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Hydrogeologic Assessment
James Thoume Construction Ltd.
Proposed Lichty Pit
Part Lots 11 and 12, Concession 4 West
Township of Centre Wellington
County of Wellington

Prepared For:

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1.0 INTRODUCTION

This report presents a hydrogeologic assessment completed for the James Thoume Construction Ltd. proposed above water table Lichty Pit (site). The site consists of properties located at 5999 and 6043, 8th Line East, and, 7190 Sideroad 12, within Part Lots 11 and 12, Concession 4 West, Township of Centre Wellington (geographic Township of Pilkington), County of Wellington. The proposed Licence boundary is shown on **Figure 1**.

According to the Aggregate Resource Act (ARA) standards, the proposal is classified as a Class A Pit Licence for above water extraction.

This hydrogeological assessment addresses the requirements of the *Aggregate resources of Ontario standards: A compilation of the four standards adopted by Ontario Regulation 244/97 under the Aggregate Resources Act* (MNRF, August 2020). This report was completed on behalf of James Thoume Construction Ltd. in support of an ARA Licence application.

1.1 BACKGROUND

The site occupies 2 properties and straddles Side Road 12, at the intersection with 8th Line, approximately half way between Inverhaugh and Ariss, Ontario. We note that initial assessment work began in early 2021 and focused on the property located south of Side Road 12. In late 2023 the property located north of Side Road 12 was added to the study (proposed licence) area.

The site consists primarily of agricultural fields, and is bordered by 8th Line along the southwest edge. Farm houses and associated buildings are located on each property. Natural environment features, including Cox Creek and a wetland system, occur along the east edge of the site.

Other lands in the immediate surrounding area consist of farms and rural residential properties.

The proposed extraction would remain 1.5 m or more above the seasonal high water table.

1.2 STUDY SCOPE

1.2.1 Summary of Provincial Standards

This study utilizes the current ARA related groundwater reporting standards (August 2020) for a Class A Pit proposing to excavate above the maximum predicted water table.

The standards indicate the following information must be included on the Existing Features section of the Site Plan:

> *18. The maximum predicted water table (metres above sea level)*

Further, the standards include the following technical report must be included with the application:

> *2.1 Maximum predicted water table report*
>
> *A report must be prepared that details how the maximum predicted water table is identified in metres above sea level, relative to the proposed depth of excavation at the site.*

> *The maximum predicted water table shall be determined by monitoring the ground water table at the site for a minimum of one (1) year to account for seasonal variations and influences due to precipitation, unless alternative information already exists (e.g. previous hydrogeological study, existing well data) to support a determination of the maximum predicted water table by a qualified person.*
>
> *An alternative method may be used for sites determining the maximum water table in Precambrian rocks of the Canadian Shield where it is difficult to determine the elevation of the water table. In such cases, the maximum predicted water table may be assumed at an elevation (metres above sea level) that is a minimum of 2.5 metres below the deepest sump or pond on the site, provided a qualified person develops and oversees a drilling and monitoring program to determine if the ground water table would be intercepted at the assumed maximum predicted water table.*
>
> *The number of drill holes and seasonal monitoring frequency shall be determined by a qualified person based on site conditions.*

The “Maximum predicted water table report” provides an assessment of the water table elevation at the site relative to the proposed extraction.

1.2.2 Impact Assessment Approach

As part of the licensing process for the site Township of Centre Wellington and County of Wellington planning applications are also expected.

A Hydrogeological Study (HS) related to groundwater and natural environment feature protection can be required as part of the planning application process. The HS should also address identified Source Protection information needs.

This report follows a typical HS approach, which is identified as follows:

- an outline of the study methodology
- a description of the topographic setting, local surface water drainage and natural environment features (including springs, wetlands, etc.);
- a description of reported local water well locations;
- a description of the geologic and hydrogeologic setting (including aquifers, groundwater/surface water interaction, water budget, etc.);
- a summary of Source Protection status of the site and adjacent area;
- a description of the proposed extraction;
- an examination of the potential impact of the proposed extraction (impact assessment), including pre and post water balance calculations;
- an assessment of measures that may be needed to mitigate impacts and ensure environmental feature protection; and,
- conclusions and recommendations.

This study addresses anticipated HS planning requirements for the proposed Lichty Pit.

2.0 METHODOLOGY

This assessment included a background information review to characterize the site setting, detailed site-specific fieldwork to characterize local conditions and the use of specific analysis methods for the water budget and impact assessment.

Standard hydrogeologic field and analysis methods are used for this study. The specific methodologies used for each step of the characterization and analysis are outlined in the respective Sections of this report.

2.1 INFORMATION REVIEW

As part of this study the following information sources were used:

1) Stovel & Associates Inc.; *Licthy Pit Site Plans.*
2) James Thoume Construction Ltd., January 8, 2021; *Lichty Test Pit* (summary), and, June 2023; *Test Pit Results Summary.*
3) Stovel and Associates Inc, 2024; Natural Environment Technical Report, Proposed Lichty Pit.
4) Grand River Conservation Authority GRIN interactive mapping application, available at: *https://data.grandriver.ca/applications.html*.
5) Ministry of the Environment Conservation and Parks (MECP) published Water Well Records, available at: *https://www.ontario.ca/page/map-well-records*.
6) Ministry of the Environment Conservation and Parks (MECP) Source Protection Atlas interactive mapping application, available at: *https://www.ontario.ca/page/source-protection*.
7) Ontario Geological Survey OGSEarth published geological mapping (KML files viewed on Google Earth); available online at: *http://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth*
8) Geographic Data Information obtained through Land Information Ontario (LIO) and licensed under the Open Government Licence – Ontario; available online at: *https://geohub.lio.gov.on.ca/*

Additional general references used are noted in the text of this report.

3.0 BACKGROUND REVIEW

The local site setting is shown in **Figure 2**. The proposed licence limit generally follows property boundaries and a set-back from Cox Creek.

3.1 SITE TOPOGRAPHY AND DRAINAGE

Please refer to the Site Plan for specific topographic information at the property. Site topography is also shown on **Figure 3**. No surface water features (creeks, drainage channels, ponds or wetlands) occur within the proposed licence. Potential runoff (overland sheet-flow) directions at the site are varied, as described below.

The property northwest of Side Road 12 is relatively flat-lying, with maximum and minimum topographic elevations of approximately 353 and 350 metres above sea level (mASL) respectively. Potential overland flow is either retained on-site (internally drained), directed to roadside ditches (flow to Cox Creek), or, flows directly to the Cox Creek system (along the east site edge). Most of this property consists of agricultural field, however also includes a residence and other farm buildings.

The property southeast of Site Road 12 slopes moderately east to southeast, toward Cox Creek. Maximum and minimum topographic elevations within the proposed Licence are approximately 352 mASL (at Side Road 12) and 345 (near Cox Creek) mASL respectively. Potential overland flow runoff would move toward the Cox Creek valley system.

Topographic elevation details at natural environment features near the site are provided in **Section 3.2**.

3.2 NATURAL ENVIRONMENT FEATURES

No wetland or surface water features occur within the proposed Licence (Stovel and Associates Inc., 2024). Cox Creek and a portion of the Provincially Significant Speed Lutteral Swan Creek Wetland Complex occur near, and within 120 m of, the site. In addition, a small man-made agricultural/recreational retention pond, which outlets to Cox Creek, occurs near the north corner of the site.

Cox Creek is described as *potential cool water fish habitat* based on reported fish species associated with the creek (Stovel and Associates Inc., 2024). Two creek branches occur near the site. A "main" branch borders the east site boundary. A tributary extends to the north/northeast of the site. Based on 0.5 m topographic contours available through the Grand River Conservation Authority (GRCA) GRIN mapping application, creek elevations bordering the site range from approximately: 343 to 343.5 mASL at Line 8; to 344 mASL at the creek confluence; to 344.5 mASL at Sideroad 12; and, to 345 mASL near the north corner of the proposed licence.

Along the east edge of the site Cox Creek occupies a valley floodplain with a wide shallow flat-lying valley floor, generally corresponding to the OAGM4 Ecological Land Classification identified vegetation community (Stovel and Associates Inc., 2024). This area is described as follows:

> *The Thoume Pit floodplain is a cattle pasture that has been used for agriculture for many years. These pasture lands are found to either side of Cox Creek. Due to low relief most of the pasture is seasonally flooded and occasionally flooded following*

> *storm events. It is expected that this was historically a complex of swamp and marsh.* (Stovel and Associates Inc., 2024).

Based on available mapping the elevation of this floodplain area varies generally from 344 to 345 mASL, and is delineated along the west edge by the agricultural field edge and fence. Observations made through the course of this assessment indicates that the floodplain has persistent "wet" soil conditions, consistent with the interpreted historical swamp/wetland condition prior to use as pasture lands.

The mapped wetland area (local portion of the Speed Lutteral Swan Creek Wetland Complex) occurs along Cox Creek, with the closest edge generally between the man-made pond and the creek north of Sideroad 12, and, between the main and north/northeast reaches of the creek. The creek forms a local hydrologic and hydrogeologic separation/divide. Based on the position of the mapped wetland area, there is no potential surface water or groundwater movement from the proposed licence to the wetland.

The main portion of this wetland feature is identified as a Thicket Swamp/Deciduous Swamp (SWT/SWD) vegetation community (Stovel and Associates Inc., 2024). As noted by Stovel and Associates Inc.: *The Thicket Swamp is influenced by variable flooding regimes with a water depth of less than 2 meters. Standing water or vernal pooling make up more than 20% of the ground coverage.*

A small PSW extension area (SWT2 - Mineral Thicket Swamp Ecosite) is identified at the south facing wetland edge (north of Cox Creek). As noted by Stovel and Associates Inc.: *Lower slopes ... typically have seepage and bottom lands ... especially flood plains as found here where there are springs and perennially wet areas. The areas that are forested are typically in rich areas where deposition due to flooding occurs yet drying occurs by mid- to late summer*. Although seepage areas are identified along the south edge of the mapped wetland, based on the position of the seepage areas relative to the creek there is no potential surface water or groundwater movement from the proposed licence to the seeps.

Based on available mapping the wetland elevation varies between approximately 345 to 345.5 mASL north of Sideroad 12, and, 344 to 345 mASL south of Sideroad 12.

The man-made pond is located between the proposed Licence and the wetland/creek (north of Sideroad 12). The pond is retained by a constructed berm and pond levels are relatively consistent, maintained by the outlet elevation. Based on a survey conducted for this assessment, the outlet elevation is estimated to be approximately 347.4 mASL.

3.3 PRIVATE WATER WELLS AND LOCAL GROUNDWATER USE

For this study MECP well records with reported locations within approximately 500 m of the site were examined to assess local water supply status. The water well locations as reported are shown on **Figure A1,** and the reported water well information is summarized in **Table A1** in **Appendix A**.

A total of 22 water well records were reviewed. Of those well records, 8 are for abandoned test holes or observation well installations (4 of which are site monitors).

The remaining 14 well records represent be deep drilled wells in use for water supply, for domestic or domestic and stock (farm) purposes. These wells were completed in either bedrock or deep confined gravel/sand (overburden) units.

The overburden water supply wells range in reported depth from approximately 29 to 32 m below ground surface (mBGS). Reported static levels at the overburden wells vary from approximately 6 to 11 mBGS. Recommended pumping rates range from 10 to 15 gallons per minute (gpm). For comparison, a pumping rate of 5 gpm will generally meet typical domestic demands.

The remaining well records report bedrock depths ranging from approximately 16 to 43 mBGS and total drilled depths of between approximately 29 to 32 mBGS. Reported static levels vary from approximatley 3 to 17 mBGS. Recommended pumping rates range from 7 to 20 gallons per minute (gpm).

3.4 SURFICIAL GEOLOGY

The published surficial geology mapping for the site and area is shown on **Figure 4**. The mapping indicates that the site is located within a gravelly glaciofluvial (river associated or outwash type) deposit. Ice-contact (kame type) sand/gravel deposits are located at surface northwest of the site and in the wider area. Based on the reported depositional sequence, the glaciofluvial and ice-contact sand/gravel deposits are likely underlain by the sandy silt to silty sand glacial Till (unsorted, diamicton type deposits)

At the site Modern Alluvial deposits are mapped along Cox Creek, extending across the creek valley.

The water well records generally confirm the sequence deposits, with sand and gravel occurring at surface (in some locations) underlain by a sequence of till and/or clay deposits. Deeper sand/gravel deposits also occur within the till sequence. This sequence extends to bedrock.

3.5 BEDROCK GEOLOGY

Bedrock in the area of the site is reported to be Guelph Formation dolostone, described as *sucrosic, fossiliferous, locally biohermal*, which corresponds well with local water well records information. Based on the closest reported water well records, total overburden thickness (i.e. depth to bedrock) in the area of the site is between 24 and 28 mBGS.

3.6 SOURCE PROTECTION SUMMARY

Based on a review of available Source Protection mapping, the site is not within any identified Well Head Protection Area (WHPA) or Intake Protection Zone (IPZ). In addition, there is no WHPA-Q area identified at or near the site. The sand and gravel deposits at and ear the site are mapped as a Significant Recharge area (due to the deposit type). As noted later in this report, the proposed extraction will remain above the water table, is expected to maintain local recharge rates and will not disturb protective geologic layers that overly any deeper aquifer systems that may exist.

3.7 TEST PIT RESULTS

Test pits to assess the available resources were completed by James Thoume Construction Ltd. in January 2021 within the southern property and in June 2023 within the northern property. Additional test pits were completed in the north property in December 2023 by Groundwater Science Corp. Test pit locations are shown on **Figure 5**. The test pit logs are provided in **Appendix B** and summarized in **Table 1**.

Test Pit Reference	Depths (m)					
	Total Depth	TS/OB To	Resource To	Resource Summary	Till/Clay At	Water At
South TP1	7.3	0.3	7.3	clean f to m sand/gravel, stones	-	7.0
South TP2	7.6	0.3	7.6	clean f to m sand/gravel, stones	-	7.0
South TP3	5.2	0.3	5.2	clean f to c sand/gravel, stones	-	4.3
South TP4	7.3	0.3	7.3	clean f to c sand/gravel, stones	-	7.0
South TP5	7.0	0.3	7.0	clean f to c sand/gravel, stones	-	6.7
North TP1	3.7	0.6	3.7	sand/gravel	-	3.7
North TP2	3	0.6	3	sand/gravel	-	3
North TP3	1.2	0.2	1.2	sand/gravel	-	-
North TP4	4.3	3	4.3	sand/gravel	-	4
North TP5	3	0.2	3	sand/gravel	-	-
North TP6	4	-	4	sand/gravel	-	-
North TP7	1.8	-	0.9	sand/gravel	-	1.8
North TP-A	7.0	1.8	7.0	m sand/gravel, cobbles	-	6.7
North TP-B	7.0	0.6	7.0	f to c sand/gravel, cobbles	7.0	6.4
North TP-C	5.8	1.2	5.8	f to c sand/gravel, cobbles	-	5.2
North TP-D	5.5	0.6	2.1	c sand/gravel, cobbles	2.1	-
North TP-E	6.7	0.6	6.7	f to c sand/gravel, cobbles	-	6.1
North TP-F	7.3	0.3	7.3	c sand/gravel, cobbles	7.3	6.7
North TP-G	6.1	0.3	6.1	c sand/gravel, cobbles	6.1	-
North TP-H	6.1	0.3	6.1	f to c sand/gravel, cobbles	6.1	-
North TP-I	2.7	0.6	2.7	c sand/gravel, cobbles	2.7	-

Table 1: Test Pit Summary

The test pit results are discussed in **Section 5** of this report.

4.0 FIELD WORK

Field work completed as part of this assessment includes additional test-pitting, monitoring well and drive-point installation/development, monitoring well response (slug) testing, detailed water level monitoring (monthly), and, stream temperature monitoring (continuous) over approximately 3 years. At present water level monitoring continues on a quarterly basis.

4.1 TEST PITS

In order to refine our understanding of geologic conditions within the property north of Side Road 12 additional test pitting (locations TP-A to TP-I) was completed in December 2023. The test pit locations are shown on Figure 2. The test pit results are summarized in **Table B1**, **Appendix B**. The test pit results are discussed in **Section 5** of this report.

4.2 DRILLING AND MONITOR INSTALLATION

As part of this study 4 boreholes were drilled in April 2021 (south of Side Road 12) and 2 boreholes were drilled in February 2024 (north of Side Road 12). At each of boreholes the soil samples were obtained at regular intervals and water table monitors (MW1 to MW6) were installed. The April 2021 drilling and monitoring well installations were completed by Noll Drilling Inc. (Breslau). The February 2024 drilling and monitoring well installations were completed by Aardvark Drilling Corp. (Guelph).

The boreholes were advanced using hollow stem augers and the soil samples obtained using a split spoon sampler. Monitoring well construction includes nominal 2-inch (5.1 cm) diameter PVC wells with 5 ft (1.5 m) or 10 ft (3 m) long well screens. Each well is equipped with a locking protective casing at surface.

In order to assess water table conditions at the north branch of Cox Creek near the proposed licence a drive-point piezometer (DP1) was installed in April 2021. The drive-point piezometer was installed by hand and consists of 1 foot (0.3 m) long nominal 1.25-inch (3 cm) diameter stainless steel manufactured screen (drive-point) and galvanized pipe riser.

In addition, in order to confirm surface water levels at the agricultural/recreational pond within the property north of Side Road 12, a measurement point (Pond) was established on a fixed structure (dock).

The drilling and monitoring locations are shown on **Figure 5**. Borehole logs are included in **Appendix B**.

All of the water table monitoring locations were developed by pumping (using a Waterra® inertial pump) and until the discharge water was relatively clear and a consistent water level response was noted.

Reference elevations (ground surface and top of well) at MW1 to MW4 were established by James Thoume Construction Ltd. and provided for this assessment. Reference elevations at MW5, MW6, DP1 and Pond monitoring locations were surveyed by

Groundwater Science Corp relative to the reported top of well elevations at MW1 and MW4. The surveyed elevations are summarized in **Table 2**.

Location	Elevations (mASL)			
	Ground Surface	Top of Well	Top of Screen	Screen Bottom
MW1	350.46	351.33	346.0	342.9
MW2	347.49	348.29	343.0	341.5
MW3	345.75	346.53	342.8	341.3
MW4	351.93	352.83	345.8	342.8
MW5	353.67	354.73	350.8	347.7
MW6	349.54	350.58	343.7	340.7
Pond	-	348.19	-	-
DP1	343.99	345.26	343.5	343.2

Table 2: Installation Summary

Each borehole was advanced through the surficial sand and gravel deposit to the underlying silt/clay till unit. Additional discussion of the drilling results in provided in **Section 5.0**.

4.3 WATER LEVEL MONITORING RESULTS

Regular (generally monthly) water level measurements have been obtained since monitors were installed, and monitoring is ongoing. The monitoring results are summarized in table and hydrograph format in **Appendix C.**

To date approximately 3 years of data has been collected at MW1 to MW4, illustrating the seasonal and annual range of water table fluctuation at the site. Water level monitoring at MW5 and MW6 illustrates high the water table conditions that occurred in spring 2024.

As shown in **Table C1**, overall seasonal/annual water table fluctuation at MW1 to MW4 is considered typical of this type of deposit in Southern Ontario, ranging from 1.0 to 1.6 m. The seasonal pattern of water level change, over the period of record, is similar at all of the monitoring wells, indicating aquifer conditions across the site are consistent, and, groundwater flow directions remain relatively consistent.

High water table conditions observed to date at MW1 to MW4 occurred in April/May 2023. Conditions in spring 2024 were approximately 0.2 m lower on average. Therefore, the maximum water table conditions at MW5 and MW6 are projected to be representative of the Spring 2024 levels plus 0.2 m.

This approach is consistent with the requirement that "*The number of drill holes and seasonal monitoring frequency shall be determined by a qualified person based on site conditions.*", and given "*…alternative information already exists (e.g. previous* *hydrogeological study, existing well data) to support a determination of the maximum predicted water table by a qualified person."*

The projected highest water table conditions at the site are shown on **Figure 6**. Using a similar methodology, low water table conditions as represented by the October/December 2022 measurements, are shown on **Figure 7**.

4.4 STREAM TEMPERATURE MONITORING RESULTS

In order to provide information relevant to the Natural Heritage assessment, stream temperature monitors were installed within Cox Creek along the perimeter of the site in August 2021. The monitoring locations (SW1 to SW3) are shown on **Figure 5**.

The stream temperature monitors consist of nominal 1.25-inch (3 cm) diameter PVC perforated pipe set vertically within the stream, attached to a stake driven into the streambed (or in the case of SW1 to DP1), and equipped with a Onset® brand TidbiT v2 temperature data logger. The datalogger is positioned within the perforated (protective) pipe at the streambed. The dataloggers were programmed to obtain a temperature measurements at an hourly interval. The temperature monitoring results are provided in graphical format in **Appendix C**.

As shown on **Figure C2**, the "north" branch of Cox Creek near the site, represented by SW1, has a typical seasonal temperature range from a winter low of between 0.2 to 0.7 °C, to a summer high generally between 16 to 20 °C. However, short-term maximum summer stream temperatures of 22 °C and 23.6 °C were observed in 2021 and 2022 respectively. This temperature range reflects both groundwater discharge and canopy shading along this section of the creek.

As shown on **Figure C3**, the "main" branch of Cox Creek just downstream of the confluence with the north branch, represented by SW2, has a typical seasonal temperature range from a winter low of less than 0.1 °C, to a summer high generally between 22 to 24 °C. However, short-term maximum summer stream temperatures above 27 °C were observed in 2021 and 2022. This temperature range reflects a greater influence of ambient air temperatures (versus groundwater discharge occurring along the "north" branch) and lack of canopy shading along the main channel in this area.

