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Hydrogeological Investigation, Water Balance and Catchment-Based Water Balance

7370 Centre Road, Uxbridge, Ontario

Preliminary Report

Prepared For:

Bridge Brook Corporation

Prepared By:

Beacon Environmental Limited

Date:	*Project:*
March 2021	**217431.2**

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1. Introduction

This report includes the preliminary findings of the hydrogeological investigation, water balance and catchment-based water balance assessments undertaken by Beacon Environmental Limited (Beacon) for the property located at 7370 Centre Road, Uxbridge, Ontario (hereafter referred to as the “subject property”).

The purpose of this hydrogeological investigation, water balance and catchment-based water balance assessment is to provide further information regarding the proposed development of the subject property.

This report is preliminary and based on information collected between December of 2017 and August 2020. A revised report will be forthcoming which includes hydrochemical analyses for the purposes of dewatering discharge plans, as well as water balance components to be based on provided Site Plans.

2. Site and Area Physical Context

The subject property is approximately 40.3 hectares (approximately 403,000 m^2) in area. As shown on **Figure 1**, the subject property is generally rectangular in shape, and is bounded to the east and west by Centre Road and Concession Road 6, respectively, and located north of Bolton Drive in Uxbridge, Ontario.

The subject property is currently occupied by agricultural farm fields, with untilled areas at the south-east and northeast corners.

2.1 Topography and Drainage Context

Surface

The subject property is situated within the jurisdiction of the Lake Simcoe Region Conservation Authority (LSRCA) and the Lake Simcoe and Couchiching/Black River Source Protection Area (SPA) in the City of Uxbridge. The subject property is located within the Severn-Lake Simcoe Quaternary Watershed (02EC-04).

The subject property is located within the *Protected Countryside – Towns and Villages* lands of the *Greenbelt Plan* area, and is therefore, subject to the corresponding policies of the *Greenbelt Plan* as well as the Regional Municipality of Durham and Township of Uxbridge Official Plans and Lake Simcoe Region Conservation Authority (LSRCA) regulations. A tributary of Uxbridge Brook traverses the southeast corner of the subject property.

The topography of the subject property is summarized as highest in the west, with a general gradient downward towards the east. Topographic elevations for the subject property range from approximately 330 metres above sea level (masl) to approximately 280 masl. The subject property is drained by sheet overflow to the wetlands and a portion of Uxbridge Brook, located in the east of the property.

Subsurface

Ministry of the Environment, Conservation and Parks (MECP) mapping indicates that the subject property is located within a Wellhead Protection Area for quantity (WHPA-Q2; Stress = moderate) and Intake Protection Zone (Score = 4.5). Parts of the subject property are situated over Highly Vulnerable Aquifers, and significant groundwater recharge areas (Score = 2).

MW6 Uxbridge Well Supply (220000763) lies approximately 1.2 km to the south of the subject property. The closest extent of the Wellhead Protection Area (WHPA-D) lies approximately 1.2 km south of the subject property.

A reconnaissance of the subject property was carried out by a certified Hydrogeologist on August 22, 2019. Within the subject property, no obvious groundwater-dependent features or seepage areas were observed at that time. It is understood that there are four Headwater Drainage Features, as defined in the EIS report (Beacon 2020).

2.2 Physiography and Geology

The subject property is located on drumlinized Till Plains (MRD228), in an areas dominated by glaciolacustrine, glacial outwash, and till deposits (OGS, 2000) adjacent to sandplains in the east. Coarse-textured glaciolacustrine deposits, characterized by sand, gravel and minor silt and clay are reported on the east and west parts of the subject property, bisected by a deposit of stone-poor sandy silt to silty sand textured till (in the general area of BH3, BH4, and BH8 described in the methodology below; MRD128).

The bedrock beneath the described overburden is reported to be composed of limestone, dolostone and shale (MRD126 2011). Bedrock units were not encountered during this investigation or during the drilling operations required to install the groundwater monitoring wells.

2.3 Available Background Groundwater Information

Based on a search of the available MECP water well record database entries, nine wells are reported on the subject property, designated 7304950, 7304143/7304142, 7304144, 7304138, 7304141, 7304145, 7304140/7304139. These wells appear to represent the groundwater monitoring wells constructed as part of the SoilEng geotechnical investigation. Three other wells, designated ID-1910316 and ID-1916323, appear to be drilled for the purposes of fresh drinking water between 2002 and 1989. The reported locations of the wells are included in **Figure 2**.

A review of the available well records shows that there are 104 reported wells within 500 metres of the subject property (see **Figure 2**). Groundwater monitoring wells purposed for domestic use were constructed between 1962 and 2011. Further information for the 104 wells are provided in **Appendix A**. It is noted that older wells may no longer be operational, and that historically there was not a requirement to register dug wells with the MECP; as such, they can be under-represented in the water well record database.

3. Site Characterization

3.1 Borehole Drilling and Monitoring Well Construction

A geotechnical investigation was carried out Soil Engineers Limited (SoilEng, 2018), which included advancing fifteen boreholes, designated BH1 through BH15. The boreholes reached a maximum depth of approximately 15.7 metres below ground level (mbgl), with most being advanced to approximately 6.6 mbgl. These depths equate to elevations, in lieu of topography, ranging from approximately 272.2 metres above sea level (masl) to approximately 327.0 masl. The locations of these wells are indicated on **Figure 1**.

Review of the SoilEng report (available in **Appendix B**) indicates that the overburden is comprised of alternating layers of silty clay and layers of silty sand. Layers of sand were reported beginning at an elevation of approximately 329 masl at BH5 and BH15, located on the west of the subject property. A layer of sand was also reported at between 321.8 masl and 318.0 masl at location BH13, located in the central north area of the property.

Standard Penetration Tests (SPT N-values) were carried out as part of the SoilEng geotechnical drilling operations. The Log of Borehole reports (**Appendix B**) indicate that soil N-values are generally less than 30 to depths of approximately 3 mbgl. Layers of more compact soils are noted at elevations of 298 masl to 285 masl at locations BH12 and BH6, respectively, and elevations of 319 masl to 310 masl at locations BH13, BH14, and BH9. These more compact areas are not specific to a sedimentary grainsize layer, and are noted because of the implied loss of effective porosity due to compaction.

It is noted that the boundaries between the strata have been inferred from drilling observations carried out by Beacon and others from non-continuous samples. They generally represent a transition from one soil type to another and should not be inferred to represent an exact plane of geological change. Further, conditions will vary between and beyond the boreholes.

Beacon cannot guarantee the accuracy of work carried out by others. Any comment based on work carried out by others is subject to the accuracy of the information supplied to Beacon. Any use of the proposed comments by parties, or any reliance on or decisions to be made based on work not carried out by Beacon is the responsibility of those parties.

3.2 Water Level Monitoring

To date, groundwater depths have been measured manually at all accessible monitoring locations over the course of the monitoring period (December 2017 to August 2020). The recorded water levels reflect the groundwater conditions on the dates they were measured and are provided in **Table 1**.

Table 1. Summary of Groundwater Monitoring Well Conditions

Location ID	**Reported Date of Construction**	**Approximate Location**		**Approximate Ground Surface**	**Reported Screened Interval**	**Soils Reported at Screened Interval**	**Approximate SPT N-Value at Screened Interval**
		Latitude	**Longitude**	**SoilEng, 2018 (Beacon, 2019)** [3]	**mbgl (masl)** [5]		
BH3 [1]	*December 15, 2017*	44.1130°	-79.1416°	*305.0* (304.421)	*2.4 to 6.1* *(302.0 to 298.3)*	*Silty Clay Till*	*37 to 27*
BH6 (S) [2]	- [2]	- [2]	- [2]	(288.078)	- [2]	BOW 7.01 m on March 16, 2020 [2]	- [2]
BH6 (D)	*December 12, 2017*	44.1148°	-79.1378°	*287.9* (288.075)	*11.6 to 15.2* *(276.4 to 272.9)*	*Silty Clay Till*	*42 to 74*
BH7	*December 15, 2017*	*44.1138°*	*-79.1399°*	*297.8* (297.606)	*2.4 to 6.1* *(295.2 to 291.5)*	*Silty Sand Till*	*20 to 48*
BH9 (S) [2]	- [2]	- [2]	- [2]	(323.17)	- [2]	BOW 6.95 m on March 16, 2020 [2]	- [2]
BH9 (D)	*December 20, 2017*	44.1135°	-79.1447°	*321.9* (323.343)	11.6 to 15.2 (311.7 to 308.1)	Silty Clay Till to Silt	68 to 74
BH10	*December 21, 2017*	44.1129°	-79.1474°	*332.6* (332.254)	2.4 to 6.1 (329.8 to 326.1)	Silty Sand Till to Silty Clay Till	18 to >100
BH11	*November 27, 2017*	44.1158°	-79.1380°	*291.4* (289.224)	2.4 to 6.1 (286.8 to 283.1)	Silty Sand Till	35 to >100
BH13	*January 15, 2018*	44.1148°	-79.1448°	322.6 (322.284)	2.4 to 6.1 (319.8 to 316.8)	Sand to Silty Clay Till	62 to >100

Italics – indicates data collected by others (SoilEng, 2018)

BOW – “bottom of well”

[1] BH3 was confirmed destroyed

[2] borehole logs were not provided in the geotechnical report

[3] ground elevations provided by SoilEng.

[4] elevation measurements from survey carried out March 19, 2020.

[5] masl measurements corrected to survey carried out March 19, 2020 using the mbgl measurements in SoilEng, 2018.

Table 2. Summary of Measured Groundwater Levels

Location ID	Approximate Top of Pipe	Approximate Ground Surface Elevation	Groundwater Measurements									
				2018					2019	2020		
			Upon Completion	Jan 31	Mar 22	June19 and July 4	Sept 6	Dec 4	Sept 11	Mar 16	Apr 28	Aug 25
	masl (mbgl)	masl	mbgs (masl)	mbgs (masl) [3]	mbgs (masl) [3]	mbgs (masl) [3]	mbgs (masl) [3]	mbgs (masl) [3]	mbgs (masl)	mbgs (masl)	mbgs (masl)	mbgs (masl)
BH3		(304.421)	302.3	0.4 (304.0)	*0.5* *(303.9)*	*1.1* *(303.3)*	*0.7* *(303.7)*	*0.2* *(304.2)*	confirmed destroyed			
BH6 S	+ 0.83	(288.078)	- [2]	- [2]	*1.2* *(286.8)*	*1.4* *(286.6)*	*1.8* *(286.2)*	*0.9* *(287.2)*	2.44 (285.63)	**0.87** **(287.13)**	1.2 (286.87)	2.49 (285.59)
BH6 D	+0.70	(288.075)	273.0	1.3 (286.7)	*1.4* *(286.6)*	*1.6* *(286.4)*	*2.0* *(286.0)*	*1.1* *(286.9)*	2.81 (285.26)	**0.98** **(287.10)**	1.45 (286.63)	2.80 (285.27)
BH7	+0.80	(297.606)	293.0	0.9 (296.7)	*1.1* *(296.5)*	*2.2* *(295.4)*	*2.5* *(295.1)*	*0.5* *(297.1)*	3.91 (293.70)	**1.04** **(296.56)**	1.71 (295.90)	3.95 (293.65)
BH9 S	+ 0.82	(323.170)	- [2]	- [2]	*1.0* *(322.1)*	*2.1* *(321.0)*	*2.3* *(320.8)*	*0.7* *(322.4)*	3.39 (319.78)	**1.30** **(321.87)**	1.50 (321.67)	3.20 (319.97)
BH9 D	+ 0.82	(323.343)	*307.3*	*7.4* *(315.9)*	*7.5* *(315.8)*	*7.9* *(315.4)*	*8.1* *(315.2)*	*7.4* *(315.9)*	8.9 (314.44)	**7.53** **(315.81)**	7.74 (315.60)	8.92 (314.42)
BH10	+ 0.93	(332.254)	*329.0*	*0.2* *(332.0)*	*0.9* *(331.3)*	*1.7* *(330.5)*	*1.4* *(330.8)*	*0.3* *(331.9)*	2.39 (329.85)	**0.52** **(331.73)**	1.20 (331.05)	2.22 (330.03)
BH11	+ 0.91	(289.224)	290.2	1.1 (288.1)	*1.1* *(288.1)*	*1.4* *(287.8)*	*1.8* *(287.4)*	*0.7* *(286.6)*	2.56 (286.66)	**0.54** **(288.68)**	1.07 (288.15)	2.56 (286.66)
BH13	+ 0.73	(322.284)	319.0	3.5 (318.8)	*3.3* *(319.0)*	*3.2* *(319.0)*	*3.7* *(318.6)*	*3.7* *(317.8)*	4.47 (317.81)	**3.08** **(319.20)**	3.24 (319.04)	4.59 (317.69)

Italics – indicates data collected by others (SoilEng, 2018)

Grey shading - indicates water level measured at the time of drilling completion - water levels measured at the time of completion are not directly comparable to the other measurements.

Bold values – indicates the highest measured groundwater levels

[2] reference to the shallow nested wells were not provided in the geotechnical report (SoilEng, 2018) – water levels are found in the subsequent monitoring program letters.

[3] masl measurements corrected to survey carried out March 19, 2020 using the mbgl measurements in SoilEng, 2018.

As summarized in **Table 2**, groundwater depths ranged from approximately 0.2 mbgs to 8.92 mbgs in relation to the topography. Groundwater elevations were found to range from approximately 332.0 masl to 285.2 masl. Groundwater elevations measured at all locations on a single site visit range from 44.4 m to 45.3 m during the length of this investigation, indicating that groundwater is responsive and connected throughout the site, including freshet periods.

Based on the information above, groundwater appears to reside unconfined within layers of silty clay and silty sand. This layer is generally interpreted to become more compact with depth.

3.3 Hydraulic Testing

3.3.1 Single Well Response Tests ('slug testing' – saturated soils)

To estimate the hydraulic conductivity (K) of the soil materials adjacent to the screened intervals at the tested monitoring wells, a single well response test was carried out at location BH6, BH7 and BH11 on April 28, 2020. The tests were carried out by rapidly removing a volume of water to the well and monitoring the subsequent water level recovery to previous conditions. The Bouwer and Rice (1976) method was applied to falling head test data, using the unconfined solution. The data was analyzed using AQTESOLV™ (v. 4.50). A summary of the single well response tests carried out is presented below in **Table 3**.

Table 3. Hydraulic conductivity estimates at Locations BH6, BH7, and BH11

Location Identification	Description of Soil Materials Adjacent to Screened Interval	Reported SPT N-Value At Screened Interval	Reported Screened Interval	Estimated Hydraulic Conductivity
			mbgl (masl)	K (cm/s)
BH6	Silty Clay Till	42 to 74	11.6 to 15.2 (276.4 to 272.9)	1.4×10^{-4}
BH7	Silty Sand Till	20 to 48	2.4 to 6.1 (295.2 to 291.5)	1.3×10^{-4}
BH11	Silty Sand Till	35 to >100	2.4 to 6.1 (286.8 to 283.1)	9.5×10^{-5}

As summarized in **Table 3**, hydraulic conductivities ranged from approximately 0.9 x 10^{-4} cm/s to 1.4 x 10^{-4} cm/s in the locations tested. These results indicate materials with semi-pervious relative permeability (Bear 1972). Reports for the *in situ* single well response tests are provided in **Appendix C.**

The estimates provided in **Table 3** are based on *in situ* testing. In addition to the size of grains in the soil, *in situ* testing considers compaction, effective porosity (as opposed to simple porosity), and existing sedimentary feature factors. The SPT N-values summarized in **Table 3**, above, are consistent with a till provenance and with specific reference to SPT's greater than 75, introduce hydraulic consideration for till fracturing associated with large nearby construction operations and stratigraphic expansion.

3.3.2 Infiltration Testing (permeameter testing – unsaturated soils)

Soil infiltration rate testing was carried out in unsaturated soils, using a Pask Permeameter instrument. Three permeameter testing locations were tested on April 28, 2020, next to locations BH6, BH7, and BH11. These were designated PT20-1, PT20-2, and PT20-3, respectively. At each of the testing locations, the permeameter was used to measure the steady-state flow rate of gravimetrically-fed water into the select unsaturated soil horizon. Field-saturated hydraulic conductivity, (K_{fs}) was calculated from the measurements using following equation:

$$K_{fs} = \frac{C_1 Q_1}{2\,\pi\,H_1^2 + \,\pi\,a^2\,C_1 + 2\,\pi\,\frac{H_1}{\alpha^*}}$$

Where:
C_1 = shape factor
Q_1 = flow rate (cm^3/s)
H_1 = water column height (cm)
a = well radius (cm)
α^* = alpha factor (0.15 cm^{-1})

(Elrick *et. al*., 1989)

The field measurement data and analysis of the infiltration rate testing are provided in **Appendix C**. Based on the resulting K_{fs} (cm/s), the corresponding infiltration rates (mm/hr) were estimated using the approximate relationship presented in the *Low Impact Development Stormwater Management Planning and Design Guide* (TRCA and CVCA, 2010). A summary of the infiltration rate testing results is presented below in **Table 4**.

Table 4. Summary of Estimated Infiltration Rates

Location ID	Soil Description	Approximate Test Depth	Estimated Field-Saturated Hydraulic Conductivity	Theoretical K_{fs} @ 4°C "freshet"	Theoretical K_{fs} @ 24°C "summer"	Estimated Infiltration Rate[1]	Correction Factor Used	Estimated Design Infiltration Rate[2]
		(mbgl)	K_{fs} (cm/s)	K_{fs} (cm/s)	K_{fs} (cm/s)	(mm/hr)		(mm/hr)
PT20-1 (near BH6)	Brown silty sand, rootlets, moist	0.42	9×10^{-5}	8×10^{-5}	1×10^{-4}	49	2.5	20
PT20-2 (near BH7)	Brown silty sand, rootlets, moist	0.26	4×10^{-5}	3×10^{-5}	6×10^{-5}	42	2.5	17
PT20-3 (near BH11)	Brown silty sand, rootlets, moist	0.62	4×10^{-5}	3×10^{-5}	5×10^{-5}	42	2.5	17

Notes:
mbgl = metres below ground surface
cm/s = centimetres per second
mm/hr = millimetres per hour

[1] – based on Estimated Field-Saturated Conductivity and Table C1 from TRCA and CVCA (2010).

[2] – correction factor in accordance with Table C2 from TRCA and CVCA (2010).

The infiltration rate estimates from this investigation are based on the test methods discussed above, and are for the corresponding native soil types encountered in undisturbed conditions. They represent the soil conditions at the tested locations and depths only; conditions may vary between and beyond the tested locations. Care should be taken during construction of the proposed infiltration measures to preserve the existing soil structure and avoid compaction and re-working which could reduce its infiltrative properties.

For detailed design purposes, a correction factor was applied to estimate the design infiltration rate in accordance with guidance provided in the *Low Impact Development Stormwater Management Planning and Design Guide* (TRCA and CVCA, 2010), to account for potential reductions in soil permeability due to compaction, smearing during the construction of a given infiltration feature and the gradual accumulation of fine sediments over the lifespan of the infiltration feature. Based on the guidance, a correction factor of 2.5 was typically applied to the estimated infiltration rates.

The estimated field saturated hydraulic conductivity values are considered to be reasonable for the soil types tested. Based on these estimates and the guidance described above, the silty sand soils have a design infiltration rate of approximately 17 mm/hr to 20 mm/hr.

3.4 Interpreted Groundwater Flow Direction and Speed

Groundwater flow direction was estimated using groundwater levels measured on March 16, 2020 using manual piezometric head measurements reported at locations BH7, BH11, and BH13 (**Figure 2**). Groundwater within the area of interest is estimated to have a general horizontal gradient of approximately 0.02 in an approximate heading of 87.7^{o} (east) at that time.

Based on the horizontal hydraulic gradient provided above, and the hydraulic conductivity estimates in **Table 3**, groundwater on the subject property can be estimated to be flowing at an approximately velocity of 0.45 cms/day to 0.66 cms/day toward the east. Spatial contours of the groundwater hydraulic head elevation at ‘high ground water levels’ and ‘low groundwater levels’ are provided in **Figure 3 and Figure 4**, respectively.

4. Water Balance

A comparative water budget assessment was carried out for Beacon by Terrapex Environmental Ltd (Terrapex) for the part of the hydrologic catchment of Uxbridge Brook located on the subject property. Estimates for existing conditions, proposed conditions, and proposed conditions with low impact development methods are compared below.

4.1 Methods

Pre-development and post-development groundwater recharge (infiltration) and surface water run-off were estimated at monthly resolutions to characterize the hydrological and hydrogeological dynamics of the subject property. The estimates take into account the following seven components:

"Inputs"	(P) Precipitation (S_i) Surface water inflow (G_i) Groundwater inflow
"Outputs"	(So) Surface water outflow (Go) Groundwater outflow (ET) Evapotranspiration
Available Storage	(SMC) soil moisture holding capacity

The basic water balance for a particular area can be expressed as:

$$P = Qs + ET + RE + \Delta S$$

(Thornthwaite and Mather 1955)

where,

P = Precipitation (rain and snow)
Qs = Runoff
ET = Evapotranspiration
RE = Recharge
ΔS = Change in Storage (assumed to be zero under steady state conditions)

Climate data was sourced from historical Environment Canada data available for Uxbridge West weather station.

located approximately 5 km northeast of the subject property, using an average of three years (2018 through 2020) for the estimates. Precipitation volumes were used from 2015, 2016, 2017, 2018, 2019, and 2020 to compensate for incomplete datasets from the weather station. Local solarradiation, incoming solar radiation, sunset hour angles, and solar declination conditions used to estimate the evapotranspiration rate were sourced from the National Aeronautical and Space Administration Langley Research Center (NASA 2018). Standard soil water holding capacities and infiltration coefficients used were provided in the *Stormwater Management Planning and Design Manual* (MOECC 2003).

Table 5 summarizes the pre-development water-holding capacities assigned in the calculations based on the above descriptions and assumptions, as well as proposed conditions.

Table 5. Summary of Soil Type, Land Use, and Assigned Water Holding Capacity [1]

Soil Type	Vegetation Community Type	Assigned Water Holding Capacity(mm/m^2)
Silty and Clayey Loam	Fallow grasses	125
Silty and Clayey Loam	Moderately rooted crops (corn and cereal grains)	200
Silty and Clayey Loam	Mature Forest	400
Silty and Clayey Loam	Urban lawn/shallow rooted crops	115
Silty and Clayey Loam	Swamps and Marshes	800

[1] Terms and assigned water holding capacities as per the *Stormwater Management Planning and Design Manual* (MOECC 2003)

The infiltration coefficients used in the estimate calculations were based on the sum of topography, surficial soil classification and cover factors, provided in the *Stormwater Management Planning and Design Manual* (MOECC 2003). The general topography of the catchment area was assigned a topographic factor of 0.2 based on visual observation. The surficial soil classification was considered ‘Silt Loam’ or ‘Clay Loam’ and assigned a soil factor of 0.2. The cover was considered ‘cultivated land’ based on the general root depth of the vegetation observed and assigned a cover factor of 0.1.A cover factor of 0.2 was given to forested areas.

Based on the above sums, the total infiltration coefficient used in the estimate calculations was 0.5 for most areas, with a total infiltration coefficient of 0.6 for forested areas.

4.2 Global Site-Specific Water Balance

4.2.1 Pre-Development Constraints

The existing pre-development conditions of the subject property includes three general vegetation types, including ‘moderately rooted crops’ (corn), ‘mature forest’, and ‘swamps and marshes’, as summarized in **Table 6.** A small amount of land dedicated to a dirt driveway bisects the property and is characterized as impermeable, due to long term compaction**.**

Table 6. Existing Pre-Development Conditions

Existing Catchment Land Use	**Approximate Pervious Land Area (m^2)**	**Approximate Impervious Land Area (m^2)**	**Sums (m^2)**
Principle Area – (corn fields)	349,668	-	349,668
Mature Forest Areas (areas defined as FOD [1])	41,220	-	41,220
Marshes and Swamp Areas (areas defined as MAS2-1 [1] and SWT-2 [1])	9,984		9,984
Driveway (4 metres wide by 732 metres long)	-	2,928	2,928
Total Areas	**400,872**	**2,928**	**403,800**

FOD – ‘deciduous forest areas’

MAS2-1 – ‘Cattail Mineral Shallow Marsh’SWT-2 – ‘Willow Mineral Thicket Swamp’

[1] Source: Figure 2 – Existing Conditions (Beacon; August, 2020)

As summarized in **Table 6**, the area of the subject property used in the calculations was 403,800 m^2 in area, which includes approximately 2,928 m^2 of impermeable area.

4.2.2 Post-Development Constraints

Post-development conditions for Phase One Conditions were based on drawings provided by SCS, dated December 2020 (**Figure**; **Appendix A**). The proposed conditions of the subject property include one general vegetation type which have been classified as Urban Lawn/Shallow Rooted Crops, as well as impervious lands comprised of concrete pavements, asphalt pavements, and building structures, as summarized in **Table 7.**

Table 7. Proposed Post-Development Conditions

Proposed Land Uses [1, 2]	**Approximate Pervious Land Area (m^2)**	**Approximate Impervious Land Area (m^2)**	**Sums (m^2)**
	Area within FOI Catchment	**Area within FOI Catchment**	
Catchment 201	104,632	150,568	255,200
Catchment 202	21,120	1,880	23,000
Catchment 203 (Wet SWMP 1)	8,700	8,700	17,400
Catchment 204	21,318	34,782	56,100
Catchment 205 (Dry SWMP 1)	3,213	3,087	6,300
Catchment 206	371	329	700
Catchment 207	1,590	1,410	3,000
Catchment 208	1,007	893	1,900
Uxbridge Brook NHS	40,200	-	40,200
Total	**202,941**	**201,649**	**403,800**

[1] Based on information provided by SCS (December 2020).

[2] These represent the area of each catchment limited to the subject property that are interpreted to flow toward the FOI.SWMP – storm water management pond

The subject property remains approximately 403,800 m^2 in area. Impermeable areas are increasedfrom approximately 1% of the subject property in pre-development conditions, to approximately 50% of the subject property in post-development conditions.

4.2.3 Comparison of Pre-Development and Post-Development Water Balance Conditions

The pre-development hydrologic budget and post-development hydrologic budget for the subject property was estimated based on the existing catchment conditions summarized above. The estimated pre-development conditions are compared to anticipated post-development conditions in **Table 8,** below.

Table 8. Theoretical Average Annual Water Budgets

Component	Pre-Development Conditions	Post-Development Conditions	
	(m^3 per annum)	(m^3 per annum)	Relative Difference from Pre-Development (m^3 per annum)
(P) Precipitation	329,905	329,905	-
(ET) Evapotranspiration	292,285	150,568	-141,717
(Q_G) Infiltration	60,883	31,668	-29,215
(Q_S) Run-off	59,532	258,987	+199,455

Based on the summary of analyses provided in **Table 8,** it is noted that the proposed changes to the subject property are anticipated to result in an annual infiltration decrease of approximately 27,764 m^3, and an annual runoff increase of approximately 199,455 m^3 in comparison to existing conditions. Further details, including a monthly resolution breakdown, are provided in **Appendix D**.

Estimated decreases in infiltration volume and increases in run-off volume are interpreted to be due to relatively greater proposed impermeable area, as well as an exchange of moderately rooted crops (e.g. corn) with shallow rooted crops (e.g. urban lawns), which have a lower assigned water holding capacity (re: **Table 5**, above).

4.2.4 Low Impact Development (LID) Measures and Influence of SWMPs

Low Impact Development Measures located within the subject property area are proposed. These include Catchbasin Infiltration/Filtration Trenches and Rear Yard At-Surface Infiltration Trenches which effectively convert runoff volume from impermeable areas to infiltration volume. As well, a wet SWMP is proposed (Catchment 203) and a dry SWMP is proposed (Catchment 205). The wet SWMP contributes to evapotranspiration processes, and has an impermeable ratio of 50% (SCS, 2020). The dry SWMP contributes to evapotranspiration processes and infiltration processes.

The combined monthly influence of these proposed mitigation methods are provided in **Appendix D**.As shown, the LID measures appear to be least active during winter months, June, and September (limited by available runoff), and are most effective during the freshet months and fall rains.

4.2.5 Comparison of Pre-Development and Post-Development Catchment-Based Water Balance Conditions (Including Mitigations)

The pre-development hydrologic budget for the subject property was estimated based on the existing catchment conditions summarized above, and the post-development hydrologic budgets were estimated based on the Post-Development Drainage Plan and related mitigation measures, summarized above. The estimated pre-development conditions are compared to anticipated post-development conditions in **Table 9,** below. A more detailed analysis of the values summarized in **Table 9** is provided at monthly resolution in **Appendix D**.

Table 9. Theoretical Average Catchment-Based Water Budgets

Component	Pre- Development FOI Catchment	Proposed Post-Development Conditions		Proposed Post-Development Conditions with Mitigation Measures (Ultimate Conditions)	
	(m^3 per annum)	(m^3 per annum)	Relative Difference from Pre- Development (m^3 per annum)	(m^3 per annum)	Relative Difference from Pre-Development (m^3 per annum)
(P) Precipitation	329,905	329,905	-	329,905	-
(ET) Evapotranspiration	292,285	150,568	-141,717	150,568	-141,717
(Q_G) Infiltration	60,883	31,668	-29,215	160,246	+99,363
(Q_S) Run-off	59,532	258,987	+199,455	130,409	+70,877

Based on the summary of analyses provided in **Table 9,** it is noted that the ultimate proposed conditions for the subject property are anticipated to result in an annual increase of infiltration by approximately 99,363 m^{3,} and an annual increase in runoff by approximately 70,877 m^3 in comparison to existing conditions.

As shown in **Appendix D**, LID measures convert approximately 4,262 m^3 to 18,498 m^3 of theoretical runoff volume to theoretical infiltration per month. Resulting monthly infiltration trends appear to have generally higher infiltration volumes. Controlled runoff volumes result in more extreme wet periods, a longer freshet period and a drier summer season.

It is acknowledged that the values and coefficients presented above are standardized estimates. It is important to understand that infiltration rates and water holding capacities are dependent upon the effective porosity and hydraulic conductivity of the surficial soils which may vary over several orders of magnitude. As such, the resulting run-off and infiltration estimates inherit potentially large margins of error. 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.

4.3 Catchment-Based Water Balance

A Catchment-Based Water Balance (CBWB) assessment was carried out for Beacon by Terrapex, limited to the catchment area belonging to the Feature of Interest (FOI). For the purposes of this report, the FOI is the portion of Uxbridge Brook located within the bounds of the subject property.

The purpose of the catchment-based water balance assessment is to compare the hydrological conditions of the proposed development conditions on the surfacewater reaching/'feeding' the FOI. For the purposes of this assessment, the FOI is defined as the portion of Uxbridge Brook and associated lower banks (presumed spring flood tier) located at the southeast corner of the subject property.

