email: jeff@friesendrillers.com

Friesen DRILLERS

# Appendix K

# Raw Water Demand Estimation

## MUNICIPALITY OF RITCHOT

## PROJECTION OF FUTURE WATER DEMANDS

As requested by Ritchot's Public Works Manager Mike Dumaine on 2023 09 07, the following projection of Ritchot's future water demand has been prepared. The selected target year is 2046, representing 25 years since the 2021 federal census. This was the target previously used by MWSB (2023 07 31) in their preliminary projections for water usage. Whereas MWSB projected growth based on the entire RM, this analysis uses the served population as a basis for projections. Currently, 71% of the population is served by the Municipality. It is a reasonable assumption that virtually all growth will occur within the four communities that are ring-dyked for flood protection and that are served by the municipal water system.

BACKGROUND DATA - 2022

In 2022, a relatively normal year for precipitation, a total 449,936$m^3$ (cubic metres, or 1000 litres) was drawn from the two wellfields (Randolph Road and PR #305), equivalent to 14.2 L/s (litres per second). Of that amount, 1.4% was used in the WTP (water treatment plant), primarily for filter backwashing. The remaining 98.6% was pumped to distribution. Therefore, net water produced for distribution was about 443,600 $m^3$/yr.

Aside from domestic use, there is significant industrial use (up to 130,000 $m^3$/yr), at the Riel Industrial Park in Ste-Agathe, primarily for the Viterra oilseed processing facility. That figure is equivalent to an average 356,000 L/d (litres per day), or 4.1 L/s. The remaining (443,600 $m^3$/yr – 130,000 $m^3$/yr =) 313,600 $m^3$/yr represents domestic usage, including residential, commercial and institutional (mostly schools), equivalent to 859,000 L/d or 9.9 L/s.

In that year, there were (on average) 2088 residential, commercial and institutional connections, plus one large industry, namely the adjacent to. Of these connections, approximately 2047 were residential, for which Statistics Canada has identified an average 2.75 residents per dwelling unit. That represents an estimated average of about (2047 x 2.75 =) 5630 residents being served through the course of that year. The gross non-industrial daily per capita consumption, inclusive of all domestic usage, was therefore (859,000 L/d / 5630 =) 152.5 L/person in 2022. This is relatively low. It reflects the continued usage in many connected older homes of private wellwater for exterior use (lawns, gardens, etc) and the use of low-flow, low-flush plumbing fixtures and water-using appliances (laundry, dishwashing) in all newer homes.

BACKGROUND DATA - 2021

For comparative purposes, in 2021, a relatively dry year for precipitation, a total 480,440$m^3$ was drawn from the two wellfields, equivalent to 15.2 L/s. there were relatively fewer connected residents (average 1931 residences, 5310 residents). Daily per capita consumption averaged about 182 L/person, after allowing for actual industrial consumption and in-plant water use.

PROJECTED GROWTH

Over recent years, there has been sustained growth. From the year 2018 through 2022, the number of connections increased by 12%, equivalent to 2.9% per year compounded, or 3% per year on a straight-line projection. A growth target of 3% has been used to project the growth to the year 2046. This is not unreasonable, considering the major new development that is starting late this year in Ile-des-Chênes (IdC) will double the population of that community, there is a

planned annexation of lands east of Arnould Road (RM of Taché) that will further allow major development at IdC and the Meadows subdivision in Grande Pointe will continue to add hundreds of additional residents in each of its phases. Therefore, the projected served residential population will be 11,672. It may be noted that this is less than what may be projected for Ritchot's overall population because there are just over 2000 people living in unconnected rural residences on large multi-acre lots with private wells. Many are in the older parts of Grande Pointe where there has been significant historic opposition to municipal piped services. There is no current anticipation that these residents will request service in the foreseeable future.

PROJECTED FUTURE AVERAGE WATER DEMAND

While average daily per capita demand has been relatively low (152-182 L/c.d), it is prudent to assume a somewhat greater demand of 200 L/c.d for future years. In part, this reflects the fact that new homes will not have existing wells to irrigate lawns and gardens, as many pre-2003 homes in IdC and St-Adolphe will have. Also, the figure of 200 L/c.d is one that WSP has used for other Capital Region municipalities in recent infrastructure planning studies, based upon the data from those RMs.

Therefore, on the basis of 200 L/c.d and a served population of 11,672, the average daily domestic water demand would be 2,334,000L (2.334ML). This is equivalent to 27 L/s. In addition, it is prudent to allow for a modest increase in industrial use, to 7 L/s. Therefore, total average day water demand would be (27 + 7 =) 34 L/s. This would increase to 34.5 L/s or 2.98 ML/d, when allowing for usage within the WTP (1.4%). This is equivalent to an annual demand of about 1088ML.

TOTAL PEAK DAY

The water supply infrastructure needs not only to meet average day needs, but also peak day needs. In addition, the infrastructure must allow for the WTP to work 20 hours per day, to allow for maintenance and minor repairs.

The peak day demand at Ritchot has ranged from 1.4 to 1.7 times average day demand. It is prudent to assume a 1.8:1 peak day factor, again to reflect that current summertime peaks have been attenuated by irrigation from private wells at older homes, a factor that will diminish in importance as new homes are built. Therefore, the peak day demand has been projected to be (<2.98 ML/d or 34.5 L/s> x 1.8 =) 5.36ML or 62.1 L/s.

REQUIRED CAPACITY OF WELLS, CONVEYANCE PIPELINES AND TREATMENT PLANT

Because the WTP will only operate to treat water for a maximum of 20 hours per day, the actual rate of water production from the wells will need to be a minimum of (62.1 L/s x 1.2 =) 74.5 L/s. Rounded up to 75 L/s, this is the target for which the wells, conveyance pipelines and treatment facilities should be designed.

Prepared on 2023 09 13 by W H Brant, P.Eng., FEC

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Water & Municipal Infrastructure, Manitoba

*he/him*

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