HARDEN ENVIRONMENTAL SERVICES LIMITED

Hydrogeological Assessment

Proposed Commercial Development
380 Hagey Boulevard
Waterloo, Ontario

Prepared For:

Kothari Group
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Record of Revisions

Revision	Date	Description of Changes
0	April 4, 2025	Submission to Client
1	April 14, 2025	Minor edits to text and reduction in trench depth from 3.0 m to 2.5 m

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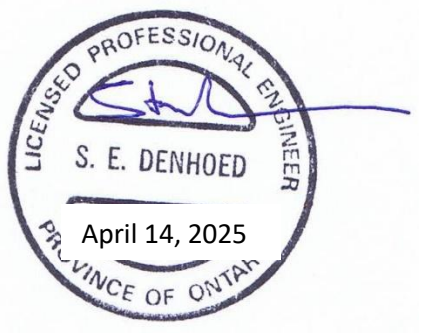


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Statement of Limitations

Harden Environmental Services Ltd. (HARDEN) conducted the work associated with this report in accordance with the scope of services, time and budget limitations imposed for this work. The work has been conducted according to reasonable and generally accepted local standards for an environmental consultant at the time of the work. No other warranty or representation, expressed or implied, is included or intended in this report.

It should be noted that subsurface conditions might vary at locations and depths other than those locations where borings, surveys or explorations were made by HARDEN or others. Other contaminants, not tested for in this work, may also potentially be present on the Site. Even with exhaustive investigation, it is not possible to warranty the Site will be free of other contaminants. Should conditions, not observed during the work, become apparent, HARDEN should be immediately notified to assess the situation and conduct additional work, where required. The findings of this report are based on conditions as they were observed at the time of the work. No assurance is made regarding changes in conditions subsequent to the time of the work.

Regulatory statutes are subject to interpretation. These statutes and their interpretation may change over time, thus these issues should be reviewed with appropriate legal counsel. HARDEN relied on information provided by others in this report. HARDEN cannot guarantee the accuracy, completeness and reliability of the information provided by others, although HARDEN staff attempted to seek clarification on information provided and verifies authenticity, where practical. The report and its attachments were prepared for and made available for the use of the client, their agents, the Region of Waterloo and the City of Waterloo. HARDEN will not be responsible for any use or interpretation of the information contained in this report by any other party without the prior expressed written consent of HARDEN.

1.0 Introduction

Harden Environmental Services Ltd. (Harden) was retained by the Kothari Group to complete a Hydrogeological Assessment for the proposed development at 380 Hagey Boulevard (the Site; Figure 1). The Site is located on the south side of Wes Graham Way, in an industrial research complex.

The hydrogeological assessment is required as part of an application for Site Plan approval with the City of Waterloo. The purpose of the assessment is to characterize the existing groundwater conditions on the Site, identify potential impacts to the local groundwater regime and provide recommendations related to groundwater control/management.

1.1 Proposed Development

The Site is approximately 1.61 ha and is presently vacant. A topographic property survey and site plan illustrating the proposed development are provided in Appendix A.

Surrounding land use is commercial to the north, east, south and west (Figures 2 and 3).

The proposed development is a hotel and conference facility. The new building will cover a total area of 3,223 m^2 of the 16,127 m^2 lot. Pavement areas including sidewalks and parking lot are proposed to be 9,395 m^2 and landscaping (grass and tree areas) is 3,509 m^2.

1.2 Study Scope

The objectives of the hydrogeological assessment included:

- Define the local hydrogeological setting.
- Determine the local water table elevation.
- Assess the extent of local groundwater / surface water interaction.
- Estimate the volume of groundwater / surface water dewatering that may be required during construction (short-term) and following construction (long-term).
- Assess the potential impact of development on all environmental receptors.
- Assess potential impact on the source water (quality and quantity) of nearby municipal wells.
- Prepare a water balance for the site.
- Estimate infiltration values to assist in the sizing of future infiltration galleries.
- Recommend measures to minimize any significant impacts identified.

1.3 Assessment Approach

Harden's completion of this study included the following tasks:

- Review of available environmental and geological background reports for the Site.
- Review of supporting background information sources including geological mapping from the Ontario Geological Survey (OGS), Ministry of the Environment, Conservation and Parks (MECP) Water Well Records and various publications available through the Grand River Conservation Authority (GRCA) and others.
- Installation of four new groundwater monitoring wells at the Site with 1.52 metre length well screens constructed to bottom depths between 6.6 and 10.7 m below ground surface (mbgs).
- Groundwater level monitoring on three occasions from March 18, 2025 to April 1, 2025.
- In situ rising/falling head recovery testing of onsite monitoring wells to estimate the hydraulic conductivity of the subsurface soils.
- Assessment of impacts to nearby environmental receptors and existing infrastructure.
- Recommendations for mitigation of potential impacts.

The collected information has been summarized with analysis and interpretation by a qualified hydrogeologist. The report was completed in general accordance with applicable provincial legislation, Ontario Water Resources Act, Ontario Regulation 387/04, R.R.O. 1990, Regulation 903: Wells and applicable municipal hydrogeological assessment guidance documents.

1.4 Summary of Previous Reports

1.4.1 Geotechnical Investigation

A geotechnical investigation was completed by Sola Engineering (Sola, 2025). Five boreholes were advanced at the Site on March 14, 2025 to depths of 6.6 to 10.7 mbgs. The borehole logs are provided in Appendix B. The stratigraphic results are summarized within this report.

1.5 Drainage, Topography and Environmental Features

The topography of the site is flat, with an elevation of approximately 347.5m AMSL (Figure 4). In general, the local land surface slopes gently to the southwest to Columbia Lake.

The Site is in the Laurel Creek subwatershed, Grand River watershed. There are no wetlands or surface water features on the site. The nearest natural surface water feature is Columbia Lake located seven hundred metres southwest of the site. The elevation of Columbia Lake is approximately 333 m AMSL. The site does not occur within the Regulated Area of the Grand River Conservation Authority (Figure 5).

1.6 Regional Geology

The site is in the Oxford Till Plain physiographic region, characterized by beveled and drumlinized till plains (Chapman and Putnam, 1984, 2007) (Figure 6). Kame moraines and outwash deposits also occur nearby.

Regional surficial quaternary geology is characterized by Tavistock Till, a silt to clayey silt till with low stone content and stratified interbeds (Figure 7; OGS, 2010). MECP (2023b) water well records within 250 m of the Site indicate clay soils near surface (Table C-2, Appendix C).

Bedrock geology mapping indicates that bedrock in the vicinity of the Site is comprised of dolostone and shales of the Salina Formation (OGS, 2011). The depth to bedrock is approximately forty metres.

1.7 Regional Hydrogeology

A search of MECP (2023b) water well records identified sixty-eight records within 500 m of the Site (Figure 8), including water supply wells, monitoring wells and well abandonment records (Table C-1, Appendix C). No water supply wells have been drilled since 1979 and none are likely to be active given the availability of municipal water. The proposed development and all surrounding properties are municipally serviced.

MECP well records within 500 m of the Site encountered primarily clay at or near ground surface, consistent with surficial geology. Most former water supply wells obtained water from the shale bedrock, however there are some nearby wells that obtained water from sand and gravel units within the clay/sit glacial till deposits.

Regional groundwater flow will be southwesterly toward Laurel Creek which is ten metres lower in elevation than the site.

1.8 Source Protection

The site is not located within a wellhead protection area (WHPA), highly vulnerable aquifer (HVA) or significant groundwater recharge area (SGRA) (Figure 9). The local Source Water Protection group stated "Currently, the Region's WHPA-Q1 has a low risk so there are no policies under the Source Protection Plan. Balancing the water budget is considered a beneficial practice and the Region supports infiltration of clean runoff and not from impervious surfaces being salted."

2.0 Site Investigation and Results

The site investigation included verifying the subsurface materials identified and assisting with the design and installation of monitoring wells.

2.1 Site Stratigraphy

Sola drilled five boreholes on the site in 2025 (Figure 10), including:

- Six boreholes advanced, using 4" diameter solid stem augers and split-spoon sampling, to depths of 6.6 mbgs, three of which were completed as monitoring wells with flush-mount casings. Each monitoring well has a 3.05 m long screen.
- One borehole advanced using 4" diameter solid stem augers and split spoon sampling to a depth of 10.7 mbgs. This monitoring well has a screen length of 1.52 m.

Harden Environmental was on-site for the drilling of BH2 (the deepest borehole) and based on those observations and the well records for the other boreholes, we summarize the near surface geology as follows.

Fill (to 0.8-1.5 m)

All boreholes were drilled through approximately 0.8 to 1.5 m of fill material with varying consistency from clayey silt to silt and some gravel.

Sandy Silt / Sandy Silt Till (to approximately 0.8-3 m)

Sandy silt to sandy silt till, trace clay to clayey, trace to some gravel, light brown to grey with oxidizations/mottles in the upper zone, moist.

Fine Sand, Silt and Clay Layers(3 to 9.6 m)

Distinct layers of fine sand, silt and clay indicative of a lacustrine environment are found below a depth of three metres.

2.2 Monitoring Well and Piezometer Installations

Groundwater monitoring wells were installed by Sola at BH2, BH3, BH4 and BH5 (Figure 11).

The following table summarizes the details of the groundwater monitoring well and piezometer installations, with locations of each monitor depicted on Figure 11.

The elevation of the top of monitors was determined using a hydrant elevation of 348.73 m AMSL from the Chamberlain Architect Services Ltd. drawing A0001.

Table 1 Monitor Installation Details

Monitor	Installation Date	Well Pipe Inside Diameter	Top of Pipe Elevation	Stick-up (m)	Ground Elevation (m AMSL)	Monitor Depth (mbct)	Monitor Depth (mbgs)	Auger Diameter (mm)	Screen Length (m)	Sand Pack Length (m)
BH2	March 13, 2024	2"/51mm	347.785	1.04	346.75	9.91	8.87	140	1.50	1.80
BH3	March 13, 2024	2"/51mm	349.125	1.03	348.10	6.73	5.70	140	1.50	1.80
BH4	March 13, 2024	2"/51mm	348.592	1.00	347.59	7.25	6.25	140	1.50	1.80
BH5	March 13, 2024	2"/51mm	349.215	1.03	348.19	7.66	6.63	140	1.50	1.80

2.3 Soil Hydraulic Conductivity

Harden completed in situ falling head recovery tests in all the groundwater monitors on March 27,2025 to estimate the hydraulic conductivity of the screened materials.

Monitoring wells were developed by purging with a Waterra™ inertial pumping system prior to conducting the field tests. The well recovery tests were conducted by adding a known volume of water to each monitor and measuring the rate of decline of the water level in the monitoring well.

An estimate of the hydraulic conductivity was determined using the following method (Hvorslev, 1951):

$$K = r^2 \ln(L/R) / 2LT_o$$

Where:

k = hydraulic conductivity (m/s)
r = radius of the well (m)
L = length of screen (m)
R = radius of borehole (m)
T_o = lag time obtained from graph (s)

The analyses are provided in Appendix D and summarized below.

Table 2: Hydraulic Conductivity – In Situ Well Response Tests

Well ID	Screened Stratigraphy	Screened Interval (mbgs)	Hydraulic Conductivity (m/s)
BH2	Sandy Silt/Clay Silt Till	7.37 to 8.87	1.3E-05
BH3	Clay Silt Till	4.2 to 5.7	1.1E-06
BH4	Clay Silt Till	4.75 to 6.35	1.0E-06
BH5	Clay Silt Till	5.13 to 6.63	6.6E-07

The calculated hydraulic conductivity for the shallow soils ranged from 6.6 x 10^{-7} to 1.1 x 10^{-6}m/s with a geometric mean of 9.1 x 10^{-7} m/s for clay silt till. The sandier sediments at a slightly greater depth have a hydraulic conductivity approximately one order of magnitude greater at 1.3 x 10^{-5} m/s.

2.4 Groundwater Levels

Harden measured groundwater levels in all accessible monitoring wells using a battery-operated water level meter on six occasions between March 2025 and April 2025 (Tables 3 and 4).

Table 3: Water Levels Below Ground Surface (m)

Monitor	Ground Elevation (m)	Water Level (mbgs)	Water Level (mbgs)	Water Level (mbgs)
		18-Mar-25	27-Mar-25	01-Apr-25
BH2	346.75	5.94	5.93	5.85
BH3	348.10	2.26	2.41	2.23
BH4	347.59	2.52	2.54	2.36
BH5	348.19	3.70	3.80	3.61
mbgs - metres below ground surface				

Table 4: Water Levels Geodetic (Metres above Mean Sea Level)

Monitor	Ground Elevation (m AMSL)	Water Level (mAMSL)	Water Level (mAMSL)	Water Level (mAMSL)
		18-Mar-25	27-Mar-25	01-Apr-25
BH2	346.75	340.805	340.82	340.90
BH3	348.10	345.835	345.69	345.87
BH4	347.59	345.072	345.05	345.23
BH5	348.19	344.485	344.39	344.58

Shallow groundwater elevations ranged from 2.2 to 3.7 metres below ground surface (mbgs) over the monitoring period from March 18, 2025 to April 1, 2025. Monitor BH2 was installed to a depth of approximately 2.5 metres deeper than the other monitors and has consistently lower groundwater levels at about six metres below ground surface. This monitor is not indicative of the water table.

The lower groundwater levels within the deeper wells represent a downward vertical gradient between the upper and lower sediments across the site.

The April 1, 2025 readings are interpreted to be representative of the 2025 seasonal groundwater high, with groundwater levels within 2.2 meters of the existing grade. It is estimated that the highest water table is 0.5 m higher than measured in 2025, resulting in an estimated high water table depth of 1.8 metres below grade.

2.5 Groundwater Quality

No water quality sample was taken.

2.6 Infiltration Testing

Infiltration values are estimated from the hydraulic testing conducted in the groundwater monitors. The relationship between hydraulic conductivity and infiltration is based on the Supplementary Guidelines to the Ontario Building Code, SG-6 Percolation Time and Soil Descriptions (Ontario Ministry of Municipal Affairs and Housing, 1997), as presented by TRCA (2012).

The infiltration test results are summarized in the following table.

Table 3: Soil Infiltration Test Results

Location	Test Material	K Saturation in cm/s	Percolation Rate mm/hour	Safety Factor	Design Infiltration Rate mm/hr
BH2	Sandy Silt Till	1.34E-03	93	2.5	37
BH3	Clay Silt Till	1.14E-04	48	2.5	19
BH4	Clay Silt Till	1.02E-04	46	2.5	19
BH5	Clay Silt Till	6.58E-05	41	2.5	17

We recommend a safety factor of 2.5, therefore depending on where infiltration galleries are located, the infiltration rate will range from 17 to 19 mm/hour. Infiltration galleries should not be installed at greater than 1.5 metres depth.

3.0 Construction and Short-Term Dewatering

The proposed building is a slab-on-grade hotel with no basement. There will be an elevator pit that extends approximately 1.5 metres below grade (Figure 12). As such, the elevator pit is expected to be above the groundwater table. No perimeter drain is designed for the elevator pit, however, a sump pump to address water accumulation at the base of the pit will be installed. Assuming a 0.15 m slab at the base of the elevator pit and 0.15 m of gravel, the maximum depth of excavation for the elevator pit will be 1.82 metres. The water table was measured 2.2 metres below grade with an estimated seasonal high-water table at 1.8 m below grade. It is unlikely that construction dewatering will be necessary for the proposed building.

