Central Earth ENGINEERING

647 Welham Road, Unit 14
Barrie, Ontario, L4N 0B7
P: (705) 719-7994
F: (888) 558-9424
www.centralearth.ca

HYDROGEOLOGICAL REPORT

Proposed Commercial Development
441 Huronia Road
Barrie, Ontario

Prepared For: Dr. Behrooz Azizi
Type of Document: Final Report
Reference Number: 19-1243A
Prepared By: Russell Wiginton, P.Eng.
Reviewed By: Alexander Winkelmann, P.Eng.
Date Issued: January 13, 2020

Table of Contents

Table of Contents (Cont.)

Figures

Appendices

1 Introduction

Central Earth Engineering Inc. (CEE) was retained by Dr. Behrooz Azizi to complete a hydrogeological study for the proposed commercial development located at 441 Huronia Road, in Barrie, Ontario. A site location plan is provided as Figure 1. The existing property is approximately 0.51 hectares in size and triangular. The property is currently a vacant field and is bounded by Huronia Road to the west, an existing commercial plaza to the north and a railway to the southeast. The site is relatively flat with grades ranging from about Elev. 261 to 262 metres.

CEE was provided with the following drawing set in preparation of this report:

- *"Huronia Road Development, 441 Huronia Road, Barrie, Ontario",* by Gerrits Engineering Limited.

This drawing set indicates a 2-storey office building with no underground levels will be constructed in the northwest corner of the site, and the remaining parts of the property will be parking and driving areas. It is understood that the drawing set is preliminary and is subject to change (e.g. the building location may change, the number of storeys may be reduced, etc.). No grading plans were provided to CEE but significant grade changes are not expected. It is expected that the site will be municipally serviced.

This report has been prepared following Conservation Authority guidelines and City of Barrie Terms of Reference for hydrogeological report submissions. CEE has also been retained to complete a geotechnical report for the site under a separate cover.

2 Site Setting

2.1 Physiography, Surficial and Bedrock Geology

The site is located within the physiographic area denoted as the Lake Simcoe Basin within the Simcoe Lowlands (Chapman & Putnam, 1984). The Simcoe Lowlands were flood by Lake Algonquin and are bordered by shorecliffs, beaches, and bouldery terraces. Thus, the Simcoe Lowlands are floored by sand, silt and clay. Based on surficial and bedrock geology mapping of the site by the Ontario Geological Survey, the surficial geology at the site consists of stone-poor, sandy silt to silty sand textured glacial till on Paleozoic terrain. At depth, limestone bedrock of the Lindsay Formation is present.

2.2 Topography and Drainage

Topographic mapping by the MNRF and County of Simcoe show that the site slopes gently to the south. The borehole ground surface elevations indicate that the site slopes from about Elev. 262.2 metres in the north to about Elev. 261.1 metres in the south. No surface water features were observed on the site.

This site is in the Lovers Creek subwatershed, which is part of the Lake Simcoe watershed. Based on the topography, it is expected that surficial runoff drains to the south. The Ontario Flow Assessment Tool (OFAT) by MNRF shows the site drains to the south into a tributary of Lovers Creek, about 500 metres southeast of the site. The tributary flows into Lovers Creek, which generally flows north and outlets into Kempenfelt Bay of Lake Simcoe.

2.3 MECP Well Records

Ministry of Environment, Conservation and Parks (MECP) water well records were obtained within 500 metres of the site area to assess the general nature of the groundwater resource in near vicinity of the site, and historical/current uses of wells in the area. Five (5) well records were found, and a summary of the data obtained from this review is presented below. The approximate MECP well locations are shown on Figure 4 and the well records are included in Appendix D along with a summary table of the well data.

The wells were installed for the following uses:

- One (1) for farming water supply;
- One (1) for municipal observation;
- One (1) for monitoring; and
- Two (2) abandoned or unknown use.

The stratigraphic descriptions within the MECP monitoring well records are typically inaccurate due to the methodology in which they are determined (observations of drill cuttings and no consistency of soil descriptions 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. In the area surrounding the site, the well records generally indicate that there is an upper deposit of “sand,” followed by “clays,” sometimes followed by deeper “sand” deposits. The well records indicate that there is an unconfined aquifer in the upper “sand” and a confined aquifer in the deeper “sand” below the confining “clays.”

2.4 Visual Inspection of Site

The property is vacant, triangular in shape and has a total area of approximately 0.51 ha. The site is vegetated with low-lying grass. The site slopes gently from the north near Elev. 262.2 metres to the south near Elev. 261.2 metres. An aerial image of the site showing the existing conditions is provided on Figure 2. In general, surface drainage is expected to occur as sheet drainage across the site and will generally flow to the south based on the site topography. A roadside ditch runs adjacent to Huronia Road along the west side of the site which likely collects sheet drainage from the site and conveys the runoff to the south.

Based on our preliminary visual estimates, it appears the following hard cover and soft cover surfaces exist:

- Hard Cover – none (0%).
- Soft Cover – flat grass area (100%).

2.5 Regulatory Requirements

2.5.1 Source Water Protection

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.

The Lake Simcoe Protection Plan (LSPP) Designated Policy (DP) 6.36 builds on the Provincial Policy Statement (PPS) and *Clean Water Act, 2006*, to define a Significant Groundwater Recharge Area (SGRA). The definition from the LSPP is below.

- *"6.36-DP: A significant groundwater recharge are is an area identified,*
    - *as a significant groundwater recharge area by any public body for the purposes of implementing the PPS;*
    - *as a significant groundwater recharge area in the assessment report required under the Clean Water Act, 2006, for the Lake Simcoe and Couchiching/Black River Source Protection Area; or*
    - *by the LSRCA in partnership with MOE and MNR as an ecologically significant groundwater recharge area in accordance with the guidelines developed under policy 6.37."*

Based on Simcoe County online mapping, the following is noted:

- Wellhead Protection Area (WHPA): The site is within WHPA Q2 (Figure 5A);
- Significant Groundwater Recharge Area (SGRA): The site is not within an SGRA (Figure 5B); and
- Highly Vulnerable Aquifer (HVA): The site is within an HVA (Figure 5C).

"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:

1. 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."*
2. 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."*
3. Designated Policy (DP) 4.8 d): *"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 proposed development is within a WHPA-Q2, therefore SPP LUP-12 applies and comments and discussion is provided in Section 5. The development is not within an SGRA, therefore DP-6.40 does not apply. The proposed development at the site is considered a major development by the Lake Simcoe Protection Plan (LSPP) since more than 500 m^2 of impervious surface (dwellings, roadway) will be created, therefore DP-4.8 applies and will be addressed in this report using a water balance as discussed in Section 5.3.

The site is within an HVA and the proposed land use will be commercial. Based on Table 2 in *"Lake Simcoe Protection Plan Water Budget Policy for LSPP 4.8-DP and 6.40-DP,"* infiltration-based practices are not permitted for this site for runoff from impervious areas. Infiltration of runoff from vegetated areas and rooftops is always permitted.

The following policy will also apply at the site:

- *"Phosphorous Offsetting Policy",* dated September 2017, by LSRCA.

Section 4.4 Phosphorous Offsetting Policies in the above document discusses the applicable policies, including that the application for a major development *"… shall be accompanied by a Preliminary Phosphorous Budget as part of an overall Functional Servicing Report or Preliminary Stormwater Management Report."* Phosphorous offsetting must be carried out as part of the stormwater management report to be completed for the site by others. Some additional details are provided in Section 5.4.3 of this report.

The following documents are also referenced for content in the hydrogeological report:

- *"Hydrogeological Study, Terms of Reference,"* City of Barrie, dated January 2019;
- *"Hydrogeological Assessment Submissions, Conservation Authority Guidelines for Development Applications,"* dated June 2013, by Conservation Authorities Geoscience Group.

2.5.2 Temporary Groundwater Dewatering

The volume of water entering the excavation will be based on both ground water infiltration and precipitation events. Based on the requirements under O. Reg. 63/16: *Registrations Under Part II.1 of the Act – Water Taking*, the following dewatering limits and requirements are as follows as they pertain to temporary groundwater dewatering for construction purposes:

- Construction Dewatering less than 50,000 L/day: The takings of both groundwater and stormwater do not require a hydrogeological report and does not require registration on the Environmental Sector Activity Registry (EASR) nor a Permit to Take Water (PTTW) from the Ministry of Environment, Conservation and Parks (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 Environmental Sector Activity Registry (EASR) but does not require a Permit to Take Water (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 Permit to Take Water (PTTW) from the MECP.

3 Procedures and Methodology

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 December 12th, 2019. A total of four boreholes (Boreholes 1 to 4) were advanced on site by Drilltech Drilling using a track-mounted drill rig, continuous flight solid stem augers and standard soil sampling equipment.

All samples were collected as per ASTM D1586 to assess the strength characteristics of the substrate. The boreholes were advanced to depths of 6.5 to 9.6 metres below existing grade. The horizontal locations were laid out in the field by CEE prior to the drilling operations. Ground surface elevations of the boreholes were measured using laser level survey equipment in reference to a geodetic benchmark (Cosine Station #00119713848) with a known geodetic elevation of 261.316 metres in reference to datum CGVD2013. GPS measurements measured with a handheld GPS unit and referenced to the NAD 83. Monitoring wells were installed in Boreholes 1, 2, and 4 to facilitate long-term measurements of groundwater levels.

The CEE 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. The boreholes were backfilled upon completion. 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 was carried out with the results included in Appendix B. Stabilized groundwater levels were measured in the three installed monitoring wells on December 20th, 2019.

4 Subsurface Conditions

4.1 General Overview

The detailed soil profiles encountered in the boreholes are indicated on the attached borehole logs in Appendix A and a subsurface profile is included as Figure 3. The borehole locations are shown on Figure 2 and laboratory test results are included as Appendix B. It should be noted that the conditions indicated on the borehole logs are for specific locations only and can vary between and beyond the borehole 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 Topsoil and Earth Fill

Borehole 1 encountered 100 mm of topsoil at the ground surface, and Borehole 4 encountered a surficial zone of earth fill that was mixed with topsoil.

Underlying the topsoil in Borehole 1 and at the ground surface in Boreholes 2 to 4, a surficial zone of earth fill was encountered that consisted of silt and sand to silty sand with trace clay and trace gravel. The earth fill extended to depths of 1.5 to 2.3 metres below grade (Elev. 259.6 to 260.6 metres) and was brown and moist. The full depth of earth fill in Borehole 4 was mixed with topsoil and was dark brown. The Standard Penetration Test (SPT) results

("N" Values) measured in the earth fill ranged from 5 to 18 blows per 300 mm of penetration, indicating a loose to compact relative density.

4.2.2 Glacial Till

Underlying the earth fill, Borehole 2 encountered a glacial till deposit with a cohesive matrix consisting of clayey and sandy silt with trace gravel and trace organics. The clayey silt glacial till was encountered at a depth of 1.5 metres below grade (Elev. 260.6 metres) and extended to a depth of 3.1 metres (Elev. 259.1 metres). The clayey silt glacial till was dark brown and moist, and the measured Standard Penetration Test (SPT) results ("N" Values) were 3 and 9, indicating a soft to stiff consistency. The disturbed soil samples collected from the split spoon sampler were also tested using a pocket penetrometer to obtain a general sense of the undrained shear strength of the deposit. The pocket penetrometer testing indicated that the undrained shear strength ranged from approximately 150 to 225 kPa.

Underlying the earth fill in Boreholes 1, 3, and 4, and underlying the clayey silt glacial till in Borehole 2, a glacial till deposit was encountered with a cohesionless matrix consisting of silty sand with trace to some clay and trace gravel. The silty sand glacial till was encountered at depths of 1.5 to 3.1 metres below grade (Elev. 260.5 to 259.1 metres) and extended beyond the vertical depth of investigation at 6.5 to 9.6 metres below grade (Elev. 255.3 to 251.8 metres). The silty sand glacial till was brown and moist, and the measured SPT "N" Values ranged from 11 to greater than 100 blows per 300 mm of penetration, indicating a compact to very dense (but generally very dense) relative density.

4.3 Groundwater

4.3.1 Groundwater Levels

Unstabilized ground water level measurements and cave measurements were taken upon completion of drilling of each borehole. These measurements provide a rough estimate of the possible excavation and temporary ground water control constructability considerations that may arise. The boreholes remained open and dry. 50 mm diameter PVC monitoring wells were installed in Boreholes 1, 2, and 4 to facilitate the measurement of stabilized groundwater levels. The results are shown on the borehole logs in Appendix A and are summarized in the table below.

Monitoring Well	Well Screen Location		Strata Screened	Depth / Elevation (m) of Groundwater Table	
	Depth (m)	Elevation (m)		Dec. 12th, 2019	Dec. 20th, 2019
1	7.6 to 9.1	254.4 to 252.9	Silty Sand Glacial Till	8.2* / 253.5	5.3 / 250.6
2	7.6 to 9.1	254.6 to 253.1		Dry	
4	7.6 to 9.1	253.6 to 252.1			

*Water level measured same day as drilling and may not represent a stabilized level.

Based on the above groundwater level measurements and moisture contents of the recovered soil samples, it is expected that the groundwater table is at or below a depth of 5.3 metres below grade. The wells installed in Boreholes 2 and 4 were dry. It is possible that the well installed in Borehole 1 captured a zone of perched water within the glacial till deposit rather than the prevailing groundwater table.

The silty sand glacial till deposit is cohesionless but contains more than 30% fines and will have a relatively lower permeability that typically precludes the free flow of water when wet. Groundwater levels are expected to show seasonal fluctuations and vary in response to prevailing climate conditions.

4.3.2 In-Situ Permeability and Infiltration

A rising head test was completed in the monitoring well installed in Borehole 1 on December 20th, 2019. Water was manually purged from the monitoring well using LDPE piping and a foot valve. The static water level within the monitoring well was measured prior to the start of testing, and the change in water level was monitored at select time intervals once the water had been purged from the monitoring well. The test was completed to estimate the horizontal hydraulic conductivity (K) of the soil at the well screen depth.