As shown on **Figure C4**, the "main" branch of Cox Creek near the south corner of the site, represented by SW3, has a typical seasonal temperature range from a winter low of between 0.8 to 1.5 °C, to a summer high generally between 18 to 21-22 °C. However, short-term maximum summer stream temperatures of 23 °C and 24 °C were observed in 2021 and 2022 respectively. We note that, similar to SW2, there is a lack of canopy shading along the creek at SW3. We also note that, as compared to upstream stations, stream depths increase and stream gradient and flow velocities are reduced at SW3. Despite the lack of canopy shading, daily and annual temperature fluctuations are reduced at SW3. The observed temperature range and daily pattern reflects the influence of groundwater discharge (e.g. versus SW2 data) and increased stream depths.

The temperature monitoring results support the interpretation that groundwater flows toward, and discharges at, Cox Creek and associated riparian valley system.

4.5 RESPONSE TEST RESULTS

After the on-site monitors were developed, response tests were completed to estimate the hydraulic conductivity (K) of the sand and gravel unit. The tests were completed on July 3, 2024 as sequential falling and rising head (slug) tests using dataloggers set to a 0.5 second sampling frequency and a slug of known volume. Sequential tests were completed at all monitoring locations which represent the sand and gravel unit at the site. A single falling head test was completed at MW1, which represents the underlying till unit.

The response data was analyzed according to the Bouwer and Rice method using the AQTESOLV® computer analysis program. The test analysis plots are included in **Appendix D**. The response test analysis is summarized in **Table 3**.

Monitor	Estimated Hydraulic Conductivity (m/s)	
	Falling Head Test	Rising Head Test
MW1	3.65E-08	-
MW2	2.44E-04	6.49E-05
MW3	4.43E-04	3.34E-04
MW4	1.63E-05	1.66E-05
MW5	1.37E-04	2.27E-04
MW6	1.96E-04	2.54E-04

Table 3: Response Test Results

Based on the results the hydraulic conductivity of the till unit is estimated to be in the range of 10^{-8} m/s. The hydraulic conductivity of the sand and gravel unit varies from location to location, however has a bulk (geometric mean) value in the range of 1.3×10^{-4} m/s.

5.0 HYDROGEOLOGIC SETTING

The hydrogeologic setting of the site is discussed in context of the known regional setting, information review undertaken for this site, and, monitoring and assessment completed as part of this study.

The drilling and test pit results confirm that aggregate resources occur within the proposed Licence area, extending to depths of up to 9 m or more. This sand and gravel unit is underlain by till (diamict) deposits that vary from silty to clayey in nature.

In order to illustrate the hydrogeologic setting in the area of the site 2 schematic cross-sections were developed based on reported topographic contours and site-specific testing. The section locations are shown on **Figure 8**. The sections are included as **Figure 9** and **Figure 10**.

Section A (**Figure 9**) runs west to east through the site. The section illustrates local topography, the elevation of local surface water features and the occurrence of the localized surficial sand deposit overlying the thick till sequence which extends to bedrock. The local water table is projected based on measurements taken onsite and wetland/creek elevations west of the site. As shown, shallow groundwater flow is controlled and directed by the till sequence, which limits vertical movement and promotes horizontal flow. The overall saturated thickness of the surficial sand/gravel unit is limited along this section, representative of a localized flow system recharged primarily on-site and which flows toward the nearest discharge point, consisting of the creek.

Most water wells in the area are completed in the bedrock aquifer, which protected from surficial influences by the thick till sequence. Comparing measured water levels within the water table monitors to reported water levels in the bedrock wells illustrates that the two systems are separate. As shown, the water wells generally encounter water bearing zones at depth within the bedrock aquifer. The primary water supply source in this area appears to be the confined bedrock aquifer system

Section B (**Figure 10**) runs north to south through the site, and illustrates a similar setting. Based on the till elevation as encountered at MW1 and MW6, the till surface can be variable within the proposed licence area north of Sideroad 12. Within this area the saturated thickness of the surficial aquifer increases, however overall flow is again controlled by the underlying till. The water table configuration north of the site is unknown, but is assume to occur within the till sequence.

The primary groundwater function of the proposed extraction area is recharge. This recharge supports groundwater conditions, and flow, within the shallow aquifer system to the local creek/wetland system.

As shown on **Figure 6** and **Figure 7**, the water table slopes across the site generally toward Cox Creek and associated valley.

The average linear groundwater flow velocity across the site is estimated using the formula:

$\tilde{v} = Ki/n$ where K = bulk average hydraulic conductivity (1.3×10^{-4} m/s)
i = water table slope (hydraulic gradient)
n = aquifer porosity (estimated to be 0.25)

At monitoring pair MW1-MW2, having a separation distance of approximately 352 m and average water level difference to date of approximately 2.71 m, an average annual gradient (i) is calculated to be 0.0077. Therefore, the average linear groundwater velocity is calculated to be 0.33 m/d.

At monitoring pair MW4-MW3, having a separation distance of approximately 237 m and average water level difference to date of approximately 0.61 m, an average annual gradient (i) is calculated to be 0.0026. Therefore, the average linear groundwater velocity is calculated to be 0.11 m/d.

Based on observed conditions within the creek valley along the east edge of the proposed Licence, the water table is maintained essentially at, or very near, surface. Again, this is likely a function of the till elevation controlling both water table elevations and direction of flow. Groundwater moves through the riparian zone sediments toward the creek, where discharge occurs. Diffuse discharge, and interflow, may also occur along the valley floor. Overall groundwater velocities are expected to be slower within the creek valley due to lower water table slopes (gradient) and finer grained nature of the alluvial deposits associated with Cox Creek.

6.0 PROPOSED EXTRACTION

The following general description of the proposed Lichty Pit extraction is provided as a framework for the impact analysis. For specific details regarding existing site conditions or the extraction plan please refer to the Site Plan(s).

The proposed licenced area is approximately 42.7 hectares (ha) in size and the proposed extraction area is approximately 29.1 ha. The proposed sand and gravel extraction operations will remain 1.5 m or more above the water table.

North of Sideroad 12 post extraction drainage (overland flow) will be maintained on-site where infiltration is expected. South of Sideroad 12 post extraction drainage will be directed toward the creek valley.

There are no other proposed water use, diversion, storage or drainage facilities on-site. As indicated by the Site Plan, a mandatory spills response program will be in place at the site.

7.0 MAXIMUM PREDICTED WATER LEVEL REPORT

The proposed extraction would occur within unconsolidated surficial sand and gravel deposits. Therefore the following definitions are used:

> *"ground water table" means*
>
> *a) for unconsolidated surficial deposits, the ground water table is the surface of an unconfined water-bearing zone at which the fluid pressure in the unconsolidated medium is atmospheric. Generally, the ground water table is the top of the saturated zone.*
>
> *"maximum predicted water table" means the maximum ground water elevation (metres above sea level) predicted by a qualified person who has considered conditions at the site and mean annual precipitation levels.*

The water table at the site was measured and determined by the installation and monitoring of 6 water table wells on the perimeter of the proposed licenced area and measurement and observation of conditions within the adjacent surface water systems. The measured water table at the site corresponds to the top of the saturated zone within the unconfined aquifer.

At the proposed Lichty Pit the maximum predicted water table elevation is shown on **Figure 6**, and ranges from 344 mASL to 350.7 mASL. Proposed extraction would remain 1.5 m or more above the predicted maximum water table.

8.0 IMPACT ASSESSMENT

The following assessment is intended to examine the potential for adverse effects to groundwater and surface water resources and their uses (e.g. water wells, ground water aquifers, surface water courses and bodies, springs, discharge areas).

The extraction will remain above the water table, therefore there will be no direct impact to the groundwater system.

A spills response program will be in place. The progressive removal of the site from agricultural use over the life of the pit will likely result in a reduced nutrient (and potentially pesticide/herbicide) loading to the shallow aquifer system, which would be beneficial during that period.

The extraction has the potential to modify site runoff conditions, therefore we provide a water balance discussion to address potential indirect effects to the groundwater system. In addition, a discussion of potential for thermal impact is provided due to the presence of possible cool water fish habitat within the creek.

8.1 SITE WATER BALANCE

The reconfiguration of site topography will result in some modifications to overland sheet-flow runoff potential and direction, and related groundwater recharge potential. A water balance analysis was completed for existing and proposed final site conditions in order to examine the potential changes in runoff and recharge associated with the proposed extraction. The assessments examine average annual conditions and are developed according to standard water balance input/output methodology. The water balance calculations are included in **Appendix E**.

"Average" climate data for the area is based on monthly precipitation and temperature climate normals (1981 to 2010) as reported by Environment Canada for the Waterloo Wellington A Weather Station. Evapotranspiration, runoff and infiltration rates are estimated in accordance with MECP development application guidelines (*Hydrogeological Technical Information Requirements for Land Development Applications*, April 1995) and stormwater management guidelines (*Stormwater Management Planning and Design Manual*, March 2003).

Separate calculations are provided for the proposed licence north of Sideroad 12, and south of Sideroad 12, given the areas are not directly connected hydrologically.

The proposed north licence area is approximately 17.6 ha in size, and consists primarily of relatively flat open agricultural fields. Natural runoff could occur, directed onto adjacent farm fields or roadside ditches. Under future conditions all runoff would be retained within the proposed licence area.

The proposed south licence area is approximately 25.2 ha in size, and consists primarily of moderately sloped open agricultural fields. Natural runoff could occur, directed to the riparian system (field) along the creek valley.

Based on the climate data monthly actual evapotranspiration (AET) estimates were calculated for differing soil and vegetation conditions relevant to the site and proposal using the *Computer Program for Estimating Evapotranspiration Using the Thornthwaite*

Method, United States Department of Commerce, National Oceanic and Atmosphere Administration (NOAA) Technical Memorandum ERL GLERL-101 (November 1996).

The AET estimates for open field agricultural areas of the site are developed using a Soil Moisture Retention (SMR) value of 150 mm (representative of moderately deep-rooted crops on fine sandy loam type soil). The SMR values reflect the fact that a soil moisture deficit, which limits the amount of water available for evapotranspiration, typically occurs during summer months.

A climate and Thornthwaite analysis summary for “average” monthly and annual conditions is provided in **Appendix E**. Annual average precipitation is estimated to be 916.3 mm/yr. The AET on open field cultivated soils is estimated to be 565.75 mm/yr.

The difference between precipitation falling on the assessment area (direct input) and evaporation/evapotranspiration (direct initial output) is termed the water “surplus”. Surplus water within an assessment area can either infiltrate to recharge the groundwater system or form surface water runoff.

Land surface runoff rates at the site are calculated according to the MECP development application guidelines methodology, which assigns an infiltration factor (IF) to apply to the water “surplus” in order to calculate recharge. The IF depends on individual factors related to topography, soil type and vegetation/cover.

Based on the topography, soil type and agricultural use an IF of 0.8 (80%) is estimated for the north assessment area, and, an IF of 0.7 (70%) is estimated for the south assessment area under existing conditions.

Under future conditions the IF becomes 1.0 (100%) within the north assessment area (due to runoff retention), and, 0.8 (80%) within the south assessment area (due to reduced topographical slopes).

Within the north assessment area under existing conditions actual annual on-site recharge is estimated to be 49,357 m^3/yr (1.57 L/s on average). Annual runoff volume is estimated to be 12,339 m^3/yr (0.39 L/s on average). Under future conditions runoff retained and allowed to infiltrate, therefore recharge becomes 61,697 m^3/yr (1.96 L/s on average). This represents a 25% increase in groundwater recharge volume.

Within the south assessment area under existing conditions actual annual on-site recharge is estimated to be 61,837 m^3/yr (1.96 L/s on average). Annual runoff volume is estimated to be 26,502 m^3/yr (0.84 L/s on average). Under future conditions topographic slopes are reduced and therefore recharge could increase. Therefore, recharge becomes 70,671 m^3/yr (2.24 L/s on average) and annual runoff volume is projected to be 17,668 m^3/yr (0.84 L/s on average). This represents a 14% increase in groundwater recharge volume.

The reconfiguration of the site results in an increase in recharge within the property due to retained or reduced runoff. The calculation indicates that no negative effect on water availability can be expected within the surrounding groundwater system due to the proposed extraction.

While runoff potential is reduced, based on the fact that existing site runoff does not flow directly into the creek, the overall effect on the creek and wetland system would be limited. Existing runoff to adjacent fields or roadside ditches (north assessment area) would have additional opportunity to recharge and would not necessarily contribute to water availability at the wetlands or creek. Existing runoff that reaches the riparian valley system (south assessment area) contributes to the highly saturated soil conditions and given the relatively flat topography is expected to contribute primarily to evapotranspiration that occurs within the valley.

In addition, as indicated by the observed conditions, groundwater contributes directly to the valley (also helping to maintain saturated soil conditions) and eventually to the creek. Given that runoff losses represent increases in groundwater recharge and flow potential to the valley and creek system, the overall effect would be relatively neutral.

8.2 THERMAL EFFECTS

Reduction in unsaturated zone thickness due to sand and gravel extraction may result in some thermal effects within the shallow groundwater flow system below the extraction area. As groundwater flow is toward Cox Creek a discussion of the potential impact to the creek is provided below.

The fact that groundwater is essentially at surface within the (wide) riparian valley, and that there is little to no shading within the valley, means that under existing conditions the groundwater temperatures within the creek valley (under both existing and future conditions) will be essentially controlled by ambient air temperatures and solar radiation. This will reduce the sensitivity of the near stream groundwater flow system to potential "additional" impacts related to the extraction. Based on the setting, any potential "additional" impacts would be mitigated by the control ambient temperatures and solar radiation has on groundwater temperatures in the (wide) riparian zone.

Another approach to examining the potential for thermal impact considers groundwater velocities at the site. The movement of any thermal plume origination from the proposed above water extraction area will be controlled by groundwater flow velocity. In this type of setting a thermal retardation factor of 0.5 (plume moves at about half the average linear velocity of groundwater) is applicable (per. *Thermal Plume Transport from Sand and Gravel Pits – Potential Thermal Impacts on Cool Water Streams*; Jeff M. Markle and Robert A. Schincariol, February 2007).

It is generally accepted that a groundwater residence time of 1 year will provide for complete thermal mitigation for below water (pond creation) effects. Potential thermal effects related to above water extraction would be expected to be much less, therefore time for complete thermal mitigation would also be reduced (i.e. much less than 1 year). For this assessment a 0.5 year (182.5 day) residence time is used as a screening tool to examine impact potential related to extraction.

The separation distance from the proposed extraction area to the main branch of Cox Creek along the east edge of site (for example near SW3) is approximately 54 m at the closest point. Within most of this riparian valley the creek distance is greater than 70 m. Using the calculated groundwater velocity from MW1 to MW2 the thermal plume front velocity is estimated to be approximately 0.165 m/d. Given the separation distance groundwater residency times of between 327 and >424 days is projected between the proposed extraction and the creek (i.e. >>182.5 days). Therefore, complete thermal attenuation would be expected.

The separation distance from the proposed extraction area to the main branch of Cox Creek along the northeast edge of the site (for example near SW1) is approximately 28 m at the closest point. Using the calculated groundwater velocity from MW4 to MW3 the thermal plume front velocity is estimated to be approximately 0.055 m/d. Given the separation distance groundwater residency times of 509 days or more is projected between the proposed extraction and the creek (i.e. >>182.5 days). Again, complete thermal attenuation would be expected.

We note that the analysis is approximate in nature, and is considered a screening exercise to determine if potential thermal plume velocities indicate more detailed analysis is warranted. In this case the analysis simply indicates that based on the setting there is no significant potential for a thermal plume “connection” through the groundwater system from the proposed extraction area to the creek.

8.3 IMPACT POTENTIAL - WATER WELLS AND GROUNDWATER USE

Given the setting and proposed extraction/rehabilitation plan, no significant change in groundwater volume or flow direction would be expected. Extraction will remain above the water table, therefore no direct changes to water availability, flow direction or water quality is expected. Standard operating controls, including fuel handling and spills response, will minimize the potential for water quality impacts. In addition, over the life of the pit agricultural loadings are expected to decrease, which will benefit the aquifer system.

Deeper wells in the area are protected by an overlying till sequence. As noted above, no reduction in water availability within the shallow groundwater system, or at local shallow water wells, is expected.

Therefore, based on this assessment, there are no significant potential impacts to water wells or groundwater uses in the area associated with the proposed extraction.

8.4 IMPACT POTENTIAL – NATURAL ENVIRONMENT FEATURES

The proposed above water table extraction will slightly increase overall groundwater recharge volumes and groundwater flow potential toward the creek system along the eastern boundary of the site. This is expected to offset any potential changes in runoff. Overall (combined) water contributions to Cox Creek and valley lands in the area are expected to be maintained. Based on the setting and groundwater residence time there is no significant potential for thermal impacts to Cox Creek.

In addition, there is no hydrologic or hydrogeologic input from the proposed licence to the identified wetland complex and associated seepage areas. Therefore, there is no potential impact to the mapped wetland/seepage area due to the proposed extraction.

Based on this assessment there is no significant potential impact to local natural environment features are associated with the proposed extraction.

Water resources protection is achieved through set-backs, appropriate extraction planning, and, implementation of operational controls, such as maximum depth of extraction relative to the water table.

8.5 HYDROGEOLOGICAL TECHNICAL RECOMMENDATIONS

In order to confirm water table elevations at the site, the following monitoring program is recommended for a period of 3 years:

1. *For a period of 3 years water level measurements shall be obtained on a quarterly (seasonal) basis at MW1, MW2, MW3, MW4, MW5 and MW6, as accessible.*
2. *The monitoring results will be summarized annually by the Operator and made available to MNRF upon request.*

9.0 CONCLUSIONS

Based on the results of the impact assessment there are no potential for significant adverse effects to groundwater and surface water resources and their uses; and, there is no potential for significant impacts to local groundwater aquifers, natural environment features or water supply associated with the proposed Lichty Pit.

All of which is respectfully submitted,

Andrew Pentney

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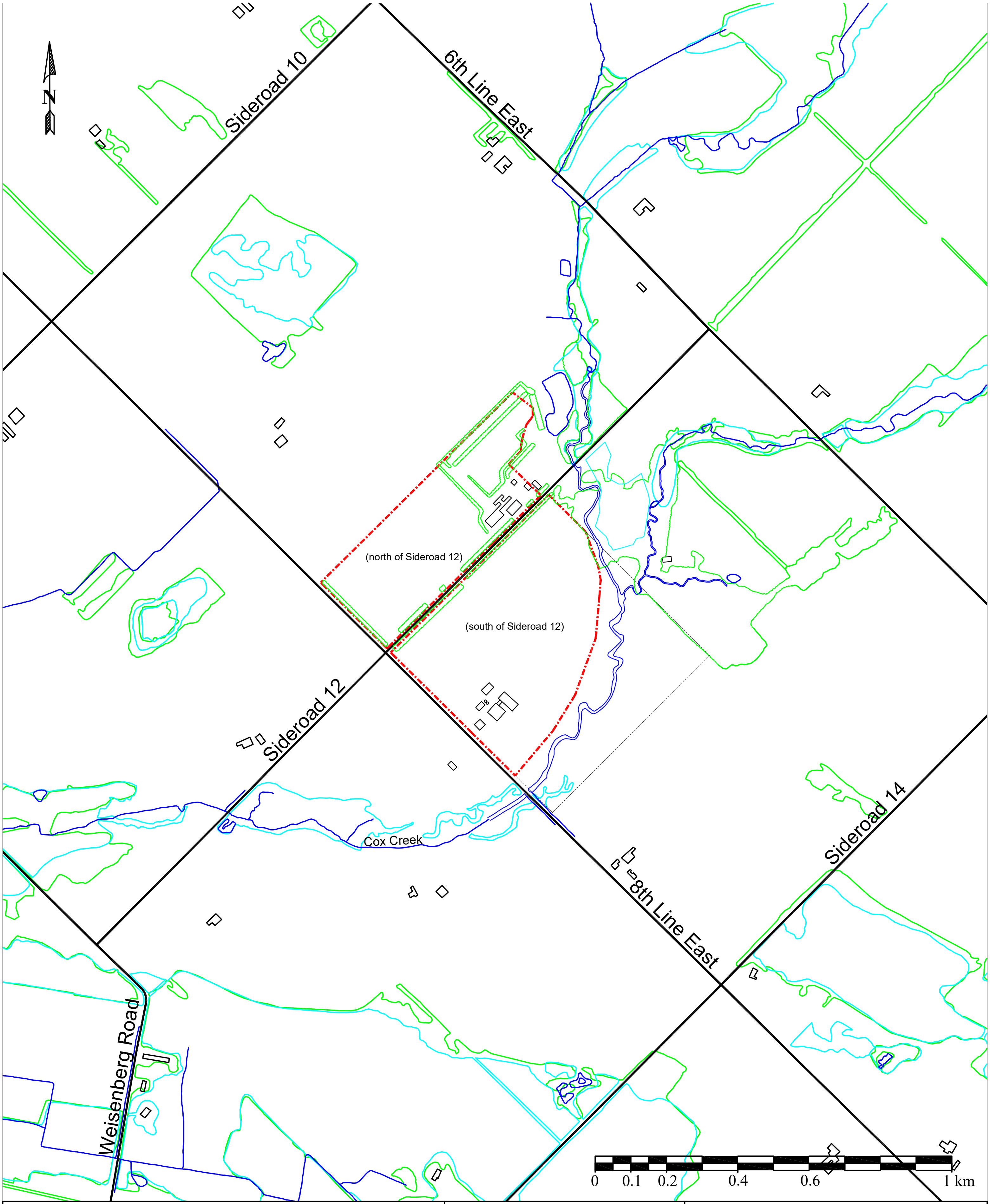
ANDREW H, PENTNEY
PRACTISING MEMBER
0652
ONTARIO

Andrew Pentney, P.Geo.
Senior Hydrogeologist
Groundwater Science Corp.