The depth of service trenches had not been determined at the time of this report submission. We have assumed a maximum depth of three metres to calculate an estimate of groundwater ingress to the trench.

Table 4: Construction Dewatering Assumptions – Servicing Trenches

Parameter	Assumed Value	Notes
Existing Grade Elevation	347.5 m AMSL	Existing elevations on servicing profile drawings (Appendix E)
Lowest Servicing Invert Elevation	345.0 m AMSL	Estimated
Dewatering Elevation Target	344 m AMSL	Assumed 1.0 m below lowest servicing invert
Excavation Length	20 m	Estimated
Excavation Area – Clinton Drive	120 m^2	Assumed 2 m trench width along total excavation length
Groundwater Elevation - High	346.2 m AMSL	Groundwater level data plus 0.5 m buffer
Hydraulic Conductivity (K) - High	1 x 10^{-6} m/s	Highest K from hydraulic conductivity tests
Base of Aquifer	333.5 m AMSL	Estimated to be 10 metres below dewatering elevation

The dewatering calculations for servicing trenches assume an open excavation two metres wide.

A rainfall allowance for a 50 mm rain event has been included in the construction dewatering calculations for each trench length.

Based on the assumed aquifer parameters and excavation dimensions, an estimated maximum volume of 36,726 L/day per 20 metres of trench may require pumping and discharge to facilitate subsurface construction activities. These estimates are based on worst-case groundwater conditions and incorporate a safety factor of 2. The linear equivalent radius of influence is estimated at up to 6.6 m.

3.1 Storm Event Accumulation of Water

There may be a need to pump out precipitation that falls or runs off into the building excavation during construction. The entire excavation is estimated to be an area of 3,223 m^2. In the unlikely event of a 52.1 mm (2”) storm, the volume of water captured in the excavation would be 168 m^3 (168,000 L). This is a highly conservative number as a 52.1 mm rain events are rare and unlikely to occur during the open excavation period of this development.

During excavation, the volume of water that may need to be handled is as follows;

The Region of Waterloo application for temporary dewatering during construction need not exceed 168,000 liters per day and can be less should storm water be retained on site for several days.

It is the responsibility of the contractor to ensure dry conditions are maintained within the excavation. Additional pumping capacity may be required to maintain dry conditions within the excavation during and following significant precipitation events.

3.2 Discharge Permits

Water takings over 50,000 L/day up to 400,000 L/day require registration on the Environmental Activity and Sector Registry (EASR), and water takings over 400,000 L/day require a Permit To Take Water (PTTW) from the Ministry of the Environment, Conservation and Parks in accordance with the Ontario Water Resources Act. Should a significant rainfall occur, an EASR may be necessary if the schedule does allow for the time for water to infiltrate.

Approval from the Region of Waterloo is required prior to any discharge to the municipal storm and/or sanitary systems. Approval is required for both short term (i.e., construction dewatering) and long term (i.e., building dewatering) discharge.

Monitoring during construction dewatering activities may be required by the Region of Waterloo and will be specified within the discharge permit. Typically, daily water taking volumes and flow rates must be logged using a flow meter and flow totalizer. Water quality monitoring requirements may also be included.

4.0 Water Balance

The general water balance for the developable portion of the subject lands is described as;

$P = I + E + RO \pm \Delta S$

Where

P -precipitation (mm/year)

I -infiltration (mm/year)

ET -evapotranspiration / evaporation(mm/year)

RO - runoff (mm/year) and

ΔS - change in storage.

Where;

Precipitation (P) – direct input of rainfall and snow. The precipitation estimates are obtained from the Environment Canada Kitchener-Waterloo weather station. The average annual precipitation from 1991 to 2020 of 851 mm was used for the analysis.

Evapotranspiration (ET) – component of water returned to the atmosphere via evapo-transpiration processes. The evapotranspiration from the open spaces at the Site is estimated to be 543 mm/year. (Appendix E). The evaporation from impervious surfaces is estimated to be 20% of precipitation, or 170 mm/year. This includes evaporation from the rooftops.

Infiltration (I) – component of water infiltrating the ground surface. Using the MECP Storm Water Planning and Design Manual (Table 3.1) the infiltration factor is estimated to be 0.6 (Appendix E).

Runoff (RO) – component of water flowing overland and to offsite locations. The runoff component on the Site.

4.1 Existing Impervious Surface Area

The site has an area of 1.61 hectares. This is a greenfield site with no impervious surface area. The developable area of the site is 1.61 hectares.

4.2 Future Impervious Surface Area

The proposed impervious areas are broken down as building rooftops and lot level hard surfaces (sidewalks and parking).

Total Developable = 1.61 ha

Rooftop of Buildings = 0.3223 ha

Hardscaping = 0.9395 ha

Total Impervious Post Development = 1.2591 ha

Total Pervious Post Development= 0.3509 ha

Table 5 Summary of Impervious Surfaces Pre and Post Development

	Impervious Surface Areas (ha)
Pre-Development	
No impervious Surfaces	0.0
Post Development	
Buildings	0.3223
Paved area and Permanent Pool of SWM	0.9395
Post Development Impervious Total	**1.2591**

The introduction of impervious surfaces to the site has the potential to both reduce infiltration and increase runoff.

Details of the pre and post water balance for the site is found in Appendix E and a summary of the potential hydrologic changes at the site are found in Table 6. It is assumed that there is 20% evaporation (of total precipitation) on all impervious surfaces.

Table 6 Summary of Water Balance Pre and Post Development

	Area	Precipitation	Evapotranspiration/ Evaporation	Runoff	Infiltration
	(hectare)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)
Pre Development Summary	1.61	13,696	8,746	1,980	2,970
Post Development Summary	1.61	13,696	4,048	9,001	647
Potential Difference without LID Strategies	-	-	- 4,697.19	7,020	- 2,323

In the absence of LID strategies, there will be a 2,323 m^3/year loss of infiltration at the site.

There is an opportunity to infiltrate roof water at this site. Assuming the capture of 80% of rooftop water, there is the opportunity to infiltrate 2,841 m^3 of water annually as shown in Table 7.

Table 7 Potential Infiltration Including Low Impact Development Strategies

	Area	Precipitation	Evapotranspiration/ Evaporation	Runoff	Infiltration
	(hectare)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)
Roof Leader Infiltration (0.3223 hectare of rooftop x 80% x 851 mm/year precipitation)					2,193
Infiltration on Pervious Surface Post Development					647
Total Potential Infiltration with Roof Water					2,841

5.0 Environmental Impact

5.1 Surface Water features

As discussed in Section 1.5, the Site is located within the Laurel Creek subwatershed and the nearest surface water features and wetlands are six hundred and fifty metres southwest of the site (Figure 4). No impacts to surface water features are expected because of the proposed development.

5.2 Groundwater Sources

As discussed in Section 1.7, no water supply wells were identified within 500 m of the site and no active PTTW are mapped within 1 km of the site. The site and all surrounding properties are municipally serviced.

No interference to nearby groundwater users is anticipated as a result of the proposed development.

5.3 Geotechnical Considerations

It is unlikely that lowering the water table will be necessary for the foundations or the elevator pit. If dewatering is required, it will be temporary and very limited in potential area of influence. It is our opinion that there will be no off-site impacts from the minor dewatering occurring at the site.

5.4 Source Water Protection Considerations

The site is in a WHPA-Q1. Currently, the Region's WHPA-Q1 has a low risk so there are no policies under the Source Protection Plan. Balancing the water budget is considered a beneficial practice and the Region supports infiltration of clean runoff and not from impervious surfaces being salted. No groundwater recharge facilities are being considered at the time of writing this report.

6.0 Conclusions

The findings of the hydrogeological assessment are summarized as follows:

- The proposed development of the 1.61 ha site includes construction of a 3,223 m^2 commercial building. The site and surrounding area are municipally serviced.
- The shallow groundwater table at the site was measured to be approximately 2.2 metres below ground surface during springtime conditions in March 2025. The March 2025 readings are indicative of the seasonal high-water table for 2025.
- The average hydraulic conductivity of the saturated silt till/clay till soils on the Site was 9.3×10^{-7} m/s.
- Construction dewatering may be required up to approximately 168,000 L/day to facilitate subsurface construction activities. This would only be needed after a 52.1 mm storm event.
- No construction dewatering for the elevator pit is expected to be needed. In the event of a major storm event, up to 168,000 liters of precipitation may need to be removed from the excavation.
- Up to 36,726 liters of water per day will need to be removed from a two and a half metre deep (below grade) trench that is 20 metres in length.
- Long-term dewatering is not anticipated for the proposed slab-on-grade building.
- There are no wetlands or surface water features in the vicinity of the site.
- There are no known private water supply wells in the vicinity of the site.

7.0 Recommendations

Harden provides the following recommendations:

1. Approval from the Region of Waterloo is required prior to any discharge to the municipal storm and/or sanitary systems.

2. If proposed excavation dimensions exceed those estimated within this report, or if any basement/subsurface areas are added to the proposed building design, the dewatering calculations should be updated.

3. All unused monitoring wells must be decommissioned in accordance with R.R.O. 1990, Reg. 903 as part of the development.

8.0 References

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Figures

Appendix A

Development Plan and Topographic Survey

Appendix B

Borehole Logs

Appendix C

MECP Water Well Records

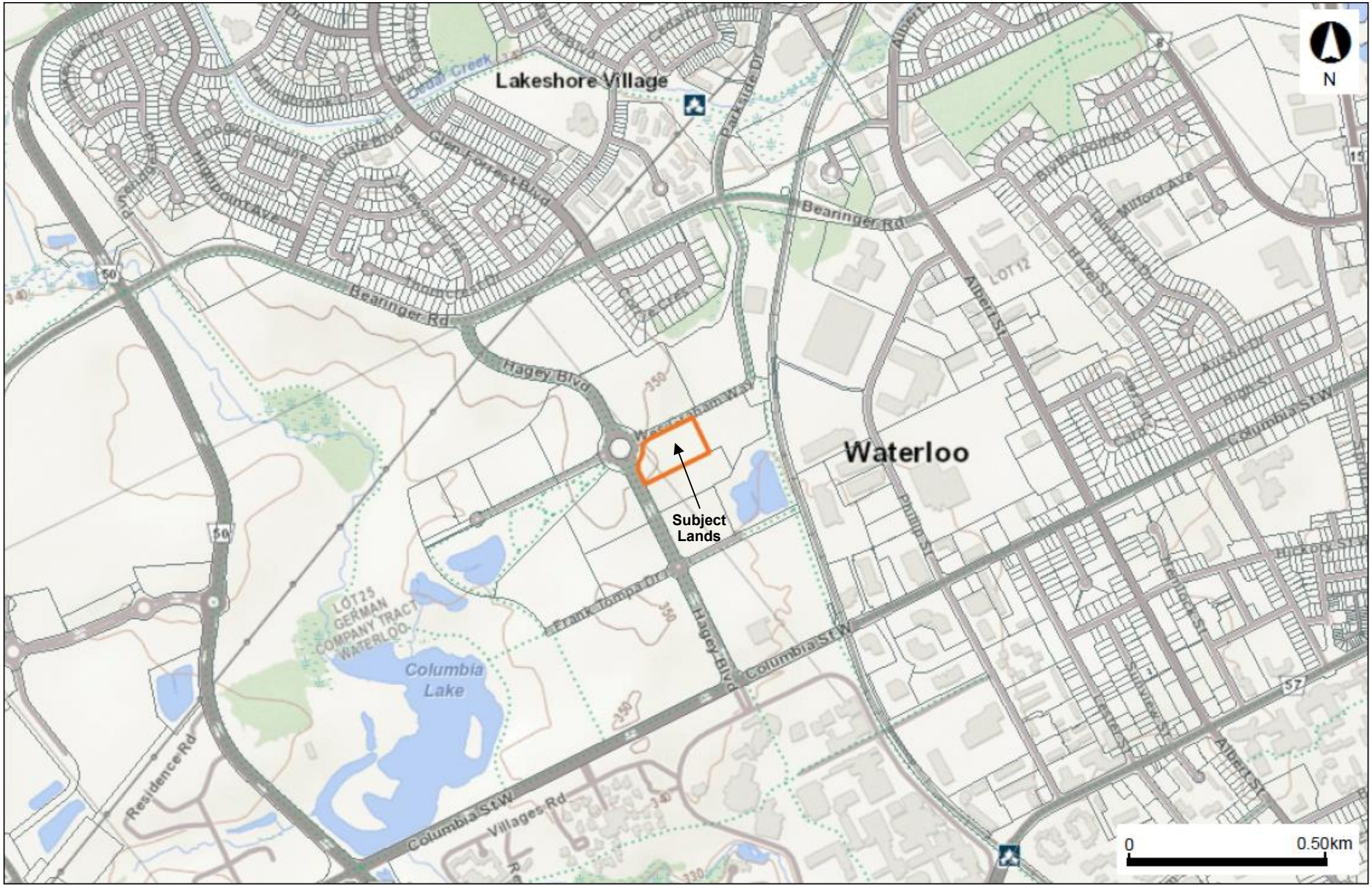
Appendix D

Hydraulic Conductivity Test Results

Appendix E

Water Balance and Dewatering Calculations

Figures



Source: MECP

HARDEN Environmental	**Project No:** 2501	Hydrogeological Assessment 380 Hagey Boulevard	**Figure 1: Location of Subject Lands**
	Date: Feb 2025	City of Waterloo, Regional Municipality of Waterloo WATERLOO LOT 12 GERMAN COMPANY TRACT	
	Drawn By: AR		

