Hydrogeological Assessment Report – Part of Lot 19, Concession 19 – Township of Galway-Cavendish and Harvey, County of Peterborough.

May 3, 2024

Prepared for:
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1.0 Introduction

Cambium Inc. (Cambium) was retained by Jeffery Homes (Client) to complete a hydrogeological assessment in support of the proposed residential development at 168 County Road 49, legally known as Part of Lot 19, Concession 19, Township of Galway-Cavendish and Harvey, County of Peterborough.

The purpose of the hydrogeological assessment was to characterize the soil and groundwater conditions at the Site, assess the pre- and post development water balance, discussion on the need for groundwater control during the construction process, assess any impacts on the surrounding natural environment due to the proposed development, and evaluate and provide conclusions and recommendations for the proposed development.

1.1 Scope of Work

This hydrogeological assessment was conducted to address the peer review comments on the previous hydrogeological investigation report described below with the following tasks:

- **Review of available background information**: a review of available geological and hydrogeological information for the Site and surrounding areas was conducted to provide background information to allow for characterization of the Site's soil and groundwater conditions.
- **Water level monitoring:** groundwater levels were measured in the existing monitoring wells to establish and/or confirm the general groundwater flow condition and to assess the fluctuations in groundwater elevations.
- **In-situ hydraulic conductivity tests:** conduct single well response tests on the monitoring wells to estimate the hydraulic conductivity of underlying soils and/or bedrock, and to assess the potential dewatering requirements, if any.
- **Instillation of drive-point piezometers:** drive-point piezometers were installed within the wetland to evaluate the relationship between the wetland and the shallow groundwater table.

- **Dewatering and impact assessment**: an assessment of short-term construction dewatering and long-term sub-drain drainage if applicable for the residential units as well as an assessment of the potential impacts on the surrounding groundwater system.
- **Water balance (preliminary):** a preliminary water balance assessment was completed for the proposed development using the Thornthwaite-Mather approach and Environment Canada climate data to determine the potential change in groundwater recharge between pre- and post-development conditions.
- **Nitrate mass balance:** based on the water balance assessment results, an assessment of nitrate dilution to occur under post development conditions was completed.
- **Source water impact assessment:** as the Site is situated within a Highly Vulnerable Aquifer (HVA) area, a Source Water Protection assessment was completed to detail threats to groundwater in terms of water quality and quantity.

1.2 Site Description and Site Development

The property consists of a total area of approximately 48.15 hectares of undeveloped land, except for a dwelling and associated structures in the westernmost area of the property bordering County Road 49. Also, the property consists of an unevaluated wetland and wetland buffer totalling 11.94 ha, leaving 36.21 ha as a developable area. The Site is bordered by existing houses on Ellwood Crescent to the south, mixed farmland and natural vegetation to the north, mixed natural vegetation, and residential land to the east on Moon Line Road North, and County Road 49 to the west.

Cambium understands the proposed development includes the construction of 59 estate lots, with 25 lots planned for Phase 1 of development. There is Site access off County Road 49 and Moon Line North. It should be noted that the client is proposing a phased development consisting of Phase 1 and Phase 2 (Appendix A), however, this report is being completed for the entire Site.

The regional location of the Site is outlined on Figure 1, the property and surrounding areas outlined on Figure 2, and the proposed development plan is included in Appendix A.

1.3 Past Investigation and Peer Review Comments

There were several comments made on the previous Hydrogeological Investigation and Terrain Analysis report prepared by Jp2g, dated October 2021 and Cambium was retained to address the following comments and produce a supplemental hydrogeological assessment report.

The following peer comments made by Stantec Consulting Ltd were being addressed by Cambium in this supplemental report:

1. The high groundwater table and shallow groundwater flow direction needs to be defined using a shallow groundwater monitoring well network assist with the following:
    a. setting basement elevations
    b. assessing the suitability of various infiltration deficit mitigation measures
    c. the placement of supply wells and sewage system envelopes on each lot (i.e., what direction(s) is groundwater flowing to assist with the placement of this infrastructure)
    d. assessing the relationship between the shallow groundwater table and the wetland (i.e., does the wetland depend on shallow groundwater inputs to maintain its form and function)
    e. septic system design (i.e., will the raised beds be required because of a shallow groundwater table or low permeability soils).
    f. assessing the need for construction dewatering
2. The function of the wetland needs to be evaluated to determine if the wetland is a groundwater recharge or discharge feature.
3. A pre- and post-development water balance must be completed to assess the infiltration deficit and identify appropriate mitigation measures to maintain pre-development infiltration rates.

4. The report needs to comment on whether the Site is situated within a Source Protection Vulnerable Area and if there are any Source Protection Policies that may impact the proposed development.

This supplemental hydrogeological report will address the above comments, except the spring high water table conditions to define the spring high water table conditions at the Site.

2.0 Environmental Features

To assess environmental features, databases maintained by the Ministry of Natural Resources and Forestry (MNRF), the Ministry of Environment, Conservation and Parks (MECP), and Kawartha Region Conservation Authority (KRCA) were reviewed.