A hydraulic conductivity value was calculated from the rising head data using Hvorslev's solution (1951). Due to lower permeability of the silty sand glacial till, the rising head test conducted in the monitoring well installed in Borehole 1 did not recover sufficiently to reach T_0, which is the time required for the water level to rise to 37% of the initial change (i.e. drop) in water level. As such, the result was approximated by extrapolating a line of best fit to estimate T_0. The semi-log plot for drawdown versus time for the rising head test from Borehole 1 is provided in Appendix C and is summarized in the table below.

Monitoring Well	Well Screen Location		Strata Screened	Hydraulic Conductivity
	Depth (m)	Elevation (m)		
1	7.6 to 9.1	254.4 to 252.9	Silty Sand Glacial Till	9×10^{-8} m/s

In addition to the above-noted permeability data, the hydraulic conductivity of the soils encountered on site was estimated from grain size distribution curves (as provided in Appendix B). According to Freeze and Cherry (1979), the typical hydraulic conductivity of the glacial till on site is on the order of 10^{-6} m/s to 10^{-12} m/s. The actual measured hydraulic conductivity of the silty sand glacial till is within the expected range. For the purposes of design, it is recommended to use a hydraulic conductivity of 1×10^{-7} m/s for the silty sand glacial till across the site.

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*". Under the Unified Soil Classification System, the silty sand glacial till would be characterized as S.M. and the clayey silt glacial till in Borehole 2 would be characterized as M.L. Based on this document, the soil type, and the results of the hydraulic conductivity testing, the estimated percolation rate (T-Time) for the near surface soils would be as follows:

- Silty Sand Glacial Till (S.M.): 20 mins/cm (30 mm/hr)
- Clayey Silt Glacial Till (M.L.): Over 50 mins/cm (less than 12 mm/hr)

4.3.3 Baseline Groundwater Chemical Testing

To assess the suitability for discharge of pumped groundwater to the land surface during potential dewatering activities, one (1) unfiltered and one (1) filtered groundwater sample were collected from the monitoring well installed in Borehole 1 on December 19th, 2019. 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 groundwater samples were submitted to CALA-accredited Caduceon Environmental Laboratories for analysis.

The groundwater samples were compared to Provincial Water Quality Objectives (PWQO). The results are provided in Appendix F and the exceedances are summarized in the table below.

Sample ID	Ground Water Sample Parameter Exceedances to PQWO
BH 1 (Unfiltered)	Zinc, Lead, Iron, Copper, Cobalt, Cadmium
BH 1 (Filtered)	Lead, Iron, Copper, Cobalt

It is expected that the measured levels of metals in the groundwater are naturally occurring and primarily from suspended solids within the groundwater sample, though a component may be from dissolved metals. The unfiltered sample typically had more total metal concentrations than the sample that was run through a 75 µm filter, since metals typically bind to sediment particles that are removed by filtration. Groundwater quality mitigation measures are discussed in Section 5.4.3.

5 Discussion and Analysis

5.1 Proposed Development Plan

CEE was provided with the following drawing set in preparation of this report:

- *"Huronia Road Development, 441 Huronia Road, Barrie, Ontario",* by Gerrits Engineering Limited.

This drawing set indicates a 2-storey office building with no underground levels will be constructed in the northwest corner of the site, and the remaining parts of the property will be parking and driving areas. It is understood that the drawing set is preliminary and is subject to change (e.g. the building location may change, the number of storeys may be reduced, etc.). No grading plans were provided to CEE but significant grade changes are not expected. It is expected that the site will be municipally serviced.

5.2 Ground Water Control Methodology

5.2.1 Temporary Construction Ground Water Control

The volume of water entering the excavation will be based on both ground water infiltration and precipitation events. Grading plans were not provided to CEE, but it is not expected that excavations or utility trenches will extend below the groundwater table that was encountered at or below a depth of 5.3 metres below grade. As excavations are expected to be above the prevailing ground water table, there should be limited ground water control issues present. During times of high precipitation, some water may collect at the base of the excavation. Local sumps placed at the base of the excavation can typically control groundwater seepage in this scenario.

Construction dewatering is expected to be less than 50,000 L/day, and per O.Reg. 63/16, registration on the Environmental Sector Activity Registry (EASR) nor a Permit to Take Water (PTTW) will be required from the Ministry of Environment, Conservation and Parks (MECP).

5.2.2 Permanent Building Drainage

The proposed commercial building has no basement levels or other below-grade space. Perimeter and under-slab drainage at the foundation level is not required, provided that the underside of concrete slab is at least 200 mm above the prevailing grade of the site and the surrounding surfaces slope away from the building at a gradient of at least 2% to promote surface water run-off and to reduce groundwater infiltration adjacent to foundations. To minimize infiltration of surface water, the upper 150 mm of backfill could comprise relatively impervious compacted soil material.

5.3 Water Balance

5.3.1 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 ground water 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 Government of Canada (Environment Canada) historical weather data for the Barrie WPCC weather station (Climate ID 6110557, Latitude 44.38 N, Longitude 79.69 W, Elevation 229 metres), which is located relatively close to 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, 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.

5.3.2 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 E, which are 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 cohesionless near surface soils (sand to silty sand) and a mostly grassed site, a soil moisture storage capacity of 75 mm was used.
- 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 MOECC 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. 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.

A post-development water balance scenario was also calculated based on the proposed land development plan, as discussed in Section 5.3.3. The drawing, *"Huronia Road Development, 441 Huronia Road, Barrie, Ontario",* by Gerrits Engineering Limited shows the proposed development including a commercial building, parking and driving areas, and some areas that are assumed to be landscaped.

It is noted that the infiltration and runoff values presented in Appendix E 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.

5.3.3 Pre and Post Water Balance

The detailed water balance calculations are included in Appendix E. The pre-development calculations are summarized in the table below:

Pre-Development Land Use		Pre-Development Average Annual Runoff Volume (m^3/year)	Pre-Development Average Annual Infiltration Volume (m^3/year)
Soft Cover	Hard Cover		
100% (flat grass areas)	0%	388	1,551

The post-development calculations are summarized in the table below:

Post-Development Land Use		Post-Development Average Annual Runoff Volume (m^3/year)	Post-Development Average Annual Infiltration Volume (m^3/year)
Soft Cover	Hard Cover		
20% (grassed and landscaped areas)	80% (buildings and pavement areas)	3,332	310

These calculations suggest that, without mitigation such as low impact development measures, the proposed development will decrease average infiltration by about 1,241 m^3/year. The proposed development will increase runoff by about 2,944 m^3/year (859% increase). The potential impacts of these changes and recommended mitigation measures are discussed below.

5.4 Recommended Mitigation Measures

5.4.1 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 (i.e., roads, parking lots, driveways, and rooftops). Impervious surfaces prevent infiltration of water into the 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:

- 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.

5.4.2 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 low impact development (LID) measures to promote infiltration. These measures can be implemented on-site.

The basic premise for low impact development is to try to minimize changes to runoff and infiltration. As outlined in the MOECC SWMP Design Manual (2003) and Low Impact Development Stormwater Management Planning and Design Guide published by the 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:

- 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 drainage ditches 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); and
- 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 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.

The details will be provided by others in a stormwater management report for the site. This includes demonstrating through plans and sections (including all dimensions, materials used and including the seasonal high groundwater level) how this infiltration deficit will be mitigated. In addition, the stormwater management report will need to include calculations to demonstrate that the LID facilities will be adequately sized both volumetrically and for area to allow completed drawdown within a 24 to 48 hours time period.

As it is 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. There are no domestic water supply wells within a 500-metre radius of the site.

5.4.3 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, bacteria and viruses. The site is within an HVA and the proposed land use will be commercial. Based on Table 2 in *"Lake Simcoe Protection*

Plan Water Budget Policy for LSPP 4.8-DP and 6.40-DP," infiltration-based practices are not permitted for this site for runoff from impervious areas. Runoff from pavement areas can become contaminated with chloride and sodium from de-icing salt applications, hydrocarbons and metals from vehicles, etc. Low Impact Development Stormwater Management Planning and Design Guide published by the CVC and TRCA (2010), indicates that runoff can be infiltrated from low to medium traffic parking lots if it is pretreated using sedimentation and / or filtration, such as oil / grit separators or biofilters, prior to infiltration. Pretreatment options should be explored by the stormwater management facility designer and may allow for infiltration from paved areas if approved by the reviewing agencies. LSRCA also has compensation programs if pre to post infiltration cannot be maintained.

Infiltration of runoff from vegetated areas and rooftops is always permitted. A general principal is that runoff from rooftops and vegetated sources should not be mixed with runoff from paved areas (even if pretreated) prior to infiltration. 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. The prevailing groundwater table beneath the site is relatively deep at 5.3 metres below grade or deeper, allowing for attenuation as infiltrated water percolates through the soil matrix before reaching the water table.

LID measures or end treatments such as oil/grit separators or wet ponds 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. The stormwater management facilities (to be designed by others) 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.

Phosphorous will also be removed from the site through implementation of measures such as LID or end treatments. This will be addressed in the stormwater management report prepared for the site by others. *"LSRCA Technical Guidelines for Stormwater Management Submissions"* (dated September 1, 2016, by LSRCA) states that 80% removal of annual Total Phosphorous is required for major developments and provides a list of typical phosphorous removal rates for various stormwater management best management practices. LID measures are recommended for this site to maintain the pre to post development water balance. LID's used in a treatment train approach remove phosphorous, and some typical removal rates are 60% for infiltration trenches, 65% for vegetated filter strips, and 87% for a perforated pipe infiltration / exfiltration system based on the LSRCA guidelines.

The results of the groundwater chemical testing compared to Provincial Water Quality Objectives (PWQOs) as provided in Appendix E and summarized in Section 4.3.3 show that there are several exceedances for metals in the unfiltered groundwater samples. Field filtering using a 75-micron filter was also carried out prior to collecting the second sample to provide a general reference to how filtering during actual dewatering activities can improve groundwater quality. The results show that filtering helps to remove or reduce the metal exceedances since metals usually bind to sediment that is readily removed using filters. This chemistry testing was carried out to establish baseline conditions but dewatering or significant discharge of groundwater during construction is not anticipated since excavations are not expected to extend below the prevailing groundwater table. As such, little to no water is expected to be discharged to the ground surface and will therefore have no impact on surface water features.

6 Limitations and Conclusion

6.1 Limitations

The investigation and comments 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, during the future development of the property, conditions not observed during this investigation may become apparent. Should this occur, Central Earth Engineering should be contacted to assess the situation and additional testing and reporting may be required.

Central Earth Engineering 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, Central Earth Engineering will assume no responsibility for interpretation of the recommendations in the report. For example, it should be appreciated that modifications to bearing levels may be required if unforeseen subsoil conditions are revealed after the excavation is exposed to full view or if final design decisions differ from those assumed in this 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 prepared by Central Earth Engineering for the account of Dr. Behrooz Azizi. 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. Central Earth Engineering accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this project.

6.2 Conclusion

It is recognized that municipal/regional governing bodies, in their capacity as the planning and building authority under Provincial statues, will make use of and rely upon this report, cognizant of the limitations thereof, both as are expressed and implied.

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.

Yours Truly,

Central Earth Engineering Inc.

Alexander Winkelmann, P.Eng.
President

Russell Wiginton, P.Eng.
Project Engineer

Figures –

FIGURE 1 – SITE LOCATION PLAN

FIGURE 2 – BOREHOLE LOCATION PLAN

FIGURE 3 – SUBSURFACE PROFILE

FIGURE 4 – MECP & CEE WELL LOCATION MAP

FIGURE 5A – WELLHEAD PROTECTION AREA MAP

FIGURE 5B – SIGNIFICANT GROUNDWATER RECHARGE MAP

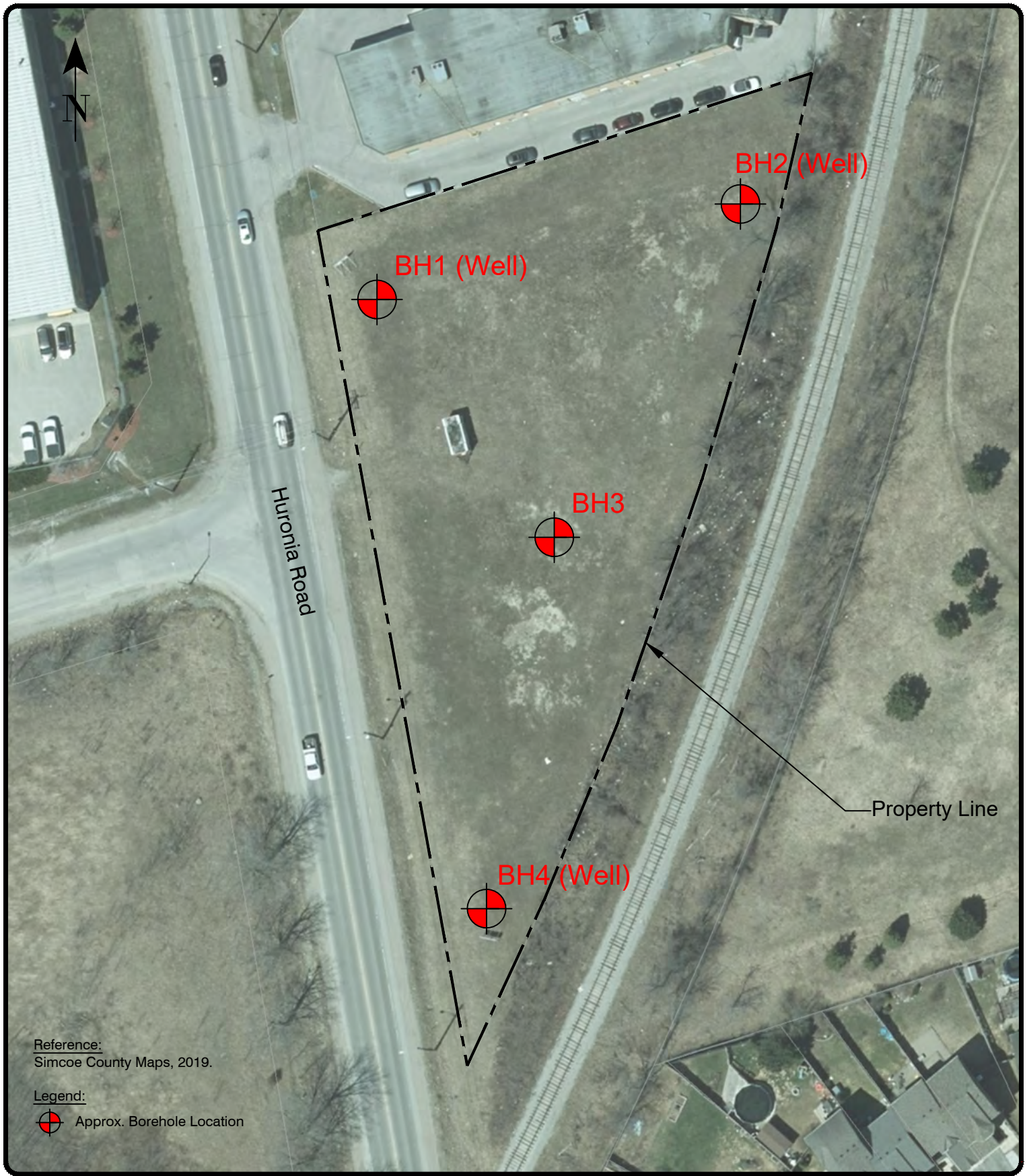
FIGURE 5C – HIGHLY VULNERABLE AQUIFER MAP