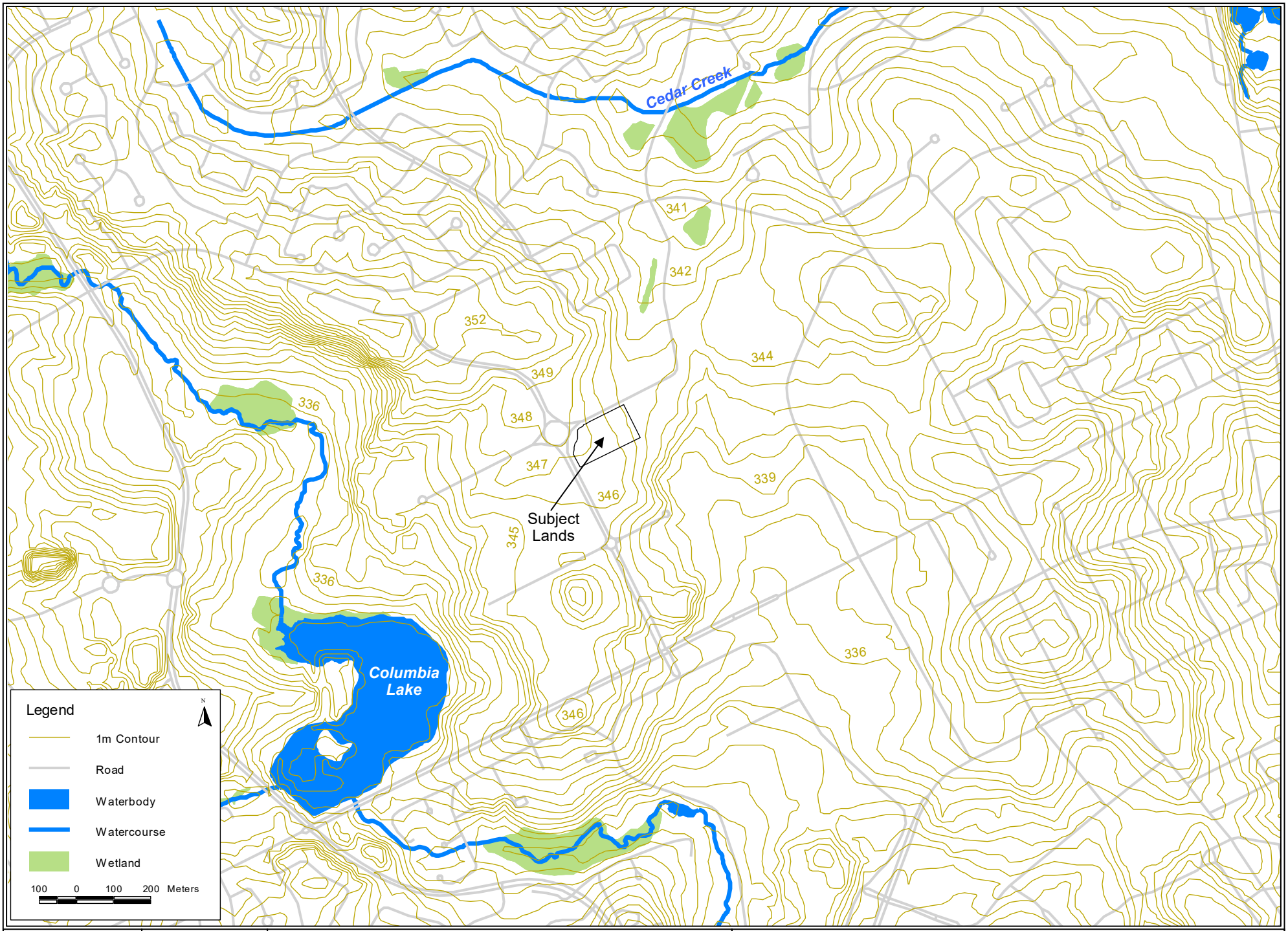


Source: MECP

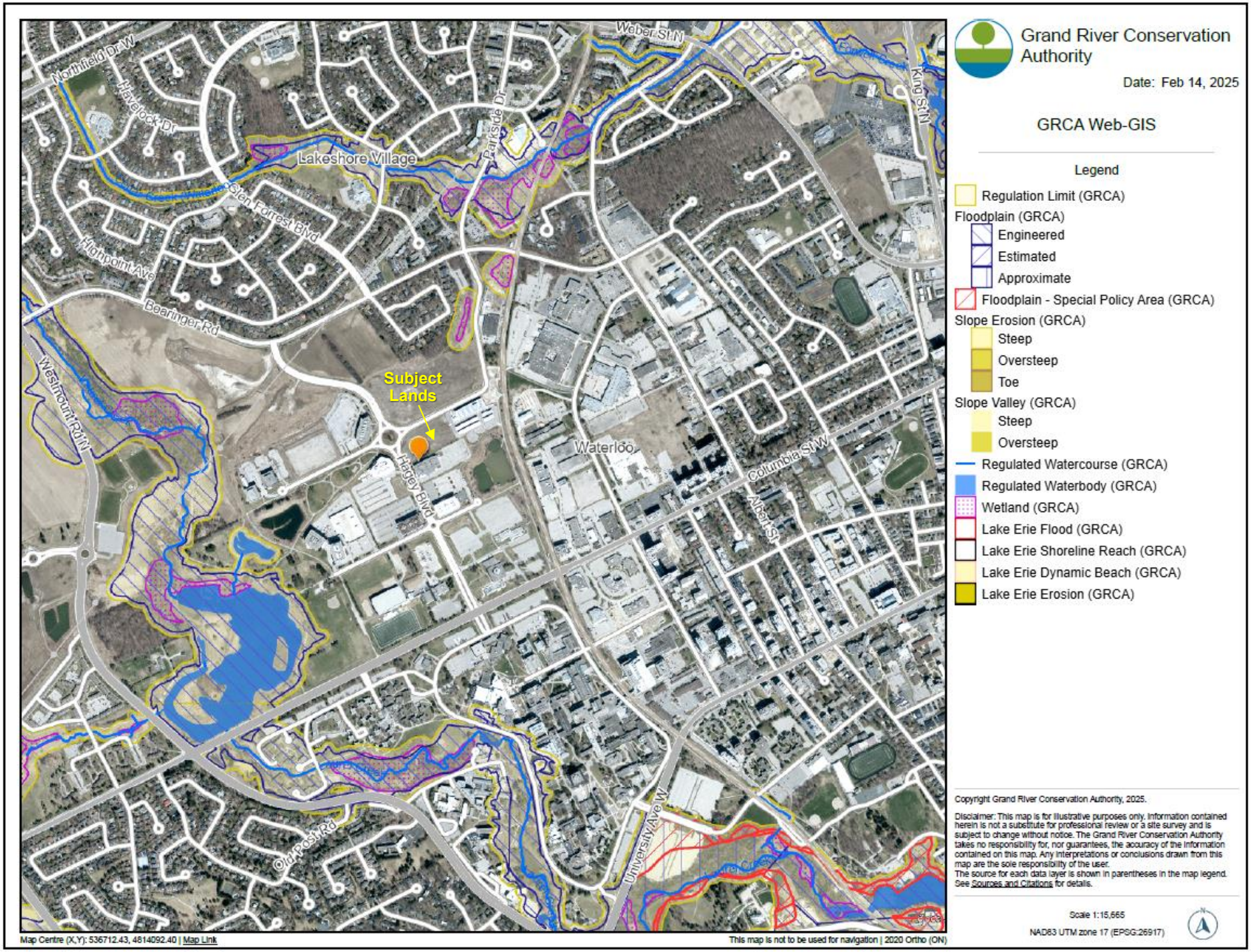
HARDEN Environmental	**Project No:** 2501	Hydrogeological Assessment 380 Hagey Boulevard	**Figure 2: Surrounding Land Use**
	Date: Feb 2025	City of Waterloo, Regional Municipality of Waterloo WATERLOO LOT 12 GERMAN COMPANY TRACT	
	Drawn By: AR		



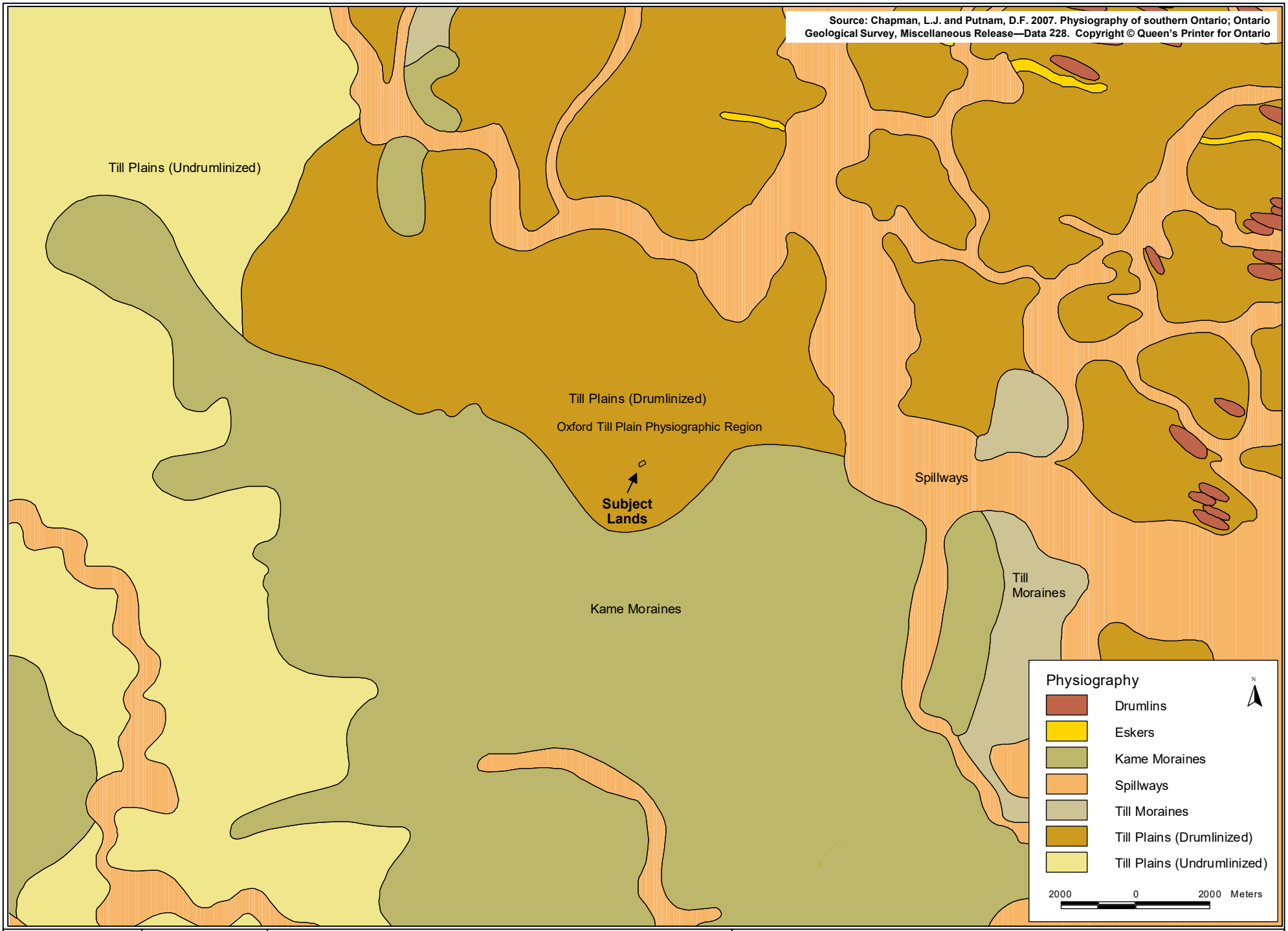
HARDEN Environmental	**Project No:** 2501	Hydrogeological Assessment 380 Hagey Boulevard	**Figure 3: Aerial Imagery 2022**
	Date: Feb 2025	City of Waterloo, Regional Municipality of Waterloo WATERLOO LOT 12 GERMAN COMPANY TRACT	
	Drawn By: AR		



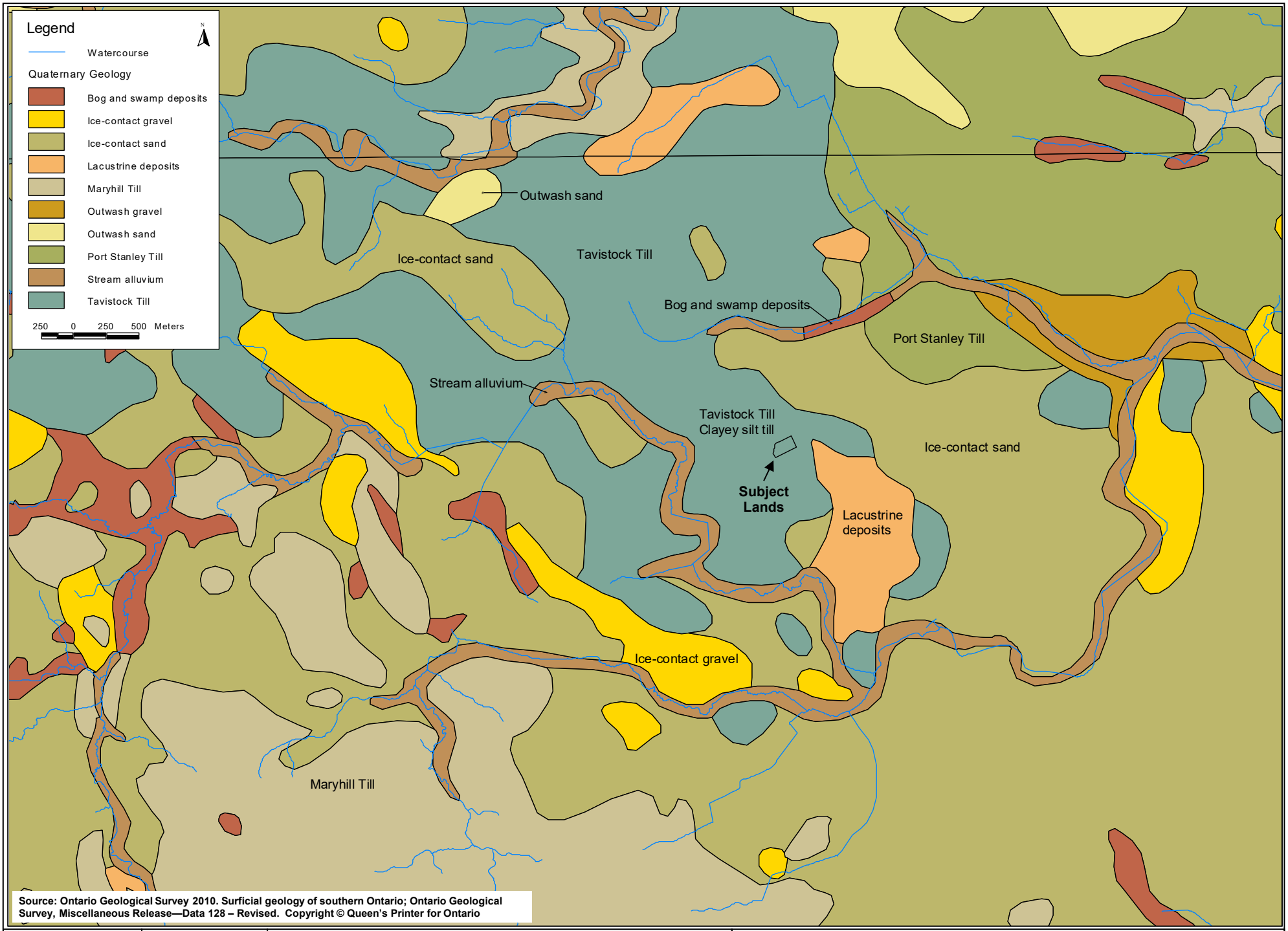
HARDEN Environmental	**Project No:** 2501	Hydrogeological Assessment 380 Hagey Boulevard
	Date: Feb 2025	City of Waterloo, Regional Municipality of Waterloo WATERLOO LOT 12 GERMAN COMPANY TRACT
	Drawn By: AR	**Figure 4: Environmental Features**



HARDEN Environmental	**Project No:** 2501	Hydrogeological Assessment 380 Hagey Boulevard
	Date: Feb 2025	City of Waterloo, Regional Municipality of Waterloo WATERLOO LOT 12 GERMAN COMPANY TRACT
	Drawn By: AR	**Figure 5: GRCA Regulated Area**