According to the data reviewed, the Site is situated within the Kawartha-Haliburton Source Protection Area and the majority of Site is located within the Pigeon Lake-Gannon Narrows watershed (MECP, 2023). A portion of the Site to the west is located within the Bobcaygeon River watershed (MECP, 2023).The Site is within KRCA regulated area per O.Reg. 182/06 (Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses) and therefore development restriction do apply to the proposed development.

As per the MECP Source Water Protection Information Atlas (SPIA), the Site is situated within a Highly Vulnerable Aquifer (HVA) area with a vulnerability score of 6.

As per the MNRF Natural Heritage System database, the Site does not have any Areas of Environmental Significance or Areas of Natural and Scientific Interests (ANSI). The Site contains a mapped unevaluated wetland, woodland areas, as well as a Natural Heritage System area (MNRF, 2023).

3.0 Physical Setting

3.1 Topography and Drainage

Based on the topographic contours provided in the topographic map (Appendix A) created using the MNRF database, the Site has a topographic high in the north-west corner of the property at approximately 305 metres above sea level (masl). From this high, land slopes to the southeast to an elevation of just above 284 masl near the south-east property boundary. There are many rolling hills with low lying areas around the existing residence in southwest corner of Site, a wetland in the centre of the Site, and overland drainage / an intermittent watercourse in the northeast corner.

The local drainage for the Site follows the topography discharging southeast off site ultimately discharging into Pigeon Lake approximately 1.3 km east of Site.

3.2 Physiography

According to the Miscellaneous Release – Data 228 from the Ontario Geological Survey (Chapman, L.J. and D.F. Putnam, 1984), the Site is located within the Dummer Moraines physiographic region.

The Dummer Moraines consists of rough stony land with an area of approximately 1550 square kilometres. The bedrock of the Dummer Moraines consists of limestone thinly covered in till and slopes gently southward. Moraines are scattered throughout the region.

3.3 Overburden Geology

According to the Ontario Geological Survey Data Set 126 – Revised (OGS, 2010), the Site overburden is characterized as till consisting of stoney, sandy silt to silty sand-textured till. A bedrock-drift complex with till cover is in the eastern portion of the Site.

3.4 Bedrock Geology

According to Miscellaneous Release – Data 219 from the Ontario Geological Survey (Ontario Geological Survey, 2007), the bedrock of the Site consists of Middle Ordovician rocks from the

Simcoe Group. The Simcoe Group consists of four formations that dip gently towards the southwest from oldest to youngest and consist of the Gull River, Bobcaygeon, Verulam, and the Lindsay Formations. The bedrock of the Site consists of two Simcoe Group formations. Western portion of the Site consists of the Verulam Formation described as limestone and shale. Eastern portion of the Site consists of the Bobcaygeon Formation described as limestone, with minor shales in the upper part of the formation.

4.0 Borehole Drilling and Monitoring Well Instillation

4.1 Borehole Investigation

Cambium completed a borehole investigation and test pit investigation on October 25 to October 27, 2023, to assess subsurface conditions at the Site. A total of fourteen (14) boreholes, designated as BH101-23 to BH114-23, were advanced to a termination depth ranging from 2.44 mbgs to 4.98 mbgs at the Site for geotechnical and hydrogeological purposes. Four boreholes, BH101-23, BH108-23, BH109-23, and BH113-23 were equipped as monitoring wells within the soil to allow for the assessment of groundwater levels and elevations over time. Borehole, and monitoring well locations are included in Figure 2. Borehole logs are included in Appendix B.

A summary of general lithological details is presented below.

Topsoil

Brown silt and sand topsoil was encountered in all boreholes, ranging from 0.075 m to 0.250 m in thickness, with an average thickness of approximately 0.150 m.

Clayey Silt

Brown clayey silt, with some sand and trace gravel, and occasional cobbles, was encountered immediately below the topsoil in boreholes BH101-23 and BH102-23. Trace amounts of organics were found within the clayey silt soil in BH102-23. The clayey silt material extended to depths 0.70 mbgs and 1.45 mbgs, respectively. The clayey silt soil was generally found to be drier than the plastic limit at the time of investigation. SPT blow counts within the clayey silt provide evidence of generally soft to stiff relative consistencies.

Till

Brown to light brown to grey till soil with a relatively even mixture of sand, gravel, and silt, and some cobbles, was encountered immediately below the topsoil in all boreholes, except BH101-23 and BH102-23, where it was encountered immediately below the clayey silt soils. The till extended to termination depth in all boreholes. The till was generally found to be moist at the

time of investigation, with BH101-23 exhibiting moist-to-wet to wet soils and BH104-23 exhibiting moist-to-wet soils beginning at 2.3 mbgs. SPT blow counts within the till provide evidence of generally compact to very dense relative densities throughout the entire soil column.

Bedrock

Presumed bedrock was encountered at depths of 3.12 mbgs, 2.44 mbgs, 3.35 mbgs, and 3.66 mbgs, in BH101-23, BH102-23, BH111-23, and BH114-23, respectively. All other boreholes were terminated in native soils at depths from 4.60 mbgs to 4.98 mbgs.