Central Earth ENGINEERING

Geotechnical Engineering and Construction
Materials Testing & Inspection

647 Welham Rd, Unit 14, Barrie, ON, L4N 0B7
P: (705) 719-7994 | E: info@centralearth.ca

Project:	441 Huronia Road, Barrie, Ontario				
Title:	SITE LOCATION PLAN				
Approved by:	A.W.	Date:	January 2020	Project No.:	19-1243A
Drawn by:	R.W.	Scale:	N.T.S.	Figure No.:	1

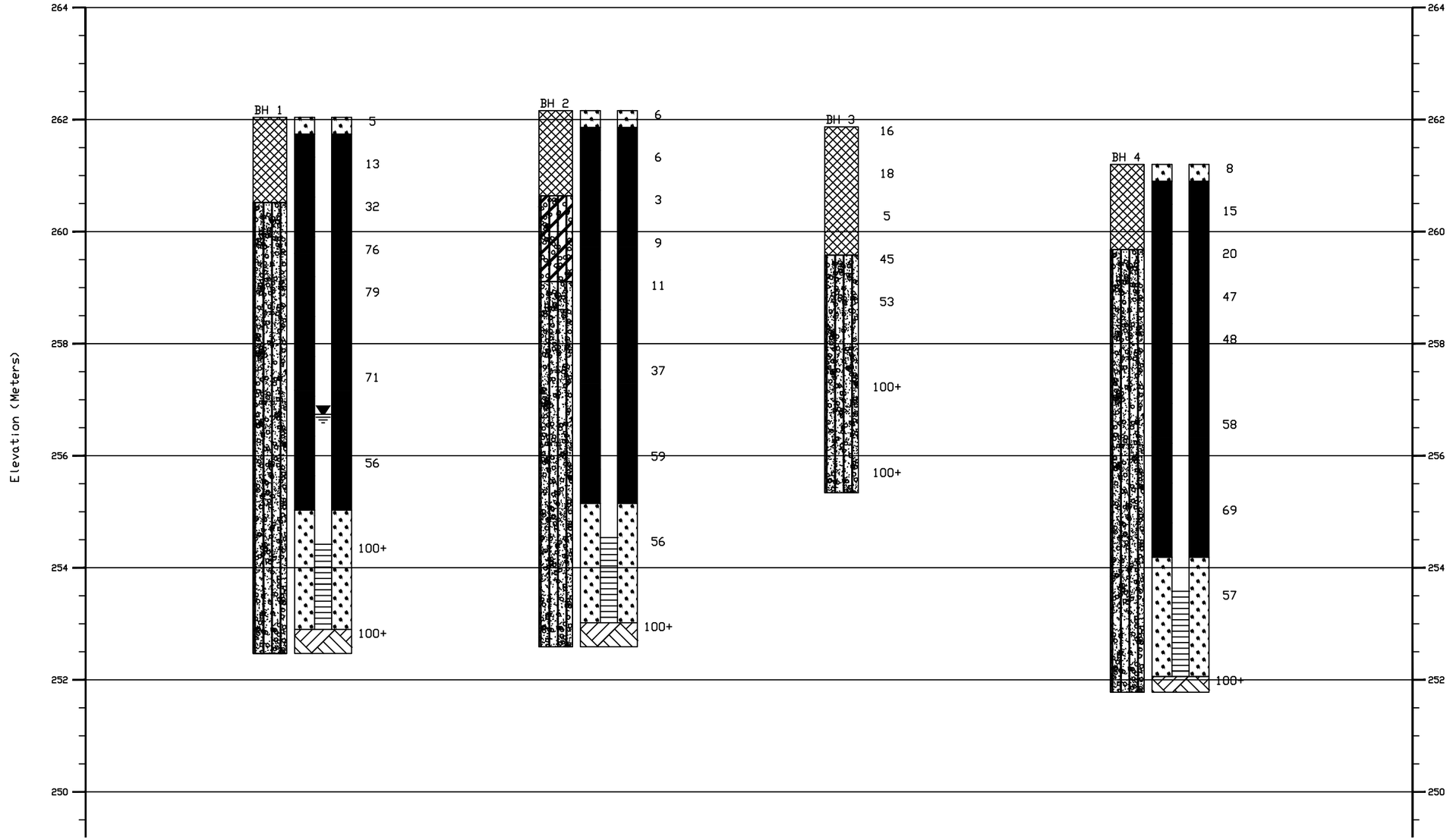


Reference:
Simcoe County Maps, 2019.

Legend:
Approx. Borehole Location

Central Earth ENGINEERING
Geotechnical Engineering and Construction
Materials Testing & Inspection
647 Welham Rd, Unit 14, Barrie, ON, L4N 0B7
P: (705) 719-7994 | E: info@centralearth.ca

Project:	441 Huronia Road, Barrie, Ontario				
Title:	BOREHOLE LOCATION PLAN				
Approved by:	A.W.	Date:	January 2020	Project No.:	19-1243A
Drawn by:	R.W.	Scale:	1:750	Figure No.:	2



Legend:

- Earth Fill
- Clayey Silt Glacial Till
- Silty Sand Glacial Till
- Water Level in Monitoring Well

Notes:

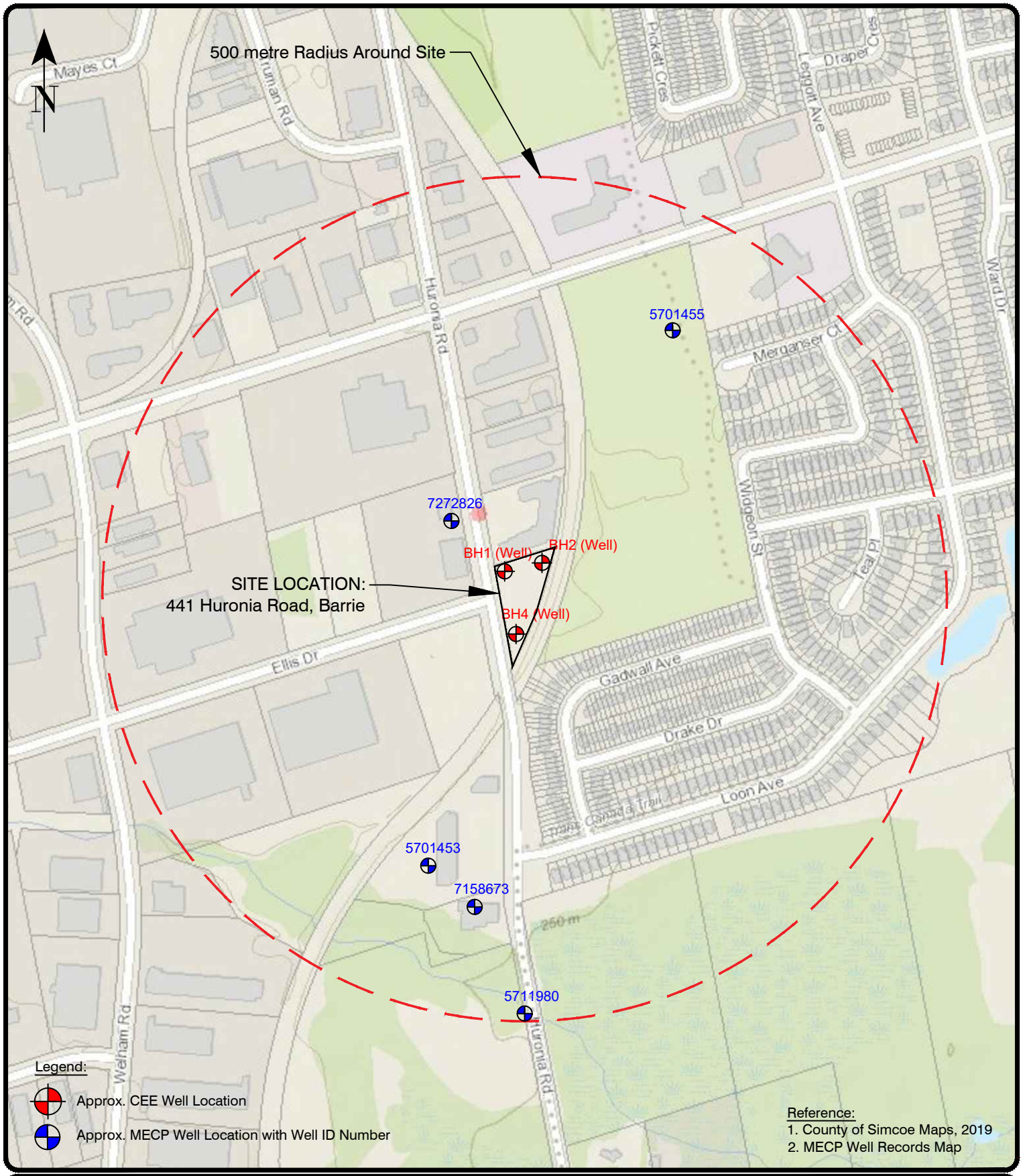
1. Horizontal distances not to scale, boreholes spaced for visualization purposes.
2. Numbers beside boreholes indicate SPT "N" Values obtained in the borehole.

Central Earth ENGINEERING

Geotechnical Engineering and Construction
Materials Testing & Inspection

647 Welham Rd, Unit 14, Barrie, ON, L4N 0B7
P: (705) 719-7994 | E: info@centralearth.ca

Project: 441 Huronia Road, Barrie			
Title: SUBSURFACE PROFILE			
Approved by: A.W.	Date: January 2020	Project No.: 19-1243A	
Drawn by: R.W.	Scale: As Shown	Figure No.: 3	



Central Earth ENGINEERING
Geotechnical Engineering and Construction
Materials Testing & Inspection
647 Welham Rd, Unit 14, Barrie, ON, L4N 0B7
P: (705) 719-7994 | E: info@centralearth.ca

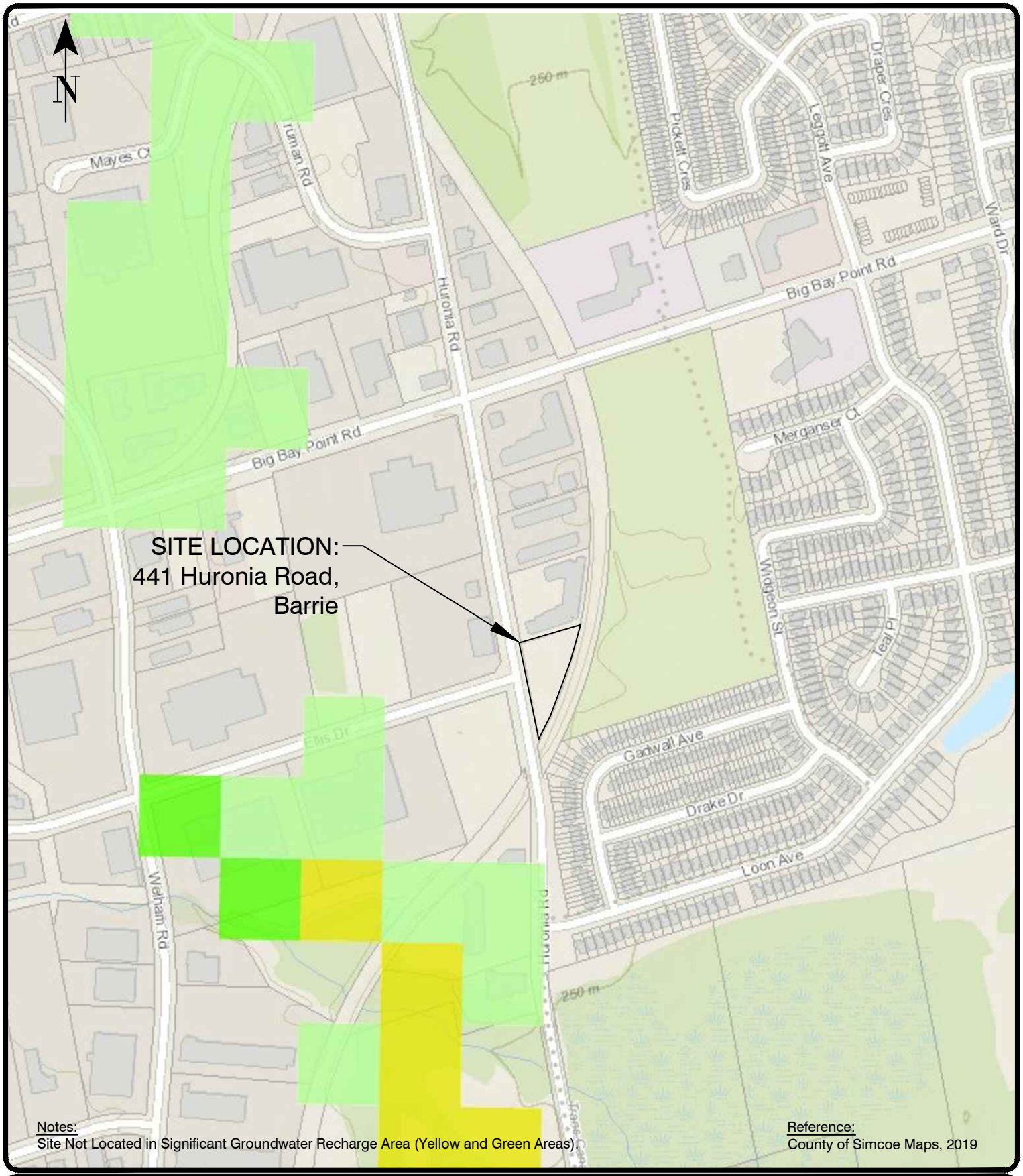
Project:	441 Huronia Road, Barrie				
Title:	MECP & CEE WELL LOCATION PLAN				
Approved by:	R.W.	Date:	January 2020	Project No.:	19-1243A
Drawn by:	R.W.	Scale:	N.T.S.	Figure No.:	4