4.3.1 Pre-Development Constraints – FOI Catchment

The existing pre-development conditions of the subject property includes three general vegetation types, including ‘moderately rooted crops’ (corn), ‘mature forest’, and ‘swamps and marshes’. A small amount of land comprised of a dirt driveway bisects the property and is characterized as impermeable, due to long term compaction**.** The existing area of the subject property dedicated to surface water catchment for the Feature of Interest used in the calculations was 372,452 m^2 in area, which includes approximately 2,928 m^2 of impermeable area, as summarized in **Table 10**.

Table 10. Existing Pre-Development Conditions –FOI Catchment

Existing Catchment Land Use	Approximate Pervious Land Area (m^2)	Approximate Impervious Land Area (m^2)	Sums (m^2)
Principle Area – (corn fields)	339,468	-	339,468
Mature Forest Areas (areas defined as FOD [1])	20,345	-	20,045
Marshes and Swamp Areas (areas defined as MAS2-1 [1] and SWT-2 [1])	9,984	-	9,984
Driveway (4 metres wide by 732 metres long)	-	2,928	2,928
Total Areas	**369,497**	**2,928**	**372,425**

FOD – ‘deciduous forest areas’
MAS2-1 – ‘Cattail Mineral Shallow
Marsh’SWT-2 – ‘Willow Mineral
Thicket Swamp’

[1] Source: Figure 2 – Existing Conditions (Beacon; August, 2020)

4.3.2 Post-Development Constraints – FOI Catchment

Post-development conditions in the FOI Catchment were based on drawings provided by SCS, dated December 2020 (**Figure 2.2**; **Appendix A**), and low impact development (LID) specifications provided by SCS (Dec 3, 2020). The proposed conditions of the subject property include one general vegetation type (Urban lawn/shallow rooted crops), as well as impervious lands comprised of concretepavements, asphalt pavements, and building structures, as summarized in **Table 11.**

Table 11. Proposed Post-Development Conditions – Proposed FOI Catchment

Proposed Land Uses [1, 2]	**Approximate Pervious Land Area (m^2)**	**Approximate Impervious Land Area (m^2)**	**Sums (m^2)**
	Area within FOI Catchment	**Area within FOI Catchment**	
Catchment 201	104,632	150,568	255,200
Catchment 202	18,405	1,880	20,285
Catchment 203 (Wet SWMP 1)	8,700	8,700	17,400
Catchment 204	15,637	25,512	41,149
Catchment 205 (Dry SWMP 1)	2,420	2,325	4,745
Catchment 208	1,007	893	1,900
Brook NHS	31,746	-	31,746
Total	**182,176**	**189,249**	**372,425**

[1] Based on information provided by SCS (December 2020).

[2] These represent the area of each catchment limited to the subject property that are interpreted to flow toward the FOI. SWMP – storm water management pond

As indicated in **Table 11**, the proposed catchment for the FOI under the proposed conditions is approximately 372,425 m^2 in area, which includes approximately 189,249 m^2 of impermeable area.

4.3.3 Comparison of Pre-Development and Post-Development Catchment-Based Water Balance Conditions

The pre-development hydrologic budget and post-development hydrologic budgets for the subject property were estimated based on the existing catchment conditions summarized above. The estimated pre-development conditions are compared to anticipated post-development conditions in **Table 12,** below. A more detailed analysis of the values summarized in **Table 12** is provided at monthly resolution in **Appendix E**.

Table 12. Theoretical Average Catchment-Based Water Budgets – FOI Catchment

Component	Pre-Development ConditionsFOI Catchment	Proposed Post-Development ConditionsFOI Catchment	
	(m^3 per annum)	(m^3 per annum)	Relative Difference from Pre-Development (m^3 per annum)
(P) Precipitation	304,271	304,271	-
(ET) Evapotranspiration	269,562	135,967	-133,595
(Q_G) Infiltration	55,898	28,571	-27,327
(Q_S) Run-off	55,510	243,283	+187,773

Based on the summary of analyses provided in **Table 12,** it is noted that the changes proposed for the subject property are anticipated to result in an annual decrease of infiltration in the FOI Catchment by approximately 27,327 m^3, and an annual increase in runoff reaching the FOI by approximately187,773 m^3 in comparison to existing conditions.

Estimated decreases in infiltration volume and increases in run-off volume are interpreted to be due to relatively greater proposed impermeable area, as well as an exchange of moderately rooted crops (e.g. corn) with shallow rooted crops (e.g. urban lawns), which have a lower assigned water holding capacity (re: **Table 5**, above).

4.3.4 Low Impact Development (LID) Measures and Influence of SWMPs

Low Impact Development Measures located within the FOI Catchment area are proposed. These include Catchbasin Filtration Trenches and Rear Yard At-Surface Infiltration Trenches which effectively convert runoff volume from impermeable areas to infiltration volume. As well, a wet SWMPis proposed (Catchment 203) and a dry SWMP is proposed (Catchment 205). The wet SWMP contributes to evapotranspiration processes, and has a impermeable ratio of 50% (SCS, 2020). The dry SWMP contributes to evapotranspiration processes and infiltration processes. The dry SWMP also sources water from outside of the traditional FOI catchment, effectively converting runoff volumeslocated in the SWMP sub-catchment and Catchment 204 to infiltration volumes.

The combined monthly influence of these proposed mitigation methods are provided in **Appendix E**.

4.3.5 Comparison of Pre-Development and Post-Development Catchment-Based Water Balance Conditions (Including Mitigations)

The pre-development hydrologic budget for the subject property was estimated based on the existing catchment conditions summarized above, and the post-development hydrologic budgets were estimated based on the Post-Development Drainage Plan and related mitigation measures, summarized above. The estimated pre-development conditions are compared to anticipated post-development conditions in **Table 13,** below. A more detailed analysis of the values summarized in **Table 13** is provided at monthly resolution in **Appendix E**.

Table 13. Theoretical Average Catchment-Based Water Budgets – FOI Catchment

Component	Pre- Development FOI Catchment	Proposed Post-Development Conditions		Proposed Post-Development Conditions with Mitigation Measures	
	(m^3 per annum)	(m^3 per annum)	Relative Difference from Pre-Development (m^3 per annum)	(m^3 per annum)	Relative Difference from Pre-Development (m^3 per annum)
(P) Precipitation	304,271	304,271	-	304,271	-
(ET) Evapotranspiration	268,562	135,967	-133,595	135,967	-132,595
(Q_G) Infiltration	55,898	28,571	-27,327	167,635	+111,737
(Q_S) Run-off	55,510	243,283	+187,773	104,219	+48,709

Based on the summary of analyses provided in **Table 13,** it is noted that the ultimate proposed conditions for the subject property are anticipated to result in an annual increase of infiltration within the FOI catchment by approximately 111,737 m^3. Similarly, ultimate proposed conditions for the subject property are anticipated to result in an annual increase of runoff by approximately 48,709 m^{3}in comparison to existing conditions.

As shown in **Appendix E**, LID measures convert approximately 2,932 m^3 to 31,773 m^3 of theoretical runoff volume to theoretical infiltration within the FOI Catchment per month. Resulting monthly infiltration trends appear to have generally higher infiltration volumes than existing conditions. Controlled runoff volumes result in an earlier freshet period.

It is acknowledged that the values and coefficients presented above are standardized estimates. It is important to understand that infiltration rates and water holding capacities are dependent upon the effective porosity and hydraulic conductivity of the surficial soils which may vary over several orders of magnitude. As such, the resulting run-off and infiltration estimates inherit potentially large margins of error. 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. Summary

In summary, this report finds that:

Hydrogeological

- The general stratigraphic package is interpreted as alternating layers of silty clay and layers of silty sand, with some areas of sand layers;
- Depths to groundwater from ground surface measured between January of 2018 and August of 2020 ranged from approximately 0.2 mbgs to 8.92 mbgs;
- Groundwater elevations were found to range from approximately 332.0 masl to 285.2 masl; and
- Groundwater is estimated to flow in a generally easterly heading at a rate of approximately 0.45 cm/day to 0.66 cm/day.

Water Balance Assessment

A Site-specific Global Water Balance Assessment was carried out for the subject property (403,800 m^2 in area). Proposed changes to the subject property during Phase Ultimate conditions are anticipated to result inan annual increase of infiltration by approximately 99,363 $m^{3,}$ and an annual increase in runoff by approximately 70,877 m^3 in comparison to existing conditions.

Catchment-Based Water Balance Assessment

A Catchment-Based Water Balance Assessment (CBWB) was carried out for the hydrologic catchment belonging to the portion of Uxbridge Brook located within the subject property.

Annual Conditions

The Catchment for the Feature of Interest (FOI) is approximately 372,425 m^2 in area. Proposed changes to the Catchment for the Feature of Interest (FOI) are anticipated to result in an annual increase of infiltration within the FOI catchment by approximately 111,737 m^3. Similarly, ultimate proposed conditions for the subject property are anticipated to result in an annual increase of runoff by approximately 48,709 m^3in comparison to existing conditions.

Monthly Conditions

Monthly infiltration volumes are generally anticipated to increase, with the largest increases occurring during the freshet periods. Monthly runoff volumes are generally similar to those seen in the existing conditions, with a slightly earlier freshet period.

Report prepared by:
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Zen Keizars, P.Geo., FGC.
Senior Hydrogeologist

Report reviewed by:
Beacon Environmental

Brian E. Henshaw
CEO, Senior Ecologist

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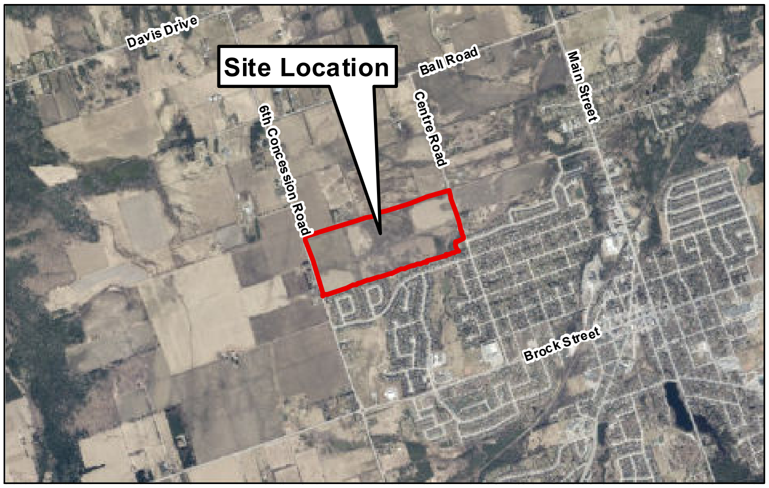
Soil Engineers Limited., 2018.
A Letter for Groundwater Monitoring Program – Proposed Development, 7370 Centre Road, Town of Uxbridge.

Figures



Site Location

Figure 1

7370 Centre Road Uxbridge

BEACON ENVIRONMENTAL

Project: 217431
Last Revised: September, 2020

Client: Mediterra Corp.

Prepared by: BD
Checked by: JM

N

1:8,100

Inset Map:1:50,000

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Well Locations

Figure 2

7370 Centre Road Uxbridge

Legend

▭ Subject Property

┅ 500 metre distance from Subject Property boundary

⊙ Wells reported in the MECP Water Well Database (accessed August, 2020)

◐ Groundwater Monitoring Wells

BEACON ENVIRONMENTAL

Project: 217431.2
Last Revised: August, 2020

Client: Mediterra Corp.

Prepared by: DU
Checked by: ZH

N

1:7,500

0 100 200 m

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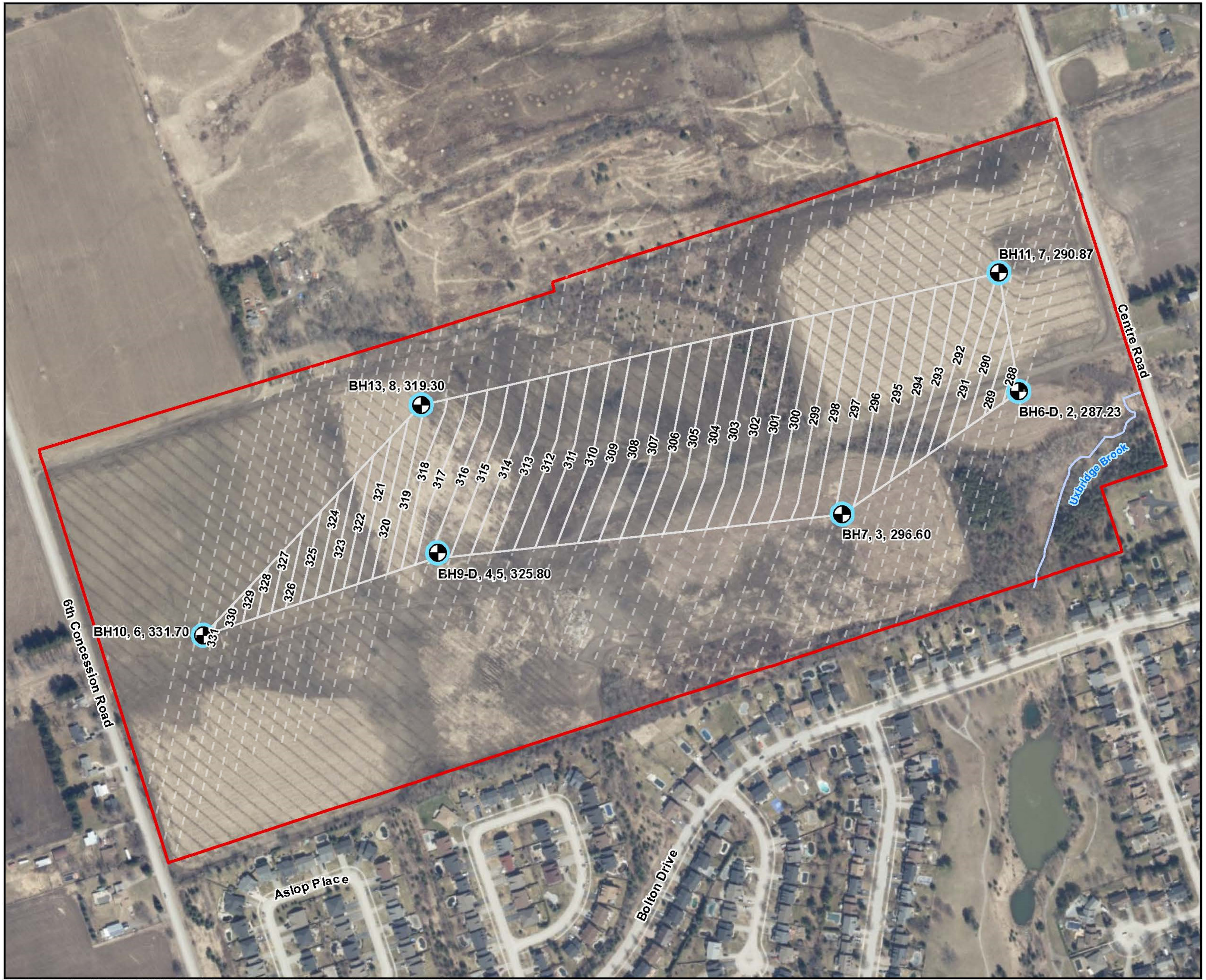

C:\Dropbox\Dropbox (Beacon)\All GIS Projects\2017\217431 7370 Centre Road Uxbridge EIS\MXD\2020-07-31_FigureXX_HydraulicHeadElevationContours_HighGroundWater_217431.mxd

Hydraulic Head Elevation Contours for the date of March 16, 2020 (High Ground Water Levels)

Figure 3

7370 Centre Road Uxbridge

Legend

- ● Monitoring Wells
- ▭ Subject Property
- — Watercourse (Beacon 2020)
- — Hydraulic Head Elevation Contours (metres above sea level)
- - - Extrapolated Hydraulic Head Elevation Contours (metres above sea level) – reduced confidence.

DRAFT FOR DISCUSSION PURPOSES

BEACON ENVIRONMENTAL

Project: 217431.2
Last Revised: July, 2020

Client: INTERNAL USE ONLY

Prepared by: DU
Checked by: ZH

N
1:3,500
0 50 100 m

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Hydraulic Head Elevation Contours for the date of June 19 + July 4, 2019 (Low Ground Water Levels)

Figure 4

7370 Centre Road Uxbridge

Legend

- ▭ Subject Property
- ⊕ Monitoring Wells
- Hydraulic Head Elevation Contours (metres above sea level), measurements by Soil Engineers (2019).
- Watercourse (Beacon 2020)
- Extrapolated Hydraulic Head Elevation Contours (metres above sea level). Reduced confidence.

DRAFT FOR DISCUSSION PURPOSES

BEACON ENVIRONMENTAL

Project: 217431.2

Last Revised: July, 2020

Client: INTERNAL USE ONLY

Prepared by: DU

Checked by: ZH

N

1:3,500

0 50 100 m

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Appendix A

Well Records (MECP)

Appendix A

Water Well Database Information

FID	BOREHOLEID	WELL_ID	COMPLETED	DEPTH	DP_BEDROCK	STATIC_LEV
0	10296870	4605554	9/20/73 0:00:00	26.2000008	0	9.1000004
1	1003924861	7182653	5/31/12 0:00:00	0	0	0
2	10073650	1904798	8/18/77 0:00:00	56.4000015	0	44.7999992
3	10083560	1914971	1/26/00 0:00:00	36	0	11.3000002
4	10296153	4604827	6/14/71 0:00:00	29	0	7.5999999
5	10295105	4603754	10/15/68 0:00:00	24.3999996	0	3
6	10296828	4605511	6/08/73 0:00:00	32	0	11.3000002
7	10297933	4606647	10/01/76 0:00:00	25	0	0.6
8	10296491	4605169	3/25/72 0:00:00	33.2000008	0	12.1999998
9	10075984	1907346	5/31/85 0:00:00	14.3000002	0	2.7
10	10076019	1907381	7/03/85 0:00:00	15.1999998	0	3.7
11	10296023	4604693	12/15/70 0:00:00	6.4000001	0	1.5
12	10082491	1913900	12/17/98 0:00:00	57.9000015	0	45.0999985
13	11173432	1917266	2008-11-04 0:00	0	0	0
14	10074334	1905496	8/17/79 0:00:00	38.0999985	0	12.1999998
15	1002477483	7124196	2006-08-09 0:00	0	0	0
16	10074997	1906216	8/26/81 0:00:00	42.7000008	0	16.7999992
17	10077253	1908623	9/21/87 0:00:00	25.6000004	0	12.1999998
18	10075909	1907270	6/28/84 0:00:00	31.3999996	0	0
19	10296210	4604884	8/17/71 0:00:00	32	0	10.6999998
20	10074386	1905550	5/11/79 0:00:00	30.2000008	0	12.1999998
21	10296511	4605189	8/03/72 0:00:00	33.5	0	13.6999998
22	10076453	1907818	7/10/86 0:00:00	26.2000008	0	14.6000004
23	10082526	1913935	1/19/99 0:00:00	74.0999985	0	50
24	10295673	4604338	3/29/69 0:00:00	7.5999999	0	3
25	10295658	4604323	9/15/69 0:00:00	8.5	0	2.4000001
26	10073956	1905105	7/24/78 0:00:00	69.8000031	0	48.7999992
27	10296244	4604920	7/05/71 0:00:00	32	0	11.3000002
28	10296158	4604832	11/12/70 0:00:00	31.7000008	0	9.1000004
29	10296277	4604953	7/19/71 0:00:00	32	0	11.8999996
30	10295996	4604666	12/30/70 0:00:00	31.3999996	0	10.6999998
31	10538025	1916454	2004-07-03 0:00	0	0	0
32	10296585	4605265	12/14/72 0:00:00	28.2999992	0	7.3000002
33	10296827	4605510	7/23/73 0:00:00	27.3999996	0	8.5

FID	BOREHOLEID	WELL_ID	COMPLETED	DEPTH	DP_BEDROCK	STATIC_LEV
34	10074068	1905219	12/18/78 0:00:00	25.2999992	0	3.7
35	10296743	4605425	4/26/73 0:00:00	18.2999992	0	4.5999999
36	10073538	1904592	4/29/77 0:00:00	18.6000004	0	6.4000001
37	10296666	4605347	10/13/72 0:00:00	33.2000008	0	7.5999999
38	10296156	4604830	5/04/71 0:00:00	28.7000008	0	9.1000004
39	10295657	4604322	9/10/69 0:00:00	34.4000015	0	11.6000004
40	10297007	4605694	10/22/73 0:00:00	33.2000008	0	13.6999998
41	10075424	1906753	10/17/83 0:00:00	22.6000004	0	7.5999999
42	1006274113	7273627		0	0	0
43	10296008	4604678	12/15/70 0:00:00	5.5	0	0.9
44	10076567	1907933	9/23/86 0:00:00	27.3999996	0	7.5999999
45	10297729	4606440	3/30/76 0:00:00	58.2000008	0	45.7000008
46	10537894	1916323	2011-12-02 0:00	23.7999992	0	0.6
47	10076070	1907433	8/28/85 0:00:00	26.2000008	0	6.0999999
48	10295248	4603898	8/29/68 0:00:00	25.2999992	0	8.5
49	10296826	4605509	7/19/73 0:00:00	35.0999985	0	12.1999998
50	10296748	4605430	5/04/73 0:00:00	29.8999996	0	10.1000004
51	10082798	1914207	9/07/99 0:00:00	30.5	0	14.6000004
52	10082492	1913901	12/09/98 0:00:00	53.9000015	0	44.7999992
53	10530664	1916126	9/25/02 0:00:00	79.1999969	52.4000015	0
54	10538024	1916453	2004-07-03 0:00	0	0	0
55	10297126	4605814	3/13/74 0:00:00	33.2000008	0	10.6999998
56	10296208	4604882	9/24/71 0:00:00	21.2999992	0	6.6999998
57	10296603	4605283	8/29/72 0:00:00	9.8000002	0	7.9000001
58	10295594	4604256	11/26/69 0:00:00	27.3999996	0	9.8000002
59	10296154	4604828	6/02/71 0:00:00	32.9000015	0	11.8999996
60	10295662	4604327	6/16/69 0:00:00	7.9000001	0	4.9000001
61	10075910	1907271	11/16/84 0:00:00	38.0999985	0	0
62	10295669	4604334	2/27/69 0:00:00	10.6999998	0	4.3000002
63	10294358	4602995	10/02/62 0:00:00	19.7999992	0	6.0999999
64	10296548	4605227	7/26/72 0:00:00	22.8999996	0	9.8000002
65	10296018	4604688	9/04/70 0:00:00	4.5999999	0	1.8
66	10073516	1904570	3/01/77 0:00:00	34.4000015	0	13.6999998
67	10295165	4603815	8/12/68 0:00:00	8.1999998	0	6.0999999
68	1003525095	7164586	2006-10-11 0:00	0	0	0
69	1004142949	7186160	2007-10-12 0:00	0	0	5.8000002
70	10080491	1911869	12/10/93 0:00:00	26.5	0	12.1999998
71	10294333	4602970	12/20/65 0:00:00	58.7999992	0	46.5999985
72	10296532	4605211	8/18/72 0:00:00	32.2999992	0	10.6999998
73	10080499	1911877	9/03/93 0:00:00	26.2000008	0	8.1999998

FID	BOREHOLEID	WELL_ID	COMPLETED	DEPTH	DP_BEDROCK	STATIC_LEV
74	10530718	1916180	9/18/02 0:00:00	0	0	0
75	10295660	4604325	2/09/70 0:00:00	7.9000001	0	2.4000001
76	10296834	4605518	7/24/73 0:00:00	36.9000015	0	11.6000004
77	10295440	4604096	3/29/69 0:00:00	7.5999999	0	1.5
78	10078942	1910316	11/29/89 0:00:00	31.7000008	0	4.5999999
79	10296640	4605321	10/18/72 0:00:00	23.2000008	0	7.5999999
80	10076569	1907935	9/18/86 0:00:00	25.6000004	21.8999996	6.0999999
81	10295998	4604668	10/22/70 0:00:00	27.1000004	0	7
82	10296795	4605478	7/23/72 0:00:00	33.5	0	12.5
83	10296490	4605168	4/20/72 0:00:00	32.2999992	0	12.1999998
84	10296586	4605266	12/12/72 0:00:00	30.7999992	0	10.1000004
85	1006342506	7279407	2011-01-16 0:00	0	0	3.7
86	10082525	1913934	1/28/99 0:00:00	0	0	0
87	10297869	4606582	6/02/76 0:00:00	29.2999992	0	8.5
88	10077152	1908519	7/08/87 0:00:00	25	0	6.0999999
89	1005373204	7241714	4/26/15 0:00:00	25.2000008	0	2.7
90	10297907	4606620	8/25/76 0:00:00	67.0999985	0	0
91	10295741	4604407	5/28/70 0:00:00	31.3999996	0	11
92	10295339	4603994	11/19/68 0:00:00	11.3000002	0	4.3000002
93	10295489	4604147	8/14/69 0:00:00	23.2000008	0	11.3000002
94	10296993	4605680	10/12/73 0:00:00	33.5	0	9.8000002
95	10296014	4604684	9/07/70 0:00:00	8.5	0	7.3000002
96	10295506	4604164	8/13/69 0:00:00	23.2000008	0	9.1000004
97	10295171	4603821	9/18/68 0:00:00	10.6999998	0	4.3000002
98	10296979	4605666	11/03/73 0:00:00	6.6999998	0	4.5999999
99	10295885	4604553	10/14/70 0:00:00	32	4.9000001	11
100	10296825	4605508	6/02/73 0:00:00	32	0	9.1000004
101	10079539	1910916	11/06/90 0:00:00	22.6000004	0	7.3000002
102	1006342509	7279408	2011-01-16 0:00	0	0	3.7
103	10296019	4604689	9/04/70 0:00:00	4.9000001	0	1.8

Appendix B

Provided Historical Work
(Soil Engineers Limited, 2018)

Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE
90 WEST BEAVER CREEK ROAD, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL (416) 754-8515 · FAX (905) 881-8335

BARRIE	MISSISSAUGA	OSHAWA	NEWMARKET	GRAVENHURST	PETERBOROUGH	HAMILTON
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February 16, 2018 Reference No. 1711-S047

Bridge Brook Corp.
55 Blue Willow Drive
Woodbridge, Ontario
L4L 9E8

Attention: Mr. John Spina

Re: A Geotechnical Investigation Report for
Proposed Residential Development
7370 Centre Road
Town of Uxbridge

Dear Sir:

Enclosed, please find 3 copies of the Geotechnical Investigation Report for the captioned project.

I trust the Report will meet your present requirements as per our proposal.

Should you have any queries concerning the above, or wish to retain us for further services, please feel free to contact the undersigned at your earliest convenience.

Yours truly,
SOIL ENGINEERS LTD.

Kin Fung Li, B.Eng.
KFL:dd

RECEIVED FEB 21 2018

Encl.

Soil Engineers Ltd.
CONSULTING ENGINEERS
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90 WEST BEAVER CREEK ROAD, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL (416) 754-8515 · FAX (905) 881-8335

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A REPORT TO
BRIDGE BROOK CORP.

A GEOTECHNICAL INVESTIGATION FOR PROPOSED RESIDENTIAL DEVELOPMENT

7370 CENTRE ROAD

TOWN OF UXBRIDGE

REFERENCE NO. 1711-S047

FEBRUARY 2018

DISTRIBUTION

3 Copies - Bridge Brook Corp.
1 Copy - Soil Engineers Ltd. (Newmarket)
1 Copy - Soil Engineers Ltd. (Richmond Hill)

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ENCLOSURES

1.0 INTRODUCTION

In accordance with written authorization dated November 9, 2017, from Mr. John Spina of Bridge Brook Corp., a geotechnical investigation was carried out on a parcel of land located on 7370 Centre Road, in the Town of Uxbridge.

The purpose of the investigation was to reveal the subsurface conditions and determine the engineering properties of the disclosed soils for the design and construction of a proposed Residential Development.

The geotechnical findings and resulting recommendations are presented in this Report.

2.0 SITE AND PROJECT DESCRIPTION

The Township of Uxbridge is situated on Peterborough Drumlin Field, where the lacustrine sand, silt, clay and water-laid till (reworked) in Lake Schomberg (glacial lake) has, in places, modified the drumlinized soil stratigraphy.

The subject property, encompasses approximately 40 hectares in area, is located on the west side of Centre Road, approximately 900 m north of Brock Street West in the Town of Uxbridge. It is currently a farm field with wooded areas and some natural drainage channels through the property. The existing site gradient generally drops towards the east direction.

It is understood that the property will be developed into a residential subdivision. Detailed design of the development, however, is not available at the time this report is prepared.

3.0 FIELD WORK

The field work, consisting of fourteen (14) boreholes to various depths ranging from 6.3 to 15.7 m, was performed between November 27 and December 21, 2017. Borehole 1 was cancelled due to accessibility. Borehole 13 was advanced on January 15, 2018 to a depth of 6.6 m. The boreholes locations are shown on the Borehole Location Plan, Drawing No. 1.

The boreholes were advanced at intervals to the sampling depths by a track-mounted, continuous-flight power-auger machine equipped for soil sampling. Standard Penetration Tests, using the procedures described on the enclosed "List of Abbreviations and Terms", were performed at the sampling depths. The test results are recorded as the Standard Penetration Resistance (or 'N' values) of the subsoil. The relative density of the granular strata and the consistency of the cohesive strata are inferred from the 'N' values. Split-spoon samples were recovered for soil classification and laboratory testing. The field work was supervised and the findings were recorded by a Geotechnical Technician.

Upon the completion of drilling and sampling, nine (9) 50 mm diameter PVC monitoring wells, including two pairs of nested wells were installed in selected borehole locations to facilitate future groundwater monitoring. The boreholes were backfilled with hole plug (bentonite) and borehole cuttings to the ground level.

The ground elevation at each of the borehole and monitoring well location was interpreted from the topographic survey provided by Stantec Geomatics Ltd.

4.0 SUBSURFACE CONDITIONS

Detailed descriptions of the encountered subsurface conditions are presented on the Borehole Logs, comprising Figures 1 to 15, inclusive.

The investigation revealed that beneath a veneer of topsoil and ploughed soils, the site is generally underlain by a complex stratigraphy consisting of silty clay and tills, with deposits of sand and silts at various depths and locations. The engineering properties of the disclosed soils are discussed herein.

4.1 Topsoil/Ploughed Soils (All Boreholes)

The existing ground surface was generally covered with topsoil with variable thickness. In the farm field area, the topsoil was mixed with ploughed soils, extending to depths of 0.6 to 1.5 m from the existing ground level.

The thickness of topsoil may vary randomly across the site. Thicker topsoil layers can occur in the low-lying areas, especially in treed areas and depressed areas beside the watercourses.

The topsoil is dark brown in colour and permeated with roots. This infers that it contains appreciable amounts of roots and humus. Similarly, the ploughed soils contains a composition of topsoil that it is unstable and compressible under loads; therefore, the topsoil and the ploughed soils are considered to be void of engineering value but can be used for general landscaping purposes. A fertility analysis can be carried out to assess their suitability for use as a planting soil or sodding medium. Due to the humus content, the topsoil will generate an offensive odour under anaerobic conditions and may produce volatile gases; therefore, it must not be buried within the building envelope, or deeper than 1.2 m below the finished grade, as it may have an adverse impact on the environmental well-being of the development.