Monitoring wells construction details including screen elevations are presented in the Table 1.

Table 1 Well Construction Details

Monitoring Well	Borehole Termination Depth (mbgs)	Monitoring Well Installation Depth (mbgs)	Ground Elevation (masl)	Screen Top (masl)	Screen Bottom (masl)
BH101-23	3.12	2.88	302.80	301.28	299.81
BH108-23	4.72	4.62	297.97	294.92	293.46
BH109-23	4.85	4.58	300.40	297.35	295.89
BH113-23	4.60	4.57	311.71	308.66	307.20

4.2 Physical Laboratory Testing

Physical laboratory testing was completed for a total of seven selected soil samples to confirm textural classification and to estimate percolation rates of the native soils. Results are presented in Appendix C and details of the grain-size analysis are presented in Table 2 below.

Table 2 Particle Size Distribution

Borehole	Depth (mbgs)	Description	% Gravel	% Sand	% Silt	% Clay	T-Time (min/cm)
BH101-23 SS4	2.3 – 2.9	Silty Gravel and Sand	34	34	25	7	20
BH102-23 SS2	0.8 – 1.4	Clayey Silt, some Sand	7	16	50	27	45
BH105-23 SS3	1.5 – 2.1	Sandy Silty Gravel some Clay	39	28	23	10	30
BH108-23 SS3	1.5 – 2.1	Gravelly Silty Sand	32	41	20	7	20
BH109-23 SS4	2.3 – 2.9	Gravelly Silty Sand	33	35	23	9	25
BH112-23 SS3	1.5 – 2.1	Sandy Silty Gravel some Clay	34	29	26	11	30

As per the data above, the percolation times (T) ranged from 45 min/cm to 20 min/cm, for the soils ranging in depth from as shallow as 0.8 mbgs to as deep as 2.9 mbgs, with a geometric average of about 27.2 min/cm. This indicates a moderate drainage and infiltration potential for the overburden soils at the Site.

4.3 Piezometer Installation

Cambium staff installed one drive point piezometer (DP101-23) within the wetland feature at the Site on November 10, 2023. Piezometer construction details including screen elevations are presented in Table 3. Location of the piezometer DP101-23 is depicted on Figure 3. The elevation of piezometer DP101-23 is approximate and based on mapped topographic contours at the location of DP101-23.

Table 3 Piezometer Construction Details

Piezometer	Piezometer Installation Depth (mbgs)	Approximate Ground Elevation (masl)	Approximate Screen Top (masl)	Approximate Screen Bottom (masl)
DP101-23	2.44	291.00	288.26	288.56

4.4 Groundwater Level Monitoring

On November 10, 2023, Cambium staff measured the depths to groundwater in the four new monitoring wells installed. A summary of groundwater elevations is presented in Table 4.

Table 4 Measured Groundwater Details – November 10, 2023

Well	BH101-23	BH108-23	BH109-23	BH113-23
Top of Pipe Elevation (masl)	303.72	298.88	301.24	312.60
Ground Surface Elevation (masl)	302.80	297.97	300.40	311.71
Stick-up (m)	0.91	0.91	0.84	0.89
Water Level (mbgs)	0.44	dry	dry	4.04
Groundwater Elevation (masl)	302.37	<293.25-	<295.55	293.93

As presented above, the manual measured groundwater levels in the monitoring wells ranged in depth from 0.44 mbgs to 4.04 mbgs, while the elevations ranged from 293.93 masl to 302.37 masl. Accordingly, the highest fall groundwater level and elevation could be 0.44 mbgs and 302.37 masl, respectively. Of note, BH108-23 and BH109-23 was dry on November 10, 2023.

Cambium proposes to complete a spring water level monitoring between March and June to obtain spring high water levels at the Site.

4.5 Piezometer Water Level

The measured water level in piezometer DP101-23 is included in Table 5. Piezometer was installed to a depth of 1.61 m below the bottom of the wetland. The surface water level at DP101-23 was 0.23 metres above the bottom of the wetland, with an approximate surface water elevation of 291.23 masl. The height of stick-up above the water surface was 0.60 m. The manual measured groundwater level in the piezometer was 2.11 mbTOP at an elevation of 289.72 masl.

Based on the groundwater elevation within the wetland, it can be classified that the wetland is groundwater recharge feature, rather than a discharge feature.

Table 5 Measured Piezometer Water Level – November 10, 2023

Well	DP101-23
Top of Pipe Elevation (masl)	291.83
Wetland Bottom Elevation (masl)	291.00
Stick-up (m above wetland bottom)	0.83
Water Level (mbTOP)	2.11
Groundwater Elevation (masl)	289.72

4.5.1 Groundwater Gradient

Wetland surface water elevation noted by Cambium staff on November 10, 2023, was 291.23 masl, while the groundwater level measured was at an elevation of 289.72 masl. Based on water level monitoring, the highest fall groundwater level and elevation could be 0.44 mbgs and 302.37 masl, respectively. As the depth to the water table at the wetland feature (289.72 masl) is lower than the groundwater elevation (302.37 masl), there is a downward vertical gradient between the surface water and the shallow groundwater localized around DP101-23.