Notes:
Site is located within Wellhead Protection Area - Q2

Reference:
County of Simcoe Maps, 2019

Central Earth ENGINEERING
Geotechnical Engineering and Construction
Materials Testing & Inspection
647 Welham Rd, Unit 14, Barrie, ON, L4N 0B7
P: (705) 719-7994 | E: info@centralearth.ca

Project:	441 Huronia Road, Barrie				
Title:	WELLHEAD PROTECTION AREA MAP				
Approved by:	R.W.	Date:	January 2020	Project No.:	19-1243A
Drawn by:	M.T.	Scale:	N.T.S.	Figure No.:	5A

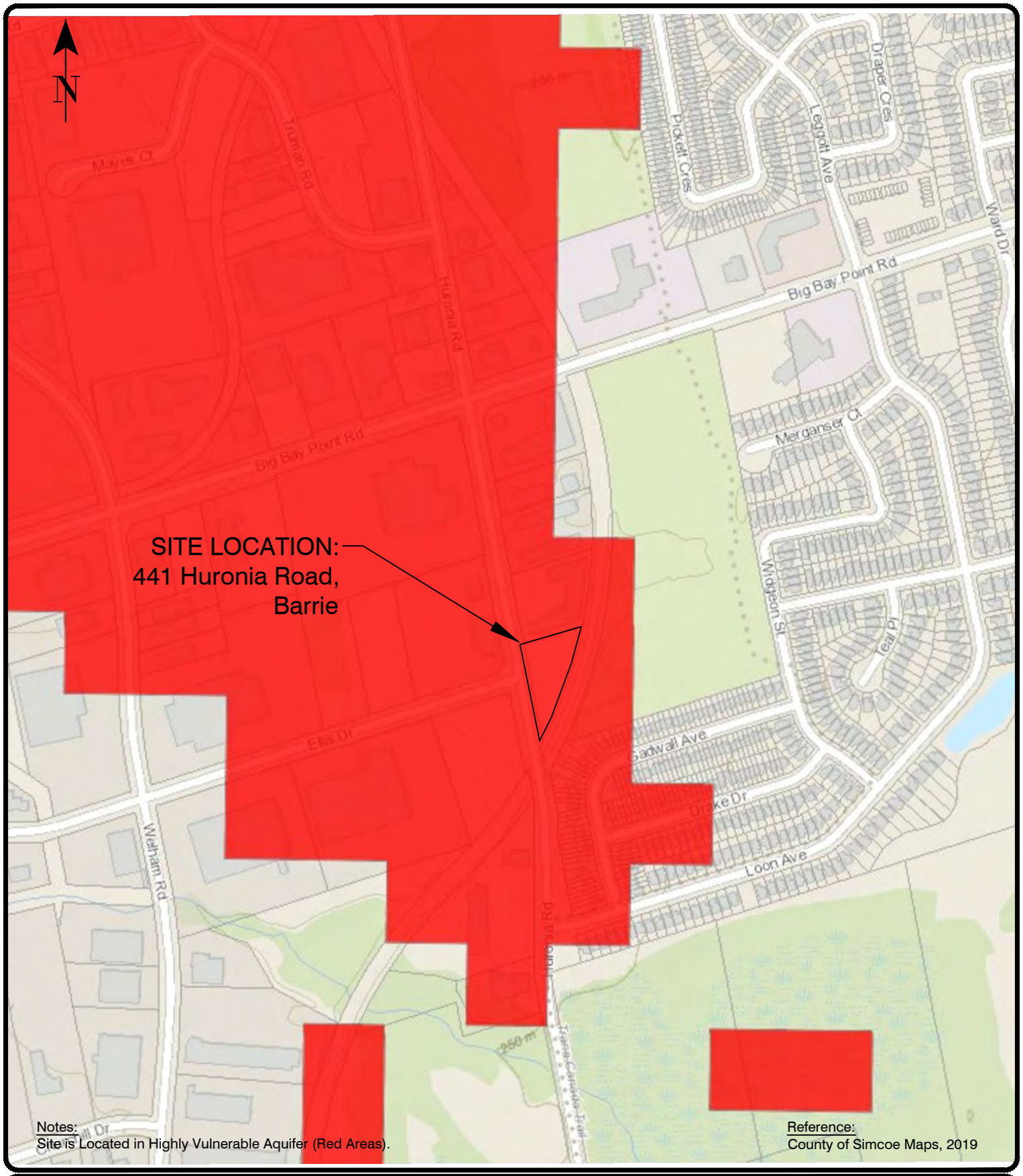


Notes:
Site Not Located in Significant Groundwater Recharge Area (Yellow and Green Areas).

Reference:
County of Simcoe Maps, 2019

Central Earth ENGINEERING
Geotechnical Engineering and Construction
Materials Testing & Inspection
647 Welham Rd, Unit 14, Barrie, ON, L4N 0B7
P: (705) 719-7994 | E: info@centralearth.ca

Project:	441 Huronia Road, Barrie				
Title:	SIGNIFICANT GROUNDWATER RECHARGE AREA MAP				
Approved by:	R.W..	Date:	January 2020	Project No.:	19-1243A
Drawn by:	M.T.	Scale:	N.T.S.	Figure No.:	5B



Notes:
Site is Located in Highly Vulnerable Aquifer (Red Areas).

Reference:
County of Simcoe Maps, 2019

Central Earth ENGINEERING

Geotechnical Engineering and Construction
Materials Testing & Inspection

647 Welham Rd, Unit 14, Barrie, ON, L4N 0B7
P: (705) 719-7994 | E: info@centralearth.ca

Project:	441 Huronia Road, Barrie				
Title:	HIGHLY VULNERABLE AQUIFER MAP				
Approved by:	R.W.	Date:	January 2020	Project No.:	19-1243A
Drawn by:	M.T.	Scale:	N.T.S.	Figure No.:	5C

Appendix A –

BOREHOLE LOGS

RECORD OF BOREHOLE No. 1

Project Number: **19-1243A**
Project Client: **Mr. Behrooz Azizi**
Project Name: **441 Huronia Road**
Project Location: **Barrie, Ontario**
Drilling Location: **NW Corner of Lot**

Drilling Method: **Solid Stem Augers** Drilling Machine: **Track Mount**
Logged By: **RD** Northing: **4911659** Date Started: **2019-12-12**
Reviewed By: **AW** Easting: **606473** Date Completed: **2019-12-12**

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: PL, LL, Water Content (%)	Instrumentation Installation		GR	SA	SI	CL
	Geodetic 262.04m														
	FILL: Silty Sand, Trace Gravel, Loose to Compact, Brown, Moist	SS	1	58	5	0	262	5	9		Topsoil = 100mm				
		SS	2	89	13			13	8						
	1.5 260.5								7						
	SILTY SAND GLACIAL TILL, Trace to Some Clay, Trace Gravel, Dense, Brown, Moist	SS	3	100	32	2	260	32							
	- - - Very Dense - - -	SS	4	100	76			76	8						
		SS	5	100	79			79	7						
						4	258								
		SS	6	100	71			71	9						
						6	256								
		SS	7	100	56			56	9			8	57	26	9
		SS	8	100	100+			100+	7						
						8	254								
	9.6 252.5	SS	9	53	100+			100+	9						
	End of Borehole @ 9.6m														

CENTRAL EARTH ENGINEERING
647 Welham Road, Unit 14
Barrie, Ontario L4N 0B8
T : (705) 719-7994
E: info.com
W: centralearth.com

Groundwater depth encountered on completion of drilling: **Dry**
Cave depth after auger removal: **Open**
Groundwater depth observed on **2019-12-12** at a depth of: **8.2m**
Observed on **2019-12-20** at a depth of: **5.3m**

Scale: **1 :100**

RECORD OF BOREHOLE No. 2

Central Earth ENGINEERING

Project Number:	**19-1243A**				
Project Client:	**Mr. Behrooz Azizi**				
Project Name:	**441 Huronia Road**	Drilling Method: **Solid Stem Augers**		Drilling Machine: **Track Mount**	
Project Location:	**Barrie, Ontario**	Logged By: **RD**	Northing: **4911674**	Date Started: **2019-12-12**	
Drilling Location:	**NE Corner of Lot**	Reviewed By: **AW**	Easting: **606525**	Date Completed: **2019-12-12**	

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
	Geodetic 262.16m											
	FILL: Silty Sand, Trace Gravel, Loose, Brown, Moist	SS	1	67	6	0	262		No topsoil present			
		SS	2	83	6							
	1.5 260.6											
	CLAYEY SILT GLACIAL TILL, Sandy, Trace Gravel, Trace Organics, Soft, Dark Brown, Moist	SS	3	50	3	2	260					
	- - - Stiff - - -	SS	4	100	9							
	3.1 259.1											
	SILTY SAND GLACIAL TILL, Trace to Some Clay, Trace Gravel, Compact, Brown, Moist	SS	5	67	11				1	66	21	12
	- - - Dense - - -	SS	6	100	37	4	258					
	- - - Very Dense - - -	SS	7	100	59	6	256					
		SS	8	100	56	8	254					
	9.6 252.6	SS	9	100	100+							
	End of Borehole @ 9.6m											

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

CENTRAL EARTH ENGINEERING
647 Welham Road, Unit 14
Barrie, Ontario L4N 0B8
T : (705) 719-7994
E: info.com
W: centralearth.com

Groundwater depth encountered on completion of drilling: **Dry**
Cave depth after auger removal: **Open**
Groundwater depth observed on **2019-12-12** at a depth of: **Dry**
Observed on **2019-12-20** at a depth of: **Dry**

Scale: **1 :100**

RECORD OF BOREHOLE No. 3

Central Earth ENGINEERING

Project Number:	**19-1243A**				
Project Client:	**Mr. Behrooz Azizi**				
Project Name:	**441 Huronia Road**	Drilling Method: **Solid Stem Augers**		Drilling Machine: **Track Mount**	
Project Location:	**Barrie, Ontario**	Logged By: **RD**	Northing: **4911625**	Date Started: **2019-12-12**	
Drilling Location:	**Centre of Lot**	Reviewed By: **AW**	Easting: **606499**	Date Completed: **2019-12-12**	

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
	Geodetic 261.87m													
	FILL: Silty Sand, Trace Clay, Trace Gravel, Compact, Brown, Moist	SS	1	100	16	0		16	8		No topsoil present			
		SS	2	78	18			18	6					
	- - - Loose, Moist to Wet - - -	SS	3	78	5	2	260	5	12		11	65	20	4
	2.3 259.6													
	SILTY SAND GLACIAL TILL, Trace to Some Clay, Trace Gravel, Dense, Brown, Moist	SS	4	100	45			45	8					
	- - - Very Dense - - -	SS	5	100	53	4	258	53 →	7					
		SS	6	100	100+			100+ →	7					
		SS	7	100	100+	6	256	100+ →	6					
	6.5 255.3													
	End of Borehole @ 6.6m													

CENTRAL EARTH ENGINEERING
647 Welham Road, Unit 14
Barrie, Ontario L4N 0B8
T : (705) 719-7994
E: info.com
W: centralearth.com

Groundwater depth encountered on completion of drilling: **Dry**

Cave depth after auger removal: **Open**

RECORD OF BOREHOLE No. 4

Central Earth ENGINEERING

Project Number:	**19-1243A**				
Project Client:	**Mr. Behrooz Azizi**				
Project Name:	**441 Huronia Road**	Drilling Method: **Solid Stem Augers**		Drilling Machine: **Track Mount**	
Project Location:	**Barrie, Ontario**	Logged By: **RD**	Northing: **4911572**	Date Started: **2019-12-12**	
Drilling Location:	**Southern Corner of Lot**	Reviewed By: **AW**	Easting: **606491**	Date Completed: **2019-12-12**	

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	DEPTH (m)	ELEVATION (m)
	Geodetic 261.20m						
	FILL: Silt & Sand, Trace Organics, Loose, Dark Brown, Moist (Topsoil)	SS	1	83	8	0	
	- - - Compact - - -	SS	2	100	15		260
	1.5 259.7						
	SILTY SAND GLACIAL TILL, Trace to Some Clay, Trace Gravel, Compact, Brown, Moist	SS	3	72	20	2	
	- - - Dense - - -	SS	4	100	47		
		SS	5	100	48		258
						4	
	- - - Very Dense - - -	SS	6	100	58		256
		SS	7	100	69	6	
							254
		SS	8	100	57	8	
	9.4 251.8	SS	9	100	100+		252
	End of Borehole @ 9.4m						