4.2 Silty Clay/Silty Clay Till (Boreholes 2, 3, 4, 6 to 10, inclusive, 13, 14 and 15)

The clay till consists of a random mixture of soils; the particle sizes range from clay to gravel, with the clay fraction exerting the dominant influence on its soil properties. Its structure is heterogeneous, showing a glacial deposit. The silty clay consists of predominantly clay and silt with occasional sand seams or layers, showing a lacustrine deposit.

Intermittent hard resistance to augering was encountered, indicating the presence of cobbles and boulders in the clay till.

The consistency of the clay and clay till and their respective 'N' values are summarized below:

	'N' Values	**Consistency**
Silty Clay	12 to 58 (median 28)	Stiff to hard, generally very stiff
Silty Clay Till	6 to over 100 (median 30)	Firm to hard, generally hard

The Atterberg Limits of representative samples of the silty clay till and silty clay, and the natural water content of all the samples were determined. The results are plotted on the Borehole Logs and summarized below:

	Silty Clay Till	**Silty Clay**
Liquid Limit	28%	35%
Plastic Limit	17%	19%
Natural Water Content	5% to 27% (median 12%)	14% to 26% (median 15%)

The above results show that the clay and clay till are cohesive materials with low plasticity. The natural water content generally lies below the plastic limit or between the plastic and liquid limits, confirming the consistencies of the clay and clay till as determined by the 'N' values.

Grain size analyses were performed on representative samples of silty clay till and silty clay; the results are plotted on Figures 16 and 17, respectively.

According to the above findings, the following engineering properties are deduced:

- Highly frost susceptible and low water erodibility.
- The silty clay has high soil-adfreezing potential.
- Virtually impervious, with an estimated coefficient of permeability of 10^{-7} cm/sec or less, an average percolation rate of 80 min/cm, and runoff coefficients of:

Slope	
0% - 2%	0.15
2% - 6%	0.20
6% +	0.28

- Cohesive soils, their shear strengths are primarily derived from consistency which is inversely related to its moisture content. The clay till also contains sand and gravel; therefore, its shear strength is augmented by internal friction.

- The shear strength of the silty clay and till is moisture dependent and, due to the dilatancy of the silt layers in the clay, the overall shear strength of the silty clay is susceptible to impact disturbance, i.e., the disturbance will induce a build-up of pore pressure within the soil mantle, resulting in soil dilation and a reduction of shear strength.
- The clay and clay till will generally be stable in a relatively steep cut; however, prolonged exposure will allow the weathered layers and the wet sand seams to become saturated which may lead to localized sloughing.
- Very poor pavement-supportive materials, with an estimated California Bearing Ratio (CBR) of 3% to 5%.
- Moderately high corrosivity to buried metal, with an estimated electrical resistivity of 3000 ohm·cm.

4.3 Silty Sand Till (Boreholes 2, 5, 6, 7, 10, 11 and 12)

The silty sand till consists of a random mixture of particle sizes ranging from clay to gravel, with sand being the dominant fraction. They are heterogeneous and amorphous in structure showing the deposit is a glacial till, part of which has been reworked by the glacial lake.

Tactile examinations of the soil samples indicated that the till is slightly cemented.

The obtained 'N' values range from 6 to over 100, with a median of 26 blows per 30 cm of penetration. This shows that the relative density of the till is loose to very dense, being generally compact. The loose soil is encountered below the ploughed soil and has been weakened by weathering.

Intermittent hard resistance to augering was encountered, indicating the presence of cobbles and boulders in the sand till.

The natural water content values of the samples were determined; the results are plotted on the Borehole Logs. The values range from 7% to 13%, with a median of 9%, confirming the generally moist condition disclosed by the sample examinations.

Grain size analyses were performed on two representative samples; the results are plotted on Figure 18.

According to the above findings, the following engineering properties are deduced:

- Highly frost susceptible and moderately water erodible.
- Low soil-adfreezing potential.
- Low permeability, with an estimated coefficient of permeability of 10^{-5} cm/sec, an average percolation rate of 40 min/cm, and runoff coefficients of:

Slope	
0% - 2%	0.11
2% - 6%	0.16
6% +	0.23

- A frictional soil, its shear strength is primarily derived from internal friction, and is augmented by cementation. Therefore, the strength is density dependent.
- It will be stable in steep cuts; however, under prolonged exposure, localized sheet collapse will likely occur.
- A fair pavement-supportive material, with an estimated CBR of 10%.

- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5000 ohm·cm.

4.4 **Sandy Silt/Silt** (Boreholes 2, 4, 9, 11, 12 and 15)

The sandy silt and silt deposit was encountered in various depths and locations. It is fine grained, with traces to some sand and clay. The natural water content of the samples range from 10% to 23%, with a median of 17%, indicating a moist to wet condition, being generally wet and likely saturated. The wet silt dilates when shaken by hand. The wet soils are water-bearing.

The obtained 'N' values range from 14 to 72 blows, with a median of 30 blows per 30 cm of penetration, indicating that the relative density of the sandy silt and silt is compact to very dense, being generally compact.

According to the above findings, the engineering properties relating to the project are given below:

- Highly frost susceptible, with high soil-adfreezing potential.
- Highly water erodible; it is susceptible to migration through small openings under seepage pressure.
- It has a high capillarity and water retention capacity.
- Low permeability, with an estimated coefficient of permeability of 10^{-5} cm/sec, an average percolation rate of 40 min/cm and runoff coefficients of:

Slope

0% - 2%	0.11
2% - 6%	0.16
6% +	0.23

- Frictional soils, their shear strength is density dependent. Due to their dilatancy, the strength of the wet silts is susceptible to impact disturbance, i.e., the disturbance will induce a build-up of pore pressure within the soil mantle, resulting in soil dilation and a reduction in shear strength.
- In excavation, the wet silts will slough and run slowly with seepage bleeding from the cut face. It will boil with a piezometric head of 0.3 m.
- Poor pavement-supportive materials, with an estimated CBR value of 5%.
- Moderately corrosive to buried metal, with an estimated electrical resistivity of 4500 ohm.cm.

4.5 Sand (Boreholes 4, 5, 13 and 15)

The sand deposit is generally fine to medium grained with some silt. Sample examinations show that the deposit is in a very moist to wet condition and is water bearing. This is confirmed by the natural water content of the soil samples, in the range of 5% to 22%, with a median of 17%. Due to the pervious nature of the deposit, some water could have been drained from the samples after they were retrieved or during the packing process. Hence, the actual water content of the deposit can be higher. The wet sand is water-bearing.

The obtained 'N' values of the sand deposit ranged from 9 to over 100, with a median of 27 blows per 30 cm of penetration, indicating the relative density of the sand is loose to very dense, being generally compact.

A grain size analysis was performed on one representative sample of the sand deposit; the result is plotted on Figure 19.

According to the above findings, the following engineering properties are deduced:

- Low frost susceptibility.
- Highly water erodible.
- Susceptible to migration through small openings under seepage pressure.
- Pervious, with an estimated coefficient of permeability of 10^{-3} cm/sec, an average percolation rate of 10 min/cm and runoff coefficients of:

Slope	
0% - 2%	0.04
2% - 6%	0.09
6% +	0.13

- A frictional soil, its shear strength is dependent on its internal friction angle and soil density. Due to its dilatancy, its shear strength is susceptible to impact disturbance, i.e., the disturbance will induce a build-up of pore pressure within the soil mantle, resulting in soil dilation and reduction of shear strength.
- In excavation, the wet sand will slough and run slowly with seepage bleeding from the cut face. It will boil with a piezometric head of 0.3 m.
- A good pavement-supportive material, with an estimated CBR value of 21%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 6000 ohm·cm.

4.6 Compaction Characteristics of the Revealed Soils

The obtainable degree of compaction is primarily dependent on the soil moisture and, to a lesser extent, on the type of compactor used and the effort applied.

As a general guide, the typical water content values of the revealed soils for Standard Proctor compaction are presented in Table 1.

Table 1 - Estimated Water Content for Compaction

Soil Type	**Determined Natural Water Content (%)**	**Water Content (%) for Standard Proctor Compaction**	
		100% (optimum)	**Range for 95% or +**
Silty Clay and Silty Clay Till	5 to 27 (median 13)	18	14 to 24
Silty Sand Till	7 to 13 (median 9)	13	8 to 16
Sandy Silt and Silt	10 to 23 (median 17)	10	7 to 14
Sand	5 to 22 (median 17)	8	5 to 11

Based on the above findings, the clay and tills are generally suitable for 95% or + Standard Proctor compaction. However, some of the clays, sand and silts are generally too wet and will require aeration prior to compaction. Aeration can be achieved by spreading them thinly on the ground during the dry and warm weather.

The clay and tills should be compacted using a heavy-weight kneading-type roller. The sand and silts can be compacted by a smooth drum roller, with or without vibration, depending on the water content of the soil being compacted. The lifts for compaction should be limited to 20 cm, or to a suitable thickness as assessed by test strips performed by the equipment which will be used at the time of construction.

When compacting the clay or tills on the dry side of the optimum, the compactive energy will frequently bridge over the chunks in the soil and be transmitted laterally into the soil mantle. Therefore, the lifts of these soils must be limited to 20 cm or less (before compaction). It is difficult to monitor the lifts of backfill placed in deep trenches; therefore, it is preferable that the compaction of backfill at depths over 1.0 m below the road subgrade be carried out on the wet side of the optimum. This would allow a wider latitude of lift thickness.

One should be aware that with considerable effort, a 90%± Standard Proctor compaction of the wet sand and silts is achievable. Further densification is prevented by the pore pressure induced by the compactive effort; however, large random voids will have been expelled, and with time, the pore pressure will dissipate and the percentage of compaction will increase. There are many cases on record where after a few months of rest, the density of the compacted mantle has increased to over 95% of its maximum Standard Proctor dry density.

If the compaction of the soils is carried out with the water content within the range for 95% Standard Proctor dry density but on the wet side of the optimum, the surface of the compacted soil mantle will roll under the dynamic compactive load. This is unsuitable for road construction since each component of the pavement structure is to be placed under dynamic conditions which will induce the rolling action of the subgrade surface and cause structural failure of the new pavement. The foundations or bedding of the sewer and slab-on-grade will be placed on a subgrade which will not be subjected to impact loads. Therefore, the structurally compacted soil mantle, with the water content on the wet side or dry side of the optimum, will provide an adequate subgrade for the construction.

The presence of boulders in the tills will prevent transmission of the compactive energy into the underlying material to be compacted. If an appreciable amount of boulders over 15 cm in size is mixed with the material, it must either be sorted or must not be used for construction of engineered fill and/or structural backfill.

5.0 GROUNDWATER CONDITIONS

The boreholes were checked for the presence of groundwater or the occurrence of cave-in upon completion of the field work. In addition, the groundwater level in monitoring wells was recorded on January 31, 2018. The records are summarized in Table 2.

Table 2 - Groundwater Level

Borehole No.	Ground El. (m)	Groundwater in Boreholes/Monitoring Wells			
		Upon Completion		On January 31, 2018	
		Depth (m)	El. (m)	Depth (m)	El. (m)
2	295.8	1.2	294.6	No Well	
3	305.0	2.7	302.3	0.4	304.6
4	318.6	0.6	318.0	No Well	
5	332.2	4.8	327.4	No Well	
6	287.9	14.9	273.0	1.3	286.6
7	297.8	4.8	293.0	0.9	296.9
8	307.0	5.4	301.6	No Well	
9	321.9	14.6	307.3	7.4	314.5
10	332.6	3.6	329.0	0.2	332.4
11	291.4	1.2	290.2	1.1	290.3
12	303.0	4.8	298.2	No Well	
13	322.6	3.6	319.0	3.5	319.1
14	322.9	3.6	319.3	No Well	
15	333.6	2.7	330.9	No Well	

Upon the completion of borehole drilling, groundwater was recorded in the boreholes between El. 273.0 m and El. 330.9 m, dropping in the east southeast direction. The stabilized groundwater in the monitoring wells was recorded between El. 286.6 m and El. 332.4 m.

Groundwater within the saturated sand and silts generally represents the permanent groundwater regime at the site. Perched water also exists in certain areas at shallower depths. The groundwater level will fluctuate with seasons.

In excavations, groundwater yield from the tills and clay will be slow and limited in quantity, whereas the groundwater yield from the saturated sand and silt deposits will be appreciable and persistent.

Where groundwater seepage is encountered in the tills and clay, the groundwater can be controlled by pumping from sumps. However, where the excavation extends into the saturated/water bearing soils, dewatering from closely spaced sumps and/or a well-point system will be required.

6.0 DISCUSSION AND RECOMMENDATIONS

The investigation revealed that beneath a veneer of topsoil and ploughed soils, the site is generally underlain by a complex stratigraphy consisting of stiff to hard, generally very stiff silty clay; firm to hard, generally hard silty clay till and loose to very dense, generally compact silty sand till, with layers of loose to very dense, generally compact sand and compact to very dense, generally compact silt deposits at various depths and locations. The wet sand and silts are water-bearing.

Upon the completion of borehole drilling, groundwater was recorded in the boreholes between El. 273.0 m and El. 330.9 m, dropping in the east southeast direction. The stabilized groundwater in the monitoring wells was recorded between El. 286.6 m and El. 332.4 m. The groundwater within the saturated sand and silt generally represents the permanent groundwater regime at the site. Perched water also exists in certain areas at shallower depths. The groundwater level will fluctuate with seasons.

In excavation, groundwater yield from the clay and tills will be slow and limited in quantity, whereas the groundwater yield from the saturated sand and silts below the water level will be appreciable and persistent.

It is understood that the property will be developed into a residential subdivision. Detailed design of the development, however, is not available at the time this report is prepared. The geotechnical findings which warrant special consideration are presented below:

1. The topsoil and ploughed soil must be removed for the development. The thickness of topsoil and ploughed soil may vary or becomes thicker in some areas, especially in the treed areas and depressed areas. In order to prevent

overstripping, a diligent control of the stripping operation will be required. A test pit programme can be carried out prior to or during construction to determine the thickness of the topsoil and ploughed soils.

2. The topsoil is void of engineering value. It must not be buried within the building envelope or deeper than 1.2 m below the exterior finished grade of the development. It can only be used for landscaping and landscape contouring purposes.
3. The weathered soils are not suitable to support any structure sensitive to movement. They must be subexcavated and sorted free of topsoil inclusions or deleterious materials before it is reused as engineered fill or structural backfill.
4. The sound natural soils below the topsoil, ploughed soil, and weathered soils, are suitable for normal spread and strip footing construction for the proposed buildings. The footings must be designed in accordance with the recommended bearing pressures in Section 6.1 and the footing subgrade must be inspected by a geotechnical engineer to ensure that its condition is compatible with the design of the foundations.
5. The footings must be maintained at least 0.5 m above the groundwater levels. If groundwater seepage is encountered during excavation, or where the subgrade of the normal foundations is found to be wet, the subgrade should be protected by a concrete mud-slab immediately after exposure. Dewatering may be required prior to and during construction.
6. Where earth fill is required to raise the site, or where extended footings are necessary, it is generally more economical to place engineered fill for normal footing, sewer and road construction.
7. A Class 'B' bedding, consisting of compacted 20-mm Crusher-Run Limestone, or equivalent, is recommended for the construction of the underground services. The pipe joints should be leak proof or wrapped with a

waterproof membrane. Where saturated soils are present or extensive dewatering is required, a Class 'A' bedding will be required.

8. All excavation should be carried out in accordance with Ontario Regulation 213/91.

The recommendations appropriate for the project described in Section 2.0 are presented herein. One must be aware that the subsurface conditions may vary between boreholes. Should this become apparent during construction, a geotechnical engineer must be consulted to determine whether the following recommendations require revision.

6.1 **Foundations**

It is assumed that the site will be regraded for the proposed development. It is generally more economical to place engineered fill for normal footing, sewer and pavement construction. Soil bearing pressures of 150 kPa (SLS) and 250 kPa (ULS) are recommended for the design of building foundations, consisting of normal spread and strip footings founded on the engineered fill or on the sound native soil stratum. The requirements for engineered fill construction are discussed in Section 6.2.

The appropriate founding levels in the natural soils range from 1.0± to 2.5± m from the prevailing ground surface, depending on the location.

The recommended soil pressures (SLS) incorporate a safety factor of 3. The total and differential settlements of the footings are estimated to be 25 mm and 15 mm, respectively.

One must be aware that the recommended bearing pressures are given as a guide for foundation design and the soils at the bearing level must be confirmed by inspection performed by a geotechnical engineer at the footing locations, at the time of construction.

If groundwater seepage is encountered during excavations, or where the subgrade of the normal foundations is found to be wet, the subgrade should be protected by a concrete mud-slab immediately after exposure. This will prevent construction disturbance and costly rectification.

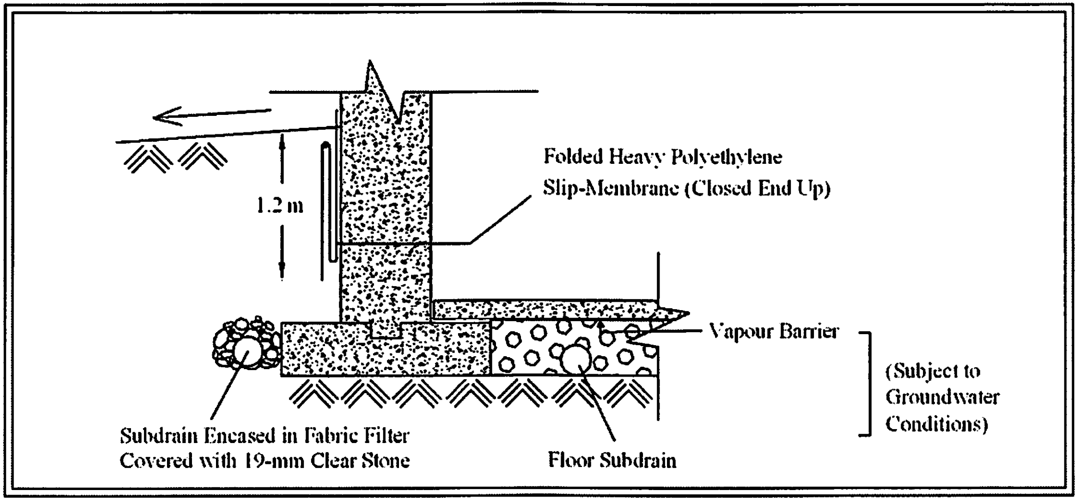
Footings exposed to weathering, or in unheated areas, should have at least 1.2 m of earth cover for protection against frost action.

The building foundation must meet the requirements specified in the latest Ontario Building Code. As a guide, the structure should be designed to resist an earthquake force using Site Classification 'D' (stiff soil).

Higher design bearing pressures of 200 to 300 kPa (SLS) and 320 to 480 kPa (ULS) are available in some locations, having the footings extending into the undisturbed sound native soil stratum at deeper levels. The allowable soil bearing pressures can be provided for individual structures, if necessary, at the time the design of the development and the site grading plan are finalized.

Most of the in situ soils have high soil-adfreezing potential. In order to alleviate the risk of frost damage, the foundation walls of the proposed buildings must be constructed of concrete and either the backfill must consist of non-frost-susceptible granular material or the foundation walls must be shielded with a polyethylene slip-membrane between the concrete wall and the backfill. The recommended measures are schematically illustrated in Diagram 1.

Diagram 1 - Frost Protection Measures



Perimeter subdrains and dampproofing of the foundation walls will be required for the project construction. If wet silt or sand is encountered at the basement subgrade, under-floor subdrains and vapour barrier will be required. All subdrains must be encased in a fabric filter to protect them against blockage by silting.

6.2 Engineered Fill

Where earth fill is required to raise the site, or where extended footings are necessary, it is generally more economical to place engineered fill for normal footing, sewer and road construction. The engineering requirements for a certifiable fill for road construction, municipal services, and footings designed with a Maximum Allowable Soil Pressure (SLS) of 150 kPa and a Factored Ultimate Soil Bearing Pressure (ULS) of 250 kPa are presented below:

1. All of the topsoil and the ploughed soils must be removed, and the subgrade must be inspected and proof-rolled prior to any fill placement.

2. The weathered soils must be subexcavated, inspected, aerated and properly compacted in layers.
3. Inorganic soils must be used for filling, and they must be uniformly compacted in lifts 20 cm thick to 98% or + of their maximum Standard Proctor dry density up to the proposed finished lot grade and/or road subgrade. The soil moisture must be properly controlled between 1% drier than optimum and 2% wetter than optimum. This is to prevent the development of excess pore-water pressures in the earth fill, which results in longer duration for pore-water pressure dissipation and ground settlement. If the site services or house foundations are to be built soon after the fill placement, the densification process for the engineered fill must be increased to 100% of the maximum Standard Proctor compaction.
4. If imported fill is to be used, it should be inorganic soils, free of deleterious or any material with environmental issue (contamination). Any potential imported earth fill from off site must be reviewed for geotechnical and environmental quality by the appropriate personnel as authorized by the developer or agency, before being hauled to the site.
5. In areas where significant engineered fill (fill more than 3.0 m) is to be placed, settlement plates must be installed and monitored on a weekly basis to assess any consolidation progress in the fill and the underlying strata. No construction of site services or house foundations can commence in these areas until the settlement records have confirmed that the settlement is reduced to a tolerable level and there is no risk of long term settlement. Where the readings remain the same for a period of 3 consecutive months, no further monitoring will be required and there is no risk for long-term settlement. The settlement of the engineered fill is anticipated to be reduced to a tolerable limit of 25 mm.
6. If the engineered fill is to be left over the winter months, adequate earth cover, or equivalent, must be provided for protection against frost action.

7. The engineered fill must extend over the entire graded area; the engineered fill envelope and the finished elevations must be clearly and accurately defined in the field, and must be precisely documented by qualified surveyors.
8. The engineered fill must not be placed during the period from late November to early April, when freezing ambient temperatures occur either persistently or intermittently. This is to ensure that the fill is free of frozen soils, ice and snow.
9. Where the ground is wet due to subsurface water seepage, an appropriate subdrain scheme must be implemented prior to the fill placement, particularly if it is to be carried out on sloping ground.
10. Where the fill is to be placed on a bank steeper than 1 vertical (V): 3 horizontal (H), the face of the bank must be flattened to 3+ so that it is suitable for safe operation of the compactor and the required compaction can be obtained.
11. The fill operation must be inspected on a full-time basis by a technician under the direction of a geotechnical engineer. In this case, the effect of long-term settlement is expected to be negligible as the fill material will be compacted to achieve an appropriate strength and capacity for structural support.
12. The footing and underground services subgrade must be inspected by the geotechnical consulting firm that inspected the engineered fill placement. This is to ensure that the foundations are placed within the engineered fill envelope, and the integrity of the fill has not been compromised by interim construction, environmental degradation and/or disturbance by the footing excavation.
13. Once the engineered fill is certified, any excavation carried out in the certified fill area must be reported to the geotechnical consultant who inspected the fill placement, in order to document the locations of excavation and/or to inspect reinstatement of the excavated areas to engineered fill status. If construction

on the engineered fill does not commence within a period of 2 years from the date of certification, the status must be assessed for re-certification.

14. Despite stringent control in the placement of engineered fill, variations in soil type and density may occur in the engineered fill. Therefore, the strip footings and the upper section of the foundation walls constructed on the engineered fill may require continuous reinforcement with steel bars, depending on the uniformity of the soils in the engineered fill and the thickness of the engineered fill underlying the foundations. Should the footings and/or walls require reinforcement, the required number and size of reinforcing bars must be assessed by considering the uniformity as well as the thickness of the engineered fill beneath the foundations. In sewer construction, the engineered fill is considered to have the same structural proficiency as a natural inorganic soil.

6.3 Underground Services

The subgrade for the underground services should consist of natural soils or engineered fill. In areas where the subgrade consists of ploughed and/or weathered soil, these soils should be subexcavated and replaced with properly compacted inorganic soil and/or bedding material compacted to at least 95% or + of their Standard Proctor compaction.

Where the sewers are to be constructed using the open-cut method, the construction must be carried out in accordance with Ontario Regulation 213/91. In areas where a vertical cut is necessary, the use of a trench box is considered to be appropriate. In the design of the trench box and/or shoring structure, the recommended lateral earth pressure coefficients presented in Table 4, Section 6.7, can be used.

A Class 'B' bedding is recommended for construction of the underground services. The bedding material should consist of compacted 20-mm Crusher-Run Limestone, or equivalent, as approved by a geotechnical engineer. Where saturated soils are present or extensive dewatering is required, a Class 'A' bedding will likely be required, and the pipe joints should be leak proof or wrapped with a waterproof membrane.

In order to prevent pipe floatation when the sewer trench is deluged with water, a soil cover with a thickness equal to the diameter of the pipe should be in place at all times after completion of the pipe installation.

Openings to subdrains and catch basins should be shielded with a fabric filter to prevent blockage by silting.

The subgrade soils of the underground services have an electrical resistivity ranging from 3000 to 6000 ohm·cm. These soils are considered corrosive to ductile iron pipes and metal fittings; therefore, the underground services should be protected against soil corrosion. For estimation of anode weight requirements, the estimated electrical resistivity of 3000 ohm·cm can be used. This, however, should be confirmed by testing the soil along the water main alignment at the time of sewer construction.

6.4 Backfilling in Trenches and Excavated Areas

The backfill in service trenches should be compacted to at least 95% of its maximum Standard Proctor dry density and increased to 98% or + below the floor slab. In the zone within 1.0 m below the road subgrade, the material should be compacted with the water content 2% to 3% drier than the optimum; and the compaction should be increased to 98% of the respective maximum Standard Proctor dry density to provide the required stiffness for pavement construction.

The tills and clay are suitable for 95% or + Standard Proctor compaction. The sands and silts are too wet for a 95% or + Standard Proctor compaction, it can be aerated by spreading it thinly on the ground for drying prior to structural compaction or it can be mixed with drier soils.

In normal construction practice, the problem areas of settlement largely occur adjacent to foundation walls, columns, manholes, catch basins and services crossings. In areas which are inaccessible to a heavy compactor, sand backfill should be used. Unless compaction of the backfill is carefully performed, settlement will occur. Often, the interface of the native soils and sand backfill will have to be flooded for a period of several days.

Narrow trenches for services crossings should be cut at 1V:2H, so that the backfill in the trenches can be effectively compacted. Otherwise, soil arching in the trenches will prevent the achievement of proper compaction. The lift of each backfill layer should be limited to a thickness of 20 cm.

One must be aware of possible consequences during trench backfilling and exercise caution as described below:

- When construction is carried out in freezing winter weather, allowance should be made for these following conditions. Despite stringent backfill monitoring, frozen soil layers may inadvertently be mixed with the structural trench backfill. Should the in situ soil have a water content on the dry side of the optimum, it would be impossible to wet the soil due to the freezing condition, rendering difficulties in obtaining uniform and proper compaction. Furthermore, the freezing condition will prevent flooding of the backfill when it is required, such as when the trench box is removed. The above will invariably cause backfill settlement that may become evident within 1 to several years, depending on the depth of the trench which has been backfilled.

- In areas where the underground services construction is carried out during winter months, prolonged exposure of the trench walls will result in frost heave within the soil mantle of the walls. This may result in some settlement as the frost recedes, and repair costs will be incurred prior to final surfacing of the new pavement.
- To backfill a deep trench, one must be aware that future settlement is to be expected, unless the side of the cut is flattened to at least 1V:1.5+H, and the lifts of the fill and its moisture content are stringently controlled; i.e., lifts should be no more than 20 cm (or less if the backfilling conditions dictate) and uniformly compacted to achieve at least 95% of the maximum Standard Proctor dry density, with the moisture content on the wet side of the optimum.
- It is often difficult to achieve uniform compaction of the backfill in the lower vertical section of a trench which is an open cut or is stabilized by a trench box, particularly in the sector close to the trench walls or the sides of the box. These sectors must be backfilled with sand. In a trench stabilized by a trench box, the void left after the removal of the box will be filled by the backfill. It is necessary to backfill this sector with sand, and the compacted backfill must be flooded for 1 day, prior to the placement of the backfill above this sector, i.e., in the upper sloped trench section. This measure is necessary in order to prevent consolidation of inadvertent voids and loose backfill which will compromise the compaction of the backfill in the upper section. In areas

where groundwater movement is expected in the sand fill mantle, anti-seepage collars should be provided.

6.5 Garages, Driveways and Landscaping

Due to high frost susceptibility of the subgrade soils, heaving of the pavement is expected to occur during the cold weather.

The driveways at the entrances to the garages must be backfilled with non-frost-susceptible granular material, with a frost taper at a slope flatter than 1V:3H.

The slab-on-grade in open areas should be designed to tolerate frost heave, and the grading around the slab-on-grade must be such that it directs runoff away from the surface.

Interlocking stone pavement and slab-on-grade to be constructed in areas susceptible to ground movement must be constructed on a free-draining granular base at least 1.0 m thick, with proper drainage, which will prevent water from ponding in the granular base.

6.6 Pavement Design

The recommended pavement design for local and collector roads is presented in Table 3.

Table 3 - Pavement Design

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	40	HL-3
Asphalt Binder	50	HL-8
Granular Base	150	Granular 'A' or equivalent
Granular Sub-base		Granular 'B' or equivalent
Local	350	
Collector	450	

In preparation of the subgrade, the topsoil, weathered soils and ploughed soils must be removed. Any new fill should consist of organic free material, compacted to 95% or + of its maximum Standard Proctor dry density. In the zone within 1.0 m below the pavement subgrade, the backfill should be compacted to at least 98% of its maximum Standard Proctor dry density, with the water content 2% to 3% drier than the optimum. The final subgrade should be inspected and proof-rolled. Any soft spots should be subexcavated, and replaced by properly compacted inorganic earth fill.

All the granular bases should be compacted to their maximum Standard Proctor dry density.

The pavement subgrade will suffer a strength regression if water is allowed to infiltrate prior to paving. The following measures should therefore be incorporated into the construction and road design:

- If the pavement construction does not immediately follow the trench backfilling, the subgrade should be properly crowned and smooth-rolled to allow interim precipitation to be properly drained.

- Lot areas adjacent to the pavement should be properly graded to prevent the ponding of large amounts of water during the interim construction period.
- If the pavement is to be constructed during the wet seasons and extremely soft subgrade occurs, the granular sub-base may require thickening. This can be further assessed during construction.
- Fabric filter-encased curb subdrains are required to meet the Town's requirements.

6.7 Soil Parameters

The recommended soil parameters for the project design are given in Table 4.