Figures



Site (approx.)

vegetation lines, wetlands, water bodies & watercourses, roads, buildings, etc. as shown

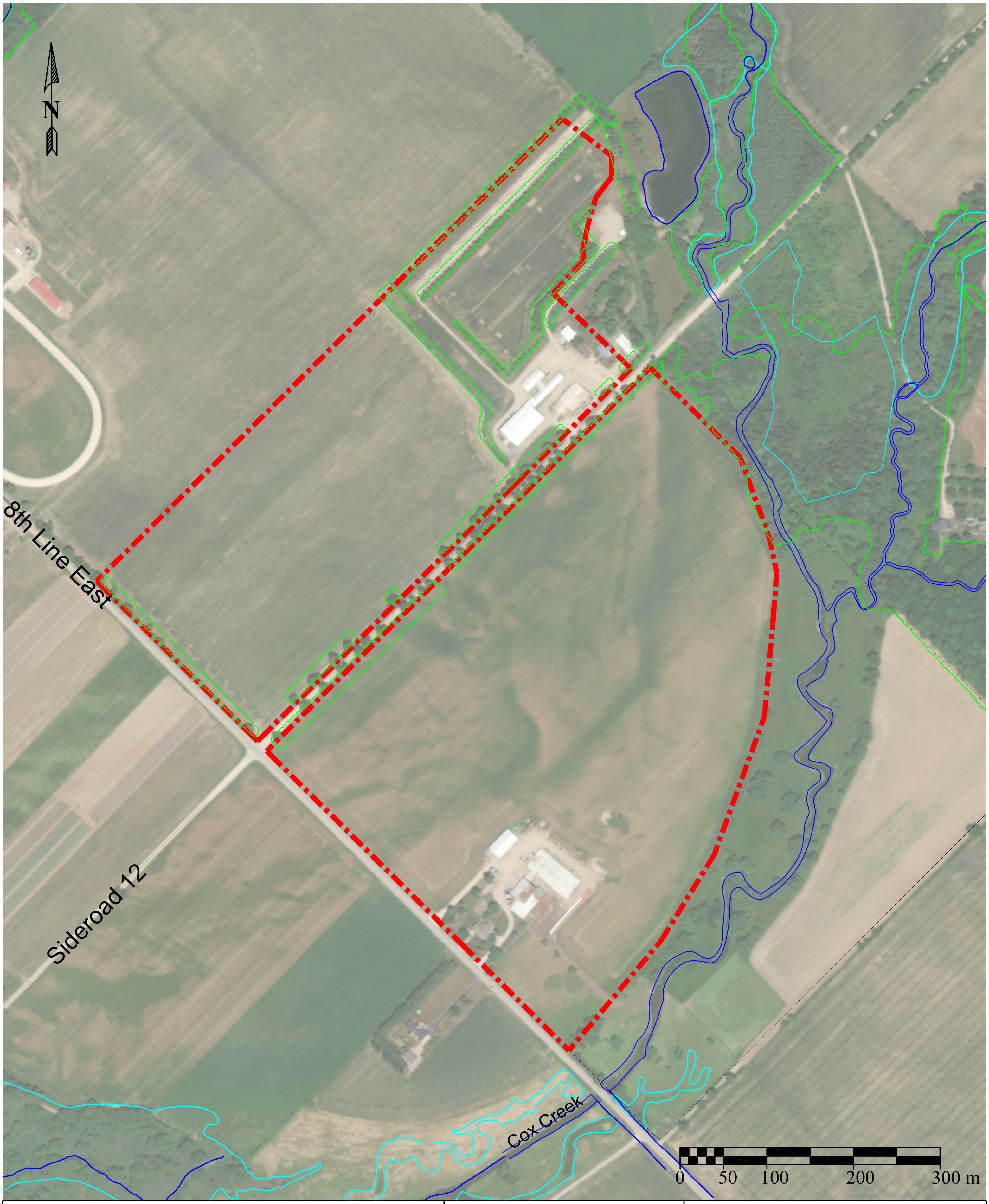
Modified from: geographic data obtained through Land Information Ontario

June 2024
Scale: as shown

GROUNDWATER SCIENCE CORP.

Figure 1: Site Location

James Thoume Construction Ltd.
Proposed Lichty Pit



Site (approx.)
air photo: ESRI imagry

vegetation lines, wetlands, water bodies & watercourses,
roads, buildings, etc. as shown

Modified from: geographic data obtained through Land Information Ontario

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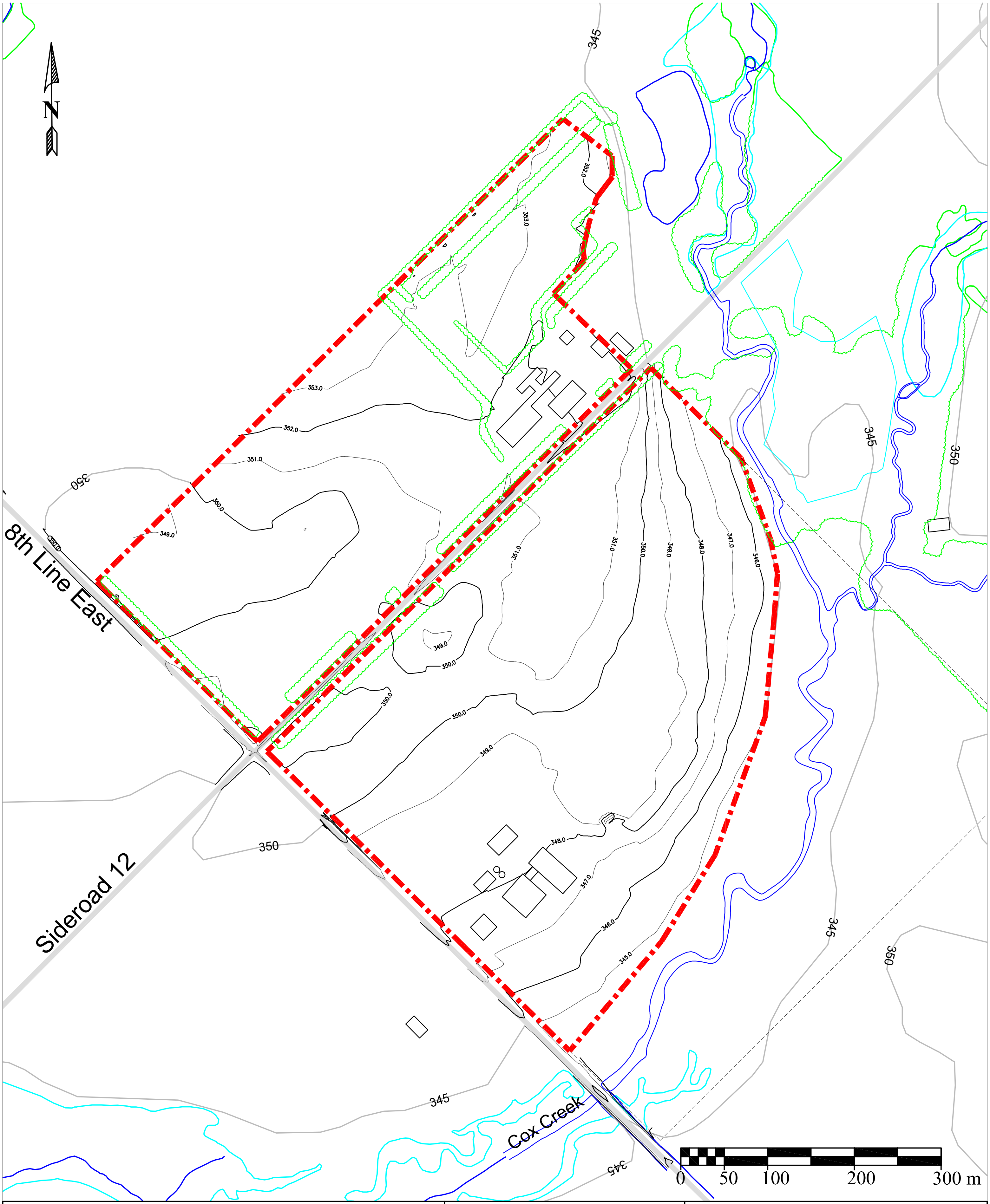
Figure 2: Site Setting

June 2024
Scale: as shown

GROUNDWATER SCIENCE CORP.

James Thoume Construction Ltd.
Proposed Lichty Pit



— · — Site (approx.)
topographic contours as shown (mASL)
vegetation lines, wetlands, water bodies & watercourses,
roads, buildings, etc. as shown

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Scale: as shown

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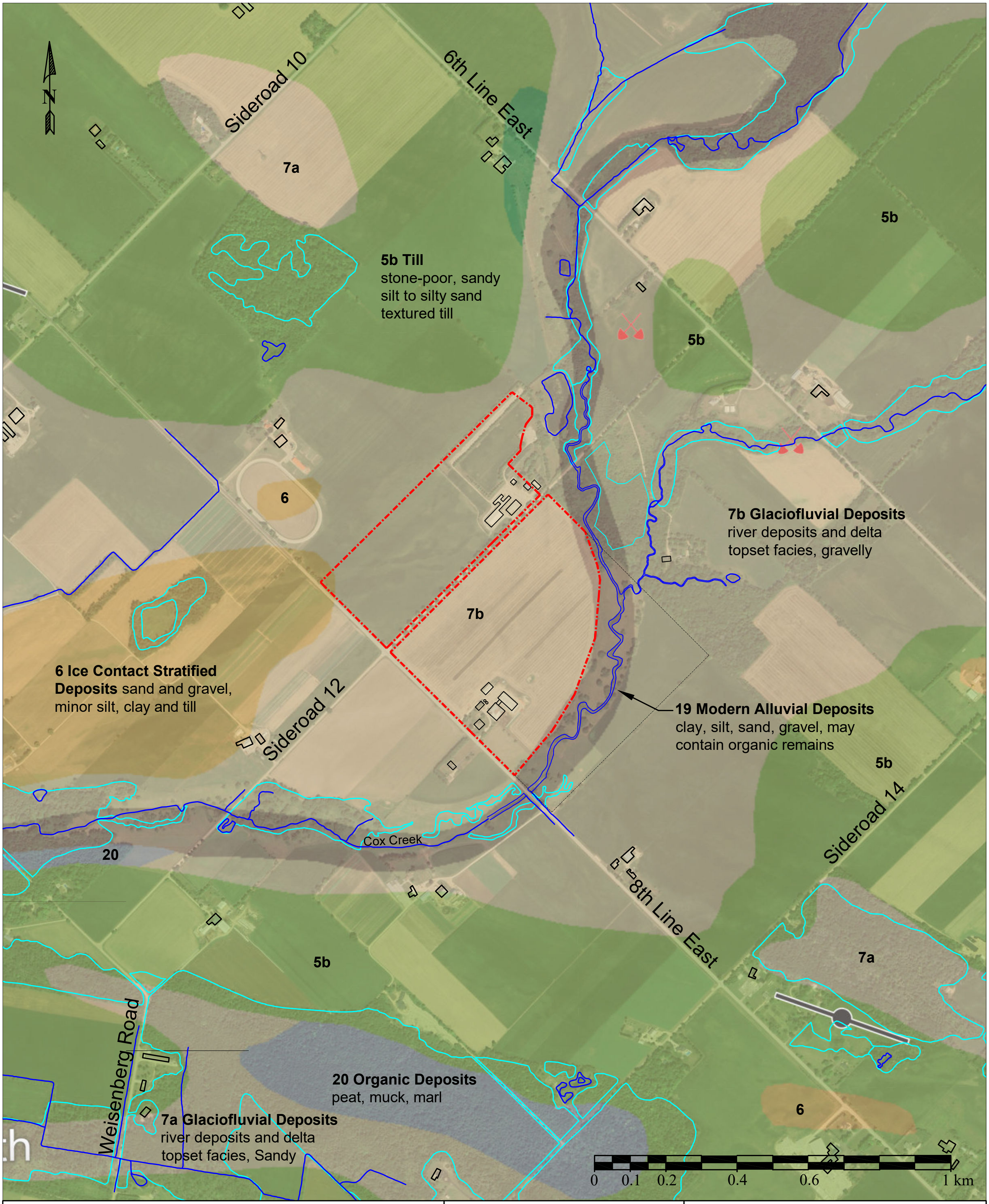
Figure 3: Local Topography

James Thoume Construction Ltd.
Proposed Lichty Pit



-·-·- Site (approx.)

surficial geology: modified from Ontario Geological Survey *OGSEarth* (viewed on Google Earth)

Modified from: geographic data obtained through Land Information Ontario

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Figure 4: Surficial Geology

June 2024
Scale: as shown

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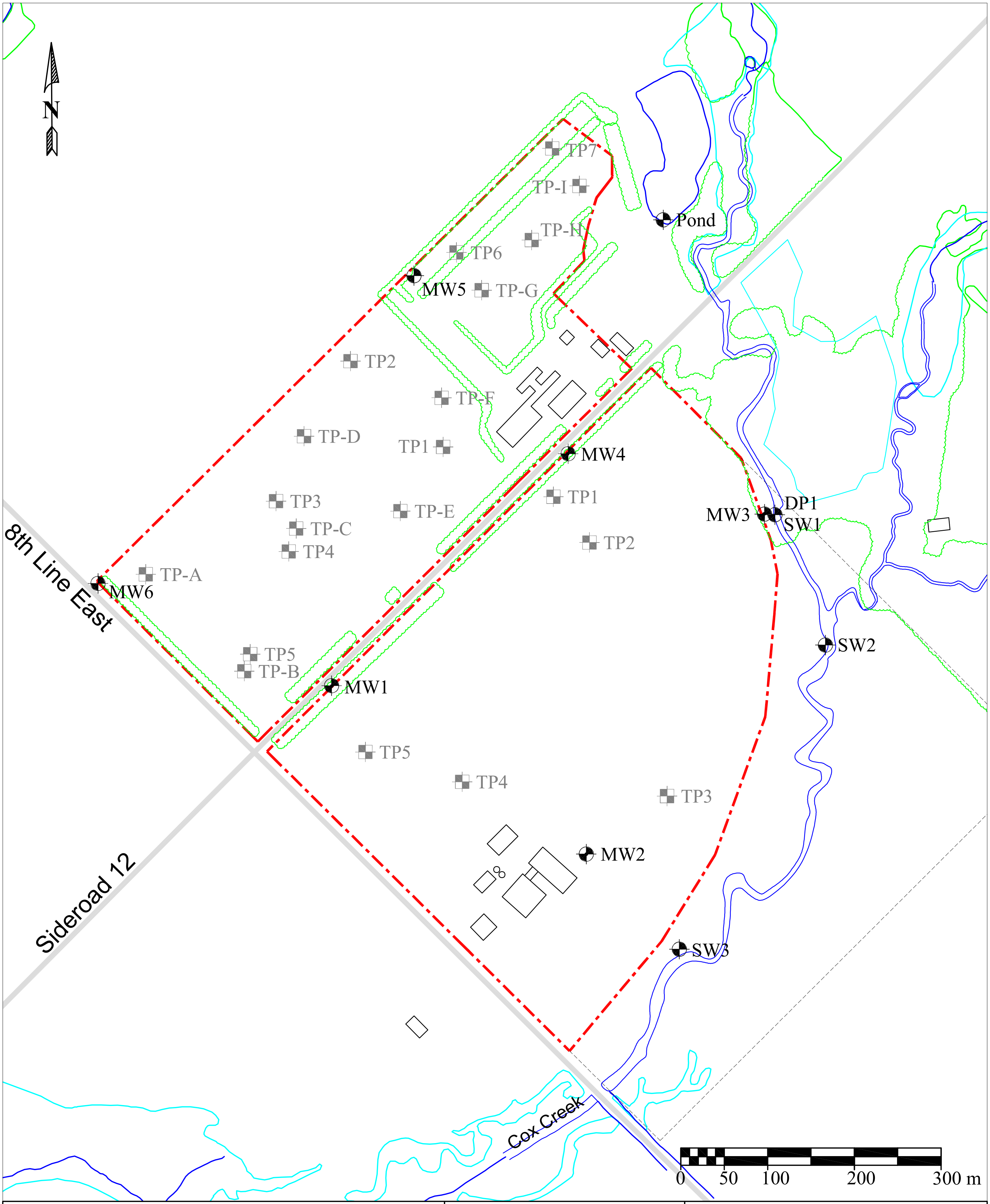
James Thoume Construction Ltd.
Proposed Lichty Pit



- · - Site (approx.)
● monitoring location
▨ test pit

vegetation lines, wetlands, water bodies & watercourses,
roads, buildings, etc. as shown

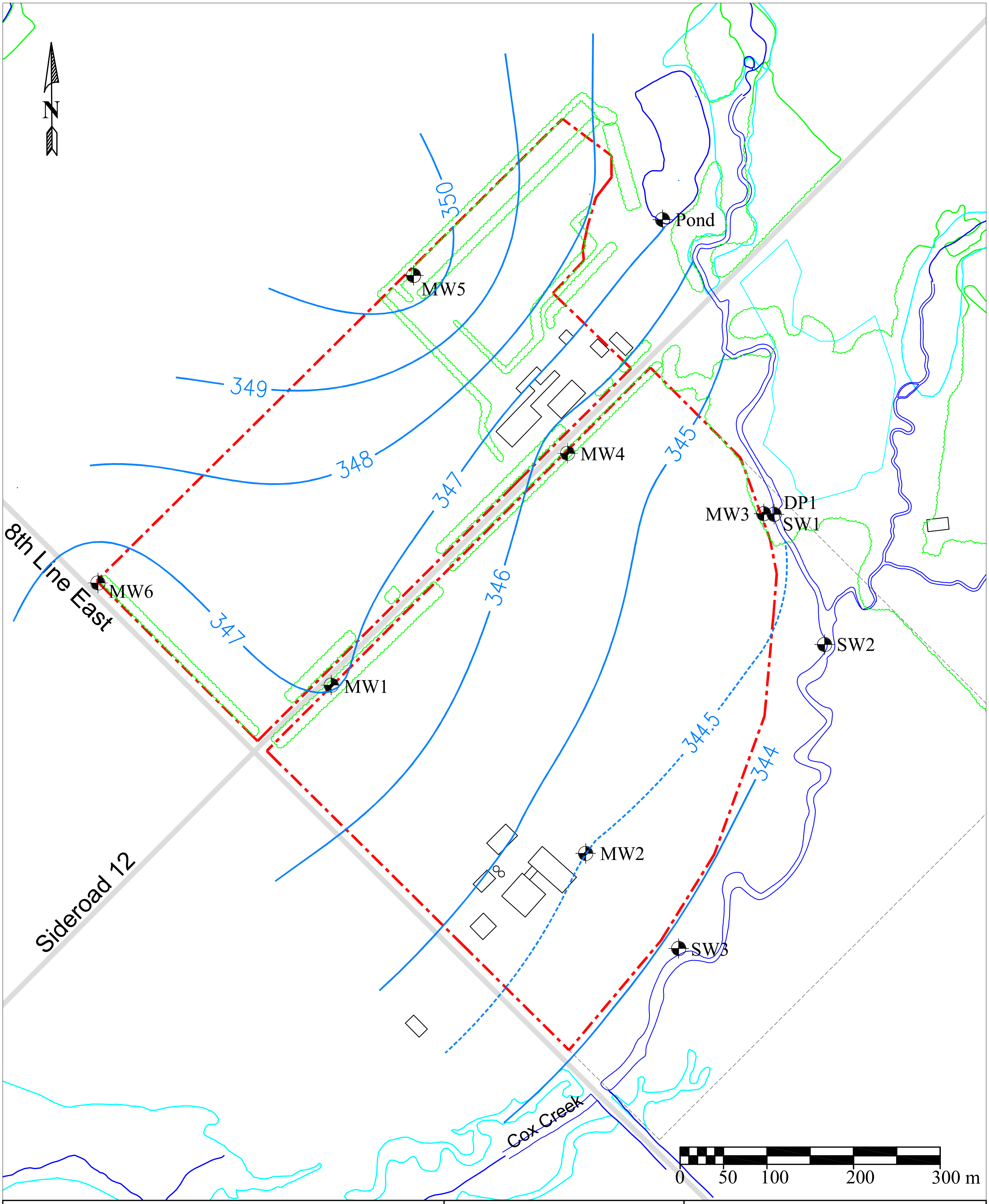
Modified from: geographic data obtained through Land Information Ontario

June 2024
Scale: as shown

GROUNDWATER SCIENCE CORP.