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

Instrumentation Installation

COMMENTS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
4	60	27	9

CENTRAL EARTH ENGINEERING
647 Welham Road, Unit 14
Barrie, Ontario L4N 0B8
T : (705) 719-7994
E: info.com
W: centralearth.com

Groundwater depth encountered on completion of drilling: **Dry**

Cave depth after auger removal: **Open**

Groundwater depth observed on **2019-12-12** at a depth of: **Dry**

Observed on **2019-12-20** at a depth of: **Dry**

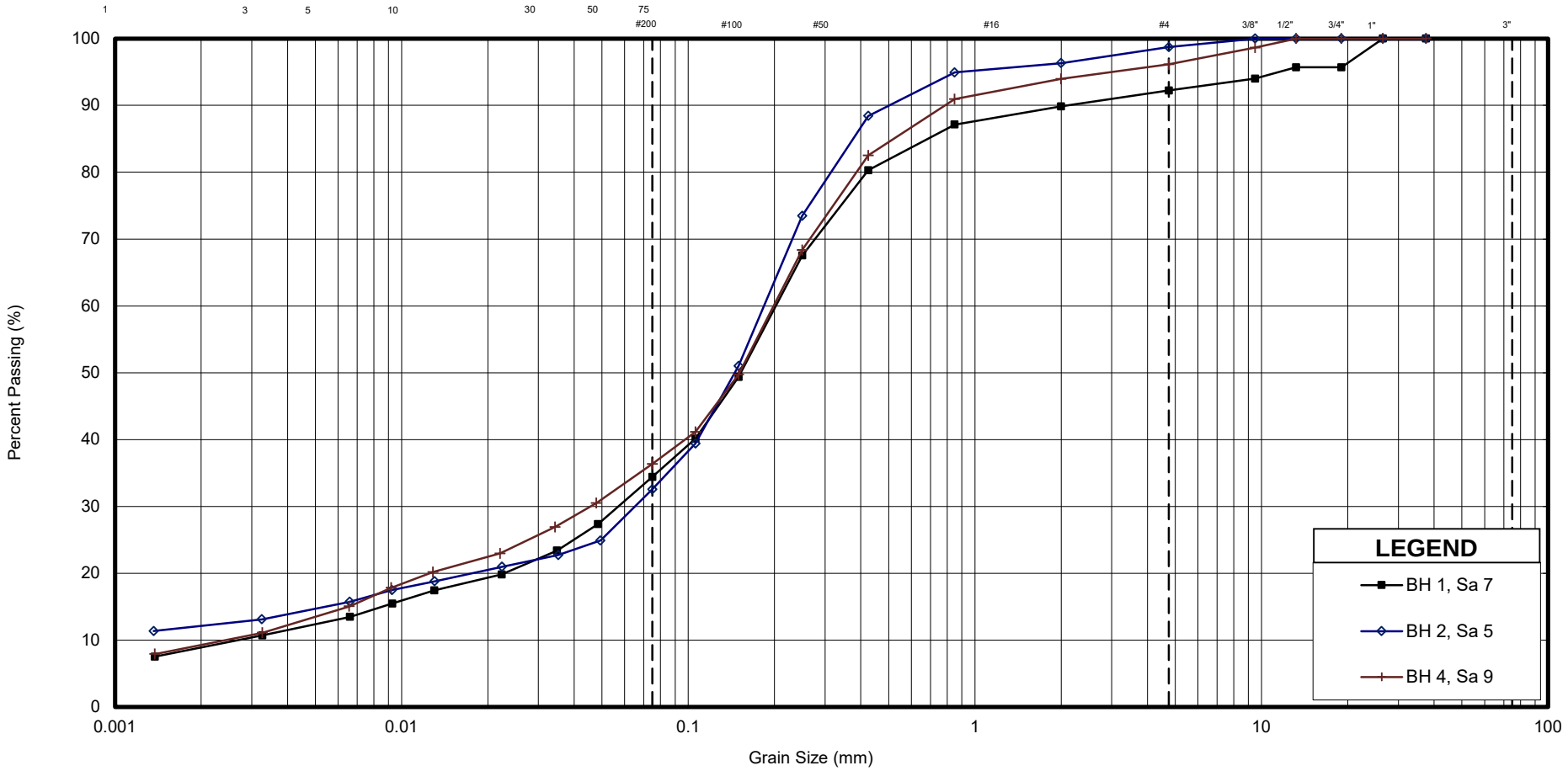
Scale: **1 :100**

Appendix B –

GEOTECHNICAL LABORATORY DATA

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
BH 1, Sa 7	SILTY SAND GLACIAL TILL, Trace Clay, Trace Gravel	8	57	26	9	0.003	0.057	0.202	75	6.0
BH 2, Sa 5	SILTY SAND GLACIAL TILL, Some Clay, Trace Gravel	1	66	21	12	0.001	0.065	0.184	184	23
BH 4, Sa 9	SILTY SAND GLACIAL TILL, Trace Clay, Trace Gravel	4	60	27	9	0.002	0.046	0.20	82	4.3

Central Earth ENGINEERING

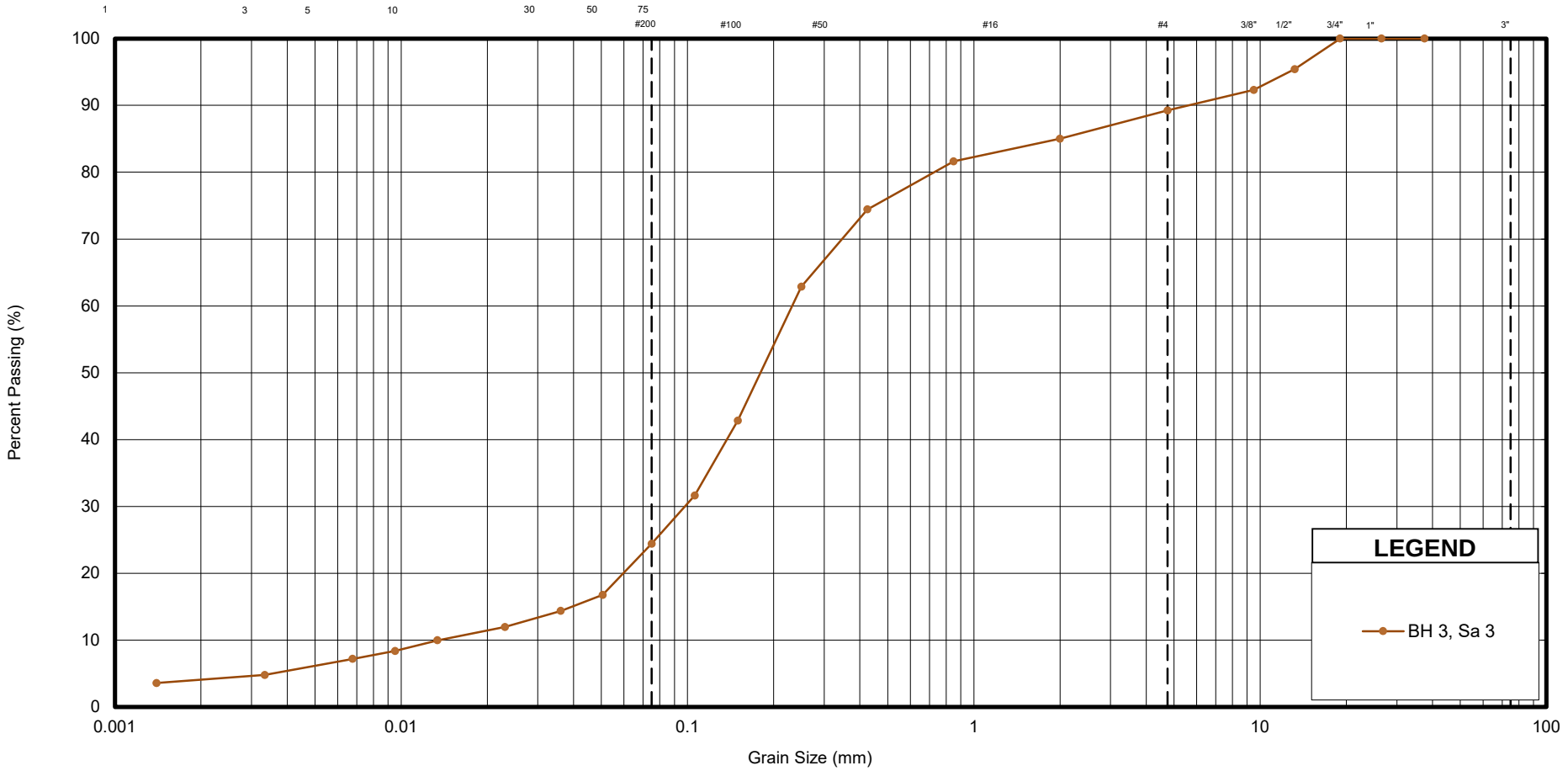
GRAIN SIZE DISTRIBUTION

SILTY SAND GLACIAL TILL

FIGURE No.	B1
REF. No.	19-1243A
DATE	January 2020

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
BH 3, Sa 3	EARTH FILL: Silty Sand, Some Gravel, Trace Clay	11	65	20	4	0.013	0.098	0.23	17.2	3.1

Central Earth ENGINEERING

GRAIN SIZE DISTRIBUTION

EARTH FILL

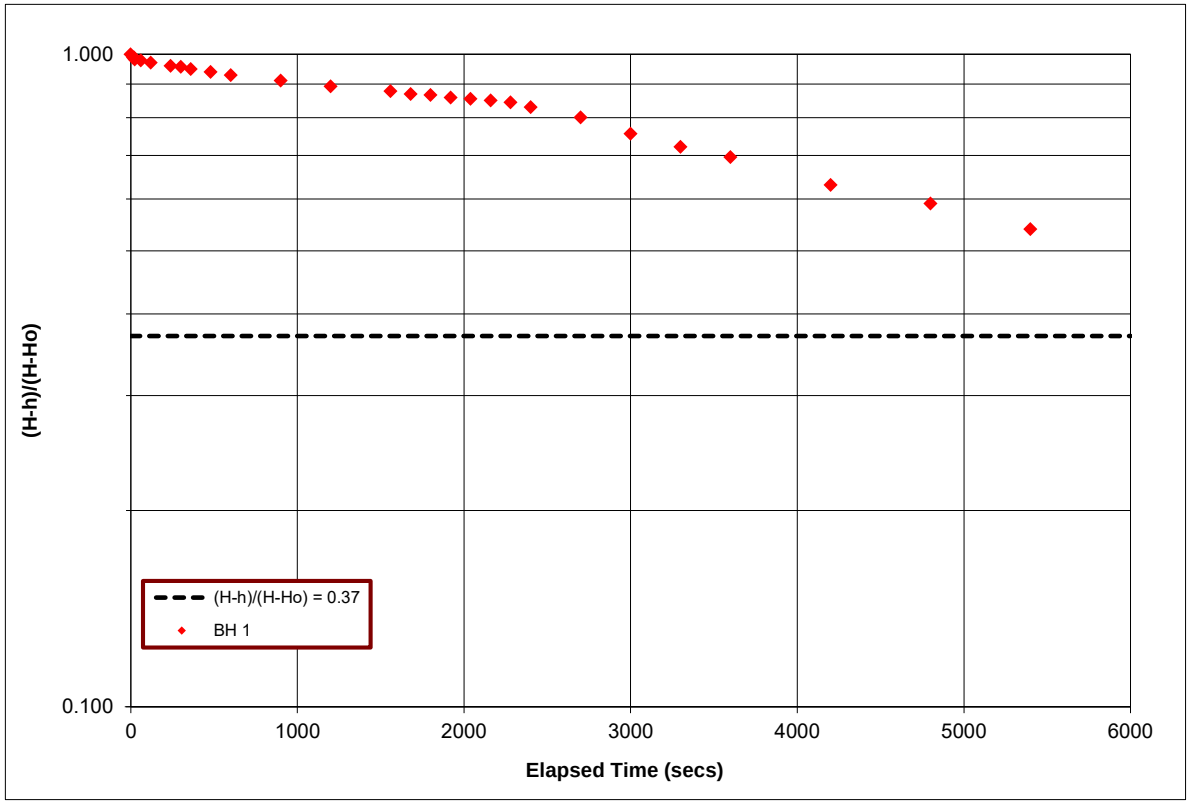
FIGURE No.	B2
REF. No.	19-1243A
DATE	January 2020

Appendix C –

RISING HEAD TEST DATA

Recovery Testing - Hvorslev Method (1951)

Time	Elapsed Time (mins)	Elapsed Time (sec)	BH 1 Water Level (m)	H-h	(H-h)/(H-Ho)
			5.300		
	0.00	0	8.06	2.760	1.000
	0.25	15	8.03	2.730	0.989
	0.33	20	8.03	2.730	0.989
	0.42	25	8.01	2.710	0.982
	1.00	60	8.00	2.700	0.978
	2.00	120	7.980	2.680	0.971
	4.00	240	7.950	2.650	0.960
	5.00	300	7.940	2.640	0.957
	6.00	360	7.920	2.620	0.949
	8.00	480	7.895	2.595	0.940
	10.00	600	7.865	2.565	0.929
	15.00	900	7.815	2.515	0.911
	20.00	1200	7.765	2.465	0.893
	26.00	1560	7.725	2.425	0.879
	28.00	1680	7.700	2.400	0.870
	30.00	1800	7.690	2.390	0.866
	32.00	1920	7.670	2.370	0.859
	34.00	2040	7.660	2.360	0.855
	36.00	2160	7.645	2.345	0.850
	38.00	2280	7.630	2.330	0.844
	40.00	2400	7.590	2.290	0.830
	45.00	2700	7.510	2.210	0.801
	50.00	3000	7.385	2.085	0.755
	55.00	3300	7.290	1.990	0.721
	60.00	3600	7.220	1.920	0.696
	70.00	4200	7.040	1.740	0.630
	80.00	4800	6.93	1.630	0.591
	90.00	5400	6.79	1.490	0.540