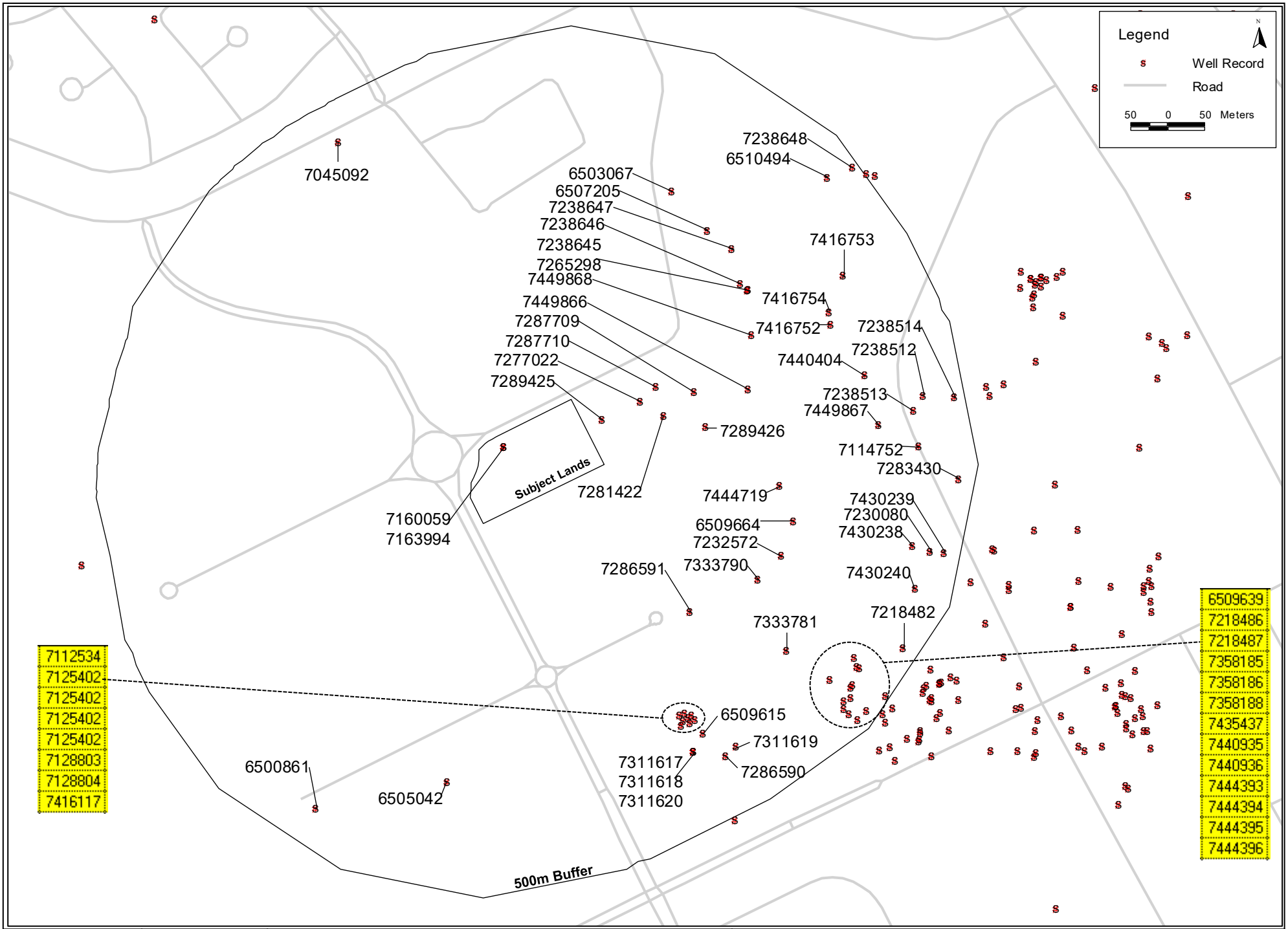


HARDEN Environmental	**Project No:** 2501	Hydrogeological Assessment 380 Hagey Boulevard
	Date: Feb 2025	City of Waterloo, Regional Municipality of Waterloo WATERLOO LOT 12 GERMAN COMPANY TRACT
	Drawn By: AR	**Figure 6: Physiography**



Source: Ontario Geological Survey 2010. Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 128 – Revised. Copyright © Queen's Printer for Ontario

HARDEN Environmental	**Project No:** 2501	Hydrogeological Assessment 380 Hagey Boulevard	**Figure 7: Quaternary Geology**
	Date: Feb 2025	City of Waterloo, Regional Municipality of Waterloo WATERLOO LOT 12 GERMAN COMPANY TRACT	
	Drawn By: AR		



HARDEN Environmental	**Project No:** 2501	Hydrogeological Assessment 380 Hagey Boulevard
	Date: Feb 2025	City of Waterloo, Regional Municipality of Waterloo WATERLOO LOT 12 GERMAN COMPANY TRACT
	Drawn By: AR	**Figure 8: Well Records Within 500m**

Ontario **Source Protection Information Atlas**
Ministry of the Environment, Conservation and Parks

- Intake Protection Zone 1
- Intake Protection Zone 2
- Intake Protection Zone 3
- Highly Vulnerable Aquifers
- WHPA-E
- *Surface Water*
- Event Based Areas

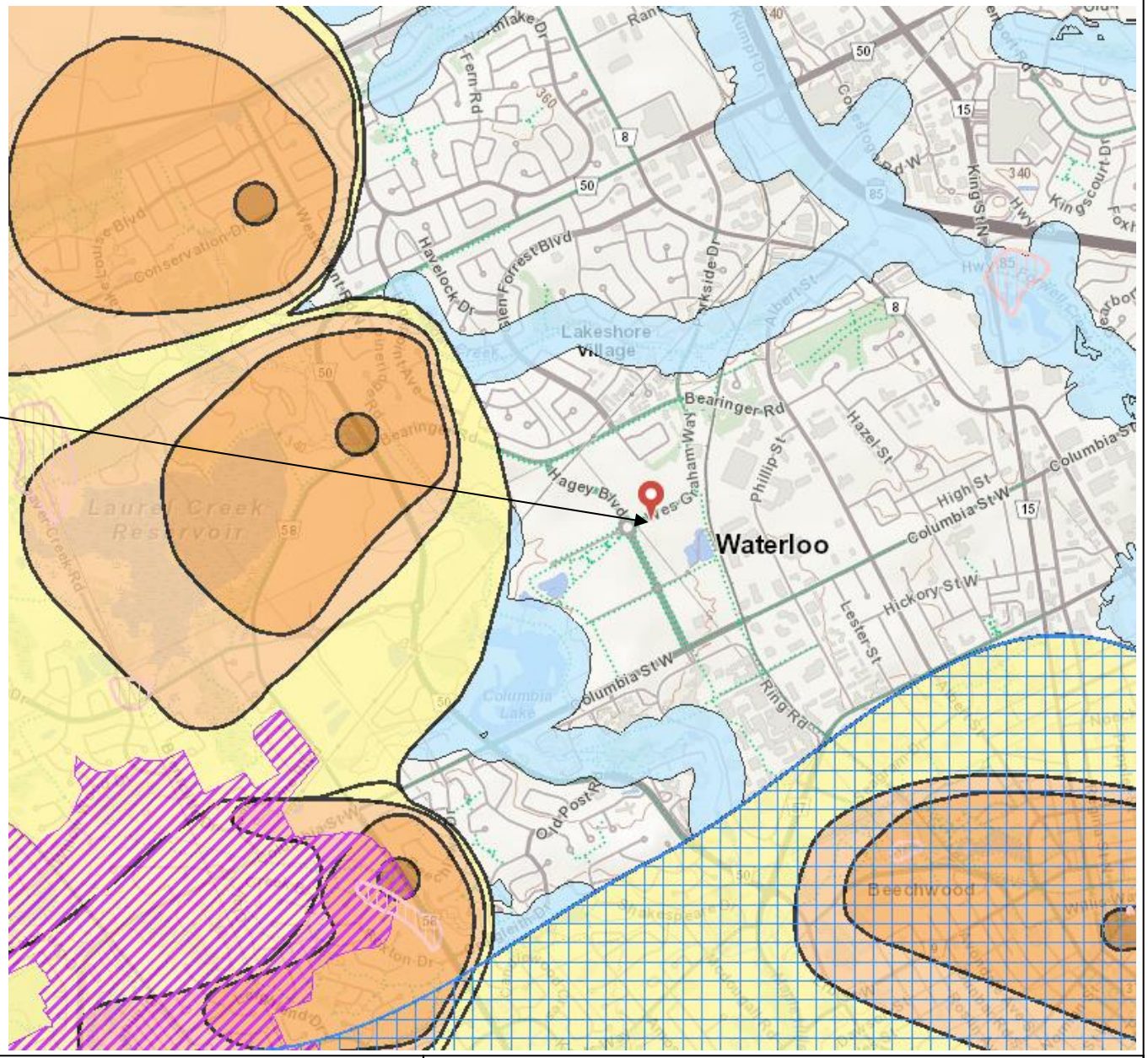
Location Information

Zoom in to confirm your location and results

Latitude: **43.48002** Longitude: **-80.54841**
UTM Zone: **17**
Easting: **536520.92** Northing: **4814221.64**
Upper Tier Municipality: **REGIONAL MUNICIPALITY OF WATERLOO**
Lower Tier Municipality: **CITY OF WATERLOO**
Township Concession and Lot: **WATERLOO LOT 12 GERMAN COMPANY TRACT**
Assessment Parcel Address: **380 Hagey Boulevard**
Assessment Roll #: **30160412500640700000**
MECP District: **Guelph**
MECP Region: **West Central Region**

Source Protection Details for Location

Source Protection Area: **Grand River**
View Source Protection Plan
Wellhead Protection Area: **No**
Wellhead Protection Area (WHPA-E): **No**
Issue Contributing Area: **No**
Significant Groundwater Recharge Area: **No**
Highly Vulnerable Aquifer: **No**
Event Based Area: **No**
Wellhead Protection Area Q1: **Yes** Stress: **Low**
Wellhead Protection Area Q2: **Yes** Stress: **Low**
Intake Protection Zone Q: **No**
Information is current as of: **December 12, 2024**



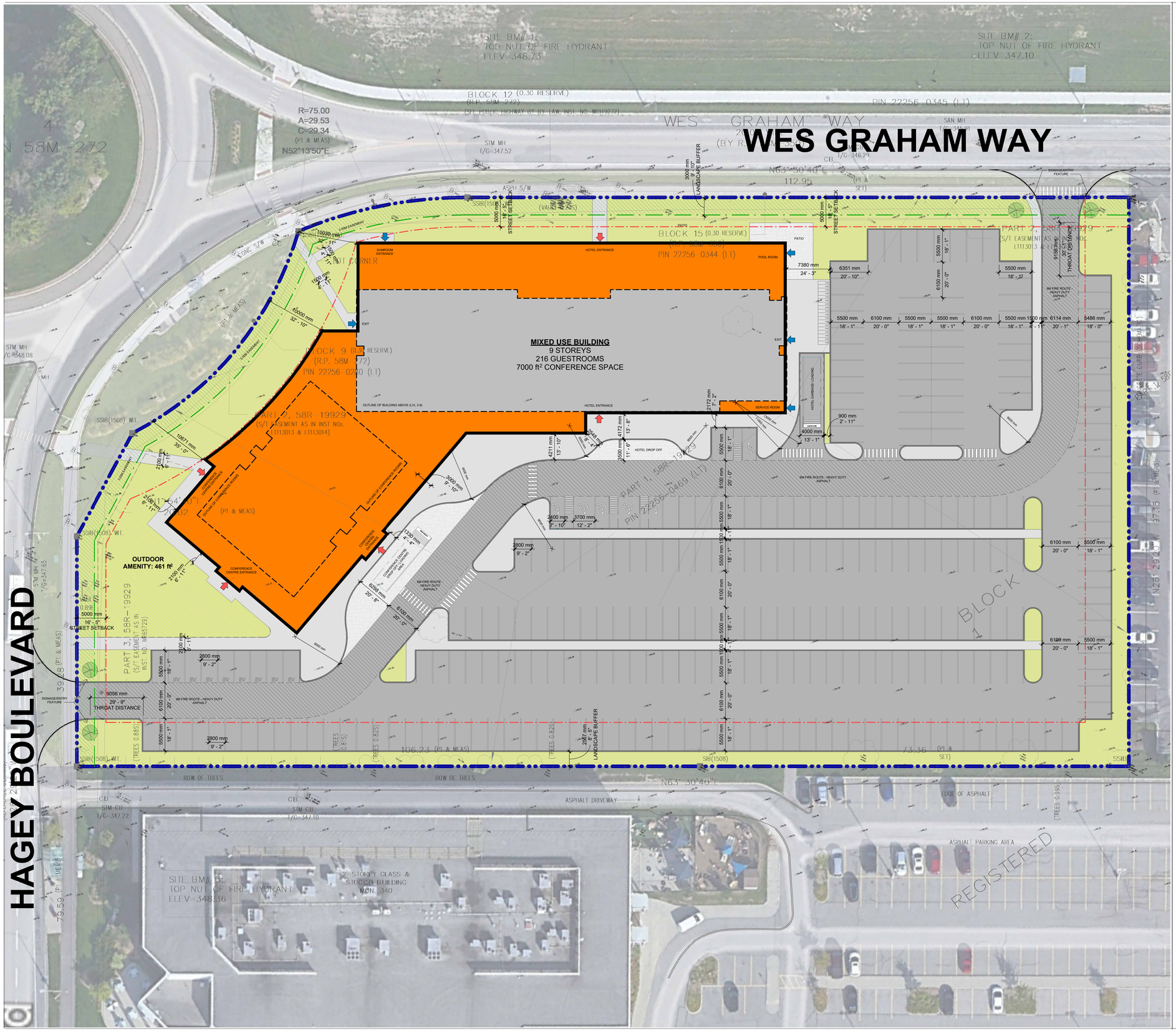
HARDEN Environmental	**Project No:** 2501	Hydrogeological Assessment 380 Hagey Boulevard
	Date: Feb 2025	City of Waterloo, Regional Municipality of Waterloo WATERLOO LOT 12 GERMAN COMPANY TRACT
	Drawn By: AR	**Figure 9: Source Water Protection**



HARDEN Environmental	**Project No:** 2501	Hydrogeological Assessment 380 Hagey Boulevard	**Figure 10: Monitoring Well and Borehole Locations**
	Date: Feb 2025	City of Waterloo, Regional Municipality of Waterloo WATERLOO LOT 12 GERMAN COMPANY TRACT	
	Drawn By: AR		

Appendix A

Development Plan and Topographic Survey



PARKING REQUIREMENTS:

HOTEL:
- 1 PARKING SPACE PER GUEST ROOM
- 5 PARKING SPACES PER 100SM OF BUILDING FLOOR AREA FOR COMMERCIAL, CONFERENCE AND/OR CONVENTION SPACE

GUESTROOM PARKING REQUIRED
216 x 1 = 216 PARKING SPACES

CONFERENCE ROOM REQUIRED
650m² x 0.05 = 33 PARKING SPACES

TOTAL PARKING REQUIRED 216 + 33 = **249 PARKING SPACES**

ACCESSIBLE PARKING REQUIRMENTS:

PARKING QTY.	TYPE A	TYPE B
167-250	3	4

TOTAL ACCESSIBLE PARKING REQUIRED
3(A) + 4(B) = 7 ACCESSIBLE PARKING SPACES

ELECTRIC VEHICLE PARKING REQUIRMENTS:

TOTAL PARKING QTY.	EV PARKING SPACES
150 OR MORE	3% (8 SPACES)

NOTWITHSTANDING ANYTHING TO THE CONTRARY, A REQUIRED TYPE B ACCESSIBLE PARKING SPACE MAY BE SATISFIED AS A TYPE A ACCESSIBLE PARKING SPACE

SITE STATISTICS				
DESCRIPTION	AREA (SM)	AREA (SF)	AREA (HA)	%
BUILDING FOOTPRINT				
HYATT DUAL BRAND & CONFERENCE CENTRE	3,501.4 m²	37,689 ft²	0.35 hectare	21.7%
	3,501.4 m²	37,689 ft²	0.35 hectare	21.7%
HARD LANDSCAPE				
ASPHALT	7,802.9 m²	83,990 ft²	0.78 hectare	48.4%
CURB	235.6 m²	2,536 ft²	0.02 hectare	1.5%
PAVERS	290.2 m²	3,124 ft²	0.03 hectare	1.8%
SIDEWALK	1,382.4 m²	14,880 ft²	0.14 hectare	8.6%
	9,711.2 m²	104,530 ft²	0.97 hectare	60.2%
SOFT LANDSCAPE				
LANDSCAPING	2,922.9 m²	31,462 ft²	0.29 hectare	18.1%
	2,922.9 m²	31,462 ft²	0.29 hectare	18.1%
	16,135.5 m²	173,681 ft²	1.61 hectare	100.0%
OVERALL SITE	16,126.8 m²	173,587 ft²	1.61 hectare	100.0%

PARKING SCHEDULE	
Type	COUNT
ACCESSIBLE - TYPE A (3.7M X 5.5M)	3
ACCESSIBLE - TYPE B (2.4M X 5.5M)	4
ELECTRIC VEHICLE PARKING (2.8M X 5.5M)	8
TYPICAL PARKING (2.8M X 5.5M)	256
	271

BIKE PARKING SCHEDULE			
Type	Description	Size	Count
TYPE B - SHORT TERM BIKE PARKING	DOUBLE SIDED RACK	3.0m x 0.6m	36

1 / A001 Site Plan
1 : 300

Chamberlain Architects Constructors Managers

Chamberlain Architect Services Limited

4671 Palladium Way (Unit 1)
Burlington, Ontario. L7M 0W9
CANADA

Phone: 905.631.7777

www.chamberlainIPD.com

NO.	ISSUED	DATE
	CLIENT REVIEW	2024-07-26
	CLIENT REVIEW	2024-08-15
	CLIENT REVIEW	2025-02-26
	ZBA SUBMISSION	2025-04-11

DO NOT SCALE DRAWINGS. USE ONLY DRAWINGS MARKED "ISSUED FOR CONSTRUCTION". VERIFY CONFIGURATIONS AND DIMENSIONS ON SITE BEFORE BEGINNING WORK. NOTIFY ARCHITECT IMMEDIATELY OF ANY ERRORS, OMISSIONS OR DISCREPANCIES.

