Hydrogeological Package

Hydrogeological Investigation

GEI Consultants

Consulting Engineers and Scientists

Hydrogeological Investigation

Proposed Firehall 6

845 Mapleview Drive East
Barrie, Ontario

Submitted to:
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1. Introduction

GEI Consultants (GEI) was retained by The Corporation of the City of Barrie (the Client) to complete a subsurface investigation and provide a hydrogeological report for the proposed Firehall 6 at 845 Mapleview Drive East, in Barrie, Ontario. A site location plan is provided as Figure 1.

The site is located at the southwest corner of the intersection of Mapleview Drive East and Prince William Way, in Barrie, Ontario. The site is irregular in shape and is about 7,200 m^2 in size. The site is currently part of a residential subdivision that is under development. The immediate area is predominately residential land uses, with a school located to the east.

Prior to the residential subdivision development, the site contained a single-family residential dwelling in the western portion with a forest and small pond in the eastern portion. The pond appears to have been filled in between 2012 and 2013 based on aerial images from the County of Simcoe online mapping service. More recently, it is understood that the site contained a temporary Storm Water Management (SWM) pond and just prior to the geotechnical field work the pond was backfilled with engineered fill.

GEI was provided with the following drawings for review:

- *"Plan of Survey Showing Topography for #845 Mapleview Drive East being Block 206, Plan 51M-1224 (Geographic Township of Innisfil), City of Barrie, County of Simcoe"* Drawing No. E-3933, dated October 12 2022, by Dearden and Stanton Ltd.
- *"Hewitt's Gate – Draft Plan of Subdivision",* dated 2017, by the Jones Consulting Group.

Based on the RFP, a two-storey structure is proposed, and a basement is being considered. The building will about 4,500 sq. ft. (3,000 sq. ft. of finished area and 1,500 sq. ft. of garage space). The facility will be connected to municipal servicing, however at this time no servicing plans have been provided. Paved parking and access will be provided. The current site plans are preliminary and may be subject to change. An aerial image of the site is provided on Figure 2A and the proposed site plan is shown on Figure 2B.

It is noted that a geotechnical investigation and report was completed by GEI concurrently and is reported under separate cover.

1.1 Purpose and Scope of Work

The main objectives of the hydrogeological Investigation were to:

a) Establish the local hydrogeological settings of the site;

b) Provide an assessment of anticipated construction dewatering flow rates for a general servicing scenario;

c) Assess use of Low Impact Development (LID) measures;

d) Assess groundwater quality and compare the results to the applicable City of Barrie Storm Sewer Use By-Law Criteria, Provincial Water Quality Objective (PWQO), and O.Reg.153/04, as amended, Site Condition Standards (SCSs);

e) Qualitatively assess the potential impact from dewatering to the nearby structures, water bodies and water uses, if any, and comment on future regulatory agency involvement;

f) Complete a water balance (pre- and post-construction); and,

g) Prepare a hydrogeological investigation report.

To achieve the investigation objectives, GEI proposed and initiated the following scope of work:

a) Conduct a background desktop review of pertinent geological and hydrogeological resources, Ministry of Environment, Conservation and Parks (MECP) Water Well Records, previous reports, and proposed site plan drawings.

b) Visit the site and note existing site conditions, site setting, topography, drainage, water features, and potential water wells within 500 m of the site, if any.

c) Utilization of the six (6) boreholes and three (3) monitoring wells, completed as part of the concurrent geotechnical investigation.

d) Revisit the site and measure groundwater levels, perform borehole permeability testing in three (3) monitoring wells, and retrieve representative groundwater samples.

e) Submit one (1) representative unfiltered groundwater sample for laboratory testing to compare against the Town of Barrie Storm Sewer Use By-Law Criteria, PWQO standards for Metals and Total Suspended Solids (TSS) and, O.Reg. 153/04, as amended, for Petroleum Hydrocarbons (PHCs), and Volatile Organic Compounds (VOCs).

f) Submit one (1) representative filtered groundwater sample for laboratory testing to compare against the PWQO standards for Metals and TSS.

g) Evaluate the background information, and field and laboratory data to assess construction dewatering and permanent dewatering requirements.

h) Complete a water balance (pre- and post-construction) for the proposed development.

1.2 Regulatory Requirements for Water Taking

1.2.1 Water Taking – Temporary

The volume of water entering the excavation during construction will be based on both groundwater infiltration and precipitation events. Based on O.Reg. 63/16, the following dewatering limits and requirements are as follows:

- Construction Dewatering less than 50,000 L/day: The takings of both groundwater and stormwater does not require a hydrogeological report, does not require registration on the Environmental Activity and Sector Registry (EASR), and does not require a Permit-to-Take-Water (PTTW) from the MECP.
- Construction Dewatering greater than 50,000 L/day and less than 400,000 L/day: The taking of groundwater and/or stormwater requires a hydrogeological report and registration on the EASR but does not require a PTTW from the MECP.
- Construction Dewatering greater than 400,000 L/day: The taking of groundwater and/or stormwater requires a hydrogeological report and requires a PTTW from the MECP.

1.2.2 Source Water Protection

The site is within the jurisdiction of the Lake Simcoe Region Conservation Authority (LSRCA). The site is also within the Lake Simcoe and Couchiching / Black River Source Protection Area, in the South Georgian Bay Lake Simcoe Source Protection Region. The following documents should be used in determination of the regulatory requirements when it comes to maintaining hydrogeological function at this site:

- *"Lake Simcoe Protection Plan",* dated July 2009, by MOECC, MNR & LSRCA.
- *"Approved South Georgian Bay Lake Simcoe Source Protection Plan*", dated January 26, 2015, by LSRCA.
- *"Lake Simcoe Protection Plan Water Budget Policy for LSPP 4.8-DP and 6.40-DP,"* dated November 2018, by LSRCA.

Based on Source Water Protection online mapping, the following is noted:

- Wellhead Protection Area (WHPA): The site is not located within a WHPA Zone A to D nor a WHPA Q2 (Figure 3).
- Intake Protection Zone (IPZ): The site is not located within an IPZ (Figure 4).
- Highly Vulnerable Aquifer (HVA): The site is not located within an HVA (Figure 5).
- Significant Groundwater Recharge Area (SGRA): The site is not located within an SGRA (Figure 6).
- The site is not located within the Oak Ridges Moraine.
- The site is not located within the Niagara Escarpment.

"Lake Simcoe Protection Plan Water Budget Policy for LSPP 4.8-DP and 6.40-DP," (by LSRCA, dated November 2018) Section 6.0 describes the policy hierarchy for water balance required for Lake Simcoe Watershed. The policies from most to least stringent are described below:

- Source Protection Plan Land Use Policy (SPP LUP) 12: *"Planning Approval Authorities shall only permit new major development (excluding single detached residential, barns and non-commercial structures that are accessory to an agricultural operation) in a WHPA-Q2 where the activity would be a significant drinking water threat, where it can be demonstrated through the submission of a hydrogeological study that the existing water balance can be maintained through the use of best management practices such as low*

impact development. Where necessary, implementation and maximization of off-site recharge enhancement within the same WHPA-Q2 to compensate for any predicted loss of recharge from the development."

- Designated Policy (DP) 6.40: *"Outside of the Oak Ridges Moraine area, an application for major development within a significant groundwater recharge area (SGRA) shall be accompanied by an environmental impact study that demonstrates that the quality and quantity of groundwater in these areas and the function of the recharge areas will be protected, improved or restored."*
- Designated Policy (DP) 4.8d: *"An application for major development shall be accompanied by a stormwater management plan that demonstrates: through an evaluation of anticipated changes in the water balance between pre-development and post-development, how such changes shall be minimized."*

The site is a "major development," and is not within a WHPA Zone Q2, not within an HVA, and is not within an SGRA, therefore DP-4.8d only applies to the site. A water balance and recommended mitigation measures are discussed in Section 5. Based on Table 2 in *"Lake Simcoe Protection Plan Water Budget Policy for LSPP 4.8-DP and 6.40-DP,"* infiltration-based practices may not be permitted from parking lots for the development (to be confirmed based on the land use classification). Infiltration of runoff from vegetated areas and rooftops is always permitted.

2. Background Review

The site is located at the southwest corner of the intersection of Mapleview Drive East and Prince William Way, in Barrie, Ontario. The site is irregular in shape and is about 7,200 m^2 in size. The site is currently part of a residential subdivision that is under development. The immediate area is predominately residential land uses, with a school located to the east.

Prior to the residential subdivision development, the site contained a single-family residential dwelling in the western portion with a forest and small pond in the eastern portion. The pond appears to have been filled in between 2012 and 2013 based on aerial images from the County of Simcoe online mapping service. More recently, it is understood that the site contained a temporary Storm Water Management (SWM) pond and just prior to the geotechnical field work the pond was backfilled with engineered fill.

2.1 Site Physiographic, Geologic and Hydrogeological Settings

The site is located approximately 310 m east of Hewitt's Creek, which outlets into Kempenfelt Bay (2.5 km north of the site). The site is within the Lake Simcoe Watershed and the Hewitt's Creek subwatershed, within the jurisdiction of the LSRCA.

The site is located within the physiographic region denoted as the Peterborough Drumlin Field and the local terrain is characterized by drumlinized till plains (Chapman and Putnam, 1984). The surficial geology of the site per the Ontario Geological Survey is described as stone-poor, sandy silt to silty sand-textured till on Paleozoic terrain.

The bedrock underlying the general area corresponds to the Verulam Formation, consisting of limestone and shale. Based on the MECP Water Well Records in the area, bedrock is anticipated at depths greater than 135 m below existing grade. Map P.170 from the Ontario Department of Mines, *"Drift Thickness Series, Barrie Area,"* (scale 1:50,000, compiled by G. L. Burwasser and M. J. Ford, 1974) indicates that bedrock could be encountered near Elev. 140 m, or about 120 m below grade at the site.

Topography mapping provided inline by the MECP indicates the surrounding area generally drains east into Hewitt's Creek. It is expected that storm sewers beneath Mapleview Drive flow east to Hewitt's Creek as well.

2.2 Review of MECP Water Well Records and Existing Water Wells

MECP water well records were obtained within 500 m of the site area to assess the general nature of the groundwater resource in the near vicinity of the site, and historical/current uses of wells in the area. One (1) well record was found on Site and twenty (20) well records were found off-site, the approximate MECP well locations are shown on Figure 7 and a well records summary table is included in Appendix A.

The on-Site well(s) was/were installed for the following use(s):

- One (1) of the records indicate domestic use and/or livestock use.

The off-site well(s) was/were installed for the following uses:

- Nine (9) of the records indicate domestic use and/or livestock use.
- Five (5) of the records indicated monitoring and observation use.
- Six (6) of the records indicated “Other” use or did not indicate the well use and are assumed to be unknown.

The stratigraphic descriptions within the MECP monitoring well records are typically inaccurate due to the methodology in which they are determined (observations of cuttings and no consistency between descriptions of soil between different drillers). Though this is the case, an overall sense of the deep stratigraphy can be determined by looking at commonalities between most stratigraphic descriptions and where the wells were terminated in an aquifer. The well records typically indicate sand and clay layers with some silt and variable gravel over limestone.

The noted domestic water supply wells were typically installed in the sand overburden with one installed in the limestone bedrock. It is noted that fresh water was encountered at depths of 4.5 to 100 m in the domestic water supply wells. As the surrounding area is municipally serviced or currently under development, it is expected that the domestic wells are no longer in use.

Stroud Municipal Supply Wells 1, 2, and 3 are located about 2.4 km south / southeast of the site. The site is not within a WHPA related to these wells.

2.3 Site Condition Standards

The MECP has developed a set of Soil, Ground water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act (April 15, 2011) and O. Reg. 153/04, as amended. The standards consist of nine tables (Table 1 through Table 9) that provide criteria for maximum concentrations of various contaminants. In general, the applicable O. Reg. 153/04, as amended, SCSs depend on the site location, land use, soil texture, bedrock depth and the applicable potable or non-potable ground water condition at the investigation site.

In order to determine the Site Sensitivity, Sections 41 and 43.1 of O. Reg. 153/04, as amended, were evaluated by GEI as shown in the following table:

CRITERIA	RESULT
Current Property Use	Vacant
Potable vs. Non-Potable Ground Water	Potable
Proximity of Areas of Natural Significance	> 30 m
Proximity to a Water Body	> 30 m
Shallow Soil Condition	No
Land Use	Residential/Parkland/Institutional (RPI)
Applicable Site Condition Standard	Table 2: Full Depth Generic Site Condition Standards in a Potable Ground Water Condition (Table 2 RPI)

2.4 Visual Inspection of the Site

A visual site inspection was carried out on December 7, 2022, by GEI staff to assess site drainage, topography and presence of surface water features.

The site is located at the southwest corner of the intersection of Mapleview Drive East and Prince William Way, in Barrie, Ontario. The site is about 130 m (east to west) by 60 m (north to south).

The site is irregular in shape and is about 7,200 m^2 in size. The site is currently part of a residential subdivision that is under development. The immediate area is predominately residential land uses, with a school located to the east.

The topography of the site is relatively flat with a gentle slope to the west / southwest from the eastern limit of the site towards the western limit such that there is an overall change in elevation of approximately 1.3 m. The local elevation across the site as measured at the boreholes, was approximately 256.3 m above sea level (masl) at the eastern limit and 255 masl at the western limit. The areas surrounding the site appear to slope westward toward Hewitt's Creek.

No water bodies were identified on Site.

3. Procedures and Methodology

Borehole locations are shown on Figures 2A and 2B, borehole logs are provided in Appendix B, and results from the geotechnical laboratory testing are provided in Appendix C.

It is noted that all elevations in this report are metric and expressed in metres (m). All measurements are also in metric and expressed in millimetres (mm), metres (m) or kilometres (km).

Prior to the commencement of drilling activities, the locations of underground utilities including natural gas, electrical, telephone, water, etc. were marked out by public and private utility locating companies. The fieldwork for the drilling program was carried out on September 22, 2022. A total of six (6) boreholes (Boreholes 1 to 6) were advanced on site by a drilling subcontractor retained by GEI. The boreholes were advanced using a truck-mounted drill, hollow stem augers, and standard soil sampling equipment. All samples were collected as per ASTM D1586 to assess the strength characteristics of the substrate. Borehole logs are provided in Appendix B.

A total of six (6) boreholes were laid out, four (4) (BHs 1 to 4) were advanced to 6.6 m depth below existing grade and two (2) (BHs 5 and 6) were advanced to 2.0 to 2.2 m depth below existing grade.

Three (3) monitoring wells were installed (Borehole/Monitoring Wells 1 to 3) by GEI to facilitate long-term groundwater monitoring, sampling, and in-situ testing. Monitoring well construction is shown on the borehole logs in Appendix B.

The horizontal locations were laid out in the field by GEI prior to the drilling operations. Borehole ground surface elevations of the boreholes and coordinates (referencing NAD 83 geodetic datum) were surveyed by GEI with a Topcon FC – 5000 GPS Survey unit.

The GEI field staff examined and classified characteristics of the soils encountered in the boreholes, including the presence of fill materials, made groundwater observations during and upon completion of the drilling, recorded observations of borehole construction, and processed the recovered samples. Soil sampling was conducted at regular intervals for the full depth of the borehole. All recovered soil samples were logged in the field, carefully packaged, and transported to the laboratory for more detailed examination and classification. In the laboratory, the samples were classified as to their visual and textural characteristics and geotechnical laboratory testing for grain size was carried out with the results provided in Appendix C.

3.1 Borehole Permeability Testing

Rising head tests were completed in the three (3) monitoring wells on site on December 7, 2022. Water was manually purged from monitoring wells using LDPE piping and a foot valve. The static water level was measured prior to the start of testing, and the change in water level was monitored using an electronic level logger. The level loggers were left in the monitoring wells to allow for adequate recovery of the groundwater. The tests were completed to estimate the horizontal hydraulic conductivity (K) of the soils at the well screen depths. The semi-log plot for drawdown versus time for the tests are provided in Appendix D.

3.2 Groundwater Sampling

To establish baseline conditions and assess the suitability for discharge of pumped groundwater to surface during potential dewatering activities, the following groundwater samples were collected from BH/MW 3 on December 7th, 2022:

- One (1) unfiltered groundwater sample was collected from BH/MW 3 and analyzed against the City of Barrie Storm Sewer Use By-Law Criteria, PWQO Metals, TSS, and O.Reg.153/04, as amended, PHCs and VOCs.
- One (1) filtered groundwater sample was collected from BH/MW 3 analyzed against PWQO Metals and TSS only.

Prior to collection of the samples, approximately three (3) standing well volumes of groundwater were purged from the well. The samples were collected and placed into pre-cleaned laboratory-supplied vials and/or bottles provided with analytical test group specific preservatives, as required. Dedicated nitrile gloves were used during sample handling. The field filtered samples were processed through a 45 µm filter prior to collection in the required vials/bottles. The samples were submitted to CALA- accredited Caduceon Environmental Laboratories for analysis. The results of the groundwater chemistry are presented in the laboratory Certificates of Analysis provided in Appendix E.

4. Subsurface Conditions

4.1 General Overview

The borehole locations are shown on Figures 2A and 2B and detailed subsurface conditions are presented on the borehole logs in Appendix B. The soil conditions encountered at the borehole locations are summarized below. Stratigraphic cross-sections across the property (as aligned on Figures 2A and 2B) are included in Figures 8 and 9.

It should be noted that the conditions indicated on the borehole logs are for specific locations only and can vary between and beyond the locations. It should be noted that the soil boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones and should not be interpreted as exact planes of geological change.

In addition, the descriptions provided in the borehole logs are inferred from a variety of factors, including: visual observations of the soil samples retrieved, laboratory testing, measurements prior to and after drilling, and the drilling process itself (speed of drilling, shaking/grinding of the augers, etc.). The passage of time also may result in changes in conditions interpreted to exist at locations where sampling was conducted.

4.2 Stratigraphy

4.2.1 Fill

A fill layer was encountered in all the boreholes at the surface and was penetrated at 1.5 to 3.0 m depth (Elev. 252.4 to 254.4). The fill typically consisted of silty sand to sandy silt with trace gravel. One (1) sample of the material was submitted for grain size analysis and the results are provided on Figure C1 in Appendix C. The fill was moist with moisture contents ranging from 5 to 17%. The fill had N values ranging from 5 to 38 indicating a loose to dense condition.

It is understood that the site was once a former temporary SWM pond and prior to the field investigation the pond/site was graded with engineered fill to the current grade. The report regarding the compaction of the engineered fill was provided to GEI for review. The report indicates that the loose/weak/poor/saturated soil was removed, and inorganic site soil was utilized as engineered fill which was placed in the pond area and the area surrounding the pond to bring the site to the surrounding grade level. The report also indicates that the engineered fill was compacted to a minimum of 98% Standard Proctor Maximum Dry Density (SPMDD).

4.2.2 Glacial Till

A glacial till deposit was observed under the fill in all the boreholes. The till extended to 3.0 to 4.6 m depth (Elev. 250.9 to 252.3) in Boreholes 1 to 4 and extended to the 2.0 m depth of exploration (Elev. 253.1 to 253.9) in Boreholes 5 and 6. The till matrix consisted of silty sand to sandy silt, with trace to some gravel and clay. One (1) sample of the material was submitted for grain size analysis and the results are provided on Figure C2 in Appendix C. The soil was moist,

and moisture contents were 7 to 12%. N values in the material were 7 to 16 blows indicating a loose to compact condition.

4.2.3 Sand/Silty Sand

A lower layer of sand, locally silty sand in Borehole 4, was observed in Boreholes 1 to 4 below the till at depths of 3.0 to 4.6 m (Elev. 250.9 and 252.3) and extended to 6.6 m depth of exploration (Elev. 248.7 to 249.7). The material was wet with moisture contents of 8 to 21%. The sand or silty sand was compact to very dense with N values of 16 to greater than 100. Two (2) samples of the material were submitted for grain size analysis and the results are provided on Figure C3 in Appendix C.

4.3 Groundwater Level Monitoring

Monitoring wells were installed in three (3) boreholes (Borehole/Monitoring Wells 1 to 3) to facilitate the measurements of stabilized groundwater levels. A 50 mm diameter PVC monitoring well with a 1.5-metre-long screen and protective casings were installed. Monitoring well construction and groundwater measurements are shown on the borehole logs in Appendix B, and the results are summarized in the table below.

Borehole / Monitoring Well	Well Screen Location Depth (m) / Elev. (m)	Unit Screened	Depth of Cave Depth (m) / Elev. (m)	Unstabilized Groundwater Level Depth (m) / Elev. (m)	Stabilized Groundwater Level (October 18, 2022) Depth (m) / Elev. (m)	Stabilized Groundwater Level (December 7, 2022) Depth (m) / Elev. (m)
1	4.3 to 5.8 / 251.2 to 249.7	Silty Sand to Sandy Silt Glacial Till / Sand	Open	4.0 / 251.5	2.5 / 253.0	2.4 / 253.1
2	4.3 to 5.8 / 252.0 to 250.5	Silty Sand to Sandy Silt Glacial Till / Sand	Open	4.0 / 252.3	2.5 / 253.8	2.5 / 253.8
3	4.1 to 5.6 / 251.2 to 249.7	Sand	Open	3.1 / 252.2	2.1 / 253.2	2.0 / 253.3

The stabilized groundwater level measurements were observed at 2.0 to 2.5 m depth, corresponding to Elev. 253.1 to 253.8 m. As shown on Figure 10, the groundwater locally beneath the site flows to the west / northwest. It is anticipated that the more regional groundwater flow will be west towards Hewitt's Creek. Groundwater levels are expected to show seasonal fluctuations and vary in response to prevailing climate conditions.

The existing variable silty sand to sandy silt glacial till are semi-permeable and will generally allow for the free flow of ground water when wet. The sand is permeable and will allow for the free flow of water when wet.

GEI is measuring groundwater levels monthly at the site for one year, to determine the seasonal high levels. The results will be summarized in a future report.

4.4 Hydraulic Conductivity Testing

Hydraulic conductivity tests were conducted in three (3) of the monitoring wells (Boreholes 1 to 3) and values were calculated from the rising head test data using Hvorslev's solution (1951) where the well screen was fully saturated. The semi-log plots for the results are provided in Appendix D and are summarized in the table below.

Borehole / Monitoring Well	Well Screen Location Depth (m) / Elev. (m)	Strata Screened	In-Situ Hydraulic Conductivity (K) (m/s)
1	4.3 to 5.8 / 251.2 to 249.7	Silty Sand to Sandy Silt Glacial Till / Sand	2.5×10^{-5}
2	4.3 to 5.8 / 252.0 to 250.5	Silty Sand to Sandy Silt Glacial Till / Sand	1.5×10^{-5}
3	4.1 to 5.6 / 251.2 to 249.7	Sand	3.6×10^{-5}

According to Freeze and Cherry (1979), the typical range in hydraulic conductivity is as follows:

- Sand: 10^{-2} m/s to 10^{-6} m/s
- Silty Sand: 10^{-3} m/s to 10^{-7} m/s
- Silt: 10^{-5} m/s to 10^{-9} m/s
- Glacial Till: 10^{-6} m/s to 10^{-12} m/s

The actual measured in-situ hydraulic conductivities for the well screened in sand indicate that 3.6×10^{-5} m/s is appropriate for water taking calculations at this site.

Some additional discontinuous zones of perched water may also be encountered within silty sand to sandy silt glacial till, or within the upper zones of earth fill. These zones, if encountered, are expected to be of limited extent.

4.5 Groundwater Quality

To assess the suitability for discharge of pumped groundwater to the land surface or City storm sewers during dewatering activities, two (2) groundwater samples, one (1) unfiltered and one (1) filtered, were collected from Borehole / Monitoring Well 3 on December 7, 2022.

For the assessment purposes, the analytical results were compared to the Town of Barrie Storm Sewer Use By-Law Criteria, PWQO, and/or O.Reg.153/04, as amended, Table 1 SCSs (the most stringent SCS). The results of the groundwater chemistry are presented in the laboratory Certificates of Analysis provided in Appendix E. A summary of the results is presented in the table below for samples relative to the City of Barrie Storm Sewer Use By-Law Criteria, PWQO, and O.Reg. 153/04, as amended, standards.

Monitoring Well Sample Location	Parameters Tested	Exceedances of City of Barrie Storm Sewer Use By-Law Criteria	Exceedances of PWQO	Exceedances of O.Reg.153/04, as amended, Table 1 SCSs.
BH/MW 3 (Unfiltered)	City of Barrie Storm Sewer Use By-Law PWQO: Metals, TSS O.Reg. 153/04: PHCs, BTEX, VOCs	Copper, TSS	PWQO: Chromium, Iron Interim PWQO: Aluminum, Cobalt, Copper, Lead, Vanadium, Zirconium	O.Reg.153/04: Chloroform
BH/MW 3 F (Filtered)	PWQO Metals, TSS	No Exceedances	No Exceedances	Not Tested

The unfiltered groundwater sample collected from BH/MW 3 exceeded the parameters tested for the City of Barrie Storm Sewer Use By-Law for copper and TSS, but met for the other parameters. Field filtering reduced the TSS concentration from 466 mg/L to less than 3 mg/L and reduced the copper concentration to meet the requirements for Town of Barrie Storm Sewer Use By-Law Criteria.

Compared to PWQO metals, exceedances were detected in the unfiltered groundwater sample for chromium and iron, and compared to interim PWQO metals, exceedances were detected for aluminum, cobalt, copper, lead, vanadium, and zirconium. The field filtered groundwater sample met PWQO metals guidelines.

If pumped groundwater will be discharged to the City of Barrie Storm Sewer or to the land surface, it must be suitably treated to remove the parameter exceedances prior to discharge (treatment methods to be determined by the dewatering contractor or civil engineer). Based on the results above, treatment of the dewatering discharge water by filtration or sedimentation to reduce the concentration of suspended solids, and thus reduce the concentrations of non-dissolved metals, is necessary and may be effective in achieving compliance with PWQO and City Storm Sewer criteria. However, other treatment methods may be necessary to reduce the concentration of dissolved analytes.

It is expected that during construction dewatering, the pumped water is to be first discharged to a silt bag and/or sedimentation tank, at a minimum, before being discharged to surface.

An exceedance for chloroform was detected compared to O. Reg. 153/04 Table 1 and Table 2 SCSs, as amended. To further assess the chloroform exceedance, the following groundwater sample was collected from BH/MW 3 on January 3rd, 2023:

- One (1) unfiltered groundwater sample was collected from BH/MW 3 and analyzed against O.Reg.153/04, as amended, for chloroform only.

Prior to collection of the samples, approximately one (1) standing well volume of groundwater was purged from the well. The sample was collected and placed into pre-cleaned laboratory- supplied

vials and/or bottles provided with analytical test group specific preservatives, as required. Dedicated nitrile gloves were used during sample handling. The samples were submitted to CALA- accredited Caduceon Environmental Laboratories for analysis. The results of the groundwater chemistry are presented in the laboratory Certificates of Analysis provided in Appendix E. A summary of the results is presented in the table below for the sample relative to the O.Reg. 153/04, as amended, standard.

Monitoring Well Sample Location	Parameters Tested	O.Reg. 153/04 Table 1 SCS (µg/L)	O.Reg. 153/04 Table 2 RPI SCS (µg/L)	Concentration Detected December 7th, 2022 (µg/L)	Concentration Detected January 3rd, 2023 (µg/g)
BH/MW 3 (Unfiltered)	Chloroform	2	2.4	4	3

It therefore appears that a minor existing background concentration of chloroform exists in the groundwater beneath the site. The chloroform concentration is only 1 to 2 µg/L above the O. Reg. 153/04 Table 1 SCS, as amended.

4.6 Preliminary Infiltration Rates

Determination of percolation rates are based on the "*Ministry of Municipal Affairs and Housing (MMAH) Supplementary Guidelines SB-6, Percolation Time and Soil Descriptions, September 14, 2012*". The boreholes indicate earth fill was encountered at surface overlying cohesionless deposits of mainly silty sand to sandy silt glacial till over sand. The results of the particle size distribution analysis are included in Appendix C. The Unified Soil Classification System classifications for the predominant soils encountered on-site are summarized below with the interpreted unfactored percolation rates (T-Time) and unfactored infiltration rates:

Unified Soil Classification System Classification	Unfactored Percolation Rate (T-Time) (mins/cm)	Unfactored Infiltration Rate (mm/hr)
M.L. Inorganic silts and very fine sands	20 to 50	12 to 30

These infiltration rates are not applicable below the groundwater table. It is generally not recommended to infiltrate into earth fill zones unless uniform soil was imported to the site and used as engineered fill. Appendix C of *"Low Impact Development Stormwater Management and Planning Design Guide"* (Version 1.0, 2010, by CVC and TRCA) suggests safety factors to be applied to infiltration rates. The safety factor applicable to the site is expected to be 2.5 but this must be confirmed once the final location and elevation of LID measures are known. This suggests the factored infiltration rate for the soils could range from about 5 to 12 mm/hr.

If LID infiltration measures will be designed and constructed on site, it is recommended to measure the in-situ infiltration rates by excavating test pits and conducting Guelph Permeameter tests in the exact footprints and elevations of the LID measures. It is noted that the infiltration rates calculated using grain size analysis results are estimates only as they do not reflect the compaction, saturation, and/or layering of the soil on site, which affect the infiltration of water on site.