Figure 5: Monitor Locations

James Thoume Construction Ltd.
Proposed Lichty Pit



- Site (approx.)
- interpreted water table (mASL, interval as shown)

vegetation lines, wetlands, water bodies & watercourses, roads, buildings, etc. as shown

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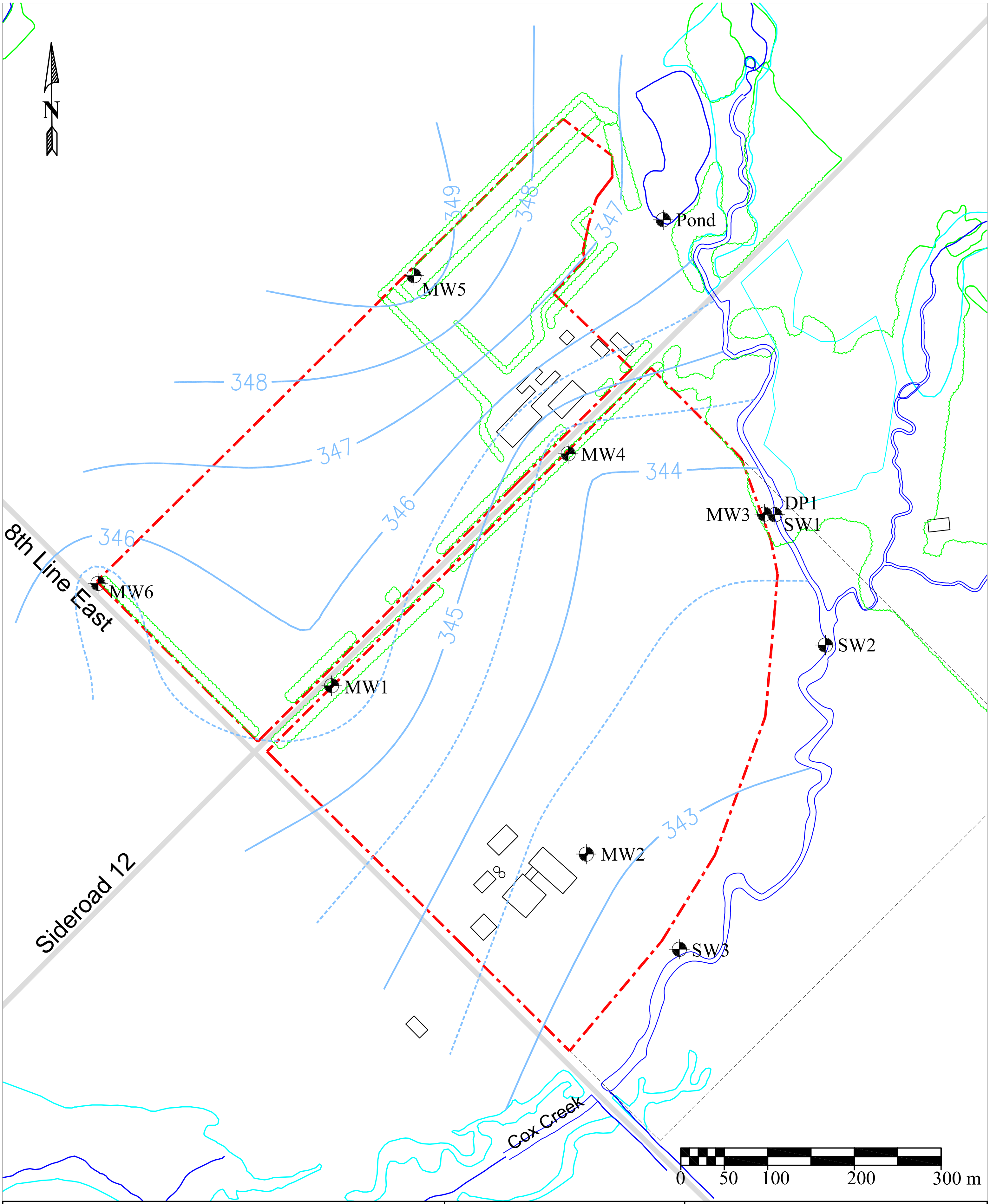
July 2024
Scale: as shown

GROUNDWATER SCIENCE CORP.

Figure 6: High Water Table Conditions

James Thoume Construction Ltd.
Proposed Lichty Pit



Site (approx.)
interpreted water table (mASL, interval as shown)
vegetation lines, wetlands, water bodies & watercourses,
roads, buildings, etc. as shown

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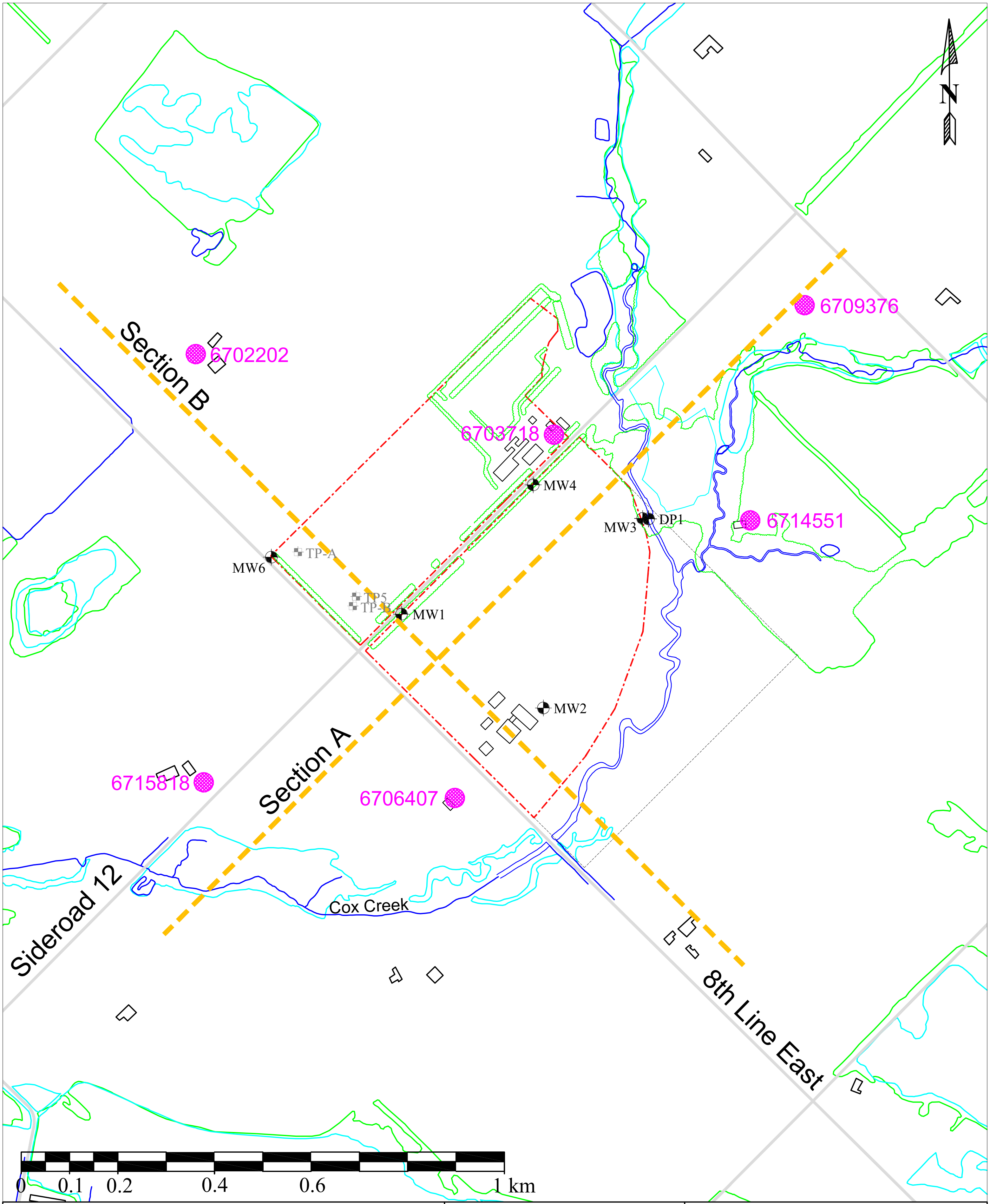
June 2024
Scale: as shown

GROUNDWATER SCIENCE CORP.

Figure 7: Low Water Table Conditions

James Thoume Construction Ltd.
Proposed Lichty Pit



- Site (approx.)
- ● reported well record location (approximate)
- section line

Modified from: geographic data obtained through Land Information Ontario

June 2024
Scale: as shown

GROUNDWATER SCIENCE CORP.

Figure 8: Schematic Section Locations

James Thoume Construction Ltd.
Proposed Lichty Pit

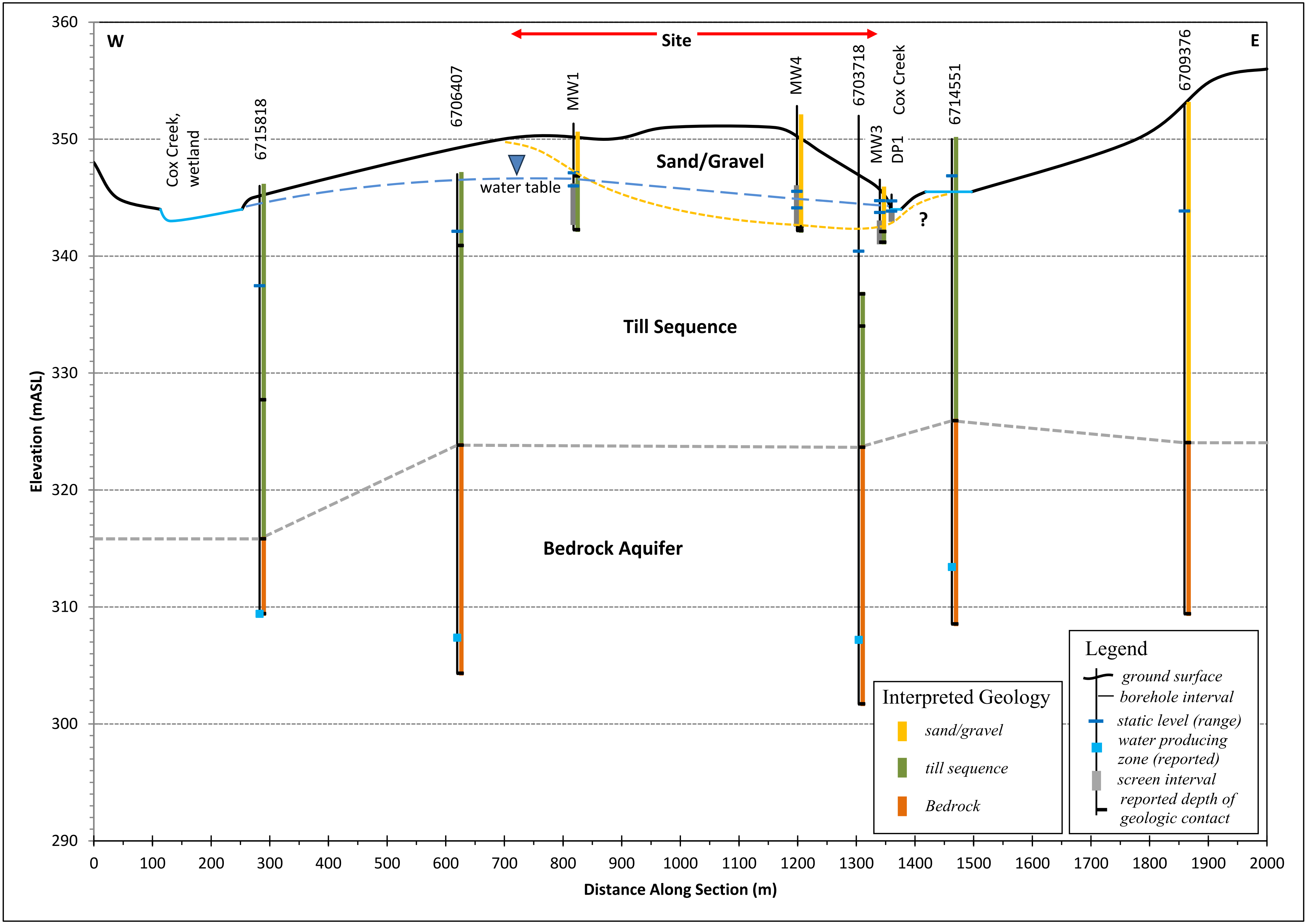


Figure 9: Schematic Section A

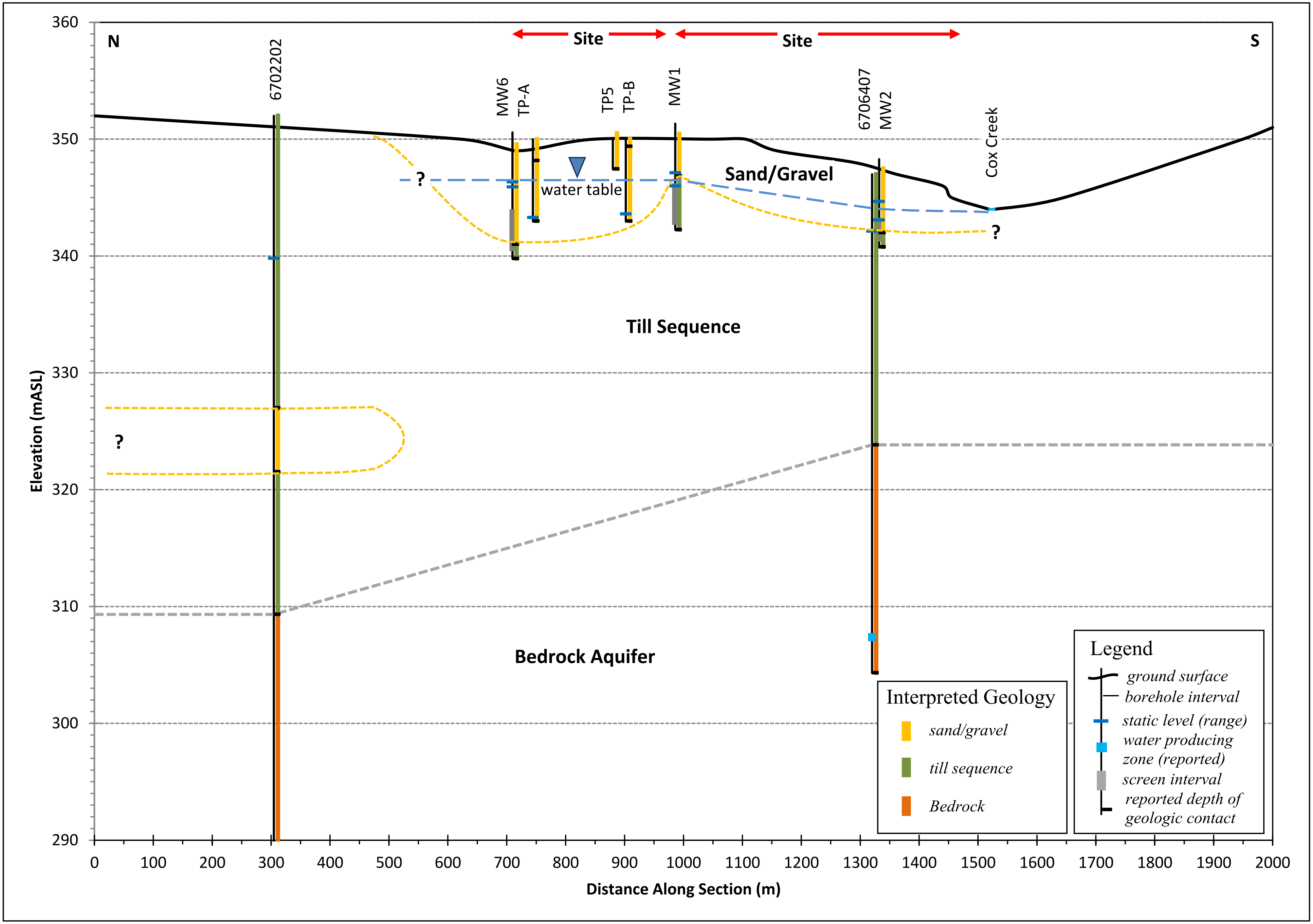
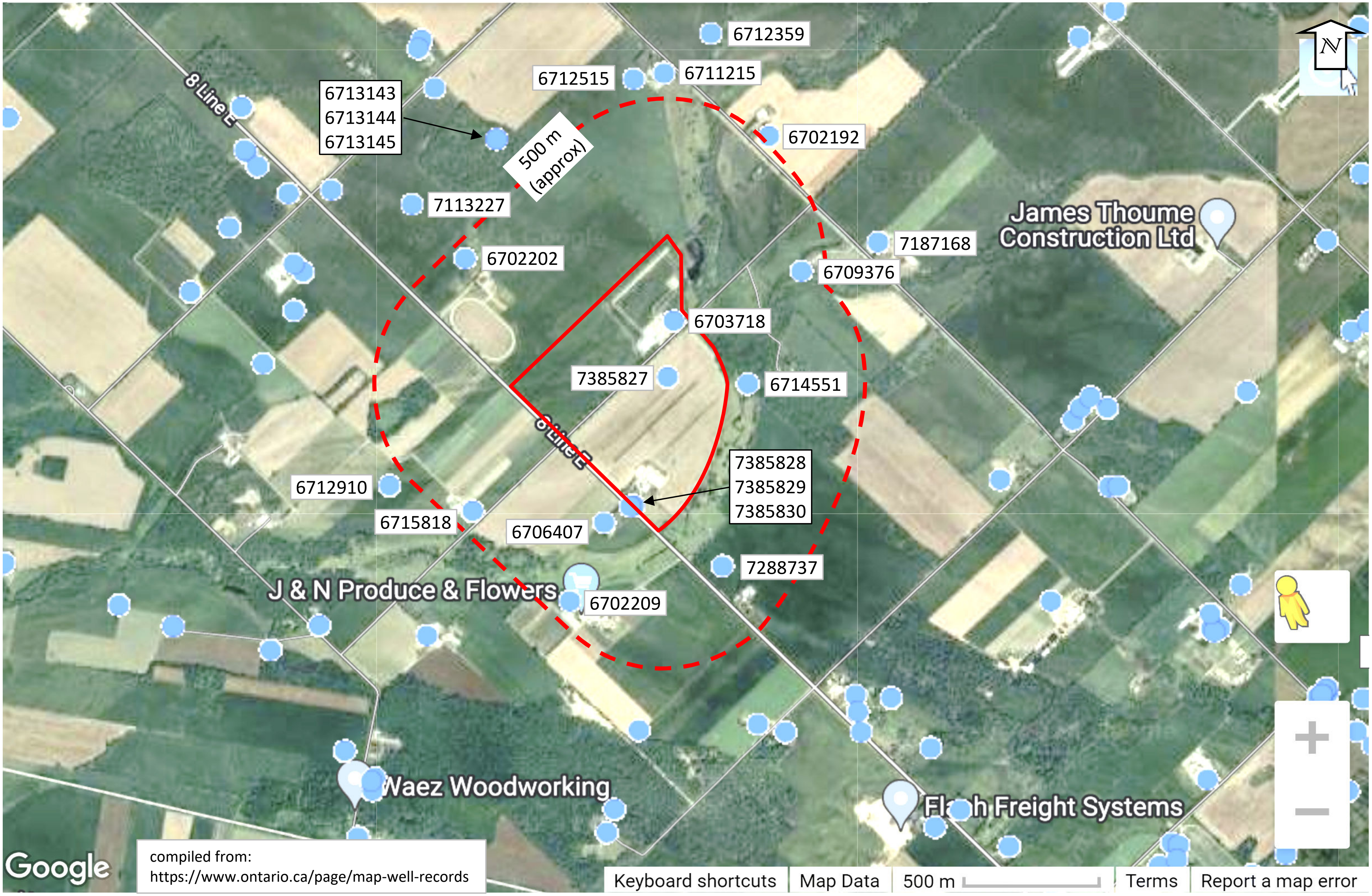


Figure 10: Schematic Section B

Appendix A

Water Well Record Review



compiled from:
https://www.ontario.ca/page/map-well-records

site (approximate)

reported water well record locations
and references as shown

Date: June 2024
scale: not to scale

Figure A1: Reported Water Well Locations

GROUNDWATER SCIENCE CORP.