CHAMBERLAIN ARCHITECT SERVICES LIMITED AND CHAMBERLAIN CONSTRUCTION SERVICES LIMITED HAVE SIMILAR OWNERSHIP.

CHAMBERLAIN ARCHITECT SERVICES LIMITED HAS COPYRIGHT. CONSTRUCTING A SUBSTANTIALLY SIMILAR BUILDING WITHOUT PERMISSION MAY INFRINGE THE COPYRIGHT OWNER'S RIGHTS. MAKING MINOR CHANGES TO PLANS DOES NOT NECESSARILY AVOID COPYRIGHT INFRINGEMENT. INNOCENT INFRINGEMENT IS NOT A DEFENSE TO COPYRIGHT INFRINGEMENT. ©

SEAL

CONSTRUCTION NORTH TRUE NORTH

HYATT DUAL BRAND - HH & HP

WES GRAHAM WAY &
HAGEY BLVD. WATERLOO

SHEET NAME

SITE PLAN

START DATE	NOVEMBER 2022
DRAWN BY	HK/SR/MW/MR
CHECKED BY	CMC
SCALE	1 : 300
PROJECT NO.	122065
DRAWING	A001

C:\Users\hkarim\Documents\122065 - Waterloo Hyatt - Site - R24 - 2024.08.13_hkarimAN2RP.rvt

3/18/2025 11:38:06 AM

Appendix B

Borehole Logs

ENCLOSURE No. 2

RECORD OF BOREHOLE No. BH1 1 OF 1 METRIC

PROJECT NUMBER 11425 LOCATION 380 Hagey, Waterloo, Ontario ORIGINATED BY CC

PROJECT NAME Proposed Hotel CLIENT Kothari Group Inc METHOD Solid Stem Augers COMPILED BY RT

DATUM Geodetic DATE 2025.03.13 - 2025.03.13 NORTHING EASTING CHECKED BY RT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
346.9	Topsoil										
0.0 / 346.7	TOPSOIL - 200 mm thick										
0.2	FILL - sandy silt, trace gravel, brown, moist		1	SS	18		346				
			2	SS	31						
345.4											
1.5	FINE SANDY SILT - trace to some clay, trace gravel, brown, compact to dense, wet		3	SS	31		345				
			4	SS	25						
343.9							344				
3.0	SILT - trace clay, trace sand, brown, compact, very moist		5	SS	27						
342.3							343				
4.6	SILTY CLAY - brownish grey, stiff, very moist		6	SS	12		342				
340.8							341				
6.1	CLAYEY SILT - trace sand, grey, very stiff, wet		7	SS	28						
340.3											
6.6	End of Borehole at Targeted Depth; Borehole Was Open and Water at 5.5 m Below Existing Ground Surface Upon Completion of Drilling Period.										

DRAFT

This log is based on the log and test results provided.

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE No. 3

RECORD OF BOREHOLE No. BH2

1 OF 2

METRIC

PROJECT NUMBER 11425 | LOCATION 380 Hagey, Waterloo, Ontario | ORIGINATED BY CC

PROJECT NAME Proposed Hotel | CLIENT Kothari Group Inc | METHOD Solid Stem Augers | COMPILED BY RT

DATUM Geodetic | DATE 2025.03.13 - 2025.03.13 | NORTHING | EASTING | CHECKED BY RT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
346.4	Topsoil									
0.0 / 346.2	TOPSOIL - 150 mm thick									
0.2	FILL - silty sand, trace gravel, trace clay, brown, moist		1	SS	16		346			
			2	SS	23					
			3	SS	24		345			
344.1										
2.3	SANDY SILT - trace clay, brown, compact, moist		4	SS	25		344			
343.4										
3.0	SILT - trace clay, brown, compact, very moist		5	SS	21		343			
341.8										
4.6	SILTY CLAY - brownish grey, stiff, very moist		6	SS	12		342			
							341			

DRAFT

This log is based on the log and test results provided.

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE No. 3

RECORD OF BOREHOLE No. BH2 2 OF 2 METRIC

PROJECT NUMBER 11425 LOCATION 380 Hagey, Waterloo, Ontario ORIGINATED BY CC

PROJECT NAME Proposed Hotel CLIENT Kothari Group Inc METHOD Solid Stem Augers COMPILED BY RT

DATUM Geodetic DATE 2025.03.13 - 2025.03.13 NORTHING EASTING CHECKED BY RT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
340.3											
6.1	SANDY SILT - trace clay, brownish grey, compact to very dense, wet		7	SS	40		340				
			8	SS	15		339				
			9	SS	53		338				
336.8							337				
9.6	End of Borehole at Targeted Depth; Borehole Caved at 7.0 m and Water at 5.8 m Below Existing Ground Surface Upon Completion of Drilling Period.										

DRAFT

This log is based on the log and test results provided.

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE No. 4

RECORD OF BOREHOLE No. BH3

1 OF 1

METRIC

PROJECT NUMBER 11425 | LOCATION 380 Hagey, Waterloo, Ontario | ORIGINATED BY CC

PROJECT NAME Proposed Hotel | CLIENT Kothari Group Inc | METHOD Solid Stem Augers | COMPILED BY RT

DATUM Geodetic | DATE 2025.03.13 - 2025.03.13 | NORTHING | EASTING | CHECKED BY RT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
348.1	Topsoil										
348.0 / 0.0	TOPSOIL - 125 mm thick						348				
0.1	FILL - clayey silt, trace gravel, trace rootlets, brown, moist		1	SS	11						
			2	SS	8		347				
346.6											
1.5	CLAYEY SILT - trace gravel, brown, very stiff, moist		3	SS	19						
345.8							346				
2.3	FINE SANDY SILT - brown, compact, wet		4A / 4B	SS	22						
345.5											
2.6	CLAYEY SILT - brown, very stiff to hard, moist		5	SS	20		345				
			6	SS	23		344				
							343				
			7	SS	36		342				
341.5											
6.6	End of Borehole at Targeted Depth; Borehole Caved at 6.0 m and Water at 5.8 m Below Existing Ground Surface Upon Completion of Drilling Period.										

DRAFT

This log is based on the log and test results provided.

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE No. 5

RECORD OF BOREHOLE No. BH4 1 OF 1 METRIC

PROJECT NUMBER 11425 LOCATION 380 Hagey, Waterloo, Ontario ORIGINATED BY CC

PROJECT NAME Proposed Hotel CLIENT Kothari Group Inc METHOD Solid Stem Augers COMPILED BY RT

DATUM Geodetic DATE 2025.03.13 - 2025.03.13 NORTHING EASTING CHECKED BY RT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
347.3	Topsoil										
0.0 / 347.1	TOPSOIL - 175 mm thick										
0.2	FILL - silty clay, trace gravel, brown, moist		1	SS	9		347				
			2	SS	15		346				
345.8											
1.5	CLAYEY SILT - brown, very stiff, moist to wet		3	SS	20						
			4	SS	25		345				
	- trace sand		5	SS	20		344				
342.7							343				
4.6	FINE SANDY SILT - trace clay, brown, dense, wet		6	SS	37						
341.2							342				
6.1	SILT - brown, very dense, moist		7	SS	53		341				
340.7											
6.6	End of Borehole at Targeted Depth; Borehole Was Open and Water at 5.3 m Below Existing Ground Surface Upon Completion of Drilling Period.										

DRAFT

This log is based on the log and test results provided.

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE No. 6

RECORD OF BOREHOLE No. BH5 1 OF 1 METRIC

PROJECT NUMBER 11425 LOCATION 380 Hagey, Waterloo, Ontario ORIGINATED BY CC

PROJECT NAME Proposed Hotel CLIENT Kothari Group Inc METHOD Solid Stem Augers COMPILED BY RT

DATUM Geodetic DATE 2025.03.13 - 2025.03.13 NORTHING EASTING CHECKED BY RT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
347.9	Topsoil										
0.0 / 347.7	TOPSOIL - 150 mm thick										
0.2	FILL - clayey silt, trace gravel, brown, moist		1	SS	18		347				
			2	SS	26						
346.4											
1.5	CLAYEY SILT - trace gravel, trace sand, brown, very stiff, moist		3	SS	25		346				
345.6											
2.3	GLACIAL TILL - clayey silt, trace gravel, greyish brown, very stiff to hard, moist		4	SS	29		345				
			5	SS	39						
343.3							344				
4.6	SILT - some clay, greyish brown, very dense, moist		6	SS	53		343				
341.8											
6.1	FINE SANDY SILT - some clay, greyish brown, very dense, wet		7	SS	79/ 28 cm		342				
341.4											
6.5	End of Borehole at Targeted Depth; Borehole Was Open and Dry Upon Completion of Drilling Period.										

DRAFT

This log is based on the log and test results provided.

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SOLA ENGINEERING

KEY TO SYMBOLS

Enclosure No.: 7

PROJECT NUMBER 11425

PROJECT NAME Proposed Hotel

LOCATION 380 Hagey boulevard, Waterloo, Ontario

CLIENT Kothari Group Inc

LITHOLOGIC SYMBOLS (Unified Soil Classification System)


CL-SL: clayey silt


CL-SL-TL: clayey silt till


FILL: TTC Fill (made ground)


SL: silt


SL-CL: silty clay


SN-SL: sandy silt


TOPSOIL: Topsoil/peat/organics

SAMPLER SYMBOLS


Split Spoon Sample

WELL CONSTRUCTION SYMBOLS


Bentonite Seal: 1 pipe group, 1 pipe


Concrete: 1 pipe group, 1 pipe


Filter Pack: 1 pipe group, 1 pipe


Slotted Pipe: 1 pipe group, 1 pipe


Slough at bottom of hole

DRAFT

Notes:

Terms describing RELATIVE DENSITY, based on Standard Penetration Test "N"-Value for COURSE GRAINED soils (major portion retained on No. 200 seive):

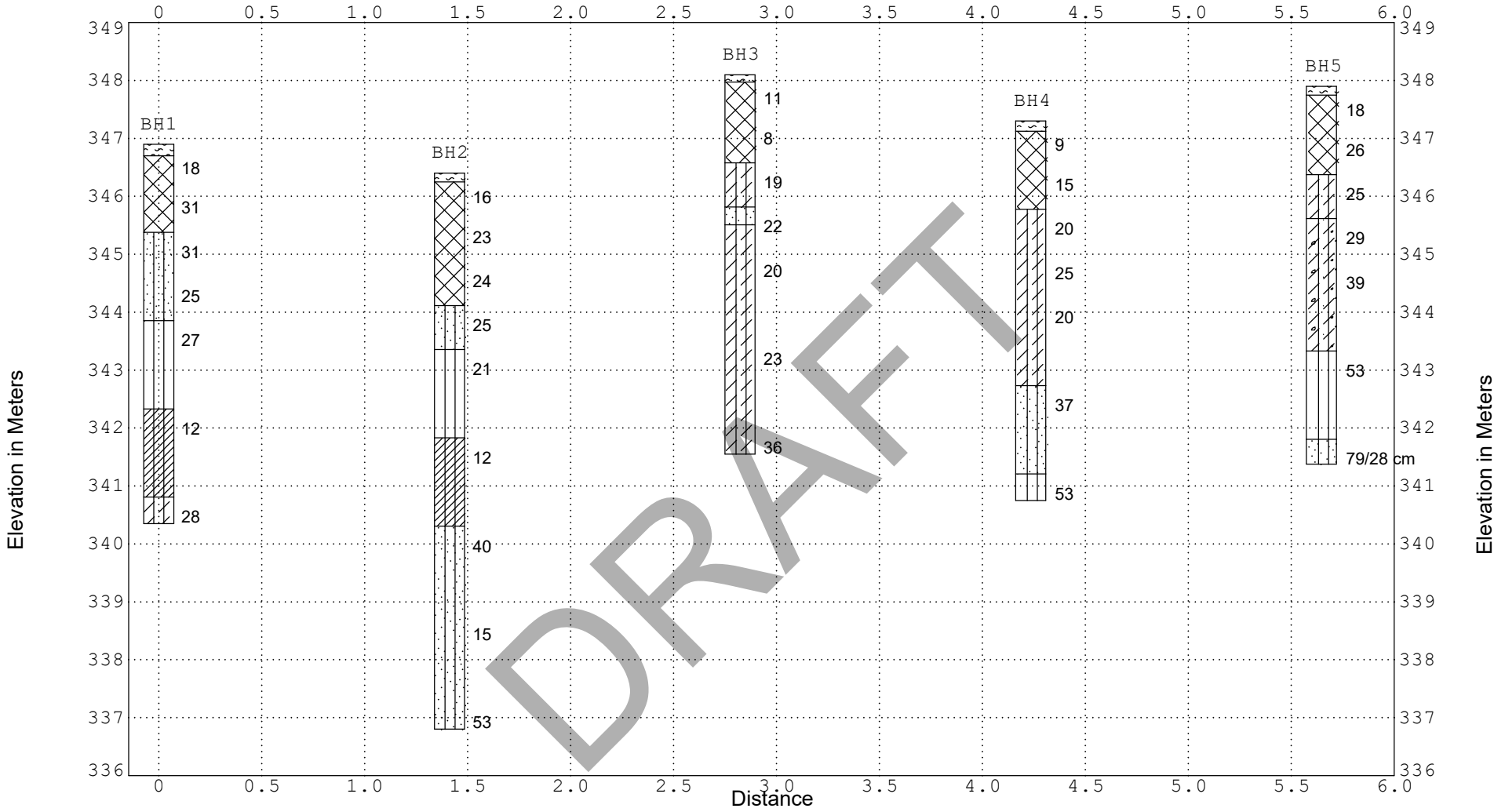
DESCRIPTIVE TERM ["N"-Value (blows/0.3m), Relative Density (%)]