4.6 Groundwater Flow Direction

Based on the groundwater elevation data obtained from the November 10, 2023, monitoring event, a site-specific groundwater elevation contour map was prepared to present the groundwater flow direction across the Site. This map was prepared using water level elevations obtained from the western monitoring wells and the drive-point piezometer from the centre of the Site. As the eastern monitoring wells are dry, groundwater contours are interpreted to be in deeper elevation in this area. As shown in Figure 4, the groundwater flow direction was found to be to the east-northeast, where it is interpreted to ultimately discharge into Pigeon Lake located 1.3 km east of the Site.

4.7 In-Situ Hydraulic Conductivity Tests

The hydraulic conductivities (K-value) of the native soils were estimated based on the results obtained from the single well hydraulic tests (SWHT) conducted on November 10, 2023. Rising head tests were performed in the monitoring wells BH103-22, and BH113-22, which had

sufficient water for SWHTs. Results of hydraulic conductivity tests are presented below in Table 6 and analytical data is included in Appendix D.

Table 6 Results of Estimated Hydraulic Conductivity as per SWHT

Monitoring Well	Estimated Hydraulic Conductivity (m/sec)		Tested Soil Type
BH101-22	Test 1	8.38×10^{-6}	Gravelly silty sand to silty gravel and sand
	Test 2	8.00×10^{-6}	
	Test 3	8.64×10^{-6}	
BH113-22	Test 1	4.51×10^{-8}	Sandy to silty gravel, some clay
	Test 2	2.45×10^{-8}	

The hydraulic conductivity was estimated utilizing Aquifer Test Pro software using the Hvorslev interpretation method. The estimated hydraulic conductivities ranged between 2.45×10^{-8} m/sec and 8.64×10^{-6} m/sec, geometric mean of 9.15×10^{-7} m/sec. The results were consistent with published values for the native till soils encountered at the respective boreholes.

5.0 Construction Dewatering Requirements

Construction dewatering is intended to lower the groundwater levels in the excavation area to ensure a dry and safe working condition.

The requirements for construction dewatering generally depend on the Site's soil and groundwater conditions including soil type, soil permeability or hydraulic conductivity, local groundwater levels, and the design of the proposed development, such as the foundation and/or basement elevation, as well as the size of proposed structure.

5.1 Proposed Development, Anticipated Excavation and Dewatering

The proposed development will include the construction of 59 estate lots, with 25 estate lots planned for Phase 1 of development. At the time of writing this report, the actual finished floor elevations (FFE) for the structures were not provided. It is assumed that the proposed FFE will be approximately the same elevation as the existing grades on Site. The geotechnical investigation report indicated exterior footings to be placed at a minimum of 1.5 metres below final grade to protect from frost penetration (Cambium, 2023). At the southwest portion of Site, dewatering may be required due to shallow measured water level of 0.44 mbgs. Assuming the excavations for building foundations will go to the frost penetration depth of 1.5 mbgs, any seepage within the excavation depths should be controllable with filtered sumps and pumps.

The rest of the Site has water levels deeper than 4 mbgs, and therefore is feasible to go for conventional basements without requiring a potential dewatering either for short-term or long-term basis. Accordingly, a Permit to Take Water (PTTW) or registry in the Environmental Activity and Sector Registry (EASR) for the Ministry of the Environment, Conservation and Parks (MECP) will not be required.

The design invert elevations for the Sites linear infrastructure were not available at the time the document was prepared. The open cut excavations for installation of linear infrastructure in the southwestern parts of the Site will likely intercept the groundwater table since the services/utilities are to be placed below the frost penetration depth of 1.5 mbgs (Cambium, 2023). The linear infrastructure installation will require construction dewatering. Preliminary

dewatering estimates were not able to be calculated for linear infrastructure, because proposed detailed design of services location and invert depths were not available at this time. Construction dewatering requirements should be revisited once a detailed design for the linear infrastructure and building basements is available.

6.0 Water Balance Assessment

According to methodology developed by Thornthwaite and Mather (Thornthwaite & Mather, 1957), a water balance is an accounting of water in the hydrologic cycle. Precipitation (P) falls as rain and snow. It can run off towards lakes and streams (R), infiltrate to the groundwater table (I), or evaporate from ground or be transpired by vegetation (ET). When long-term average values of P, R, I, and ET are used, there is minimal or no net change to groundwater storage (ΔS) in a steady-state system.

The annual water budget of a Site can be expressed as:

$$P = ET + R + I + \Delta S$$

Where:

P = Precipitation (mm/year)

ET = Evapotranspiration (mm/year)

R = Run-off (mm/year)

I = Infiltration (mm/year)

ΔS = Change in groundwater storage (taken as zero) (mm/year)

The calculations presented here compare the pre- and post-development water balance changes within the Site boundaries because of the proposed development. It is noted that the water balance described herein does not account for catchment areas that extend off-site.