K = Hydraulic Conductivity
r = radius of well casing
R = Radius of well screen or filter pack
L = Length of the well screen (in Slug Test) or the length of submerged portion of the well screen (in Rising Head)
T_0 = time for water level to rise or fall to 37% of the initial change

Notes:
1 - All water levels are in metres from ground surface
1 - R is radius of sand pack
2 - T_o is determined from plots where (H-h)/(H-Ho) = 0.37
3 - Analysis based off of Horslev (1951)

r (m) =	0.025	
L (m) =	1.5	
R (m) =	0.05	
T_o (sec) =	8,000	(Extrapolated)
K (m/s) =	**9E-08**	

Central Earth ENGINEERING

RISING HEAD TEST - BOREHOLE 1

APPENDIX:	C
REF. No.:	19-1243A
DATE:	January 2020

Appendix D –

MECP Well Records

Well ID	Date Installed	Well Use	Depth to Top of Screen	Water Level	Stratigraphy Summary
5701453	03-Aug-67	Unknown	Unknown	4.0 m	0 to 2.4 m - Sand 2.4 to 6.7 m - Clay 6.7 to 7.6 m - Gravel
5701455	05-Jun-67	Farming	39.6 m	19.8 m	0 to 20.4 m - Sand 20.4 to 28.0 m - Clay 28.0 to 31.3 m - Gravel and Sand 31.3 to 39.0 m - Fine Sand 39.0 to 40.5 m - Coarse Sand
5711980	02-Aug-74	Municipal Observation Well	Unknown	86.9 m	0 to 28.7 m - Clay 28.7 to 39.9 - Sand 39.9 to 86.9 m - Clay 86.9 to 94.5 m - Sands 94.5 to 97.9 m - Clay 97.9 to 98.8 m - Sand 98.8 to 100.6 m - Clay
7158673	06-Jan-11	Well Abandnment Record	n/a	n/a	n/a
7272826	12-Sep-16	Monitoring Well	3.1 m	Unknown	0 to 4.6 m - Sand

UTM 17Z 606384E
5R 4911097N
Elev. 5R 0835

57 No. 1453

The Ontario Water Resources Commission Act

WATER WELL RECORD

Basin 22
County or District Simcoe
Township, Village, Town or City Innisfil
Con. 12 Lot 10
Date completed 3 (day) Aug (month) 1967 (year)
Owner [redacted]
Address RR#5 Barrie

Casing and Screen Record

Inside diameter of casing 30
Total length of casing 25'
Type of screen tiled Well
Length of screen
Depth to top of screen
Diameter of finished hole 30

Pumping Test

Static level 13
Test-pumping rate 2 G.P.M.
Pumping level
Duration of test pumping
Water clear or cloudy at end of test clear.
Recommended pumping rate 2. G.P.M.
with pump setting of 23 feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Water Record: Depth(s) at which water(s) found	Water Record: Kind of water (fresh, salty, sulphur)
Sand	0	8		
Brown clay	8	15'	13	Fresh.
Grey clay	15'	22		
Gravel	22	25'		

For what purpose(s) is the water to be used?

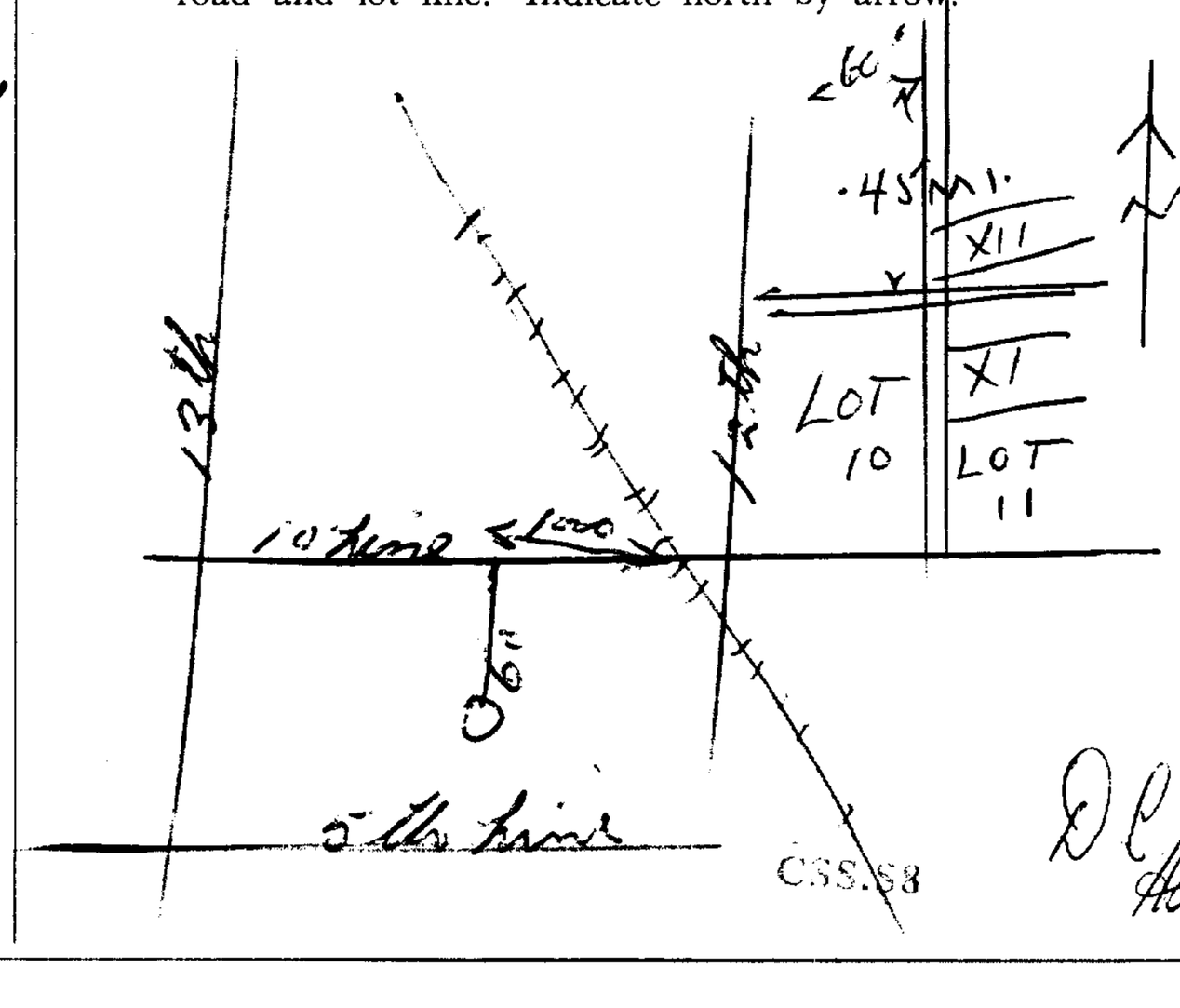
Is well on upland, in valley, or on hillside? upland
Drilling or Boring Firm Roch Well Digging
Address RR#5 Barrie
Licence Number 116
Name of Driller or Borer B. Roch
Address Same
Date
B Roch.
(Signature of Licensed Drilling or Boring Contractor)

Form 7 15M-60-4138

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



SB

UTM 17Z 6016613E

15R 491171 9N

Elev. 15R 0850

Basin 22

WATER WELL RECORD

The Ontario Water Resources Commission Act

WATER RESOURCES DIVISION
AUG 29 1967
ONTARIO WATER RESOURCES COMMISSION
No. 1465

B

County or District SIMCOE Township, Village, Town or City INNISFIL

Con. 12 Lot 11 Date completed 5 (day) — 6 (month) — 67 (year)

Owner [redacted] Address RR #4 BARRIE ONT

Casing and Screen Record

Inside diameter of casing 6¼

Total length of casing 133 ft.

Type of screen Johnson S.S. Slot 25.

Length of screen 3 ft.

Depth to top of screen 130 ft.

Diameter of finished hole 6¼

Pumping Test

Static level 65 ft.

Test-pumping rate 10 G.P.M.

Pumping level 125

Duration of test pumping 3 hrs

Water clear or cloudy at end of test Clear.

Recommended pumping rate 8 G.P.M.

with pump setting of 110 feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Water Record: Depth(s) at which water(s) found	Water Record: Kind of water (fresh, salty, sulphur)
Dug well	0	67		
Sandy clay. Brown.	67	92.		
gravel and sand.	92	102.		
fine sand.	102.	128.		
coarse sand.	128	133.	128-133	fresh.

For what purpose(s) is the water to be used? farm.

Is well on upland, in valley, or on hillside? upland.

Drilling or Boring Firm Henry Hammers Well Drilling Contractor

Address RR. 3. Barrie, Ont.

Licence Number 257C.

Name of Driller or Borer John Vanderheyden.

Address RR#1. Barrie, Ont.

Date June 8/67

Henry Hammers

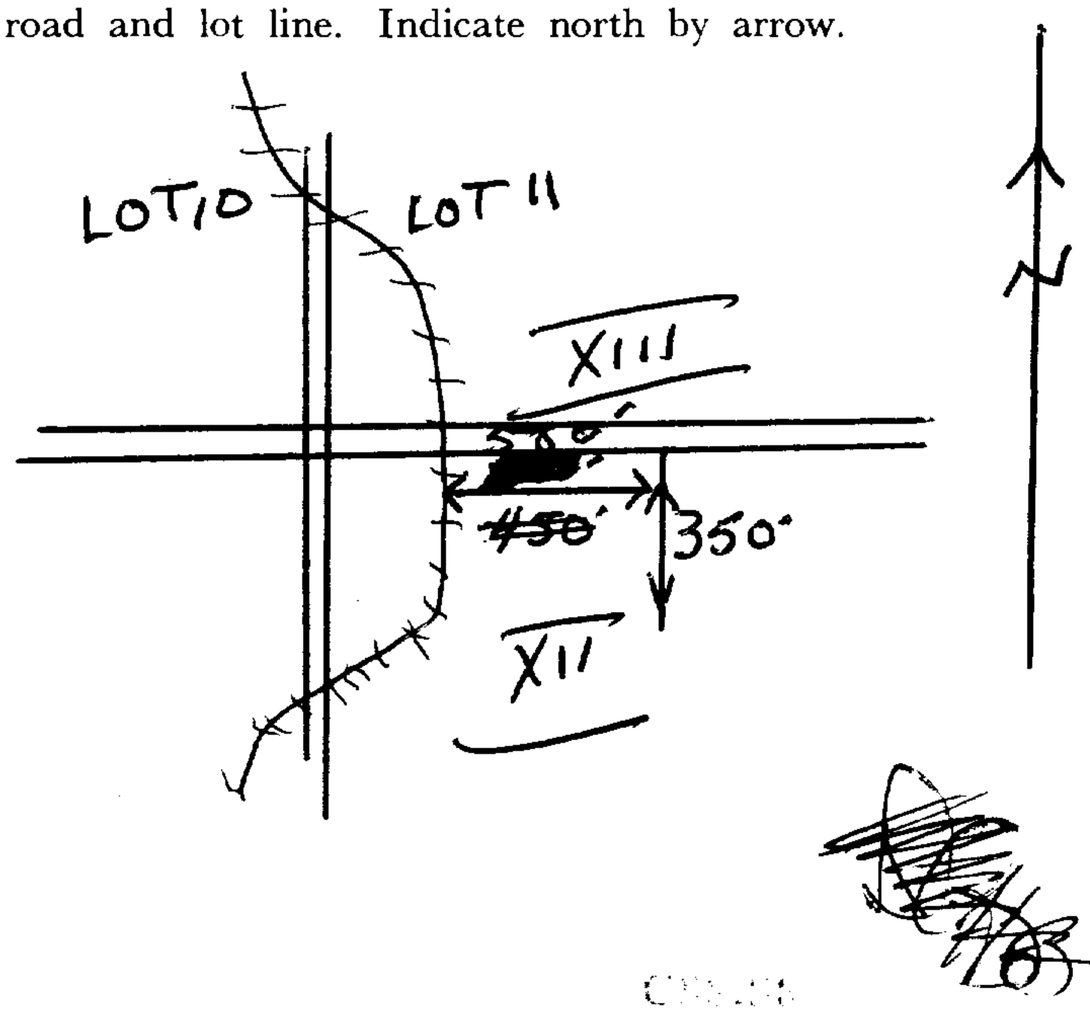
(Signature of Licensed Drilling or Boring Contractor)

Form 7 15M-60-4138

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



MINISTRY OF THE ENVIRONMENT

The Ontario Water Resources Act

WATER WELL RECORD

3105E

Ontario

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11

5711980 | MUNICIP. 57005 | CON. CON | 12

COUNTY OR DISTRICT: Simcoe

TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE: Innisfil

CON., BLOCK, TRACT, SURVEY, ETC.: XII

LOT: 11 + 28 BP

ADDRESS: [redacted]

DATE COMPLETED: DAY 02 MO. 08 YR. 74

21 | UTM ZONE 17 | EASTING 606500 | NORTHING 4910900 | RC. 5 | ELEVATION 0820 | RC. 5 | BASIN CODE 22

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH FROM	DEPTH TO
	clay &	gravel		0	94
	sand		cemented	94	131
	clay &	silt		131	285
	sand		fine	285	290
	sand		medium	290	301
	sand		coarse	301	310
	clay	w/sand layers		310	321
	sand		cemented	321	324
	clay	w/gravel		324	330
		T D 305			

31: 0094 05 11 | 0131 2860 | 0285 0506 | 0290 08 | 0301 09 | 0310 10

32: 0321 05 28 74 | 0324 2860 | 0330 05 11

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
0285	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL — #5
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH FROM	DEPTH TO
02	1 [X] STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE		0	0310
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.): —