- **Very Loose [less than 4, less than 15]**
- **Loose [4 to 10, 15 to 35]**
- **Compact or Medium [10 to 30, 35 to 65]**
- **Dense [30 to 50, 65 to 85]**
- **Very Dense [greater than 50, greater than 85]**

Terms describing CONSISTENCY, based on Standard Penetration Test "N"-Value for FINE GRAINED soils (major portion passing No. 200 sieve):

DESCRIPTIVE TERM [Unconfined Compressive Strength (kPa), "N"-Value (blows/0.3m)]

- **Very Soft [less than 25, less than 2]**
- **Soft [25 to 50, 2 to 4]**
- **Firm [50 to 100, 4 to 8]**
- **Stiff [100 to 200, 8 to 15]**
- **Very Stiff [200 to 400, 15 to 30]**
- **Hard [greater than 400, greater than 30]**



Plan View

SOLA ENGINEERING

SOLA ENGINEERING INC.
CONCEPTUAL SOIL PROFILE

Horizontal Scale:	Drawn By:	
Vertical Scale:	Approved By:	

Proposed Hotel
380 Hagey boulevard, Waterloo, Ontario

Project Number: 11425 | Enclosure No.: 8

Appendix C

MECP Water Well Records

Well Records within 500m

Well ID	Date Completed	Depth (m)	Depth to Bedrock (m)	Static Water Level (m)	TAG	Final Status	Use 1	Use 2
6500861	1/23/56	75.3	67.1	13.7		Water Supply	Domestic	
6503067	7/31/69	21.3		4.6		Water Supply	Commerical	
6505042	10/04/79	15.8		8.5		Water Supply	Domestic	
6507205	10/03/91	70.1	68.0			Observation Wells	Not Used	
6509615	2/11/04	59.9	55.5		A000156	Observation Wells		
6509639	3/31/04				A008927	Observation Wells		
6509664	4/05/04	5.0			A010222	Observation Wells		
6510494	10/07/05					Abandoned-Other		
7045092	6/01/07	6.0			A048754	Observation Wells		
7112534	4/25/08	18.0			A069641	Test Hole	Other	
7114752	10/21/08						Other	
7125402					A059236	Test Hole	Monitoring	
7125402								
7125402								
7125402	12/11/07	16.3						
7128803	8/21/09	12.2			A082745	Monitoring and Test Hole	Test Hole	
7128804	5/21/09	12.2			A082713	Monitoring and Test Hole	Test Hole	
7160059	2/14/11				A097904			
7163994	5/27/11				A097904	Abandoned-Other		
7218482	2/24/14	4.6			A159522	Test Hole	Test Hole	
7218486	2/26/14	4.6			A159517	Test Hole	Test Hole	
7218487	2/26/14	4.6			A159518	Test Hole	Test Hole	
7230080	9/03/14				A171635			
7232572	10/27/14				A144501		Test Hole	
7238512	1/21/15	6.1			A161934	Observation Wells	Monitoring and Test Hole	
7238513	1/21/15	5.4			A161935	Observation Wells	Monitoring and Test Hole	
7238514	1/21/15	4.5			A162162	Observation Wells	Monitoring and Test Hole	
7238645	1/22/15	5.8			A176670	Observation Wells	Monitoring and Test Hole	
7238646	1/22/15	4.9			A176671	Observation Wells	Monitoring and Test Hole	
7238647	1/22/15	4.9			A176672	Observation Wells	Monitoring and Test Hole	
7238648	1/15/15	4.9			A177264		Monitoring	
7265298	6/02/16	6.1			A176775	Monitoring and Test Hole	Monitoring and Test Hole	
7277022	11/12/16	6.1			A156790	Observation Wells	Monitoring	
7281422	2/06/17	160.0		19.2	A216958	Observation Wells	Commerical	
7283430	2/10/17	4.2			A216733	Observation Wells	Monitoring	
7286590	4/27/17	8.2			A222245	Observation Wells	Monitoring	
7286591	4/27/17	9.1			A222243	Observation Wells	Monitoring	
7287709	4/17/17				A156790	Abandoned-Other		
7287710	4/17/17				A156790	Abandoned-Other		
7289425	6/12/17	160.0		31.4	A216958	Water Supply	Commerical	Cooling And A/C
7289426	6/12/17	160.0		20.7	A216959	Recharge Well	Commerical	Other
7311617	4/26/18	7.6			A237277			
7311618	4/26/18	9.1			A237279			
7311619	4/26/18	9.1			A237276	Observation Wells	Monitoring	
7311620	4/26/18	7.6			A237278	Observation Wells	Monitoring	
7333781	4/25/19	6.7			A266352	Observation Wells	Monitoring	
7333790	4/25/19	8.5			A266353	Observation Wells	Monitoring	
7358185	3/02/20	4.0			A290423	Monitoring and Test Hole	Monitoring and Test Hole	
7358186	3/02/20	4.0			A290422	Monitoring and Test Hole	Monitoring and Test Hole	
7358188	3/02/20	4.0			A290421	Monitoring and Test Hole	Test Hole	
7416117	4/22/22	9.1			A346132	Observation Wells	Monitoring	
7416752	3/17/22				A341022			
7416753	3/17/22				A341021			
7416754	3/17/22				A341023			
7430238	9/13/22	4.6		1.5	A362454	Observation Wells	Monitoring	
7430239	9/12/22	4.6			A362455	Observation Wells	Monitoring	
7430240	9/12/22	4.6		1.5	A362456	Observation Wells	Monitoring	

Well ID	Date Completed	Depth (m)	Depth to Bedrock (m)	Static Water Level (m)	TAG	Final Status	Use 1	Use 2
7435437	11/16/22	4.6			A358298	Monitoring and Test Hole	Test Hole	
7440404	2/07/23	6.1			A368885	Monitoring and Test Hole	Test Hole	
7440935	11/15/22				A361246			
7440936	11/15/22				A364541			
7444393	3/29/23	12.2			A373764	Observation Wells	Monitoring	
7444394	3/29/23	12.2			A373765	Observation Wells	Monitoring	
7444395	3/29/23	12.2			A373766	Observation Wells	Monitoring	
7444396	3/30/23	17.8			A373767	Observation Wells	Monitoring	
7444719	2/07/23				A368884			
7449866	2/28/23				A368842			
7449867	2/28/23				A368846			
7449868	2/28/23				A368849			

Well Records within 500m Stratigraphy

Well ID	Thickness (m)	Colour	Material 1	Material 2	Material 3	Depth (m)
6500861	2.44		PREVIOUSLY DUG			2.44
6500861	3.05	YELLOW	MEDIUM SAND			5.49
6500861	18.90	BLUE	CLAY			24.38
6500861	17.68		HARDPAN			42.06
6500861	5.18	RED	CLAY	MEDIUM SAND		47.24
6500861	3.05	BLUE	CLAY	MEDIUM SAND		50.29
6500861	16.76		CLAY	MEDIUM SAND		67.06
6500861	4.57		SHALE			71.63
6500861	3.05	BLUE	ROCK			74.68
6500861	0.61		LIMESTONE			75.29
6503067	8.23		CLAY	MEDIUM SAND		8.23
6503067	9.45	GREY	CLAY			17.68
6503067	0.91		MEDIUM SAND	CLAY	GRAVEL	18.59
6503067	0.61		CLAY			19.20
6503067	1.22		MEDIUM SAND	GRAVEL		20.42
6503067	0.91		CLAY	STONES		21.34
6505042	1.22	BROWN	CLAY			1.22
6505042	3.96	GREY	CLAY			5.18
6505042	0.61	GREY	SAND			5.79
6505042	3.05	BLUE	CLAY			8.84
6505042	0.91	BLUE	CLAY	SANDY		9.75
6505042	3.35		SAND			13.11
6505042	0.91	BLUE	CLAY			14.02
6505042	1.83		CLAY	SANDY		15.85
6507205	0.61	BLACK	TOPSOIL			0.61
6507205	7.62	BROWN	SAND	SILT	FINE SAND	8.23
6507205	44.20	BROWN	CLAY	STONES	HARD	52.43
6507205	5.49	BROWN	SAND	FINE SAND	COARSE SAND	57.91
6507205	3.66	GREY	SILT			61.57
6507205	6.40	RED	CLAY			67.97
6507205	2.13	WHITE	LIMESTONE	ROCK		70.10
6509615	0.80		FILL			0.80
6509615	1.90		SILT	CLAY	SAND	2.70
6509615	2.20		SAND	SILT	CLAY	4.90
6509615	1.60		SILT	CLAY		6.50
6509615	1.40		GRAVEL	SAND		7.90
6509615	1.70		CLAY	SILT		9.60
6509615	2.70		SAND	SILT	CLAY	12.30
6509615	4.60		CLAY	SILT	TILL	16.90
6509615	5.80		SAND	SILT	TILL	22.70
6509615	0.80		CLAY	SILT	TILL	23.50
6509615	12.00		SAND	SILT	TILL	35.50
6509615	0.60		SAND	GRAVEL		36.10
6509615	2.20		SAND	SILT	TILL	38.30
6509615	1.80		SILT	CLAY	SAND	40.10
6509615	3.00		SAND	SILT	TILL	43.10
6509615	1.10		GRAVEL	SAND	SILTY	44.20
6509615	1.20		SILT	GRAVEL		45.40
6509615	3.10		SAND	SILT	TILL	48.50
6509615	2.10		CLAY	SILT		50.60
6509615	1.40		CLAY	SILT	TILL	52.00
6509615	3.60		SAND	SILT	TILL	55.60
6509615	3.10		SHALE			58.70

Well Records within 500m Stratigraphy

Well ID	Thickness (m)	Colour	Material 1	Material 2	Material 3	Depth (m)
6509615	1.20		UNKNOWN TYPE			59.90
6509664	0.60	BROWN	GRAVEL	SAND		0.60
6509664	4.40	BROWN	SILT	SAND		5.00
7045092	6.00	BROWN	CLAY	SILT	SAND	6.00
7112534	0.30	BROWN	SILT	SAND	FILL	0.30
7112534	2.70	BROWN	FINE SAND	SILT	LOOSE	3.00
7112534	4.00	GREY	FINE SAND	SILT	LOOSE	7.00
7112534	4.00	GREY	SILT	SAND		11.00
7112534	3.00	BROWN	SAND	GRAVEL	LOOSE	14.00
7112534	4.00	GREY	CLAY	SILT		18.00
7125402	0.50	BROWN	SAND	SILT		0.50
7125402	9.50	BROWN	SAND	GRAVEL		10.00
7125402	5.00	GREY	SILT	GRAVEL	TILL	15.00
7125402	1.30	GREY	SAND	GRAVEL		16.30
7128803	0.76	BROWN	TOPSOIL			0.76
7128803	1.98	BROWN	CLAY		LOOSE	2.74
7128803	2.59	BROWN	FINE SAND	SILT	LOOSE	5.33
7128803	1.68	GREY	CLAY	SILT	HARD	7.01
7128803	0.61	BROWN	FINE SAND	SILT	LOOSE	7.62
7128803	1.52	BROWN	CLAY		SOFT	9.14
7128803	1.53	BROWN	SAND	SILT	CLAY	10.67
7128803	1.21	BROWN	SAND	SILT	GRAVEL	11.88
7128803	0.34	BROWN	CLAY		TILL	12.22
7128804	0.76	BLUE	TOPSOIL			0.76
7128804	2.90	BROWN	CLAY	SILT	SAND	3.66
7128804	0.91	BROWN	FINE SAND	SILT	LOOSE	4.57
7128804	2.44	GREY	CLAY	SILT	HARD	7.01
7128804	0.61	BROWN	FINE SAND		LOOSE	7.62
7128804	1.52	GREY	CLAY	SILT	SOFT	9.14
7128804	2.44	GREY	FINE SAND	SILT	GRAVEL	11.58
7128804	0.64	BROWN	CLAY	TILL		12.22
7218482	1.80	BROWN	SAND	GRAVEL	FILL	1.80
7218482	1.50	BROWN	SAND	SILT	WATER-BEARING	3.30
7218482	1.30	GREY	SILT		WATER-BEARING	4.60
7218486	1.80	BROWN	SAND	GRAVEL	FILL	1.80
7218486	1.50	BROWN	SAND	SILT	WATER-BEARING	3.30
7218486	1.30	GREY	SILT	SAND	WATER-BEARING	4.60
7218487	1.80	BROWN	SAND	GRAVEL	FILL	1.80
7218487	1.50	BROWN	SAND	SILT	WATER-BEARING	3.30
7218487	1.30	GREY	SILT	SAND	WATER-BEARING	4.60
7238512	0.15	BLACK			HARD	0.15
7238512	5.94	BROWN	FINE SAND	SILT	SOFT	6.10
7238513	1.00	BROWN	TOPSOIL	SAND	SOFT	1.00
7238513	4.40	BROWN	SAND	SILT	GRAVEL	5.40
7238514	0.10	BLACK			SOFT	0.10
7238514	1.40	BROWN	SAND	GRAVEL	SOFT	1.50
7238514	3.00	BROWN	SAND	SILT	SOFT	4.50
7238645	3.05	BROWN	SILT	SAND		3.05
7238645	2.74	BROWN	SILT	SAND	WATER-BEARING	5.79
7238646	3.05	BROWN	SAND	SILT		3.05
7238646	1.83	BROWN	SAND	SILT	WATER-BEARING	4.88
7238647	3.05	BROWN	SAND	SILT		3.05
7238647	1.83	BROWN	SILT	SAND	WATER-BEARING	4.88