5. Discussion and Analysis

5.1 Construction Dewatering

5.1.1 Temporary Groundwater Control

The site is located at the southwest corner of the intersection of Mapleview Drive East and Prince William Way, in Barrie, Ontario. The site is about 130 m (east to west) by 60 m (north to south), as shown on Figure 2B.

The stabilized groundwater level measurements were observed at 2.0 to 2.5 m depth, corresponding to Elev. 253.1 to 253.8 m.

Based on the RFP, a two-storey structure is proposed, and a basement is being considered. The building will be about 4,500 sq. ft. (3,000 sq. ft. of finished area and 1,500 sq. ft. of garage space). The facility will be connected to municipal servicing, however at this time no servicing plans have been provided. Paved parking and access will be provided. The current site plans are preliminary and may be subject to change. The depth of site services and/or basements are unknown at this time but general site servicing has been assumed to extend approximately 4 m below site grades. Excavations for the building basement level and footings could extend about 3.5 m below grade. Based on this, excavations at the site are expected to extend up to approximately 2 m below the prevailing groundwater table.

For conservative purposes, the construction dewatering calculation is based on an open cut excavation at the present time. To excavate under dry conditions, the water level is anticipated to be lowered at least to a minimum of approximately 1.0 m below the proposed excavation depth. Based on the subsurface conditions encountered during the field investigation, a hydraulic conductivity of 3.6×10^{-5} m/s has been applied to the entire site.

Additional dewatering capacity may be required to maintain dry conditions within the excavation during and following significant precipitation events. It should be noted that the dewatering estimates provided in this report are based on the assumed site servicing depths. GEI must be provided with final site servicing and grading plans to verify the design assumptions or update the water taking estimates as needed.

The exact scenario where these groundwater control techniques will work are estimates only and are directly correlated to how coarse/fine the native soils are in an excavation and both the lateral and vertical extent of the cohesionless deposits encountered. If the groundwater table is not controlled during construction, the base of the excavations will probably be unstable, leading to difficulties in excavating and placement of pipes or footings. A dewatering contractor must review and assess the subsurface conditions to verify which dewatering techniques will work for the site and proposed utility installations, based on their experience and interpretation of the data. A test dig could be carried out to assist prospective contractors determine the most appropriate dewatering methods based on their own means and methods.

5.1.2 Construction Dewatering Assumptions

The assumptions used for the calculation of the dewatering rates for the proposed development are presented below:

- Based on the results of the field investigation, a hydraulic conductivity of 3.6 x 10^{-5} m/s has been applied to the entire site.
- Based on the site elevation survey provided the lowest ground elevation in the vicinity of the firehall is approximately 255.1 masl.
- The general site servicing scenario assumes the site servicing will extend 40 m north from servicing along Tobias Lane and will excavated 5 m wide and 4 m deep (Elev. 251.1 masl).
- The building basement levels and footings could extend about 3.5 m below site grades (Elev. 251.6 masl). It is understood the main building will be 3,000 square feet in size (about 280 m^2) or about 17 by 17 m.
- Groundwater levels should be lowered a minimum of 1.0 m below the excavation base.
- The local high groundwater level was measured at approximately 253.8 masl.

5.1.3 Radius of Influence

The Radius of Influence (ROI) for the construction dewatering is based on the empirical Sichardt Equation. This equation is used to predict the distance at which the drawdown resulting from pumping is negligible. This equation is empirical and was developed to provide representative flow rates using the steady state flow dewatering equations, as discussed below.

It is noted that in steady state conditions, the radius of influence of pumping will extend until boundary flow conditions are reached and provide sufficient water inputs to the aquifer, such as recharge and surface water bodies. As a result, the distance of influence calculated using Sichardt equation is used to provide a representative flow rate calculation, but it is not precise in determining the actual radius influenced by pumping.

The ROI of pumping (dewatering) for radial flow was calculated based on the Sichardt equation, which is described as follows:

$$R_0 = 3000\ (\mathrm{H} - \mathrm{h})\sqrt{\mathrm{K}}$$

Where:

K	= Hydraulic conductivity (m/s)
H	= Static Saturated Head (m)
h	= Dynamic Saturated Head (m)
R_0	= Radius of influence (m)

Based on the Sichardt equation, the hydraulic conductivity of 3.6 x 10^{-5} m/s and the total groundwater drawdown required at this site, the ROI is expected to be up to 67 m from the centre of the excavations. Calculation details are provided in Appendix F, and zone-specific ROIs are summarized below:

Dewatering Zone	Description	ROI (m)
1	General Site Servicing Scenario	67
2	Building Basement Excavation	57

The ROI calculation is a conservative methodology and is calculated based on the assumption of active pumping during the construction dewatering. It should be noted that most of the water will be pumped during the first stage of the construction period or when a rain event occurs.

5.1.4 Temporary Dewatering Flow Rate Calculations

The Dupuit equation for linear flow from an unconfined aquifer for a fully penetrating excavation was used to obtain a flow rate estimate for the proposed linear infrastructure, and is expressed as follows:

$$Q_w = Kx\frac{H^2 - h^2}{L_0}$$

Where:

Q_w = Rate of pumping (m³/s)
X = Length of excavation (m)
L_0 = Length of influence (m) ($L_0 = \frac{R_0}{2}$)
K = Hydraulic conductivity (m/s)
H = Head beyond the influence of pumping (static groundwater elevation) (m)
h = Head above base of aquifer at the excavation (m)

For the proposed basement level, the Dupuit-Forcheimer and equivalent well radius method for radial flow from an unconfined aquifer for a fully penetrating excavation was used to obtain a flow rate estimate for the proposed linear infrastructure building and townhome excavations, and is expressed as follows:

$$Q = \frac{\pi K(H^2 - h^2)}{In\,{}^{R_0}/_{r_s}}$$

Where:

Q = Rate of pumping (m³/s)
K = Hydraulic conductivity (m/s)
H = Head beyond the influence of pumping (static groundwater elevation) (m)
h = Head above base of aquifer at the excavation (m)
R_0 = Radius of Influence (m)

r_s = Equivalent well radius (m)

The dewatering rates are expected to decrease once the target water levels are achieved in the excavation footprints as groundwater will have been removed locally from storage resulting in lower seepage rates into the excavations.

Based on the assumptions provided in this report, the results of the dewatering rate estimates are summarized below, and calculation details are provided in Appendix F:

Location and Scenario	Construction Dewatering Flow Rate Without Safety Factor	Construction Dewatering Flow Rate Including Safety Factor of 2	Construction Dewatering Flow Rate Including Safety Factor of 2 with a 10 mm Rainfall Event
	L/day		
1 - General Site Servicing Scenario	88,600	177,200	179,200
2 – Building Basement Excavation	81,700	163,400	166,300

The total construction dewatering flow rate includes a factor of safety of 2.0 to account for seasonal fluctuations in the groundwater table and variation in hydrogeological properties beyond those encountered during the course of this study. This total dewatering flow rate also provides additional capacity for the dewatering contractors. A 10 mm rain event was also included in the water taking calculation. Therefore, a posting on the EASR run by the MECP will be required.

Please note that it is the responsibility of the contractor to ensure dry conditions are maintained within the excavations at all times. Based on the calculated water taking rates, a series of sump pumps and/or well points might be adequate to control seepage at this site (means and methods determined by the dewatering contractor). Additional pumping capacity may be required to maintain dry conditions within the excavation during and following significant precipitation events. Additionally, the presence of near-surface fill material could hold significant perched groundwater. The contractor must ensure that water taking rates remain below 400,000 L/day. If the rates will exceed 400,000 L/day, a PTTW from the MECP will be required for the site.

The maximum flow calculation is intended to provide a conservative estimate to account for unforeseeable conditions that may arise during construction. It should be noted that the dewatering estimates provided in this report are based on assumptions and details available at the time of this report. If changes to the design are implemented (e.g., increases to planned excavation depths, widening of excavations, etc.), the dewatering estimates must be revised to include and reflect future changes.

The maximum flow calculation is intended to provide a conservative estimate to account for unforeseeable conditions that may arise during construction. It should be noted that the dewatering estimates provided in this report are based on the proposed development information available at this time. If changes to the design are implemented (e.g., increase to planned excavation depths, widening of excavations, etc.), the dewatering estimates must be revised to include and reflect future changes.

5.1.5 Remedial Dewatering Activities

The dewatering contractor is responsible for finalizing and implementing the discharge plan including information such as the exact discharge location, erosion control methods, method of conveyance, treatment systems, temperature of the discharged groundwater, etc. It is the contractor's responsibility to implement a treatment system to ensure that discharged groundwater meets the PWQO or City Storm Sewer Use By-Law for the necessary parameters. It is the responsibility of the dewatering contractor to obtain the necessary discharge permits from the City prior to discharge of pumped groundwater into their infrastructure.

The dewatering discharges should follow the best management practices, including sediment and erosion control measures, removal of suspended solids by a decanting tank, as well as a water quality and quantity control monitoring programs. The contractor should be aware that the purpose of the dewatering system is to maintain stable excavation slopes and dry working conditions during excavation.

The extent and details of the dewatering scheme (trench or well dimensions, spacing, pump levels, screen size and wick gradation) are left solely to the contractor's discretion to achieve the performance objectives for maintaining stable slopes and dry working conditions and will be based on their own interpretation and analysis of site conditions, equipment, experience, and plant efficiency. The contractor should also appreciate that additional dewatering means and modifications may be required as variations in site conditions are encountered. The recommended groundwater taking and discharge plans are provided in Appendices H and I, respectively.

5.1.6 Impact Assessment for Groundwater Dewatering

The impact assessment for groundwater dewatering is provided in the groundwater taking and discharge plans which are provided in Appendices H and I, respectively.

5.2 Preliminary Water Balance

5.2.1 Water Balance Components

A water balance is an accounting of the water resources within a given area. The water balance equates the precipitation (P) over a given area to the summation of the change in groundwater storage (S), evapotranspiration/evaporation (ET), surface water runoff (R) and infiltration (I) using the following equation:

$$\mathrm{P} = S + I + ET + R$$

The components of the water balance vary in space and time and depend on climatic conditions as well as the soil and land cover conditions (i.e., rainfall intensity, land slope, soil hydraulic conductivity and vegetation). For example, runoff occurs at a higher percentage during periods of snowmelt when the ground is frozen or during intense rainfall events.

Precise measurement of the water balance components is difficult, and as such, approximations and simplifications are made to characterize the water balance of a property. Field observations of the drainage conditions, land cover and soil types, groundwater levels and local climatic records are important inputs to the water balance calculations.

- Precipitation (P): For the purposes of approximating the annual precipitation at this site, the monthly rainfall between 1981 and 2010 was used based on Environment Canada historical weather data for the Shanty Bay MOE weather station (Climate ID 6117684, Latitude 44.38 N, Longitude 79.63 W, Elevation 250 m), which is located about 5.7 km north of the site.
- Storage (S): Although there are groundwater storage gains and losses on a short-term basis, the net change in groundwater storage on a long-term basis is assumed to be zero.
- Evapotranspiration/Evaporation (PET): The evapotranspiration and evaporation components vary based on the characteristics of the land surface cover (i.e., type of vegetation, soil moisture conditions, perviousness of surfaces, etc.). Potential evapotranspiration refers to the water loss from a vegetated surface to the atmosphere under conditions of an unlimited water supply. Evaporation occurs from a hard surface (such as flat rooftops, asphalt, gravel parking areas, etc.).
- Water Surplus (R + I): The difference between the mean precipitation and evapotranspiration is referred to as the water surplus. The water surplus is divided into two parts: as surface or overland runoff (R) and the infiltration into the surficial soil (I). The infiltration is comprised of two end member components: one component that moves vertically downward to underlying aquifers (referred to as percolation, deep infiltration or net recharge) and a second component that moves laterally through the near surface soil profile or shallow soils as interflow that re-emerges locally to surface (i.e., as runoff) at some short distance and time following precipitation.

5.2.2 Approach and Methodology

The analytical approach to calculate the water balance involves monthly soil-moisture balance calculations to determine the pre-development infiltration volumes. The detailed water balance calculation is provided in Appendix G, which is summarized in this and subsequent sections of the report. The following assumptions were used as part of the soil-moisture balance calculations:

- A soil moisture balance approach assumes that soils do not release water as potential recharge while a soil moisture deficit exists.
- During wetter periods, any excess of precipitation over evapotranspiration first goes to restore soil moisture. Considering the nature of the near surface soils (sandy silt to silty sand earth fill), a soil moisture storage capacity of 125 mm was used for the site which is vegetated with mostly grasses / is bare. It is assumed that post-construction permeable areas will be shallow urban vegetation and the same storage capacity was used post-development for the permeable areas.
- Once the soil moisture deficit is overcome, any further excess water can then pass through the soil as infiltration and either become interflow (indirect runoff) or recharge (deep infiltration).

Monthly potential evapotranspiration calculations accounting for latitude, climate and the actual evapotranspiration and water surplus components of the water balance based on the monthly precipitation and soil moisture conditions was calculated. The *MECP SWM Planning and Design Manual* (2003) methodology for calculating total infiltration based on topography, soil type and land cover was used, and a corresponding infiltration factor was calculated for pre- and post-development conditions. The water surplus was multiplied by the infiltration factor to determine both the pre-existing and post-condition annual volumes for run-off and infiltration for the property.

The pre-development scenario was estimated from the site inspection and aerial images, with 100% being permeable and 0% being impermeable. The post-development water balance scenario was estimated based on *"Hewitt's Gate – Draft Plan of Subdivision",* dated 2017, by the Jones Consulting Group. An estimated area of 1,804 m^2 (about 25% of the site) will consist of impermeable land (e.g. the buildings and parking / paved areas) in the post-construction scenario. The water balance must be updated following final site configuration to reflect the final site plans.

It is noted that the infiltration and runoff values presented in Appendix G are estimates only. Single values are used for the water balance calculations, but it is important to understand that infiltration rates are dependent upon the hydraulic conductivity of the surficial soils which may vary over several orders of magnitude. As such, the margins of error for the calculated infiltration and runoff component values are potentially quite large. These margins of error are recognized, but for the purposes of this assessment, the numbers used in the water balance calculations are considered reasonable estimates based on the site-specific conditions and useful for comparison of pre- to post-development conditions.

5.2.3 Pre and Post Development Water Balance

The detailed water balance calculations are included in Appendix G. The pre and post development calculations are summarized in this section are preliminary only and must be updated once site plans are finalized.

The table below summarizes the pre and post construction water balance as per the proposed site development plans.

Condition	Permeable Areas	Impermeable Areas	Average Annual Runoff Volume (m^3/year)	Average Annual Infiltration Volume (m^3/year)
Pre-Development Land Use	100%	0%	550	2,198
Post-Development Land Use (Preliminary Plan)	75%	25% (Firehall, Parking)	1,896	1,649

These calculations suggest that, without mitigation such as LID measures, the proposed development will decrease average infiltration by about 550 m^3/year (25% decrease). The proposed development will increase runoff by about 1,346 m^3/year (245% increase). This means

about 550 m^3/year of infiltration is required to maintain the water balance. The potential impacts of these changes and recommended mitigation measures are discussed below.

5.2.4 Recommended Mitigation Measures

The three broad categories which typically need to be mitigated and accounted for are:

- Reducing the volume and speed in which additional surface water runoff occurs;
- Increasing the amount of infiltration to match pre-development conditions; and
- Ensuring that the quality of existing surface water features and groundwater will not be adversely impacted.

5.2.4.1 Runoff Quantity

Urban development of an area affects the natural water balance. The most significant difference is the addition of impervious surfaces as a type of surface cover (e.g., roads, parking lots, driveways, rooftops). Impervious surfaces prevent infiltration of water into the underlying soils and the removal of the vegetation reduces the evapotranspiration component of the natural water balance. The evaporation component from impervious surfaces is relatively minor (estimated to be 15% of precipitation) compared to the evapotranspiration component that occurs with vegetation in this area (up to two thirds of precipitation). So, the net effect of the urbanization of the site is that most of the precipitation that falls onto impervious surfaces increases the surplus water resulting in more direct runoff from developed areas and reduced natural infiltration.

In conjunction with increased runoff, there is a reduction in infiltration to the shallow groundwater system. A reduction in infiltration can potentially lead to a lowering of the local water table and reduce the potential for this seasonal water table intersection and discharge.

Methods which do not necessarily increase infiltration rate, but decrease the volume and concentration of surface water runoff can be considered at this site include (but are not limited to):

- Increasing the topsoil thickness by about two times the normal thickness (up to 30 cm) to retain more water in storage; and
- Implementation of rainwater harvesting which intercepts, diverts and stores roof runoff (i.e., cisterns) for future use.

5.2.4.2 Mitigation Measures for Maintaining Infiltration

The increases in surface water runoff that will occur with urban development and mitigation of the potential impacts to the local water table due to reduction of infiltration may be minimized by using appropriate stormwater management and using LID measures to promote infiltration. These measures can be implemented on-site.

The basic premise for LID is to try to minimize changes to runoff and infiltration. As outlined in the *MECP SWMP Design Manual* (2003) and *Low Impact Development Stormwater Management*

Planning and Design Guide published by the Credit Valley Conservation (CVC) and TRCA (2010), there are a suite of techniques that may be considered to promote infiltration and reduce runoff.

In order to maintain ground water function at the site the following typical LID measures can be considered as part of typical site developments (can depend on land use):

- Collection of runoff from the building rooftops and redirection to grass areas and overland flow. If feasible, it is recommended that there be a minimum 5 metre flow path over pervious areas to allow this mitigation method to be fully effective;
- Provision of gentle slopes in open areas or along grass swales in order to allow time for water infiltration;
- Construction of engineered infiltration measures such as soakaway pits, infiltration galleries or bioswales. Subsurface infiltration methods can only be considered in areas where there is sufficient soil permeability and depth to water table to accommodate the systems within the unsaturated zone (typically the infiltration elevation must be kept 1 metre or more above the seasonal high groundwater level).
- Construction of grass channels or filter strips which allow infiltration, discharge at a lower rate and direct roof runoff to overland flow.

Implementation of LID measures will not only allow for infiltration of the surface water into the near-surface groundwater regime but will also allow for increase in natural filtration of surficial runoff, prevent sedimentation transport and potential erosion, and help reduce flooding by increasing the transit time for water on the site. These types of LID techniques promote natural infiltration by providing additional water volumes in the pervious areas. This is particularly effective in the summer months when natural infiltration would not generally occur because the additional water overcomes the natural soil moisture deficit.

At this time no details or designs for LID measures have been provided. Should LID measures be implement for the site, the details and designs should demonstrate through plans and sections (including all dimensions, materials used and including the seasonal high groundwater level) how this infiltration deficit will be mitigated.

As it is typically a requirement of maintaining the same levels of infiltration post construction, no appreciable change in the groundwater table elevation should occur over the long-term condition.

It is noted that the infiltration rates calculated by the use of grain size analysis results are estimates only as they do not reflect the compaction, saturation, and/or layering of the soil on site, which affect the infiltration of water on site. Vertical, field-saturated hydraulic conductivity can be measured in-situ with a Guelph Permeameter apparatus to provide more accurate infiltration rates at specific locations and depths to inform LID designs should it be required.

5.2.4.3 Groundwater Quality

Depending on land use, runoff from urban developments may contain a variety of dilute contaminants such as suspended solids, chloride from road salt, oil and grease, metals, pesticide residues, phosphorous, bacteria and viruses. For groundwater, generally except for the dissolved

constituents such as nitrogen and salt, most contaminants are attenuated by filtration during groundwater flow through the soils.

LID measures or end treatments such as oil/grit separators or wet ponds also help to remove suspended solids and other contaminants in runoff prior to infiltration or conveying the flows off the site, especially when a treatment train approach is taken for stormwater management. Any stormwater management facilities must be designed such that the water quality is maintained or improved prior to discharging water from the site or infiltrating water into the ground.

Runoff from rooftops and landscaped areas is considered “clean” and can be infiltrated. Runoff from the paved areas from the proposed firehall would need to be confirmed with LSRCA but may be permitted for infiltration with pre-treatment.

Since only clean or pre-treated runoff will be infiltrated, the groundwater quality will not be degraded. No impacts are expected to nearby domestic wells, watercourses or other nearby environmental features.

6. Limitations

The recommendations and comments provided are necessarily on-going as new information of underground conditions becomes available. More specific information with respect to the conditions between samples, or the lateral and vertical extent of materials may become apparent during excavation operations. The interpretation of the borehole information must, therefore, be validated during excavation operations. Consequently, conditions not observed during this investigation may become apparent. Should this occur, GEI should be contacted to assess the situation and additional testing and reporting may be required.

GEI should be retained for a general review of the final design drawings and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, GEI will assume no responsibility for interpretation of the recommendations in the report.

The comments given in this report are intended only for the guidance of the design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. could be greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

This report was authorized by, and prepared by GEI for, the account of The Corporation of the City of Barrie (as provided the signed Standard Professional Services Agreement). Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. GEI accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this project.

7. Closure

We trust that this information is satisfactory for your purposes. Should you have any questions or comments, please do not hesitate to contact our office.

Yours truly,

GEI Consultants

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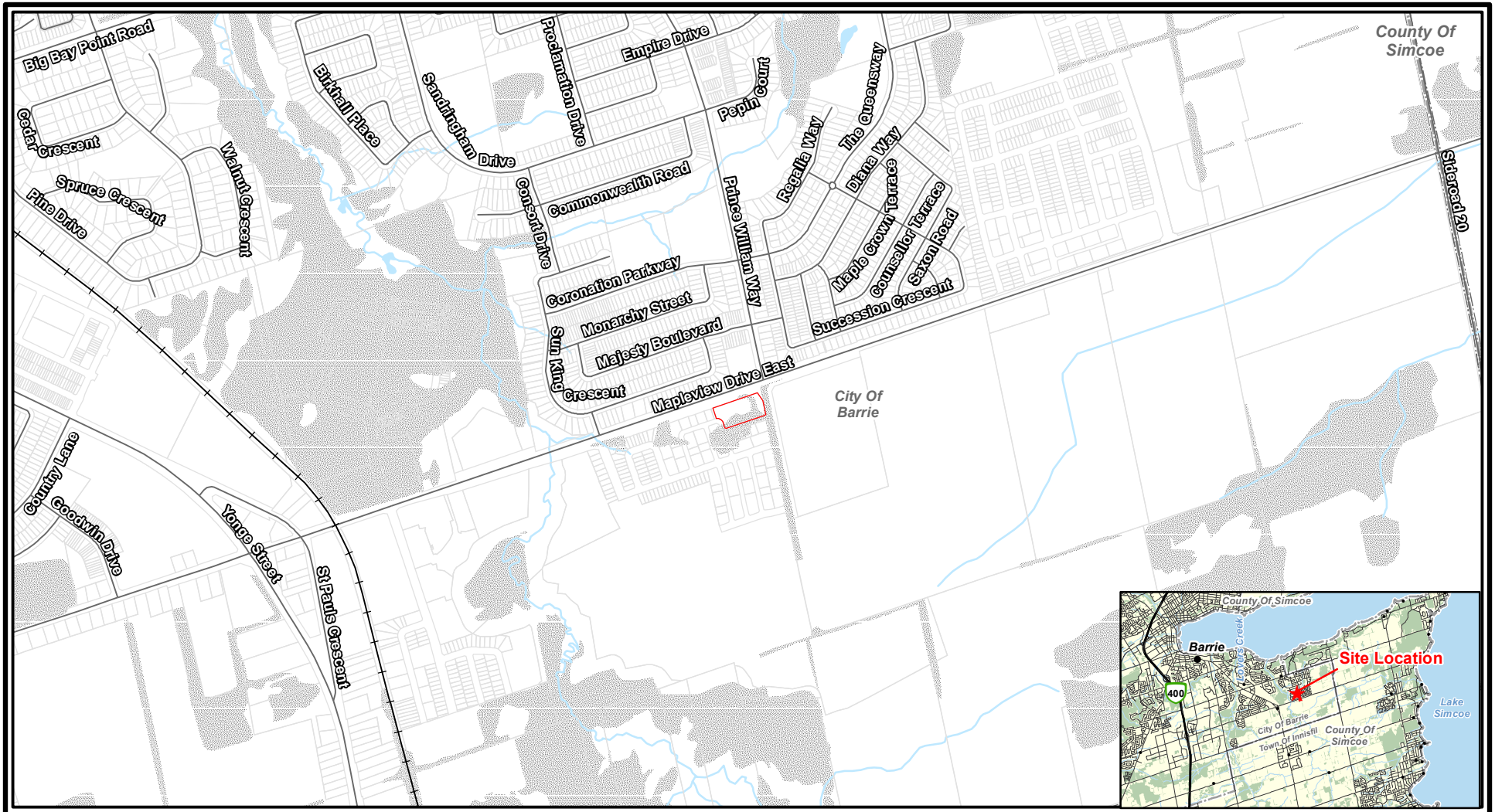
Sarah Griffith, G.I.T., Hydrogeologist-in-Training

Reviewed By:

Russell Wiginton, P.Eng.
Senior Geotechnical Engineer

Figures



Legend

Site Location | Road | Wooded Area
Parcels | Watercourse
Railway | Waterbody

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario,© City of Barrie (Parcels), 2022.

0 190 380 m

1:15,000

N

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Proposed Barrie Fire Station 6
Development
Barrie, ON

City of Barrie

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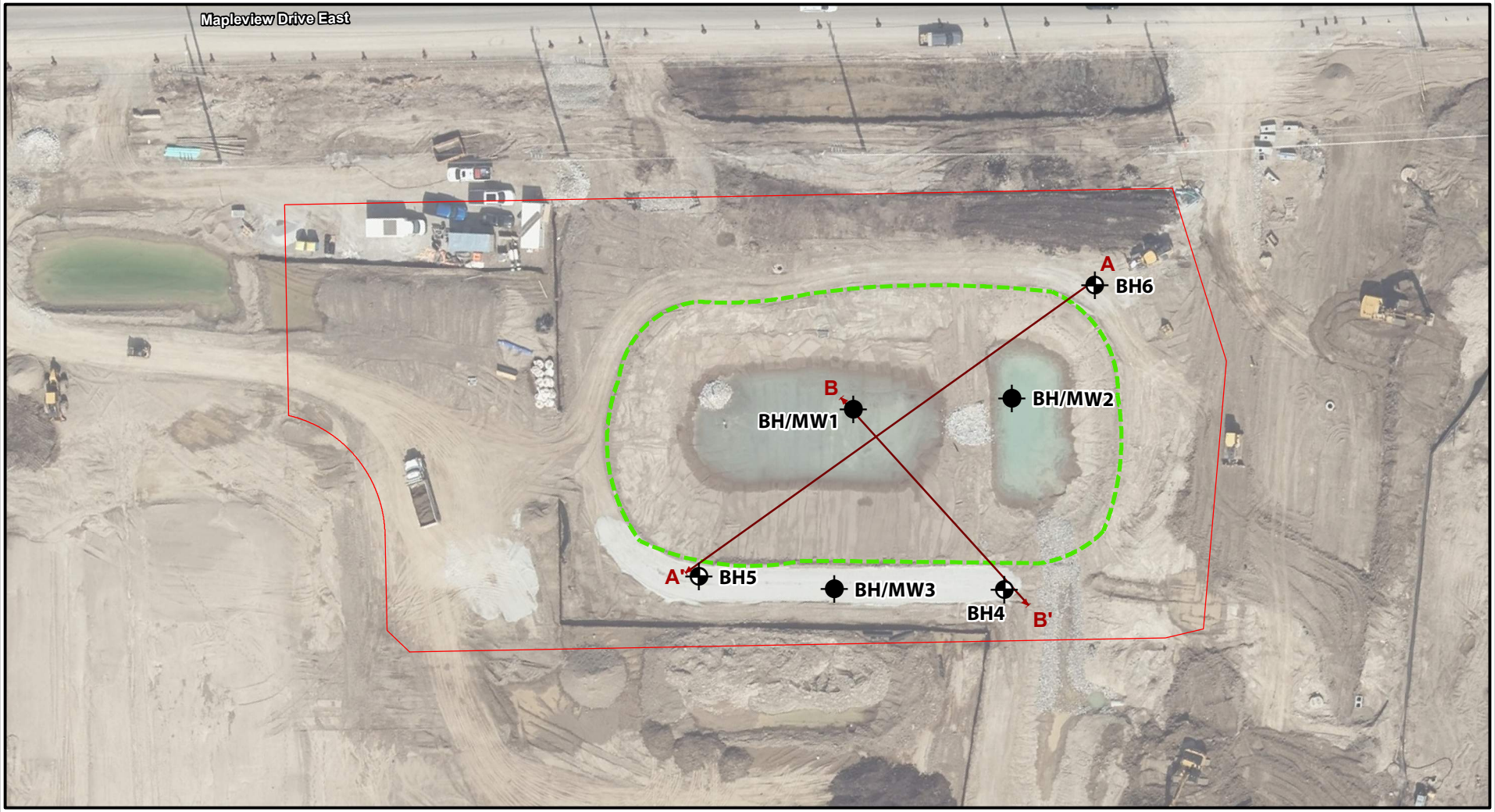
SITE LOCATION PLAN

Project 2203244 | December 2022 | Fig. 1



Legend

- Site Location
- Area with Existing Engineered Fill
- Approximate Borehole Location
- Approximate Borehole/Monitoring Well Location
- Cross Section Location

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario,© City of Barrie (Parcels), 2022.
3. Orthoimagery © First Base Solutions, 2022. Imagery taken in 2021.