Table 4 - Soil Parameters

Unit Weight and Bulk Factor

	Unit Weight (kN/m^3)		Estimated Bulk Factor	
	Bulk	**Submerged**	**Loose**	**Compacted**
Silty Clay	20.0	10.0	1.33	0.98
Silty Clay Till	22.0	12.0	1.30	1.00
Silty Sand Till	22.5	12.5	1.20	1.00
Sand and Silts	21.0	11.0	1.20	1.00

Lateral Earth Pressure Coefficients

	Active K_a	**At Rest** K_o	**Passive** K_p
Silty Clay and Silty Clay Till	0.40	0.55	2.50
Silty Sand Till, Sand and Silts	0.33	0.45	3.00

Coefficients of Friction

Between Concrete and Granular Base	0.5
Between Concrete and Sound Native Soils	0.4

6.8 Excavation

Excavation should be carried out in accordance with Ontario Regulation 213/91. For excavation purposes, the types of soils are classified in Table 5.

Table 5 - Classification of Soils for Excavation

Material	Type
Sound Silty Clay and Tills	2
Weathered Soils, drained Sand and Silts	3
Ploughed soils and saturated Sand and Silts	4

In excavations, groundwater yield from the tills and clay will be slow and limited in quantity, whereas the groundwater yield from the saturated sand and silts layers will be appreciable and likely persistent.

Where groundwater seepage is encountered in the tills and clay, the groundwater can be removed by pumping from sumps. However, where the excavation extends into the saturated/water-bearing soils, dewatering from closely spaced sumps and/or a well-point system will be required.

Prospective contractors must be asked to assess the in situ subsurface conditions for soil cuts by digging test pits to at least 0.5 m below the sewer subgrade. These test pits should be allowed to remain open for a period of at least 4 hours to assess the trenching conditions.

7.0 LIMITATIONS OF REPORT

This report was prepared by Soil Engineers Ltd. for the account of Bridge Brook Corp., for review by its designated consultants, financial institutions, and government agencies. Use of this report is subject to the conditions and limitations of the contractual agreement. The material in the report reflects the judgement of Kin Fung Li, B.Eng., and Daniel Man, P.Eng., in light of the information available to it at the time of preparation. Any use which a Third Party makes of this report, or any reliance on decisions to be made based on it, are the responsibility of such Third Parties. Soil Engineers Ltd. accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

SOIL ENGINEERS LTD.

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D.S.C. MAN
28853117
Feb 18/18
PROVINCE OF ONTARIO

LIST OF ABBREVIATIONS AND DESCRIPTION OF TERMS

The abbreviations and terms commonly employed on the borehole logs and figures, and in the text of the report, are as follows:

SAMPLE TYPES

AS	Auger sample
CS	Chunk sample
DO	Drive open (split spoon)
DS	Denison type sample
FS	Foil sample
RC	Rock core (with size and percentage recovery)
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

PENETRATION RESISTANCE

Dynamic Cone Penetration Resistance:

A continuous profile showing the number of blows for each foot of penetration of a 2-inch diameter, 90° point cone driven by a 140-pound hammer falling 30 inches.

Plotted as '—•—'

Standard Penetration Resistance or 'N' Value:

The number of blows of a 140-pound hammer falling 30 inches required to advance a 2-inch O.D. drive open sampler one foot into undisturbed soil.

Plotted as '○'

WH	Sampler advanced by static weight
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
NP	No penetration

SOIL DESCRIPTION

Cohesionless Soils:

'N' (blows/ft)	Relative Density
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

Cohesive Soils:

Undrained Shear Strength (ksf)	'N' (blows/ft)	Consistency
less than 0.25	0 to 2	very soft
0.25 to 0.50	2 to 4	soft
0.50 to 1.0	4 to 8	firm
1.0 to 2.0	8 to 16	stiff
2.0 to 4.0	16 to 32	very stiff
over 4.0	over 32	hard

Method of Determination of Undrained Shear Strength of Cohesive Soils:

x 0.0 Field vane test in borehole; the number denotes the sensitivity to remoulding

△ Laboratory vane test

☐ Compression test in laboratory

For a saturated cohesive soil, the undrained shear strength is taken as one half of the undrained compressive strength

METRIC CONVERSION FACTORS

1 ft = 0.3048 metres
1lb = 0.454 kg
1 inch = 25.4 mm
1ksf = 47.88 kPa

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CONSULTING ENGINEERS
GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE

JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 1

FIGURE NO.: 1

PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING:

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE:

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES			Depth Scale (m)	● Dynamic Cone (blows/30 cm) 10 30 50 70 90 ✕ Shear Strength (kN/m²) 50 100 150 200 ○ Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL ├──┤ LL ● Moisture Content (%) 10 20 30 40	WATER LEVEL
		Number	Type	N-Value				
0.0								
	CANCELLED DUE TO ACCESS ISSUE				0 1 2 3 4 5 6 7 8 9 10			

Soil Engineers Ltd.

JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 2

FIGURE NO.: 2

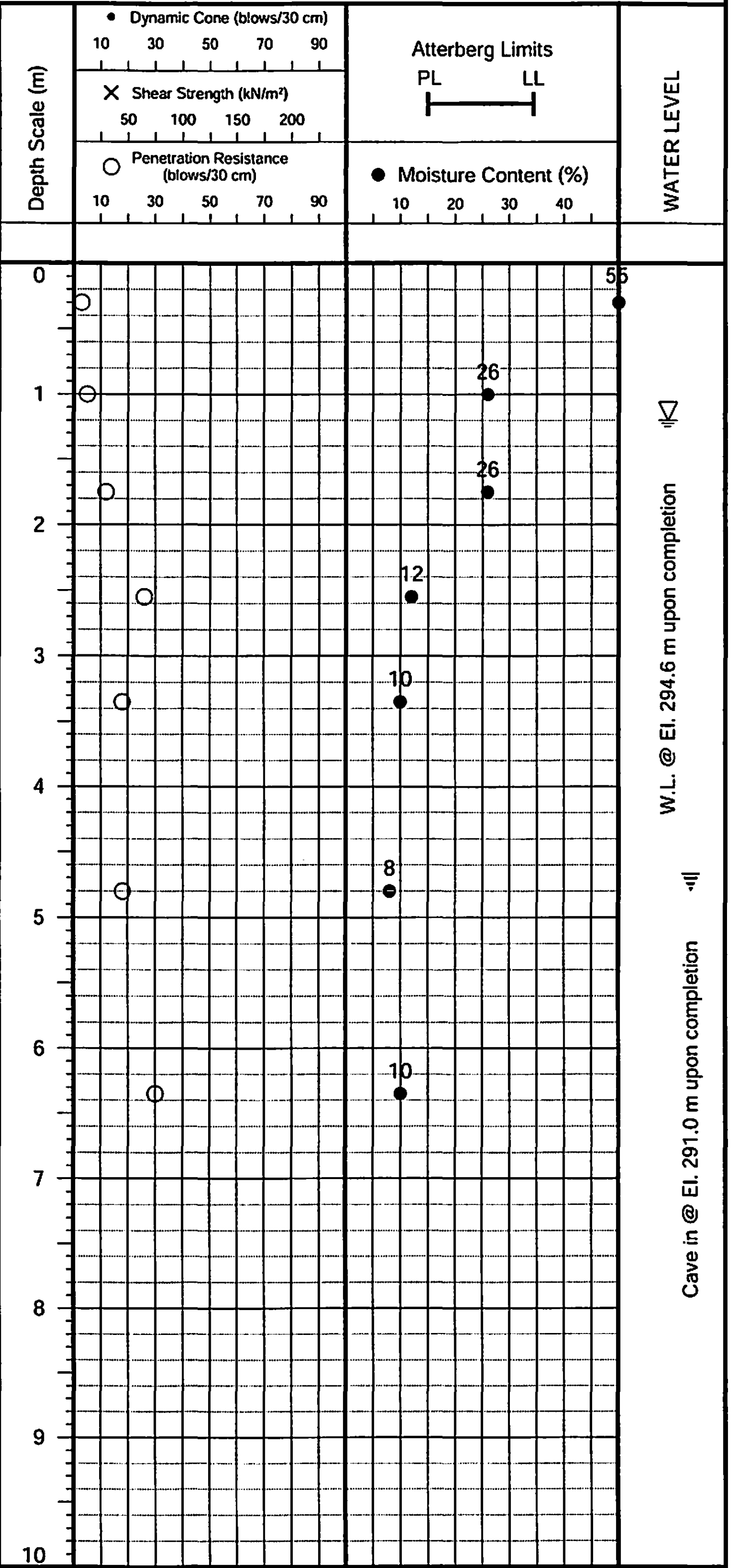
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: December 20, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES		
		Number	Type	N-Value
295.8	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	3
		2	DO	5
294.6 1.2	Brown, stiff **SILTY CLAY**	3	DO	12
293.5 2.3	Compact **SILTY SAND TILL** some gravel a trace of clay	4	DO	26
		5	DO	18
	brown grey	6	DO	18
290.3 5.5	Grey, dense **SILT** some sand a trace of clay	7	DO	30
289.2 6.6	**END OF BOREHOLE**			



Soil Engineers Ltd.

JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 3

FIGURE NO.: 3

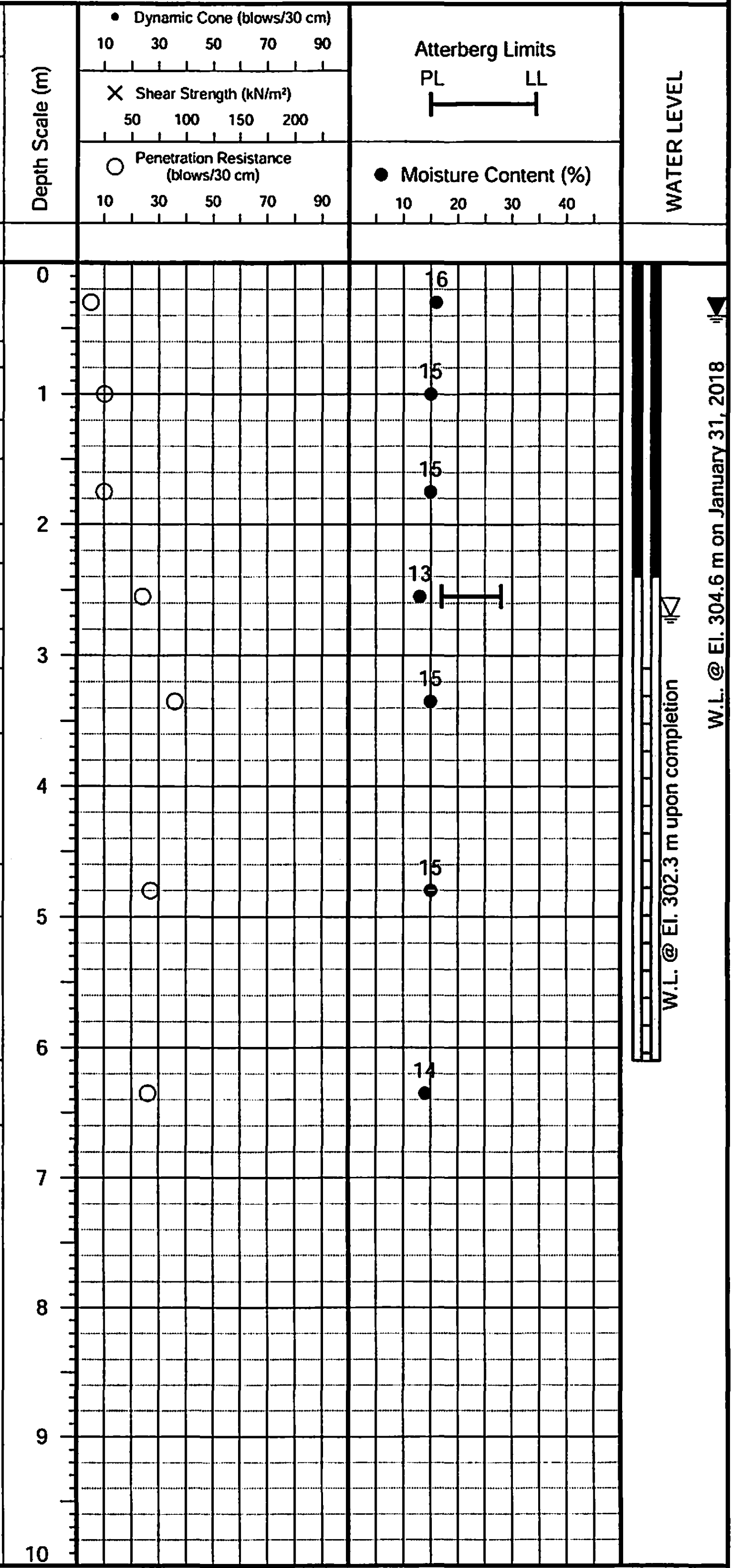
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: December 15, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
305.0	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	5
304.0 1.0	Stiff to hard	2	DO	10
	SILTY CLAY TILL			
	sandy a trace of gravel	3	DO	10
		4	DO	24
		5	DO	36
	brown grey	6	DO	27
		7	DO	26
298.4 6.6	**END OF BOREHOLE**			



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JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 4

FIGURE NO.: 4

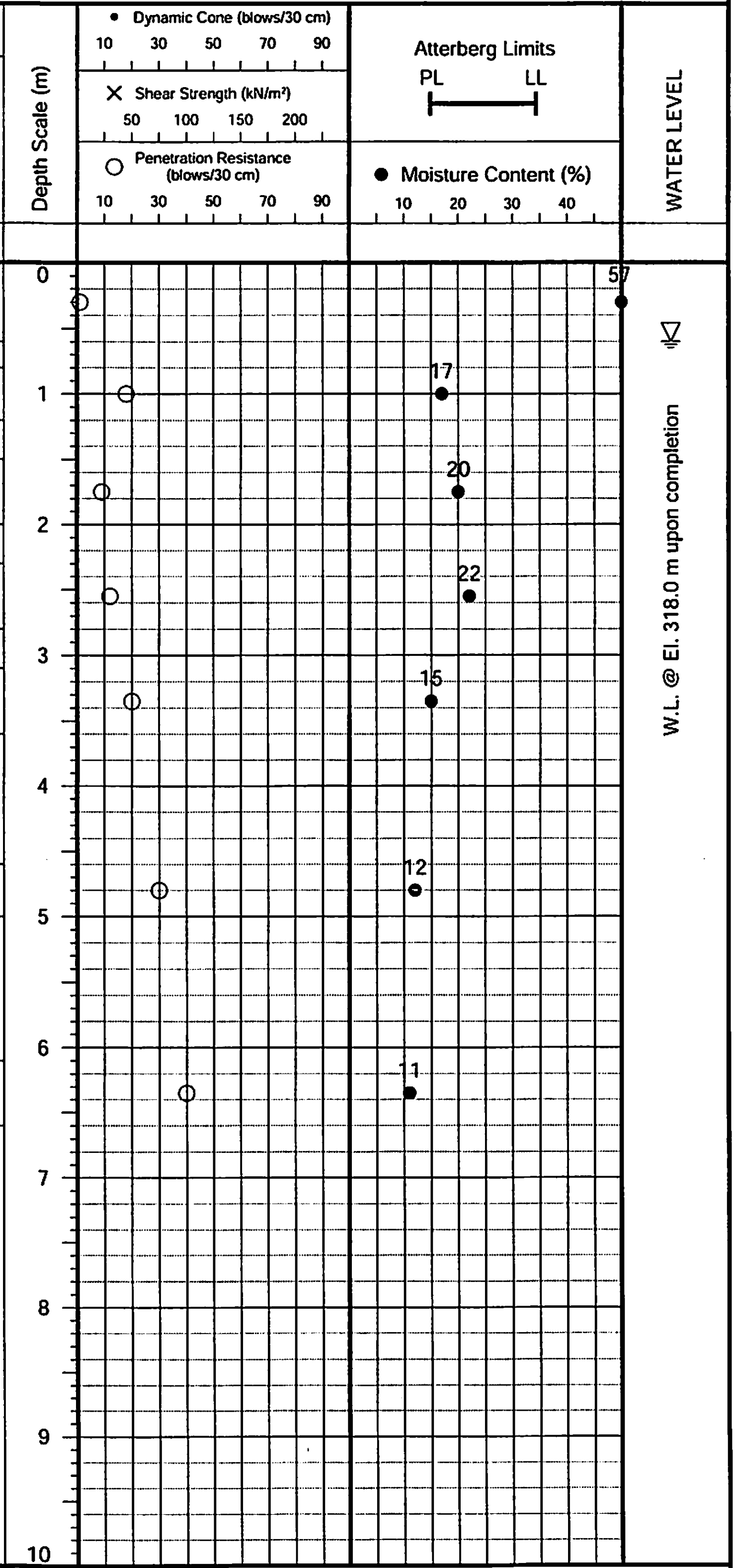
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: December 21, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
318.6	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	1
317.8 0.8	Brown, compact **SANDY SILT**	2	DO	18
317.1 1.5	occ. topsoil inclusion Brown, loose to compact **SAND** fine to medium grained	3	DO	9
		4	DO	12
315.5 3.1	Very stiff to hard **SILTY CLAY TILL** some sand a trace of gravel	5	DO	20
	brown grey	6	DO	30
		7	DO	40
312.0 6.6	**END OF BOREHOLE**			



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JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 5

FIGURE NO.: 5

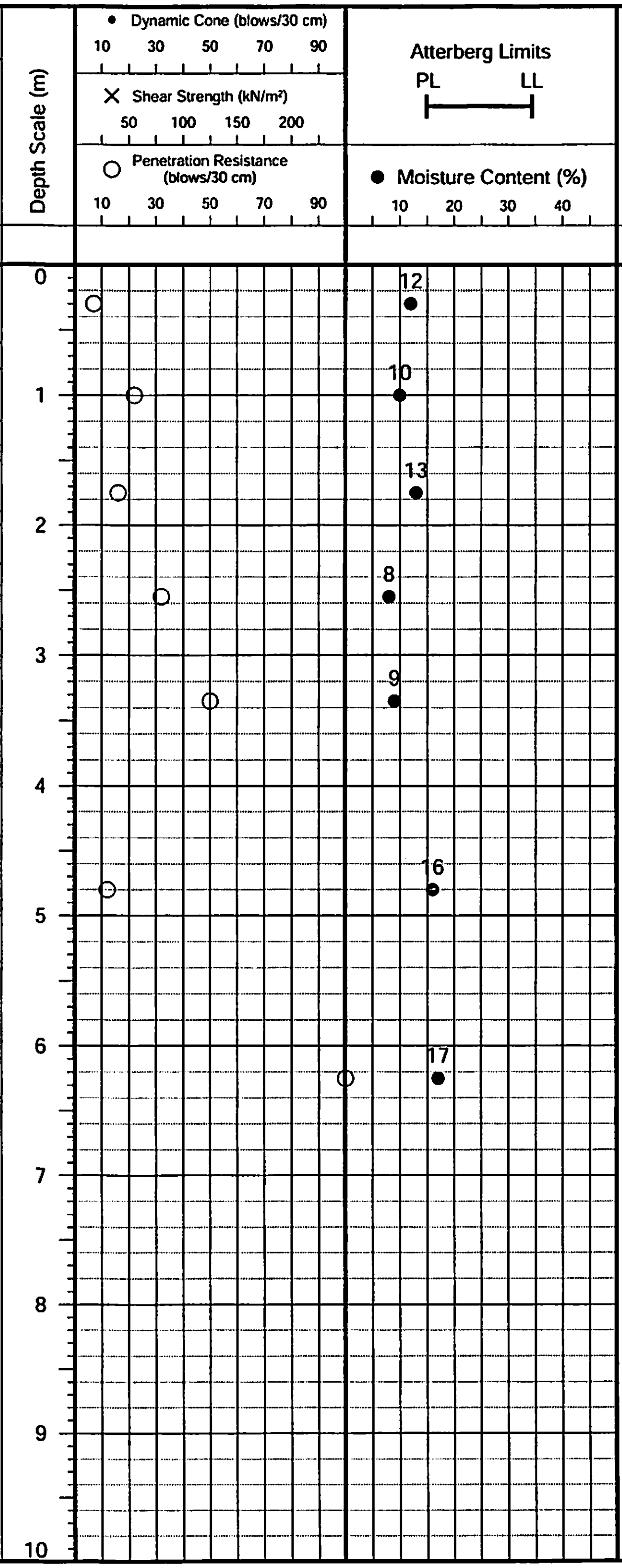
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: December 21, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
332.2	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	7
331.4 0.8	Brown, compact to very dense **SILTY SAND TILL** some clay a trace of gravel sandy silt layer	2	DO	22
		3	DO	16
		4	DO	32
		5	DO	50
328.2 4.0	Brown, compact to very dense **SAND** fine to medium grained	6	DO	12
		7	DO	50/15
325.8 6.4	**END OF BOREHOLE**			



WATER LEVEL

∇ W.L. @ El. 327.4 m upon completion

Soil Engineers Ltd.

JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 6

FIGURE NO.: 6

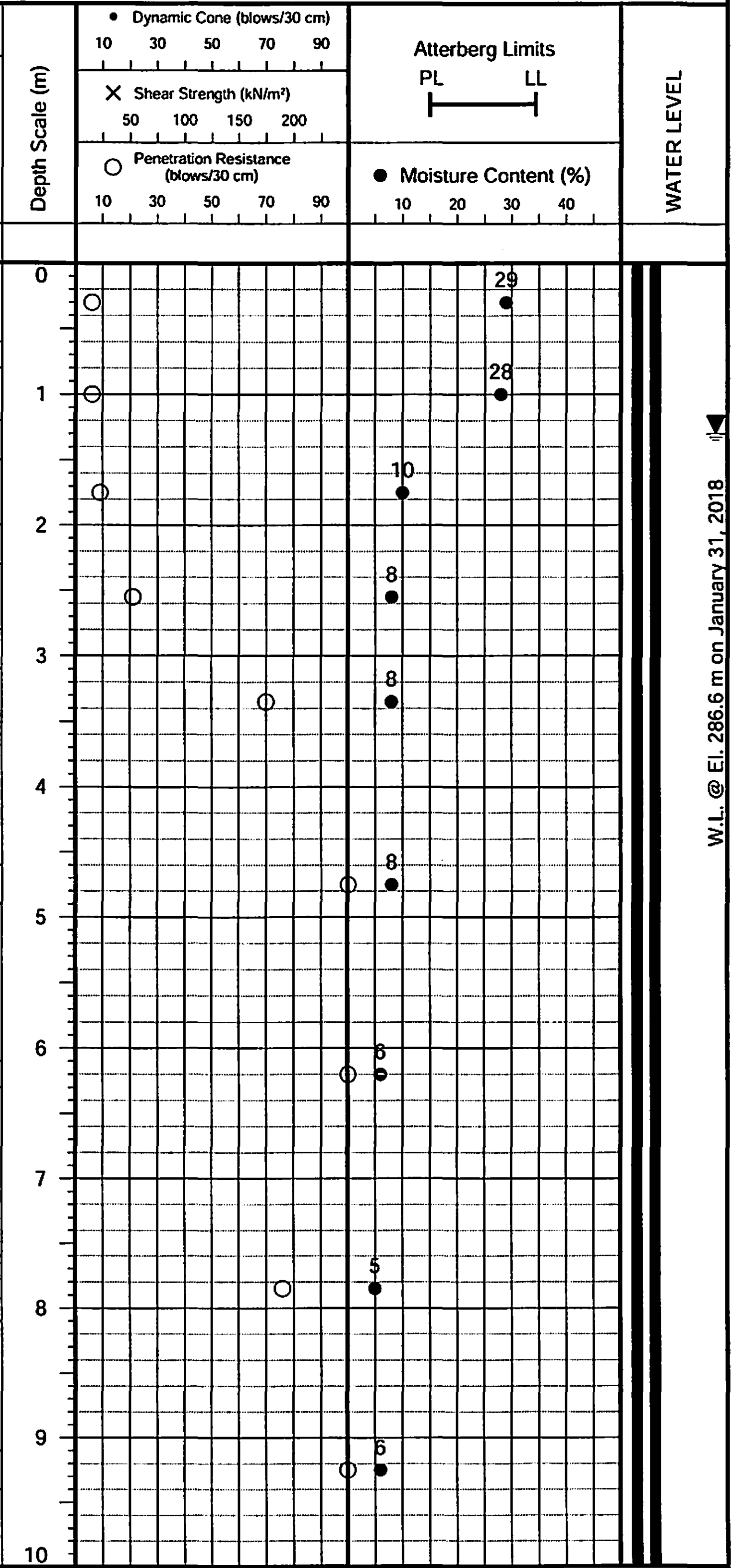
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: December 12, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
287.9	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	6
		2	DO	6
286.4 1.5	Brown, loose to very dense **SILTY SAND TILL** some gravel a trace of clay	3	DO	9
		4	DO	21
	occ. cobbles and boulders	5	DO	70
283.9 4.0	Grey, hard **SILTY CLAY TILL** sandy some gravel occ. cobbles and boulders	6	DO	50/15
		7	DO	50/15
		8	DO	76
		9	DO	50/10
277.9				



W.L. @ El. 286.6 m on January 31, 2018

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Page: 1 of 2

JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 6

FIGURE NO.: 6

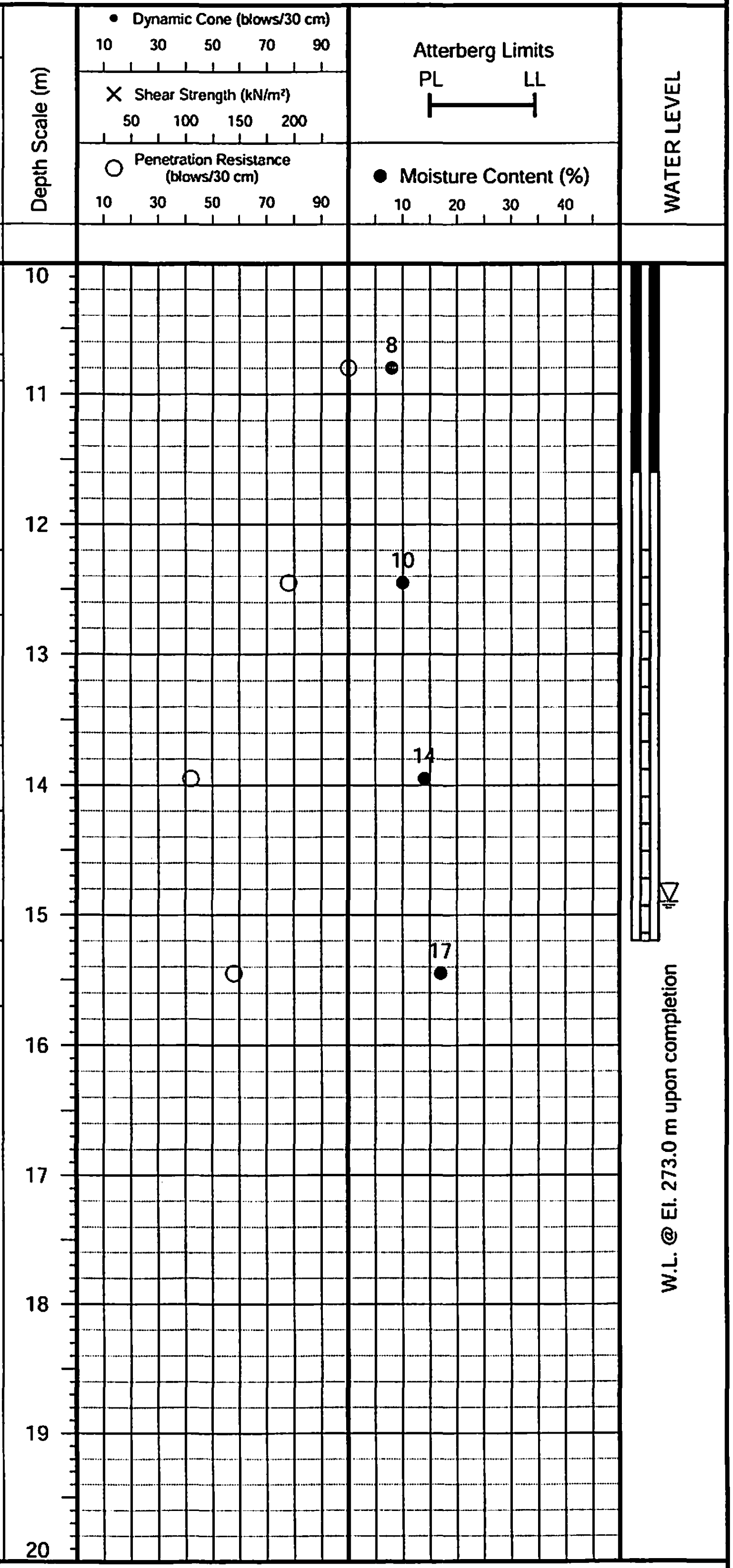
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: December 12, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
10.0	Grey, hard **SILTY CLAY TILL** sandy some gravel occ. cobbles and boulders	10	DO	50/15
		11	DO	78
		12	DO	42
		13	DO	58
272.2 15.7	**END OF BOREHOLE**			



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JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 7

FIGURE NO.: 7

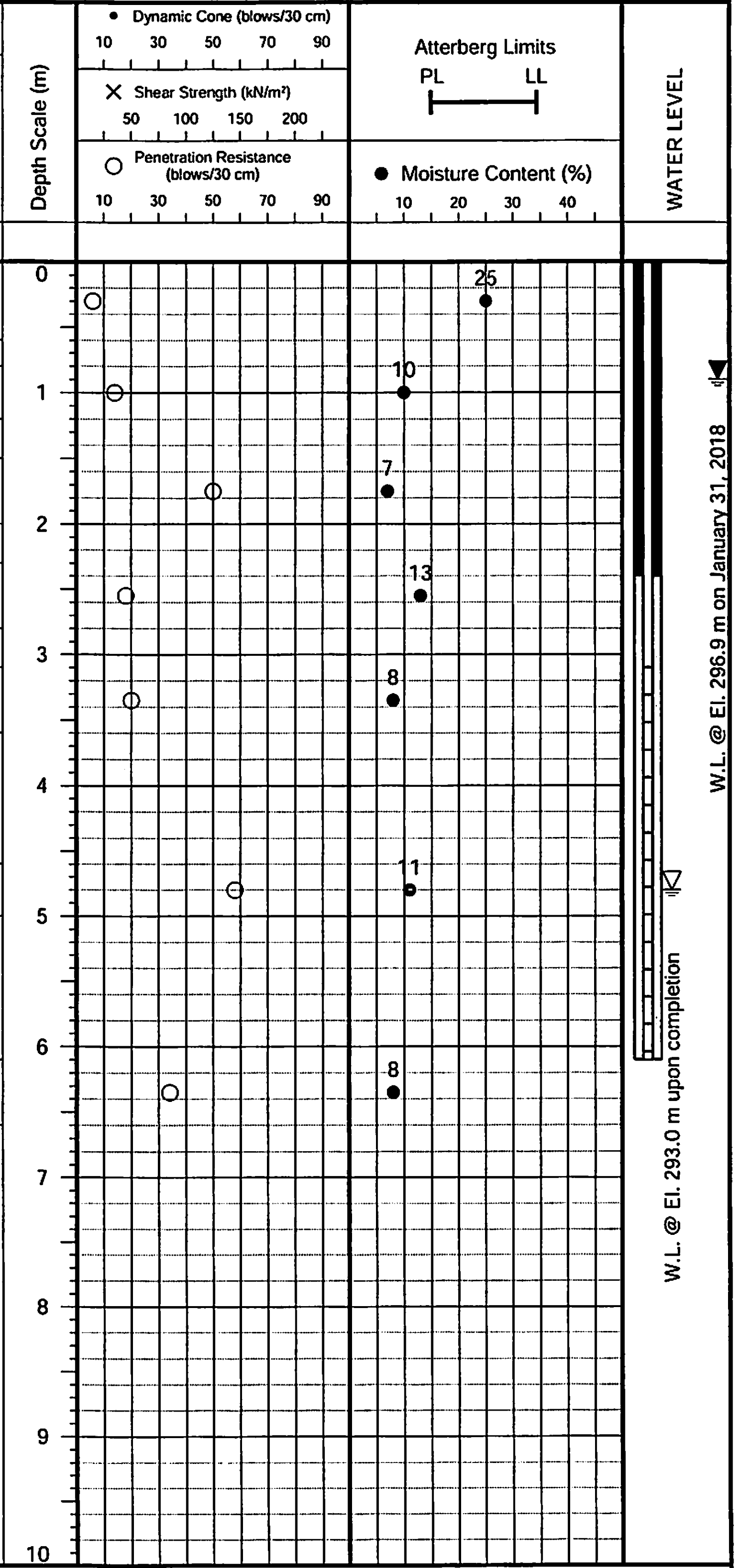
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: December 15, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES		
		Number	Type	N-Value
297.8	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	6
297.0 0.8	Brown, stiff to hard **SILTY CLAY TILL** sandy some gravel occ. cobbles and sand layer	2	DO	14
		3	DO	50
295.5 2.3	Brown, compact to very dense **SILTY SAND TILL** some gravel a trace of clay	4	DO	18
		5	DO	20
		6	DO	58
		7	DO	34
291.2 6.6	**END OF BOREHOLE**			