Based on the available design information, the pre- and post-development Site coverage can be generally categorized into three types: paved areas, roof areas, and landscaped areas.

A summary of the surface areas of the development is listed in Table 8. The pre-development Site area is underlain by a mixture of silt, sand, and gravel till. Detailed design layouts for residential lots were not available for review at the time this document was prepared; therefore, some assumptions had to be made regarding pervious and impervious surfaces. The impermeable paved area for the residential lot driveways were assumed to be 10% of the lot area, the roofed area for the structures on the lots were assumed to be about 232 m^2 (2,500

ft^2), and the rest of the lot was assumed to be pervious landscaped area. The pre-development land coverage area is depicted on Figure 5 and the Site statistics in Table 7 below.

Table 7 Pre-Development Site Statistics

Type of Land Coverage	Pre-Development Areas (ha)
Paved Area	0.07
Roof Area	0.03
Landscaped Area	48.05
Total	**48.15**

The table below (Table 8) shows the post-development Site statistics and while the areas were depicted schematically on Figure 6. The development of Site is proposed to happen in two phases, Phase 1, and Phase 2. The water balance calculations will consider the whole Site for both phases and will not consider the two phases independently.

Table 8 Post-Development Site Statistics

Type of Land Coverage		Post-Development Areas (ha)
Phase 1 Lot Area	Paved Area	1.35
	Roof Area	0.58
	Landscaped Area	11.55
Phase 2 Lot Area	Paved Area	1.93
	Roof Area	0.79
	Landscaped Area	16.55
Paved Area - Roadways		4.18
Landscaped - Wetland & Open Space		11.23
Total		**48.15**

Supporting information referenced herein (including detailed water balance calculations) is attached in Appendix E.

6.1 Water Surplus

Water surplus is calculated by determining the difference between precipitation and evapotranspiration over the course of a year (changes in soil water storage were assumed to

be negligible). The volume of water surplus is further sub-divided into portions that infiltrate the on-site soils and that are directed off-site as runoff.

The 30-year climate normal data, including monthly average temperature and precipitation, was obtained from Environment Canada, for Peterborough Trent U (Climate ID: 6166455) located about 29.11 km distance from the Site. The average annual precipitation was recorded to be 882 mm/yr and the average annual evapotranspiration was estimated to be about 540 mm/yr using the USGS Thornthwaite Monthly Water Balance methodology (Thornthwaite & Mather, 1957). Accordingly, the water surplus of the Site was calculated to be 342 mm/yr.

Transpiration does not occur from structures and paved areas. It was assumed that 10% of precipitation falling on such surfaces is lost directly to evaporation. The remaining depth (i.e., 90% of precipitation) was considered surplus and converted either to infiltration and/or runoff.

6.2 Infiltration Rates

The volume of surplus water that infiltrates through pervious surfaces on-site was determined by applying an infiltration factor to the surplus depth. The surplus water that does not infiltrate into pervious surfaces will leave the Site as surface water runoff. The infiltration factor varies from 0 to 1 and is estimated based on topography, soils, and vegetation cover as per the *Stormwater Management Planning and Design Manual* (Ministry of the Environment, 2003).

The rate of infiltration at a Site is expected to vary, based on several factors to be considered in any infiltration model. To partition the available water surpluses into infiltration and surface run-off, the Ministry of Environment, Conservation and Parks (MECP) infiltration factors were used. The MECP Storm Water Management Planning and Design Manual (2003) methodology for calculating total infiltration based on topography, soil type and land cover was used, and a corresponding run-off component was calculated for the soil moisture storage conditions.

The Site has a slight rolling topography and based on the results of the borehole investigation and the grain size analysis, the subsurface conditions at the Site are combinations of silty sand

and gravelly till dominant soils. Therefore, an infiltration factor of 0.65 was calculated for the Site using the MECP method.

6.3 Pre-Development Water Balance

The water balance for the existing conditions of the Site is summarized in Table 9. The pre-development infiltration rate was calculated to be about 106,815 m^3/yr and the runoff rate was about 58,310 m^3/yr.

Table 9 Pre-Development Water Balance

Land Use		Area (m^2)	Precipitation (m^3)	Evapo-transpiration (m^3)	Infiltration (m^3)	Run-off (m^3)
Impervious Areas	Paved Area	700	617	62	-	556
	Roof Area	300	265	26	-	238
Pervious Areas	Landscape Area	480,500	423,801	259,470	106,815	57,516
Total		**481,500**	**424,683**	**259,558**	**106,815**	**58,310**

Assuming no infiltration occurring in paved and roof areas, and 10% of precipitation to be evaporated from paved and roof areas.

6.4 Post-Development Water Balance

The post-development water balance is summarized in Table 10. The post-development infiltration rate was calculated to be approximately 87,422 m^3/yr and the runoff volume was about 117,126m^3/yr.