0 10 20 m

1:800

N

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Proposed Barrie Fire Station 6 Development
Barrie, ON

City of Barrie

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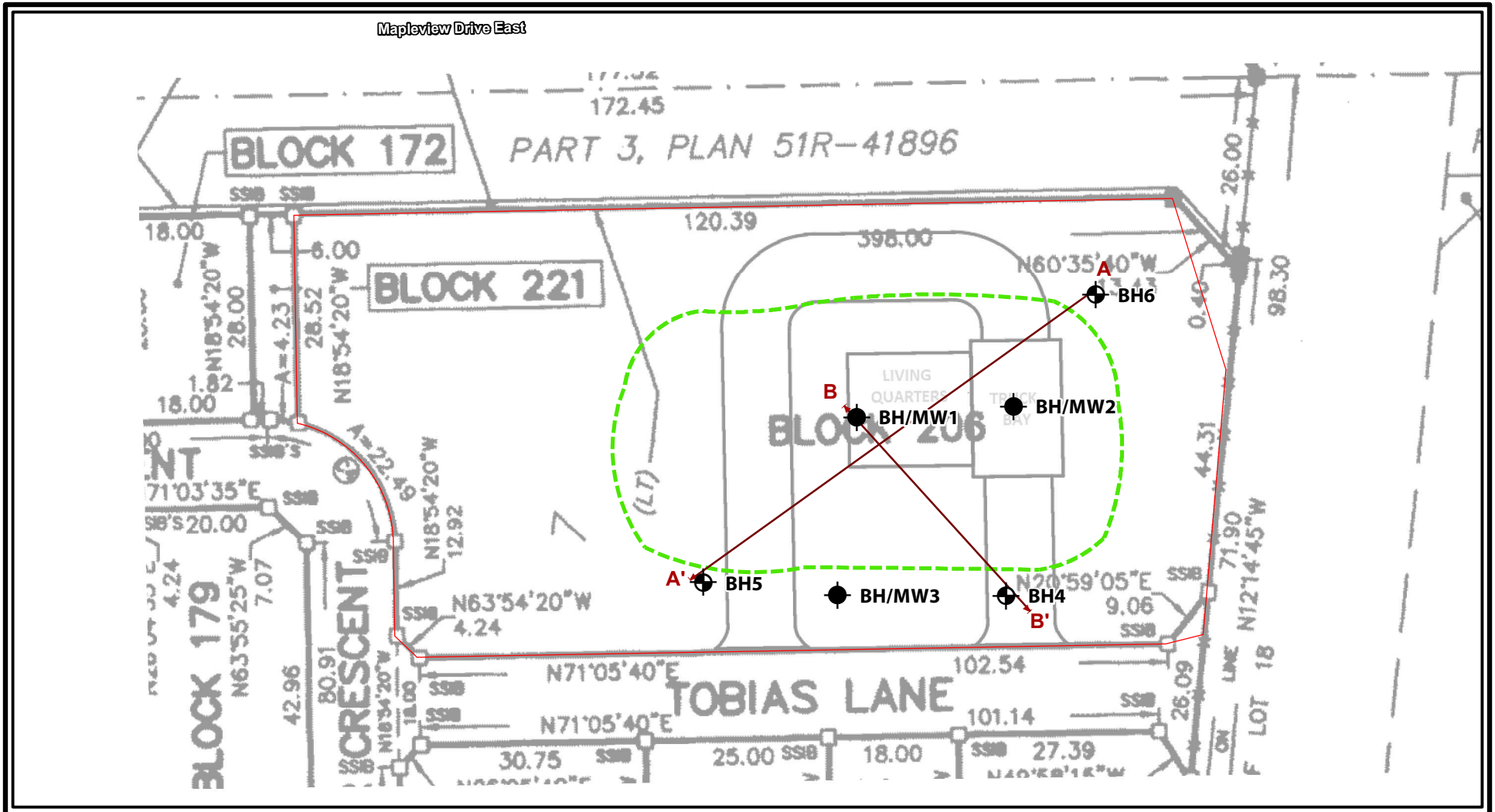
BOREHOLE LOCATION PLAN (AERIAL)

Project 2203244 | December 2022 | Fig. 2A



Legend

- Site Location
- Area with Existing Engineered Fill
- Approximate Borehole Location
- Approximate Borehole/Monitoring Well Location
- Cross Section Location

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario,© City of Barrie (Parcels), 2022.
3. Site Plan: 'Hewitt's Gate - Draft Plan of Subdivision', Jones Consulting Group (2017).

0 10 20 m

1:800

N

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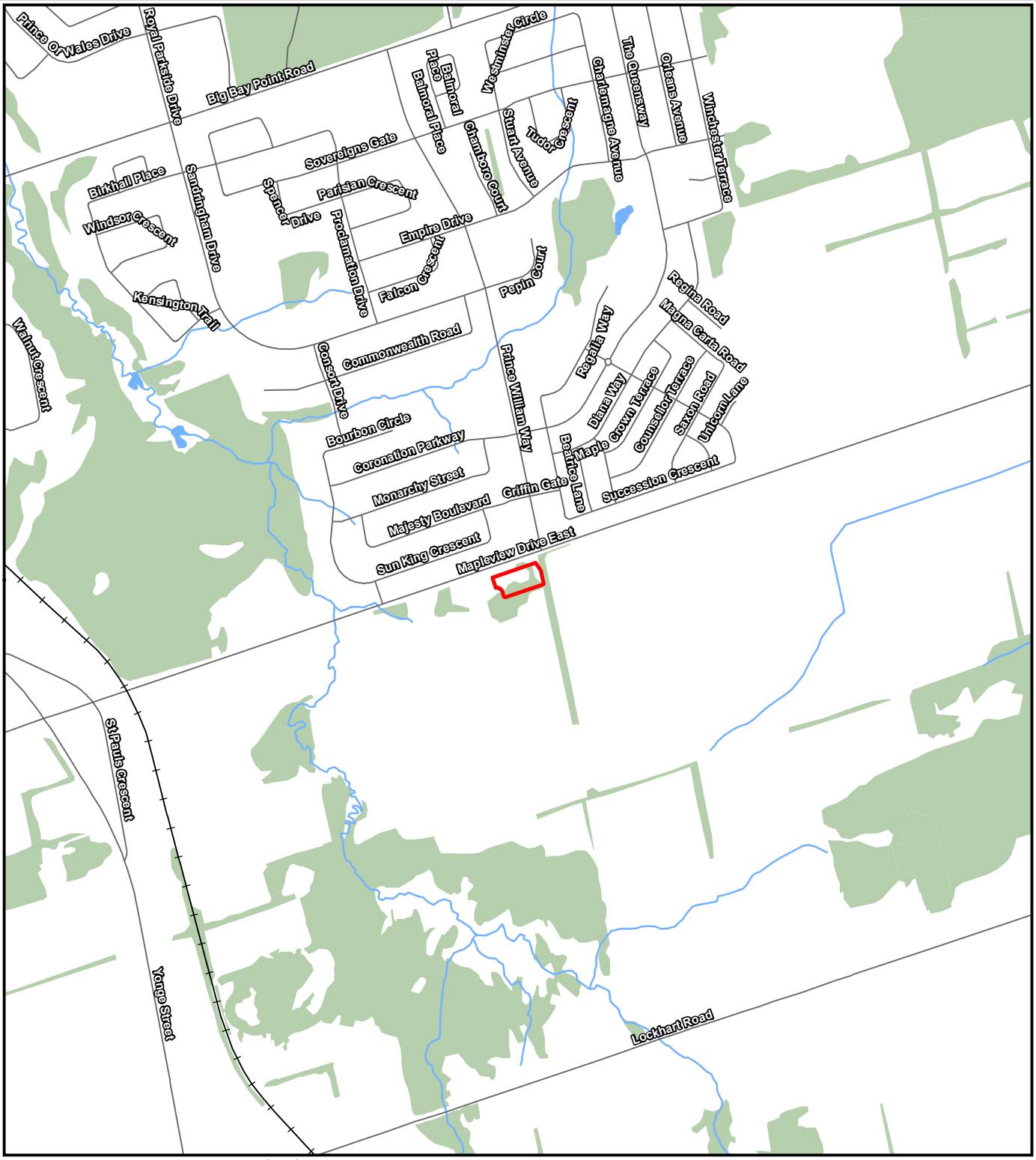
BOREHOLE LOCATION PLAN (SITE PLAN)

December 2022

Fig. 2B



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Legend

- Subject Lands
- Railway
- Road
- Watercourse
- Waterbody
- Wooded Area

Wellhead Protection Area (LSRCA 2022)

Zone
- A
- B
- C
- C1
- D
- Q1Q2

- No Wellhead Protection Areas Within Map Extents -

N

0 150 300 m

1:15,000

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Proposed Barrie Fire Station 6
Development
Barrie, ON

City of Barrie

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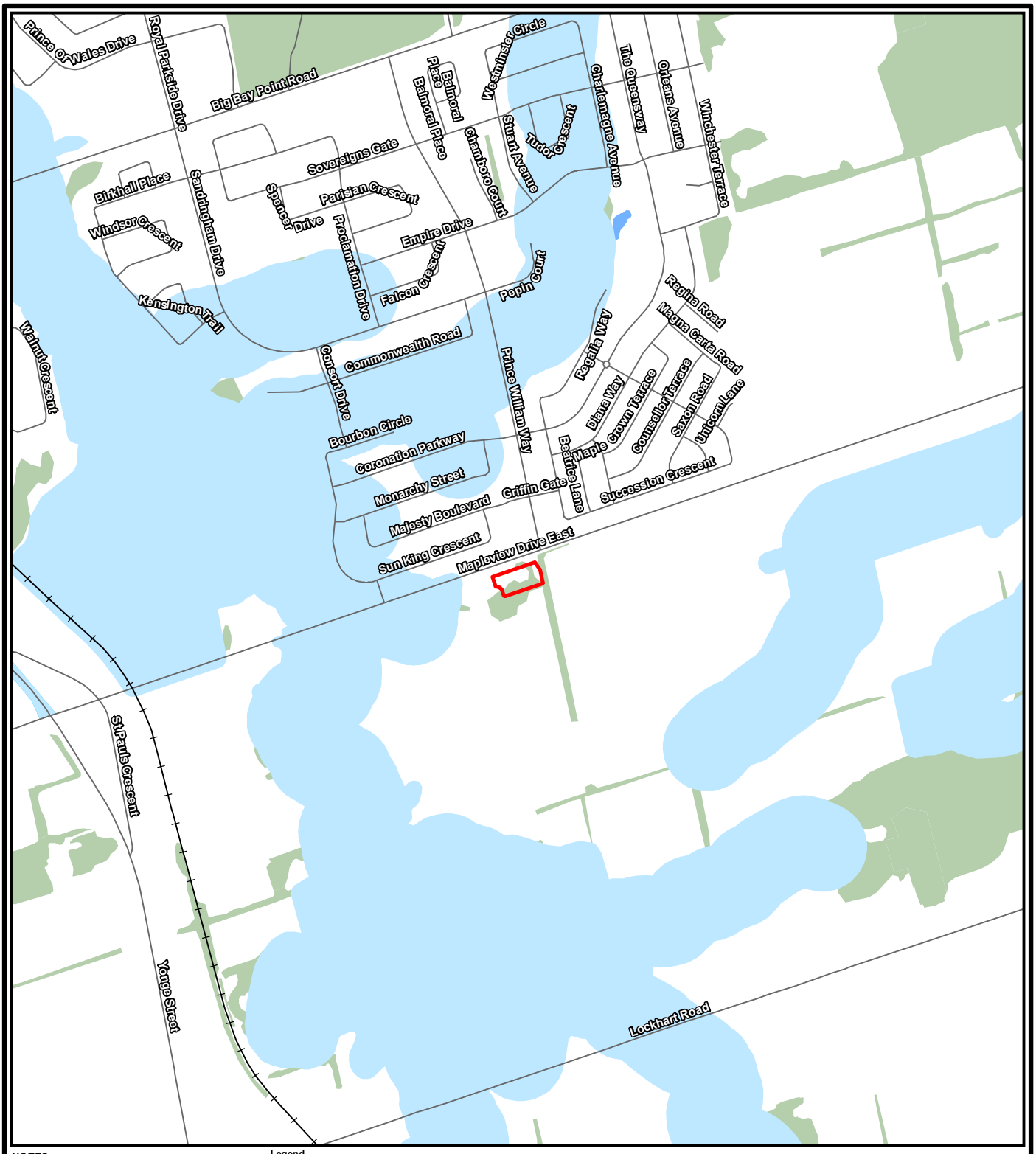
WELLHEAD PROTECTION AREAS

Project 2203244

December 2022

Fig. 3



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Legend

- Subject Lands
- Railway
- Road
- Watercourse
- Waterbody
- Wooded Area

Intake Protection Zone (LSRCA 2022)

Zone

- 1
- 2
- 3

N

0 150 300 m

1:15,000

Hydrogeological Report
Proposed Barrie Fire Station 6
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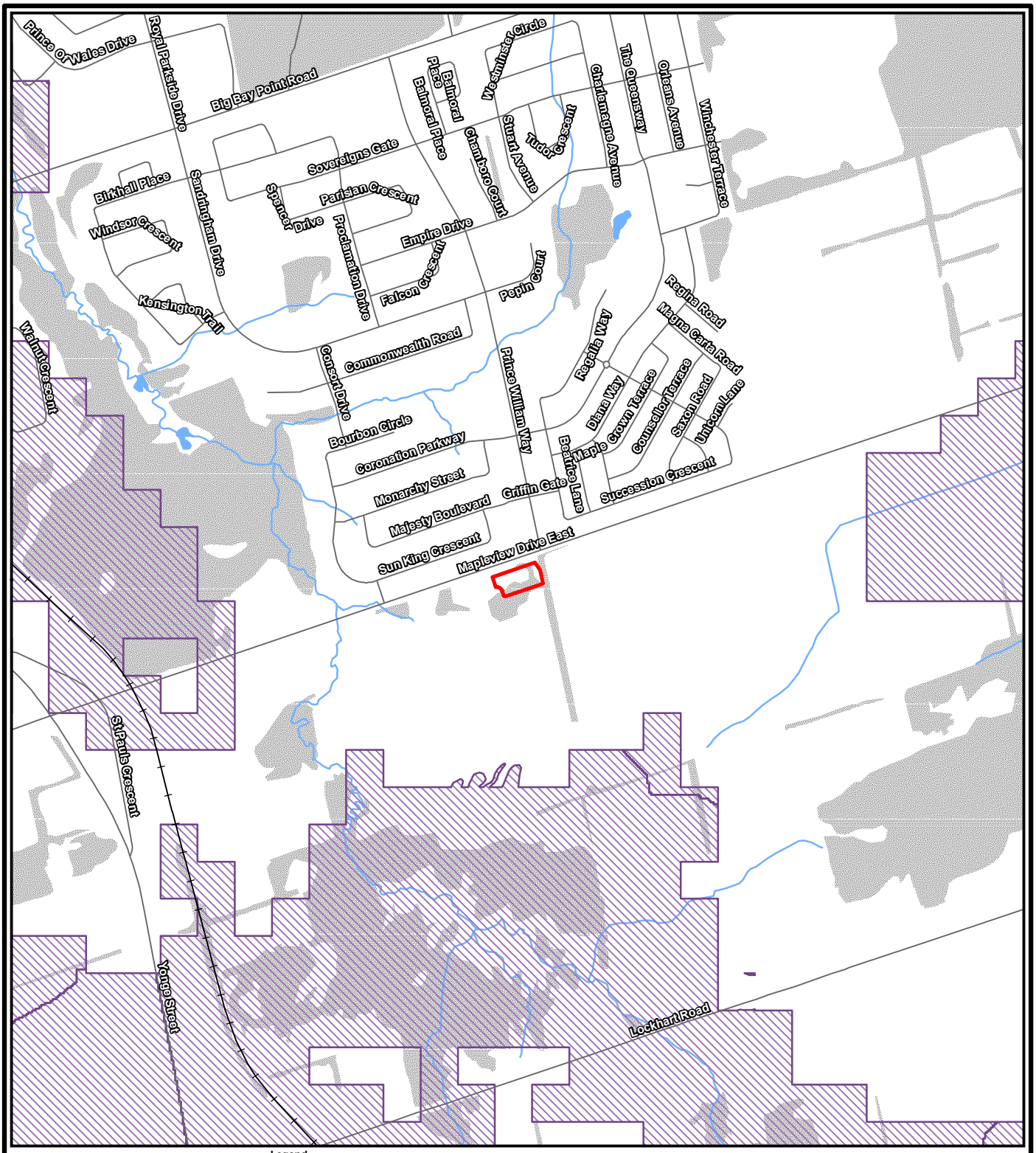
INTAKE PROTECTION ZONES

Project 2203244

December 2022

Fig. 4



NOTES:

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Legend

- Subject Lands
- Railway
- Road
- Watercourse
- Waterbody
- Wooded Area
- Highly Vulnerable Aquifer (LSRCA 2022)

N

0 150 300 m

1:15,000

Hydrogeological Report
Proposed Barrie Fire Station 6
Development
Barrie, ON

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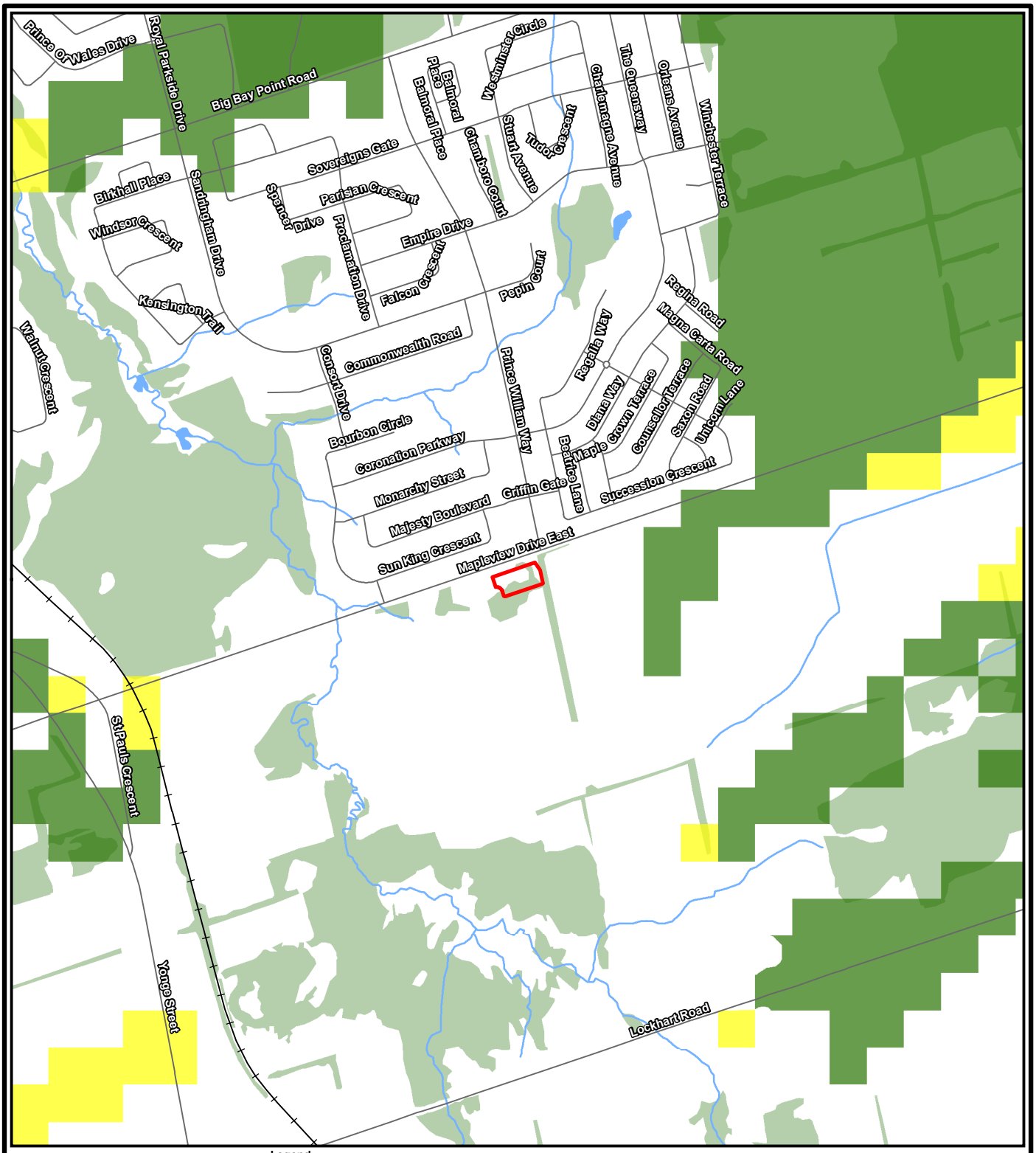
HIGHLY VULNERABLE AQUIFER

Project 2203244

December 2022

Fig. 5



NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
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3. Contains Information made available under Lake Simcoe Region Conservation Authority Open Data Licence v1.0.

Legend

- Subject Lands
- Railway
- Road
- Watercourse
- Waterbody
- Wooded Area

Significant Groundwater Recharge Area (LSRCA 2022)

Vulnerability Score

- 2-4
- 6

N

0 150 300 m

1:15,000

Hydrogeological Report
Proposed Barrie Fire Station 6
Development
Barrie, ON

City of Barrie

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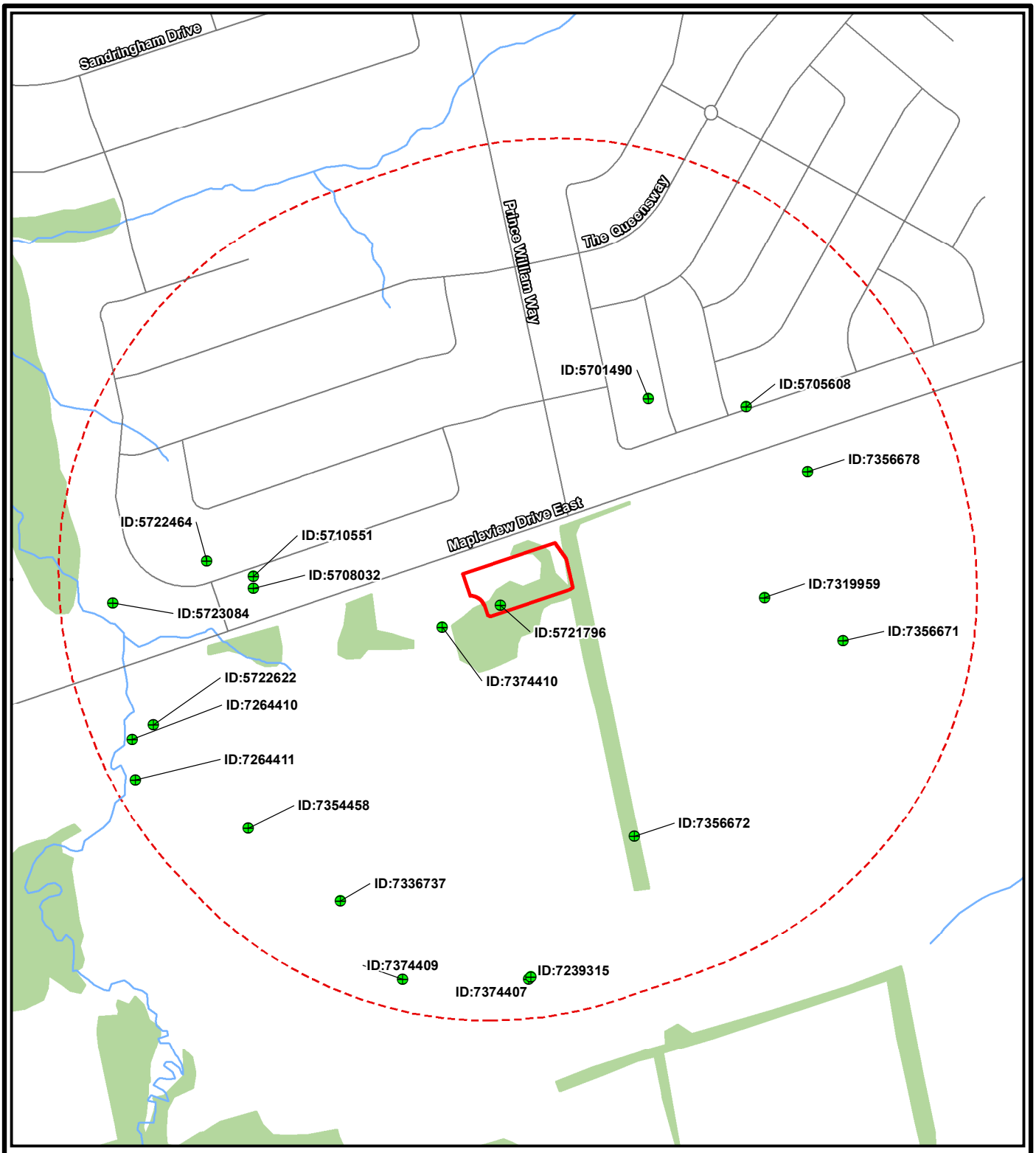
SIGNIFICANT GROUNDWATER RECHARGE AREAS

Project 2203244

December 2022

Fig. 6



NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
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Legend

- Site Location
- Site Location +500m
- MECP Well Records Within 500m of Site Location
- Road
- Watercourse
- Wooded Area

N

0 50 100 m

1:6,900

Hydrogeological Report
Proposed Barrie Fire Station 6
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Barrie, ON

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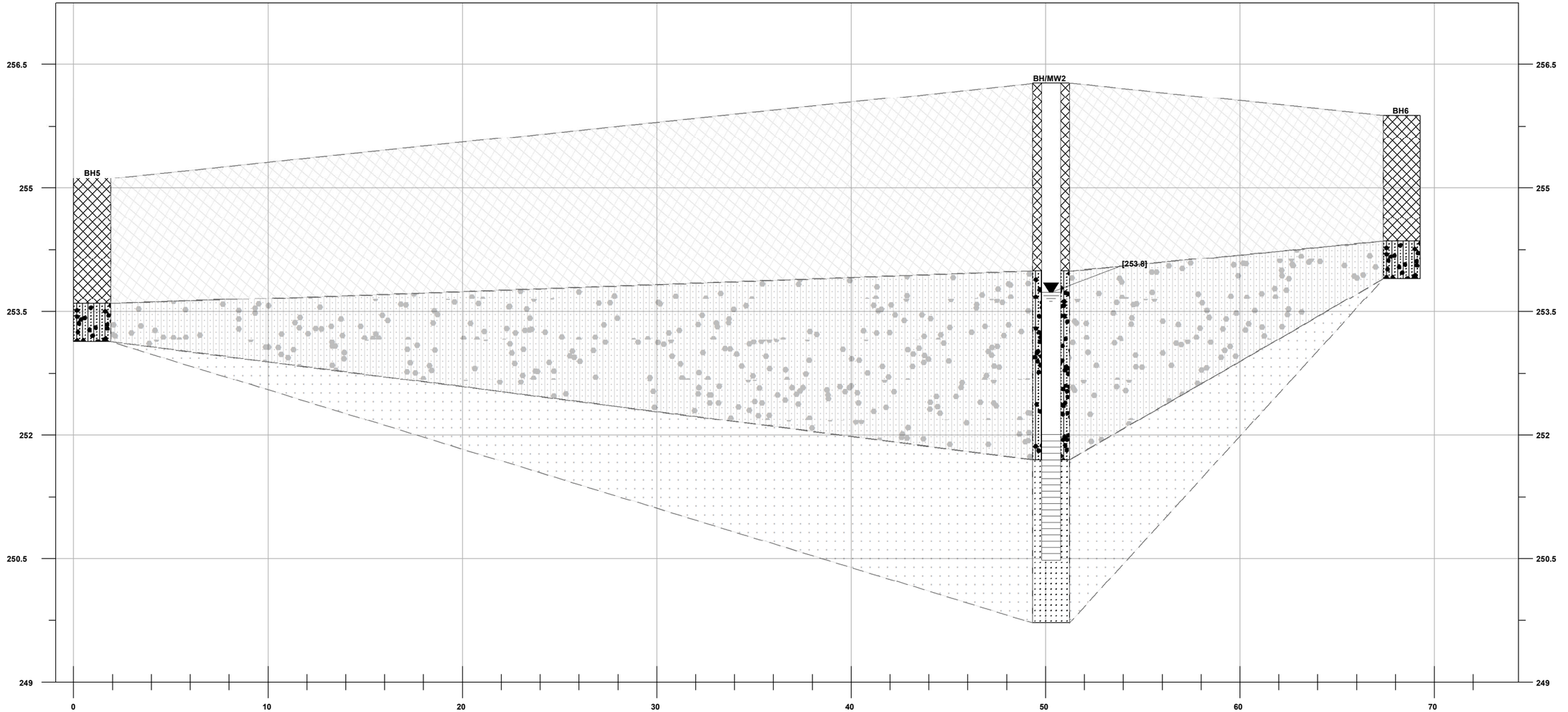
MECP WELL RECORD LOCATIONS

Project 2203244 | December 2022 | Fig. 7



NOTES:
1. Subsurface conditions known only at borehole locations.