Well Records within 500m Stratigraphy

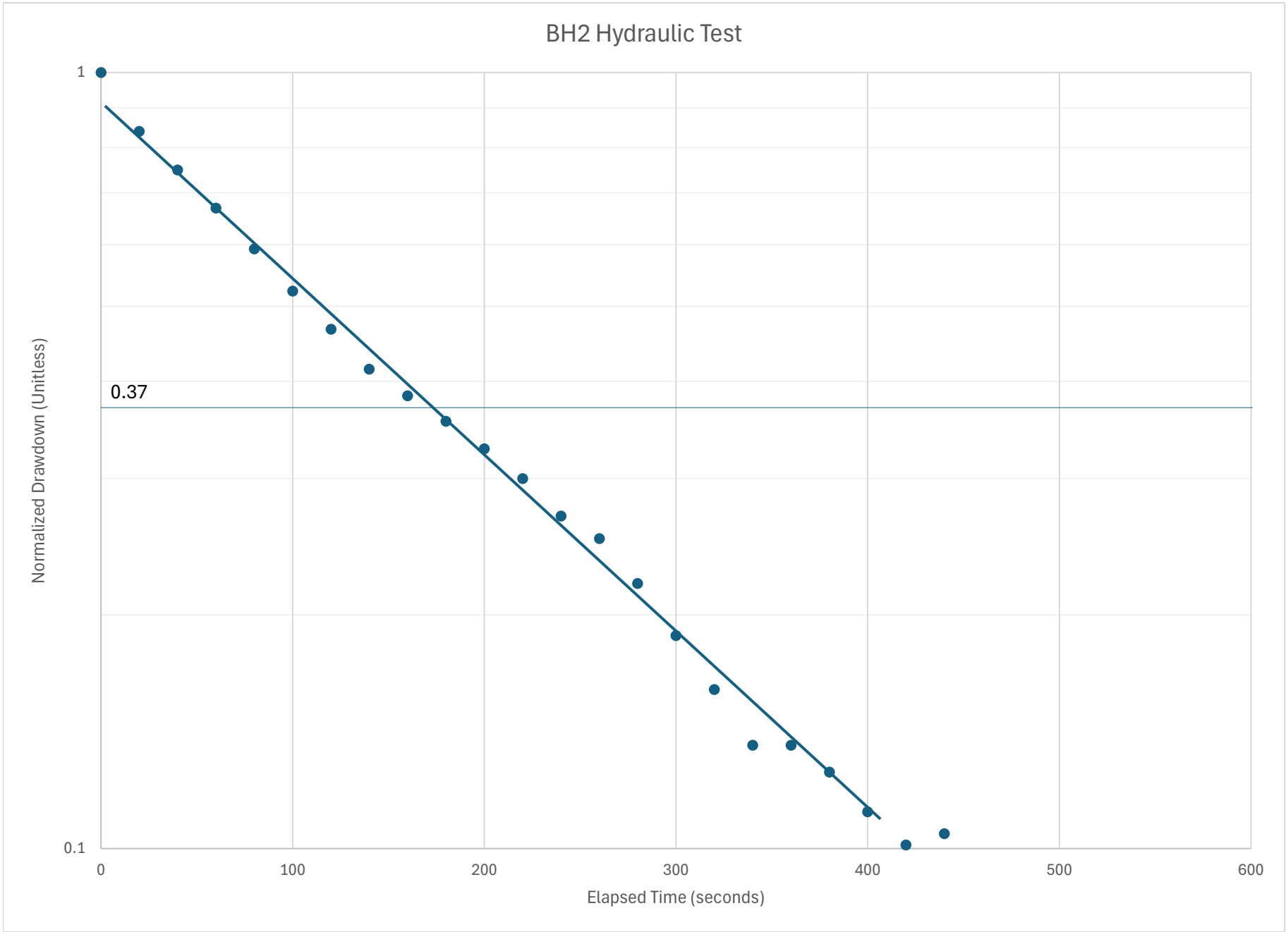
Well ID	Thickness (m)	Colour	Material 1	Material 2	Material 3	Depth (m)
7238648	1.52	GREY	GRAVEL	ROCK	SAND	1.52
7238648	3.35	BROWN	SILT	SAND	WATER-BEARING	4.88
7265298	0.30	BLACK	TOPSOIL	FINE SAND	SOFT	0.30
7265298	2.74	BROWN	FINE SAND	TILL	SOFT	3.05
7265298	3.05	GREY	SILT	FINE SAND	SOFT	6.10
7277022	3.05	GREY	CLAY	SILT	DENSE	3.05
7277022	3.05	GREY	SILT	SAND	DENSE	6.10
7281422	3.35	BROWN	CLAY			3.35
7281422	20.73	BROWN	CLAY	STONES		24.08
7281422	12.50	GREY	MEDIUM GRAVEL		FINE SAND	36.58
7281422	8.23	GREY	CLAY	STONES	SAND	44.81
7281422	14.02	GREY	HARDPAN			58.83
7281422	8.23	BROWN	SHALE			67.06
7281422	3.05	BROWN	LIMESTONE			70.10
7281422	10.67	GREY	SHALE			80.77
7281422	79.25	BROWN	LIMESTONE			160.02
7283430	0.60	BROWN	FILL			0.60
7283430	3.60	BROWN	SAND			4.20
7286590	0.10		TOPSOIL			0.10
7286590	8.13		SAND	SILT	CLAY	8.23
7286590	0.00					
7286591	0.10		TOPSOIL			0.10
7286591	9.04		SAND	SILT	CLAY	9.14
7287709	0.00					
7287710	0.00					
7289425	3.96	BROWN	CLAY		SOFT	3.96
7289425	5.79	BROWN	SAND			9.75
7289425	10.97	GREY	CLAY	STONES		20.73
7289425	15.85	GREY	SAND		SILTY	36.58
7289425	7.01	GREY	HARDPAN			43.59
7289425	14.33	GREY	CLAY	STONES		57.91
7289425	3.66	GREY	GRAVEL			61.57
7289425	3.35	GREY	LIMESTONE	MARL	SOFT	64.92
7289425	95.10	BLUE	LIMESTONE	SHALE	LAYERED	160.02
7289426	8.53	BROWN	CLAY		SOFT	8.53
7289426	14.33	BROWN	SAND	CLAY	STONES	22.86
7289426	2.74	GREY	GRAVEL		SILTY	25.60
7289426	24.38	GREY	CLAY	STONES	SILT	49.99
7289426	4.88	GREY	CLAY	STONES		54.86
7289426	1.52	GREY	GRAVEL			56.39
7289426	22.86	GREY	LIMESTONE	SHALE	LAYERED	79.25
7289426	57.91	BROWN	LIMESTONE			137.16
7289426	22.86	BROWN	LIMESTONE			160.02
7311617	1.52		TOPSOIL	FILL	DRY	1.52
7311617	1.83		CLAY	SILTY	DRY	3.35
7311617	4.27		SILT	SANDY	WATER-BEARING	7.62
7311618	1.52		TOPSOIL	FILL	DRY	1.52
7311618	3.05		CLAY	SILTY	DRY	4.57
7311618	1.52		SILT	WATER-BEARING		6.10
7311618	1.52		SAND	SILTY	WATER-BEARING	7.62
7311618	1.52		SAND		WATER-BEARING	9.14
7311619	6.10		CLAY			6.10
7311619	1.52		SILT			7.62

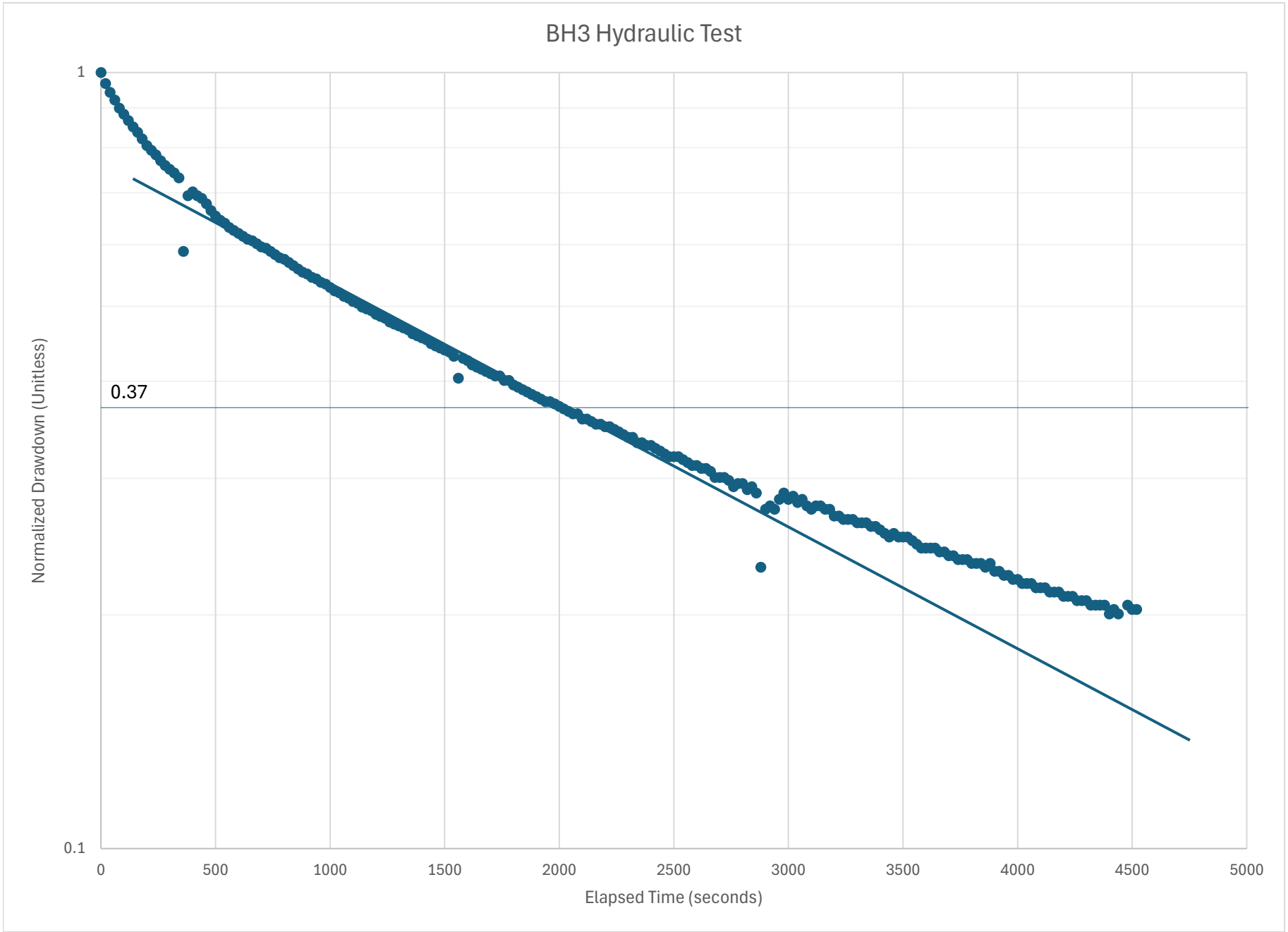
Well Records within 500m Stratigraphy

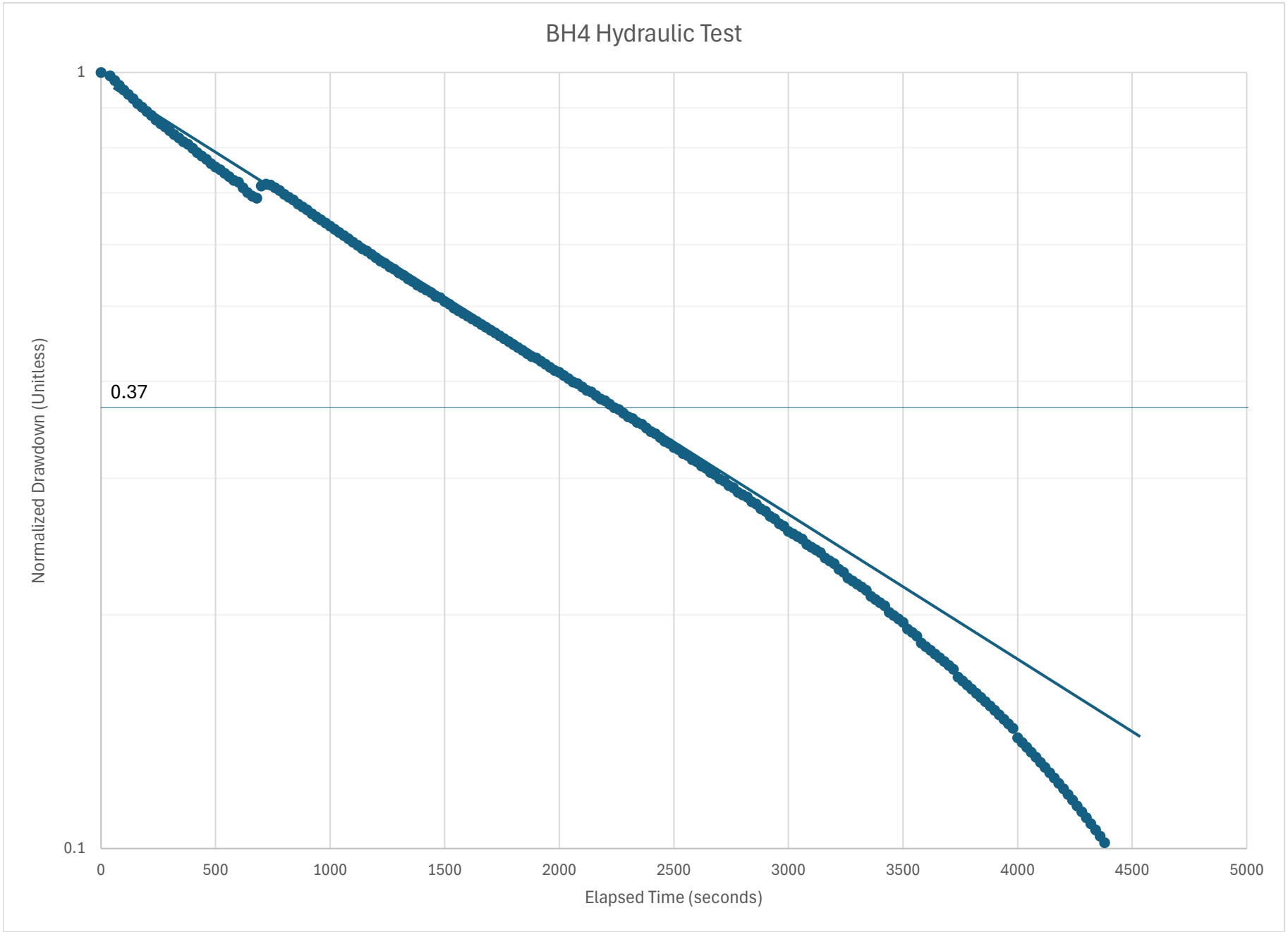
Well ID	Thickness (m)	Colour	Material 1	Material 2	Material 3	Depth (m)
7311619	1.52		SAND			9.14
7311620	4.57		CLAY			4.57
7311620	1.52		SILT			6.10
7311620	1.52		SAND			7.62
7333781	6.71		SILT	CLAY	STONES	6.71
7333790	8.53		SILT	CLAY	STONES	8.53
7358185	1.22	BROWN	SAND	GRAVEL		1.22
7358185	0.91	BROWN	SAND	SILT		2.13
7358185	1.83	GREY	SILT	CLAY		3.96
7358186	1.52	BROWN	SAND	GRAVEL		1.52
7358186	0.61	BROWN	SILT	SAND		2.13
7358186	1.83	GREY	SILT	CLAY		3.96
7358188	1.52	BROWN	SAND	GRAVEL		1.52
7358188	0.61	BROWN	SAND	SILT		2.13
7358188	1.83	GREY	SILT	CLAY		3.96
7416117	0.61		TOPSOIL			0.61
7416117	2.44		TILL	SANDY		3.05
7416117	6.10		SAND	SILTY		9.14
7430238	0.05	BLACK	TOPSOIL			0.05
7430238	0.26	BROWN	SAND	GRAVEL	LOOSE	0.30
7430238	4.27	GREY	SILT	FINE SAND	DENSE	4.57
7430239	0.05	BLACK			HARD	0.05
7430239	0.41	BROWN	SAND	GRAVEL	LOOSE	0.46
7430239	1.37	GREY	SILT	SAND	FILL	1.83
7430239	1.22	BROWN	SILT	SAND	DENSE	3.05
7430239	1.52	GREY	SILT	SAND	SOFT	4.57
7430240	0.08	BLACK			HARD	0.08
7430240	0.69	BROWN	SAND	GRAVEL	LOOSE	0.76
7430240	2.29	BROWN	SILT	FINE SAND	DENSE	3.05
7430240	1.52	GREY	SILT	FINE SAND	DENSE	4.57
7435437	0.60	BROWN	SAND	GRAVEL	FILL	0.60
7435437	3.06	BROWN	SAND	SILT		3.66
7435437	0.91	GREY	CLAY			4.57
7440404	0.61	BROWN	SAND	GRAVEL	FILL	0.61
7440404	3.99	BROWN	SAND			4.60
7440404	1.50	BROWN	SAND			6.10
7444393	0.61	BROWN	SAND	GRAVEL	DENSE	0.61
7444393	2.44	BROWN	SILT	CLAY	DENSE	3.05
7444393	9.14	GREY	SILT	CLAY	DENSE	12.19
7444394	0.76	BROWN	SAND	GRAVEL	DENSE	0.76
7444394	2.90	BROWN	SILT	CLAY	DENSE	3.66
7444394	8.53	GREY	SILT	CLAY	DENSE	12.19
7444395	0.91	BROWN	SAND	GRAVEL	DENSE	0.91
7444395	3.05	BROWN	SILT	CLAY	DENSE	3.96
7444395	8.23	GREY	SILT	CLAY	DENSE	12.19
7444396	0.91	BROWN	SAND	GRAVEL	DENSE	0.91
7444396	2.74	BROWN	SILT	CLAY	DENSE	3.66
7444396	7.01	GREY	SILT	CLAY	DENSE	10.67
7444396	7.16	GREY	TILL	SILT	HARD	17.83