DIAMETER: 02 11 INCHES

LENGTH: 21' 1" FEET

MATERIAL AND TYPE: slotted pipe

DEPTH TO TOP OF SCREEN: FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)
310	330	drill cuttings

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☐ PUMP 2 ☐ BAILER — Air

PUMPING RATE: 0037 GPM

DURATION OF PUMPING: 20 HOURS 00 MINS

STATIC LEVEL: 010 FEET

WATER LEVEL END OF PUMPING: 070 FEET

WATER LEVELS DURING: 1 ☐ PUMPING 2 ☒ RECOVERY

15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
10.5 FEET	10.4 FEET	10.45 FEET	10.42 FEET

IF FLOWING, GIVE RATE: — GPM

PUMP INTAKE SET AT: — FEET

WATER AT END OF TEST: 1 ☐ CLEAR 2 ☐ CLOUDY

RECOMMENDED PUMP TYPE: ☐ SHALLOW ☐ DEEP

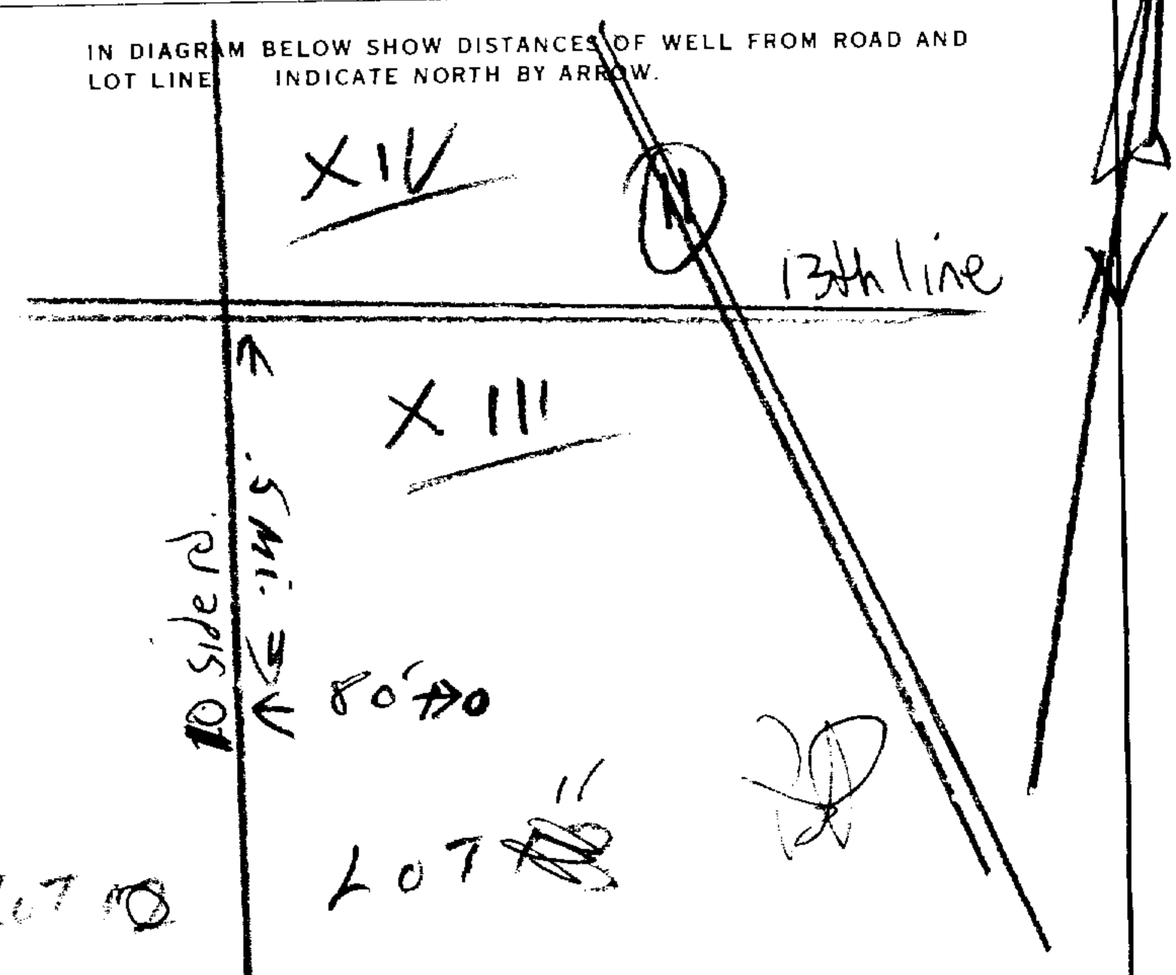
RECOMMENDED PUMP SETTING: — FEET

RECOMMENDED PUMPING RATE: — GPM

— — — . — GPM./FT. SPECIFIC CAPACITY

LOCATION OF WELL 0610

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS:

74 FINAL STATUS OF WELL: 3

1 ☐ WATER SUPPLY; 2 ☒ OBSERVATION WELL; 3 ☒ TEST HOLE; 4 ☐ RECHARGE WELL; 5 ☐ ABANDONED, INSUFFICIENT SUPPLY; 6 ☐ ABANDONED, POOR QUALITY; 7 ☐ UNFINISHED

55-56 WATER USE: 06

1 ☐ DOMESTIC; 2 ☐ STOCK; 3 ☐ IRRIGATION; 4 ☐ INDUSTRIAL; ☐ OTHER; 5 ☐ COMMERCIAL; 6 ☒ MUNICIPAL; 7 ☐ PUBLIC SUPPLY; 8 ☐ COOLING OR AIR CONDITIONING; 9 ☐ NOT USED

57 METHOD OF DRILLING: 2

1 ☐ CABLE TOOL; 2 ☒ ROTARY (CONVENTIONAL); 3 ☐ ROTARY (REVERSE); 4 ☐ ROTARY (AIR); 5 ☐ AIR PERCUSSION; 6 ☐ BORING; 7 ☐ DIAMOND; 8 ☐ JETTING; 9 ☐ DRIVING

CONTRACTOR

NAME OF WELL CONTRACTOR: Snider Drilling, — LICENCE NUMBER: 4816

ADDRESS: CRAIGHURST, Ont.

NAME OF DRILLER OR BORER: David Burton, — LICENCE NUMBER:

SIGNATURE OF CONTRACTOR: Ralph Snider. — SUBMISSION DATE: DAY 20 MO. 03 YR. 75

OFFICE USE ONLY

DATA SOURCE: 1 — CONTRACTOR: 4816 — DATE RECEIVED: 200375

DATE OF INSPECTION: May 14/76 — INSPECTOR: J.B.

REMARKS: TEST WELL # 2-74

P BP

WI

FORM 7 07-091

MINISTRY OF THE ENVIRONMENT COPY

80'E

Ontario Ministry of the Environment

Measurements recorded in: ☐ Metric ☐ Imperial

Well Tag No. (A) A 082330

A082330

Well Record

Regulation 903 Ontario Water Resources Act

Page 1 of 3

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	☐ Well Constructed by Well Owner
LES	BERTRAM & SONS		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
500 Huronia Rd.	Barrie	Ont	L4N9H4	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
500 Huronia Rd.	Barrie		

County/District/Municipality	City/Town/Village	Province	Postal Code
Simcoe	Barrie	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 8 3		606445	4911259		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
			abandonment of bored well - 24'		

Annular Space

Depth Set at (m/ft) From	Depth Set at (m/ft) To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
24'	22'	clean sand	
22'	16'	Bentonite	14 bags
16'	to surface	clean sand	

Method of Construction

☐ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Boring ☐ Digging ☐ Air percussion ☐ Other, *specify* _____

Well Use

☐ Public ☐ Commercial ☐ Not used ☐ Domestic ☐ Municipal ☐ Dewatering ☐ Livestock ☐ Test Hole ☐ Monitoring ☐ Irrigation ☐ Cooling & Air Conditioning ☐ Industrial ☐ Other, *specify* _____

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	Depth (m/ft) To

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) To

Status of Well

☐ Water Supply ☐ Replacement Well ☐ Test Hole ☐ Recharge Well ☐ Dewatering Well ☐ Observation and/or Monitoring Hole ☐ Alteration (Construction) ☐ Abandoned, Insufficient Supply ☐ Abandoned, Poor Water Quality ☒ Abandoned, other, *specify* ☐ Other, *specify*

Water Details

Water found at Depth (m/ft)	Gas	Kind of Water: Fresh	Untested	Other, specify

Hole Diameter

Depth (m/ft) From	Depth (m/ft) To	Diameter (cm/in)

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, *specify*

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping _____ hrs + _____ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min-/ GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

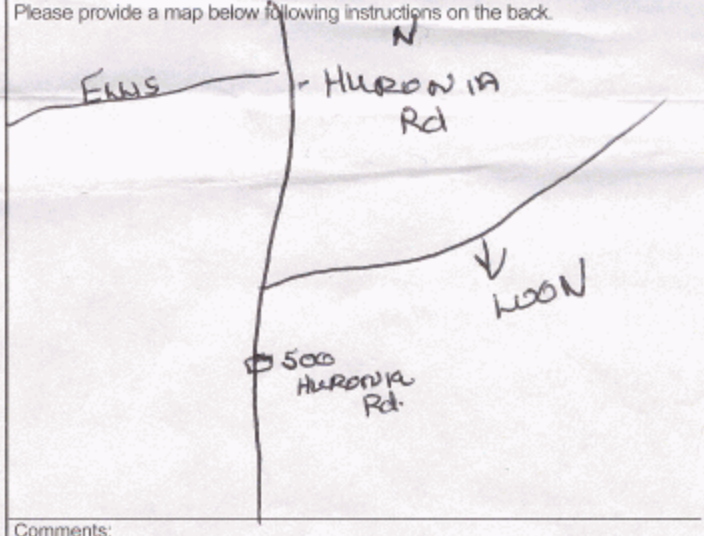
Well production (l/min / GPM)

Disinfected? ☐ Yes ☐ No

	Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level				
1			1	
2			2	
3			3	
4			4	
5			5	
10			10	
15			15	
20			20	
25			25	
30			30	
40			40	
50			50	
60			60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Buer Buker Drilling Ltd	1467

Business Address (Street Number/Name)	Municipality
3396 Penetanguishene Rd	Barrie

Province	Postal Code	Business E-mail Address
Ont	L4M4G8	buker@lock.ca

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
7057283819	Brian Buker

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
T226	Brian Buker	2011/01/06

Well owner's information package delivered ☐ Yes ☐ No

Date Package Delivered: Y Y Y Y M M D D

Date Work Completed: 2010 M M D D

Ministry Use Only

Audit No. Z 94549

FEB 02 2011 Received

0506E (12/2007)

Ministry's Copy

Well ID

Well ID Number: 7272826
Well Audit Number: *Z238664*
Well Tag Number: *A156794*

This table contains information from the original well record and any subsequent updates.

Well Location

Address of Well Location	
Township	BARRIE CITY (INNISFIL)
Lot	
Concession	
County/District/Municipality	SIMCOE
City/Town/Village	
Province	ON
Postal Code	n/a
UTM Coordinates	NAD83 — Zone 17 Easting: 606420.00 Northing: 4911700.00
Municipal Plan and Sublot Number	
Other	

Overburden and Bedrock Materials Interval

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
BRWN	SAND	SILT		0 ft	15 ft

Annular Space/Abandonment Sealing Record

Depth From	Depth To	Type of Sealant Used (Material and Type)	Volume Placed
0 ft	5 ft	BENTONITE	
5 ft	15 ft	SAND	

Method of Construction & Well Use

Method of Construction	Well Use
Rotary (Convent.)	
	Monitoring

Status of Well

Observation Wells

Construction Record - Casing

Inside Diameter	Open Hole or material	Depth From	Depth To
.75 inch	PLASTIC	0 ft	5 ft

Construction Record - Screen

Outside Diameter	Material	Depth From	Depth To
.75 inch	PLASTIC	10 ft	15 ft

Well Contractor and Well Technician Information

Well Contractor's Licence Number: 7190

Results of Well Yield Testing

After test of well yield, water was	
If pumping discontinued, give reason	
Pump intake set at	
Pumping Rate	
Duration of Pumping	
Final water level	
If flowing give rate	
Recommended pump depth	
Recommended pump rate	
Well Production	
Disinfected?	N

Draw Down & Recovery

Draw Down Time(min)	Draw Down Water level	Recovery Time(min)	Recovery Water level
SWL			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	

15	15
20	20
25	25
30	30
40	40
45	45
50	50
60	60

Water Details

Water Found at Depth	Kind
	Untested

Hole Diameter

Depth From	Depth To	Diameter
0 ft	15 ft	6 inch

Audit Number: Z238664

Date Well Completed: September 12, 2016

Date Well Record Received by MOE: October 11, 2016

Appendix E –

WATER BALANCE ANALYSIS

19-1243A - 441 Huronia Road Water Balance Analysis

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	-6.6	-2.1	5.6	12.3	17.9	20.8	19.7	15.3	8.7	2.7	-3.5	6.9
	Heat Index: i=(T/5)$^{1.514}$	0.00	0.00	0.00	1.19	3.91	6.90	8.66	7.97	5.44	2.31	0.39	0.00	36.8
	Unadjusted Daily Potential Evapotranspiration: U (mm)	0.0	0.0	0.0	25.2	59.0	88.5	104.1	98.1	74.7	40.6	11.5	0.0	501.7
	Adjusting Factor for U (Latitude 44^{o})	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.20	1.04	0.95	0.81	0.77	-
	Adjusted Potential Evapotranspiration - PET (mm)	0.0	0.0	0.0	28.2	74.3	113.3	134.3	117.8	77.7	38.6	9.3	0.0	593.4
Pervious Components	Precipitation: P (mm)	82.5	61.8	58.1	62.2	82.4	84.8	77.2	89.9	94.0	77.5	88.9	73.6	932.9
	Adjusted Potential Evapotranspiration: PET (mm)	0.0	0.0	0.0	28.2	74.3	113.3	134.3	117.8	77.7	38.6	9.3	0.0	593.4
	P - PET	82.5	61.8	58.1	34.0	8.1	-28.5	-57.1	-27.9	16.3	38.9	79.6	73.6	339.5
	Change in Soil Moisture Storage (mm)	0.0	0.0	0.0	0.0	0.0	-28.5	-57.1	-27.9	16.3	38.9	0.0	0.0	-
	Water Holding Capacity (max. 75 mm)	75.0	75.0	75.0	75.0	75.0	46.5	0.0	0.0	16.3	55.3	75.0	75.0	-
	Water Surplus Available for Infiltration or Runoff	82.5	61.8	58.1	34.0	8.1	0.0	0.0	0.0	0.0	0.0	59.9	73.6	377.9
	Potential Infiltration based on MOECC Infiltration Factor (mm)	66.0	49.4	46.5	27.2	6.4	0.0	0.0	0.0	0.0	0.0	47.9	58.9	302.3
	Potential Surface Water Runoff (mm)	16.5	12.4	11.6	6.8	1.6	0.0	0.0	0.0	0.0	0.0	12.0	14.7	75.6
Impervious Components	Precipitation: P (mm)	-												932.9
	Potential Evaporation: PE (mm), Assume 15%	-												139.9
	Potential Surface Water Runoff: P - PE (mm)	-												793.0