Legend

Water Level in Monitoring Well
[xx.xx] Water Levels (m asl), Measured Oct 18, 2022

Strata

Fill
Silty Sand to Sandy Silt Glacial Till
Sand

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Proposed Barrie Fire Station 6 Development
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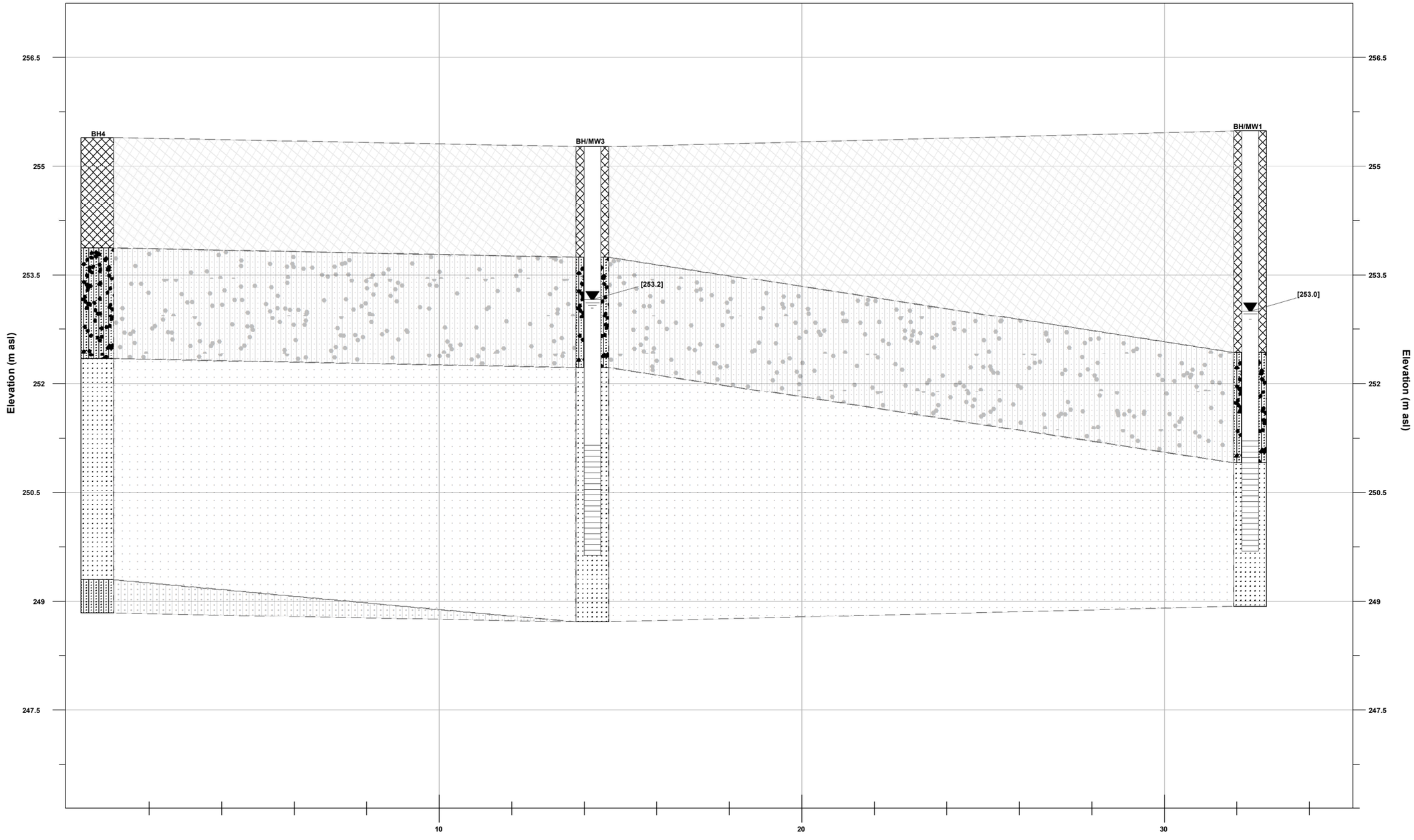
GEOLOGICAL CROSS SECTION A-A'

December 2022 Fig. 8



NOTES:
1. Subsurface conditions known only at borehole locations.

Legend

Water Level in Monitoring Well
[xx.xx] Water Levels (m asl), Measured Oct 18, 2022

Strata

Fill
Silty Sand to Sandy Silt Glacial Till
Silty Sand
Sand

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Proposed Barrie Fire Station 6 Development
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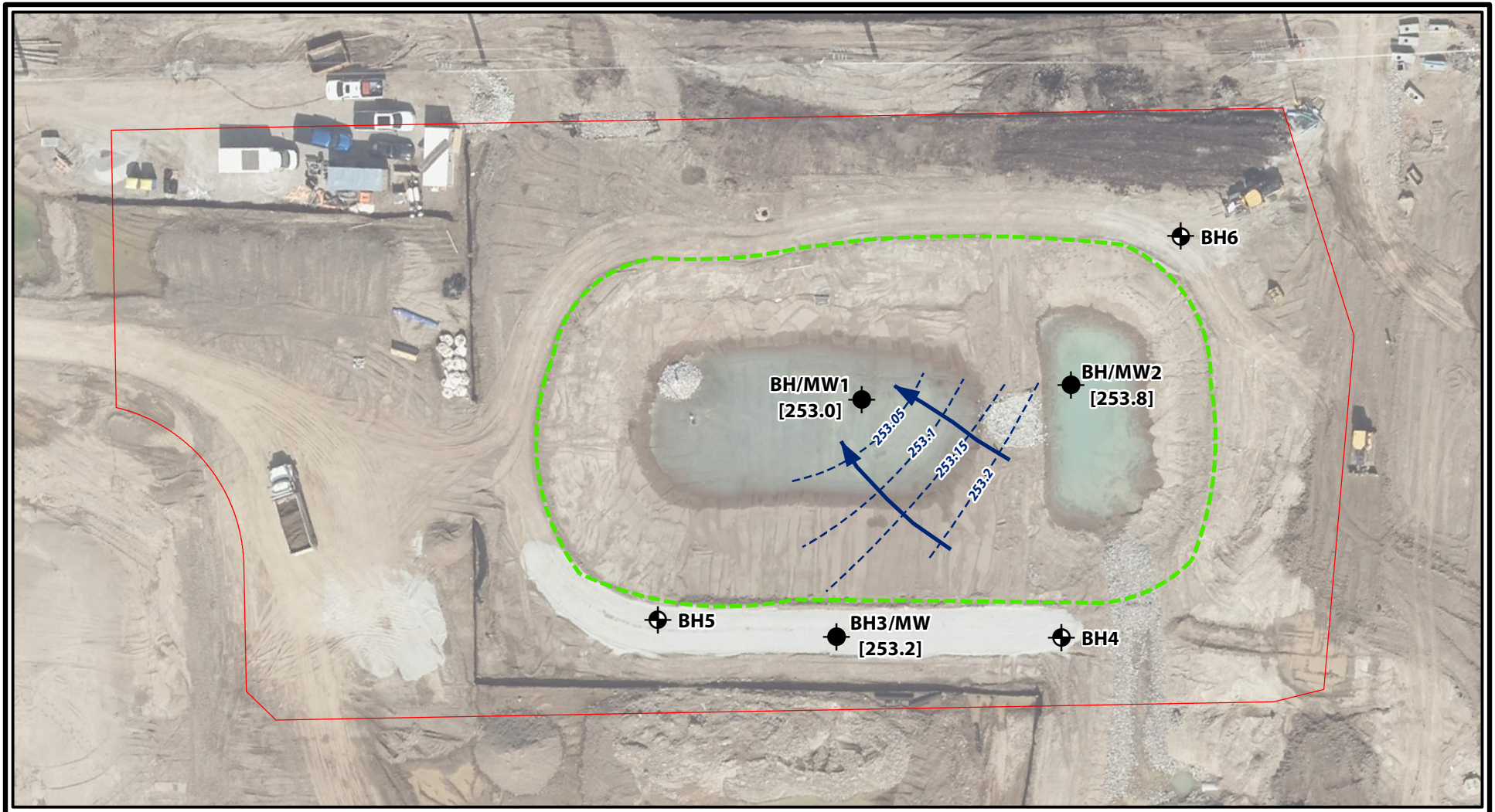
GEOLOGICAL CROSS SECTION B-B'

December 2022 Fig. 9



Legend

- Site Location
- Area with Existing Engineered Fill
- Approximate Borehole Location
- Approximate Borehole/Monitoring Well Location
- [xx.xx] Groundwater Level (m asl), measured Oct. 18, 2022
- Groundwater Contour
- Interpreted Direction of Groundwater Flow

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
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3. Orthoimagery © First Base Solutions, 2022. Imagery taken in 2021.

0 7.5 15 m

1:600

N

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Proposed Barrie Fire Station 6
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SHALLOW GROUNDWATER CONTOUR MAP

Project 2203244

December 2022

Fig. 10

Appendix A

MECP Water Well Records

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	Well ID Only	WELL	FORMATION
INNISFIL TOWNSHIP	17 610675 4911365 W	2014/04 6809						7239315	7239315 (C25737) A152267 P	
INNISFIL TOWNSHIP	17 610967 4911837 W	2018/08 7201	2			MO		7319959	7319959 (Z251496) A	
INNISFIL TOWNSHIP	17 610806 4911541 W	7314	5.19			MO		7356672	7356672 (Z330215) A276930	BRWN LOAM 0000 BRWN SILT GRVL 0002 BRWN SILT GRVL DNSE 0006
INNISFIL TOWNSHIP	17 611064 4911783 W	7314	5.19			MO		7356671	7356671 (Z315473) A276928	BRWN LOAM 0000 BRWN SILT GRVL 0002 BRWN SAND FSND DNSE 0005 GREY SAND WBRG 0006
INNISFIL TOWNSHIP	17 610849 4911343 W	7314	5.19			MO		7356673	7356673 (Z330214) A276931	BRWN LOAM 0000 BRWN SAND SILT DNSE 0001 BRWN SAND SILT 0006
INNISFIL TOWNSHIP	17 611020 4911992 W	7314	5.19			MO		7356678	7356678 (Z330212) A276927	BRWN LOAM 0000 BRWN SILT TILL DNSE 0006 BRWN FSND SILT WBRG 0007
INNISFIL TOWNSHIP	17 610063 4911659 W	7314	0.83				0006 2	7359857	7359857 (Z315448) A293954 A	
INNISFIL TOWNSHIP CON 11 014	17 610160 4911830 W	1987/12 3135	6	FR 0063	13/37/25/ 1:30	DO	0062 6	5723084	5723084 (18726)	CLAY SOFT 0015 CLAY GRVL 0058 SAND GRVL 0063 SAND 0069
INNISFIL TOWNSHIP CON 11 017	17 610188 4911611 W	2016/03 4645	36					7264411	7264411 (Z224000) A	
INNISFIL TOWNSHIP CON 11 017	17 610184 4911661 W	2016/03 4645	36					7264410	7264410 (Z223999) A	
INNISFIL TOWNSHIP CON 11 017	17 610442 4911461 W	7314		FR 0000				7336737	7336737 (Z315537) A139404	BRWN LOAM 0000 BRWN SAND SILT CLAY 0002 GREY SAND STNS LOOS 0003 GREY SAND SILT DNSE 0004
INNISFIL TOWNSHIP CON 11 017	17 610328 4911551 W	7314		FR 0000		OT		7354458	7354458 (Z315523) A276854 A	BRWN LOAM SAND 0001 BRWN SAND SILT TILL 0003 GREY SILT SNDY CLAY 0004
INNISFIL TOWNSHIP CON 11 017	17 610210 4911679 W	1987/09 4919	30	UK 0010	10/24//1: 0	DO		5722622	5722622 (17841)	BRWN SAND PCKD 0028
INNISFIL TOWNSHIP CON 11 018	17 611126 4911376 L	1986/06 1467	5	FR 0031	11/33/5/3 :0	DO	0037 4	5720922	5720922 (NA)	BRWN SAND 0031 GREY FSND 0041

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	Well ID Only	WELL	FORMATION
INNISFIL TOWNSHIP CON 11 019	17 610640 4911827 W	1987/04 3413	30 30	FR 0015	15/20/10/ 2:0	DO		5721796	5721796 (06333)	BRWN SAND 0015 BRWN GRVL 0030
INNISFIL TOWNSHIP CON 12 016	17 610084 4911763 W	1976/02 2514	30 6	FR 0096	45/100/7/ 2:0	ST DO	0096 8	5713067	5713067 ()	PRDG 0040 BRWN CLAY PCKD 0051 BRWN CLAY SAND GRVL 0069 BRWN CLAY HARD 0090 YLLW SILT PCKD 0096 YLLW FSND PCKD 0109
INNISFIL TOWNSHIP CON 12 017	17 610334 4911863 W	1973/04 3109	30	FR 0032	18//0/:	DO		5710551	5710551 ()	LOAM 0002 BRWN CLAY SAND STNS 0018 BLUE CLAY SAND STNS 0032 GRVL 0033 BRWN CLAY STNS 0041
INNISFIL TOWNSHIP CON 12 017	17 610334 4911848 W	1971/05 3109	30	FR 0028	16///:	DO		5708032	5708032 ()	LOAM 0002 CLAY STNS 0024 GRVL SAND CLAY 0031
INNISFIL TOWNSHIP CON 12 017	17 610276 4911882 W	1987/04 2801	5		5/26/3/2: 0	DO ST	0054 3	5722464	5722464 (05158)	GRVL 0005 GRVL CLAY 0035 CLAY SILT 0042 FSND 0060 CLAY SILT 0102
INNISFIL TOWNSHIP CON 12 018	17 610823 4912083 W	1958/12 2514	5	FR 0325	98/230/1 0/9:0	DO		5701490	5701490 ()	PRDG 0020 CLAY MSND 0100 BLUE CLAY 0450 LMSN 0486
INNISFIL TOWNSHIP CON 12 018	17 610944 4912073 W	1968/06 1510	4	FR 0045	24/34/5/1 :0	DO	0041 4	5705608	5705608 ()	BRWN CLAY LOAM 0003 BRWN CLAY 0015 HPAN 0042 CSND 0045

Appendix B

Borehole Logs

RECORD OF BOREHOLE No. 1

Project Number: **2203244**
Project Client: **City of Barrie**
Project Name: **Proposed Firehall 6**
Project Location: **Barrie, ON**
Drilling Location: **See Borehole Location Plan**
Local Benchmark:

Drilling Method: **Hollow Stem Augers** Drilling Machine: **Truck Mount**
Logged By: **BH** Northing: **4911863.7** Date Started: **Sep 22/22**
Reviewed By: **GRW** Easting: **610675.3** Date Completed: **Sep 22/22**

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	DEPTH (m)	ELEVATION (m)	FIELD TESTING (Shear Strength Testing (kPa); Penetration Testing SPT/DCPT)	LAB TESTING (Combustible Organic Vapour (ppm); Combustible Organic Vapour (%LEL); Total Organic Vapour (ppm); Atterberg Limits PL–LL; Water Content (%))	Instrumentation Installation	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	0.0					0	255.5							
	FILL: Silt and sand, trace to some clay, trace gravel, loose, brown, moist	SS	1	40	6			6	8					
		SS	2	100	6		255	6	9					
		SS	3	100	7	1.5		7	7		2	48	36	14
		SS	4	100	8		253.5	8	11					
	3.0					3	252.4							
	SILTY SAND TO SANDY SILT GLACIAL TILL: Some gravel, some clay, cobbles and boulders, loose, brown, moist	SS	5	100	7			7	10					
	4.6					4.5	250.9							
	SAND: Some silt, compact, brown, wet	SS	6	100	29		252	29	16					First water strike SS6
							250.5							
	- - - Trace gravel, dense - - -	SS	7	100	46	6		46	20					
	6.6						249							
	Borehole Terminated at 6.6 m													

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Groundwater depth encountered on completion of drilling: 4.0 m. Cave depth after auger removal: Open
Groundwater depth observed on: Oct 18/22 at depth of: 2.5 m. Groundwater Elevation: 253.0 m

Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :75**
Page: **1 of 1**

RECORD OF BOREHOLE No. 2

Project Number:	**2203244**						
Project Client:	**City of Barrie**						
Project Name:	**Proposed Firehall 6**	Drilling Method:	**Hollow Stem Augers**	Drilling Machine:	**Truck Mount**		
Project Location:	**Barrie, ON**	Logged By:	**BH**	Northing:	**4911872.0**	Date Started:	**Sep 22/22**
Drilling Location:	**See Borehole Location Plan**	Reviewed By:	**GRW**	Easting:	**610695.6**	Date Completed:	**Sep 22/22**
Local Benchmark:							

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Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	DEPTH (m)	ELEVATION (m)	FIELD TESTING (Shear Strength Testing (kPa); Penetration Testing: SPT ○ DCPT ●)	LAB TESTING (Combustible Organic Vapour (ppm) △; Combustible Organic Vapour (%LEL) ▲; Total Organic Vapour (ppm) ◇; Atterberg Limits PL–LL; Water Content (%) ○)	Instrumentation Installation	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	0.0 / 256.3					0					
	FILL: Silty sand to sandy silt, trace gravel, trace clay, loose, brown, moist	SS	1	100	5			5	7		
		SS	2	100	6		255	6	8		
		SS	3	100	8	1.5		8	10		
	2.3 / 254.0										
	SILTY SAND TO SANDY SILT GLACIAL TILL: Some gravel, some clay, cobbles and boulders, compact, brown, moist	SS	4	100	11		253.5	11	8		
		SS	5	100	13	3		13	9		
	4.6 / 251.7						252				
	SILT AND SAND: Trace clay, trace gravel, compact, brown, wet	SS	6	100	29	4.5		29	20		First water strike SS6 1 55 41 2
	- - - Very dense - - -	SS	7	100	52	6	250.5	52 →	20		
	6.6 / 249.7										
	Borehole Terminated at 6.6 m										

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Groundwater depth encountered on completion of drilling: 4.0 m. Cave depth after auger removal: Open

Groundwater depth observed on: Oct 18/22 at depth of: 2.5 m. Groundwater Elevation: 253.8 m

Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :75**

RECORD OF BOREHOLE No. 3

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Project Number:	**2203244**						
Project Client:	**City of Barrie**						
Project Name:	**Proposed Firehall 6**	Drilling Method:	**Hollow Stem Augers**	Drilling Machine:	**Truck Mount**		
Project Location:	**Barrie, ON**	Logged By:	**BH**	Northing:	**4911839.1**	Date Started:	**Sep 22/22**
Drilling Location:	**See Borehole Location Plan**	Reviewed By:	**GRW**	Easting:	**610681.0**	Date Completed:	**Sep 22/22**
Local Benchmark:							

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	DEPTH (m)	ELEVATION (m)	Instrumentation Installation	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	0.0 / 255.3					0	255					
	FILL: Silty sand to sandy silt, trace gravel, trace clay, dense, brown, moist	SS	1	100	30							
		SS	2	100	32							
	1.5 / 253.7					1.5	253.5					
	SILTY SAND TO SANDY SILT GLACIAL TILL: Some gravel, some clay, cobbles and boulders, loose, brown, moist - - - Moist to wet - - -	SS	3	100	7				12	47	28	13
		SS	4	100	9							
	3.0 / 252.2					3	252					
	SAND: Trace silt, trace gravel, compact, brown, wet	SS	5	100	16				First water strike SS5			
		SS	6	100	17	4.5	250.5		13	84	3	
	- - - Very dense - - -	SS	7	100	57	6	249					
	6.6 / 248.7											
	Borehole Terminated at 6.6 m											

FIELD TESTING
Shear Strength Testing (kPa)
× Other Test
+ Pocket Penetrometer
▲ Field Vane (Intact)
△ Field Vane (Remolded)
40 80 120 160
Penetration Testing
○ SPT ● DCPT
10 20 30 40

LAB TESTING
△ Combustible Organic Vapour (ppm)
▲ Combustible Organic Vapour (%LEL)
◇ Total Organic Vapour (ppm)
100 200 300 400
Atterberg Limits
PL ○ Water Content (%) LL
10 20 30 40

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Groundwater depth encountered on completion of drilling: 3.1 m. Cave depth after auger removal: Open

Groundwater depth observed on: Oct 18/22 at depth of: 2.1 m. Groundwater Elevation: 253.2 m

Scale: **1 :75**

RECORD OF BOREHOLE No. 4

Project Number: **2203244**
Project Client: **City of Barrie**
Project Name: **Proposed Firehall 6**
Project Location: **Barrie, ON**
Drilling Location: **See Borehole Location Plan**
Local Benchmark:

Drilling Method: **Hollow Stem Augers** Drilling Machine: **Truck Mount**
Logged By: **BH** Northing: **4911846.3** Date Started: **Sep 22/22**
Reviewed By: **GRW** Easting: **610702.2** Date Completed: **Sep 22/22**

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	DEPTH (m)	ELEVATION (m)	FIELD TESTING (Shear Strength Testing (kPa); Penetration Testing SPT/DCPT)	LAB TESTING (Combustible Organic Vapour (ppm); Combustible Organic Vapour (%LEL); Total Organic Vapour (ppm); Atterberg Limits; Water Content (%))	Instrumentation Installation	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	0.0 255.4					0	255				
	FILL: Silty sand to sandy silt, trace gravel, trace clay, compact, brown, moist to wet	SS	1	75	11			11	8		
		SS	2	100	20			20	12		
	1.5 253.9					1.5	253.5				
	SILTY SAND TO SANDY SILT GLACIAL TILL: Some gravel, some clay, cobbles and boulders, loose, brown, moist	SS	3	100	8			8	7		
		SS	4	100	16			16	11		First water strike SS5
	3.0 252.3					3	252				
	SAND: Trace silt, trace gravel, compact, brown, wet	SS	5	100	23			23	20		
	- - - Dense - - -	SS	6	100	37	4.5	250.5	37	8		
	6.1 249.3					6	249				
	SILTY SAND: Very dense, brown, moist 6.6 248.8	SS	7	35	+100			+100	18		
	Borehole Terminated at 6.6 m										

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Groundwater depth encountered on completion of drilling: 2.7 m. Cave depth after auger removal: 2.7 m.
Groundwater depth observed on: Groundwater Elevation:

Scale: **1 :75**

RECORD OF BOREHOLE No. 5

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Project Number:	**2203244**						
Project Client:	**City of Barrie**						
Project Name:	**Proposed Firehall 6**	Drilling Method:	**Hollow Stem Augers**		Drilling Machine:	**Truck Mount**	
Project Location:	**Barrie, ON**	Logged By:	**BH**	Northing:	**4911835.0**	Date Started:	**Sep 22/22**
Drilling Location:	**See Borehole Location Plan**	Reviewed By:	**GRW**	Easting:	**610662.5**	Date Completed:	**Sep 22/22**
Local Benchmark:							

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING			COMMENTS & GRAIN SIZE DISTRIBUTION (%)			
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	DEPTH (m)	ELEVATION (m)	Shear Strength Testing (kPa): Other Test, Pocket Penetrometer, Field Vane (Intact), Field Vane (Remolded); Penetration Testing: SPT, DCPT	Combustible Organic Vapour (ppm), Combustible Organic Vapour (%LEL), Total Organic Vapour (ppm); Atterberg Limits; Water Content (%)	Instrumentation Installation	GR	SA	SI	CL
	0.0 / 255.1													
	FILL: Silty sand to sandy silt, trace gravel, trace clay, dense, brown, moist	SS	1	75	38	0	255	38	8					
	- - - Trace organics, compact - - -	SS	2	100	15			15	13					
	1.5 / 253.6					1.5	253.5							
	SILTY SAND TO SANDY SILT GLACIAL TILL: Some gravel, some clay, cobbles and boulders, compact, brown, moist	SS	3	100	12			12	8					
	2.0 / 253.1													
	Borehole Terminated at 2.0 m													

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Groundwater depth encountered on completion of drilling: Dry
Groundwater depth observed on:
Cave depth after auger removal: Open
Groundwater Elevation:

Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :75**
Page: **1 of 1**

RECORD OF BOREHOLE No. 6

Project Number: **2203244**
Project Client: **City of Barrie**
Project Name: **Proposed Firehall 6**
Project Location: **Barrie, ON**
Drilling Location: **See Borehole Location Plan**
Local Benchmark:

Drilling Method: **Hollow Stem Augers** Drilling Machine: **Truck Mount**
Logged By: **BH** Northing: **4911890.0** Date Started: **Sep 22/22**
Reviewed By: **GRW** Easting: **610701.4** Date Completed: **Sep 22/22**

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	DEPTH (m)	ELEVATION (m)
	0.0 255.9					0	
	FILL: Silty sand to sandy silt, trace gravel, trace clay, dense, brown, moist	SS	1	100	38		
	- - - Compact - - -	SS	2	100	15		255
	1.5 254.4					1.5	
	SILTY SAND TO SANDY SILT GLACIAL TILL: Some gravel, some clay, cobbles and boulders, compact, brown, moist	SS	3	100	12		
	2.0 253.9 Borehole Terminated at 2.0 m						

FIELD TESTING
Shear Strength Testing (kPa)
× Other Test
+ Pocket Penetrometer
▲ Field Vane (Intact)
△ Field Vane (Remolded)
40 80 120 160
Penetration Testing
○ SPT ● DCPT
10 20 30 40
38
15
12

LAB TESTING
△ Combustible Organic Vapour (ppm)
▲ Combustible Organic Vapour (%LEL)
◇ Total Organic Vapour (ppm)
100 200 300 400
Atterberg Limits
PL LL
○ Water Content (%)
10 20 30 40
10
17
9

Instrumentation Installation

COMMENTS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL

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Groundwater depth encountered on completion of drilling: Dry
Groundwater depth observed on:
Cave depth after auger removal: Open
Groundwater Elevation:

Scale: **1 :75**

Appendix C

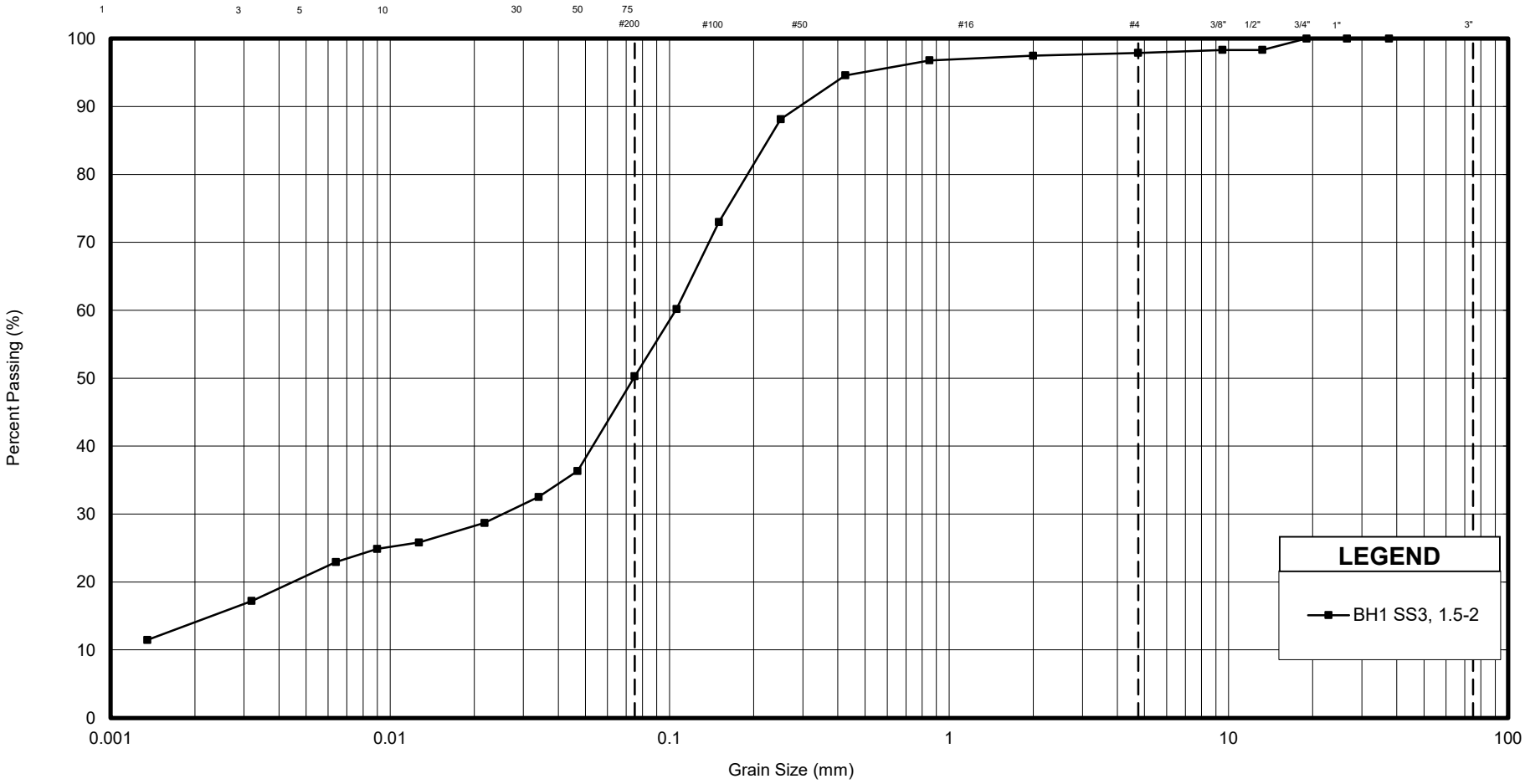
Geotechnical Laboratory Testing

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION (IMPERIAL)