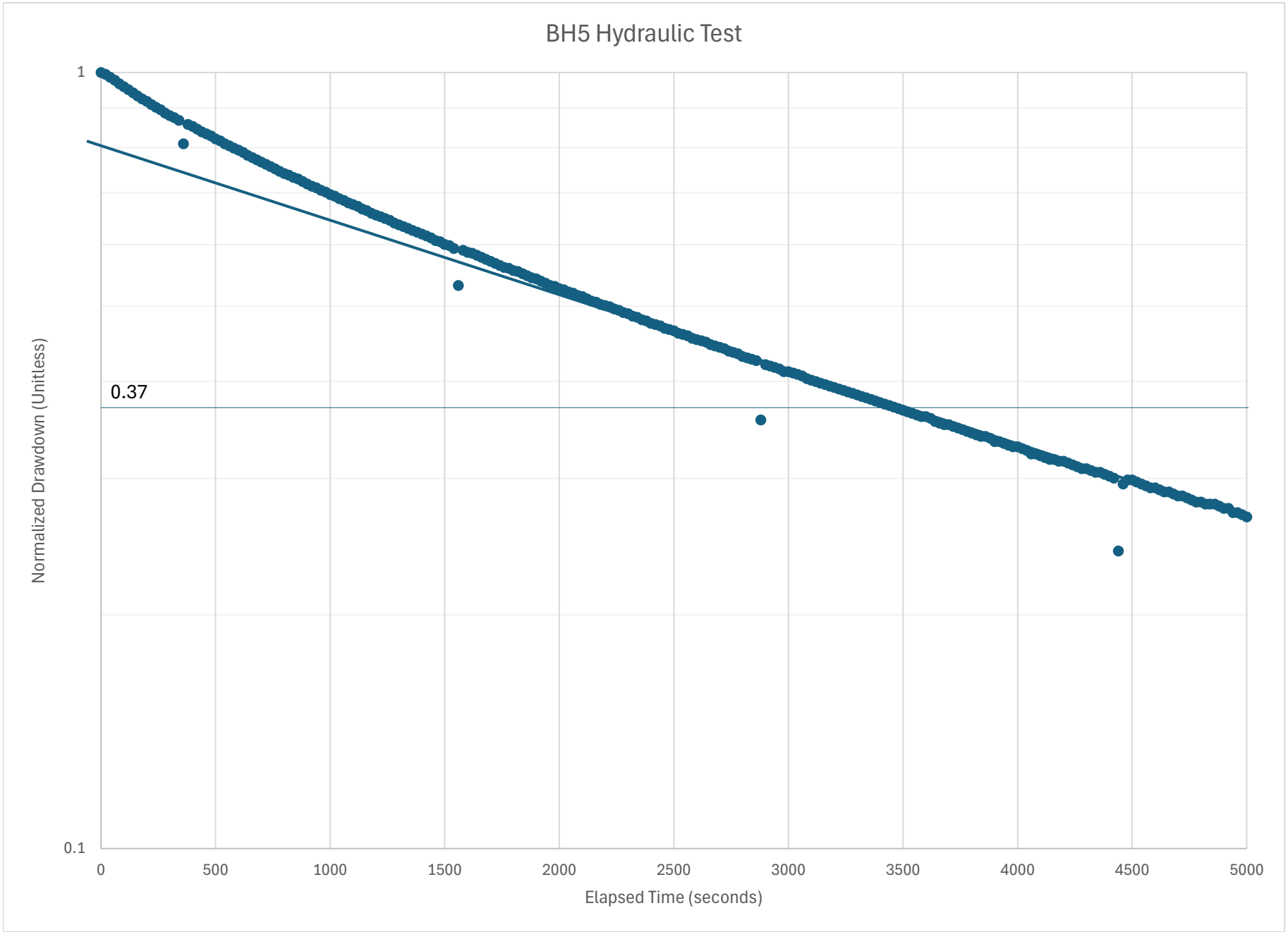
Appendix D

Hydraulic Conductivity Test Results


BH2 Hydraulic Test
1
0.37
0.1
Normalized Drawdown (Unitless)
0
100
200
300
400
500
600
Elapsed Time (seconds)


BH3 Hydraulic Test
1
0.37
0.1
Normalized Drawdown (Unitless)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Elapsed Time (seconds)


BH4 Hydraulic Test
1
0.37
0.1
Normalized Drawdown (Unitless)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Elapsed Time (seconds)


BH5 Hydraulic Test
1
0.37
0.1
Normalized Drawdown (Unitless)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Elapsed Time (seconds)

Appendix E

Water Balance and Dewatering Calculations

Thornthwaite and Mather Components - Waterloo Ontario

August 21, 2024

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 100 mm

Climate data from Kitchener Waterloo Climate Station (1991 - 2020)

POTENTIAL EVAPOTRANSPIRATION CALCULATIONS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Average Temperature (Degree C) [1]	-6.3	-5.9	-0.8	5.9	12.6	17.8	20.2	19.1	15.2	8.8	2.6	-2.8	**8.1**
Precipitation (P) [1]	66.3	46.1	57	81.2	80.2	80.5	96.2	67.2	75.2	71	74.9	54.9	**851**
Heat index: i = (t/5)$^{1.514}$	0.00	0.00	0	1.28	4.05	6.84	8.28	7.61	5.38	2.35	0.37	0.00	**36.2**
Adjusting Factor for U (Latitude 43 N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77	
Unadjusted Daily Potential Evapotranspiration U (mm)	0	0	0	27	61	88	100	95	74	41	11	0	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	30	76	112	130	114	77	39	9	0	**588**
P - PET	66	46	57	51	4	-32	-33	-46	-2	32	66	55	263
APWL	0	0	0	0	0	-32	-65	-112	-114	0	0	0	
Soil Moisture Storage max 100 mm	166	146	157	100	100	73	51	32	31	63	100	155	
Soil Moisture Deficit max 100 mm	0	0	0	0	0	5	11	27	1	0	0	0	
Change in Soil Moisture Storage	0	0	0	0	0	-27	-22	-19	-1	32	37	0	
Actual Evapotranspiration (AET) (mm)	0	0	0	30	76	108	118	86	76	39	9	0	**543**
Surplus Water (P-AET) (mm) - for infiltraiton or runoff	66	46	57	51	4	0	0	0	0	0	28	55	**308**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	40	28	34	31	2	0	0	0	0	0	17	33	**185**
Potential Direct Surface Water Runoff (independent of temperature)	27	18	23	20	1	0	0	0	0	0	11	22	**123**
IMPERVIOUS COMPONENTS - WATER SURPLUS (RUNOFF AND EVAPORATION)													
Precipitation (P) (mm)	66	46	57	81	80	81	96	67	75	71	75	55	**851**
Potential Evaporation (PE); Assume 15% (mm)	10	7	9	12	12	12	14	10	11	11	11	8	**128**
Potential Surface Water Runoff (P-PE) (mm)	56	39	48	69	68	68	82	57	64	60	64	47	**723**

Assume January storage is 100% of Soil Moisture Storage

Soil Moisture Storage [3] - pasture and shrubs in fine sandy loam soils: 100 mm

MOE SWM infiltration calculations [4]

topography -flat	0.3
Soils - medium	0.2
cover - cultivated land (wetland/pasture)	0.1
Infiltration factor	**0.6**

Latitude of site (or climate station): 43 ^{O} N

Notes:

1. Environment Canada Climate Normals (Stouffville WCPC, 1971-2000)
2. Lorente, J.M. 1961. Pg. 206 "Adjusting Factors for U".
3. MOE SWMPDM. 2003. Table 3.1 "Water Holding Capicity" values.
4. MOE SWMPDM. 2003. Table 3.1 "Infiltration Factors" values.

380 Hagey Boulevard, Waterloo, Ontario
Water Balance April 4, 2025

Feature	Description	Factor
Cover	Cultivated	0.1
Cover	Woodland	0.2
Soil	Medium	0.2
Soil	Open Sandy	0.4
Soil	Tight	0.1
Topo	Flat	0.3
Topo	Hilly	0.1
Topo	Rolling	0.2
Infiltration Factor		0.6

Pre Development Conditions

	Value	Units	
Precipitation Rate	851	mm/year	
Evapotranspiration Rate	543	mm/year	
Open Water Evaporation Rate	652	mm/year	
Impervious Surface Evaporation Rate	170	mm/year	20% of PT
Impervious Surface Runoff Rate	681	mm/year	
Total Area	1.6100	hectare	
Wetland Area	0.00	hectare	

Pre-Development Water Balance

	Area	Precipitation	Evapotranspiration/ Evaporation	Runoff	Infiltration
	(hectare)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)
Pervious	1.61	13,696	8,746	1,980	2,970
Impervious	-	-	-	-	-
Pre Development Summary	1.6100	13,696	8,746	1,980	2,970

Impervious Areas (assume 20% evaporation)

Post Development Conditions

		Units		
Precipitation	851	mm/year		
Evapotranspiration Landscaped Area	543	mm/year		
Impervious Surface Evaporation	170	mm/year		
Impervious Surface Runoff	681	mm/year		
Total Area	1.6100	hectare	Infiltration Factor	
Pervious	0.3509	hectare	0.6	Based on Cultivated, Medium Soil and Flat Topo
Impervious	1.2591	hectare		
Total Area	1.6100			
Roof Top	0.3223			

Post Development Water Balance

	Area	Precipitation	Evapotranspiration/ Evaporation	Runoff	Infiltration
	(hectare)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)
Development Pervious	0.35	2,985	1,906	432	647
Impervious	1.26	10,711	2,142	8,569	-
Post Development Summary	1.6100	13,696	4,048	9,001	647

Summary of Pre to Post Development Water Balance

	Area	Precipitation	Evapotranspiration/ Evaporation	Runoff	Infiltration
	(hectare)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)
Pre Development Summary	1.61	13,696	8,746	1,980	2,970
Post Development Summary	1.61	13,696	4,048	9,001	647
Potential Difference without LID Strategies	-	-	- 4,697.19	7,020	- 2,323

Summary of Pre to Post Development Water Balance including Low Impact Development Strategies

	Area	Precipitation	Evapotranspiration/ Evaporation	Runoff	Infiltration
	(hectare)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)
Roof Leader Infiltration (0.3223 hectare of rooftop x 80% x 851 mm/year precipitation)					2,193
Infiltration on Pervious Surface Post Development					647
Total Potential Infiltration with Roof Water					2,841

HARDEN

APPENDIX F
Groundwater Dewatering Calculations

SERVICING TRENCHES

Construction Dewatering Calcuations (Worst-Case Conditions Estimate)

Dupuit-Forchheimer equation to calculate flow from a line source into a trench or linear excavation in an unconfined aquifer:

$$Q = \frac{xK(H^2 - h^2)}{L}$$

Note: forumla estimates flow from both sides of the linear excavation

Where:

- Q = pumping rate (m^3/s)
- x = length of the trench (m)
- K = hydraulic conductivity (m/s)
- H = hydraulic head of the original water table (m)
- h = hydraulic head at the base of the trench (m)
- L = equivalent radius of influence for a line source (m)
- R_o = radius of influence of Well or Point Source (m)

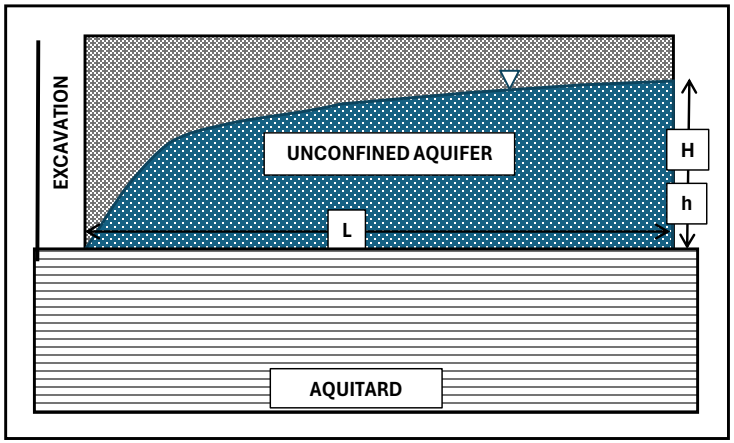
Sichart and Kryieleis equation to estimate the equivalent radius of influence (R_o) from a line source (L):

$$R_o = 3000(H - h)\sqrt{K}$$

Equivalent distance to linear source (L) from radius of influence (Ro):

$$L = R_o$$

Unconfined flow from a line source to a drainage trench



Input Parameters:

Ground Surface Elevation	347.50	masl	
Static Water Elevation	346.20	masl	highest GW level
Excavation Invert	345.00	masl	
Dewatering Base Elevation	344.00	masl	
Dewatering Drawdown	2.20	m	
Base of Aquifer	333.50	masl	
Hydraulic Conductivity K =	1.00E-06	m/s	Highest K
Excavation Length x =	20	m	Estimated total for servicing
Excavation Area =	200	m^2	assumes 2m trench width

Calculated Flow Q for Construction Dewatering:

Q =	0.00015	m^3/s	Flow from both sides of trench
Q =	13	m^3/day	Flow from both sides of trench
	13,363	**L/day**	**Estimated peak daily flow**
	26,726	**L/day**	**Incorporates x2 safety factor**
Rainwater Allowance	50	mm/day	
Rainwater Volume	10,000	L/day	
Total Estimated Q =	**23,363**	**L/day**	
	36,726	**L/day**	**Incorporates x2 safety factor plus rainwater allowance**

Calculated Parameters:

Saturated aquifer thickness (static)	H =	12.7 m
Saturated aquifer thickness (pumping)	h =	10.5 m
Radius of Dewatering Influence	**R_o =**	**6.6 m**
Dewatering Influence - Line Source Distance	**L =**	**6.6 m**

Reference:

Powers, J.P., A.B. Corwin, P.C. Schmall and W.E. Kaeck, 2007. Construction dewatering and groundwater control, new methods and approaches, 3rd ed. John Wiley & Sons, Inc.