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Page: 1 of 1

JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 8

FIGURE NO.: 8

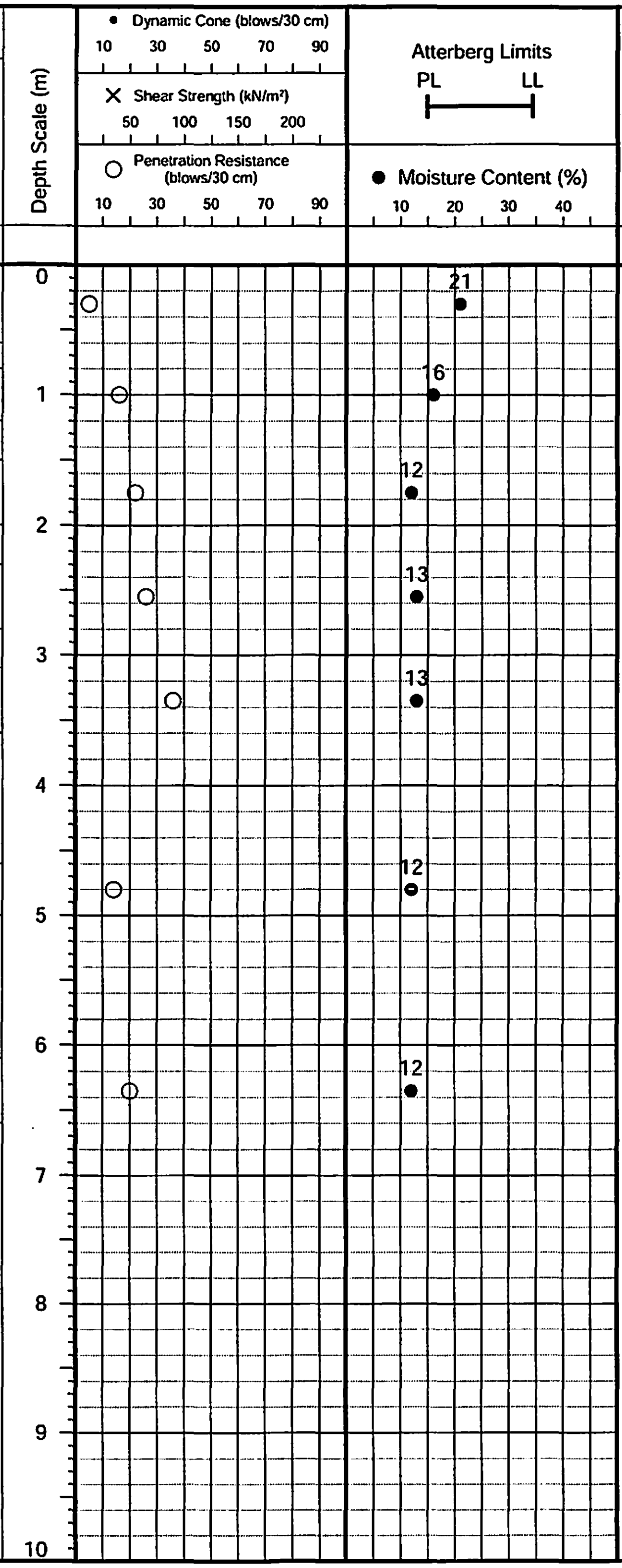
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: December 15, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
307.0	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	5
306.0 1.0	Stiff to hard **SILTY CLAY TILL** sandy a trace of gravel	2	DO	16
		3	DO	22
		4	DO	26
		5	DO	36
	brown grey	6	DO	14
		7	DO	20
300.4 6.6	**END OF BOREHOLE**			



WATER LEVEL

∇

W.L. @ El. 301.6 m upon completion

Soil Engineers Ltd.

JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 9

FIGURE NO.: 9

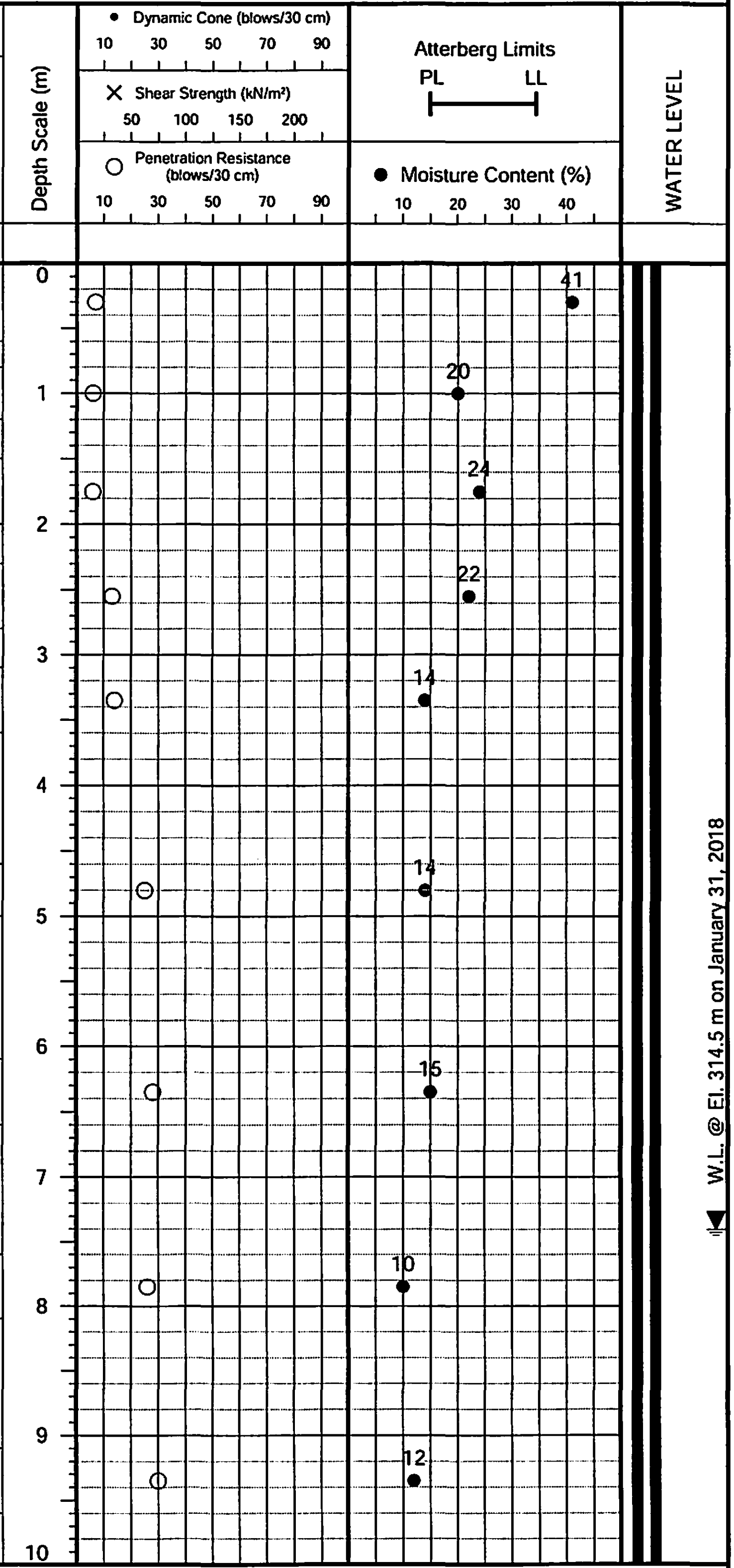
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: December 20, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
321.9	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	7
321.3 0.6	Brown, firm to stiff **SILTY CLAY TILL** traces of sand and gravel	2	DO	6
	weathered	3	DO	6
		4	DO	13
318.8 3.1	Stiff to very stiff **SILTY CLAY**	5	DO	14
		6	DO	25
	brown grey	7	DO	28
314.3 7.6	Grey, very stiff to hard **SILTY CLAY TILL** some sand a trace of gravel occ. cobbles and boulders	8	DO	26
		9	DO	30
311.9				



Soil Engineers Ltd.

JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 9

FIGURE NO.: 9

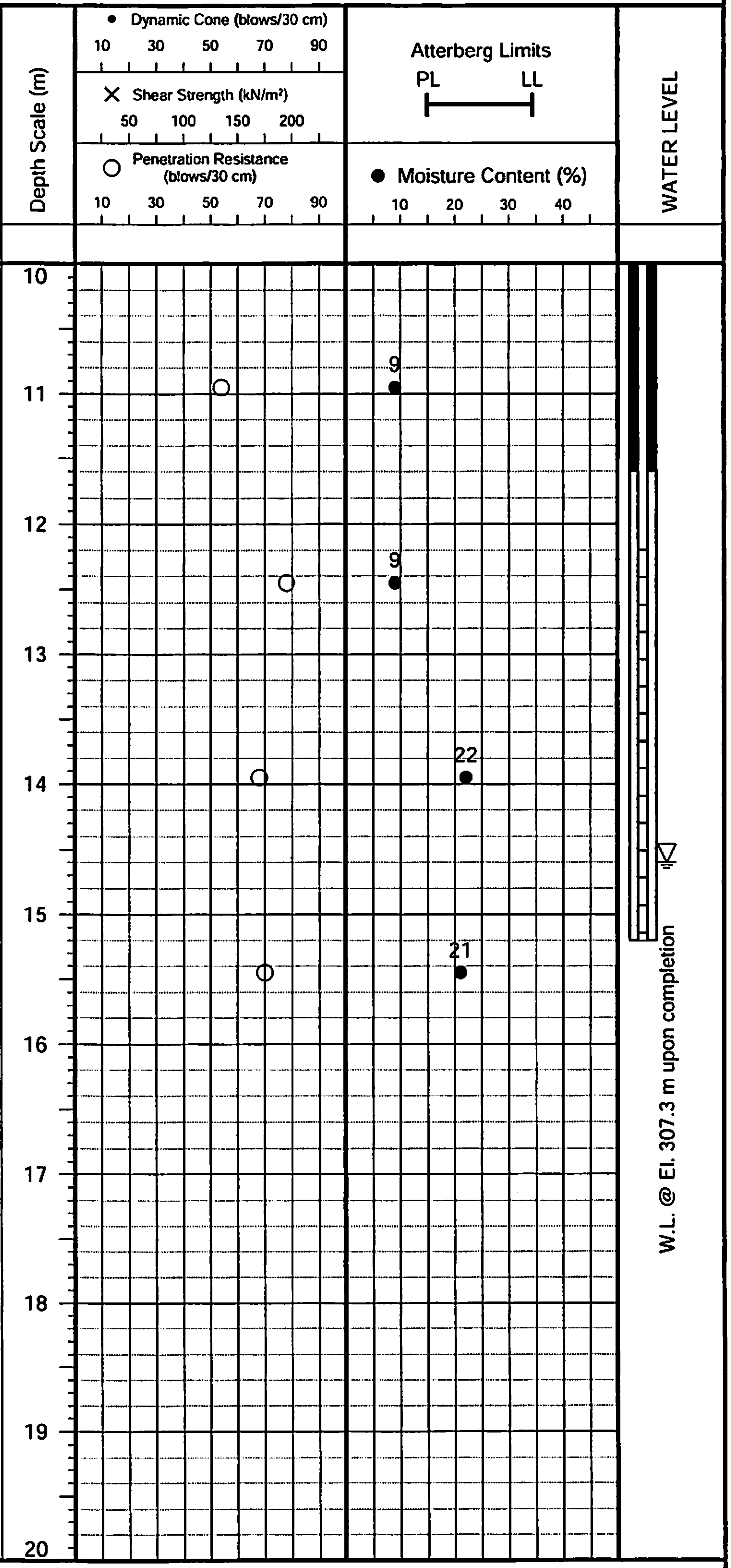
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: December 20, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
10.0	Grey, very stiff to hard **SILTY CLAY TILL** some sand a trace of gravel occ. cobbles and boulders	10	DO	54
		11	DO	78
308.9 13.0	Grey, very dense **SILT**	12	DO	68
		13	DO	70
306.2 15.7	**END OF BOREHOLE**			



JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 10

FIGURE NO.: 10

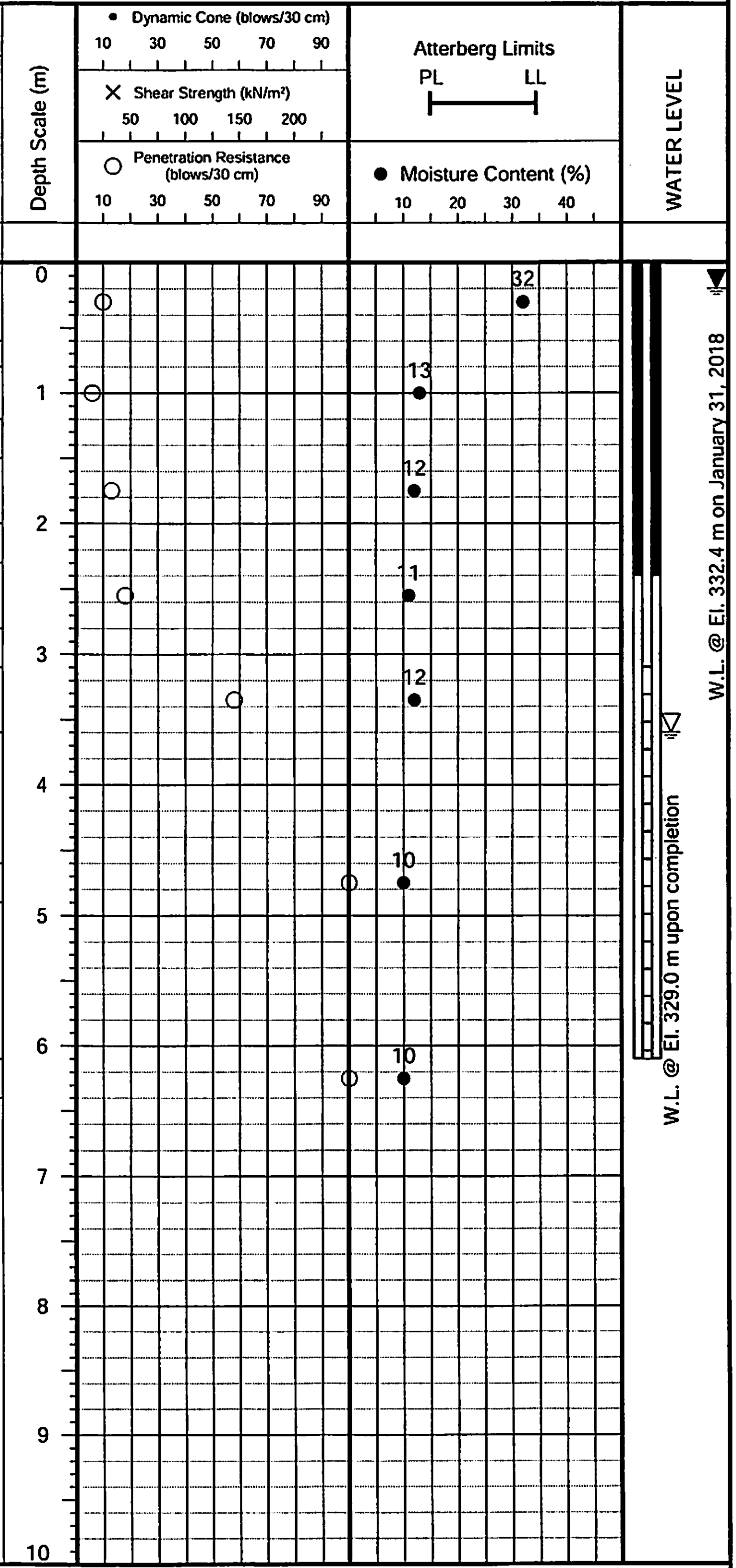
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: December 21, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
332.6	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	10
331.8 0.8	Brown, loose to compact **SILTY SAND TILL** some gravel a trace of clay	2	DO	6
	weathered			
		3	DO	13
330.1 2.5	Hard **SILTY CLAY TILL** some sand a trace of gravel occ. cobbles and boulders	4	DO	18
		5	DO	58
	brown grey	6	DO	50/15
		7	DO	50/15
326.2 6.4	**END OF BOREHOLE**			



Soil Engineers Ltd.

Page: 1 of 1

JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 11

FIGURE NO.: 11

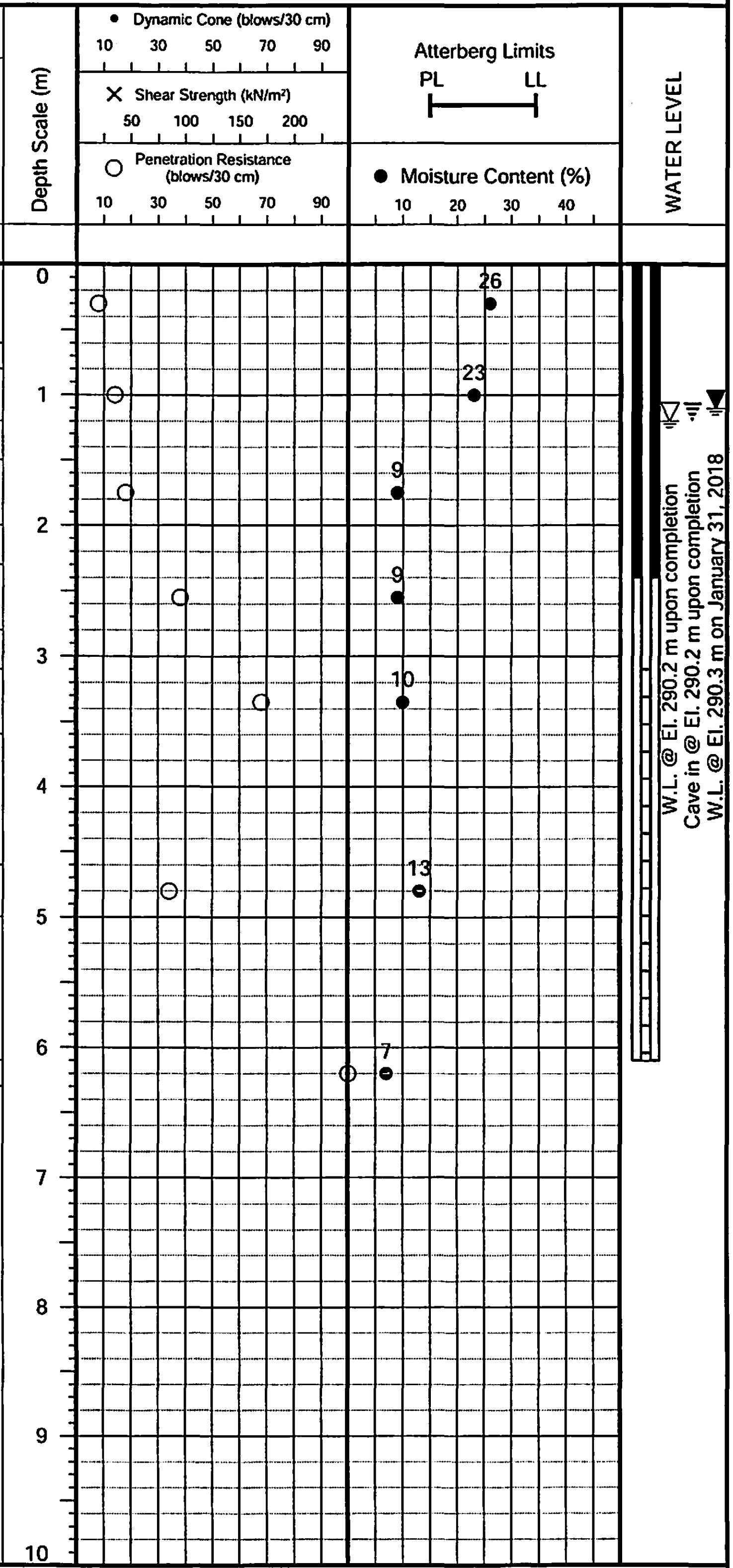
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: November 27, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
291.4	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	8
290.6 0.8	Brown, compact **SILT**	2	DO	14
289.9 1.5	Brown, compact to very dense **SILTY SAND TILL** some gravel a trace of clay occ. cobbles	3	DO	18
		4	DO	38
		5	DO	68
		6	DO	34
		7	DO	50/5
285.1 6.3	**END OF BOREHOLE**			



Soil Engineers Ltd.

Page: 1 of 1

JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 12

FIGURE NO.: 12

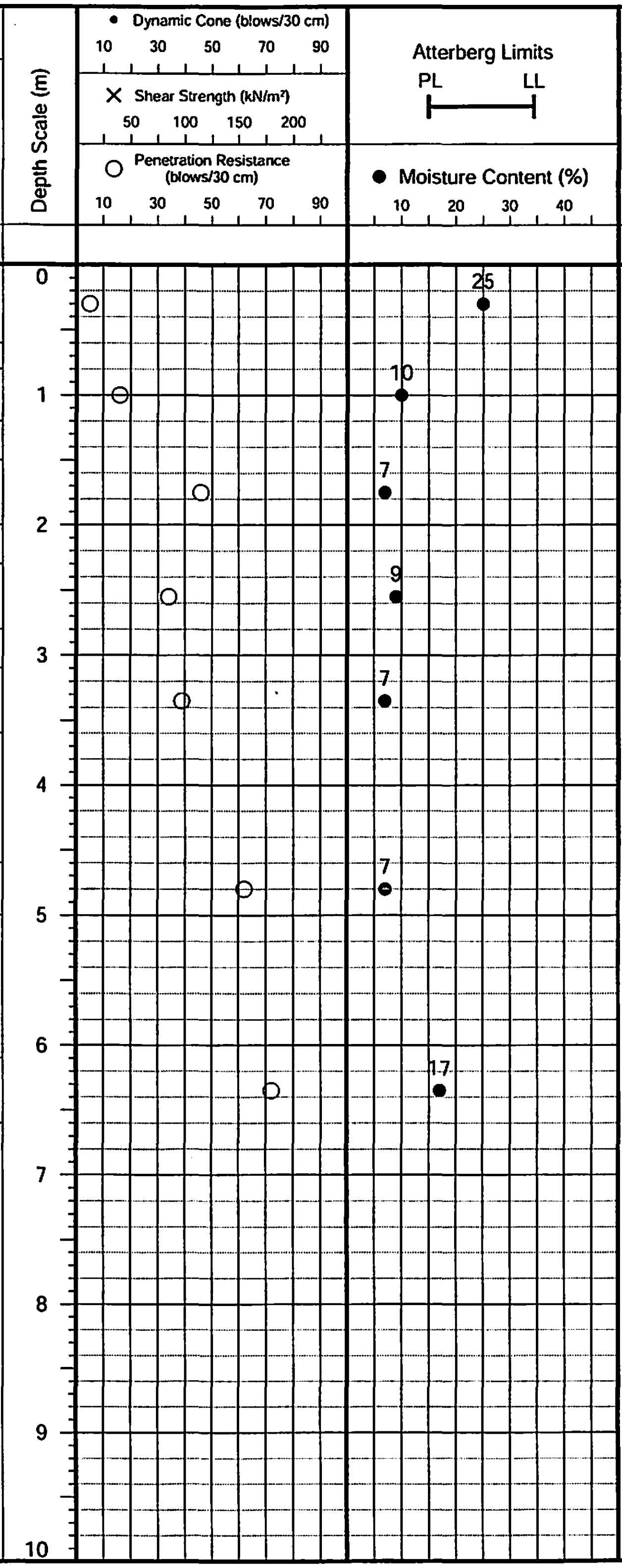
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: November 27, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
303.0	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	5
302.0 1.0	Brown, compact to very dense **SILTY SAND TILL** some gravel a trace of clay occ. cobbles	2	DO	16
		3	DO	46
		4	DO	34
		5	DO	39
		6	DO	62
297.5 5.5	Brown, very dense **SILT**	7	DO	72
296.4 6.6	**END OF BOREHOLE**			



WATER LEVEL

W.L. @ El. 298.2 m upon completion

Soil Engineers Ltd.

JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 13

FIGURE NO.: 13

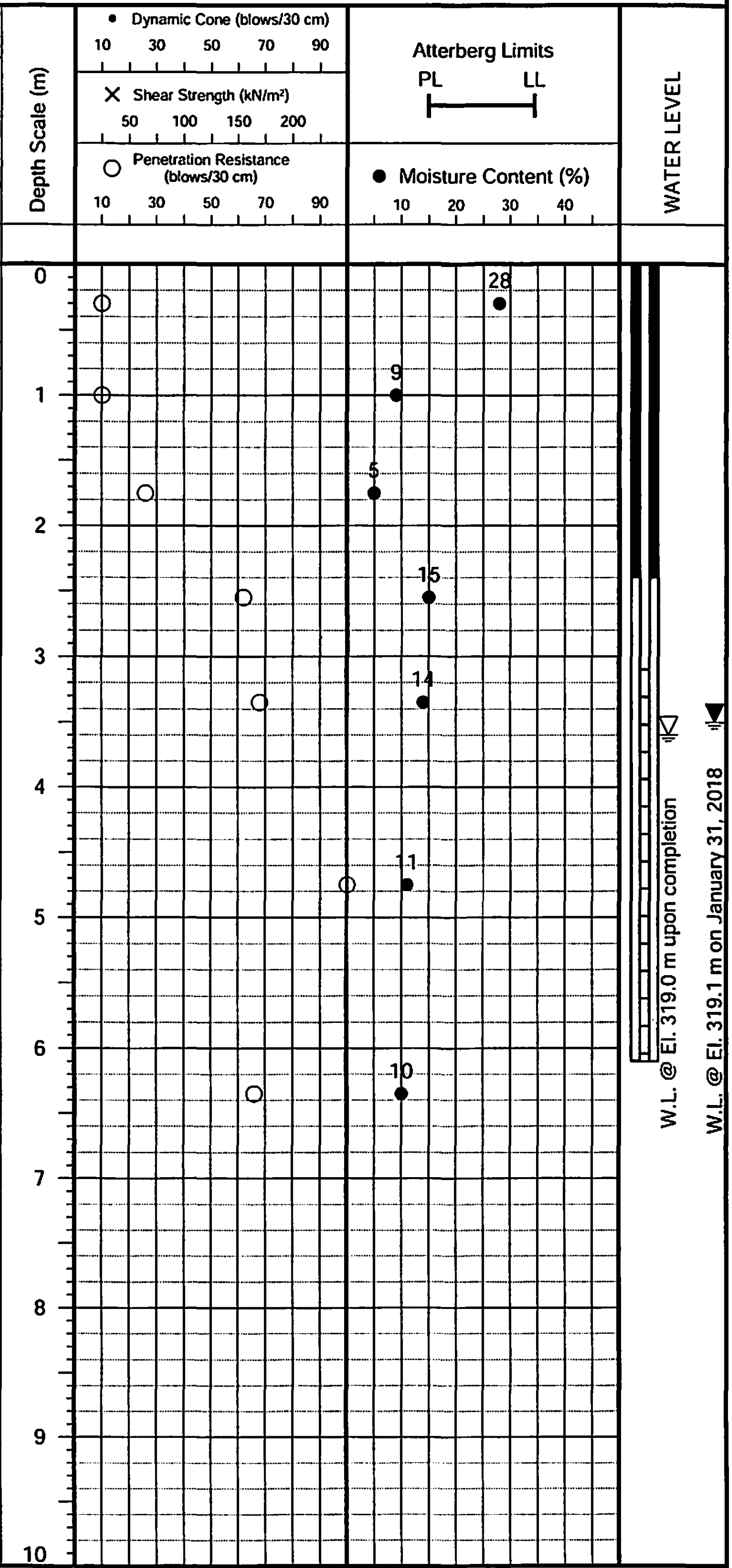
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: January 15, 2018

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value
322.6	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	10
321.8 0.8	Brown, compact to very dense — — silty **SAND** fine to coarse grained a trace to some silt a trace of gravel	2	DO	10
		3	DO	26
		4	DO	62
		5	DO	68
318.0 4.6	Brown, hard **SILTY CLAY TILL** sandy some gravel — brown/grey	6	DO	50/15
		7	DO	66
316.0 6.6				



Soil Engineers Ltd.