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
BH1 SS3	SILT AND SAND, Some Clay, Trace Gravel	2	48	36	14	-	0.025	0.105	-	-

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GRAIN SIZE DISTRIBUTION - Firehall 6 Development

FILL: SILT AND SAND

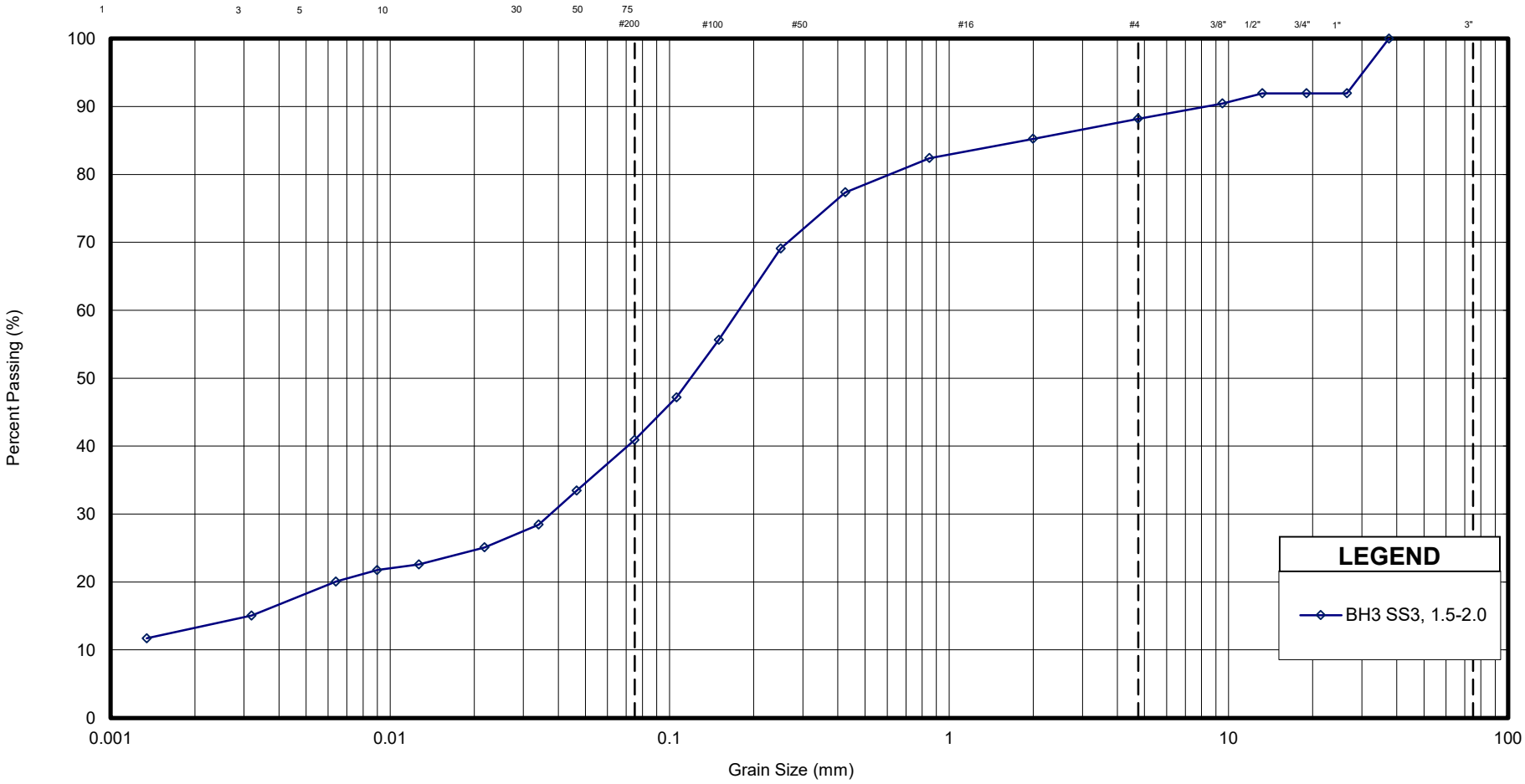
FIGURE No.	C1
REF. No.	2203244
DATE	December 2022

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION (IMPERIAL)



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
BH3 SS3	SILTY SAND, Some Clay, Some Gravel	12	47	28	13	-	0.037	0.177	-	-

GEI Consultants

GRAIN SIZE DISTRIBUTION - Firehall 6 Development

GLACIAL TILL: SILTY SAND

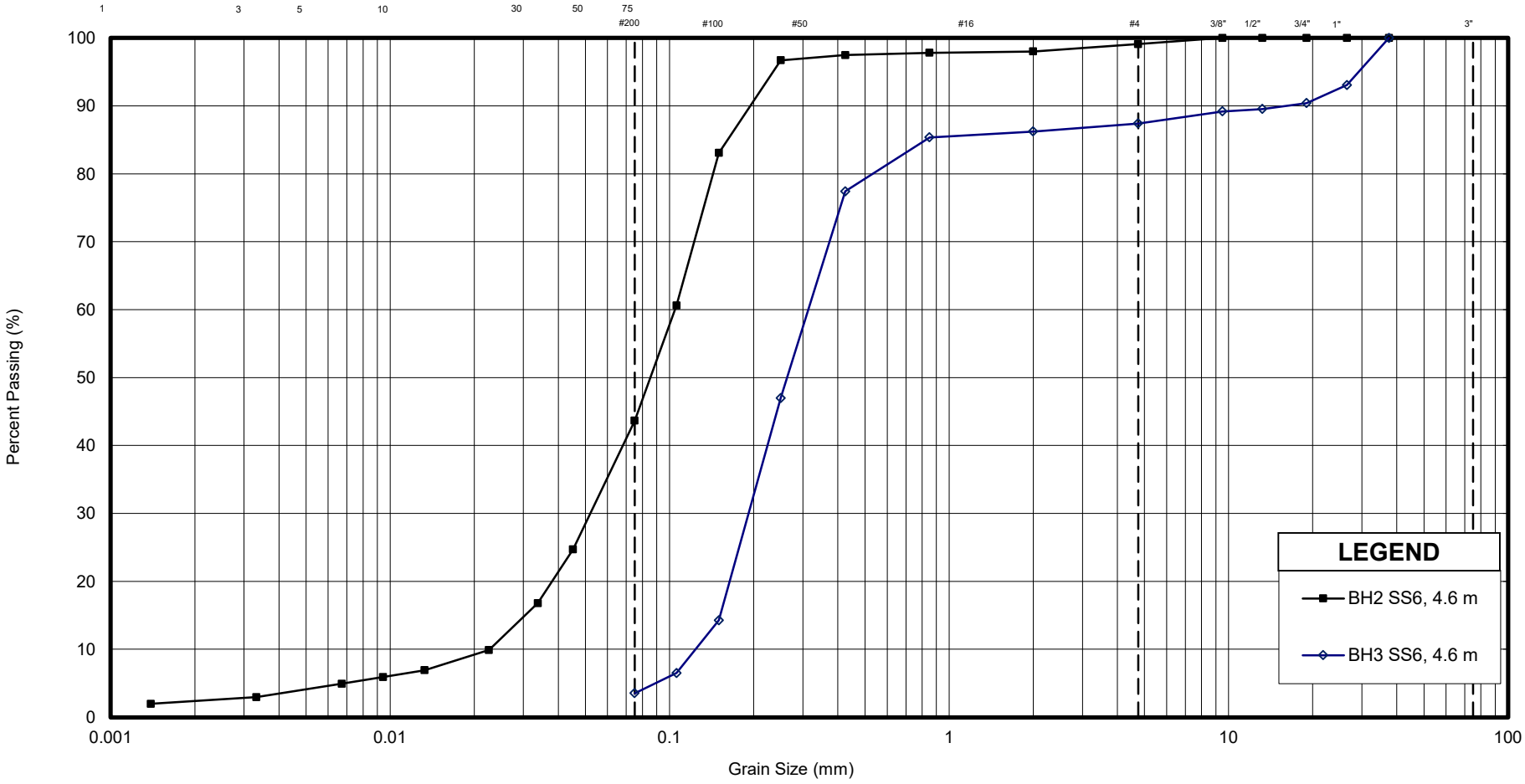
FIGURE No.	C2
REF. No.	2203244
DATE	December 2022

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION (IMPERIAL)



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
BH2 SS6	SILT AND SAND, Trace Clay, Trace Gravel	1	55	41	2	0.023	0.052	0.105	4.6	1.1
BH3 SS	SAND, Some Gravel, Trace Silt	13	84	3	-	0.124	0.192	0.314	2.5	0.9

GEI Consultants

GRAIN SIZE DISTRIBUTION - Firehall 6

FIGURE No. C3

REF. No. 2203244

DATE December 2022

Appendix D

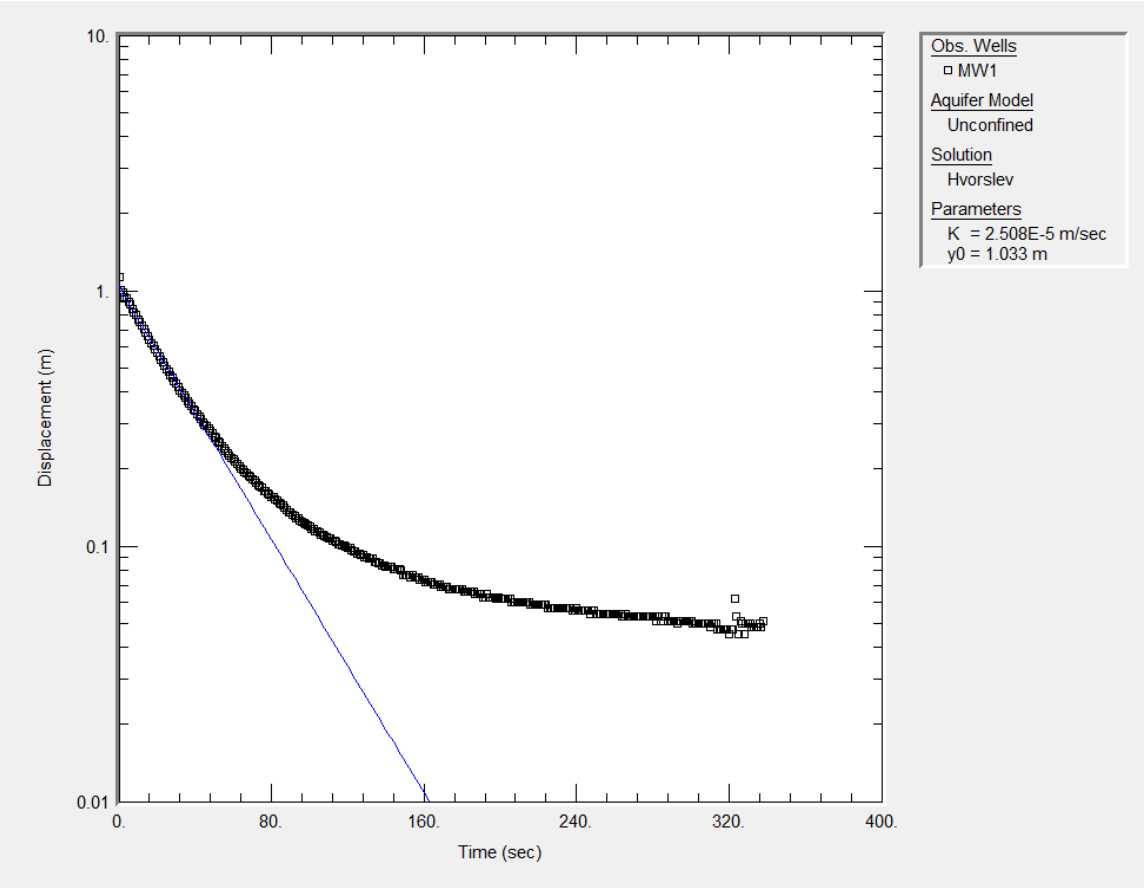
Borehole Permeability Plots

GEI Consultants

Estimation of K by Slug Test, based on Hvorslev's equation

Date:	December 7, 2022
Conducted by:	D.Jeon

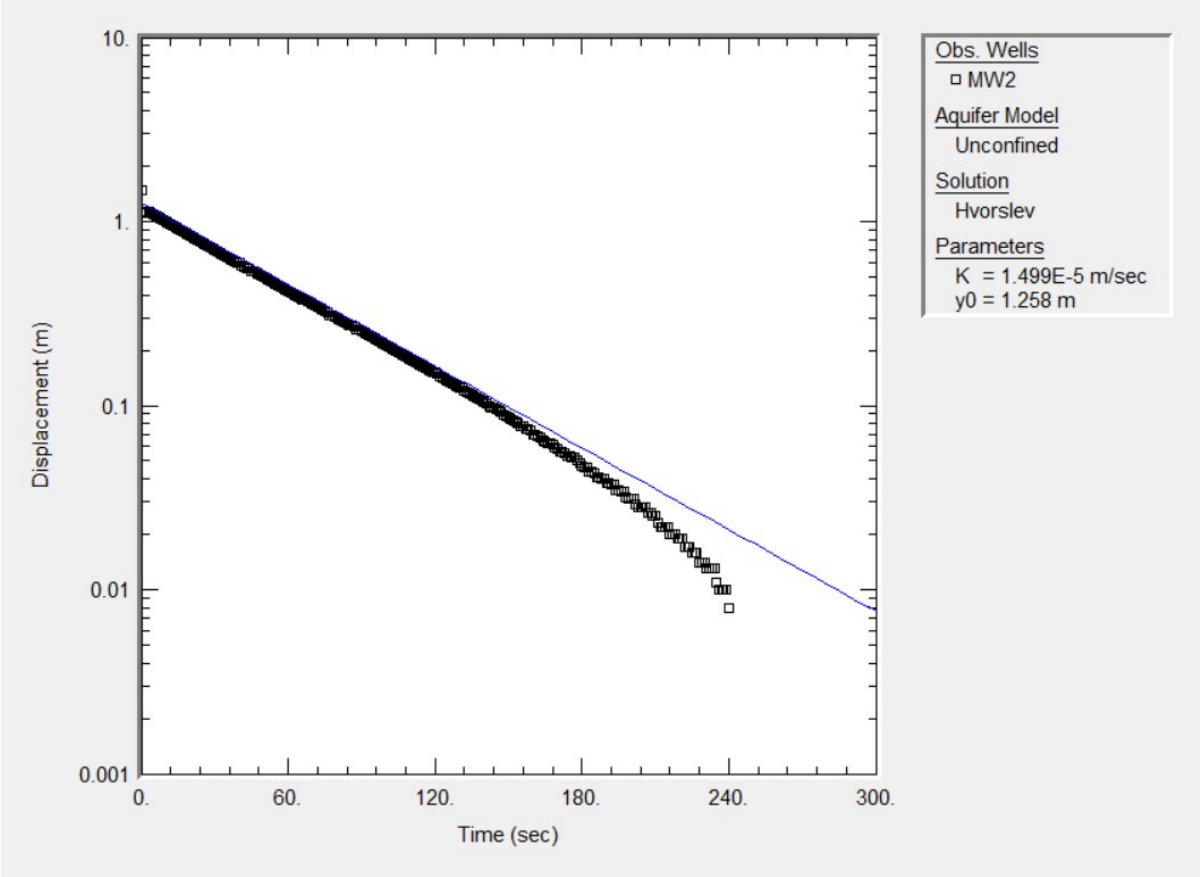
Well Number:	GEI-MW1	
Well Screen Bottom:	5.69	mbgs
Top of Pipe:	0.74	mags
Well Casing Diameter:	5.08	cm
Local Well Elevation:	255.55	masl
Static Water Level:	2.37	mbgs
$K = r^2\ln(L/R)/(2LTo) =$	**$2.508x10^{-5}$**	m/s



Estimation of K by Slug Test, based on Hvorslev's equation

Date:	December 7, 2022
Conducted by:	D.Jeon

Well Number:	GEI-MW2	
Well Screen Bottom:	5.83	mbgs
Top of Pipe:	0.88	mags
Well Casing Diameter:	5.08	cm
Local Well Elevation:	256.30	masl
Static Water Level:	2.46	mbgs
$K = r^2\ln(L/R)/(2LTo)$ =	**$1.499x10^{-5}$**	m/s

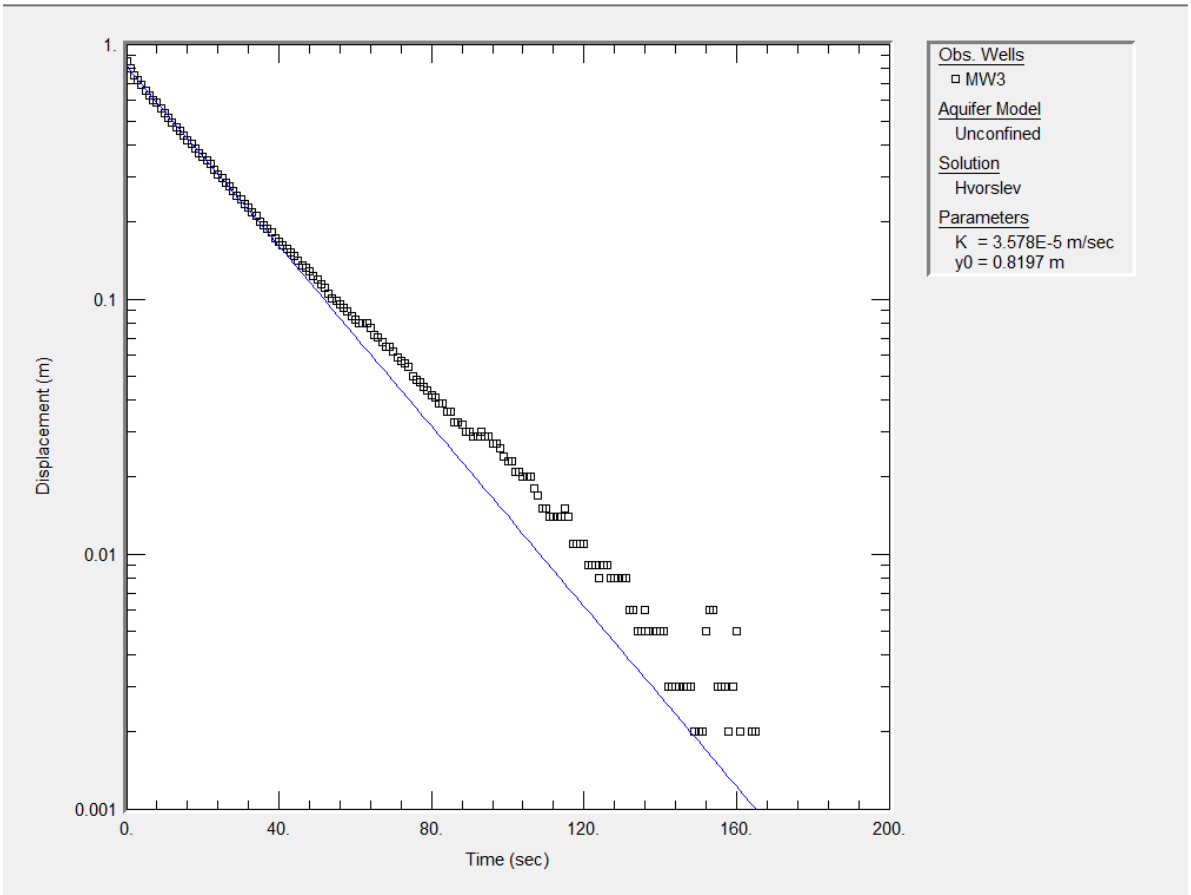


GEI Consultants

Estimation of K by Slug Test, based on Hvorslev's equation

Date:	December 7, 2022
Conducted by:	D.Jeon

Well Number:	GEI-MW3	
Well Screen Bottom:	5.58	mbgs
Top of Pipe:	0.83	mags
Well Casing Diameter:	5.08	cm
Local Well Elevation:	255.30	masl
Static Water Level:	2.01	mbgs
$K = r^2\ln(L/R)/(2LTo)$ =	**$3.578x10^{-5}$**	m/s



Appendix E

Water Quality Laboratory Certificate Of Analysis And Chain Of Custody

CADUCEON™ ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B22-35771 (i)

Rev. 1

Report To:

GEI Consultants
647 Welham Rd, Unit 14,
Barrie ON L4N 0B7 Canada
Attention: Sarah Griffith

Caduceon Environmental Laboratories
112 Commerce Park Drive
Barrie ON L4N 8W8
Tel: 705-252-5743
Fax: 705-252-5746

DATE RECEIVED: 07-Dec-22
DATE REPORTED: 15-Dec-22
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:

P.O. NUMBER: 2203244
WATERWORKS NO.

Parameter	Qty	Site Analyzed	Analyst Initials	Date Analyzed	Lab Method	Reference Method
Anions	1	Holly Lane	pcu	12-Dec-22	A-IC-01 (o)	SM4110C
pH	1	Holly Lane	SYL	09-Dec-22	A-PH-01 (o)	SM 4500H
Total Suspended Solids	2	Kingston	ama	09-Dec-22	A-TSS-001 (k)	SM2540D
BOD	1	Kingston	JWF	09-Dec-22	C-BOD-001 (k)	SM 5210B
Chromium (VI)	2	Holly Lane	ST	13-Dec-22	D-CRVI-01 (o)	MOE E3056
Mercury	2	Holly Lane	PBK	12-Dec-22	D-HG-02 (o)	SM 3112 B
Metals - ICP-OES	2	Holly Lane	CWp	12-Dec-22	D-ICP-01 (o)	SM 3120
Metals - ICP-OES	2	Holly Lane	NHG	12-Dec-22	D-ICP-01 (o)	SM 3120
Metals - ICP-MS	2	Holly Lane	TPR	12-Dec-22	D-ICPMS-01 (o)	EPA 200.8

Barrie Sanitary - Barrie Sanitary & Combined and Storm
Barrie-Storm Sewer - Storm Sewer Guidelines

Christine Burke
Lab Manager

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SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 2203244
WATERWORKS NO.

	Client I.D.		MW3	MW3F			Barrie Sanitary	
	Sample I.D.		B22-35771-1	B22-35771-2			Barrie-Storm Sewer	
	Date Collected		07-Dec-22	07-Dec-22				
Parameter	**Units**	**R.L.**						
pH @25°C	pH Units		7.92				9.5	
Total Suspended Solids	mg/L	3	**466**	< 3			15	
BOD(5 day)	mg/L	3	< 3				15	
Chloride	mg/L	0.5	91.4					
Aluminum	mg/L	0.01	4.11	0.03				
Antimony	mg/L	0.0001	0.0003	< 0.0001				
Arsenic	mg/L	0.0001	0.0009	< 0.0001				
Beryllium	mg/L	0.002	< 0.002	< 0.002				
Boron	mg/L	0.005	0.066	0.062				
Cadmium	mg/L	0.000015	0.000053	< 0.000015			0.001	
Chromium	mg/L	0.001	0.007	< 0.001			0.08	
Chromium (VI)	mg/L	0.001	0.002	< 0.001 [1]				
Cobalt	mg/L	0.0001	0.0062	0.0001				
Copper	mg/L	0.0001	**0.0123**	0.0006			0.01	
Iron	mg/L	0.005	8.36	< 0.005				
Lead	mg/L	0.00002	0.00359	< 0.00002			0.05	
Mercury	mg/L	0.00002	< 0.00002	< 0.00002				
Molybdenum	mg/L	0.01	< 0.01	< 0.01				
Nickel	mg/L	0.0002	0.0070	0.0005			0.05	
Selenium	mg/L	0.001	< 0.001	< 0.001				
Silver	mg/L	0.0001	< 0.0001	< 0.0001				
Thallium	mg/L	0.00005	0.00007	< 0.00005				
Tungsten	mg/L	0.01	< 0.01	< 0.01				
Uranium	mg/L	0.00005	0.00057	0.00039				

Barrie Sanitary - Barrie Sanitary & Combined and Storm
Barrie-Storm Sewer - Storm Sewer Guidelines

Christine Burke
Lab Manager

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Fax: 705-252-5746

DATE RECEIVED: 07-Dec-22
DATE REPORTED: 15-Dec-22
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 2203244
WATERWORKS NO.

	Client I.D.		MW3	MW3F			Barrie Sanitary	
	Sample I.D.		B22-35771-1	B22-35771-2			Barrie-Storm Sewer	
	Date Collected		07-Dec-22	07-Dec-22				
Parameter	**Units**	**R.L.**						
Vanadium	mg/L	0.005	0.010	< 0.005				
Zinc	mg/L	0.005	0.019	< 0.005			0.04	
Zirconium	mg/L	0.003	0.007	< 0.003				

1 . Chromium (VI) result is based on total Chromium

Barrie Sanitary - Barrie Sanitary & Combined and Storm
Barrie-Storm Sewer - Storm Sewer Guidelines

Christine Burke
Lab Manager

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JOB/PROJECT NO.:
P.O. NUMBER: 2203244
WATERWORKS NO.

Summary of Exceedances

Storm Sewer Guidelines

MW3	Found Value	Limit
Total Suspended Solids (mg/L)	466	15
Copper (mg/L)	0.0123	0.01

Barrie Sanitary - Barrie Sanitary & Combined and Storm
Barrie-Storm Sewer - Storm Sewer Guidelines

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SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:

P.O. NUMBER: 2203244
WATERWORKS NO.

Parameter	Qty	Site Analyzed	Analyst Initials	Date Analyzed	Lab Method	Reference Method
Chromium (VI)	2	Holly Lane	ST	13-Dec-22	D-CRVI-01 (o)	MOE E3056
Mercury	2	Holly Lane	PBK	12-Dec-22	D-HG-02 (o)	SM 3112 B
Metals - ICP-OES	2	Holly Lane	CWp	12-Dec-22	D-ICP-01 (o)	SM 3120
Metals - ICP-OES	2	Holly Lane	NHG	12-Dec-22	D-ICP-01 (o)	SM 3120
Metals - ICP-MS	2	Holly Lane	TPR	12-Dec-22	D-ICPMS-01 (o)	EPA 200.8

PWQO - Provincial Water Quality Objectives
Interim PWQO - Interim PWQO
PWQO - Provincial Water Quality Objectives

Christine Burke
Lab Manager

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SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 2203244
WATERWORKS NO.

	Client I.D.		MW3	MW3F			PWQO	
	Sample I.D.		B22-35771-1	B22-35771-2			Interim PWQO	PWQO
	Date Collected		07-Dec-22	07-Dec-22				
Parameter	**Units**	**R.L.**						
Aluminum	µg/L	10	**4110**	30			75	
Antimony	µg/L	0.1	0.3	< 0.1			20	
Arsenic	µg/L	0.1	0.9	< 0.1			5	5
Beryllium	µg/L	2	< 2	< 2				11
Boron	µg/L	5	66	62			200	
Cadmium	µg/L	0.015	0.053	< 0.015			0.1	0.2
Chromium	µg/L	1	7	< 1				
Chromium (VI)	µg/L	1	**2**	< 1 [1]				1
Cobalt	µg/L	0.1	**6.2**	0.1			0.9	
Copper	µg/L	0.1	**12.3**	0.6			5	
Iron	µg/L	5	**8360**	< 5				300
Lead	µg/L	0.02	**3.59**	< 0.02			1	5
Mercury	µg/L	0.02	< 0.02	< 0.02				0.2
Molybdenum	µg/L	10	< 10	< 10			40	
Nickel	µg/L	0.2	7.0	0.5				25
Selenium	µg/L	1	< 1	< 1				100
Silver	µg/L	0.1	< 0.1	< 0.1				0.1
Thallium	µg/L	0.05	0.07	< 0.05			0.3	0.3
Tungsten	µg/L	10	< 10	< 10			30	
Uranium	µg/L	0.05	0.57	0.39			5	
Vanadium	µg/L	5	**10**	< 5			6	
Zinc	µg/L	5	19	< 5			20	30
Zirconium	µg/L	3	**7**	< 3			4	

1 . Chromium (VI) result is based on total Chromium

PWQO - Provincial Water Quality Objectives
Interim PWQO - Interim PWQO
PWQO - Provincial Water Quality Objectives

Christine Burke
Lab Manager

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

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DATE RECEIVED: 07-Dec-22
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SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 2203244
WATERWORKS NO.

Summary of Exceedances

Interim PWQO

MW3	Found Value	Limit
Zirconium (µg/L)	7	4
Vanadium (µg/L)	10	6
Lead (µg/L)	3.59	1
Copper (µg/L)	12.3	5
Cobalt (µg/L)	6.2	0.9
Aluminum (µg/L)	4110	75

Provincial Water Quality Objectives

MW3	Found Value	Limit
Iron (µg/L)	8360	300
Chromium (VI) (µg/L)	2	1

PWQO - Provincial Water Quality Objectives
Interim PWQO - Interim PWQO
PWQO - Provincial Water Quality Objectives

Christine Burke
Lab Manager

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SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:

P.O. NUMBER: 2203244
WATERWORKS NO.