James Thoume Construction Ltd.
Proposed Lichty Pit

Record No.	Date Constructed	Total Depth (m)	Type		Use	Static Level (m)	Bedrock Depth (m)	Recommended Rate (gpm)	Source Classification
			constr.	source unit					
6702192	21-Feb-67	46.9	drilled	bedrock	domestic	3.7	22.9	10	confined bedrock aquifer
6702202	13-Feb-59	70.4	drilled	bedrock	domestic, stock	12.2	42.7	10	confined bedrock aquifer
6702209	9-Apr-64	28.7	drilled	gravel	domestic, stock	6.1	-	10	confined overburden aquifer
6703718	18-Jun-70	50.3	drilled	bedrock	domestic, stock	11.6	28.3	10	confined bedrock aquifer
6706407	12-May-77	42.7	drilled	bedrock	domestic	4.9	23.2	15	confined bedrock aquifer
6709376	17-Jun-88	43.6	drilled	bedrock	domestic	9.1	29.0	12	unconfined bedrock aquifer
6711215	16-Jun-93	32.0	drilled	gravel	domestic	11.2	-	15	confined overburden aquifer
6712359	2-Oct-97	29.9	drilled	gravel, sand	domestic, stock	7.4	-	10	confined overburden aquifer
6712515	16-Jun-93	32.0	drilled	gravel	domestic	11.2	-	15	confined overburden aquifer
6712910	15-Jan-99	45.7	drilled	bedrock	domestic, stock	10.9	31.7	7	confined bedrock aquifer
6713143	23-Nov-99	-	drilled	none	test hole, abandoned	-	-	-	not used
6713144	23-Nov-99	4.9	drilled	none	test hole, abandoned	-	-	-	not used
6713145	23-Nov-99	-	drilled	none	test hole, abandoned	-	-	-	not used
6714551	17-Jul-03	41.5	drilled	bedrock	domestic	3.1	24.1	8	confined bedrock aquifer
6715818	9-May-06	36.6	drilled	bedrock	domestic	8.5	30.2	15	confined bedrock aquifer
7113227	29-Aug-08	45.8	drilled	bedrock	domestic	16.6	15.9	10	unconfined bedrock aquifer
7187168	4-Jun-12	34.7	drilled	bedrock	domestic	6.6	25.3	20	confined bedrock aquifer
7288737	18-Apr-17		observation well drilled for Metrolinx in Scarborough - incorrect location						
7385827	23-Apr-21	9.1	drilled	sand, gravel	site observation well	-	-	-	unconfined overburden aquifer
7385828	23-Apr-21	4.6	drilled	sand, gravel	site observation well	-	-	-	unconfined overburden aquifer
7385829	22-Apr-21	6.1	drilled	sand, gravel	site observation well	-	-	-	unconfined overburden aquifer
7385830	23-Apr-21	7.6	drilled	sand, gravel	site observation well	-	-	-	unconfined overburden aquifer

Table A1: Water Well Record Review Summary

Appendix B
Test Pit and Drilling Results

Litchy Test Pits January 8, 2021					
TP#	Total Depth (ft)	Water Depth (ft)	Depth (ft)		Description
			from	to	
1	24	23	0	1	Topsoil
			1	10	Fine to medium sand, fine gravel and stones, clean
			10	24	Fine to medium sand, some medium gravel, stony and clean
					Wet at 23
2	25	23	0	1	Topsoil
			1	9	Fine to medium sand, fine gravel and stones, clean
			9	25	Fine to medium sand, some medium gravel, stony and clean
					Wet at 23
3	15	14	0	1	Topsoil
			1	7	Fine sand, fine gravel and stones
			7	12	Medium to coarse sand, fine to medium gravel & some stones
			12	17	Fine to medium sand, fine to coarse gravel, stony
					Wet at 14
4	24	23	0	1	Topsoil
			1	10	Medium sand and coarse gravel
			10	24	Fine to medium sand, fine to coarse gravel, stony
					Wet at 23
5	23	22	0	1	Topsoil
			1	7	Medium sand and coarse gravel, clean
			7	12	Medium to coarse sand, fine to medium gravel & some stones
			12	23	Fine to medium sand, fine to coarse gravel, stony
					Wet at 22

Lichty Test Pits, North Property, June 2023				
Test Pit	Ground Elevation (mASL)	Observed Conditions		
		Depth (m)	Elevation (mASL)	Material
1	352.0	0.3	351.7	topsoil
		0.6	351.4	overburden
		3.7	348.3	sand/gravel
		3.7	348.3	water
2	353.0	0.3	352.7	topsoil
		0.6	352.4	overburden
		3.0	350.0	sand/gravel
		3.0	350.0	water
3	350.5	0.2	350.3	topsoil
		1.2	349.3	sand/gravel
4	349.0	3.0	346.0	topsoil
		4.3	344.7	sand/gravel
		4.0	345.0	water
5	350.5	0.3	350.2	topsoil
		0.2	350.3	overburden
		3.0	347.5	sand/gravel
6	353.0	4.0	349.0	sand/gravel
7	353.0	0.9	352.1	sand/gravel
		1.8	351.2	silty clay

Lichty Test Pits, North Property, December 13, 2023

TP#	Total Depth (ft)	Water Depth (ft)	Depth (ft)		Description
			from	to	
A	23	22	0	1	Topsoil
			1	6	clayey silty sand
			6	23	medium sand with gravel to cobbles/boulders
					wet at 22
B	23	21	0	1	topsoil
			1	2	clayey silty sand
			2	14	coarse sand with gravel to cobbles/boulders
			14	17	fine-medium sand and gravel
			17	23	sand and coarse gravel, wet at 21
			23		grey clay till
C	19	17	0	1	topsoil
			1	4	clayey silty sand
			4	6	fine yellow-brown sand
			6	19	coarse sand and gravel to cobbles/boulders
					wet at 17
D	18	>18	0	1	topsoil
			1	2	red brown clayey silty sand
			2	7	coarse sand and gravel to cobbles/boulders
			7	18	grey clay till, dry
E	22	20	0	1	topsoil
			1	2	grey silty clayey fine sand
			2	13	medium to coarse sand and gravel to cobbles/boulders
			13	22	fine to medium sand, some fine gravel
					wet at 20
F	24	22	0	1	topsoil
			1	24	coarse sand and gravel to cobbles/boulders
			24		grey brown clay till
					wet at 22
G	20	>20	0	1	sandy red brown soil
			1	20	coarse sand and gravel to cobbles/boulders
			20		grey brown clay till
					dry
H	20	>20	0	1	sandy red brown soil
			1	16	coarse sand and gravel to cobbles/boulders
			16	20	fine to medium sand, some gravel
			20		grey brown clay till, dry
I	9	>9	0	2	sandy red brown soil
			2	9	coarse sand with cobbles to very large boulders
			9		grey brown clay till
					dry

BOREHOLE LOG

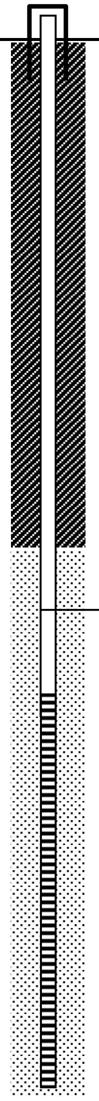
Borehole: MW1

Project: Ariss Pit
Location: near west corner of site
Method: Hollow stem auger
Samples: auger cuttings (A) and split spoon (S)

Date: April 22, 2021
Supervisor: AP
Elevations TOC: 351.33 mASL
GS: 350.46 mASL

Sample				Description
type	no.	Interval (m)	rec.%	
				Topsoil - sandy/silty
A				
				Sand, Gravel
A				- sandy/gravel auger cuttings
S	1	1.5 to 2.1	50%	- medium sand and coarse gravel, clean, dry
S	2	3.0 to 3.7	50%	- fine to medium sand, some fine gravel and stones to 3.6m, dry
				Till - brown dense silty clay till with minor fine gravel clasts to 3.7m, dry
S	3	4.6 to 5.2	100%	- dark grey silty clay till with some fine gravel, dense to very dense
S	4	6.1 to 6.7	50%	- dark grey till, varies from clayey silt/sand to silty clay to clay till, moderately dense to soft
S	5	7.6 to 8.2	50%	- dark grey silt till, numerous gravel clasts, minor clay, dense to very dense
				End of Hole at 8.2m

Monitor Installation



Groundwater Science Corp.

BOREHOLE LOG

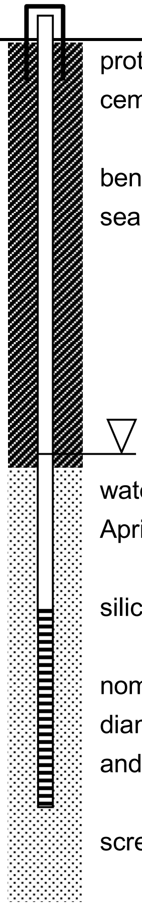
Borehole: MW2

Project: Ariss Pit
Location: east of barn
Method: Hollow stem auger
Samples: auger cuttings (A) and split spoon (S)

Date: April 22, 2021
Supervisor: AP
Elevations TOC: 348.29 mASL
GS: 347.49 mASL

Sample				Description
type	no.	Interval (m)	rec.%	
				Sand, Gravel
A				
				- stony drilling
S	1	1.5 to 2.1	10%	- fine sand, fine gravel and stones, dry (sample refusal on stone)
A				
S	2	3.0 to 3.7	50%	- medium to coarse sand, fine to medium gravel, some stones, dry
S	3	4.6 to 5.2	25%	- fine to medium sand, fine to coarse gravel, stony, some silt, wet
				Till - change in drilling
S	4	6.1 to 6.7	100%	- dark grey silt till, some sand and clay, with numerous gravel clasts, moderately dense
				End of Hole at 6.7m

Monitor Installation



protective casing, cement at surface

bentonite (holeplug) seal

water level 3.29 mBGS April 23, 2021.

silica sand pack

nominal 5.1 cm diameter PVC riser and slotted screen

screen length 1.5 m

Groundwater Science Corp.

BOREHOLE LOG

Borehole: MW3

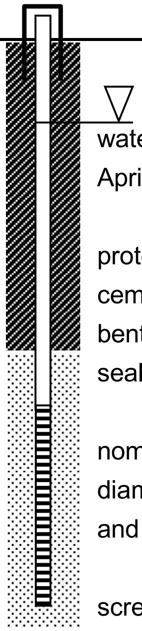
Project: Ariss Pit
Location: northeast edge of site, next to creek
Method: Hollow stem auger
Samples: auger cuttings (A) and split spoon (S)

Date: April 23, 2021
Supervisor: AP
Elevations TOC: 346.53 mASL
GS: 345.75 mASL

Depth
ft.: 0 5 10 15 20 25 30 35 40
m.: 0 1 2 3 4 5 6 7 8 9 10 11 12

Sample type	Sample no.	Sample Interval (m)	rec.%	Description
A				**Topsoil** - dark, silty
				Silt/Sand - silty/sandy auger cuttings
				Sand and Gravel
S	1	1.5 to 2.1	25%	- medium to coarse sand, fine gravel and stones, clean, moist
A				
S	2	3.0 to 3.7	50%	- as above, wet to 3.5m
				Till - grey silt till, some clay, with fine gravel to 3.7m, soft to slightly dense, wet
				End of Hole at 4.6m

Monitor Installation



water level 0.65 mBGS April 23, 2021.

protective casing, cement at surface bentonite (holeplug) seal at surface

nominal 5.1 cm diameter PVC riser and slotted screen

screen length 1.5 m

Groundwater Science Corp.

BOREHOLE LOG

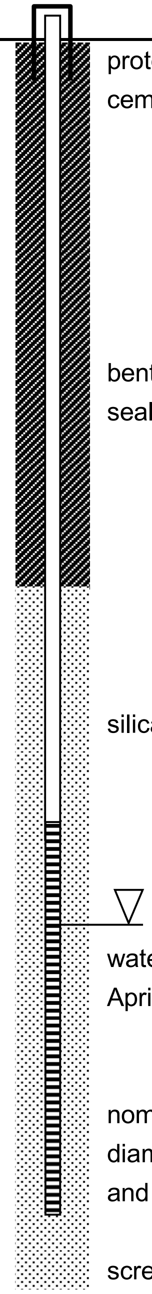
Borehole: MW4

Project: Ariss Pit
Location: near north corner of site
Method: Hollow stem auger
Samples: auger cuttings (A) and split spoon (S)

Date: April 23, 2021
Supervisor: AP
Elevations TOC: 352.83 mASL
GS: 351.93 mASL

Sample type	no.	Interval (m)	rec.%	Description
				Topsoil - sandy
A				**Sand and Gravel** - stony drilling
S	1	1.5 to 2.1	20%	- fine to medium sand, fine gravel and stones, clean, dry
S	2	3.0 to 3.7	75%	- fine to medium sand, some medium gravel, stony, clean, dry
S	3	4.6 to 5.2	50%	- as above
				- stony drilling
S	4	6.1 to 6.7	50%	- as above, consistent, dry
S	5	7.6 to 8.2	25%	- medium to coarse sand, fine to coarse gravel, stony, some silt, wet
S	6	9.1 to 9.8		- fine sand, fine gravel and stones to 9.6m
				Till - brown clayey silt till, slightly dense
				End of Hole at 9.8m

Monitor Installation



protective casing, cement at surface

bentonite (holeplug) seal

silica sand pack

water level 6.98 mBGS April 23, 2021.

nominal 5.1 cm diameter PVC riser and slotted screen

screen length 3.0 m

Groundwater Science Corp.

BOREHOLE LOG

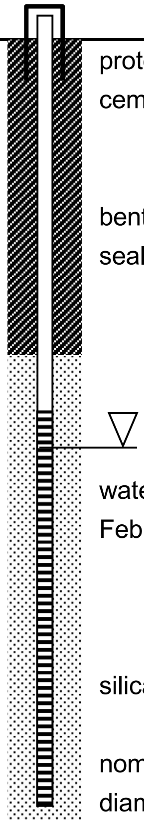
Borehole: MW5

Project: Lichty Pit
Location: Northwest corner of field, along tree line
Method: Hollow Stem Auger
Samples: split spoon (S) and auger cuttings (A)

Date: February 26, 2024
Supervisor: DN
Elevations TOC: 354.73 mASL
GS: 353.67 mASL

Sample type	no.	Interval (m)	rec.%	Description
A				**Topsoil**
A				**Sand and Gravel** - fine to medium sand, with coarse gravel, dry
A				
S	1	1.5 to 2.1	61%	- sand becoming coarser with depth
				- wet at 10'
A				
S	2	3.0 to 3.7	46%	- coarse sand and gravel, wet
A				
S	3	4.6 to 5.2	61%	
				Till - grey silty clay till, dense, wet
A				
				End of hole at 6.1m

Monitor Installation



protective casing, cement at surface

bentonite (holeplug) seal

water level 3.2 mBGS
February 26, 2024

silica sand pack

nominal 5.1 cm diameter PVC riser and slotted screen

screen length 3.0 m

GROUNDWATER SCIENCE CORP.

BOREHOLE LOG

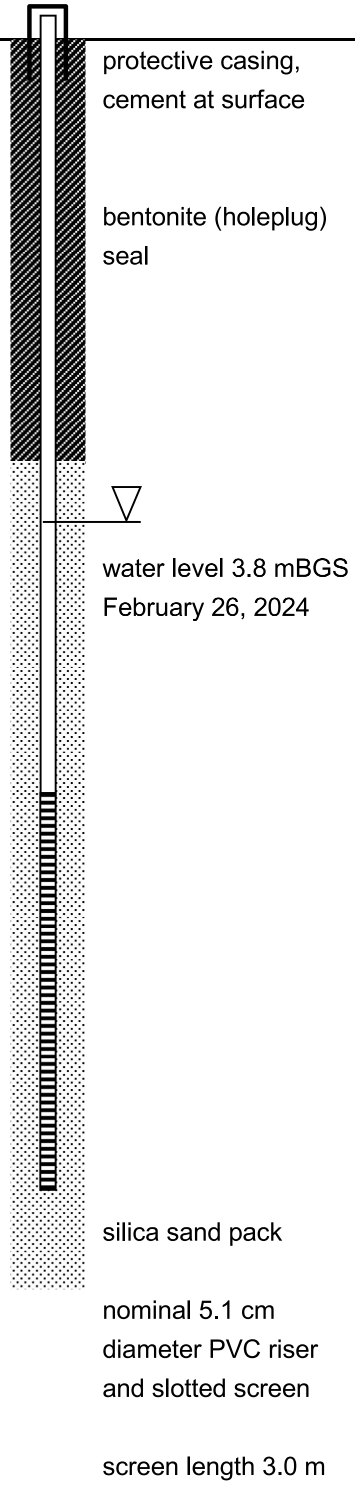
Borehole: MW6

Project: Lichty Pit
Location: Along 8th Line, corner of property
Method: Hollow Stem Auger
Samples: split spoon (S) and auger cuttings (A)

Date: February 26, 2024
Supervisor: DN
Elevations TOC: 350.58 mASL
GS: 349.54 mASL

Sample				Description
type	no.	Interval (m)	rec.%	
A				**Topsoil**
				Silty Sand
				- brown silty fine sand, dry
A				
S	1	1.5 to 2.1	61%	
				Sand, Gravel, Cobbles
A				
S	2	3.0 to 3.7	30%	- fine sand and gravel, dry
A				- wet at 14'
S	3	4.6 to 5.2	61%	- coarse sand with gravel to cobbles, wet
A				
S	4	6.1 to 6.7	25%	- as above
A				
S	5	7.6 to 8.2	0%	- cobbles to boulders by 25'
				Till
				- grey silty clay till, dense
S	6	9.1 to 9.8	20%	
				End of hole at 9.8m

Monitor Installation



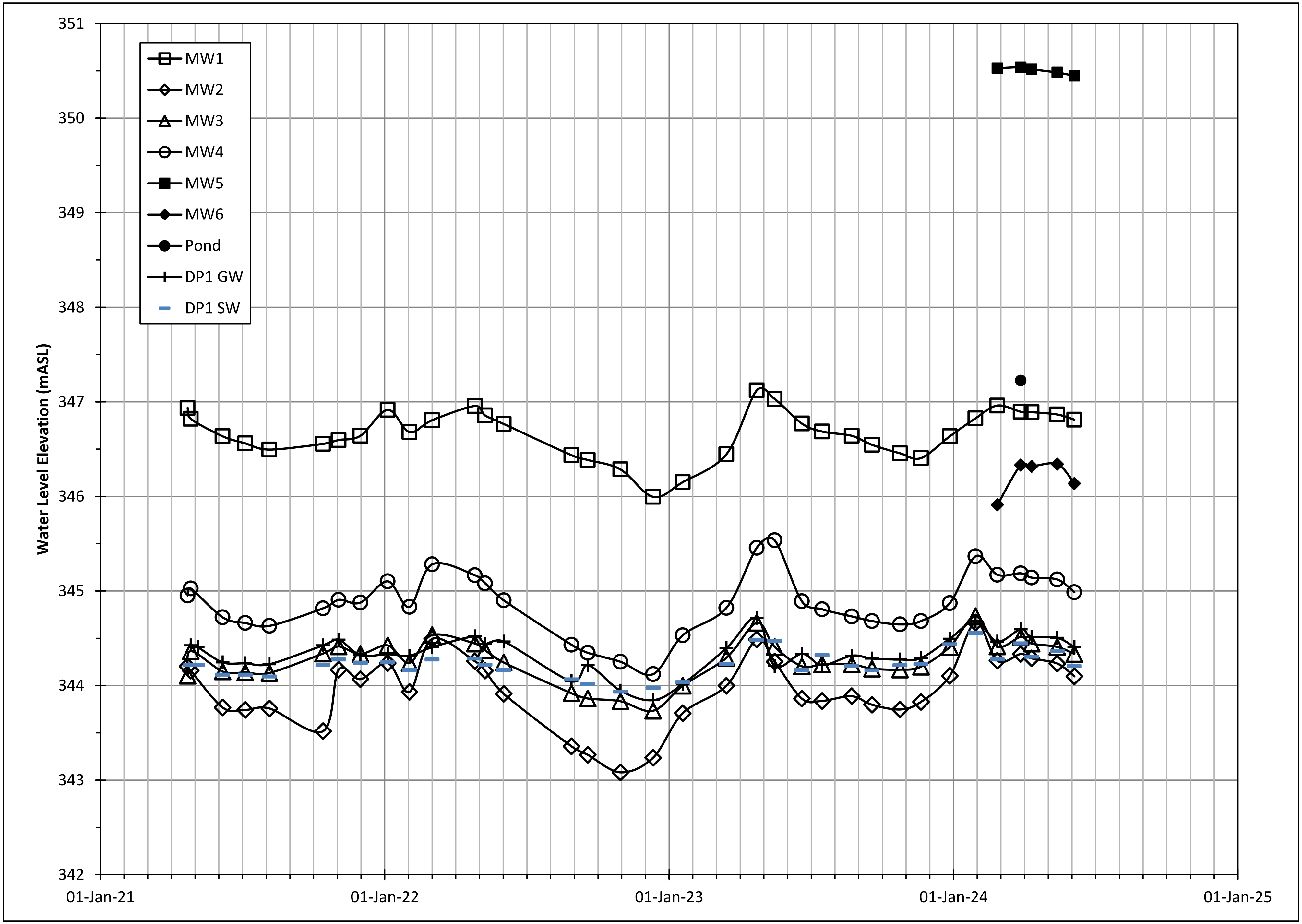
GROUNDWATER SCIENCE CORP.