Page: 1 of 1

JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 14

FIGURE NO.: 14

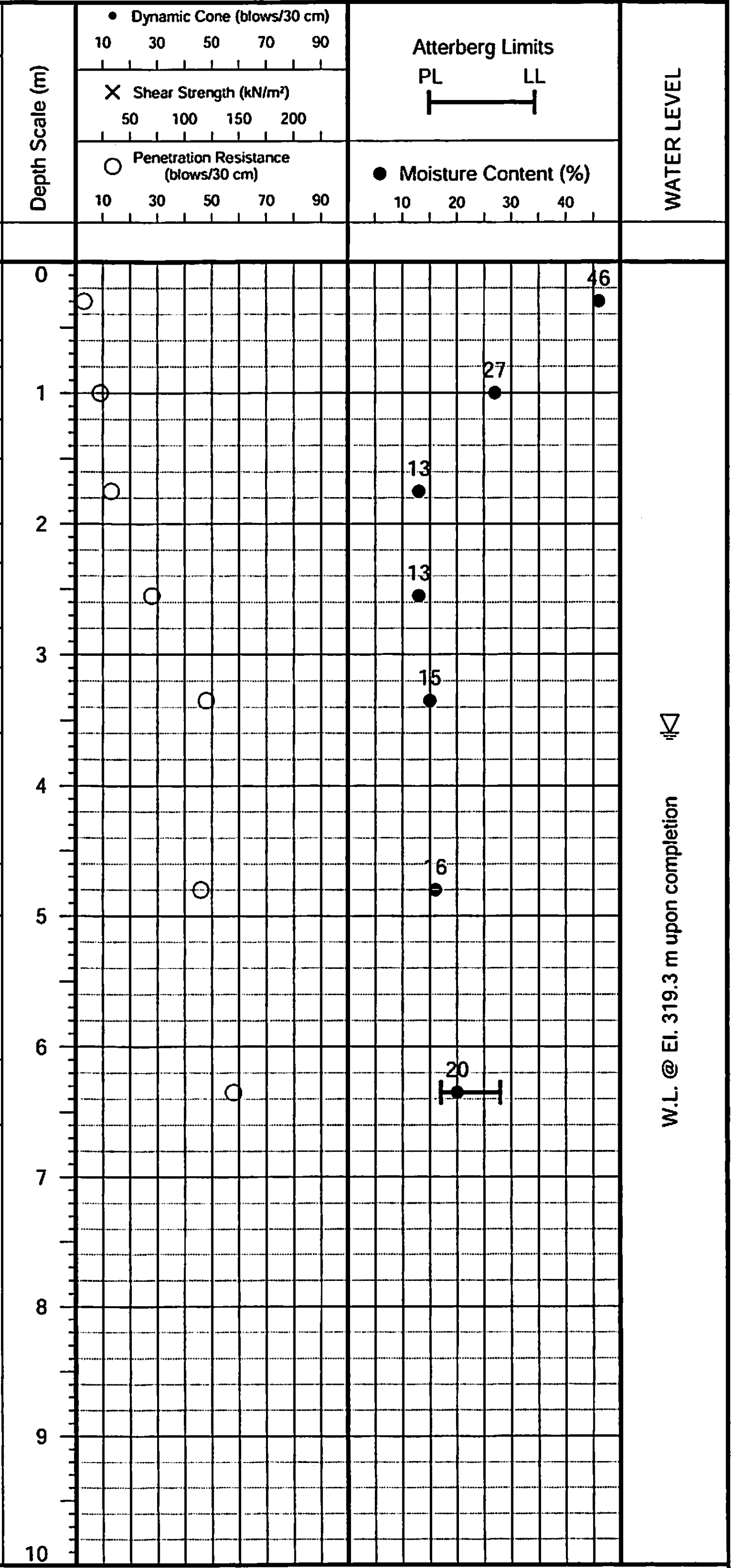
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: December 21, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
322.9	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	3
322.1 0.8	Brown, stiff to very stiff **SILTY CLAY TILL** weathered traces of sand and gravel	2	DO	9
		3	DO	13
		4	DO	28
319.8 3.1	Hard **SILTY CLAY**	5	DO	48
	brown grey	6	DO	46
		7	DO	58
316.3 6.6	**END OF BOREHOLE**			



Soil Engineers Ltd.

JOB NO.: 1711-S047

LOG OF BOREHOLE NO.: 15

FIGURE NO.: 15

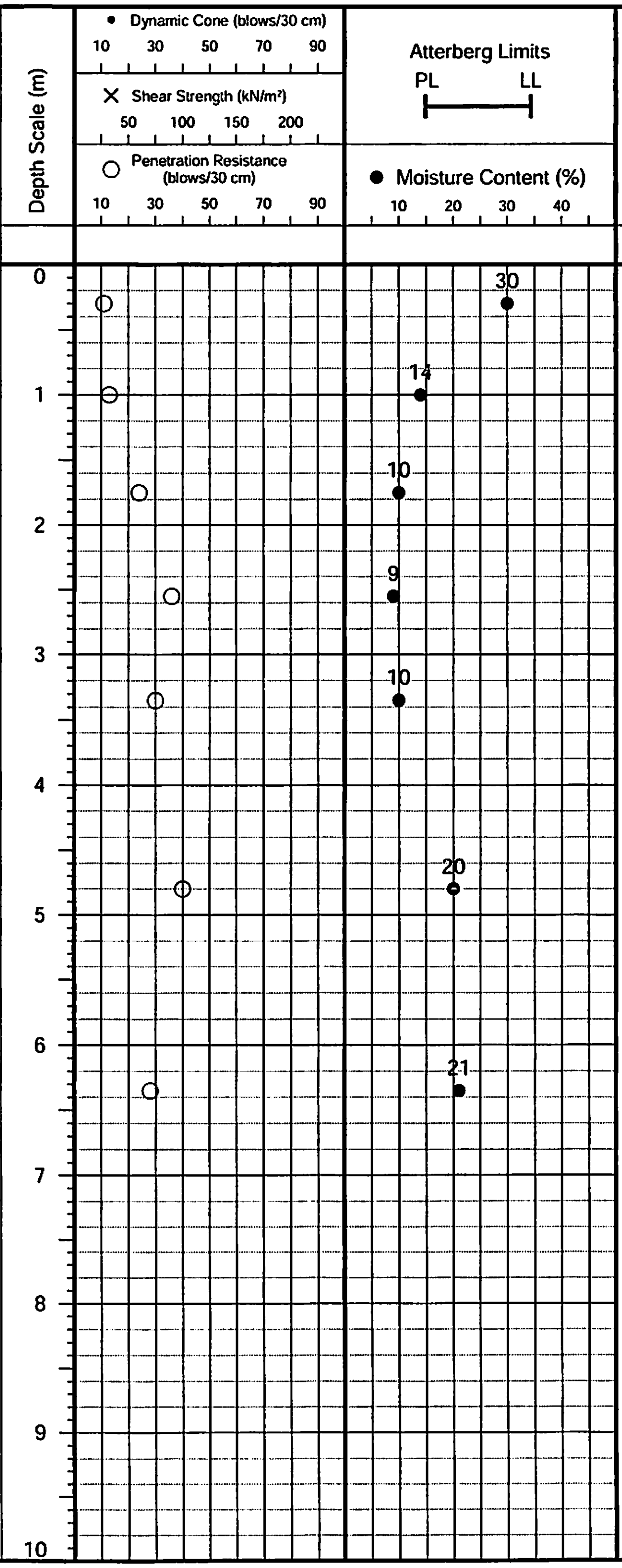
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: 7370 Centre Road, Town of Uxbridge

DRILLING DATE: December 21, 2017

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
333.6	Ground Surface			
0.0	**TOPSOIL/PLOUGHED SOIL**	1	DO	11
332.8 0.8	Brown, stiff to hard **SILTY CLAY TILL** sandy some gravel	2	DO	13
		3	DO	24
		4	DO	36
330.5 3.1	Brown, dense **SANDY SILT** a trace of clay	5	DO	30
329.6 4.0	Brown, compact to dense **SAND** fine grained some silt	6	DO	40
		7	DO	28
327.0 6.6	**END OF BOREHOLE**			



WATER LEVEL

W.L. @ El. 330.9 m upon completion

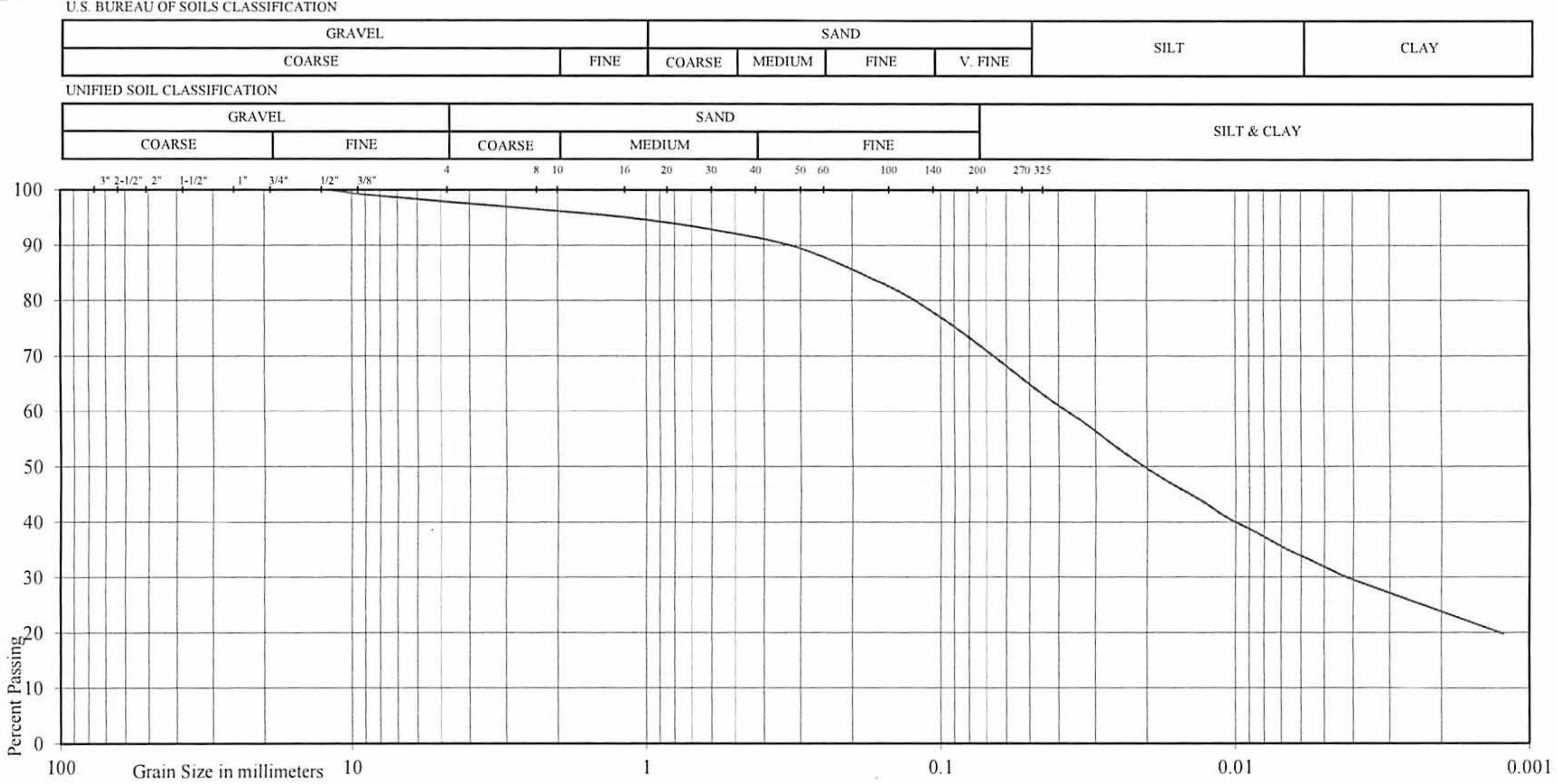
Cave in @ El. 329.4 m upon completion

Soil Engineers Ltd.

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 1711-S047



Project: Proposed Residential Development

Location: 7370 Centre Road, Town of Uxbridge

Borehole No: 3

Sample No: 4

Depth (m): 2.5

Elevation (m): 302.5

Liquid Limit (%) = 28

Plastic Limit (%) = 17

Plasticity Index (%) = 11

Moisture Content (%) = 13

Estimated Permeability (cm./sec.) = 10^{-7}

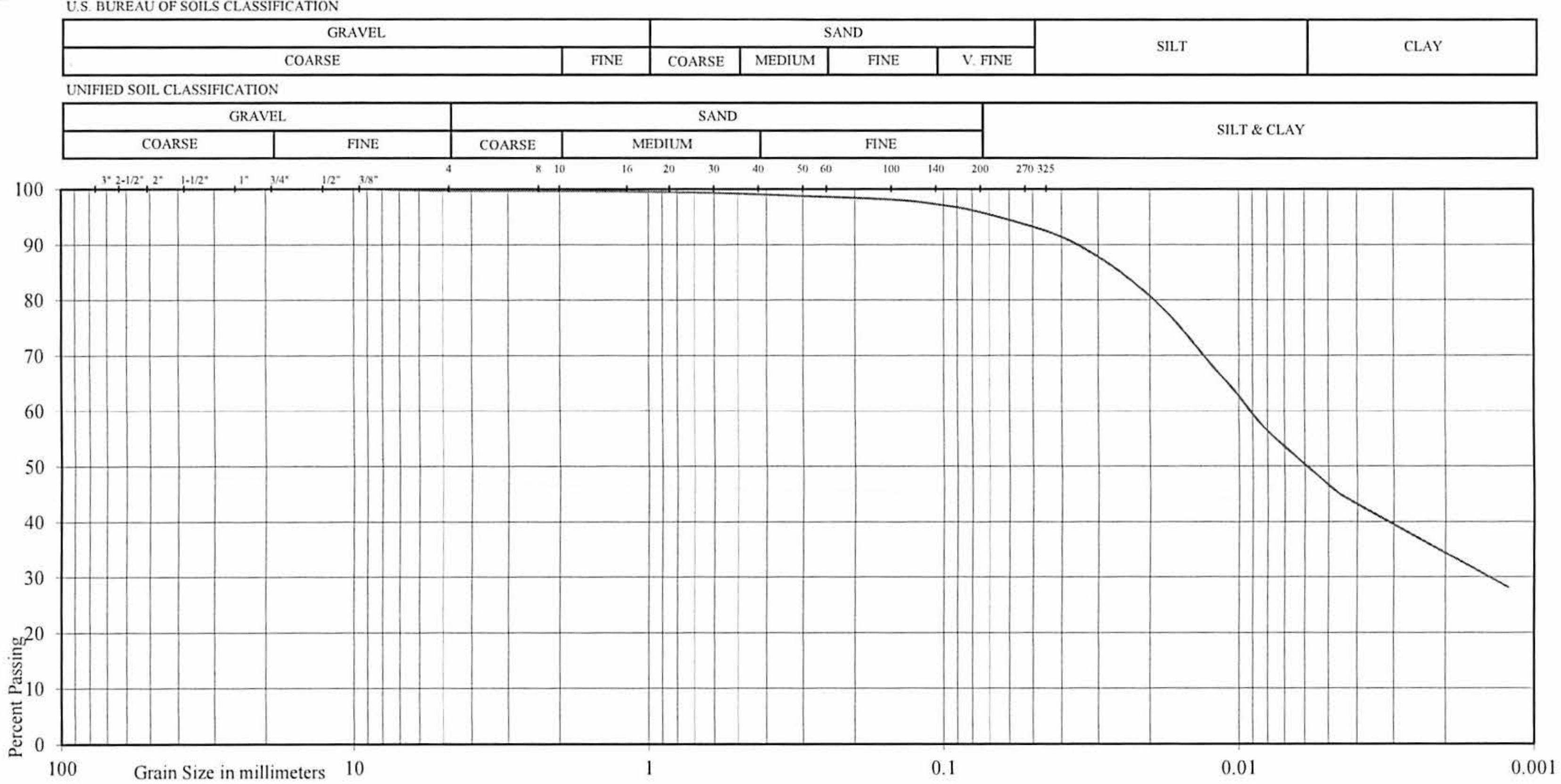
Classification of Sample [& Group Symbol]: SILTY CLAY TILL, sandy, a trace of gravel

Figure: 16

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 1711-S047



Project:	Proposed Residential Development		
Location:	7370 Centre Road, Town of Uxbridge	Liquid Limit (%) =	35
		Plastic Limit (%) =	19
Borehole No:	14	Plasticity Index (%) =	16
Sample No:	7	Moisture Content (%) =	20
Depth (m):	6.3	Estimated Permeability	
Elevation (m):	316.6	(cm./sec.) =	10^{-7}

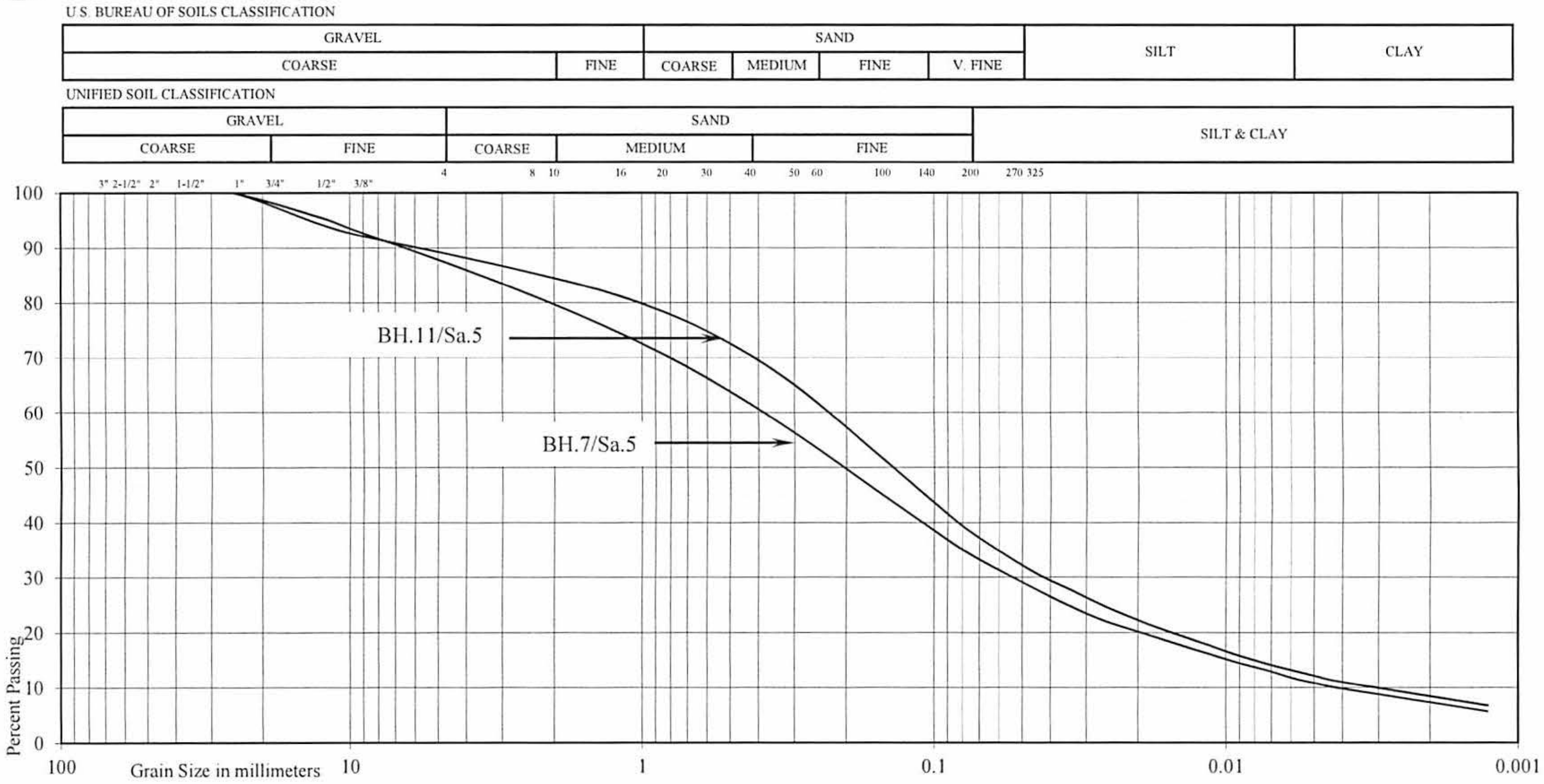
Classification of Sample [& Group Symbol]: SILTY CLAY, a trace of fine sand

Figure: 17

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 1711-S047



Project: Proposed Residential Development

Location: 7370 Centre Road, Town of Uxbridge

Borehole No:	7	11
Sample No:	5	5
Depth (m):	3.3	3.3
Elevation (m):	294.5	288.1

BH./Sa.	7/5	1/5
Liquid Limit (%) =	-	-
Plastic Limit (%) =	-	-
Plasticity Index (%) =	-	-
Moisture Content (%) =	8	10
Estimated Permeability (cm./sec.) =	10^{-5}	10^{-5}

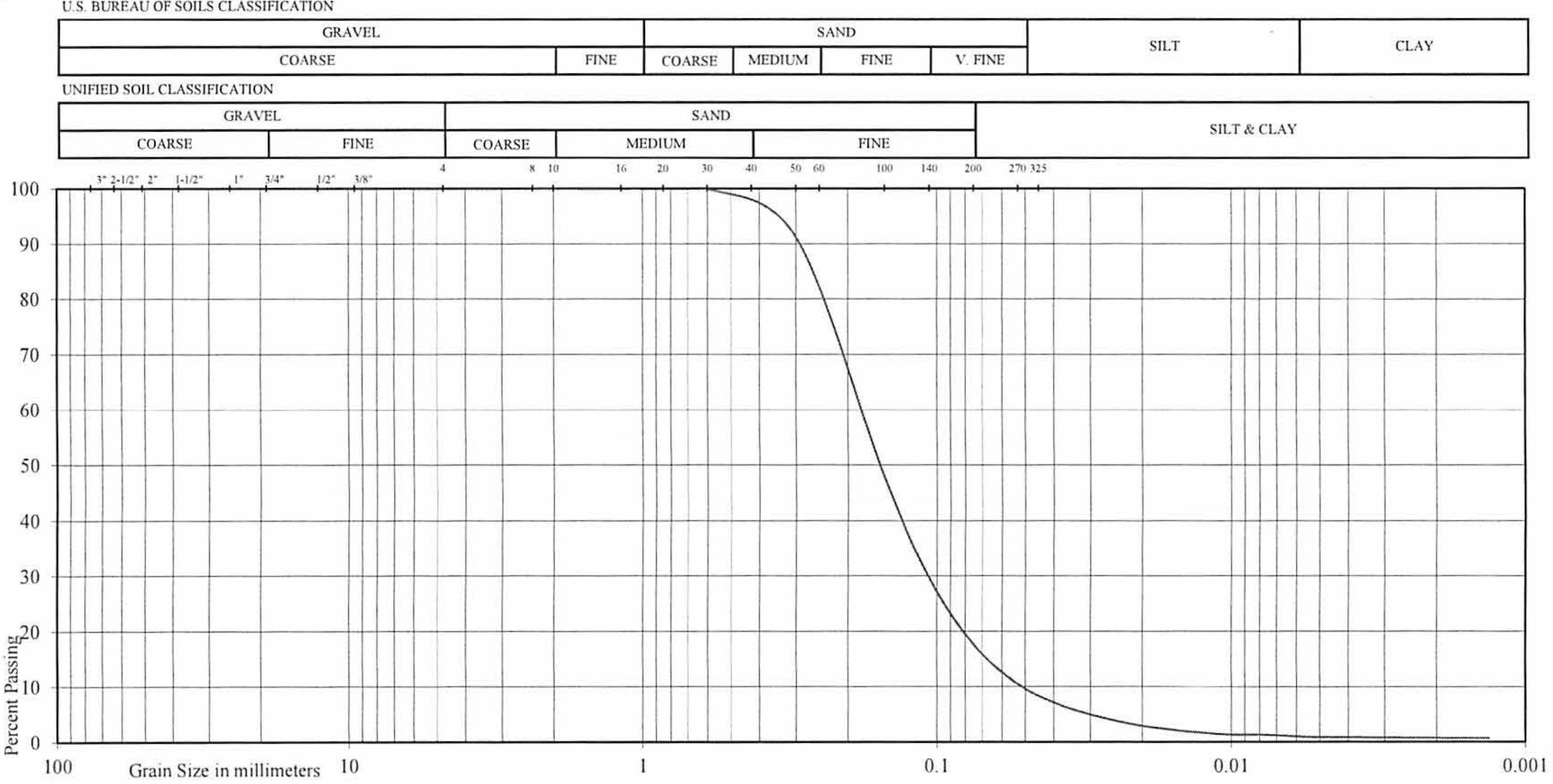
Classification of Sample [& Group Symbol]: SILTY SAND TILL
some gravel, a trace of clay

Figure: 18

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

Reference No: 1711-S047



Project: Proposed Residential Development

Location: 7370 Centre Road, Town of Uxbridge

Liquid Limit (%) = -

Plastic Limit (%) = -

Plasticity Index (%) = -

Moisture Content (%) = 21

Estimated Permeability (cm./sec.) = 10^{-3}

Borehole No: 15

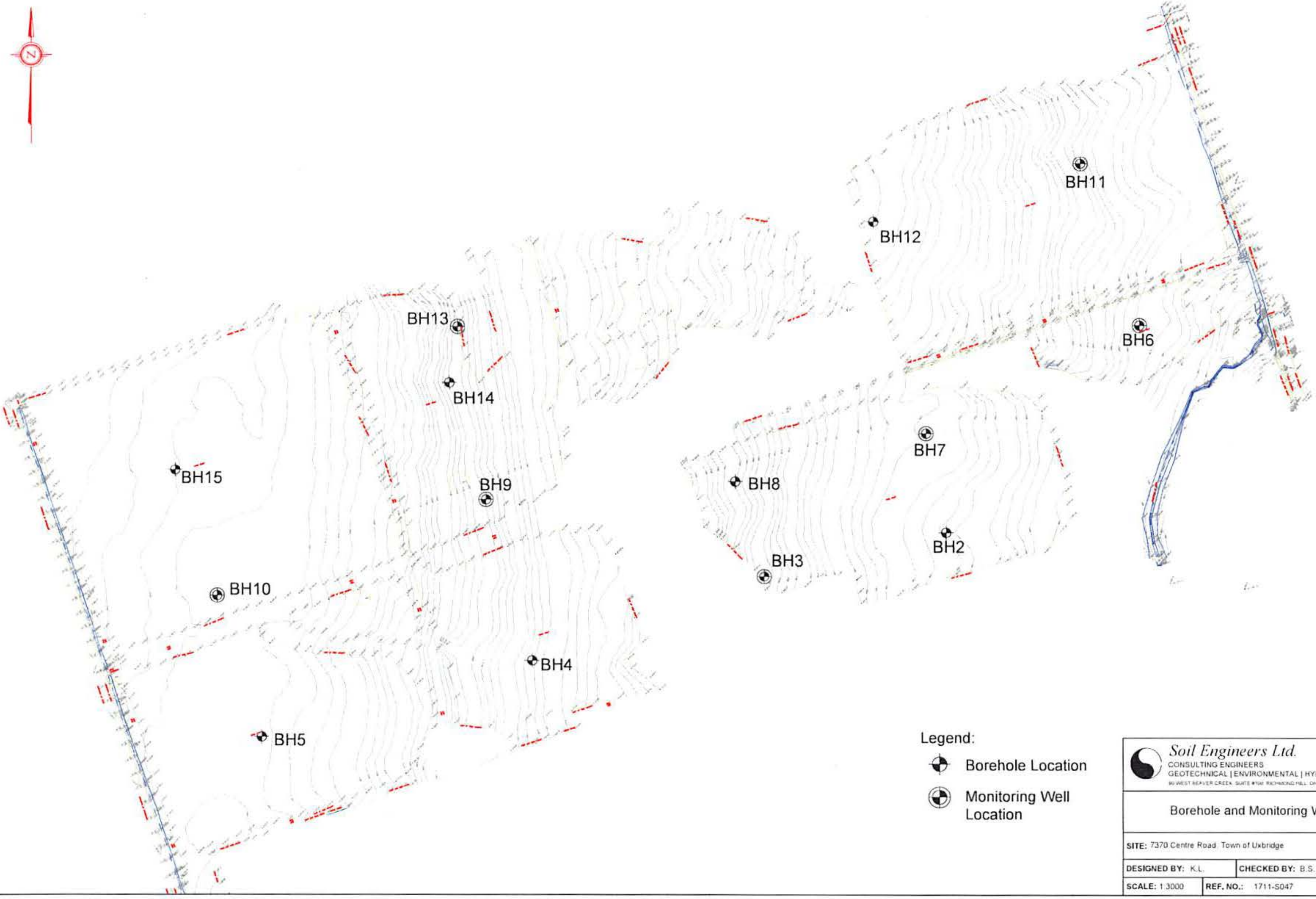
Sample No: 7

Depth (m): 6.3

Elevation (m): 327.3

Classification of Sample [& Group Symbol]: FINE SAND, some silt, a trace of clay

Figure: 19



Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL | ENVIRONMENTAL | HYDROGEOLOGICAL | BUILDING SCIENCE
90 WEST BEAVER CREEK, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 TEL: (416) 754-8515 FAX: (905) 881-8335

Borehole and Monitoring Well Location Plan

SITE: 7370 Centre Road, Town of Uxbridge

DESIGNED BY: K.L.
CHECKED BY: B.S.
DWG NO.: 1
SCALE: 1:3000
REF. NO.: 1711-S047
DATE: February 2018
REV -

Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE
90 WEST BEAVER CREEK ROAD, SUITE #100, RICHMOND HILL, ONTARIO, L4B 1E7 · TEL (416) 754-8515 · FAX (905) 881-8335

BARRIE	MISSISSAUGA	OSHAWA	NEWMARKET	GRAVENHURST	PETERBOROUGH	HAMILTON
TEL: (705) 721-7863	TEL: (905) 542-7605	TEL: (905) 440-2040	TEL: (905) 853-0647	TEL: (705) 684-4242	TEL: (905) 440-2040	TEL: (905) 777-7956
FAX: (705) 721-7864	FAX: (905) 542-2769	FAX: (905) 725-1315	FAX: (416) 754-8516	FAX: (705) 684-8522	FAX: (905) 725-1315	FAX: (905) 542-2769

March 26, 2018

Reference No. 1711-S047
Page 1 of 2

Bridgebrook Corp.
55 Blue Willow Drive
Woodbridge, Ontario
L4L 9E8

RECEIVED APR 09 2018

Attention: Mr. John Spina

Re: A Letter for Groundwater Monitoring Program
Proposed Development
7370 Centre Road
Town of Uxbridge

Dear Sir:

As requested, Soil Engineers Ltd. conducted a periodic groundwater monitoring for the subject site at 7370 Centre Road in Uxbridge. The groundwater monitoring was conducted on March 22, 2018 at the monitoring wells installed during the geotechnical investigation (Reference No. 1711-S047) prepared in January 2018 and the results are summarized in the below table:

Borehole No.	Ground Elevation (m)	Measured Groundwater Level	
		Depth (m)	Elevation (m)
3	305.0	0.5	304.5
6S	287.9	1.2	286.7
6D	287.9	1.4	286.5
7	297.8	1.1	296.7
9S	321.9	1.0	320.9
9D	321.9	7.5	314.4
10	332.6	0.9	331.7
11	291.4	1.1	290.3
13	322.6	3.3	319.3

We trust this letter satisfies your present requirements; however, should any queries arise, please feel free to contact this office.

Yours truly,
SOIL ENGINEERS LTD.

Kin Fung Li, B.Eng.