Parameter	Qty	Site Analyzed	Analyst Initials	Date Analyzed	Lab Method	Reference Method
PHC(F2-F4)	1	Kingston	KPR	09-Dec-22	C-PHC-W-001 (k)	MOE E3421
VOC's	1	Richmond Hill	FAL	12-Dec-22	C-VOC-02 (rh)	EPA 8260
PHC(F1)	1	Richmond Hill	FAL	12-Dec-22	C-VPHW-01 (rh)	MOE E3421

O. Reg. 153 - Soil, Ground Water and Sediment Standards
Tbl. 1 - GW (µg/L) - Table 1 - Ground Water

Christine Burke
Lab Manager

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DATE RECEIVED: 07-Dec-22
DATE REPORTED: 15-Dec-22
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 2203244
WATERWORKS NO.

	Client I.D.		MW3				O. Reg. 153	
	Sample I.D.		B22-35771-1				Tbl. 1 - GW (µg/L)	
	Date Collected		07-Dec-22					
Parameter	**Units**	**R.L.**						
Acetone	µg/L	30	< 30				2700	
Benzene	µg/L	0.5	< 0.5				0.5	
Bromodichloromethane	µg/L	2	< 2				2	
Bromoform	µg/L	5	< 5				5	
Bromomethane	µg/L	0.5	< 0.5				0.89	
Carbon Tetrachloride	µg/L	0.2	< 0.2				0.2	
Monochlorobenzene (Chlorobenzene)	µg/L	0.5	< 0.5				0.5	
Chloroform	µg/L	1	4				2	
Dibromochloromethane	µg/L	2	< 2				2	
Dichlorobenzene,1,2-	µg/L	0.5	< 0.5				0.5	
Dichlorobenzene,1,3-	µg/L	0.5	< 0.5				0.5	
Dichlorobenzene,1,4-	µg/L	0.5	< 0.5				0.5	
Dichlorodifluoromethane	µg/L	2	< 2				590	
Dichloroethane,1,1-	µg/L	0.5	< 0.5				0.5	
Dichloroethane,1,2-	µg/L	0.5	< 0.5				0.5	
Dichloroethylene,1,1-	µg/L	0.5	< 0.5				0.5	
Dichloroethene, cis-1,2-	µg/L	0.5	< 0.5				1.6	
Dichloroethene, trans-1,2-	µg/L	0.5	< 0.5				1.6	
Dichloropropane,1,2-	µg/L	0.5	< 0.5				0.5	
Dichloropropene, cis-1,3-	µg/L	0.5	< 0.5					
Dichloropropene, trans-1,3-	µg/L	0.5	< 0.5					

O. Reg. 153 - Soil, Ground Water and Sediment Standards
Tbl. 1 - GW (µg/L) - Table 1 - Ground Water

Christine Burke
Lab Manager

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DATE RECEIVED: 07-Dec-22
DATE REPORTED: 15-Dec-22
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 2203244
WATERWORKS NO.

	Client I.D.		MW3				O. Reg. 153	
	Sample I.D.		B22-35771-1				Tbl. 1 - GW (µg/L)	
	Date Collected		07-Dec-22					
Parameter	**Units**	**R.L.**						
Dichloropropene 1,3-cis+trans	µg/L	0.5	< 0.5				0.5	
Ethylbenzene	µg/L	0.5	< 0.5				0.5	
Dibromoethane,1,2-(Ethylene Dibromide)	µg/L	0.2	< 0.2				0.2	
Hexane	µg/L	5	< 5				5	
Methyl Ethyl Ketone	µg/L	20	< 20				400	
Methyl Isobutyl Ketone	µg/L	20	< 20				640	
Methyl-t-butyl Ether	µg/L	2	< 2				15	
Dichloromethane (Methylene Chloride)	µg/L	5	< 5				5	
Styrene	µg/L	0.5	< 0.5				0.5	
Tetrachloroethane,1,1,1,2-	µg/L	0.5	< 0.5				1.1	
Tetrachloroethane,1,1,2,2-	µg/L	0.5	< 0.5				0.5	
Tetrachloroethylene	µg/L	0.5	< 0.5				0.5	
Toluene	µg/L	0.5	< 0.5				0.8	
Trichloroethane,1,1,1-	µg/L	0.5	< 0.5				0.5	
Trichloroethane,1,1,2-	µg/L	0.5	< 0.5				0.5	
Trichloroethylene	µg/L	0.5	< 0.5				0.5	
Trichlorofluoromethane	µg/L	5	< 5				150	
Vinyl Chloride	µg/L	0.2	< 0.2				0.5	
Xylene, m,p-	µg/L	1.0	< 1.0					
Xylene, o-	µg/L	0.5	< 0.5					

O. Reg. 153 - Soil, Ground Water and Sediment Standards
Tbl. 1 - GW (µg/L) - Table 1 - Ground Water

Christine Burke
Lab Manager

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

REPORT No. B22-35771 (i)

Rev. 2

Report To:

GEI Consultants
647 Welham Rd, Unit 14,
Barrie ON L4N 0B7 Canada
Attention: Sarah Griffith

Caduceon Environmental Laboratories
112 Commerce Park Drive
Barrie ON L4N 8W8
Tel: 705-252-5743
Fax: 705-252-5746

DATE RECEIVED: 07-Dec-22
DATE REPORTED: 15-Dec-22
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 2203244
WATERWORKS NO.

	Client I.D.		MW3				O. Reg. 153	
	Sample I.D.		B22-35771-1				Tbl. 1 - GW (µg/L)	
	Date Collected		07-Dec-22					
Parameter	**Units**	**R.L.**						
Xylene, m,p,o-	µg/L	1.1	< 1.1				72	
PHC F1 (C6-C10)	µg/L	25	< 25				420	
PHC F2 (>C10-C16)	µg/L	50	< 50				150	
PHC F3 (>C16-C34)	µg/L	400	< 400				500	
PHC F4 (>C34-C50)	µg/L	400	< 400				500	

O. Reg. 153 - Soil, Ground Water and Sediment Standards
Tbl. 1 - GW (µg/L) - Table 1 - Ground Water

Christine Burke
Lab Manager

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: ---

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Attention: Sarah Griffith

Caduceon Environmental Laboratories
112 Commerce Park Drive
Barrie ON L4N 8W8
Tel: 705-252-5743
Fax: 705-252-5746

DATE RECEIVED: 07-Dec-22
DATE REPORTED: 15-Dec-22
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 2203244
WATERWORKS NO.

Summary of Exceedances

Table 1 - Ground Water

MW3	Found Value	Limit
Chloroform (µg/L)	4	2

O. Reg. 153 - Soil, Ground Water and Sediment Standards
Tbl. 1 - GW (µg/L) - Table 1 - Ground Water

Christine Burke
Lab Manager

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

GENERAL SAMPLE SUBMISSION FORM

CADUCEON ENVIRONMENTAL LABORATORIES
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SAMPLES SUBMITTED TO:

Kingston	
Ottawa	
Richmond Hill	
Barrie	x
London	
Windsor	

TESTING REQUIREMENTS

x	O'Reg 153/04	1	Table (1 - 9)		Record of Site
	O'Reg 406/19		Table (1 - 9.1)		SPLP Table (1 - 9.1)
	RPI		ICC		Agricultural
	Coarse		Medium/Fine		O'Reg 558 TCLP
	MISA	x	PWQO		Landfill Monitoring
	Other:		City of Barrie Storm Sewer		

REPORT NUMBER (Lab Use)

B22-35771

Are any samples to be submitted intended for Human Consumption under any Drinking Water Regulations? [ ] Yes [x] No (If yes, submit all Drinking Water Samples on a Drinking Water Chain of Custody)

Organization: GEI Consultants	Address: 647 Wellham Road, Barrie	Invoicing Address (if different):
Contact: Sarah Griffith		
Tel: 226-791-5382 / Fax:		
Email: sgriffith@geiconsultants.com	Quote #:	Project Name/#: 2203244
Additional Info (email, cell, etc):	P.O. #:	Additional Info:

ANALYSES REQUESTED

PWQO Metals; O'Reg 153/04 PHC/VOCs; PWQO TSS; City of Barrie Storm Sewer; Suspected Highly Contaminated

TURNAROUND SERVICE REQUESTED (see back page)

*Must be arranged in advance

[ ]	Platinum*	200% Surcharge
[ ]	Gold*	100% Surcharge
[ ]	Silver	50% Surcharge
[ ]	Bronze	25% Surcharge
[x]	Standard	5-7 days
[ ]	Specific Date:	

* Sample Matrix Legend: WW=Waste Water, SW=Surface Water, GW=Groundwater, LS=Liquid Sludge, SS=Solid Sludge, S=Soil, Sed=Sediment, PC=Paint Chips, F=Filter, Oil = Oil

Lab No.	Sample Source and/or Sample Identification	S.P.L.	Sample Matrix *	Date Collected (yy-mm-dd)	Time Collected	Indicate Test For Each Sample By Using A Check Mark In The Box Provided	X	Field pH	Field Temp.	# Bottles/ Sample	Field Filtered Y/N
1	MW3		GW	22-12-7		x x x				9	N
2	MW3 (F)		GW	22-12-7		x x				4	Y
	#1&2 gn chem + #1 sm L Amber -> K										
	#1 gn chem -> O										
	#1&2 metals + Hg + CrVi -> O										
	#1 vials -> RH										

SAMPLE SUBMISSION INFORMATION

	Sampled by:	Submitted by:
Print:	S.Patrick	S.Patrick
Sign:		
	22-12-07	22-12-07
	Date (yy-mm-dd)/Time:	Date (yy-mm-dd)/Time:

SHIPPING INFORMATION

Courier (Client account)		Invoice	
Courier (Caduceon account)			
Drop Off	x	# of Pieces	
Caduceon (Pick-up)			

REPORTING / INVOICING

Report by Fax	
Report by Email	x
Invoice by Email	x
Invoice by Mail	

SAMPLE RECEIVING INFORMATION (LABORATORY USE ONLY)

Received By (print): Autumn Signature: AH
Date Received (yy-mm-dd): 22-12-7 Time Received: 1632
Laboratory Prepared Bottles: [X] Yes [ ] No
Sample Temperature °C: 8.4 Labeled by: AH

Comments:

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G106110 **REPORT No. B23-00058**

Report To:

GEI Consultants
647 Welham Rd, Unit 14,
Barrie ON L4N 0B7 Canada
Attention: Sarah Griffith

Caduceon Environmental Laboratories
112 Commerce Park Drive
Barrie ON L4N 8W8
Tel: 705-252-5743
Fax: 705-252-5746

DATE RECEIVED: 03-Jan-23
DATE REPORTED: 06-Jan-23
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 2203244
WATERWORKS NO.

Parameter	Qty	Site Analyzed	Analyst Initials	Date Analyzed	Lab Method	Reference Method
VOC's	1	Richmond Hill	FAL	04-Jan-23	C-VOC-02 (rh)	EPA 8260

µg/g = micrograms per gram (parts per million) and is equal to mg/Kg
F1 C6-C10 hydrocarbons in µg/g, (F1-btex if requested)
F2 C10-C16 hydrocarbons in µg/g, (F2-napth if requested)
F3 C16-C34 hydrocarbons in µg/g, (F3-pah if requested)
F4 C34-C50 hydrocarbons in µg/g
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
Any deviations from the method are noted and reported for any particular sample.
nC6 and nC10 response factor is within 30% of response factor for toluene:
nC10,nC16 and nC34 response factors within 10% of each other:
C50 response factors within 70% of nC10+nC16+nC34 average:
Linearity is within 15%:
All results expressed on a dry weight basis.
Unless otherwise noted all chromatograms returned to baseline by the retention time of nC50.

Unless otherwise noted all extraction, analysis, QC requirements and limits for holding time were met.
If analyzed for F4 and F4G they are not to be summed but the greater of the two numbers are to be used in application to the CWS PHC
QC will be made available upon request.

O. Reg. 153 - Soil, Ground Water and Sediment Standards
Tbl. 1 - GW (µg/L) - Table 1 - Ground Water

Christine Burke
Lab Manager

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G106110 **REPORT No. B23-00058**

Report To:

GEI Consultants
647 Welham Rd, Unit 14,
Barrie ON L4N 0B7 Canada
Attention: Sarah Griffith

Caduceon Environmental Laboratories
112 Commerce Park Drive
Barrie ON L4N 8W8
Tel: 705-252-5743
Fax: 705-252-5746

DATE RECEIVED: 03-Jan-23
DATE REPORTED: 06-Jan-23
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 2203244
WATERWORKS NO.

	Client I.D.		MW3				O. Reg. 153 Tbl. 1 - GW (µg/L)	
	Sample I.D.		B23-00058-1					
	Date Collected		03-Jan-23					
Parameter	**Units**	**R.L.**						
Chloroform	µg/L	1	**3**				2	

O. Reg. 153 - Soil, Ground Water and Sediment Standards
Tbl. 1 - GW (µg/L) - Table 1 - Ground Water

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Christine Burke
Lab Manager

CADUCEON™ ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G106110 **REPORT No. B23-00058**

Report To:

GEI Consultants
647 Welham Rd, Unit 14,
Barrie ON L4N 0B7 Canada
Attention: Sarah Griffith

Caduceon Environmental Laboratories
112 Commerce Park Drive
Barrie ON L4N 8W8
Tel: 705-252-5743
Fax: 705-252-5746

DATE RECEIVED: 03-Jan-23
DATE REPORTED: 06-Jan-23
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.:
P.O. NUMBER: 2203244
WATERWORKS NO.

Summary of Exceedances

Table 1 - Ground Water

MW3	Found Value	Limit
Chloroform (µg/L)	3	2

O. Reg. 153 - Soil, Ground Water and Sediment Standards
Tbl. 1 - GW (µg/L) - Table 1 - Ground Water

Christine Burke
Lab Manager

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

GENERAL SAMPLE SUBMISSION FORM

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SAMPLES SUBMITTED TO:
- [ ] Kingston
- [ ] Ottawa
- [ ] Richmond Hill
- [X] Barrie
- [ ] Windsor

TESTING REQUIREMENTS
- [X] O'Reg 153/04 — Table (1 - 9): Table 1
- [ ] O'Reg 406/19 — Table (1 - 9.1)
- [ ] RPI
- [ ] Coarse
- [ ] MISA
- [ ] Other:
- [ ] ICC
- [ ] Medium/Fine
- [X] PWQO (struck out)
- Record of Site
- SPLP Table (1-9.1)
- [ ] Agricultural
- [ ] O'Reg 558 TCLP
- [ ] Landfill Monitoring

REPORT NUMBER (Lab Use): B23-00058

Are any samples to be submitted intended for Human Consumption under any Drinking Water Regulations? [ ] Yes [ ] No (If yes, submit all Drinking Water Samples on a Drinking Water Chain of Custody)

Organization:	GEI Consultants
Contact:	Sarah Griffith.
Tel:	
Fax:	
Email:	Sgriffith@geiconsultants.com.
Additional Info (email, cell, etc):	
Address:	647 Welham Rd, Barrie
Quote #:	
P.O. #:	
Invoicing Address (if different):	
Project Name or #:	2203244
Additional Info:	

ANALYSES REQUESTED: [struck out]; Chloroform O.Reg 153

Suspected Highly Contaminated

TURNAROUND SERVICE REQUESTED (see back page)
*Must be arranged in advance
- [ ] Platinum* — 200% Surcharge
- [ ] Gold* — 100% Surcharge
- [ ] Silver — 50% Surcharge
- [ ] Bronze — 25% Surcharge
- [X] Standard — 5-7 days
- [ ] Specific Date:

* Sample Matrix Legend: WW=Waste Water, SW=Surface Water, GW=Groundwater, LS=Liquid Sludge, SS=Solid Sludge, S=Soil, Sed=Sediment, PC=Paint Chips, F=Filter, Oil = Oil

Lab No.	Sample Source and/or Sample Identification	S.P.L. (Watertrax)	Sample Matrix*	Date Collected (yy-mm-dd)	Time Collected	Indicate Test For Each Sample By Using A Check Mark In The Box Provided	X	Field pH	Field Temp.	# Bottles/ Sample	Field Filtered Y/N
1	MW3		GW	23-1-3	AM	[struck out]; X (Chloroform O.Reg 153)				2	N
	Vials → RH										

SAMPLE SUBMISSION INFORMATION

	Sampled by:	Submitted by:
Print:	Scott Patrick	Scott Patrick
Sign:	[signature]	[signature]
Date (yy-mm-dd)/Time:	23-01-03	23-01-03

SHIPPING INFORMATION
- [ ] Courier (Client account)
- [ ] Courier (Caduceon account)
- [X] Drop Off
- [ ] Caduceon (Pick-up)

Invoice
# of Pieces

REPORTING / INVOICING
- [ ] Report by Fax
- [X] Report by Email
- [X] Invoice by Email
- [ ] Invoice by Mail

SAMPLE RECEIVING INFORMATION (LABORATORY USE ONLY)

Received By (print):	Autumn
Signature:	AH
Date Received (yy-mm-dd):	23-01-03
Time Received:	1315
Laboratory Prepared Bottles:	[X] Yes [ ] No
Sample Temperature °C:	7.8
Labeled by:	AH

Comments:

Page 1 of 1

G 106110

Appendix F

Construction Dewatering Calculations

GEI Consultants

Construction Dewatering Rate Estimate

Proposed Firehall 6, 845 Mapleview Drive East, Barrie, Ontario - General Site Servicing Scenario

Temporary Construction Dewatering Rate Estimates

Description	Symbol	Values	Unit	Explanation
Input Data				
Assumed Ground Elevation		255.1	m asl	Lowest Measured Elevation of Borehole in the Area (BH5)
Highest Groundwater Elevation		253.8	m asl	Measure at BH/MW 2 on December 7th, 2022
Lowest Proposed Excavation		251.1	m asl	
Aquifer Bottom		249.1	m asl	Assume target water level
Hydraulic Conductivity	K	3.60E-05	m/s	
Length of Excavation	x	40	m	Based on site plan
Width of Excavation	a	5	m	Based on site plan
Output				
Top of Aquifer		253.8	m asl	Average measured groundwater level
Target Water Level		250.1	m asl	Assume 1.0 m below lowest proposed excavation
Water Level above aquifer bottom before dewatering	H	4.7	m	
Target Water Level above above aquifer bottom	h	1.0	m	
Radius of Influence	R_0	66.60	m	Sichardt Equation
Precipitation		2000	L/day	10 mm rain event
Construction Dewatering Flow Rate - Steady State	Q	88.6	m^3/day	Construction Dewatering Flow - Dupuit Equation
Maximum Construction Flow Rate (safety factor of 2)	2Q	177.3	m^3/day	

Construction Dewatering Flow Rate - Steady State	Q	**88,600**	L/day
Maximum Construction Flow Rate (safety factor of 2)	2Q	**177,200**	L/day
Maximum Construction Flow Rate (safety factor of 2) with 10 mm rainfall event	2Q	**179,200**	L/day

Equivalent Well Radius Method

Proposed Firehall 6, 845 Mapleview Drive East, Barrie, Ontario - Basement Excavation

Inputs

Rs (m)	Ro (m)	H (m)	h (m)	k (m/s)	Trench Length, x (m)	Trench Width, b (m)
9.6	56.8	4.2	1.0	3.50E-05	17	17

Elevations (m)

Ground Surface	255.1
Highest Water Level	253.8
Base of Excavation	251.6
Drawdown Target	250.6
Aquifer Bottom	249.6

Groundwater Flows		
Flow Rate, Q=	0.0009	m3/s
Q=	81,712	L/day
Safety Factor	2	
Q factored =	**163,424**	L/day

Precipitation		
Rainfall Event	10	mm
Excavation Area	289	m2
Rainfall Q =	**2,890**	L/day

TOTAL Factored Q =	**166,314**	**L/day**

Appendix G

Preliminary Water Balance

Hydrogeological Investigation – Proposed Firehall 6
845 Mapleview Drive East, Barrie, ON
Project No. 2203244, November, 2022

Water Balance - Proposed Firehall 6

MONTHLY AND YEARLY WATER BALANCE COMPONENTS														
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Potential Evapotranspiration Calculation	Average Temperature: T (^{o}C)	-7.7	-6.5	-1.9	5.7	12.1	17.4	20.1	19.2	15.2	8.7	2.6	-3.6	6.8
	Heat Index: $i=(T/5)^{1.514}$	0.00	0.00	0.00	1.22	3.81	6.61	8.22	7.67	5.38	2.31	0.37	0.00	35.6
	Unadjusted Potential Evapotranspiration: U (mm)	0.0	0.0	0.0	26.4	58.8	86.4	100.8	96.0	74.9	41.4	11.5	0.0	496.0
	Adjusting Factor for U (Latitude 44^{o})	0.81	0.81	1.02	1.13	1.27	1.28	1.30	1.20	1.04	0.94	0.80	0.76	-
	Adjusted Potential Evapotranspiration - PET (mm)	0.0	0.0	0.0	29.8	74.6	110.6	131.0	115.2	77.9	38.9	9.2	0.0	587.2
Pervious Components	Precipitation: P (mm)	88.8	69.8	63.8	65	79.9	88.6	73.2	86.2	92.2	78.2	98	84.3	968.0
	Adjusted Potential Evapotranspiration: PET (mm)	0.0	0.0	0.0	29.8	74.6	110.6	131.0	115.2	77.9	38.9	9.2	0.0	587.2
	P - PET	88.8	69.8	63.8	35.2	5.3	-22.0	-57.8	-29.0	14.3	39.3	88.8	84.3	380.8
	Change in Soil Moisture Storage (mm)	0.0	0.0	0.0	0.0	0.0	-22.0	-57.8	-29.0	14.3	39.3	0.0	0.0	-
	Water Holding Capacity (max. 125 mm)	125.0	125.0	125.0	125.0	125.0	103.0	45.2	16.2	30.5	69.8	125.0	125.0	-
	Water Surplus Available for Infiltration or Runoff	88.8	69.8	63.8	35.2	5.3	0.0	0.0	0.0	0.0	0.0	33.7	84.3	380.8
	Potential Infiltration based on MECP Infiltration Factor (mm)	71.0	55.8	51.0	28.1	4.2	0.0	0.0	0.0	0.0	0.0	26.9	67.4	304.7
	Potential Surface Water Runoff (mm)	17.8	14.0	12.8	7.0	1.1	0.0	0.0	0.0	0.0	0.0	6.7	16.9	76.2
Impervious Components	Precipitation: P (mm)	-												968.0
	Potential Evaporation: PE (mm), Assume 15%	-												145.2
	Potential Surface Water Runoff: P - PE (mm)	-												822.8

PRE- AND POST-DEVELOPMENT WATER BALANCE (NO LOW IMPACT DEVELOPMENT MEASURES IN PLACE)							
		Total Land Area (m^2)	Est. Fraction of Land	Est. Land Area (m^2)	Runoff (m^3/annum)	Infiltration (m^3/annum)	**Runoff Increase Pre to Post**
Existing Land Use (Pre-Development)	Pervious Area	7215.0	100%	7215.0	549.5	2198.2	245%
	Impervious Area		0%	0.0	0.0	0.0	**Infiltration Decrease Pre to Post**
	TOTAL	-	100%	7215.0	549.5	2198.2	-25%
Proposed Land Use (Post-Development)	Pervious Area	7215.0	75%	5411.3	412.2	1648.6	**Infiltration Required to Meet Pre-Development Conditions (m^3)**
	Impervious Area (Firehall, pavements)		25%	1803.8	1484.1	0.0	
	TOTAL	-	100%	7215.0	1896.3	1648.6	550

Notes
1. Both potential infiltration and surface water runoff are independent of temperature
2. Assumption is in January maximum soil moisture storage value is present (125mm)
3. Water Holding Capacity & Infiltration Factors taken from Table 3.1 of MOE SWMPDM, 2003
4. Average Temp. and Precip. taken from Environment Canada station "Shanty Bay" between 1981 and 2010
5. Adjusting Factor for U based on Lorente, 1961

Infiltration Criteria	Site Description	Infiltration Factor
Topography	Flat Land - Average Slope Less Than 0.6 m/km	0.3
Soils	Open Sandy Loam	0.4
Cover	Cultivated Land	0.1
	Sum of Infiltration Factors	**0.8**

Appendix H

Groundwater Taking Plan

Construction Dewatering Discharge Rate and Zone of Influence

The Radius of Influence and temporary dewatering discharge rates were estimated in Section 5.1 and the details are summarized below.

Dewatering Zone	Description	ROI (m)
1	General Site Servicing Scenario	67
2	Building Basement Excavation	57

Location and Scenario	Construction Dewatering Flow Rate Without Safety Factor	Construction Dewatering Flow Rate Including Safety Factor of 2	Construction Dewatering Flow Rate Including Safety Factor of 2 with a 10 mm Rainfall Event
	L/day		
1 - General Site Servicing Scenario	88,600	177,200	179,200
2 – Building Basement Excavation	81,700	163,400	166,300

The total construction dewatering flow rate includes a factor of safety of 2.0 to account for seasonal fluctuations in the groundwater table and variation in hydrogeological properties beyond those encountered during the course of this study. This total dewatering flow rate also provides additional capacity for the dewatering contractors. A 10 mm rain event was also included in the water taking calculation. Therefore, a posting on the EASR run by the MECP will be required.

Dewatering Impact Assessment

Potential Settlement and Land Stability

For the assumed maximum groundwater drawdown of about 2 metres, settlement of the soil within the radius of influence must be calculated based on the increase in effective stress (10 kPa per metre of drawdown) from reducing the pore water pressures. Settlement has the potential to damage buried utilities, building foundations, or cause subsidence in adjacent lands. The maximum amount of settlement will occur adjacent to the dewatering system where the maximum drawdown occurs, and the amount of settlement will decrease exponentially to zero towards the radius of influence limit.

At the trench location where dewatering will occur, the maximum settlement due to drawdown is estimated at 5 mm or less. The nearest residential houses or commercial buildings are more than 50 metres from the expected dewatering locations (across Mapleview Drive East), and at this distance the settlement is estimated to be less than 2 mm due to the exponential decrease in drawdown with depth.

Generally, buildings are designed to accommodate up to 25 mm of absolute settlement, and infrastructure is typically less settlement sensitive and can typically accommodate 50 to 100 mm of absolute settlement. To be conservative, the settlement tolerances that GEI believes is reasonable that can be accommodated by the existing buildings and infrastructure is 50% of what is typically allowed before significant mitigation measures are required. This is summarized below:

- Structures: Maximum 12.5 mm of absolute settlement.
- Servicing/Roadways: Maximum 25 mm of absolute settlement.

It is expected that less than 2 mm of settlement will occur for any nearby structures within the ROI, and no impacts are expected. This assessment must be confirmed once final construction details are provided to GEI and the final ROI, maximum drawdowns, and dewatering locations are known. The surrounding land should be inspected / monitored during construction dewatering to ensure there are no impacts.

The cohesionless deposits beneath the site are elastic materials and historic fluctuations in groundwater levels (e.g. seasonal or from past dewatering works for existing services) may have partially induced additional stress in the cohesionless deposits, resulting in elastic settlement (reduction in void space and re-arrangement of soil particles), most of which was likely non-recoverable. For this reason, the amount of settlement related to dewatering could be lower than estimated.

Another cause of significant dewatering related settlement is due to pumping of fines through the system. It is imperative that any dewatering systems shall be designed and installed adequately to ensure no soil is conveyed through the system. Sufficient filtering techniques will need to be incorporated at the entry point to avoid migration of fines in the pumping/dewatering system.

Potential Impact on Other Water Users

Since the proposed residential subdivision and the surrounding areas are municipally serviced temporary dewatering activities will not impact any water well users. Some domestic wells were

noted on the MECP water well record database, but since the surrounding area is municipally serviced or currently under development, it is expected that the domestic wells are no longer in use.

Potential Impact to Water Bodies or Environmental Features

Given the short duration of the proposed construction dewatering and that the water removed will ultimately be returned back to the watershed, it is not anticipated that the proposed construction dewatering activity will negatively impact the groundwater flow to the tributary of Hewitt's Creek. No surface water features are noted within the dewatering ROI.

Water Quantity, Quality and Ground Water Level Monitoring Program

If the dewatering discharge water is treated by filtration (a silt bag at a minimum) to remove sediment and fines, the water quality is expected to improve to likely meet the PWQO and City of Barrie Storm Sewer B-Law criteria based on the testing completed during the hydrogeological study.

Discharge Options

Based on the groundwater quality analysis to date dewatering discharge will be directed to the surface provided groundwater quality during dewatering activities comply with the applicable PWQO. Alternatively, the groundwater can be discharged into City storm sewers provided the contractor obtains the necessary discharge permits from the City.

If the groundwater quality of the construction dewatering discharge does not meet the applicable standards treatment options should be evaluated and/or the system should be shut down.

Water Quality Monitoring and Potential Treatment Plan

The monitoring plan for discharge to the surface is outlined on Table H-1.

Ground Water Level Monitoring Program

The groundwater level monitoring program is outlined on Table H-2.