Appendix C
Monitoring Results

Water Level Elevation (mASL)									
Date	MW1	MW2	MW3	MW4	MW5	MW6	Pond	DP1 GW	DP1 SW
TOW:	351.33	348.29	346.53	352.83	354.73	350.58	348.19	345.26	345.26
23-Apr-21	346.94	344.20	344.10	344.95	-	-	-	n/a	n/a
27-Apr-21	346.82	344.16	344.36	345.03	-	-	-	344.43	344.22
6-May-21	n/a	n/a	n/a	n/a	-	-	-	344.41	344.22
7-Jun-21	346.64	343.77	344.15	344.72	-	-	-	344.25	344.12
6-Jul-21	346.56	343.74	344.14	344.66	-	-	-	344.24	344.12
6-Aug-21	346.50	343.76	344.13	344.63	-	-	-	344.23	344.10
14-Oct-21	346.56	343.52	344.34	344.82	-	-	-	344.43	344.22
3-Nov-21	346.60	344.17	344.41	344.91	-	-	-	344.49	344.28
1-Dec-21	346.64	344.07	344.33	344.88	-	-	-	344.32	344.24
5-Jan-22	346.92	344.24	344.42	345.10	-	-	-	344.33	344.25
2-Feb-22	346.68	343.93	344.24	344.83	-	-	-	344.32	344.17
3-Mar-22	346.81	344.49	344.53	345.28	-	-	-	344.41	344.28
27-Apr-22	346.96	344.26	344.44	345.17	-	-	-	344.52	344.29
10-May-22	346.86	344.16	344.37	345.08	-	-	-	344.44	344.22
3-Jun-22	346.77	343.91	344.24	344.90	-	-	-	344.47	344.17
29-Aug-22	346.44	343.36	343.92	344.43	-	-	-	344.05	344.07
19-Sep-22	346.39	343.27	343.86	344.35	-	-	-	344.22	344.02
31-Oct-22	346.29	343.08	343.83	344.25	-	-	-	343.95	343.94
12-Dec-22	346.00	343.24	343.73	344.12	-	-	-	343.85	343.98
19-Jan-23	346.15	343.71	344.00	344.53	-	-	-	344.02	344.04
16-Mar-23	346.45	344.00	344.29	344.82	-	-	-	344.40	344.23
24-Apr-23	347.12	344.49	344.66	345.46	-	-	-	344.72	344.49
17-May-23	347.03	344.25	344.41	345.54	-	-	-	344.21	344.47
21-Jun-23	346.77	343.86	344.20	344.89	-	-	-	344.34	344.17
17-Jul-23	346.69	343.84	344.22	344.81	-	-	-	344.22	344.32
24-Aug-23	346.64	343.89	344.22	344.73	-	-	-	344.32	344.21
19-Sep-23	346.55	343.80	344.18	344.68	-	-	-	344.29	344.16
25-Oct-23	346.46	343.75	344.17	344.65	-	-	-	344.28	344.22
21-Nov-23	346.41	343.83	344.20	344.68	-	-	-	344.29	344.23
28-Dec-23	346.64	344.10	344.41	344.87	-	-	-	344.50	344.44
30-Jan-24	346.83	344.67	344.73	345.37	-	-	-	344.68	344.56
27-Feb-24	346.96	344.26	344.41	345.17	350.53	345.91	-	344.47	344.28
28-Mar-24	346.90	344.33	344.51	345.19	350.54	346.33	347.23	344.60	344.45
11-Apr-24	346.89	344.29	344.44	345.14	350.52	346.32	-	344.52	344.31
14-May-24	346.87	344.23	344.41	345.12	350.48	346.34	-	344.51	344.37
5-Jun-24	346.81	344.10	344.33	344.99	350.45	346.14	-	344.41	344.21

notes:
mASL = metres above sea level
TOW = top of well
n/a = not available
GW = groundwater level
SW = surface water level

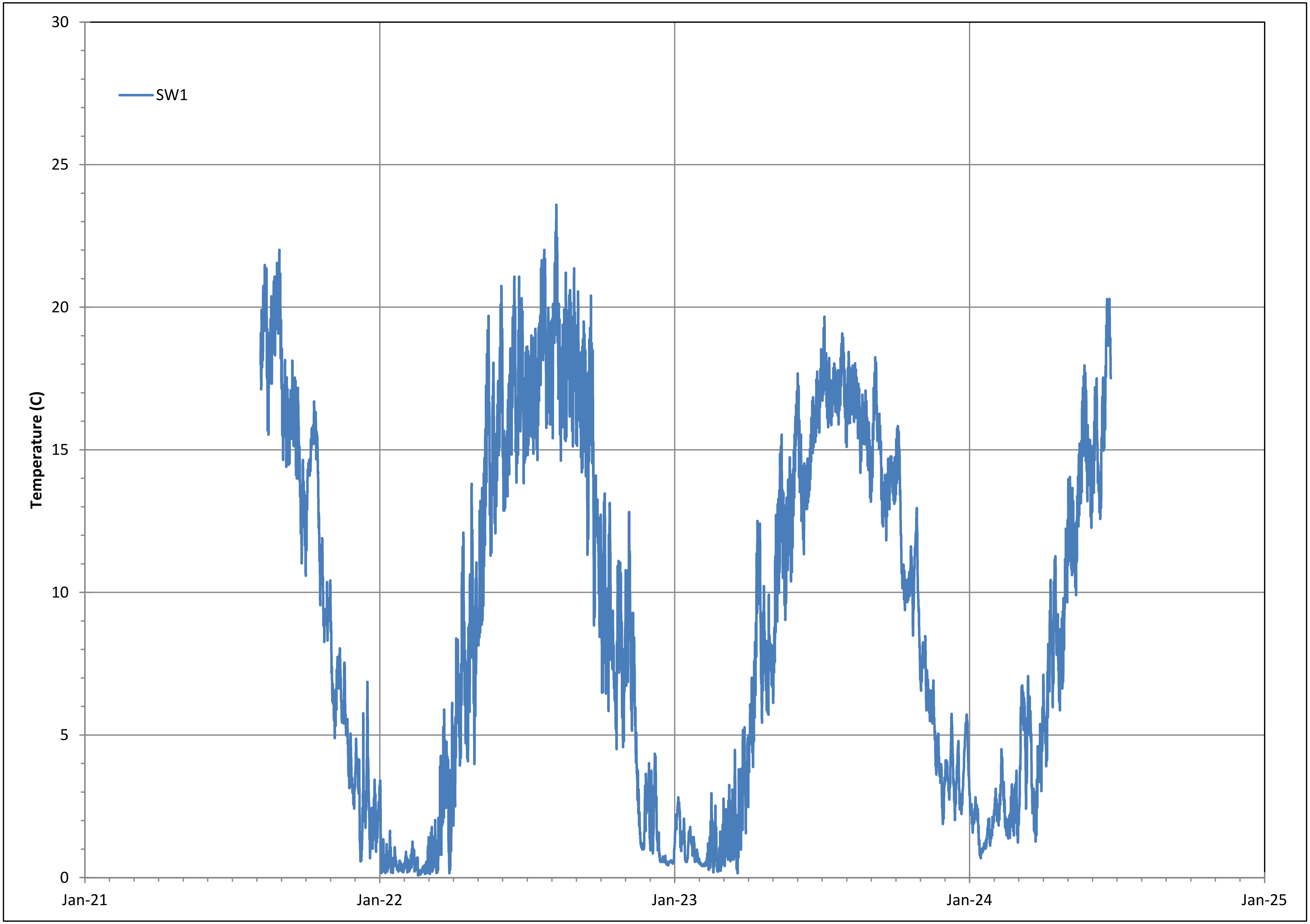
Table C1: Water Level Measurements



James Thoume Construction Ltd
Proposed Lichty Pit

Figure C1: Water Level Hydrograph

Groundwater Science Corp.
Hydrogeologic Assessment



James Thoume Construction Ltd.
Proposed Lichty Pit

Figure C2: Stream Temperature At SW1

Groundwater Science Corp
Hydrogeological Assessment

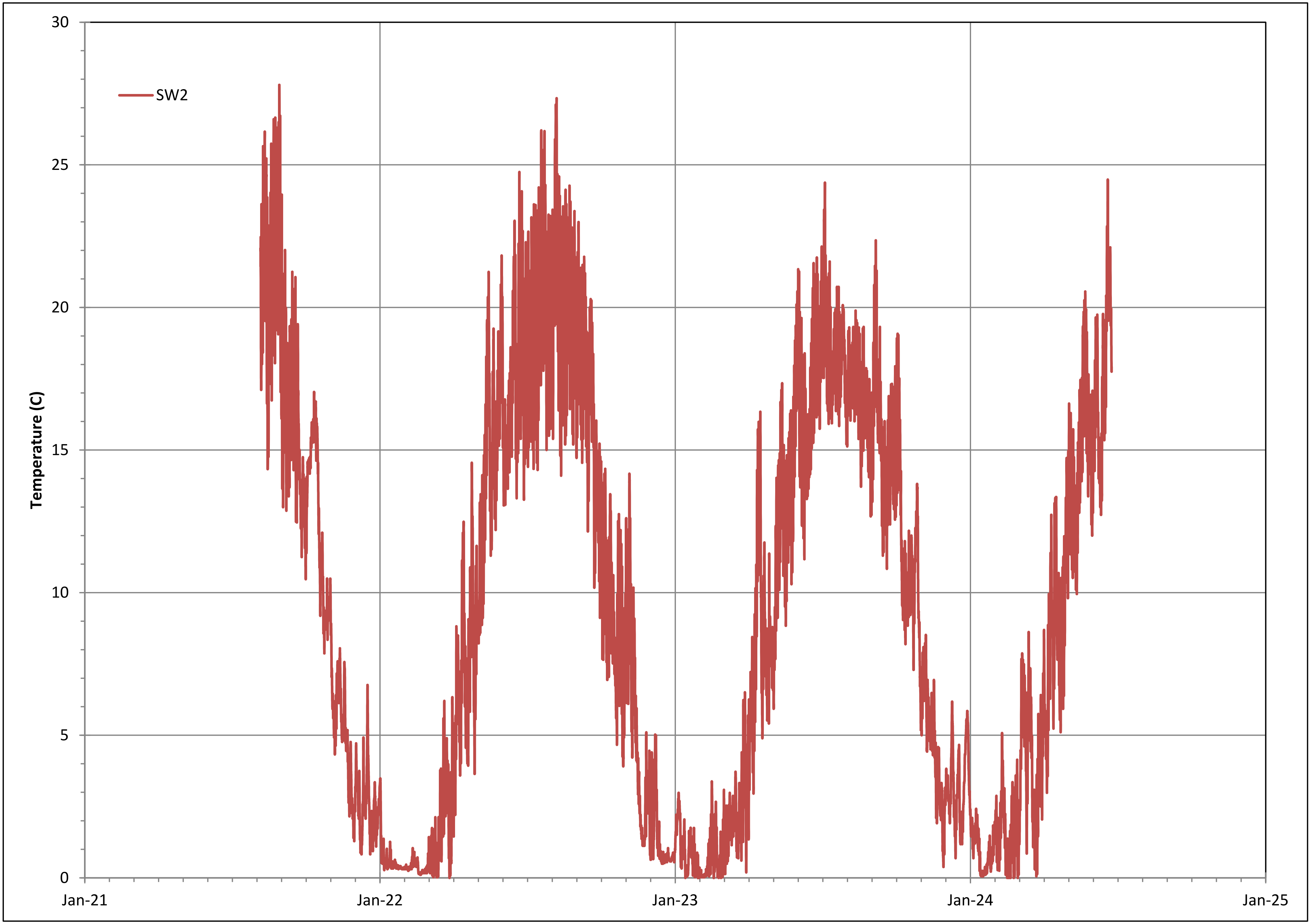


Figure C3: Stream Temperature at SW2

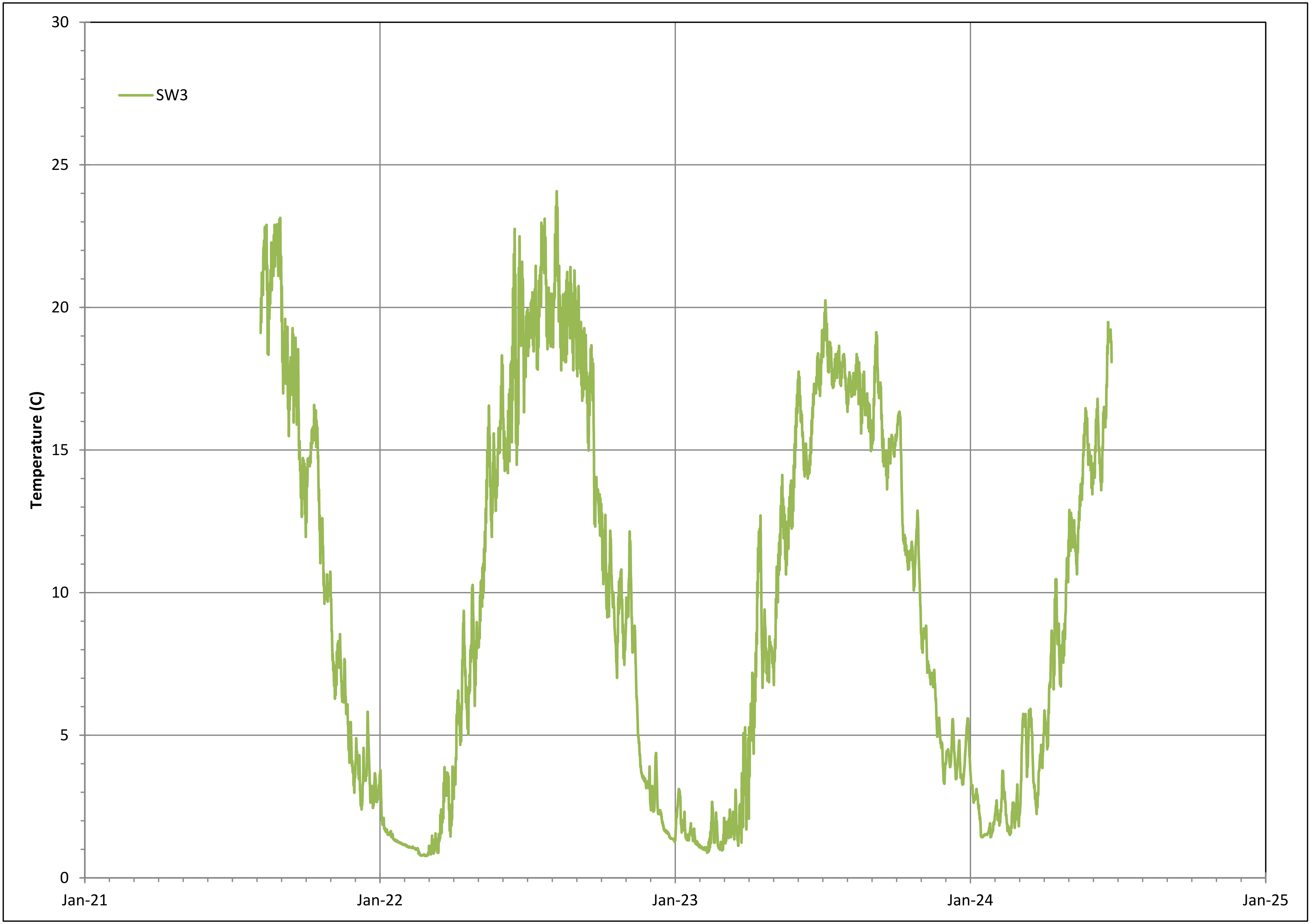
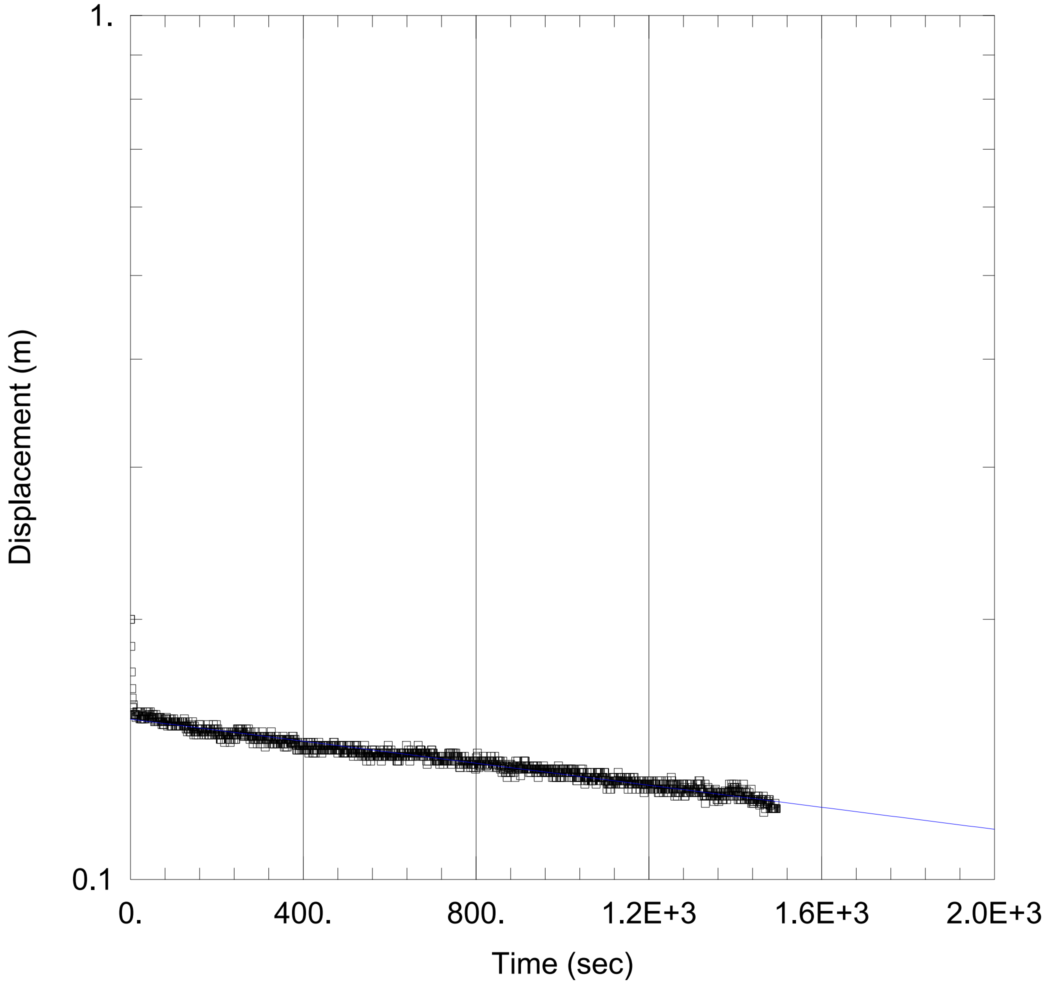


Figure C4: Stream Temperature At SW3

Appendix D
Response Test Analysis



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Thoume Construction
Location: Lichty Pit
Test Well: MW Slug Test
Test Date: July 3, 2024

AQUIFER DATA

Saturated Thickness: 6. m
Anisotropy Ratio (Kz/Kr): 1.

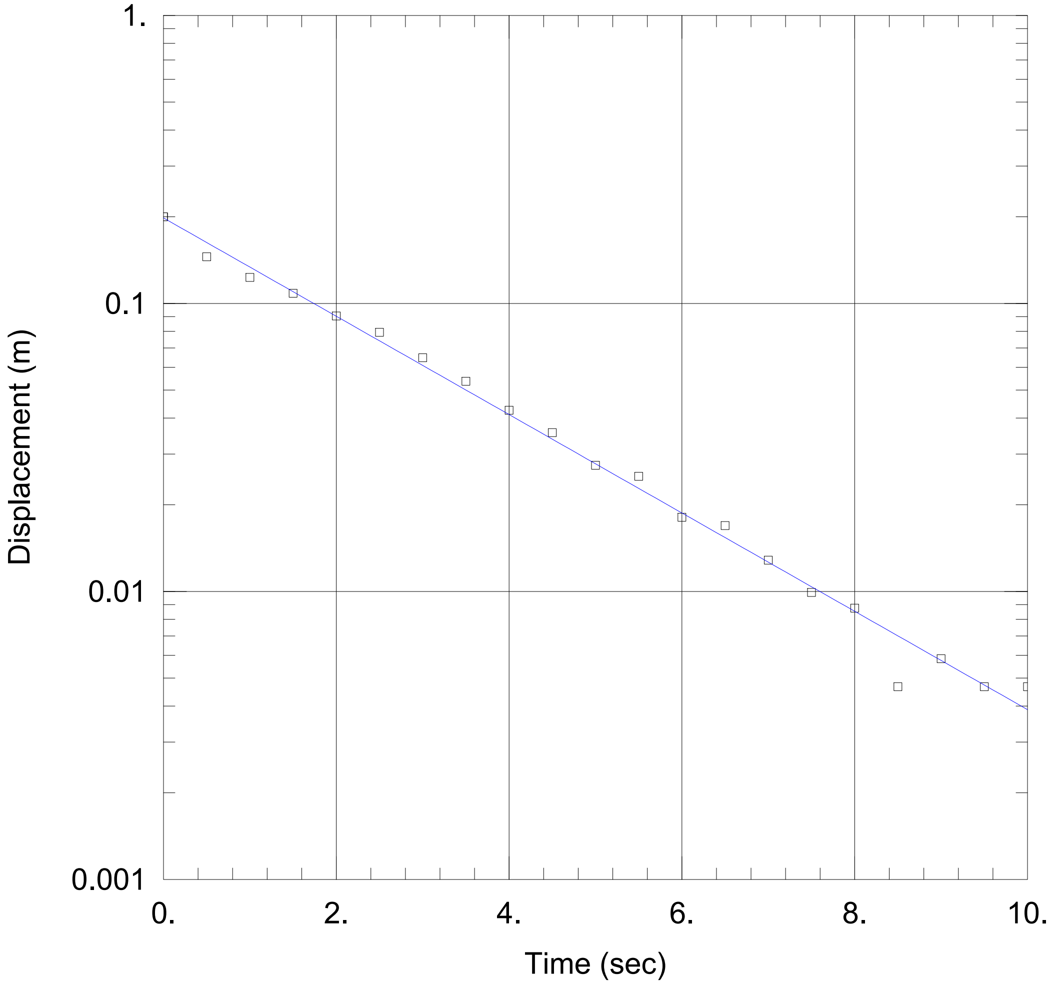
WELL DATA (MW1 falling head)

Initial Displacement: 0.2 m
Static Water Column Height: 3.82 m
Total Well Penetration Depth: 3.82 m
Screen Length: 3.05 m
Casing Radius: 0.0254 m
Well Radius: 0.1016 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 3.649E-8 m/sec
y0 = 0.1533 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Thoume Construction
Location: Lichty Pit
Test Well: MW Slug Test
Test Date: July 3, 2024

AQUIFER DATA

Saturated Thickness: 3. m

Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW2 falling head)

Initial Displacement: 0.2 m
Total Well Penetration Depth: 2.54 m
Casing Radius: 0.0254 m