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 Change Pre to Post**
Existing Land Use (Pre-Development)	Pervious Area	5131.0	100%	5131.0	387.8	1551.2	859%
	Impervious Area		0%	0.0	0.0	0.0	**% Infiltration Change Pre to Post**
	TOTAL	-	100%	5131.0	387.8	1551.2	20%
Proposed Land Use (Post-Development)	Pervious Area	5131.0	20%	1026.2	77.6	310.2	**Infiltration Required to Meet Pre-Development Conditions (m^3)**
	Impervious Area (Estimated from *"Huronia Road Development"*)		80%	4104.8	3255.0	0.0	
	TOTAL	-	100%	5131.0	3332.5	310.2	1241

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 (75mm)
3. Water Holding Capacity & Infiltration Factors taken from Table 3.1 of MOE SWMPDM, 2003
4. Average Temperature and Preciptation taken from Barrie WPCC 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 F –

GROUNDWATER CHEMISTRY CERTIFICATES OF ANALYSIS

CADUCEON™ ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G85593

REPORT No. B19-41122 (i)

Rev. 1

Report To:

Central Earth Engineering Inc
647 Welham Rd, Unit 14,
Barrie ON L4N 0B7 Canada
Attention: Alex Winkelmann

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

DATE RECEIVED: 23-Dec-19
DATE REPORTED: 08-Jan-20
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 441 Huronia Road
P.O. NUMBER: 19-1243A
WATERWORKS NO.

Parameter	Qty	Site Analyzed	Analyst Initials	Date Analyzed	Lab Method	Reference Method
Alkalinity (as CaCO3)	2	Holly Lane	VK	27-Dec-19	A-ALK-03 (o)	SM 2320B
Cyanide	2	Kingston	US	27-Dec-19	A-CN-001 (k)	SM 4500CN
Colour	2	Holly Lane	ST	30-Dec-19	A-COL-01 (o)	SM 2120C
Conductivity	2	Holly Lane	VK	27-Dec-19	A-COND-02 (o)	SM 2510B
Anions	2	Holly Lane	LMG	31-Dec-19	A-IC-01 (o)	SM4110C
Nitrogen - Ammonia (N)	2	Kingston	SHU	27-Dec-19	A-NH3-001 (k)	SM4500-NH3-H
o-Phosphorus (P)	2	Kingston	SHU	27-Dec-19	A-o-PO4 K	PE4500-S
pH	2	Holly Lane	VK	27-Dec-19	A-PH-01 (o)	SM 4500H
Turbidity	2	Holly Lane	ST	30-Dec-19	A-TURB-01 (o)	SM 2130
Chromium (VI)	2	Holly Lane	LMG	03-Jan-20	D-CRVI-01 (o)	MOE E3056
Mercury	2	Holly Lane	PBK	03-Jan-20	D-HG-02 (o)	SM 3112 B
Metals - ICP-OES	2	Holly Lane	AHM	02-Jan-20	D-ICP-01 (o)	SM 3120
Metals - ICP-MS	2	Holly Lane	TPR	30-Dec-19	D-ICPMS-01 (o)	EPA 200.8
Calculation	2	Holly Lane	JGC	03-Jan-20	D-Ion Balance	Calc.

PWQO - Provincial Water Quality Objectives
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

CADUCEON™ ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G85593

REPORT No. B19-41122 (i)

Rev. 1

Report To:

Central Earth Engineering Inc
647 Welham Rd, Unit 14,
Barrie ON L4N 0B7 Canada
Attention: Alex Winkelmann

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

DATE RECEIVED: 23-Dec-19
DATE REPORTED: 08-Jan-20
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 441 Huronia Road
P.O. NUMBER: 19-1243A
WATERWORKS NO.

	Client I.D.		MW BH 1 (filtered)	MW BH 1 (unfiltered)			PWQO	
	Sample I.D.		B19-41122-1	B19-41122-2			PWQO	
	Date Collected		19-Dec-19	19-Dec-19				
Parameter	**Units**	**R.L.**						
pH @25°C	pH Units		7.73	7.71			8.5	
Conductivity @25°C	µmho/cm	1	1100	1110				
Alkalinity(CaCO3) to pH4.5	mg/L	5	365	358				
Hardness (as CaCO3)	mg/L	1	585	1440				
Cyanide (Free)	µg/L	5	< 5	< 5			5	
Chloride	mg/L	0.5	127	131				
Fluoride	mg/L	0.1	< 0.1	< 0.1				
Nitrite (N)	mg/L	0.1	< 0.1	< 0.1				
Nitrate (N)	mg/L	0.1	4.7	4.7				
Sulphate	mg/L	1	18	18				
Colour	TCU	2	< 2	< 2				
Turbidity	NTU	0.1	4.4	1470				
Ammonia (N)-Total	mg/L	0.01	0.01	0.05				
o-Phosphate (P)	mg/L	0.002	0.010	0.014				
Calcium	µg/L	20	187000	501000				
Magnesium	µg/L	20	28600	46100				
Potassium	µg/L	100	3100	3300				
Sodium	µg/L	200	56000	57400				
Antimony	µg/L	0.1	0.1	0.1			20	
Arsenic	µg/L	0.1	0.5	1.5			5	
Barium	µg/L	1	109	241				
Beryllium	µg/L	0.1	< 0.1	0.3			11	
Boron	µg/L	5	37	37			200	

PWQO - Provincial Water Quality Objectives
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

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G85593

REPORT No. B19-41122 (i)

Rev. 1

Report To:

Central Earth Engineering Inc
647 Welham Rd, Unit 14,
Barrie ON L4N 0B7 Canada
Attention: Alex Winkelmann

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

DATE RECEIVED: 23-Dec-19
DATE REPORTED: 08-Jan-20
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 441 Huronia Road
P.O. NUMBER: 19-1243A
WATERWORKS NO.

	Client I.D.		MW BH 1 (filtered)	MW BH 1 (unfiltered)			PWQO	
	Sample I.D.		B19-41122-1	B19-41122-2			PWQO	
	Date Collected		19-Dec-19	19-Dec-19				
Parameter	**Units**	**R.L.**						
Cadmium	µg/L	0.015	0.027	**0.137**			0.1	
Chromium	µg/L	2	< 2	2				
Chromium (VI)	µg/L	1	< 1	< 1			1	
Cobalt	µg/L	0.1	**1.8**	**6.0**			0.9	
Copper	µg/L	2	**11**	**7**			5	
Iron	µg/L	5	**1200** 3	**1840** 3			300	
Lead	µg/L	0.02	**1.24**	**4.38**			1	
Mercury	µg/L	0.02	< 0.02	< 0.02			0.2	
Manganese	µg/L	1	198	930				
Molybdenum	µg/L	0.1	0.5	0.3			40	
Nickel	µg/L	0.2	3.2	5.9			25	
Selenium	µg/L	1	< 1	< 1			100	
Silver	µg/L	0.1	< 0.1	< 0.1			0.1	
Thallium	µg/L	0.05	< 0.05	< 0.05			0.3	
Uranium	µg/L	0.05	0.48	0.66			5	
Vanadium	µg/L	0.1	1.9	4.7			6	
Zinc	µg/L	5	5	**24**			20	
Anion Sum	meq/L		11.6	11.6				
Cation Sum	meq/L		14.3	31.5				
% Difference	%		10.4 1	46.4 2				
Ion Ratio	AS/CS		0.812	0.367				
Sodium Adsorption Ratio	-		1.01	0.658				
TDS(ion sum calc.)	mg/L	1	661	995				
Conductivity (calc.)	µmho/cm		1215	1927				

PWQO - Provincial Water Quality Objectives
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

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G85593

REPORT No. B19-41122 (i)

Rev. 1

Report To:

Central Earth Engineering Inc
647 Welham Rd, Unit 14,
Barrie ON L4N 0B7 Canada
Attention: Alex Winkelmann

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

DATE RECEIVED: 23-Dec-19
DATE REPORTED: 08-Jan-20
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 441 Huronia Road
P.O. NUMBER: 19-1243A
WATERWORKS NO.

	Client I.D.		MW BH 1 (filtered)	MW BH 1 (unfiltered)			PWQO	
	Sample I.D.		B19-41122-1	B19-41122-2			PWQO	
	Date Collected		19-Dec-19	19-Dec-19				
Parameter	**Units**	**R.L.**						
TDS(calc.)/EC(actual)	-		0.599	0.897				
EC(calc.)/EC(actual)	-		1.10	1.74				
Langelier Index(25°C)	S.I.		1.09	1.46				

1 . Outside of 10% Acceptance Criteria
2 . Outside of 10% Acceptance Criteria, solids present
3 . Sediment present
4 . Revised report to correct project name and number as per client request

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

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
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G85593

REPORT No. B19-41122 (i)

Rev. 1

Report To:

Central Earth Engineering Inc
647 Welham Rd, Unit 14,
Barrie ON L4N 0B7 Canada
Attention: Alex Winkelmann

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

DATE RECEIVED: 23-Dec-19
DATE REPORTED: 08-Jan-20
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 441 Huronia Road
P.O. NUMBER: 19-1243A
WATERWORKS NO.

Summary of Exceedances

Provincial Water Quality Objectives

MW BH 1 (filtered)	Found Value	Limit
Lead (µg/L)	1.24	1
Iron (µg/L)	1200	300
Copper (µg/L)	11	5
Cobalt (µg/L)	1.8	0.9
MW BH 1 (unfiltered)	Found Value	Limit
Zinc (µg/L)	24	20
Lead (µg/L)	4.38	1
Iron (µg/L)	1840	300
Copper (µg/L)	7	5
Cobalt (µg/L)	6.0	0.9
Cadmium (µg/L)	0.137	0.1

PWQO - Provincial Water Quality Objectives
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

CADUCEON™ ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G85593

REPORT No. B19-41122 (ii)

Rev. 1

Report To:

Central Earth Engineering Inc
647 Welham Rd, Unit 14,
Barrie ON L4N 0B7 Canada
Attention: Alex Winkelmann

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

DATE RECEIVED: 23-Dec-19
DATE REPORTED: 08-Jan-20
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 441 Huronia Road
P.O. NUMBER: 19-1243A
WATERWORKS NO.

Parameter	Qty	Site Analyzed	Analyst Initials	Date Analyzed	Lab Method	Reference Method
PHC(F2-F4)	2	Kingston	KPR	30-Dec-19	C-PHC-W-001 (k)	MOE E3421
VOC's	2	Richmond Hill	JE	27-Dec-19	C-VOC-02 (rh)	EPA 8260
PHC(F1)	2	Richmond Hill	JE	27-Dec-19	C-VPHW-01 (rh)	MOE E3421

PWQO - Provincial Water Quality Objectives
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

CADUCEON™ ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G85593

REPORT No. B19-41122 (ii)

Rev. 1

Report To:

Central Earth Engineering Inc
647 Welham Rd, Unit 14,
Barrie ON L4N 0B7 Canada
Attention: Alex Winkelmann

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

DATE RECEIVED: 23-Dec-19
DATE REPORTED: 08-Jan-20
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 441 Huronia Road
P.O. NUMBER: 19-1243A
WATERWORKS NO.

	Client I.D.		MW BH 1 (filtered)	MW BH 1 (unfiltered)			PWQO	
	Sample I.D.		B19-41122-1	B19-41122-2			PWQO	
	Date Collected		19-Dec-19	19-Dec-19				
Parameter	**Units**	**R.L.**						
Benzene	µg/L	0.5	< 0.5	< 0.5			100	
Toluene	µg/L	0.5	< 0.5	< 0.5			0.8	
Ethylbenzene	µg/L	0.5	< 0.5	< 0.5			8	
Xylene, m,p-	µg/L	1.0	< 1.0	< 1.0				
Xylene, o-	µg/L	0.5	< 0.5	< 0.5			40	
Xylene, m,p,o-	µg/L	1.1	< 1.1	< 1.1				
PHC F1 (C6-C10)	µg/L	50	< 50	< 50				
PHC F2 (>C10-C16)	µg/L	50	< 50	< 50				
PHC F3 (>C16-C34)	µg/L	400	< 400	< 400				
PHC F4 (>C34-C50)	µg/L	400	< 400	< 400				

1 . Revised report to correct project name and number as per client request

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

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
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G85593

REPORT No. B19-41122 (ii)

Rev. 1

Report To:

Central Earth Engineering Inc
647 Welham Rd, Unit 14,
Barrie ON L4N 0B7 Canada
Attention: Alex Winkelmann

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

DATE RECEIVED: 23-Dec-19
DATE REPORTED: 08-Jan-20
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: 441 Huronia Road
P.O. NUMBER: 19-1243A
WATERWORKS NO.

Summary of Exceedances

PWQO - Provincial Water Quality Objectives
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