Table 10 Post-Development Water Balance

Land Use		Area (m^2)	Precipitation (m^3)	Evapo-transpiration (m^3)	Infiltration (m^3)	Run-off (m^3)
Impervious Areas	Paved Area	74,540	65,744	6,574	-	59,170
	Roof Area	13,710	12,092	1,209	-	10,883
Pervious Areas	Landscape Area	393,260	346,855	212,360	87,422	47,073
Total		**481,510**	**424,692**	**220,144**	**87,422**	**117,126**
Assuming no infiltration occurring in paved and roof areas, and 10% of precipitation to be evaporated from paved and roof areas.						

6.5 Water Balance Comparison

The water balances of the pre-development and post-development scenarios are summarized below in Table 11.

Table 11 Water Balance Comparison

	Precipitation (m^3)	Evapotranspiration (m^3)	Infiltration (m^3)	Run-off (m^3)
Pre-Development	424,683	259,558	106,815	58,310
Post-Development	424,692	220,144	87,422	117,126
Change in Volume	9	-39,414	-19,393	58,816
Change in %	0	**-15**	**-18**	**101**

Based on the above, there is a net infiltration deficit of about 19,400 m^3/year compared to the pre-development infiltration, while the runoff rate upon development of the Site will increase by about 58,800 m^3/year.

The roof surfaces of the proposed development are projected to generate 10,880 m^3/year of runoff (Table 10). Reinfiltrating the roof runoff at the Site could account for approximately 56% of the infiltration deficit.

A summary of the water balance could be provided as below:

- There is a net increase in run-off at the Site of about 58,816 m^3/year. This increase is a result of the development of the Site with more impervious areas such as roof and paved areas and a decrease in pervious areas.

- Post-development landscape area was decreased by about 87,420 m^2 when compared to pre-development conditions. These conditions resulted in less infiltration across the Site.
- Without implementing any mitigation measures the projected infiltration deficit is 19,400 m^3/year.
- Re-infiltrating approximately 100% of the roof runoff will account for approximately 56% of the projected infiltration deficit.
- Low impact development (LID) practices should be investigated to help offset the infiltration deficit.

6.6 Discussions on LID Measures

Low impact development (LID) practices have received increasing attention as these strategies attempt to capture the runoff and mimic the natural hydrologic cycle. It is important to maintain the natural hydrologic cycle as much as possible as reduction in infiltration reduces groundwater recharge and soil moisture replenishment and can also lead to reductions in stream baseflows which are needed to sustain aquatic life.

In general, there are two primary types of LIDs. The first promotes the infiltration of stormwater run-off close to the source. These infiltration type LIDs are preferred when hydrogeological and physical conditions are optimal and allow for their emplacement. The second type of LID captures and slowly releases stormwater to the groundwater water system through a process of storage and filtration by infiltration LIDs.

The conceptual water balance indicates that there will be an infiltration deficit of 19,400 m^3/year in the post-development infiltration upon development of the Site, compared to the pre-development condition.

Infiltration targets at the Site may be achieved through LIDs and incorporation of a variety of stormwater management techniques including reduced lot grading, roof downspout disconnection, roof leaders discharging to ponding areas or soak away pits, infiltration trenches, and grassed swales. Re-infiltrating roof runoff is a common solution to addressing the infiltration deficit, especially when there is a good extent of landscape area available.

However, the calculated roof runoff generated will only account for 56% of the infiltration deficit. A stormwater engineer should be retained to design the LID infrastructure and to address runoff flow generated from roof surfaces, as well as roadways if allowed. If runoff from roadways is accepted, the entire infiltration deficit can be accounted for.

It is noted that groundwater levels were measured between 0.44 mbgs and 2.95 mbgs in the western part of the Site on November 10, 2023, with the highest levels to groundwater recorded on the southwestern well BH101-23. LID features require one metre of vertical separation between the invert of a LID and high groundwater level; therefore, LID implementation should be considered for the eastern portion of the Site where dry conditions were noted at a depth of >4.6 mbgs (elevations between 293.46 masl and 295.89 masl). Consideration should be given to the thickness and percolation rates of unsaturated soils when finalizing the stormwater management plan and LID measures for the Site.

It should be noted that water levels will vary based on seasonal events and therefore, should be measured regularly to confirm high water conditions prior to construction.

In-situ infiltration testing is proposed as a supplementary investigation to determine infiltration rates expected in specific areas of the Site and to aid the detailed design process of the LID measures.

7.0 Wastewater Assessment (Nitrate Mass Balance)

As per Guideline D-5-4 Technical Guideline for Individual On-Site Sewage Systems: Water Quality Risk Assessment (MECP, 1996) an assessment was completed to determine the feasibility of utilizing on-site sewage disposal for the development.

Guideline D-5-4 requires the septic effluent plume at the Site boundary to be less than the Ontario Drinking Water Quality Standards (ODWQS) limit of 10 mg/L for nitrate to prevent contamination of groundwater on adjacent properties. Although natural processes and soil interaction can result in nitrate being attenuated in the receiving aquifer system, Guideline D-5-4 states that only dilution can be used as the attenuation mechanism to predict future nitrate concentrations. As such, a mass balance calculation is used to predict the impact of developing residential lots on the Site.