Static Water Column Height: 2.55 m
Screen Length: 1.52 m
Well Radius: 0.1016 m

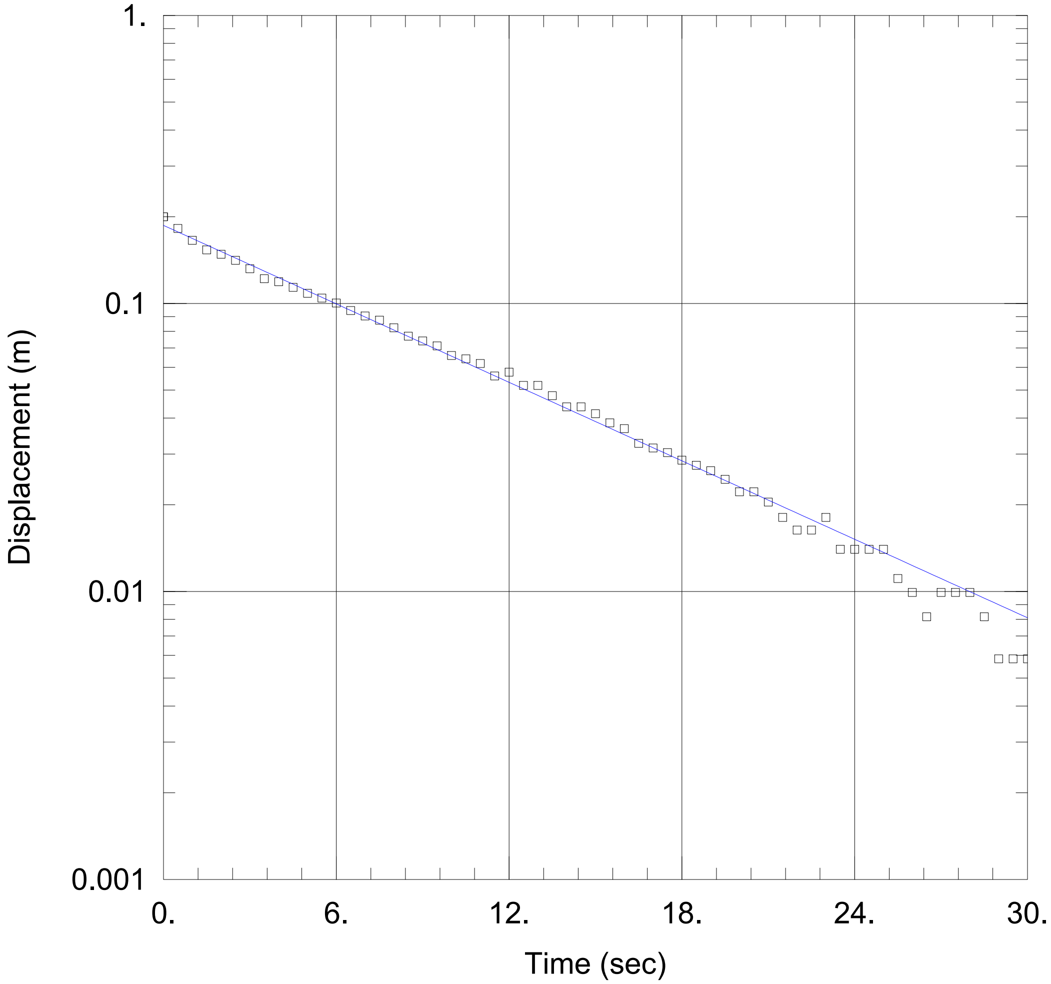
SOLUTION

Aquifer Model: Unconfined

Solution Method: Bouwer-Rice

K = 0.0002439 m/sec

y0 = 0.1981 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Thoume Construction
Location: Lichty Pit
Test Well: MW Slug Test
Test Date: July 3, 2024

AQUIFER DATA

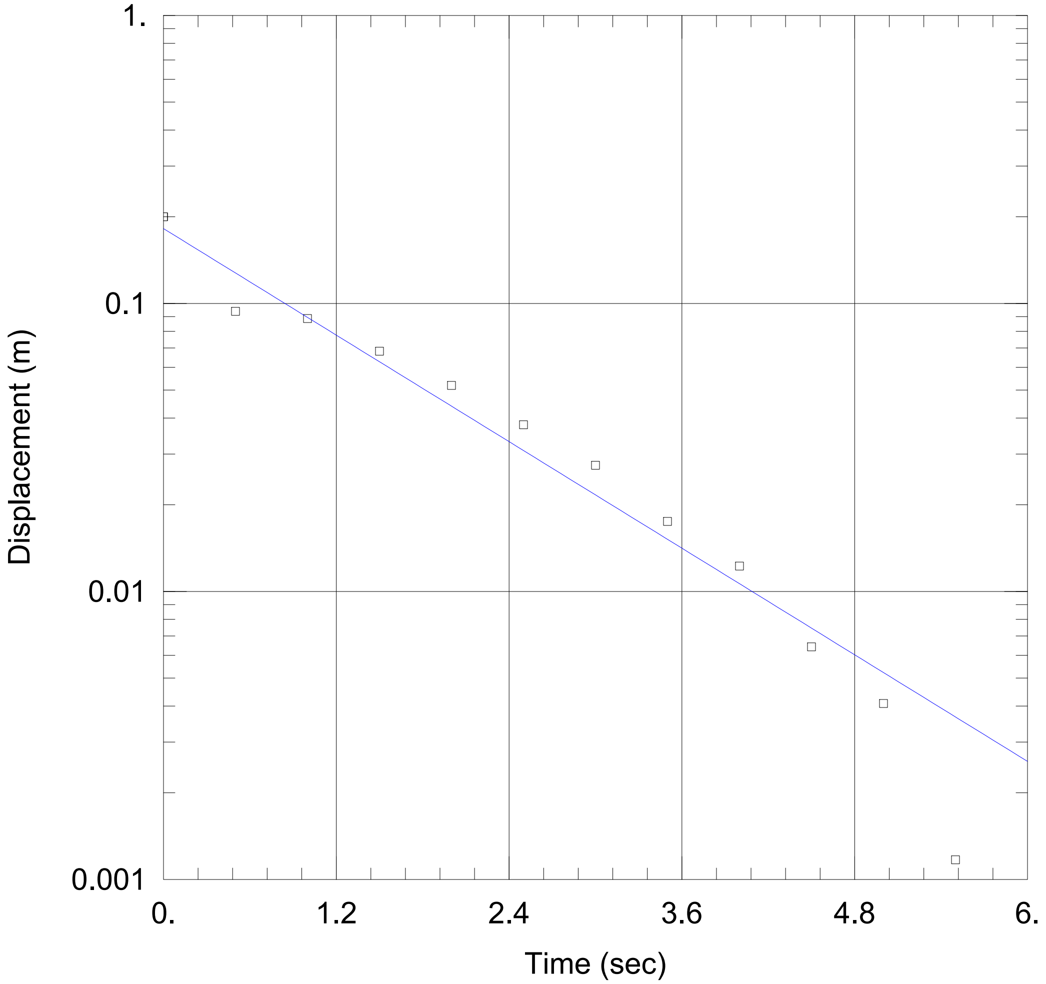
Saturated Thickness: 3. m
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW2 rising head)

Initial Displacement: 0.2 m
Total Well Penetration Depth: 2.54 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.55 m
Screen Length: 1.52 m
Well Radius: 0.1016 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 6.49E-5 m/sec
y0 = 0.1867 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Thoume Construction
Location: Lichty Pit
Test Well: MW Slug Test
Test Date: July 3, 2024

AQUIFER DATA

Saturated Thickness: 4. m
Anisotropy Ratio (Kz/Kr): 0.1

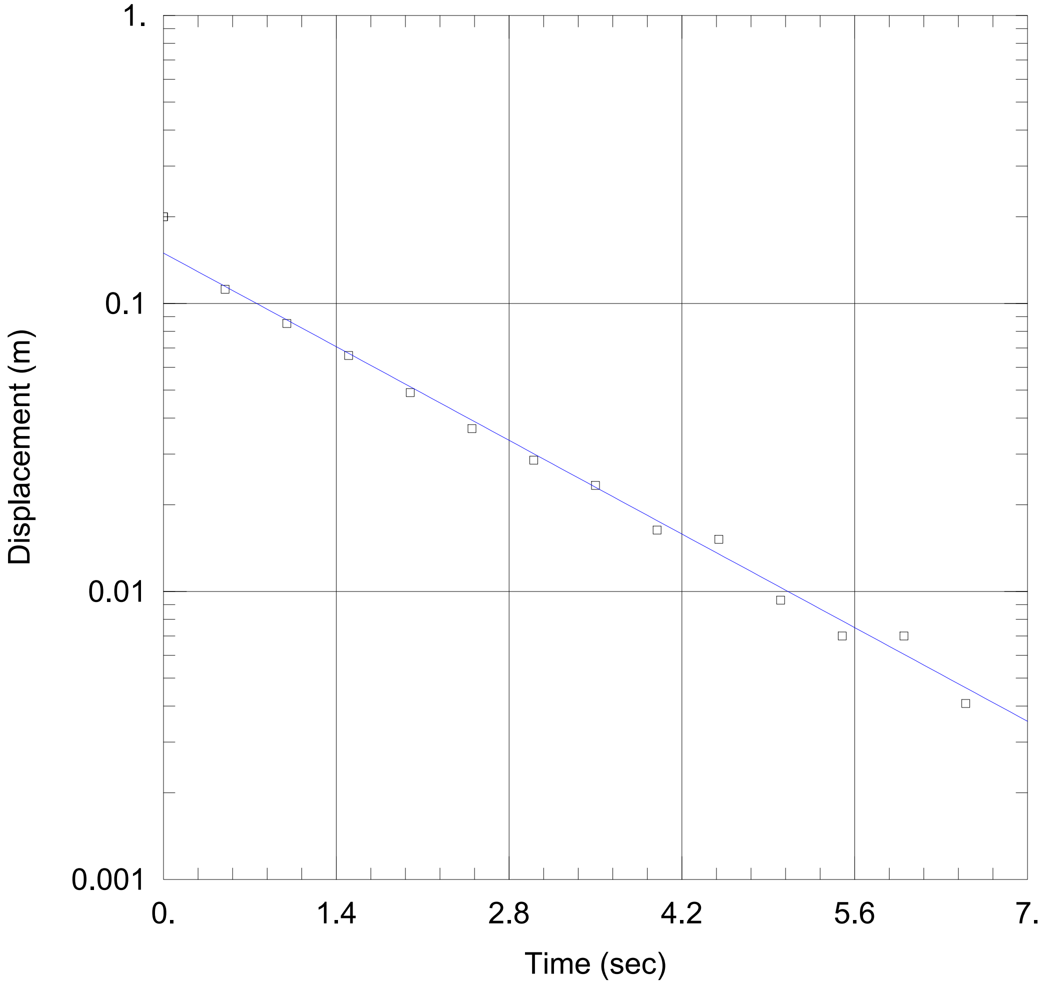
WELL DATA (MW3 falling head)

Initial Displacement: 0.2 m
Total Well Penetration Depth: 3.02 m
Casing Radius: 0.0254 m
Static Water Column Height: 3.02 m
Screen Length: 1.52 m
Well Radius: 0.1016 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.0004428 m/sec
y0 = 0.1819 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Thoume Construction
Location: Lichty Pit
Test Well: MW Slug Test
Test Date: July 3, 2024

AQUIFER DATA

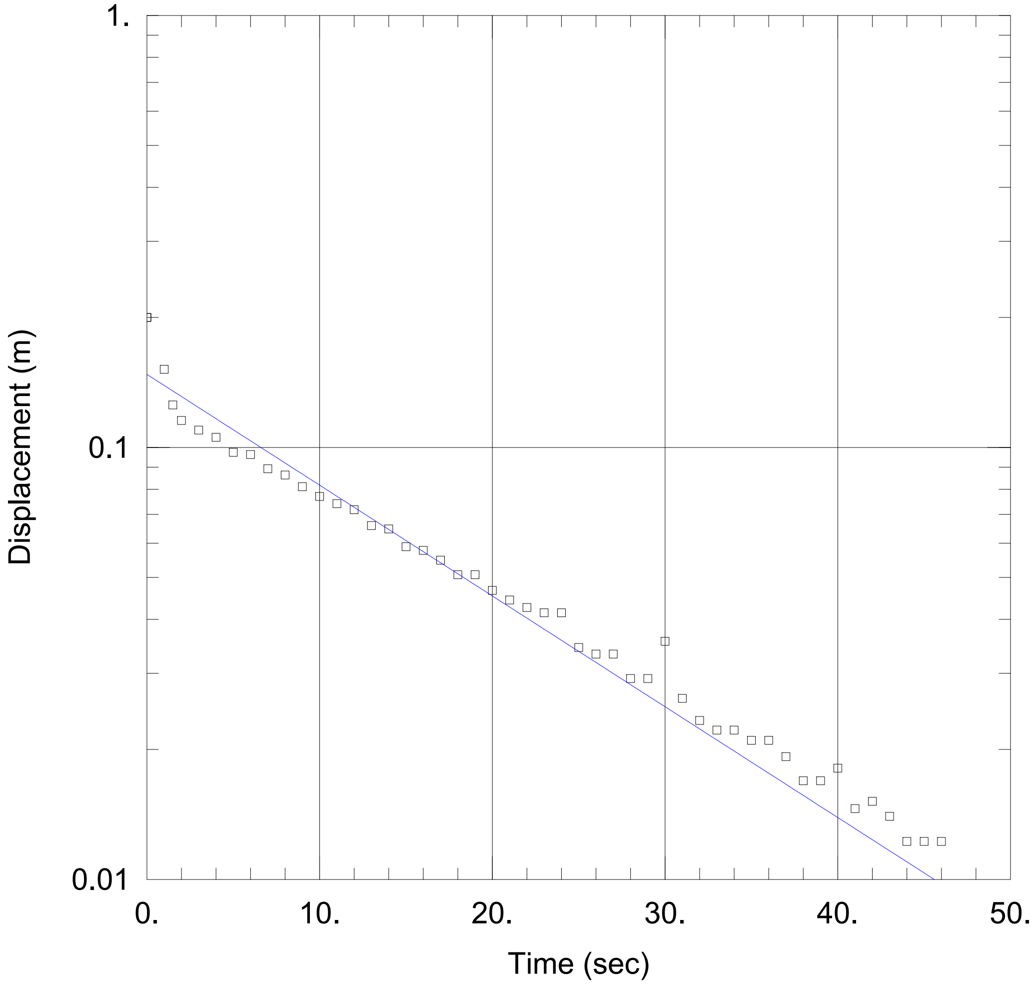
Saturated Thickness: 4. m
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW3 rising head)

Initial Displacement: 0.2 m
Static Water Column Height: 3.02 m
Total Well Penetration Depth: 3.02 m
Screen Length: 1.52 m
Casing Radius: 0.0254 m
Well Radius: 0.1016 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.0003336 m/sec
y0 = 0.1496 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Thoume Construction
Location: Lichty Pit
Test Well: MW Slug Test
Test Date: July 3, 2024

AQUIFER DATA

Saturated Thickness: 3. m
Anisotropy Ratio (Kz/Kr): 0.1

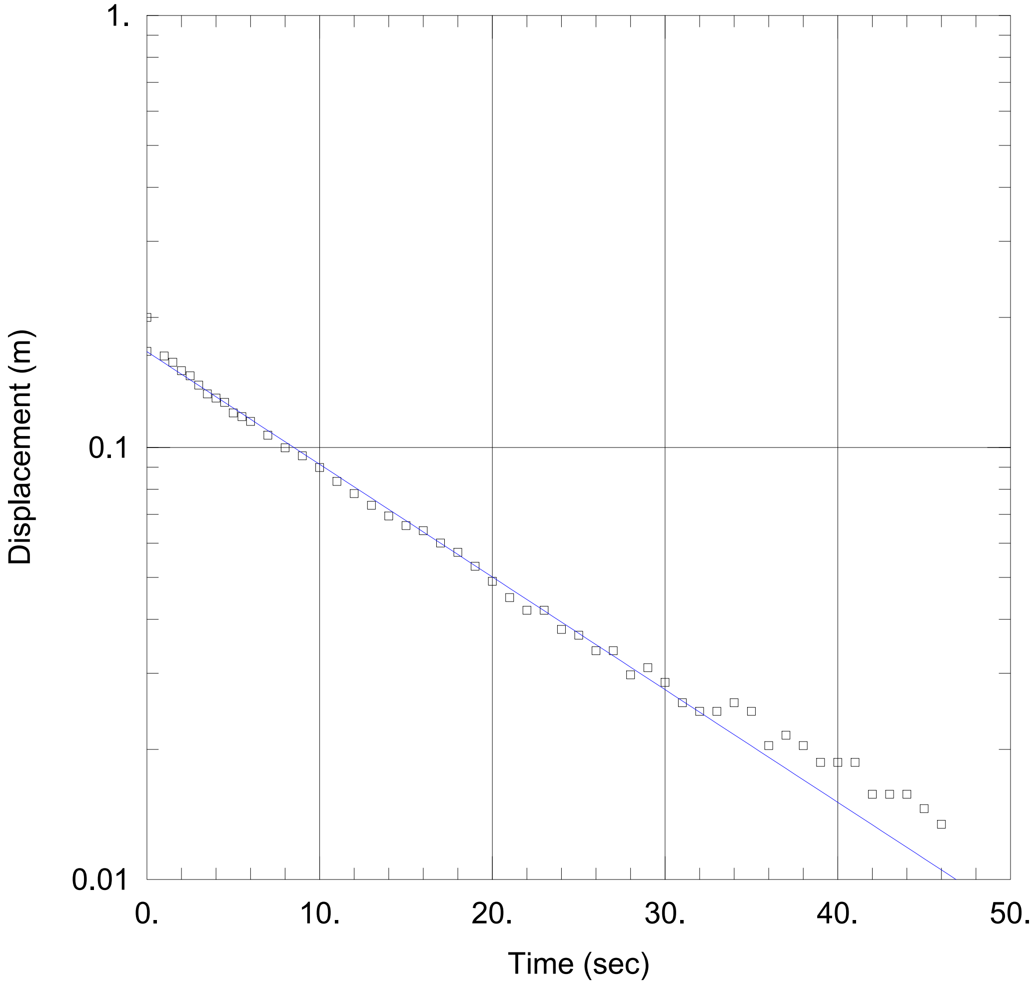
WELL DATA (MW4 falling head)

Initial Displacement: 0.2 m
Total Well Penetration Depth: 3.05 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.18 m
Screen Length: 3.05 m
Well Radius: 0.1016 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.63E-5 m/sec
y0 = 0.1476 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Thoume Construction
Location: Lichty Pit
Test Well: MW Slug Test
Test Date: July 3, 2024

AQUIFER DATA

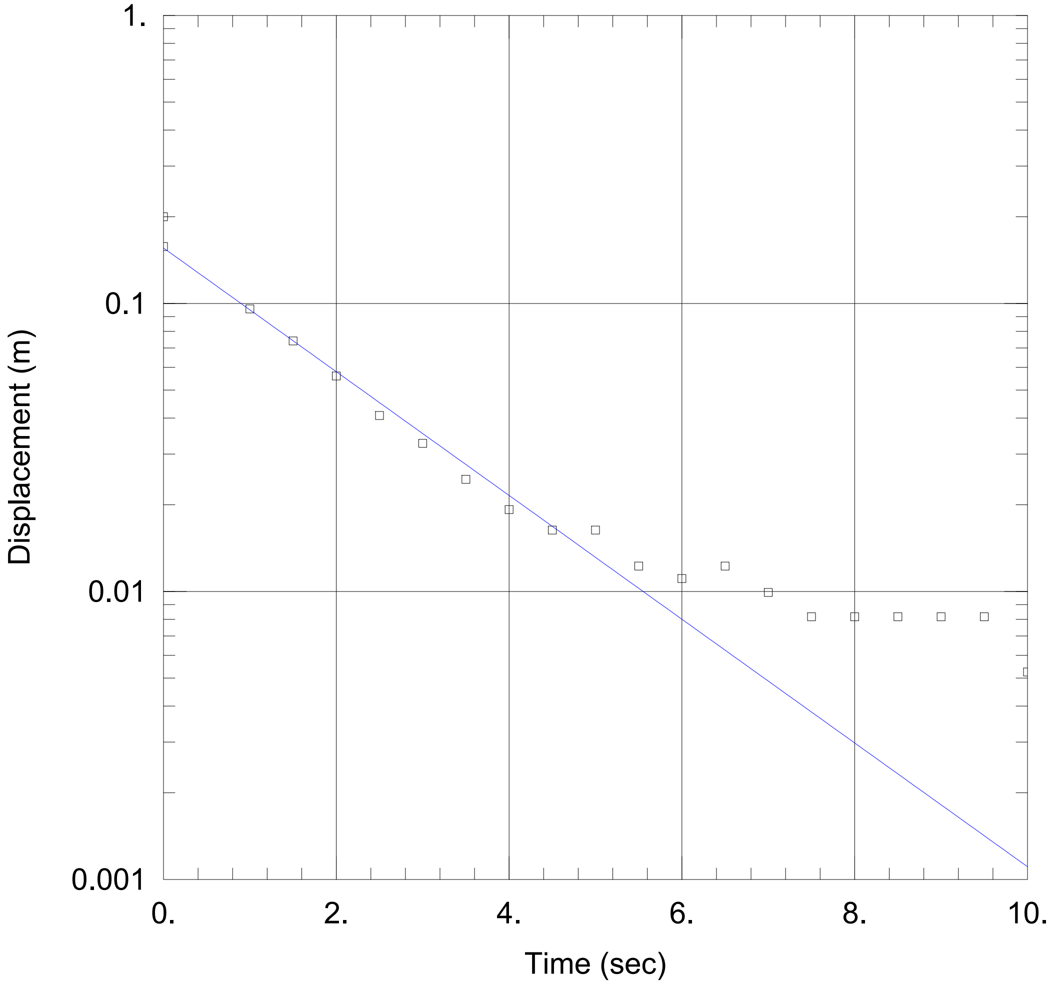
Saturated Thickness: 3. m
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW4 rising head)

Initial Displacement: 0.2 m
Static Water Column Height: 2.18 m
Total Well Penetration Depth: 3.05 m
Screen Length: 3.05 m
Casing Radius: 0.0254 m
Well Radius: 0.1016 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 1.658E-5 m/sec
y0 = 0.1666 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Thoume Construction
Location: Lichty Pit
Test Well: MW Slug Test
Test Date: July 3, 2024