Discharge Rate Monitoring

The total groundwater volume pumped must be measured and recorded daily by the dewatering contractor. The water taking rates should be measured using an electronic device, and the daily water volumes must be reported to MECP on the Water Taking and Reporting System (WTRS)

or through the Regulatory Self Reporting System. The volume of water taken daily for each dewatered work area shall be reported to the ministry on or before March 31 in each year, for each location from which water was taken in the previous calendar year. If no water is taken, then a “no taking” report must be entered.

The contractor will maintain a record of all water takings. This record will include the dates and duration of water takings, and the total measured volume of water pumped per day for each day that water is taken and will be updated and reported to the Client weekly. Daily precipitation must also be recorded by the contractor. The records must be kept up to date and available at or near the site and provided to the MECP upon request.

Summary of Qualifications

Russell Wiginton, P.Eng.

Russell Wiginton is a licensed Professional Engineer in Ontario. He received his Bachelor of Science in Civil Engineering from Queen's University in Kingston. He has 10 years of experience in geotechnical and hydrogeological engineering. His experience includes subsurface field investigations, in-situ groundwater sampling and testing, geotechnical and hydrogeological engineering analysis, finite element modelling for groundwater flow, and preparation of engineering reports to support PTTW applications, EASR postings, or for review by various agencies such as Conservation Authorities.

Date of Plan Preparation

This plan prepared on the date January 20, 2023.

TABLE H-1

WATER QUALITY MONITORING PLAN FOR DEWATERING DISCHARGE TO SURFACE OR STORM SEWERS [1]

Period	Monitoring Location	Parameters[2]	Monitoring Frequency[3]	Trigger For Mitigation	Mitigation Measures / Comments
Trial Dewatering or at the Start of Construction	Dewatering discharge	○ PWQO Metals ○ City of Barrie Storm Sewer Use By-Law Criteria	Once during trial dewatering or on the first day of dewatering (with rushed samples)	Exceeds the PWQO and/or the City of Barrie Storm Sewer Use By-Law Criteria	Modify treatment method and/or shut down.
During Construction Dewatering	Dewatering system discharge location	○ PWQO Metals ○ City of Barrie Storm Sewer Use By-Law Criteria	Weekly then every four weeks after 3 consecutive weekly compliant samples[3]	Exceeds the PWQO and/or the City of Barrie Storm Sewer Use By-Law Criteria	Modify treatment method and/or shut down.
		○ Turbidity	Daily until stable (minimum 5 samples) then weekly[3]	Exceeds 15 NTU	
		○ Hydrocarbon sheen in discharge	Daily	Hydrocarbon sheen observed	Stop dewatering until the source can be determined and remediate prior to continuing to discharge.
		○ Total groundwater pumping / discharge rate	Daily with electronic device	Flows exceeds 400,000 L/day (e.g. due to heavy rainfall event)	Temporarily reduce pumping rate or shorten the length of trench being dewatered until rate drops.
		○ Record the daily precipitation at the construction site	Daily	N/A	N/A
	Within the ROI from the Dewatering Location / Trench	○ Signs of erosion, sediment, or flooding	Daily	Sedimentation, erosion, flooding observed.	Reduce pumping and/or improve sediment/erosion control measures.

		○ Settlement / Subsidence of nearby land	Daily	Visual indication of settlement/subsidence	Reduce pumping and consult both dewatering contractor and geotechnical engineer
		○ N/A	N/A	Complaint received with respect to water taking and pertains to natural environment	Document and evaluate if actually related to dewatering, implement mitigation measures. Submit complaint and mitigation measures to local MECP office

Notes:
(1) It is recommended that discharge be treated by a sediment control facility such as a decantation tank or filtration bags.
(2) Parameters may be removed from future testing after three consecutive compliant results and with agreement by QP. If dewatering moves to a different location all initial parameters must be retested.
(3) If dewatering moves to a different location or a non-compliant result is detected, the sampling will return to the initial frequency.

TABLE H-2

SUMMARIZED GROUNDWATER LEVEL MONITORING PLAN

Period	Monitoring Location	Method	Monitoring Frequency	Trigger For Mitigation	Mitigation Measures / Comments
During Construction	On-site monitoring wells	Water level meter	Weekly	Groundwater levels drop more than 1 metre below the drawdown target	Reduce pumping
Post-Construction	On-site monitoring wells	Water level meter	Monthly until 90% recovery	Water level recovery less than 90% of baseline level	Continue monitoring

Appendix I

Discharge Plan

Construction Dewatering Discharge Rate and Zone of Influence

The Radius of Influence and temporary dewatering discharge rate were estimated in Section 5.1 and the details are summarized below.

Location and Scenario	Construction Dewatering Flow Rate Without Safety Factor	Construction Dewatering Flow Rate Including Safety Factor of 2	Construction Dewatering Flow Rate Including Safety Factor of 2 with a 10 mm Rainfall Event
	L/day		
1 - General Site Servicing Scenario	88,600	177,200	179,200
2 – Building Basement Excavation	81,700	163,400	166,300

Proposed Discharge Method and Location

It is understood that the preferred discharge location would be to the land surface or to the City storm sewers. Dewatering discharge will be directed by hose or pipe from the dewatering system to any pre-treatment systems (i.e., silt bag and/or sediment tank), and then by hose or pipe to the preferred discharge location.

In the event of a significant rainfall event (100-year storm event), on-site excavation will cease until the dewatering system can be re-evaluated and/or storm water flow subsides. The dewatering contractor is responsible for obtaining discharge permits from the City as needed.

Erosion and Sediment Control Measures

The construction dewatering setup will include sediment and erosion control measures, and sufficient filtration to ensure removal of suspended solids prior to discharge in accordance with typical Best Management Practices. Means and methods to be determined by the dewatering contractor.

Statements

If discharge is directed to the surface or City storm sewers with adherence to the water quantity and quality monitoring program outlined in the Water Taking Plan in Appendix H, no adverse effect on the environment is expected.

The discharge water temperature was considered in determining the method of transfer and discharge and is not expected to have an adverse impact.

Summary of Qualifications

Russell Wiginton, P.Eng.

Russell Wiginton is a licensed Professional Engineer in Ontario. He received his Bachelor of Science in Civil Engineering from Queen's University in Kingston. He has 10 years of experience in geotechnical and hydrogeological engineering. His experience includes subsurface field investigations, in-situ groundwater sampling and testing, geotechnical and hydrogeological engineering analysis, finite element modelling for groundwater flow, and preparation of engineering reports to support PTTW applications, EASR postings, or for review by various agencies such as Conservation Authorities.

Date of Plan Preparation

This plan prepared on the date January 20, 2023

Monthly Groundwater Monitoring Assessment

September 27, 2023 Reference No. 2203244

The Corporation of the City of Barrie
157 Bradford Street
P.O. Box 400
Barrie, Ontario
L4M 4T5

Re: Monthly Groundwater Monitoring Assessment
Proposed Firehall 6
845 Mapleview Drive East, Barrie, Ontario

It has become more common for municipalities and conservation authorities to require potential site developments to provide an evaluation of the degree of seasonal variation of groundwater elevations over an entire year based on site-specific measured data.

This is intended to provide a site-typical seasonal high groundwater elevation so that basement levels and the base of LID measures can be situated permanently above the groundwater table, and to ultimately assess potential dewatering requirements more accurately across different seasons.

GEI Consultants Inc. (GEI) was retained to conduct monthly groundwater levels within the monitoring wells previously installed on site to establish a seasonal high groundwater elevation for use in the design of on-site structures. This letter summarizes the groundwater measurements recorded between October of 2022 to September of 2023 to capture the groundwater fluctuations and seasonal high groundwater table, which is typically observed during the spring months. The site location is shown in Figure 1.

Details on the site and on the previous characterization of the hydraulic conditions of the site, as prepared by GEI, is provided in the following report:

- "*Hydrogeological Investigation – Proposed Firehall 6*", Project No. 2203244, dated January 20, 2023, by GEI Consultants Inc.

This letter report was prepared as a supplementary document to the original hydrogeological investigation noted above. The letter report summarizes the results of the long-term monitoring of groundwater levels at three (3) monitoring wells to confirm hydrogeological engineering recommendations for the proposed development. The construction details of each monitoring well are provided in Table 1. The borehole and monitoring well locations are shown in Figures 2A and 2B.

Table 1: Monitoring Well Details

Monitoring Well	Ground Surface Elevation (m)*	Top of Screen		Bottom of Screen		Strata Screened
		Depth (m)	Elev. (m)	Depth (m)	Elev. (m)	
1	255.5	4.3	251.2	5.8	249.7	Silty Sand to Sandy Silt Glacial Till / Sand
2	255.8#	4.3	251.5	5.8	250.0	
3	255.3	4.1	251.2	5.6	249.7	Sand

*** Note**: Ground surface elevations were surveyed by GEI with a Topcon FC – 5000 GPS Survey Unit (referencing NAD 83 geodetic datum).
# Note: Ground surface elevation updated since Hydrogeological Investigation by GEI (2023).

Groundwater level measurements were taken directly using a manual water level reader in each of the three (3) monitoring wells installed on site. A minimum of four (4) months of groundwater monitoring was conducted within the expected spring freshet period (which is typically when the highest groundwater elevations occur) along with an additional eight (8) monthly readings for a total of twelve (12) direct groundwater level measurements. Graphs of the measured groundwater elevations are also attached. A summary of the groundwater level and elevation readings are summarized below.

Table 2: Results of Monthly Groundwater Monitoring

Date of Groundwater Level Reading	Depth (m) / Geodetic Elevation (m) of Groundwater Table					
	1		2		3	
18-Oct-22	2.5	253.0	2.5	253.2	2.1	253.2
30-Nov-22	2.4	253.1	2.5	253.3	2.0	253.3
16-Dec-23	2.5	253.0	2.5	253.3	2.1	253.2
16-Jan-23	2.5	253.0	2.1	253.7	1.9	253.4
22-Feb-23	2.2	253.3	2.2	253.5	1.8	253.5
30-Mar-23	2.0	253.5	2.1	253.7	1.6	253.6
25-Apr-23	2.0	253.5	2.1	253.7	1.6	253.7
31-May-23	2.1	253.4	2.2	253.6	1.7	253.6
29-Jun-23	2.8	252.7	3.0	252.8	2.4	252.9
26-Jul-23	2.8	252.7	3.0	252.8	2.4	252.9
18-Aug-23	2.8	252.7	3.0	252.8	2.4	252.9
13-Sep-23	2.8	252.7	3.0	252.8	2.4	252.9
Maximum	**2.0**	**253.5**	**2.1**	**253.7**	**1.6**	**253.7**
Degree of Fluctuation	**0.8**		**0.9**		**0.8**	

Based on the monthly groundwater level measurements recorded by GEI during this monitoring period, the highest groundwater elevation measured for each of the monitoring wells, to be considered during design, was as follows:

- Borehole BH1: Elev. 253.5 metres (depth of 2.0 metres below grade).
- Borehole BH2: Elev. 253.7 metres (depth of 2.1 metres below grade).
- Borehole BH3: Elev. 253.7 metres (depth of 1.6 metres below grade).

We trust this report is complete within our terms of reference, and the information presented is sufficient for your present purposes. If you have any questions, or when we may be of further assistance, please do not hesitate to contact our office.

Regards,

GEI Consultants

Prepared By:

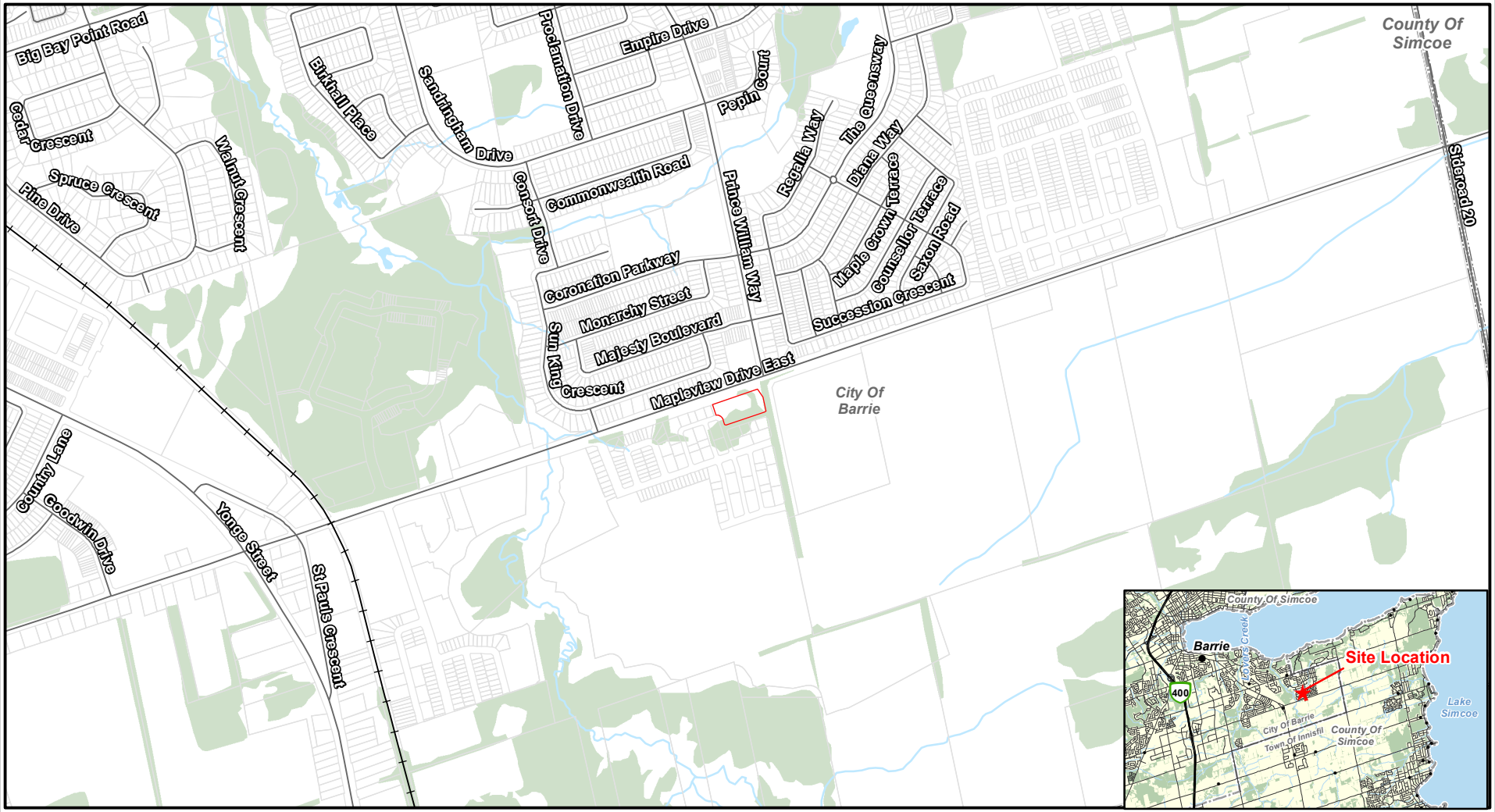
Frankie Huang, E.I.T.
Geotechnical Engineer in Training

Reviewed By:

Kimberly Gilder, P.Geo.
Senior Hydrogeologist

SITE LOCATION PLAN

BOREHOLE LOCATION PLAN



Legend

Site Location | Road | Wooded Area
Parcels | Watercourse
Railway | Waterbody

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario,© City of Barrie (Parcels), 2022.

0 190 380 m

1:15,000

N

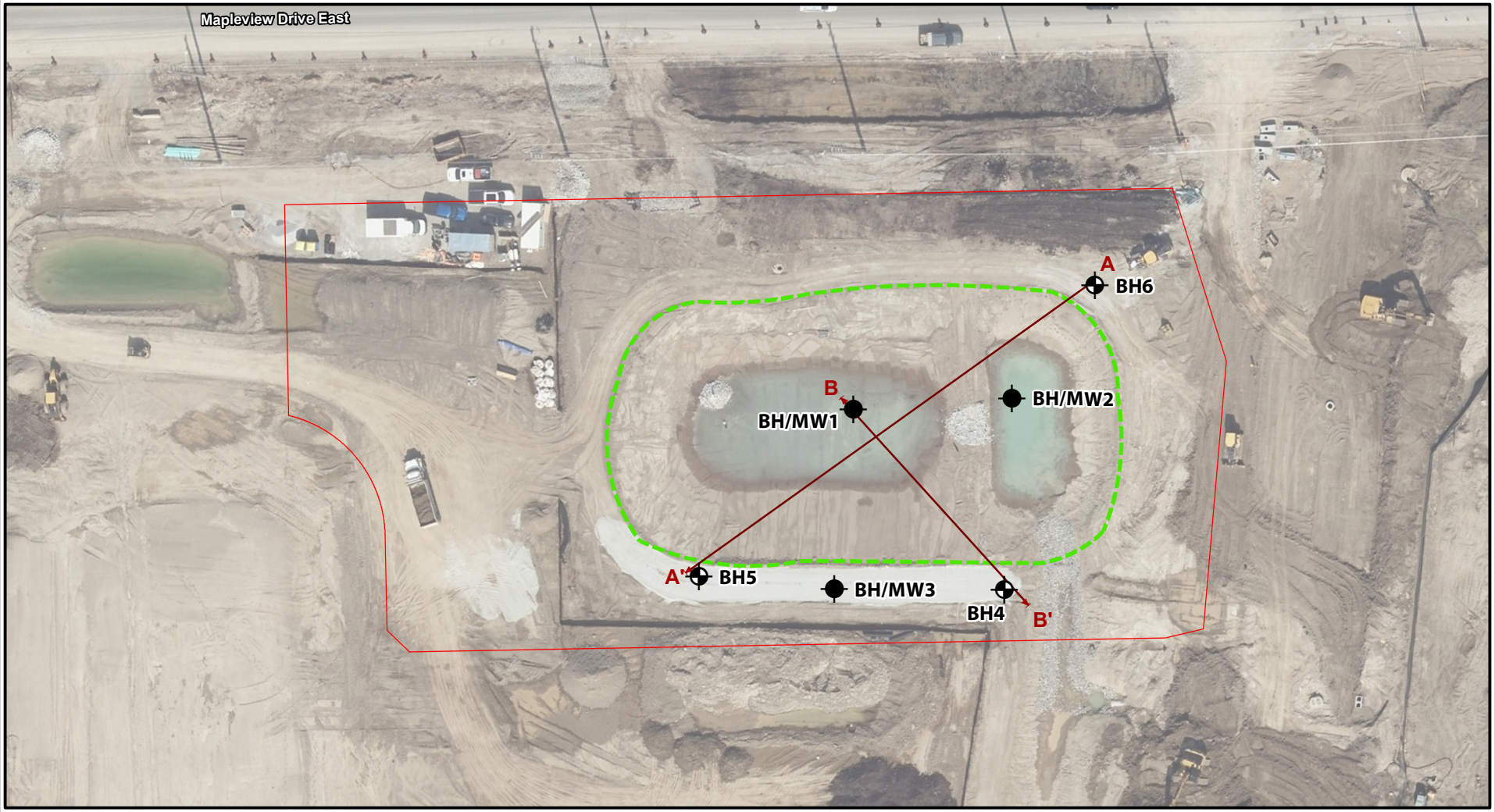
Hydrogeological Report
Proposed Barrie Fire Station 6
Development
Barrie, ON

City of Barrie

GEI Consultants

SITE LOCATION PLAN

Project 2203244 | December 2022 | Fig. 1



Legend

- Site Location
- Area with Existing Engineered Fill
- Approximate Borehole Location
- Approximate Borehole/Monitoring Well Location
- Cross Section Location

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario,© City of Barrie (Parcels), 2022.
3. Orthoimagery © First Base Solutions, 2022. Imagery taken in 2021.

0 10 20 m

1:800

N

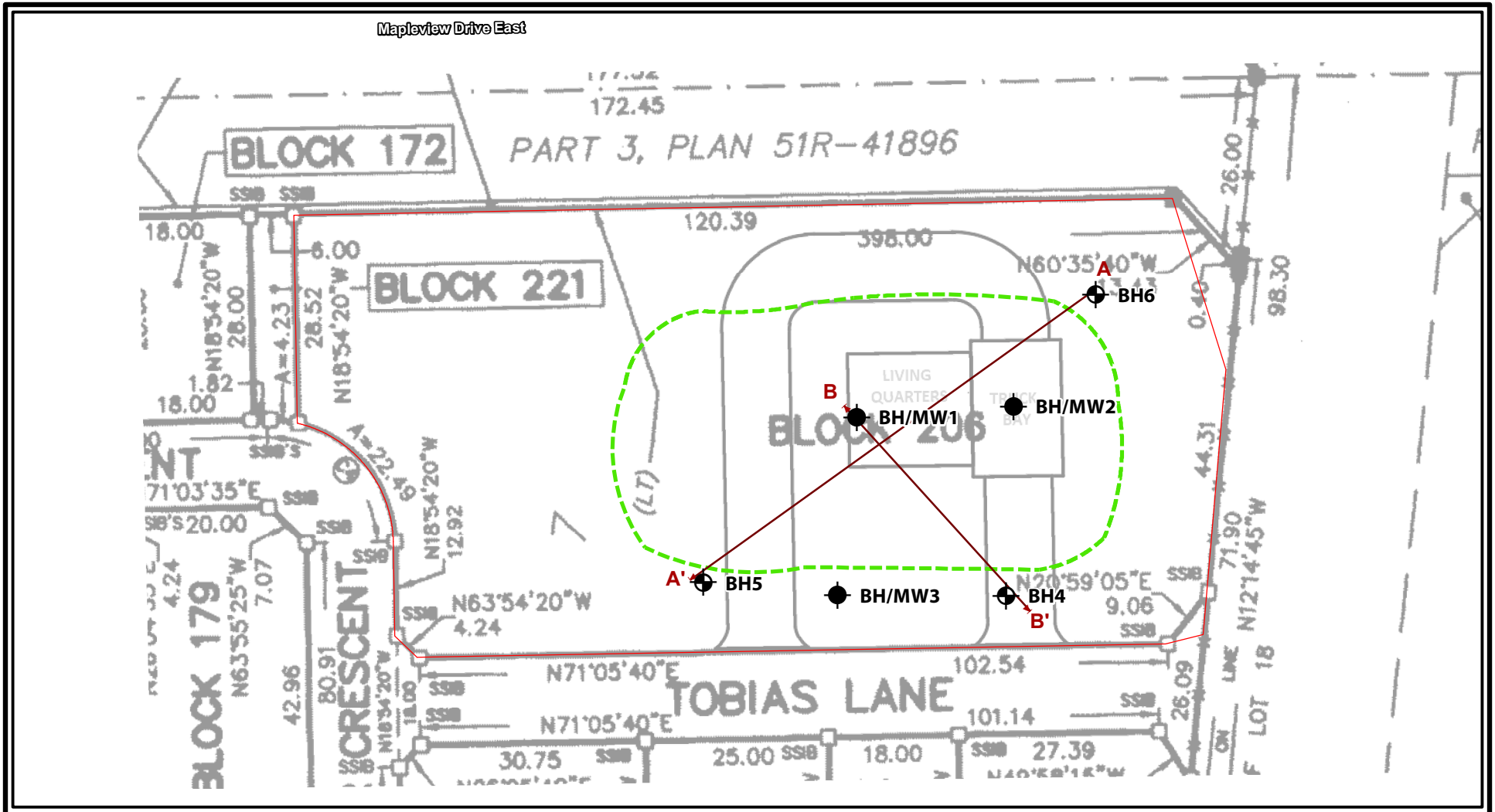
Hydrogeological Report
Proposed Barrie Fire Station 6
Development
Barrie, ON

City of Barrie

GEI Consultants

BOREHOLE LOCATION PLAN
(AERIAL)

Project 2203244 | December 2022 | Fig. 2A



Legend

- Site Location
- Area with Existing Engineered Fill
- Approximate Borehole Location
- Approximate Borehole/Monitoring Well Location
- Cross Section Location

NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario,© City of Barrie (Parcels), 2022.
3. Site Plan: 'Hewitt's Gate - Draft Plan of Subdivision', Jones Consulting Group (2017).

0 10 20 m

1:800

N

Hydrogeological Report
Proposed Barrie Fire Station 6 Development
Barrie, ON

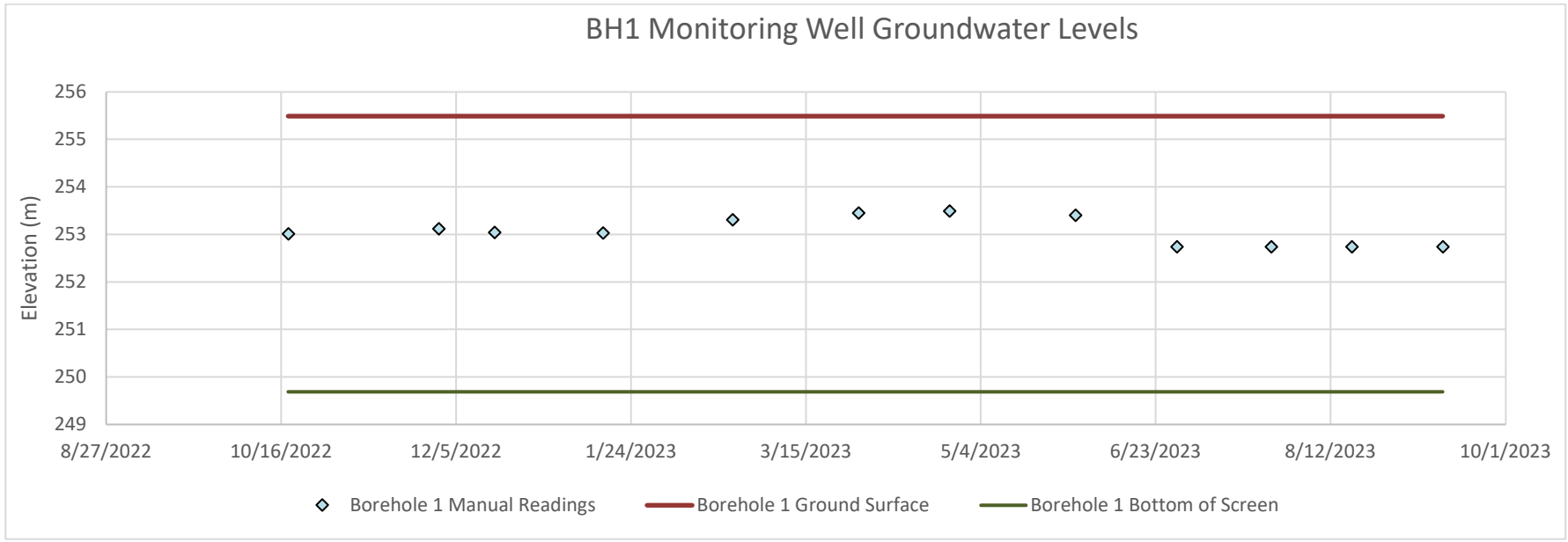
City of Barrie

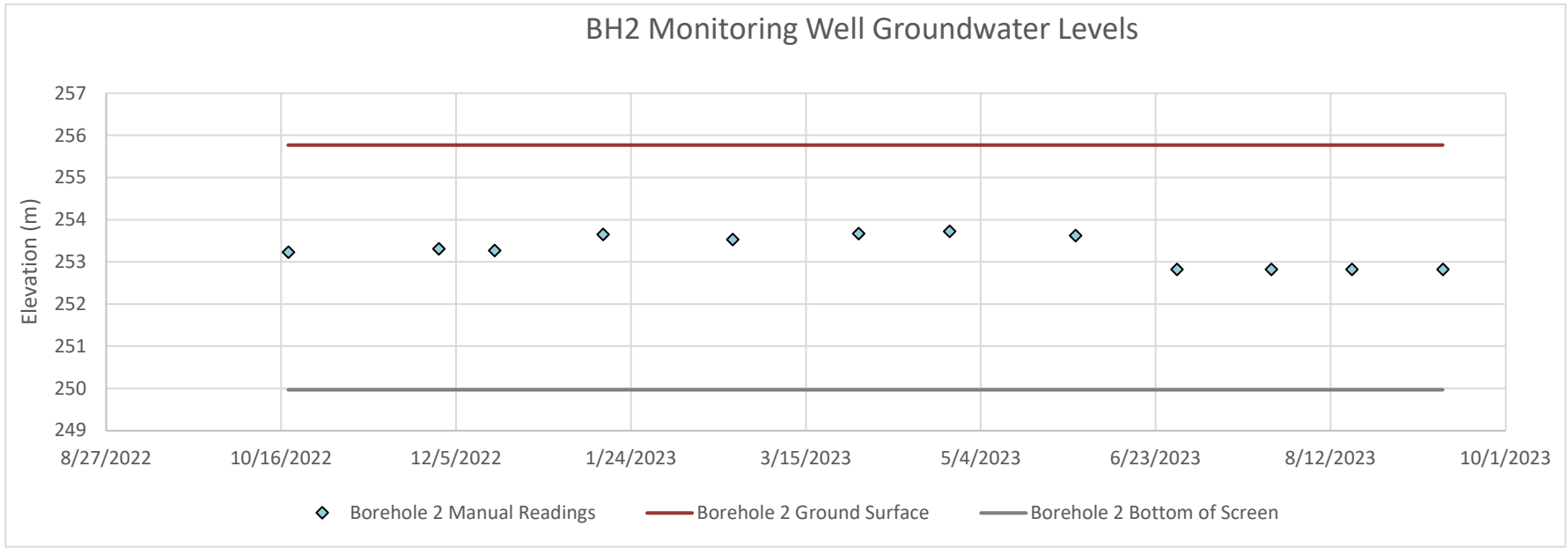
GEI Consultants

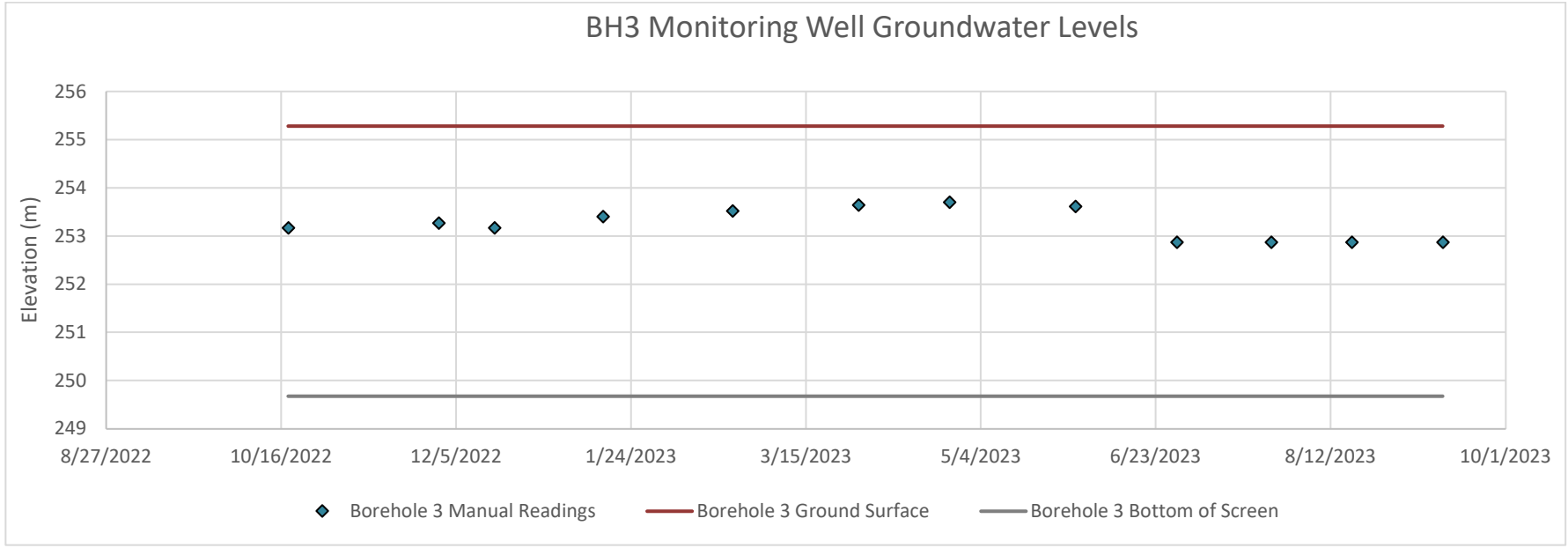
BOREHOLE LOCATION PLAN (SITE PLAN)