7.1 Available Dilution

The total available dilution for the Site is estimated by the following equation:

$$Qi = A \times S \times I$$

Where: Qi – Volume of Available dilution water

A – Area of the Site

S – Water surplus

I – Infiltration factor

To calculate the water surplus, the thirty-year climate normal data collected between 1981 and 2010 at the Peterborough Trent U (ID 6166455) weather station was used. The data was accessed through the Environment Canada website (Environment Canada, 2022).The total yearly precipitation, on average, was 882 mm.

The Thornthwaite method was used to determine the amount of evapotranspiration that will occur at the Site (S. Lawrence Dingman, 2008). The calculated depth of evapotranspiration was 540 mm/year, and the water surplus was calculated to be 342 mm per year. The evapotranspiration calculations are attached in Appendix E.

To determine the fraction of surplus water that infiltrates into the soils at the Site, the volume of surplus water is multiplied by an infiltration factor. As described the infiltration factor was determined to be 0.65 using the Stormwater Management Planning and Design Manual (Ministry of the Environment, 2003).

The volume of dilution water was calculated based on the post-development permeable area. The areas of the roads, roofs, and standing surface water were assumed to be impermeable. For road areas, water was assumed to run-off towards the permeable areas of the Site, therefore road surfaces were included in the dilution calculations. The proposed roofed area was included in the permeable area as it is assumed that roof leaders will direct any roof runoff to landscaped areas as is typical in rural subdivisions and therefore will not contribute to a post-development recharge deficit. Therefore, the only land that isn't being used within the dilution calculations is the wetland area with standing water (11.94 ha). The area available for dilution is the developable area at 36.21 ha.

The calculations of the available dilution water for the Site are outlined below Table 12.

Table 12 Available Dilution Calculations

Infiltration Factor			
Topography		Rolling Land = 0.2	
Soil		Combination of silt, sand, and gravel till = 0.3	
Cover		Cultivated and woodland mix =0.15	
Infiltration Factor (I)		0.65	
Volume of Precipitation Water			
Parameter	**Symbol**	**Units**	
Dilution Area	A	m^2	362,100
Surplus	S	m/day	0.000937
Volume of Surplus Water (Per Day)	A * S	m^3	339.41
Volume of Available Dilution Water (Per Day)	A * S * I	m^3	220.62
Volume of Runoff Water (Per Day)	A * S * (1-I)	m^3	118.79

7.2 Predictive Assessment

As per the procedure in Guideline D-5-4, a nitrate loading of 40 grams/lot/day is required to simulate the effluent loading from conventional septic systems on the receiving groundwater system. Total nitrogen (all species) ultimately converts to nitrate through the wastewater treatment process, so nitrate is the critical contaminant in sewage effluent. Each proposed lot is anticipated to generate an average discharge of 1,000 L/day of sewage effluent which contributes to the dilution of the total nitrate load.

To determine if the proposed lot density is adequate for nitrate dilution, a mass balance calculation is used to determine the sewage loading for nitrate on the property boundary. The mass balance calculations are outlined below as:

$$Q_tC_t = Q_eC_e + Q_iC_i$$

Where: Q_t = Total volume ($Q_e + Q_i$)

C_t = Total concentration of nitrate at the property boundary

Q_e = Volume of septic effluent

C_e = Concentration of nitrate in effluent (40 mg/L)

Q_i = Volume of available dilution water

C_i = Concentration of nitrate in dilution water (0.1 mg/L)

To determine the concentration of nitrate at the property boundary (C_t), the above mass balance equation can be arranged as follows:

$$C_t = \frac{Q_e C_e + Q_i C_i}{Q_t}$$

This equation was used to determine the dilution of wastewater by including infiltration on both the developable and non-developable portions of the Site. The results of the equation have been outlined in Table 13 below. Detailed calculations are included in Appendix F.

Table 13 Predictive Assessment of Nitrate Concentration

Variable	Value
Number of Lots	59
Q_e (L)	50,000
C_e (mg/L)	40
Q_i (L)	220,618
C_i (mg/L)	0.1
Q_t (L)	279,618
C_t (mg/L)	**8.52**

At the time of the assessment, the proposed development includes the construction of 59 new residential dwellings. The development of Site is proposed to happen in two phases, with Phase 1 being developed with 25 lots. The nitrate calculations will consider the whole Site for both phases and will not consider the two phases independently.

The predicted nitrate concentration at the Site boundary based on this 59-lot density using the calculated dilution volume, is 8.52 mg/L, which is less than the maximum allowable limit of 10 mg/L. Therefore, the Site can accommodate the proposed 59 new lots according to Guideline D-5-4.

The actual nitrate concentration is anticipated to be even lower due to the natural attenuation that will occur within the soil since this calculation only assumes dilution. In addition, conservative estimates were used for infiltration factors for the non development area with the limited information on soil characteristics in the area.

8.0 Source Water Protection and Risk Management

As per the Trent Protection Plan (LSPP), the Site is located within an HVA (Appendix A).