Bernard Lee, P.Eng.
KFL/BL

LICENSED PROFESSIONAL ENGINEER
Mar 26, 2018
B. P. Y. LEE
100104568
PROVINCE OF ONTARIO

Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE
90 WEST BEAVER CREEK ROAD, SUITE #100, RICHMOND HILL, ONTARIO, L4B 1E7 · TEL (416) 754-8515 · FAX (905) 881-8335

BARRIE	MISSISSAUGA	OSHAWA	NEWMARKET	GRAVENHURST	PETERBOROUGH	HAMILTON
TEL: (705) 721-7863	TEL: (905) 542-7605	TEL: (905) 440-2040	TEL: (905) 853-0647	TEL: (705) 684-4242	TEL: (905) 440-2040	TEL: (905) 777-7956
FAX: (705) 721-7864	FAX: (905) 542-2769	FAX: (905) 725-1315	FAX: (416) 754-8516	FAX: (705) 684-8522	FAX: (905) 725-1315	FAX: (905) 542-2769

July 9, 2018

Reference No. 1711-S047
Page 1 of 2

Bridgebrook Corp.
55 Blue Willow Drive
Woodbridge, Ontario
L4L 9E8

Attention: Mr. John Spina

RECEIVED JUL 20 2018

Re: A Letter for Groundwater Monitoring Program
Proposed Development
7370 Centre Road
Town of Uxbridge

Dear Sir:

As requested, Soil Engineers Ltd. conducted a periodic groundwater monitoring for the subject site at 7370 Centre Road in Uxbridge. The groundwater monitoring was conducted on June 19 and July 4, 2018 at the monitoring wells installed during the geotechnical investigation (Reference No. 1711-S047) prepared in January 2018 and the results are summarized in the below table:

Borehole No.	Ground Elevation (m)	Measured Groundwater Level	
		Depth (m)	Elevation (m)
3	305.0	1.1	303.9
6S	287.9	1.4	286.5
6D	287.9	1.6	286.3
7	297.8	2.2	295.6
9S	321.9	2.1	219.8
9D	321.9	7.9	314.0
10	332.6	1.7	330.9
11	291.4	1.4	290.0
13	322.6	3.2	319.4

We trust this letter satisfies your present requirements; however, should any queries arise, please feel free to contact this office.

Yours truly,
SOIL ENGINEERS LTD.

Kin Fung Li, B.Eng.

Bernard Lee, P.Eng.
KFL/BL

LICENSED PROFESSIONAL ENGINEER
July 9 2018
B. P. Y. LEE
100104568
PROVINCE OF ONTARIO

Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE
90 WEST BEAVER CREEK ROAD, SUITE #100, RICHMOND HILL, ONTARIO, L4B 1E7 · TEL (416) 754-8515 · FAX (905) 881-8335

BARRIE	MISSISSAUGA	OSHAWA	NEWMARKET	GRAVENHURST	PETERBOROUGH	HAMILTON
TEL: (705) 721-7863	TEL: (905) 542-7605	TEL: (905) 440-2040	TEL: (905) 853-0647	TEL: (705) 684-4242	TEL: (905) 440-2040	TEL: (905) 777-7956
FAX: (705) 721-7864	FAX: (905) 542-2769	FAX: (905) 725-1315	FAX: (416) 754-8516	FAX: (705) 684-8522	FAX: (905) 725-1315	FAX: (905) 542-2769

October 15, 2018

Reference No. 1711-S047
Page 1 of 2

Bridgebrook Corp.
55 Blue Willow Drive
Woodbridge, Ontario
L4L 9E8

RECEIVED OCT 19 2018

Attention: Mr. John Spina

Re: A Letter for Groundwater Monitoring Program
Proposed Development
7370 Centre Road
Town of Uxbridge

Dear Sir:

As requested, Soil Engineers Ltd. conducted a periodic groundwater monitoring for the subject site at 7370 Centre Road in Uxbridge. The groundwater monitoring was conducted on September 6, 2018 at the monitoring wells installed during the geotechnical investigation (Reference No. 1711-S047) prepared in January 2018 and the results are summarized in the below table:

Borehole No.	Ground Elevation (m)	Measured Groundwater Level	
		Depth (m)	Elevation (m)
3	305.0	0.7	304.3
6S	287.9	1.8	286.1
6D	287.9	2.0	285.9
7	297.8	2.5	295.3
9S	321.9	2.3	319.6
9D	321.9	8.1	313.8
10	332.6	1.4	331.2
11	291.4	1.8	289.6
13	322.6	3.7	318.9

We trust this letter satisfies your present requirements; however, should any queries arise, please feel free to contact this office.

Yours truly,
SOIL ENGINEERS LTD.

Kin Fung Li, P.Eng.

LICENSED PROFESSIONAL ENGINEER
K. F. LI
100169280
Oct 15 2018
PROVINCE OF ONTARIO

Bernard Lee, P.Eng.
KFL/BL

LICENSED PROFESSIONAL ENGINEER
Oct 15, 2018
B. P. Y. LEE
100104568
PROVINCE OF ONTARIO

Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL • ENVIRONMENTAL • HYDROGEOLOGICAL • BUILDING SCIENCE
90 WEST BEAVER CREEK ROAD, SUITE #100, RICHMOND HILL, ONTARIO, L4B 1E7 · TEL (416) 754-8515 · FAX (905) 881-8335

BARRIE	MISSISSAUGA	OSHAWA	NEWMARKET	GRAVENHURST	PETERBOROUGH	HAMILTON
TEL: (705) 721-7863	TEL: (905) 542-7605	TEL: (905) 440-2040	TEL: (905) 853-0647	TEL: (705) 684-4242	TEL: (905) 440-2040	TEL: (905) 777-7956
FAX: (705) 721-7864	FAX: (905) 542-2769	FAX: (905) 725-1315	FAX: (416) 754-8516	FAX: (705) 684-8522	FAX: (905) 725-1315	FAX: (905) 542-2769

December 4, 2018

Reference No. 1711-S047
Page 1 of 2

Bridgebrook Corp.
55 Blue Willow Drive
Woodbridge, Ontario
L4L 9E8

Attention: Mr. John Spina

Re: A Letter for Groundwater Monitoring Program
Proposed Development
7370 Centre Road
Town of Uxbridge

Dear Sir:

As requested, Soil Engineers Ltd. conducted a periodic groundwater monitoring for the subject site at 7370 Centre Road in Uxbridge. The groundwater monitoring was conducted on December 4, 2018 at the monitoring wells installed during the geotechnical investigation (Reference No. 1711-S047) prepared in January 2018 and the results are summarized in the below table:

Borehole No.	Ground Elevation (m)	Measured Groundwater Level	
		Depth (m)	Elevation (m)
3	305.0	0.2	304.8
6S	287.9	0.9	287.0
6D	287.9	1.1	286.8
7	297.8	0.5	297.3
9S	321.9	0.7	321.2
9D	321.9	7.4	314.5
10	332.6	0.3	332.3
11	291.4	0.7	290.7
13	322.6	3.7	318.9

We trust this letter satisfies your present requirements; however, should any queries arise, please feel free to contact this office.

Yours truly,
SOIL ENGINEERS LTD.

Kin Fung Li, P.Eng.

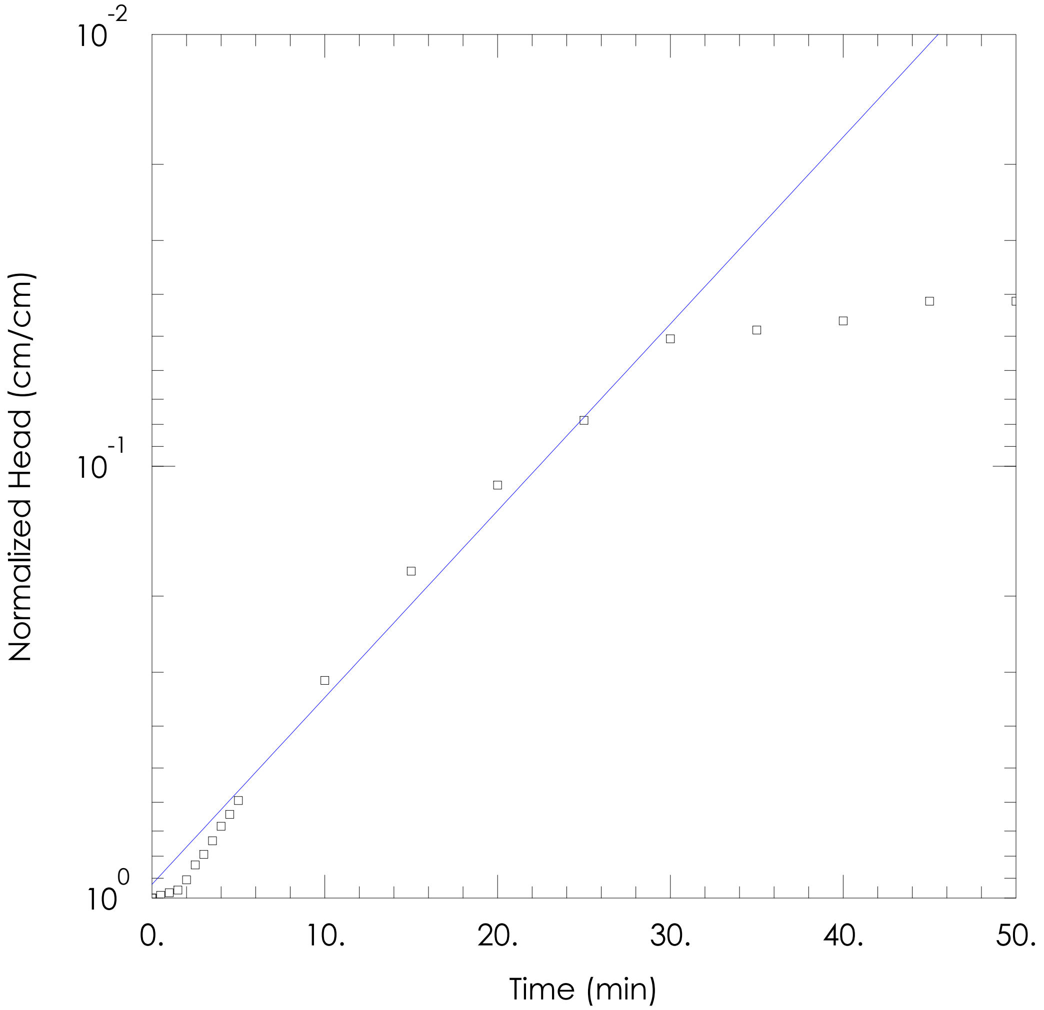
Bernard Lee, P.Eng.
KFL/BL

LICENSED PROFESSIONAL ENGINEER
K. F. LI
100169280
Dec 4, 2018
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
Dec 4, 2018
B. P. Y. LEE
100104568
PROVINCE OF ONTARIO

Appendix C

Hydrogeological Analyses
and
Water Balance Assessments



RISING HEAD TEST REPORT

Data Set: D:\CentreRd Uxbridge\AqtwBH6.aqt
Date: 08/28/20 Time: 11:30:13

PROJECT INFORMATION

Company: Beacon Environmental
Project: 217431.2
Location: 7370 Centre Road, Uxbridge
Test Well: BH6
Test Date: 28 April 2020

AQUIFER DATA

Saturated Thickness: 1317. cm
Anisotropy Ratio (Kz/Kr): 1.

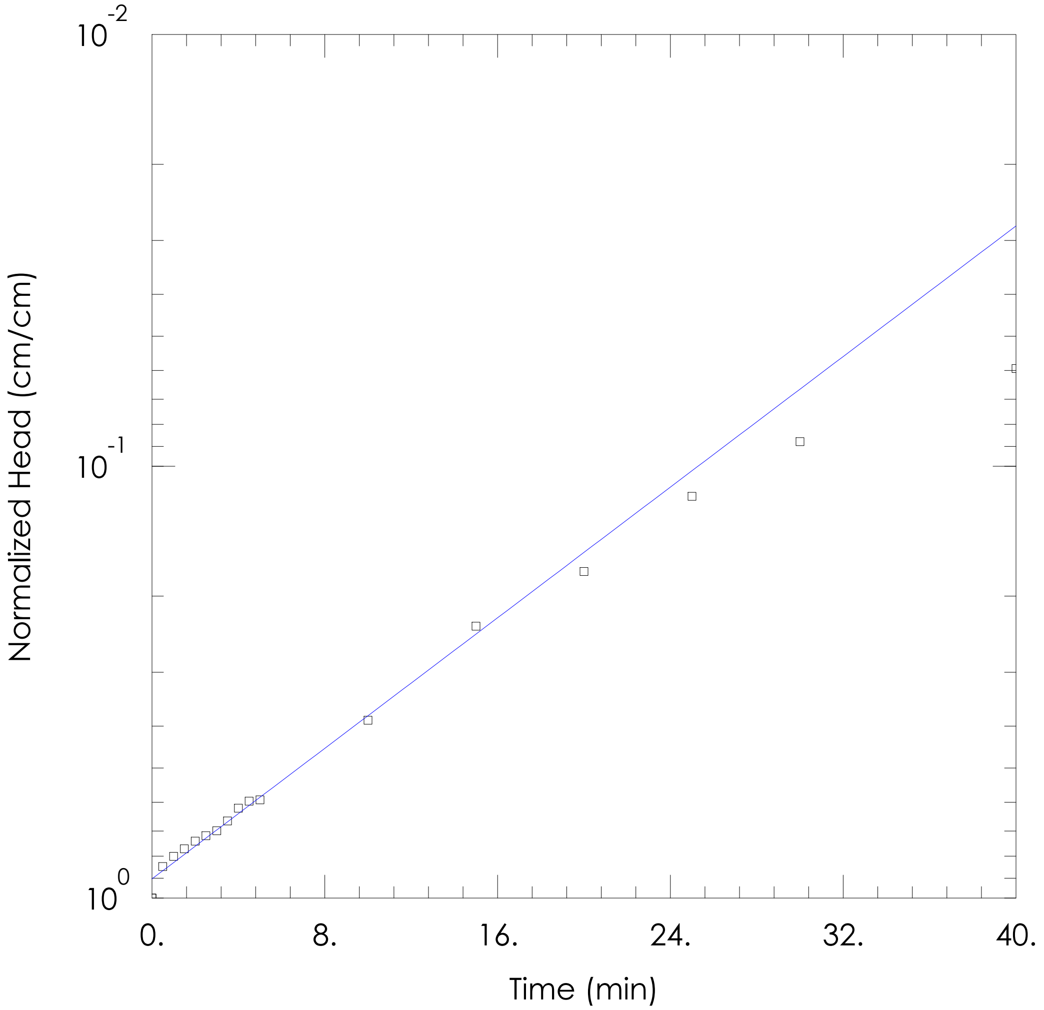
WELL DATA (BH4)

Initial Displacement: 217. cm
Static Water Column Height: 2000. cm
Total Well Penetration Depth: 1520. cm
Screen Length: 360. cm
Casing Radius: 4.42 cm
Well Radius: 15.24 cm

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.0001435 cm/sec
y0 = 201.7 cm



RISING HEAD TEST REPORT

Data Set: D:\CentreRd Uxbridge\AqtwBH7.aqt
Date: 08/28/20 Time: 11:36:39

PROJECT INFORMATION

Company: Beacon Environmental
Project: 217431.2
Location: 7370 Centre Road, Uxbridge
Test Well: BH7
Test Date: 28 April 2020

AQUIFER DATA

Saturated Thickness: 359. cm Anisotropy Ratio (Kz/Kr): 1.

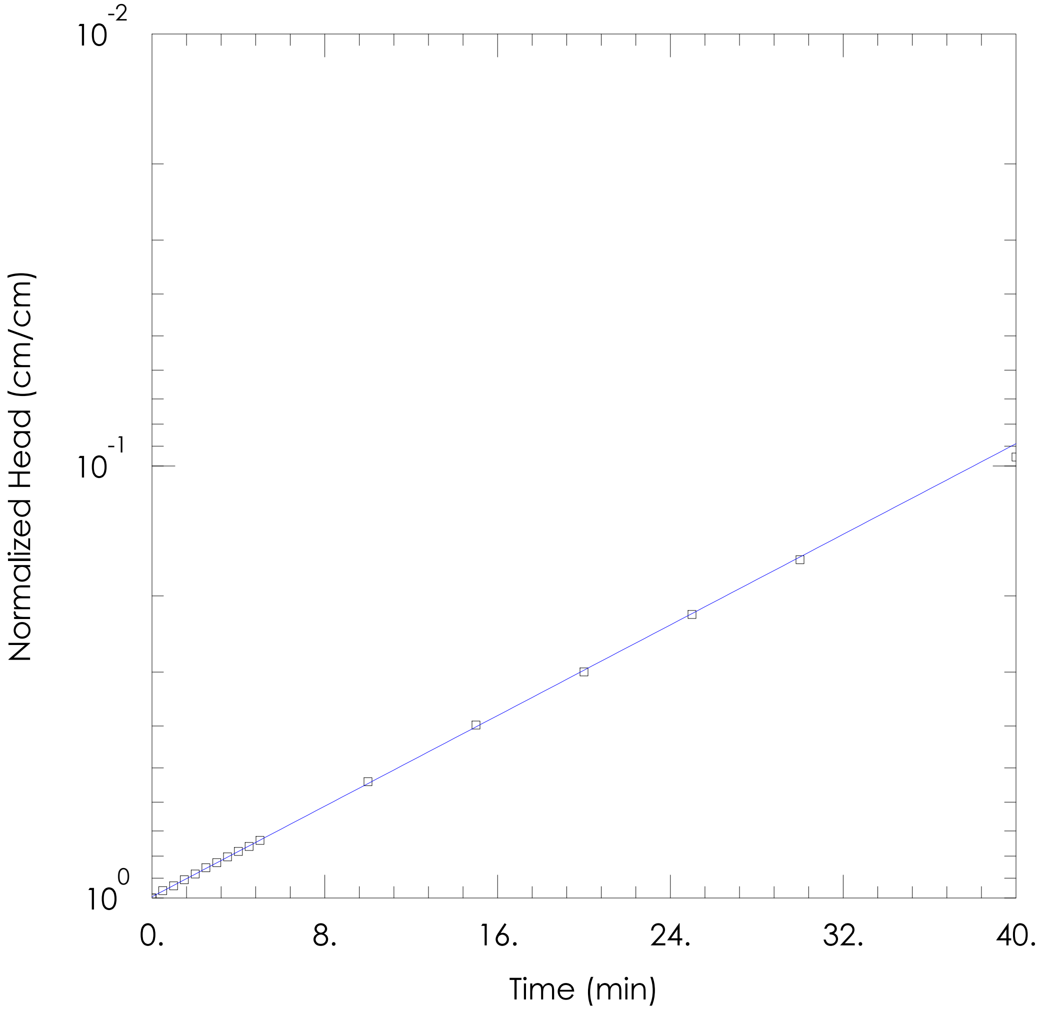
WELL DATA (BH4)

Initial Displacement: 353.5 cm Static Water Column Height: 1000. cm
Total Well Penetration Depth: 2760. cm Screen Length: 360. cm
Casing Radius: 4.42 cm Well Radius: 15.24 cm

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.0001377 cm/sec y0 = 319.3 cm



RISING HEAD TEST REPORT

Data Set: D:\CentreRd Uxbridge\AqtwBH11.aqt
Date: 08/28/20 Time: 11:43:42

PROJECT INFORMATION

Company: Beacon Environmental
Project: 217431.2
Location: 7370 Centre Road, Uxbridge
Test Well: BH11
Test Date: 28 April 2020

AQUIFER DATA

Saturated Thickness: 412. cm Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (BH4)

Initial Displacement: 367. cm Static Water Column Height: 1000. cm
Total Well Penetration Depth: 2760. cm Screen Length: 360. cm
Casing Radius: 4.42 cm Well Radius: 15.24 cm

SOLUTION

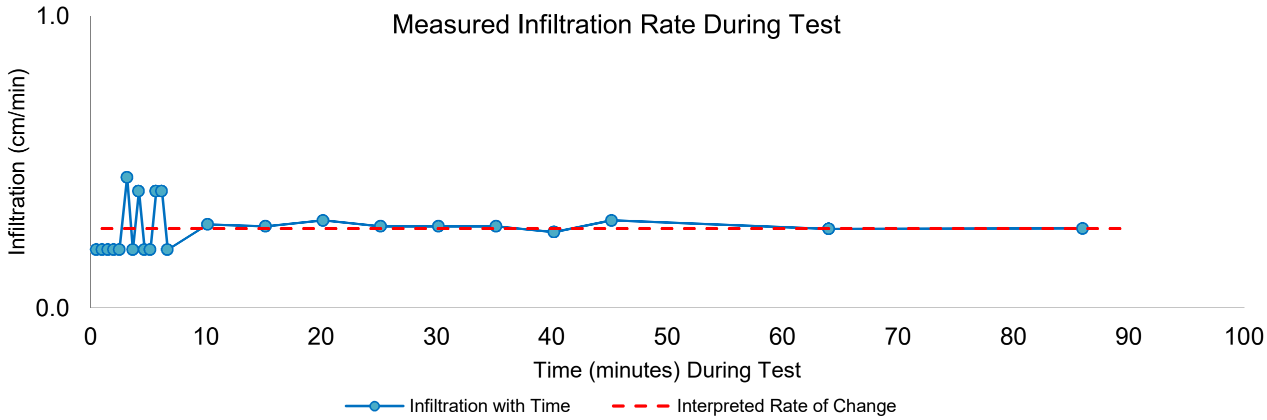
Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 9.526E-5 cm/sec y0 = 364.8 cm

Constant Head Well Permeameter Test Report

BEACON ENVIRONMENTAL

Project: 7370 Centre Road, Uxbridge
Project Number: 217431.2
Location Name PT20-01
Approximate Location: 44.1140 degrees
-79.1378 degrees
Approximate Depth Tested: 0.42 mbgl



Field Measurements:

Elapsed Time (min)	Water Level in Reservoir (cm)	Water Level Change (cm)	Infiltration (cm/min)
0	43.5	-	-
0.5	43.4	0.10	0.20
1	43.3	0.10	0.20
1.5	43.2	0.10	0.20
2	43.1	0.10	0.20
2.5	43	0.10	0.20
3.17	42.7	0.30	0.45
3.67	42.6	0.10	0.20
4.17	42.4	0.20	0.40
4.67	42.3	0.10	0.20
5.17	42.2	0.10	0.20
5.67	42	0.20	0.40
6.17	41.8	0.20	0.40
6.67	41.7	0.10	0.20
10.16	40.7	1.00	0.29
15.16	39.3	1.40	0.28
20.16	37.8	1.50	0.30
25.16	36.4	1.40	0.28
30.16	35	1.40	0.28
35.16	33.6	1.40	0.28
40.16	32.3	1.30	0.26
45.16	30.8	1.50	0.30
64	25.7	5.10	0.27
86	19.7	6.00	0.27

Soil Description

0 cm to 42 cm	Brown silty sand, rootlets, moist

Test Conditions:

Instrument: ETC Pask (Constant Head Well) Permeameter

hole radius (a) = 8.3 cm
Water column height in hole (H_1) = 15 cm
Ambient Air Temperature at Testing = 10 ^{o}C

Interpretations:

Soil Type = 0
Soil Type Coefficient (α*) = 0.12 cm^{-1}

Average Water Level Change (R_1) = 0.00 cm/s
Steady Intake Water Rate (Q_1) = 0.24 cm^3/s
Shape factor for H_1/a = (C_1) = 0.89 -

Field Saturated Hydraulic Conductivity (K_{fs}):

K_{fs} = 9E-05 cm/s
'Freshet' K_a (K_{fs} corrected to 4°C) [1]= 8E-05 cm/s
'Summer' K_a (K_{fs} corrected to 24°C) [1]= 1E-04 cm/s

Date of Field Measurements: 28-Apr-20
Field Representative: HB
Reviewed: ZK

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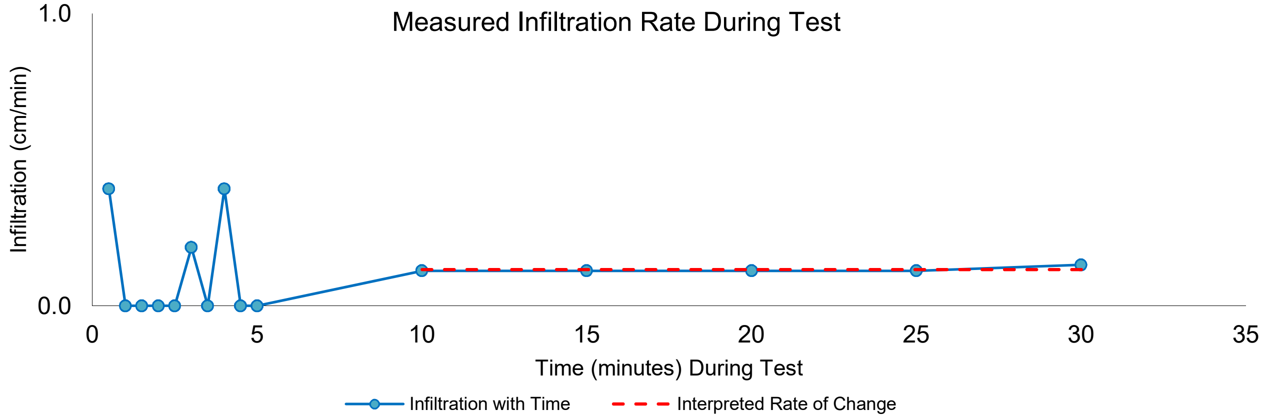
[1] (Streeter and Wylie, 1975)

Constant Head Well Permeameter Test Report

Project: 7370 Centre Road, Uxbridge
Project Number: 217431.2
Location Name PT20-02
Approximate Location: 44.1138 degrees
-79.1399 degrees
Approximate Depth Tested: 0.26 mbgl



Field Measurements:

Elapsed Time (min)	Water Level in Reservoir (cm)	Water Level Change (cm)	Infiltration (cm/min)
0	37.7	-	-
0.5	37.5	0.20	0.40
1	37.5	0.00	0.00
1.5	37.5	0.00	0.00
2	37.5	0.00	0.00
2.5	37.5	0.00	0.00
3	37.4	0.10	0.20
3.5	37.4	0.00	0.00
4	37.2	0.20	0.40
4.5	37.2	0.00	0.00
5	37.2	0.00	0.00
10	36.6	0.60	0.12
15	36	0.60	0.12
20	35.4	0.60	0.12
25	34.8	0.60	0.12
30	34.1	0.70	0.14

Soil Description	
0 cm to 26 cm	Brown silty sand, rootlets, moist

Test Conditions:

Instrument: ETC Pask (Constant Head Well) Permeameter
hole radius (a) = 8.3 cm
Water column height in hole (H_1) = 15 cm
Ambient Air Temperature at Testing = 10 °C

Interpretations:

Soil Type = Moderate
Soil Type Coefficient (α*) = 0.12 cm^{-1}

Average Water Level Change (R_1) = 0.00 cm/s
Steady Intake Water Rate (Q_1) = 0.11 cm^3/s
Shape factor for H_1/a = (C_1) = 0.89 -

Field Saturated Hydraulic Conductivity (K_{fs}):

K_{fs} = 4E-05 cm/s
'Freshet' K_a (K_{fs} corrected to 4°C) [1]= 3E-05 cm/s
'Summer' K_a (K_{fs} corrected to 24°C) [1]= 6E-05 cm/s

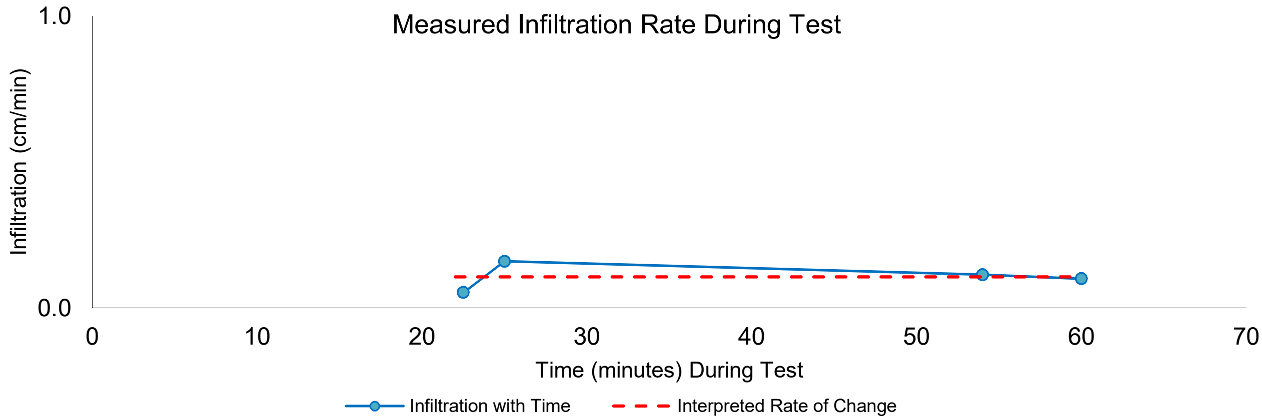
Date of Field Measurements: 28-Apr-20
Field Representative: HB
Reviewed: ZK

[1] (Streeter and Wylie, 1975)

Constant Head Well Permeameter Test Report

BEACON ENVIRONMENTAL

Project: 7370 Centre Road, Uxbridge
Project Number: 217431.2
Location Name PT20-03
Approximate Location: 44.1158 degrees
-79.1380 degrees
Approximate Depth Tested: 0.62 mbgl



Field Measurements:

Elapsed Time (min)	Water Level in Reservoir (cm)	Water Level Change (cm)	Infiltration (cm/min)
0	43.7	-	-
22.5	42.5	1.20	0.05
25	42.1	0.40	0.16
54	38.8	3.30	0.11
60	38.2	0.60	0.10

Soil Description	
0 cm to 62 cm	Brown silty sand, rootlets, moist

Test Conditions:

Instrument: ETC Pask (Constant Head Well) Permeameter

hole radius (a) = 8.3 cm

Water column height in hole (H_1) = 15 cm

Ambient Air Temperature at Testing = 10 ^{o}C

Interpretations:

Soil Type = Moderate

Soil Type Coefficient (α*) = 0.12 cm^{-1}

Average Water Level Change (R_1) = 0.00 cm/s

Steady Intake Water Rate (Q_1) = 0.10 cm^3/s

Shape factor for H_1/a = (C_1) = 0.89 -

Field Saturated Hydraulic Conductivity (K_{fs}):

K_{fs} = 4E-05 cm/s

'Freshet' K_a (K_{fs} corrected to 4^{o}C) [1]= 3E-05 cm/s

'Summer' K_a (K_{fs} corrected to 24^{o}C) [1]= 5E-05 cm/s

Date of Field Measurements: 28-Apr-20
Field Representative: HB
Reviewed: ZK

[1] (Streeter and Wylie, 1975)

Appendix D

Theoretical Global Site Water Balance Analyses

TERRAPEX

THEORETICAL SITE WATER BALANCE ASSESSMENT - REVISED DRAFT

Project: Hydrogeological Investigation and CBWB
7370 Centre Road, Uxbridge, Ontario