AQUIFER DATA

Saturated Thickness: 3. m
Anisotropy Ratio (Kz/Kr): 0.1

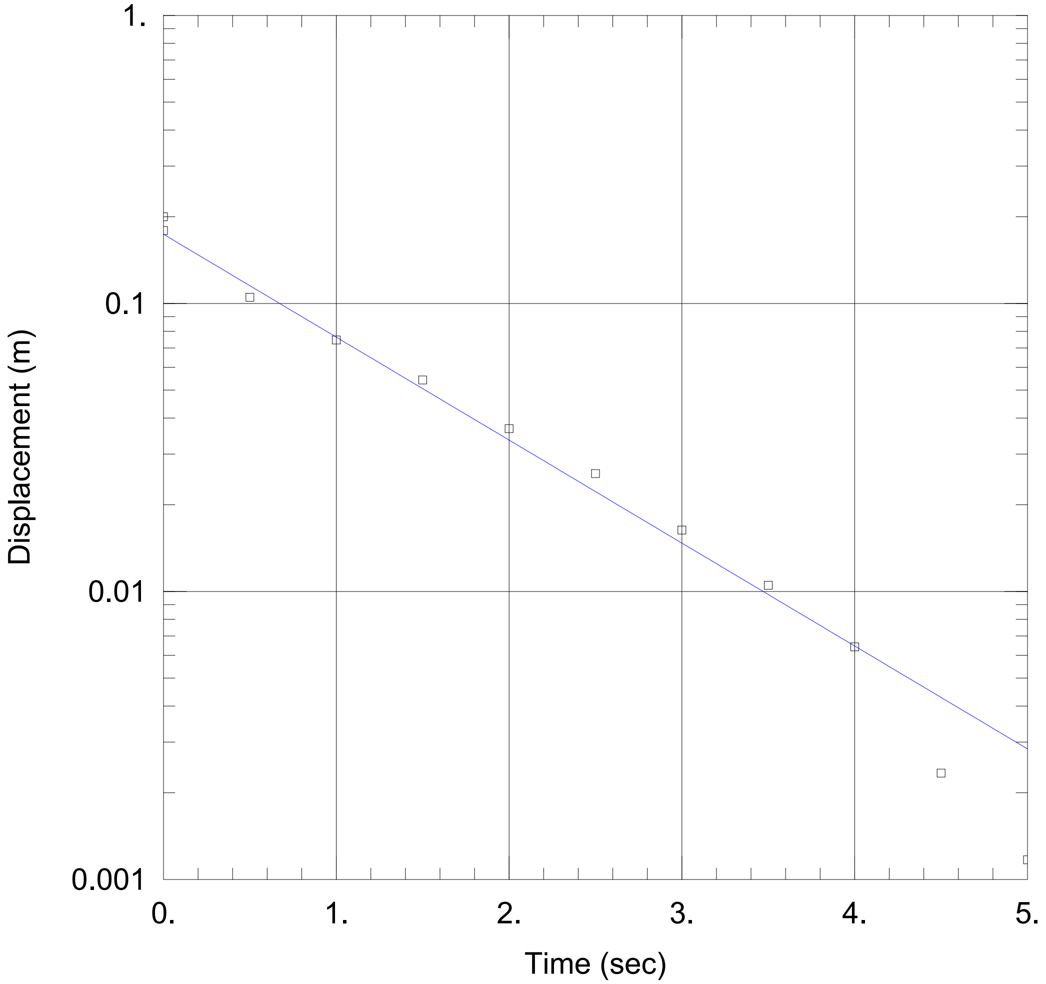
WELL DATA (MW5 falling head)

Initial Displacement: 0.2 m
Total Well Penetration Depth: 3.05 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.68 m
Screen Length: 3.05 m
Well Radius: 0.1016 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.0001365 m/sec
y0 = 0.1558 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Thoume Construction
Location: Lichty Pit
Test Well: MW Slug Test
Test Date: July 3, 2024

AQUIFER DATA

Saturated Thickness: 3. m
Anisotropy Ratio (Kz/Kr): 0.1

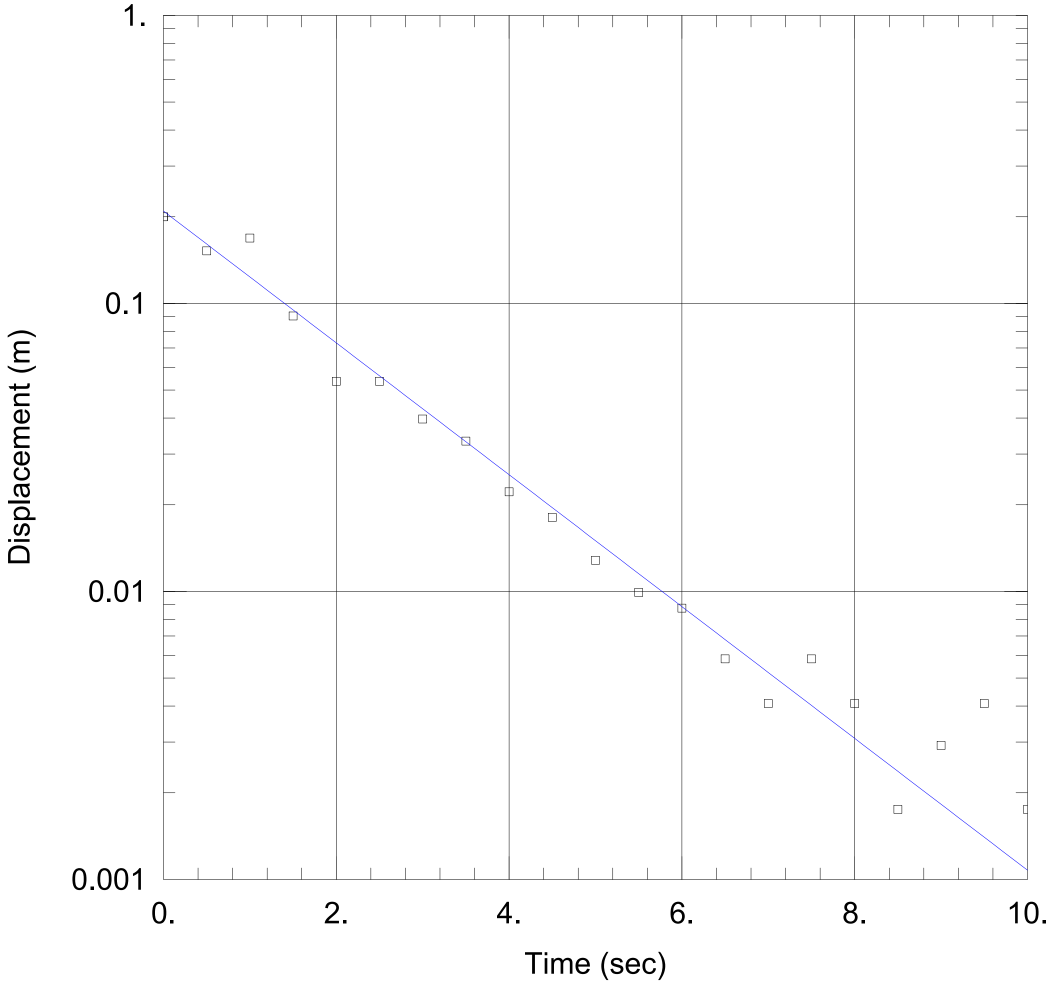
WELL DATA (MW5 rising head)

Initial Displacement: 0.2 m
Total Well Penetration Depth: 3.05 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.68 m
Screen Length: 3.05 m
Well Radius: 0.1016 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.0002271 m/sec
y0 = 0.1738 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Thoume Construction
Location: Lichty Pit
Test Well: MW Slug Test
Test Date: July 3, 2024

AQUIFER DATA

Saturated Thickness: 6. m
Anisotropy Ratio (Kz/Kr): 0.1

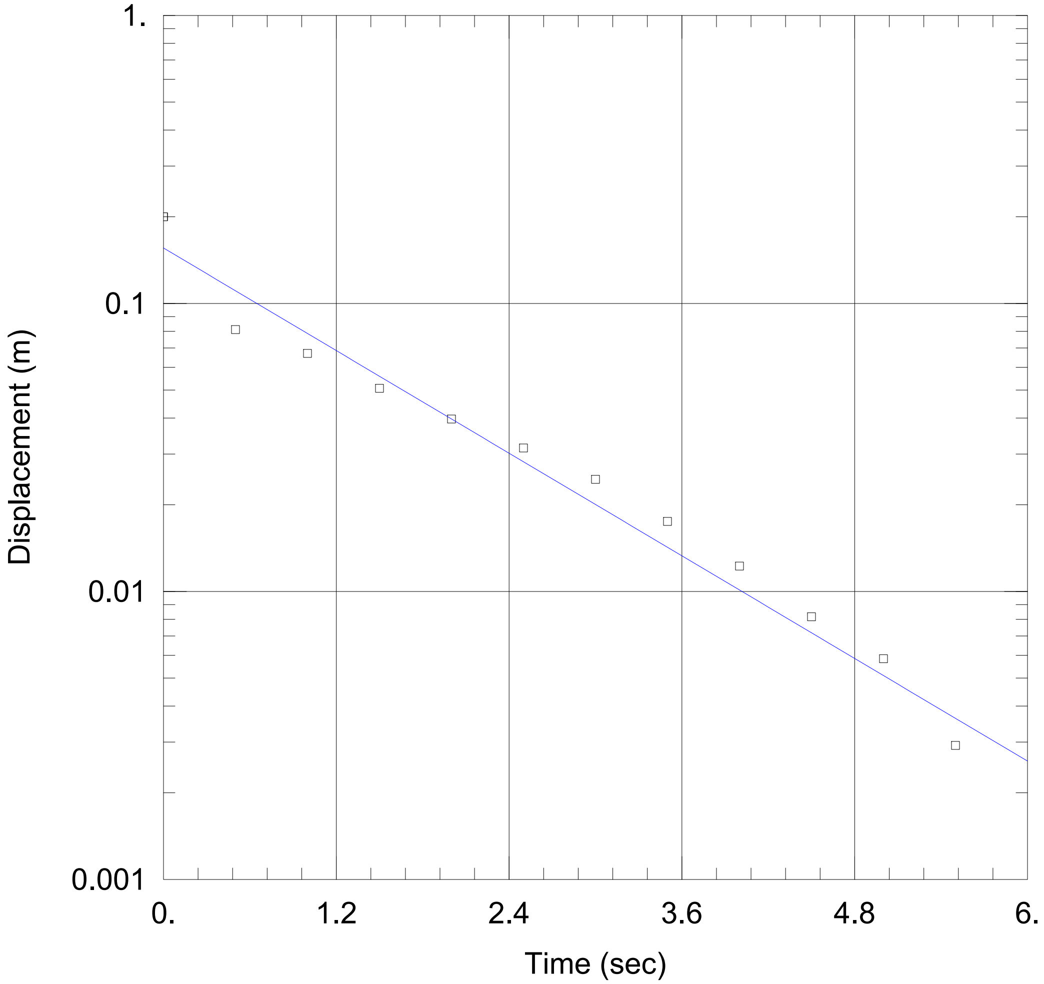
WELL DATA (MW6 falling head)

Initial Displacement: 0.2 m
Total Well Penetration Depth: 5.24 m
Casing Radius: 0.0254 m
Static Water Column Height: 5.24 m
Screen Length: 3.05 m
Well Radius: 0.1016 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.0001959 m/sec
y0 = 0.2092 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Thoume Construction
Location: Lichty Pit
Test Well: MW Slug Test
Test Date: July 3, 2024

AQUIFER DATA

Saturated Thickness: 6. m
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (MW6 rising head)

Initial Displacement: 0.2 m
Static Water Column Height: 5.24 m
Total Well Penetration Depth: 5.24 m
Screen Length: 3.05 m
Casing Radius: 0.0254 m
Well Radius: 0.1016 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.0002542 m/sec
y0 = 0.1557 m

Appendix E
Water Balance Calculations

SMR = Soil Moisture Retention (mm)					
Soil Type	Vegetation Type				
	Shallow Rooted Crops (e.g. beans)	Moderately Deep Rooted Crops (e.g. corn)	Deep Rooted Crops (e.g. pasture)	Orchards	Closed Mature Forest
Fine Sand	50	75	100	150	250
Fine Sandy Loam	75	**150**	150	250	300
Silt Loam	125	200	250	300	400
Clay Loam	100	200	250	250	400
Clay	75	50	200	200	350

Source: *Instructions and Tables For Computing Potential Evapotranspiration And The Water Balance,* C.W. Thornthwaite and J.R. Mather, 1957

Estimated Evapotranspiration Values (mm) using Environment Canada WATERLOO WELLINGTON A Weater Station 1981 to 2010 Climate Normals

Month	Daily Average Temperature (C.)	Average Monthly Precipitaiton (mm)	PET (mm)*	AET (mm)* (150 mm SMR)	Surplus (mm)
January	-6.5	65.2	0.0	0.0	65.20
February	-5.5	54.9	0.0	0.0	54.90
March	-1.0	61.0	0.0	0.0	61.00
April	6.2	74.5	33.6	33.6	40.90
May	12.5	82.3	75.6	75.6	6.70
June	17.6	82.4	111.4	108.4	-26.00
July	20.0	98.6	131.6	123.6	-25.00
August	18.9	83.9	115.2	102.9	-19.00
September	14.5	87.8	74.9	74.9	12.92
October	8.2	67.4	37.1	37.1	30.35
November	2.5	87.1	9.7	9.7	77.38
December	-3.3	71.2	0.0	0.0	71.20
Annual Total (mm):		916.30	588.99	565.75	350.55

* Source: *Computer Program for Estimating Evapotranspiration Using the Thornthwaite Method* , United States Department of Commerce, National Oceanic and Atmosphere Administration (NOAA) Technical Memorandum ERL GLERL-101 (November 1996)

MOE Infiltration Factors

Topography Factor								
Classification	Criteria					Slope (%)	Value of Infiltration Factor	
Flat land	Average Slope Not Exceeding:	0.6	m per	1	km	0.06	**0.3**	**North**
Rolling land	Average slope of:	2.8	m per	1	km	0.28	**0.2**	**South**
	to:	3.8	m per	1	km	0.38		
Hilly land	Average slope of:	28	m per	1	km	2.8	0.1	
	to:	47	m per	1	km	4.7		

Soil Factor	
Soil Type	Value of Infiltration Factor
Tight impervious clay	0.1
Medium combinations of clay and loam	0.2
Open sandy loam	**0.4**

Cover Factor	
Classification	Value of Infiltration Factor
Cultivated lands	**0.1**
Woodland	0.2

Source:
MOEE Hydrogeological Technical Information Requirements for Land Development Applications,
Ontario Ministry of the Environment and Energy, April 1995

Proposed Lichty Pit - Recharge Water Balance: Site North of Sideroad 12

Purpose:

To assess present and future recharge contributions to the local groundwater system

Assumptions:

- climate conditions at the site represented by Environment Canada reported 1981 - 2010 Climate Normals for the WATERLOO WELLINGTON A weather station
- evapotranspiration rates estimated using the Thornthwaite and Mather method
- runoff rates estimated using MECP Infiltration Factors (*MOEE Hydrogeological Technical Information Requirements For Land Development Applications* , April 1995).
- assessment area consisting of proposed licence north of Sideroad 12 (17.6 ha)
- existing conditions include sandy soil, relatively flat slopes, farm fields, runoff potential to adjacent fields or roadside ditch
- future conditions all runoff is retained

1) Water Balance Components

Existing Infiltration Factor for Land Surface Within Runoff Areas

surplus = precipitation - evapotranspiration

Flat land	0.3		
Open sandy loam	0.4		
Cultivated lands	0.1		
Factor:	0.8	80	% of surplus becomes infiltration recharge
	0.2	20	% of surplus becomes runoff

General Site Recharge Calculation (includes pond areas)

site recharge = precipitation - evapotranspiration - runoff

2) Estimate of Existing Recharge

Precipitation Rate = 0.91630 m/yr
Evapotrans. Rate = 0.56575 m/yr
Surplus Rate = 0.35055 m/yr
Recharge Rate = 0.28044 m/yr
Runoff Rate = 0.07011 m/yr

Assessment Area = 17.6 ha
= 176,000 m^2

Site Precip. Input = 161,269 m^3/yr
Field Evapotrans. = 99,572 m^3/yr
Site Surplus = 61,697 m^3/yr

Existing Recharge = 49,357 m^3/yr
= 1.57 L/s

Existing Runoff = 12,339 m^3/yr
= 0.39 L/s

3) Estimate of Future Recharge

Recharge Rate = 0.35055 m/yr

Site Precip. Input = 161,269 m^3/yr
Field Evapotrans. = 99,572 m^3/yr
Site Surplus = 61,697 m^3/yr

Future Recharge = 61,697 m^3/yr
= 1.96 L/s

Proposed Lichty Pit - Recharge Water Balance: Site North of Sideroad 12

Purpose:

To assess present and future recharge contributions to the local groundwater system

Assumptions:

- climate conditions at the site represented by Environment Canada reported 1981 - 2010 Climate Normals for the WATERLOO WELLINGTON A weather station
- evapotranspiration rates estimated using the Thornthwaite and Mather method
- runoff rates estimated using MECP Infiltration Factors (*MOEE Hydrogeological Technical Information Requirements For Land Development Applications*, April 1995).
- assessment area consisting of proposed licence south of Sideroad 12 (25.2 ha)
- existing conditions include sandy soil, moderate slopes, farm fields, runoff potential to creek valley
- future conditions topopgraphic slopes reduced, runoff direction maintained

1) Water Balance Components

Existing Infiltration Factor for Land Surface Within Runoff Areas

Rolling land	0.2		surplus = precipitation - evapotranspiration
Open sandy loam	0.4		
Cultivated lands	0.1		
Factor:	0.7	70	% of surplus becomes infiltration recharge
	0.3	30	% of surplus becomes runoff

Future Infiltration Factor for Land Surface Within Runoff Areas

Flat land	0.3		surplus = precipitation - evapotranspiration
Open sandy loam	0.4		
Cultivated lands	0.1		
Factor:	0.8	80	% of surplus becomes infiltration recharge
	0.2	20	% of surplus becomes runoff

General Site Recharge Calculation (includes pond areas)

site recharge = precipitation - evapotranspiration - runoff

2) Estimate of Existing Recharge

Precipitation Rate = 0.91630 m/yr
Evapotrans. Rate = 0.56575 m/yr
Surplus Rate = 0.35055 m/yr
Recharge Rate = 0.24539 m/yr
Runoff Rate = 0.10517 m/yr

Assessment Area = 25.2 ha
= 252,000 m^2

Site Precip. Input = 230,908 m^3/yr
Field Evapotrans. = 142,569 m^3/yr
Site Surplus = 88,339 m^3/yr

Existing Recharge = 61,837 m^3/yr
= 1.96 L/s

Existing Runoff = 26,502 m^3/yr
= 0.84 L/s

3) Estimate of Future Recharge

Precipitation Rate = 0.91630 m/yr
Evapotrans. Rate = 0.56575 m/yr
Surplus Rate = 0.35055 m/yr
Recharge Rate = 0.28044 m/yr
Runoff Rate = 0.07011 m/yr

Assessment Area = 25.2 ha
= 252,000 m^2

Site Precip. Input = 230,908 m^3/yr
Field Evapotrans. = 142,569 m^3/yr
Site Surplus = 88,339 m^3/yr

Future Recharge = 70,671 m^3/yr
= 2.24 L/s

Future Runoff = 17,668 m^3/yr
= 0.56 L/s

Appendix F
Qualifications

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GROUNDWATER SCIENCE CORP.

Andrew Pentney, B.Sc., P.Geo.

Qualifications

June 2024

Current Position

Principal, Senior Hydrogeologist

Groundwater Science Corp., Stratford, ON

- Providing hydrogeological consulting expertise to regulatory agencies, environmental consultants and industry. Services ranging from individual consulting and assessments to project support for larger study teams, including testimony at OMB (OLT) hearings.
- Over 35 years of hydrogeologic consulting experience.

Education

B.Sc. (1987) : University of Waterloo, Waterloo, ON

- General Science, including Geology courses (stratigraphy, quaternary geology and hydrogeology).

Professional memberships

Registered Professional Geoscientist in Ontario

Licenced MECP Contractor

Range of Experience

- Technical consultation for 8 Subwatershed Scale characterization studies (GRCA, CVC). Focus on assessing groundwater – surface water interaction (at rivers, streams, wetlands, ponds).
- Planning approval and environmental peer review, watershed planning support to Credit Valley Conservation on an as-needed basis from 2001 to 2014. Focus on protecting stream and wetland systems.
- Community Scale Septic System Impact studies for Alton, Cheltenham and Erin as part of Village Planning Assessments.
- Water supply development, testing and impact assessment, Permit To Take Water consulting, Source Water Protection characterization and water balance studies for municipal water supplies, golf courses, industrial supply (over 20 assessments).
- Aggregate Resource Act groundwater assessments, and associated Zoning and Official Plan amendment impact assessments, at over 50 above water and 30 below water extraction sites (pits and quarries). Extensive assessment and analysis of groundwater impact potential, private wells, groundwater-surface water interactions (most studies assessed, rivers, streams, wetlands, springs and/or ponds).
- Aggregate Resource Act compliance monitoring at over 70 above water or below water extraction sites. Includes measurement and analysis of water level, water quality, private well impact potential, thermal impact potential and groundwater-surface water interaction.