Project 2203244 | December 2022 | Fig. 2B

GRAPHS OF MEASURED WATER LEVELS


BH1 Monitoring Well Groundwater Levels
Elevation (m)
256
255
254
253
252
251
250
249
8/27/2022
10/16/2022
12/5/2022
1/24/2023
3/15/2023
5/4/2023
6/23/2023
8/12/2023
10/1/2023
Borehole 1 Manual Readings
Borehole 1 Ground Surface
Borehole 1 Bottom of Screen


BH2 Monitoring Well Groundwater Levels
Elevation (m)
257
256
255
254
253
252
251
250
249
8/27/2022
10/16/2022
12/5/2022
1/24/2023
3/15/2023
5/4/2023
6/23/2023
8/12/2023
10/1/2023
Borehole 2 Manual Readings
Borehole 2 Ground Surface
Borehole 2 Bottom of Screen


BH3 Monitoring Well Groundwater Levels
Elevation (m)
256
255
254
253
252
251
250
249
8/27/2022
10/16/2022
12/5/2022
1/24/2023
3/15/2023
5/4/2023
6/23/2023
8/12/2023
10/1/2023
Borehole 3 Manual Readings
Borehole 3 Ground Surface
Borehole 3 Bottom of Screen

Groundwater Chloroform Source Review for Firehall 6

September 29, 2023

The Corporation of the City of Barrie
157 Bradford Street
P.O. Box 400
Barrie, Ontario
LM4 4T5

Attn: Jasmine Juneau, Project Manager (Capital Facilities), Corporate Facilities Department, City of Barrie

RE: Groundwater Chloroform Source Review for Firehall 6
845 Mapleview Drive East, Barrie, Ontario
Project No. 2203244

GEI Consultants (GEI) was contacted by the City of Barrie (the client) to review potential sources to explain the groundwater chemistry results originally reported by GEI in the report "Hydrogeological Investigation, Proposed Firehall 6, 845 Mapleview Drive East, Barrie, Ontario," Project Number: 2203244, dated January 20, 2023.

This review was prompted specifically by the concentration of chloroform that was found in the groundwater at 845 Mapleview Drive East (the site) that exceeded the City of Barrie's allowable concentrations. To identify potential sources of chloroform upgradient from the site, GEI reviewed both historical and current conditions at and within the site's vicinity.

We are pleased to present the summarized results of our Groundwater Chloroform Source Review in support of the proposed Firehall 6 at 845 Mapleview Road East, Barrie, Ontario.

1. SITE DETAILS

The site is located at the southwest corner of the intersection of Mapleview Drive East and Prince William Way, in Barrie, Ontario. The site is irregular in shape and is about 7,200 m^2 in size. The site is currently part of a residential subdivision that is under development. The immediate area is predominately residential land uses, with a school located to the east.

Prior to the residential subdivision development, the site contained a single-family residential dwelling in the western portion with a forest and small pond in the eastern portion. The pond appears to have been filled in between 2012 and 2013 based on aerial images from the County of Simcoe online mapping service. More recently, it is understood that the site contained a

temporary Storm Water Management (SWM) pond and just prior to the geotechnical field work the pond was backfilled with engineered fill.

The following documents that provide details of the previous site investigations conducted by GEI and the proposed development:

- "Monthly Groundwater Monitoring Assessment, Proposed Firehall 6, 845 Mapleview Drive East, Barrie, Ontario", Project Number: 2203244, dated September 27, 2023, by GEI.
- "Hydrogeological Investigation, Proposed Firehall 6, 845 Mapleview Drive East, Barrie, Ontario", Project Number: 2203244, dated January 20, 2023, by GEI.
- "Hewitt's Gate – Draft Plan of Subdivision", dated 2017, by the Jones Consulting Group.

The following document provides the layout and details for some of the subsurface servicing installations that have been completed as of 2022, prior to the hydrogeological investigation and groundwater sampling:

- "Plan of Survey Showing Topography for #845 Mapleview Drive East being Block 206, Plan 51M-1224 (Geographic Township of Innisfil), City of Barrie, County of Simcoe" Drawing No. E-3933, dated October 12 2022, by Dearden and Stanton Ltd.

2. GROUNDWATER CHEMISTRY SAMPLING

Based on GEI's hydrogeological investigation, two (2) groundwater samples, one (1) unfiltered and one (1) filtered, were collected from Borehole / Monitoring Well 3 on December 7, 2022. For the assessment purposes, the analytical results were compared to the Town of Barrie Storm Sewer Use By-Law Criteria, Provincial Water Quality Objective (PWQO), and/or Ontario Regulation (O.Reg.) 153/04, as amended, Table 1 Full Depth Background Site Condition Standards (Table 1 SCS, the most stringent SCS).

The unfiltered groundwater sample collected from Borehole/Monitoring Well (BH/MW) 3, met the City of Barrie Storm Sewer Use By-Law Criteria with the exception of copper and TSS. The field filtered groundwater sample met the City of Barrie Storm Sewer Use By-Law Criteria for the parameters tested (metals and TSS).

The unfiltered groundwater sample collected from BH/MW 3, met PWQO for the parameters tested (metals and TSS) with the exception of chromium and iron, and met interim PWQO for the parameters tested (metals and TSS) with the exception of aluminum, cobalt, copper, lead, vanadium, and zirconium. The field filtered groundwater sample met PWQO and interim PWQO for the parameters tested (metals and TSS).

The unfiltered groundwater sample collected from BH/MW 3, met O.Reg. 153/04 Table 1 SCS for the parameters tested (PHCs and VOCS), with the exception of chloroform. A field filtered sample was not collected from the analysis of PHCs and VOCs.

To confirm the elevated concentration of chloroform within the groundwater of BH/MW 3, GEI collected a second unfiltered groundwater sample from BH/MW 3 on January 3, 2023 for the analysis of chloroform.

A summary of the chloroform concentrations measured on-site within the groundwater in BH/MW3 are presented in the table below for the sample relative to the O.Reg. 153/04, as amended, SCSs.

Monitoring Well Sample Location	Parameters Tested	O.Reg. 153/04 Table 1 SCS (µg/L)	O.Reg. 153/04 Table 2 RPI SCS (µg/L)	Concentration Detected December 7, 2022 (µg/L)	Concentration Detected January 3, 2023 (µg/g)
BH/MW 3 (Unfiltered)	Chloroform	2	2.4	4	3

As both samples collected from BH/MW 3 on December 7, 2023 and January 3, 2023 exceeded the applicable site standard at similar concentrations (O.Reg. 153/04 Table 2: Full Depth Generic Site Condition Standards in a Potable Ground Water Condition for Residential/Parkland/Institutional land use), in addition to the O.Reg. 153/04 Table 1 SCS, the elevated chloroform found on-site in the groundwater at BH/MW 3 is unlikely to be a result of laboratory error.

It should also be noted that for all the other PHCs and VOCs that were analyzed, the concentrations of these parameters were below the laboratory's detection limit.

3. BACKGROUND AND SITE CONDITION ASSESSMENT

Based on a review of the Plan of Survey by Dearden and Stanton Ltd. (2022) municipal servicing was installed for the subdivisions such that fire hydrant lines that were installed upgradient of the site and in close proximity to BH/MW 3.

Ivahnenko, T. and Zogorski, J. S. (2006) in their report "Sources and occurrence of chloroform and other trihalomethanes in drinking-water supply wells in the United States" found,

> *Chloroform and three other trihalomethanes (THMs)—bromodichloromethane, dibromochloromethane, and bromo-form—are disinfection by-products commonly produced during the chlorination of water and wastewater* (1986–2001: U.S. Geological Survey Scientific Investigations Report 2006 – 5015, 13 p., accessed online from [https://pubs.usgs.gov/sir/2006/5015/sir2006-5015.pdf]).

As such, nearby fire hydrant lines and treated municipal water and/or sewer servicing identified upgradient of the site, in close proximity to BH/MW 3, could contribute chloroform to the groundwater system, should a leak be present.

Additionally, GEI completed a cursory review upgradient (east / southeast) of and adjacent to the site to identify Potential Contaminating Activities (PCAs) that could contribute chloroform as a Potential Contaminant of Concern (PCOC).

Based on a review of aerial imagery from the Simcoe County Interactive Map and Google Earth, the site and adjacent property had been previously used for residential, agricultural, and/or community purposes since at least 1954 (first available aerial photography of the site). The development and land use history of the site and adjacent properties has been summarized in the table below.

Aerial Photograph Year	Source	Observations	Possible PCA contributing Chloroform as a PCOC to Site?
1954	Simcoe County Interactive Maps	a) The site appears to be an undeveloped wooded area. b) The land north adjacent to the site appears to be developed as a roadway (Mapleview Drive East) follow by agricultural lands. c) The lands east and west adjacent to the site appears to be agricultural lands. d) The land south appears to be undeveloped woodland, followed by agricultural lands.	Unlikely
1978	Simcoe County Interactive Maps	a) The site appears to be unchanged. b) The land to the west of the site appears to have a gravel road leading to an agricultural structure	Unlikely
1989	Simcoe County Interactive Maps	a) The site has been cleared of most trees and developed with a residential dwelling and a pond. b) The property west of the site appears to have been developed with a residential or agricultural structure	Unlikely
1997	Simcoe County Interactive Maps	a) The site and adjacent properties appear to be unchanged.	Unlikely

Aerial Photograph Year	Source	Observations	Possible PCA contributing Chloroform as a PCOC to Site?
2002	Simcoe County Interactive Maps	a) The site and adjacent properties appear to be unchanged.	Unlikely
2008	Simcoe County Interactive Maps	a) The site appears to be unchanged. b) Residential subdivisions have been developed on the north side of Mapleview Drive East, northeast and northwest of the site.	Unlikely; activity is downgradient from the site
2012	Simcoe County Interactive Maps	a) The site appears to be unchanged. b) A residential subdivision has been developed on the north side of Mapleview Drive East, north of the site.	Unlikely; activity is downgradient from the site
2013	Simcoe County Interactive Maps	a) The pond on-site appears to have been filled in. b) The adjacent properties appear to be unchanged.	Potential; fill of unknown quality imported to the site
2016	Simcoe County Interactive Maps	a) The site appears to be unchanged. b) A commercial has been developed on the north side of Mapleview Drive East, north of the site.	Unlikely; activity is downgradient from the site
2018	Simcoe County Interactive Maps	a) The site and adjacent properties appear to be unchanged.	Unlikely

Aerial Photograph Year	Source	Observations	Possible PCA contributing Chloroform as a PCOC to Site?
2022	Simcoe County Interactive Maps	a) The site has been cleared and is occupied by a temporary stormwater management pond. b) The land east adjacent to the site (and upgradient) appears to be developed as roadway (extension of Prince William Way), followed by the development of an institutional property (high school). It is assumed municipal servicing (including water, storm, and sanitary mains) was installed at this time. c) The lands west and south appear to be developed as roadways (Tobias Lane and Pumpkin Cor Crescent), followed by land cleared for future residential development. It is assumed municipal servicing (including water, storm, and sanitary mains) was installed at this time.	Potential; fill of unknown quality imported adjacent to the site Potential; installation of municipal servicing upgradient
2023	Google Earth	a) The temporary stormwater management pond on-site appears to have been filled in. b) The adjacent properties appear to be unchanged.	Potential; fill of unknown quality imported to the site

Based on the review of the aerial photographs and the 2022 plan survey (dated October 12 2022, by Dearden and Stanton Ltd, referenced in Section 1), the following PCAs were identified:

- Fill material may have been brought to the site in 2012 to 2013 and 2022 to 2023 to fill in ponded water on site. At this time, the quality of the imported fill is unknown.
- Fill material may have been imported immediately adjacent to the site in 2022 to 2023 for road construction immediately adjacent and upgradient of the site. At this time, the quality of the imported fill is unknown.
- Site servicing was likely installed beneath the road or in the shoulder immediately adjacent to the site in 2022 to 2023 prior to road construction immediately adjacent and upgradient of the site.

Based on this cursory review of PCAs on or adjacent to the site the fill of unknown quality imported to the site and/or leakage of chlorinated municipal water from servicing situated upgradient from

BH/MW3 may be considered as potential sources of the elevated chloroform concentrations found in the groundwater at BH/MW 3.

It is noted that this cursory review of PCAs on or adjacent to the site does not constitute an environmental site assessment nor assessment of past use as defined by O.Reg. 153/04 nor O.Reg. 406/19 and should not be construed as such.

4. CONCLUSION

We trust this information is sufficient for your present purposes. Should you have any questions concerning the above, or can be of any further assistance, please do not hesitate to contact the undersigned.

Yours truly,
GEI Consultants

Prepared By:

Sarah Griffith, G.I.T.
Hydrogeologist-in-Training

Reviewed By:

Kimberly Gilder, P.Geo.
Senior Hydrogeologist

Updated Groundwater Chloroform Source Review for Firehall 6

March 20, 2024

The Corporation of the City of Barrie
157 Bradford Street
P.O. Box 400
Barrie, Ontario
LM4 4T5

Attn: Jasmine Juneau, Project Manager (Capital Facilities), Corporate Facilities Department, City of Barrie

RE: Updated Groundwater Chloroform Source Review for Firehall 6
845 Mapleview Drive East, Barrie, Ontario
Project No. 2203244

GEI Consultants (GEI) was contacted by the City of Barrie (the client) to review potential sources to explain the groundwater chemistry results originally reported by GEI in the report "Hydrogeological Investigation, Proposed Firehall 6, 845 Mapleview Drive East, Barrie, Ontario," Project Number: 2203244, dated January 20, 2023.

This review was prompted by the concentration of chloroform found in the groundwater at 845 Mapleview Drive East (the site), which exceeded the City of Barrie's allowable concentrations. To identify potential sources of chloroform upgradient from the site, GEI reviewed both historical and current conditions within the site's vicinity.

Additionally, the client approved the supplemental collection and chemical analysis of groundwater via email on March 14, 2024, to confirm any persistent presence of chloroform within the site and aide risk management assessment efforts by the City of Barrie.

We are pleased to present the summarized results of our Updated Groundwater Chloroform Source Review in support of the proposed Firehall 6 at 845 Mapleview Road East, Barrie, Ontario.

1. SITE DETAILS

The site is located at the southwest corner of the intersection of Mapleview Drive East and Prince William Way, in Barrie, Ontario. The site is irregular in shape and is about 7,200 m^2 in size. The site is currently part of a residential subdivision that is under development. The immediate area is predominately residential land uses, with a school located to the east.

Prior to the residential subdivision development, the site contained a single-family residential dwelling in the western portion with a forest and small pond in the eastern portion. The pond appears to have been filled in between 2012 and 2013 based on aerial images from the County of Simcoe online mapping service. More recently, it is understood that the site contained a temporary Storm Water Management (SWM) pond and just prior to the geotechnical field work the pond was backfilled with engineered fill.

The following documents that provide details of the previous site investigations conducted by GEI and the proposed development:

- "Monthly Groundwater Monitoring Assessment, Proposed Firehall 6, 845 Mapleview Drive East, Barrie, Ontario", Project Number: 2203244, dated September 27, 2023, by GEI.
- "Hydrogeological Investigation, Proposed Firehall 6, 845 Mapleview Drive East, Barrie, Ontario", Project Number: 2203244, dated January 20, 2023, by GEI.
- "Hewitt's Gate – Draft Plan of Subdivision," dated 2017, by the Jones Consulting Group.

The following document provides the layout and details for some of the subsurface servicing installations that have been completed as of 2022, prior to the hydrogeological investigation and groundwater sampling:

- "Plan of Survey Showing Topography for #845 Mapleview Drive East being Block 206, Plan 51M-1224 (Geographic Township of Innisfil), City of Barrie, County of Simcoe" Drawing No. E-3933, dated October 12 2022, by Dearden and Stanton Ltd.

2. GROUNDWATER CHEMISTRY SAMPLING

Based on GEI's hydrogeological investigation (2023), two (2) groundwater samples, one (1) unfiltered and one (1) filtered, were collected from Borehole / Monitoring Well 3 on December 7, 2022. For the assessment purposes, the analytical results were compared to the Town of Barrie Storm Sewer Use By-Law Criteria, Provincial Water Quality Objective (PWQO), and/or Ontario Regulation (O.Reg.) 153/04, as amended, Table 1 Full Depth Background Site Condition Standards (Table 1 SCS, the most stringent SCS).

The unfiltered groundwater sample collected from Borehole/Monitoring Well (BH/MW) 3, met the City of Barrie Storm Sewer Use By-Law Criteria with the exception of copper and TSS. The field filtered groundwater sample met the City of Barrie Storm Sewer Use By-Law Criteria for the parameters tested (metals and TSS).

The unfiltered groundwater sample collected from BH/MW 3, met PWQO for the parameters tested (metals and TSS) with the exception of chromium and iron, and met interim PWQO for the parameters tested (metals and TSS) with the exception of aluminum, cobalt, copper, lead, vanadium, and zirconium. The field filtered groundwater sample met PWQO and interim PWQO for the parameters tested (metals and TSS).

The unfiltered groundwater sample collected from BH/MW 3, met O.Reg. 153/04 Table 1 SCS for the parameters tested (PHCs and VOCS), with the exception of chloroform. A field filtered sample was not collected for the analysis of PHCs and VOCs.

To confirm the elevated concentration of chloroform within the groundwater of BH/MW 3, GEI collected a second unfiltered groundwater sample from BH/MW 3 on January 3, 2023 for the analysis of chloroform.

To further investigate the potential ongoing presence of chloroform in the groundwater within BH/MW 3, GEI collected a third unfiltered groundwater sample from BH/MW 3 on March 18, 2024, specifically for the analysis of chloroform (provided in Enclosure 1).

A summary of the chloroform concentrations measured on-site within the groundwater in BH/MW3 are presented in the table below for the sample relative to the O.Reg. 153/04, as amended, SCSs.

Monitoring Well Sample Location	Parameters Tested	Laboratory Detection Limit	O.Reg. 153/04		Concentration Detected		
			Table 1 SCS	Table 2 RPI SCS	December 7, 2022	January 3, 2023	March 18, 2024
		(µg/L)					
BH/MW 3 (Unfiltered)	Chloroform	1	2	2.4	4	3	<1

As both samples collected from BH/MW 3 on December 7, 2023 and January 3, 2023 exceeded the applicable site standard at similar concentrations (O.Reg. 153/04 Table 2: Full Depth Generic Site Condition Standards in a Potable Ground Water Condition for Residential/Parkland/Institutional land use), in addition to the O.Reg. 153/04 Table 1 SCS, the elevated chloroform found on-site in the groundwater at BH/MW 3 is unlikely to be a result of laboratory error. It should also be noted that, for all the other PHCs and VOCs that were collected and analyzed (on December 7, 2022), the concentrations of these parameters were below the laboratory's detection limits.

The concentration of chloroform with the groundwater sample collected from BH/MW 3 on March 18, 2024, was detected below the laboratory detection limit, more than one year after the first two samples were collected. This suggests that the previously elevated chloroform concentration found on-site in the groundwater may have been the result of an isolated event.

3. BACKGROUND AND SITE CONDITION ASSESSMENT

Based on a review of the Plan of Survey by Dearden and Stanton Ltd. (2022) municipal servicing was installed for the subdivisions such that fire hydrant lines that were installed upgradient of the site and in close proximity to BH/MW 3.

Ivahnenko, T. and Zogorski, J. S. (2006) in their report "Sources and occurrence of chloroform and other trihalomethanes in drinking-water supply wells in the United States" found,

> *Chloroform and three other trihalomethanes (THMs)—bromodichloromethane, dibromochloromethane, and bromo-form—are disinfection by-products commonly produced during the chlorination of water and wastewater* (1986–2001: U.S. Geological Survey Scientific Investigations Report 2006 – 5015, 13 p., accessed online from [https://pubs.usgs.gov/sir/2006/5015/sir2006-5015.pdf]).

As such, nearby fire hydrant lines and treated municipal water and/or sewer servicing identified upgradient of the site, in close proximity to BH/MW 3, could contribute chloroform to the groundwater system, should a leak be present. Additionally, GEI completed a cursory review upgradient (east / southeast) of and adjacent to the site to identify Potential Contaminating Activities (PCAs) that could contribute chloroform as a Potential Contaminant of Concern (PCOC).

Based on a review of aerial imagery from the Simcoe County Interactive Map and Google Earth, the site and adjacent property had been previously used for residential, agricultural, and/or community purposes since at least 1954 (first available aerial photography of the site). The development and land use history of the site and adjacent properties has been summarized in the table below.

Aerial Photograph Year	Source	Observations	Possible PCA contributing Chloroform as a PCOC to Site?
1954	Simcoe County Interactive Maps	a) The site appears to be an undeveloped wooded area. b) The land north adjacent to the site appears to be developed as a roadway (Mapleview Drive East) follow by agricultural lands. c) The lands east and west adjacent to the site appears to be agricultural lands. d) The land south appears to be undeveloped woodland, followed by agricultural lands.	Unlikely
1978	Simcoe County Interactive Maps	a) The site appears to be unchanged. b) The land to the west of the site appears to have a gravel road leading to an agricultural structure	Unlikely
1989	Simcoe County Interactive Maps	a) The site has been cleared of most trees and developed with a residential dwelling and a pond. b) The property west of the site appears to have been developed with a residential or agricultural structure	Unlikely
1997	Simcoe County Interactive Maps	a) The site and adjacent properties appear to be unchanged.	Unlikely

Aerial Photograph Year	Source	Observations	Possible PCA contributing Chloroform as a PCOC to Site?
2002	Simcoe County Interactive Maps	a) The site and adjacent properties appear to be unchanged.	Unlikely
2008	Simcoe County Interactive Maps	a) The site appears to be unchanged. b) Residential subdivisions have been developed on the north side of Mapleview Drive East, northeast and northwest of the site.	Unlikely; activity is downgradient from the site
2012	Simcoe County Interactive Maps	a) The site appears to be unchanged. b) A residential subdivision has been developed on the north side of Mapleview Drive East, north of the site.	Unlikely; activity is downgradient from the site
2013	Simcoe County Interactive Maps	a) The pond on-site appears to have been filled in. b) The adjacent properties appear to be unchanged.	Potential; fill of unknown quality imported to the site
2016	Simcoe County Interactive Maps	a) The site appears to be unchanged. b) A commercial has been developed on the north side of Mapleview Drive East, north of the site.	Unlikely; activity is downgradient from the site
2018	Simcoe County Interactive Maps	a) The site and adjacent properties appear to be unchanged.	Unlikely
2022	Simcoe County Interactive Maps	a) The site has been cleared and is occupied by a temporary stormwater management pond. b) The land east adjacent to the site (and upgradient) appears to be developed as roadway (extension of Prince William Way), followed by the development of an institutional property (high school). It is assumed municipal servicing (including water, storm, and sanitary mains) was installed at this time. c) The lands west and south appear to be developed as roadways (Tobias Lane and Pumpkin Cor Crescent), followed by land cleared for future residential development. It is assumed municipal servicing (including water, storm, and sanitary mains) was installed at this time.	Potential; fill of unknown quality imported adjacent to the site Potential; installation of municipal servicing upgradient
2023	Google Earth	a) The temporary stormwater management pond on-site appears to have been filled in. b) The adjacent properties appear to be unchanged.	Potential; fill of unknown quality imported to the site

Based on the review of the aerial photographs and the 2022 plan survey (dated October 12, 2022, by Dearden and Stanton Ltd, referenced in Section 1), the following PCAs were identified:

- Fill material may have been brought to the site in 2012 to 2013 and 2022 to 2023 to fill in ponded water on site. At this time, the quality of the imported fill is unknown.
- Fill material may have been imported immediately adjacent to the site in 2022 to 2023 for road construction immediately adjacent and upgradient of the site. At this time, the quality of the imported fill is unknown.

- Site servicing was likely installed beneath the road or in the shoulder immediately adjacent to the site in 2022 to 2023 prior to road construction immediately adjacent and upgradient of the site.

Based on this cursory review of PCAs on or adjacent to the site the fill of unknown quality imported to the site and/or leakage of chlorinated municipal water from servicing situated upgradient from BH/MW3 may be considered as potential sources of the elevated chloroform concentrations found in the groundwater at BH/MW 3.

It is noted that this cursory review of PCAs on or adjacent to the site does not constitute an environmental site assessment nor assessment of past use as defined by O.Reg. 153/04 nor O.Reg. 406/19 and should not be construed as such.

4. CONCLUSION

We trust this information is sufficient for your present purposes. Should you have any questions concerning the above, or can be of any further assistance, please do not hesitate to contact the undersigned.

Yours truly,
GEI Consultants

Prepared By:

Sarah Griffith, G.I.T.
Hydrogeologist-in-Training

Reviewed By:

PROFESSIONAL GEOSCIENTIST
KIMBERLY GILDER (K.G.)
PRACTISING MEMBER
2417
ONTARIO

Kimberly Gilder, P.Geo.
Senior Hydrogeologist

Enclosure 1 – March 2024 Chemical Analysis

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: -

REPORT No: 24-007145 - Rev. 0

Report To:
GEI Consultants
647 Welham Rd, Unit 14
Barrie, ON L4N 0B7

CADUCEON Environmental Laboratories
112 Commerce Park Dr Unit L
Barrie, ON L4N 8W8

Attention: Sarah Griffith

DATE RECEIVED: 2024-Mar-18
DATE REPORTED: 2024-Mar-19
SAMPLE MATRIX: Ground Water

CUSTOMER PROJECT: 2203244
P.O. NUMBER:

Analyses	Qty	Site Analyzed	Authorized	Date Analyzed	Lab Method	Reference Method
VOC-Volatiles Full (Water)	1	RICHMOND_HILL	FLENA	2024-Mar-19	C-VOC-02	EPA 8260

R.L. = Reporting Limit
NC = Not Calculated
Test methods may be modified from specified reference method unless indicated by an *

				Client I.D.	MW3
				Sample I.D.	24-007145-1
				Date Collected	2024-Mar-18
Parameter	**Units**	**R.L.**	**Limits**	**Reg 153 - Liquid**	-
Chloroform	µg/L	1	2	T1GW	<1

Reg 153 - Liquid: Reg 153 - Liquid
T1GW: R153 Tbl. 1 - GW

Michelle Dubien
Data Specialist