Project Number: CT3058 (BE-217431.2)
For: Bridge Brook Corporation

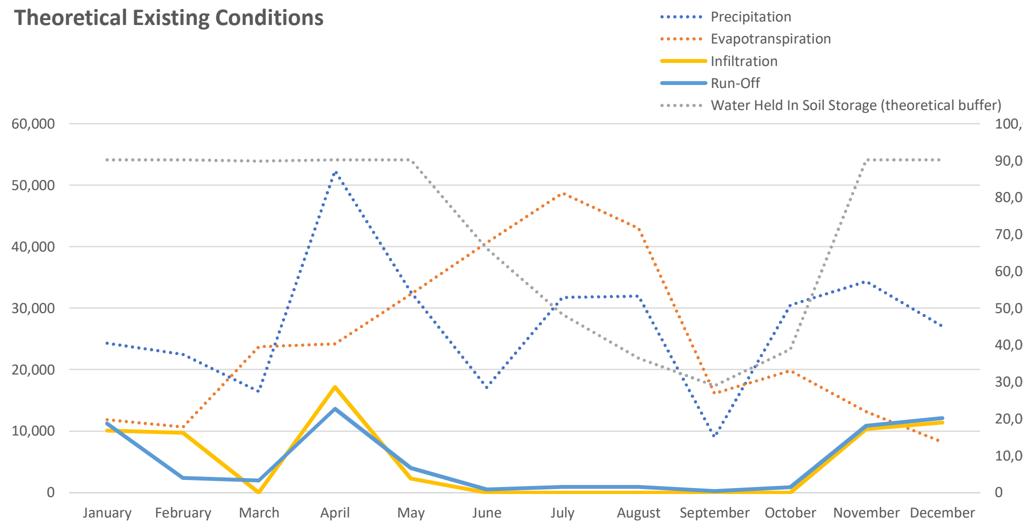
Date: February, 2021
Reviewed By: ZK

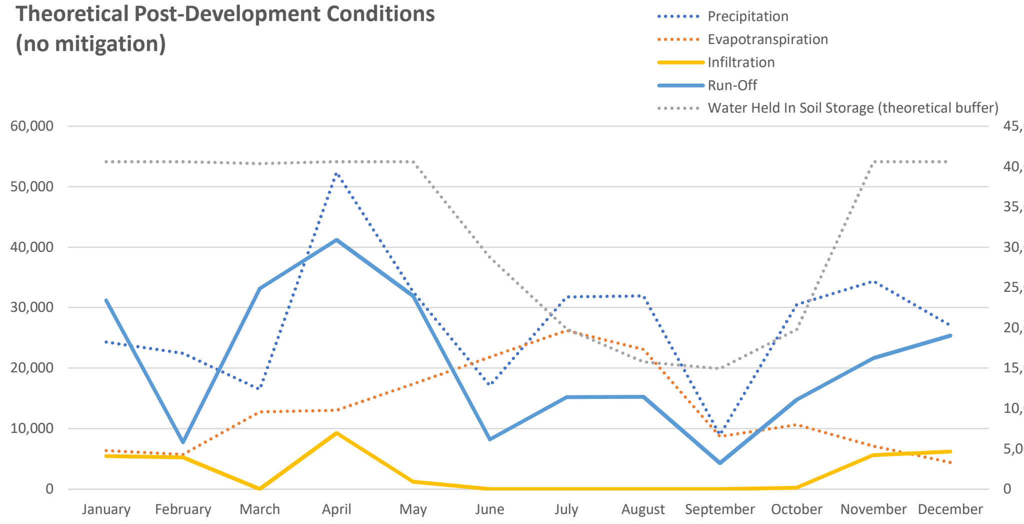
Theoretical Existing Conditions

	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
January	24,309	11,842	90,174	10,065	11,233
February	22,451	10,655	90,174	9,705	2,355
March	16,435	23,712	89,828	0	1,955
April	52,373	24,191	90,174	17,183	13,634
May	32,627	32,284	90,174	2,247	4,001
June	17,121	40,618	66,194	0	483
July	31,752	48,732	48,319	0	895
August	31,927	42,976	36,371	0	900
September	8,964	16,105	28,977	0	253
October	30,507	19,811	38,813	0	860
November	34,363	13,165	90,174	10,323	10,876
December	27,075	8,195	90,174	11,360	12,088
	0	0	0	0	0
Minimum (Monthly)	8,964	8,195	28,977	0	253
Maximum (Monthly)	52,373	48,732	90,174	17,183	13,634
Average Monthly	27,492	24,357	70,795	5,074	4,961
Per Annum	329,905	292,285	-	60,883	59,532

Theoretical Post-Development Conditions (no mitigation)

	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
January	24,309	6,365	40,604	5,439	31,211
February	22,451	5,727	40,604	5,236	7,734
March	16,435	12,746	40,348	0	33,128
April	52,373	13,004	40,604	9,264	41,189
May	32,627	17,354	40,604	1,192	31,921
June	17,121	21,834	28,724	0	8,177
July	31,752	26,196	19,868	0	15,165
August	31,927	23,101	15,760	0	15,249
September	8,964	8,657	14,917	0	4,281
October	30,507	10,649	19,790	207	14,778
November	34,363	7,077	40,604	5,616	21,670
December	27,075	4,405	40,604	6,164	25,370
Minimum (Monthly)	8,964	4,405	14,917	0	4,281
Maximum (Monthly)	52,373	26,196	40,604	9,264	41,189
Average Monthly	27,492	13,093	31,919	2,760	20,823
Per Annum	329,905	157,115	-	33,119	249,874


Theoretical Existing Conditions


Theoretical Post-Development Conditions (no mitigation)

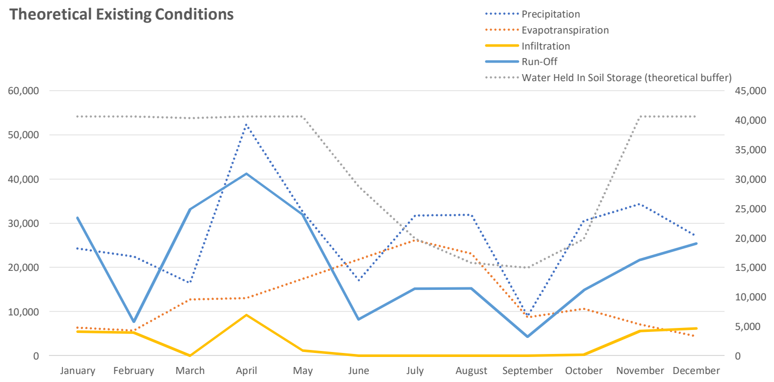
TERRAPEX

THEORETICAL SITE WATER BALANCE ASSESSMENT - REVISED DRAFT

Project: Hydrogeological Investigation and CBWB
7370 Centre Road, Uxbridge, Ontario
Project Number: CT3058 (BE-217431.2)
For: Bridge Brook Corporation
Date: February, 2021
Reviewed By: ZK

Theoretical Proposed Conditions

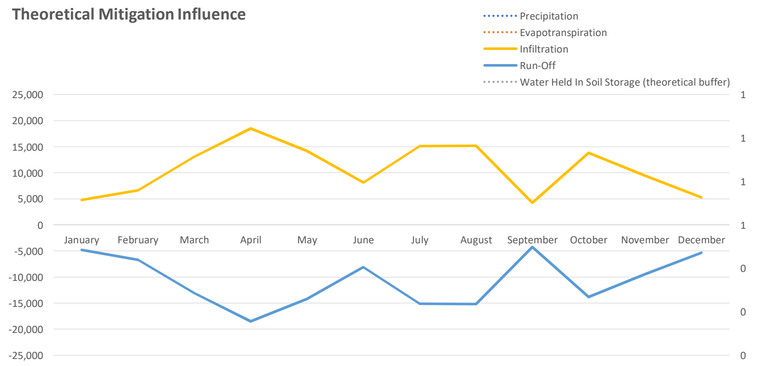
	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
January	24,309	6,365	40,604	5,439	31,211
February	22,451	5,727	40,604	5,236	7,734
March	16,435	12,746	40,348	0	33,128
April	52,373	13,004	40,604	9,264	41,189
May	32,627	17,354	40,604	1,192	31,921
June	17,121	21,834	28,724	0	8,177
July	31,752	26,196	19,868	0	15,165
August	31,927	23,101	15,760	0	15,249
September	8,964	8,657	14,917	0	4,281
October	30,507	10,649	19,790	207	14,778
November	34,363	7,077	40,604	5,616	21,670
December	27,075	4,405	40,604	6,164	25,370
Minimum (Monthly)	8,964	4,405	14,917	0	4,281
Maximum (Monthly)	52,373	26,196	40,604	9,264	41,189
Average Monthly	27,492	13,093	31,919	2,760	20,823
Per Annum	329,905	157,115	383,030	33,119	249,874



Theoretical Existing Conditions

Theoretical Mitigation Influence

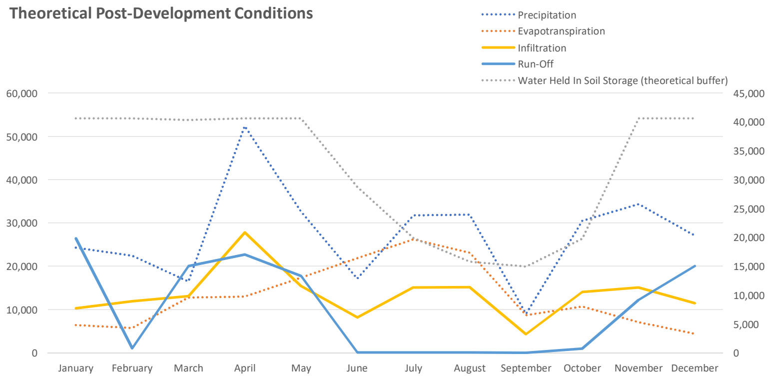
	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
January				4,815	-4,815
February				6,669	-6,669
March				13,098	-13,098
April				18,498	-18,498
May				14,207	-14,207
June				8,139	-8,139
July				15,095	-15,095
August				15,178	-15,178
September				4,262	-4,262
October				13,825	-13,825
November				9,475	-9,475
December				5,317	-5,317
Minimum (Monthly)					
Maximum (Monthly)					
Average Monthly					
Per Annum					



Theoretical Mitigation Influence

Resulting Theoretical Proposed Post-Development Conditions

	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
Jan	24,309	6,365	40,604	10,254	26,397
Feb	22,451	5,727	40,604	11,906	1,065
Mar	16,435	12,746	40,348	13,098	20,030
Apr	52,373	13,004	40,604	27,762	22,691
May	32,627	17,354	40,604	15,399	17,713
Jun	17,121	21,834	28,724	8,139	38
Jul	31,752	26,196	19,868	15,095	70
Aug	31,927	23,101	15,760	15,178	71
Sep	8,964	8,657	14,917	4,262	20
Oct	30,507	10,649	19,790	14,032	953
Nov	34,363	7,077	40,604	15,092	12,195
Dec	27,075	4,405	40,604	11,481	20,053
Minimum (Monthly)	8,964	4,405	14,917	4,262	20
Maximum (Monthly)	52,373	26,196	40,604	27,762	26,397
Average Monthly	27,492	13,093	31,919	13,475	10,108
Per Annum	329,905	157,115	-	161,696	121,296



Theoretical Post-Development Conditions

TERRAPEX

THEORETICAL SITE WATER BALANCE ASSESSMENT - **REVISED DRAFT**

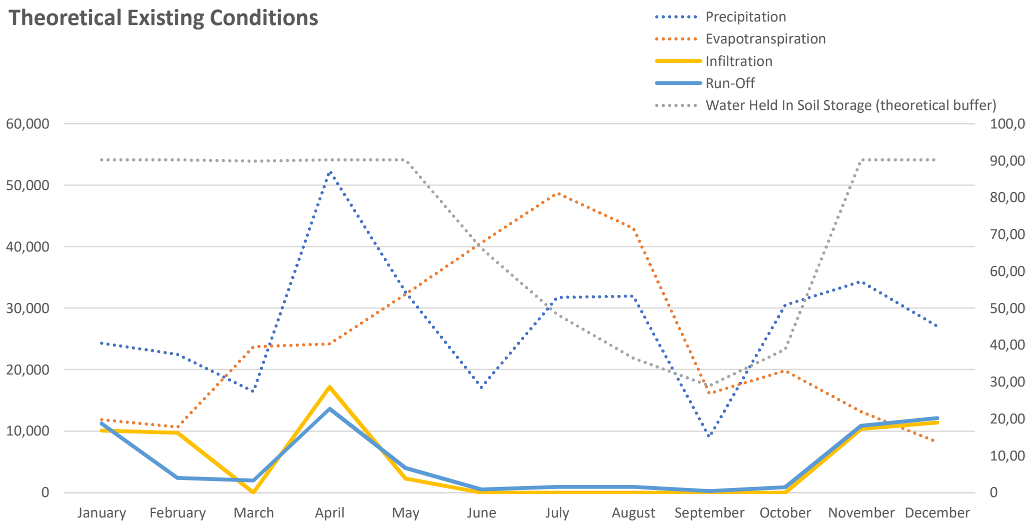
Project: Hydrogeological Investigation and CBWB
7370 Centre Road, Uxbridge, Ontario

Project Number: CT3058 (BE-217431.2)
For: Bridge Brook Corporation

Date: February, 2021
Reviewed By: ZK

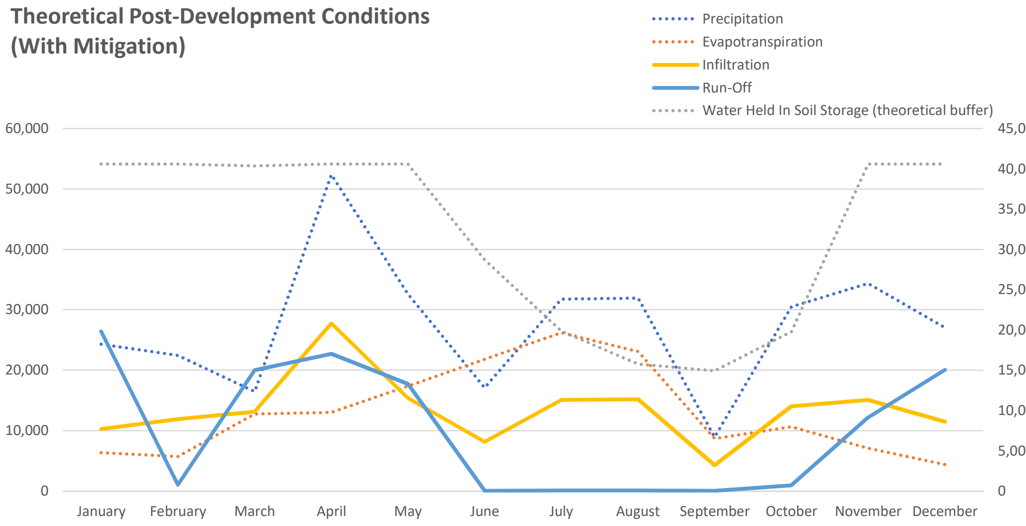
Theoretical Existing Conditions

	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
January	24,309	11,842	90,174	10,065	11,233
February	22,451	10,655	90,174	9,705	2,355
March	16,435	23,712	89,828	0	1,955
April	52,373	24,191	90,174	17,183	13,634
May	32,627	32,284	90,174	2,247	4,001
June	17,121	40,618	66,194	0	483
July	31,752	48,732	48,319	0	895
August	31,927	42,976	36,371	0	900
September	8,964	16,105	28,977	0	253
October	30,507	19,811	38,813	0	860
November	34,363	13,165	90,174	10,323	10,876
December	27,075	8,195	90,174	11,360	12,088
	0	0	0	0	0
Minimum (Monthly)	8,964	8,195	28,977	0	253
Maximum (Monthly)	52,373	48,732	90,174	17,183	13,634
Average Monthly	27,492	24,357	70,795	5,074	4,961
Per Annum	329,905	292,285	-	60,883	59,532



Theoretical Post-Development Conditions (With Mitigation)

	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
January	24,309	6,365	40,604	10,254	26,397
February	22,451	5,727	40,604	11,906	1,065
March	16,435	12,746	40,348	13,098	20,030
April	52,373	13,004	40,604	27,762	22,691
May	32,627	17,354	40,604	15,399	17,713
June	17,121	21,834	28,724	8,139	38
July	31,752	26,196	19,868	15,095	70
August	31,927	23,101	15,760	15,178	71
September	8,964	8,657	14,917	4,262	20
October	30,507	10,649	19,790	14,032	953
November	34,363	7,077	40,604	15,092	12,195
December	27,075	4,405	40,604	11,481	20,053
Minimum (Monthly)	8,964	4,405	14,917	4,262	20
Maximum (Monthly)	52,373	26,196	40,604	27,762	26,397
Average Monthly	27,492	13,093	31,919	13,475	10,108
Per Annum	329,905	157,115	-	161,696	121,296



Appendix E

Theoretical Catchment Based Water Balance Analyses

TERRAPEX

THEORETICAL CATCHMENT-BASED WATER BALANCE ASSESSMENT - REVISED DRAFT

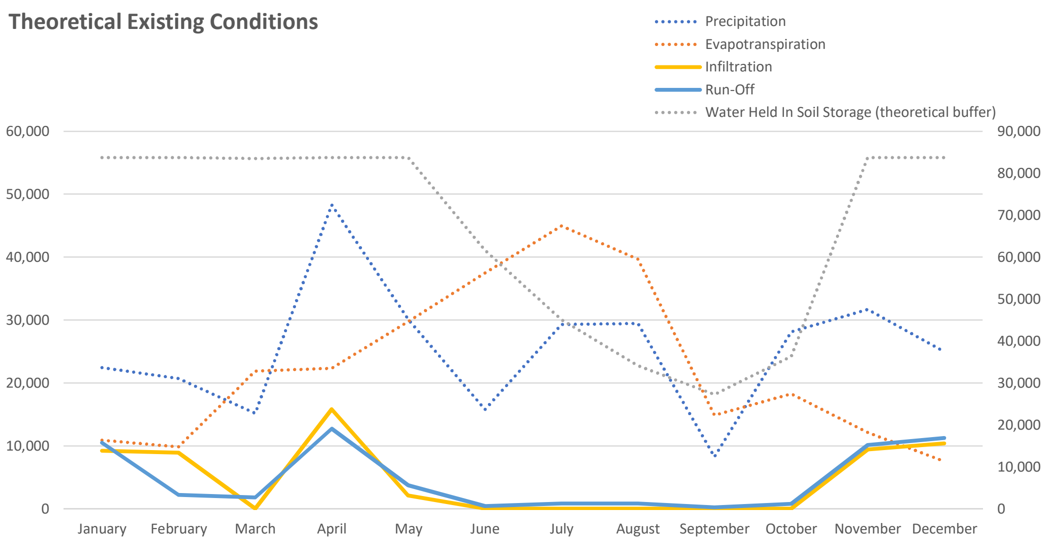
Project: Hydrogeological Investigation and CBWB
7370 Centre Road, Uxbridge, Ontario

Project Number: CT3058 (BE-217431.2)
For: Bridge Brook Corporation

Date: February, 2021
Reviewed By: ZK

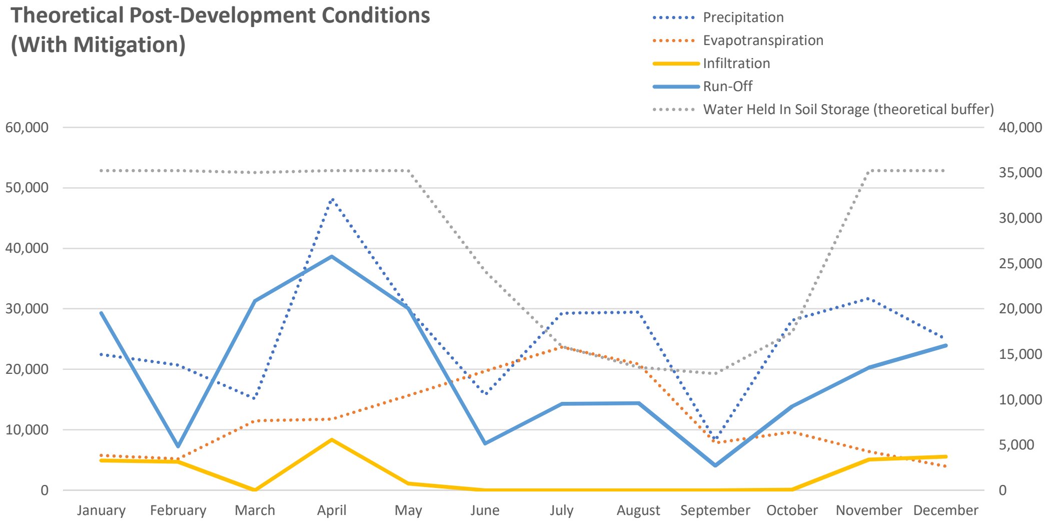
Theoretical Existing Conditions

	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
January	22,420	10,921	83,709	9,242	10,489
February	20,707	9,827	83,709	8,924	2,200
March	15,158	21,868	83,493	0	1,806
April	48,304	22,310	83,709	15,813	12,745
May	30,092	29,774	83,709	2,094	3,743
June	15,791	37,460	61,593	0	446
July	29,285	44,944	45,108	0	827
August	29,446	39,634	34,088	0	831
September	8,268	14,853	27,270	0	233
October	28,137	18,271	36,341	0	794
November	31,693	12,141	83,709	9,427	10,125
December	24,971	7,558	83,709	10,397	11,269
Minimum (Monthly)	8,268	7,558	27,270	0	233
Maximum (Monthly)	48,304	44,944	83,709	15,813	12,745
Average Monthly	25,356	22,463	65,845	4,658	4,626
Per Annum	304,271	269,562	-	55,898	55,510



Theoretical Post-Development Conditions (With Mitigation)

	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
January	22,420	5,746	35,237	4,904	29,265
February	20,707	5,170	35,237	4,723	7,261
March	15,158	11,505	35,019	0	31,266
April	48,303	11,738	35,237	8,356	38,647
May	30,092	15,665	35,237	1,079	30,087
June	15,791	19,708	24,133	0	7,718
July	29,285	23,645	15,856	0	14,313
August	29,446	20,852	13,538	0	14,392
September	8,268	7,814	12,854	0	4,041
October	28,137	9,613	17,408	109	13,861
November	31,693	6,388	35,237	5,056	20,250
December	24,971	3,976	35,237	5,552	23,948
Minimum (Monthly)	8,268	3,976	12,854	0	4,041
Maximum (Monthly)	48,303	23,645	35,237	8,356	38,647
Average Monthly	25,356	11,818	27,519	2,482	19,587
Per Annum	304,271	141,819	-	29,779	235,047



TERRAPEX

THEORETICAL SITE WATER BALANCE ASSESSMENT - REVISED DRAFT

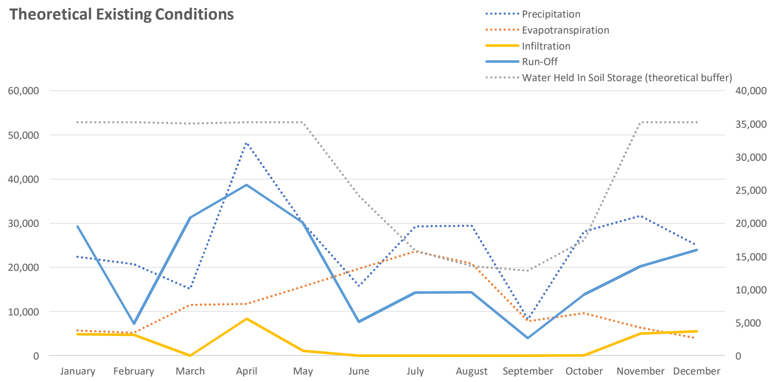
Project: Hydrogeological Investigation and CBWB
7370 Centre Road, Uxbridge, Ontario

Project Number: CT3058 (BE-217431.2)
For: Bridge Brook Corporation

Date: February, 2021
Reviewed By: ZK

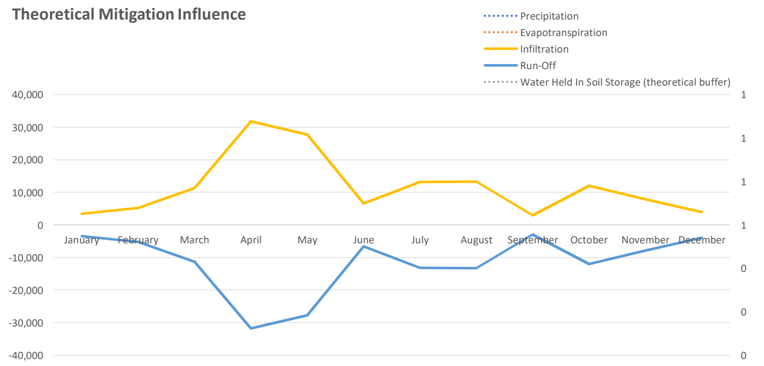
Theoretical Proposed Conditions

	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
January	22,420	5,746	35,237	4,904	29,265
February	20,707	5,170	35,237	4,723	7,261
March	15,158	11,505	35,019	0	31,266
April	48,303	11,738	35,237	8,356	38,647
May	30,092	15,665	35,237	1,079	30,087
June	15,791	19,708	24,133	0	7,718
July	29,285	23,645	15,856	0	14,313
August	29,446	20,852	13,538	0	14,392
September	8,268	7,814	12,854	0	4,041
October	28,137	9,613	17,408	109	13,861
November	31,693	6,388	35,237	5,056	20,250
December	24,971	3,976	35,237	5,552	23,948
Minimum (Monthly)	8,268	3,976	12,854	0	4,041
Maximum (Monthly)	48,303	23,645	35,237	8,356	38,647
Average Monthly	25,356	11,818	27,519	2,482	19,587
Per Annum	304,271	141,819	330,228	29,779	235,047


Theoretical Existing Conditions

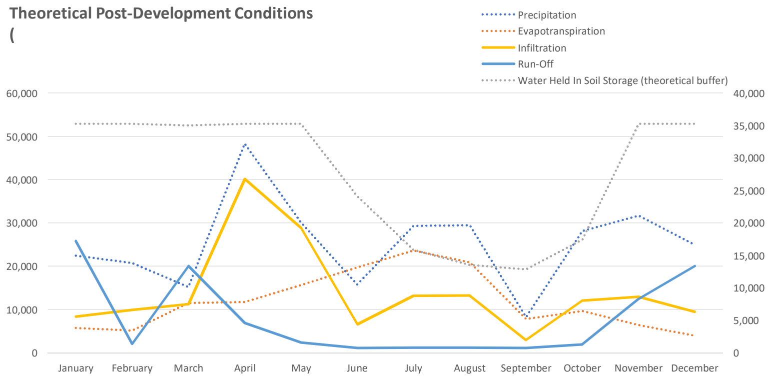
Theoretical Mitigation Influence

	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
January				3,453	-3,453
February				5,203	-5,203
March				11,269	-11,269
April				31,773	-31,773
May				27,725	-27,725
June				6,590	-6,590
July				13,153	-13,153
August				13,232	-13,232
September				2,932	-2,932
October				11,955	-11,955
November				7,851	-7,851
December				3,928	-3,928
Minimum (Monthly)				2,932	-31,773
Maximum (Monthly)				31,773	-2,932
Average Monthly				11,589	-11,589
Per Annum					


Theoretical Mitigation Influence

Resulting Theoretical Proposed Post-Development Conditions

	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
Jan	22,420	5,746	35,237	8,357	25,812
Feb	20,707	5,170	35,237	9,926	2,058
Mar	15,158	11,505	35,019	11,269	19,997
Apr	48,303	11,738	35,237	40,129	6,874
May	30,092	15,665	35,237	28,804	2,362
Jun	15,791	19,708	24,133	6,590	1,127
Jul	29,285	23,645	15,856	13,153	1,160
Aug	29,446	20,852	13,538	13,232	1,160
Sep	8,268	7,814	12,854	2,932	1,109
Oct	28,137	9,613	17,408	12,064	1,906
Nov	31,693	6,388	35,237	12,907	12,399
Dec	24,971	3,976	35,237	9,480	20,020
Minimum (Monthly)	8,268	3,976	12,854	2,932	1,109
Maximum (Monthly)	48,303	23,645	35,237	40,129	25,812
Average Monthly	25,356	11,818	27,519	14,070	7,999
Per Annum	304,271	141,819	-	168,843	95,983


Theoretical Post-Development Conditions
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TERRAPEX

THEORETICAL CATCHMENT-BASED WATER BALANCE ASSESSMENT - REVISED DRAFT

Project: Hydrogeological Investigation and CBWB
7370 Centre Road, Uxbridge, Ontario

Project Number: CT3058 (BE-217431.2)
For: Bridge Brook Corporation

Date: February, 2021
Reviewed By: ZK

Theoretical Existing Conditions

	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
January	22,420	10,921	83,709	9,242	10,489
February	20,707	9,827	83,709	8,924	2,200
March	15,158	21,868	83,493	0	1,806
April	48,304	22,310	83,709	15,813	12,745
May	30,092	29,774	83,709	2,094	3,743
June	15,791	37,460	61,593	0	446
July	29,285	44,944	45,108	0	827
August	29,446	39,634	34,088	0	831
September	8,268	14,853	27,270	0	233
October	28,137	18,271	36,341	0	794
November	31,693	12,141	83,709	9,427	10,125
December	24,971	7,558	83,709	10,397	11,269
Minimum (Monthly)	8,268	7,558	27,270	0	233
Maximum (Monthly)	48,304	44,944	83,709	15,813	12,745
Average Monthly	25,356	22,463	65,845	4,658	4,626
Per Annum	304,271	269,562	-	55,898	55,510

Theoretical Post-Development Conditions (With Mitigation)

	Precipitation (m^3/month)	Evapotranspiration (m^3/month)	Water Held In Soil Storage (theoretical buffer) (m^3/month)	Infiltration (m^3/month)	Run-Off (m^3/month)
January	22,420	5,746	35,237	8,357	25,812
February	20,707	5,170	35,237	9,926	2,058
March	15,158	11,505	35,019	11,269	19,997
April	48,303	11,738	35,237	40,129	6,874
May	30,092	15,665	35,237	28,804	2,362
June	15,791	19,708	24,133	6,590	1,127
July	29,285	23,645	15,856	13,153	1,160
August	29,446	20,852	13,538	13,232	1,160
September	8,268	7,814	12,854	2,932	1,109
October	28,137	9,613	17,408	12,064	1,906
November	31,693	6,388	35,237	12,907	12,399
December	24,971	3,976	35,237	9,480	20,020
Minimum (Monthly)	8,268	3,976	12,854	2,932	1,109
Maximum (Monthly)	48,303	23,645	35,237	40,129	25,812
Average Monthly	25,356	11,818	27,519	14,070	7,999
Per Annum	304,271	141,819	-	168,843	95,983