8.1 HVA

An HVA is an aquifer that can be easily changed or affected by contamination from both human activities and natural processes. This is a result of preferential pathways to the aquifer or the areas intrinsic susceptibility as a function of the thickness and permeability of the overlying soils. In Ontario, a HVA is defined as having an Intrinsic Susceptibility Index (ISI) of less than 30. In general, an HVA will consist of granular materials (e.g., sand and/or gravel) or fractured rock that has a high permeability and is near the surface of the ground. It is important to protect highly vulnerable areas to prevent drinking water contamination.

The land use practices at the proposed development Site are not expected to cause any contamination to the water resources as it is assumed that there are no chemicals, fertilizers, or petroleum hydrocarbons proposed to be stored at or handled on Site.

9.0 Assessment of Potential Impacts

Based on the information available, the proposed development consists of a 59 estate lots with 25 estate lots planned for Phase 1 of development. The potential impacts due to the Site development were assessed as below.

9.1 Natural Features

As discussed, an unevaluated wetland occupies much of the central portion and northeast of the Site and therefore, there could be some impacts on the local natural features due to the Site development. Therefore, as per Ont. Reg. 179/06. (Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses), set-back distances or buffer zones as prescribed by KRCA should be followed to protect the natural features.

9.2 Water Supply Wells near the Site

Based on the Site-specific conditions and the nature of the proposed development, it is highly unlikely that large scale dewatering activity will take place and additionally, water well records from the surrounding area indicate that the depth to water in the bedrock aquifer (which provides local water supply) has a geometric mean depth of 18.3 mbgs. It is therefore not expected that the water present in the shallow subsurface at the Site is connected to the water supply aquifer. Thus, no groundwater quantity impacts on local water wells (private or public), are anticipated due to the proposed development.

9.3 Considerations on Drinking Water Vulnerability

The entire area of the Site is identified as a HVA with moderate vulnerability. The proposed development therefore has potential to be affected by contamination from both human activities and natural processes, which can then in turn impact local drinking water supplies. The risk to drinking water quality can be minimized by preventing the infiltration of poor-quality runoff from paved surfaces such as driveways and roadways. As discussed in Section 8.1 The land use practices at Site are not expected to cause contamination to the water resources as it

is assumed that there are no chemicals, fertilizers, or petroleum hydrocarbons proposed to be stored at or handled on Site. A multi-pronged approach is advised to reduce the impact of winter salt application and promote best practices for residential outdoor use of chemicals and pesticides.

10.0 Conclusion and Recommendations

Cambium Inc. (Cambium) was retained by Jeffery Homes (the Client) to complete a hydrogeological assessment of the property known as Part of Lot 19, Concession 19, Township of Galway-Cavendish and Harvey, County of Peterborough.

The Site is situated in KRCA regulated area. The Site has an unevaluated wetland, woodlands, as well as a Natural Heritage System Area mapped on the Site. The unevaluated wetland occupies much of the central and northeast portions of the Site and therefore, there could be some impacts on the local natural features due to the Site development. Set-back distances or buffer zones as prescribed by the KRCA should be followed to protect the natural features.

The measured groundwater levels in the monitoring wells and piezometer during the November 2023 ranged in depths from 0.44 mbgs to 4.04 mbgs, and the elevations ranged from 289.72 masl to 302.36 masl. Dry conditions on the east portion of Site were noted to the explored depths of approximately 4.6 mbgs in BH108-23 and BH109-23 (bottom of well elevations ranging from 295.89 masl to 293.46 masl). Groundwater flow was determined to be to the east-northeast where is it interpreted to discharge into Pigeon Lake, located 1.3 km east of the Site.

The estimated hydraulic conductivities ranged between 2.45×10^{-8} m/sec and 8.64×10^{-6} m/sec, geometric mean of 9.15×10^{-7} m/sec.

As proposed development will include the construction of 59 estate lots, with 25 planned for Phase 1 of development. Construction excavation dewatering may be required for linear infrastructure. At the time of writing this report, the actual FFEs for the structures and services were not provided. As construction of structures is likely to occur in a dry season, and footings are to be placed above the water table, especially in eastern part of the Site, significant groundwater seepage is not anticipated within the excavation depths for the structures. Detailed design for Site servicing including locations and invert elevations were unavailable, so dewatering estimates were not provided. When Site plan drawings are made available, the dewatering estimates for linear infrastructure should be revisited.

The conceptual water balance indicates that there will be an infiltration deficit upon development of the Site in the order of about 19,400 m^3/year based off the current proposed Site plan. To compensate the infiltration deficit, roof downspout disconnection discharge to the sloped areas away from the building footprint should be implemented. Based on the estimation, a diversion of 100% of general roof water for infiltration would allow for 56% offset of the infiltration deficit of proposed development to maintain an enhanced infiltration after the development.

Additional LID measures (ex. soak away pits, infiltration trenches, and grassed swales) should be explored to offset the remainder of the infiltration deficit. LIDs should not be incorporated in the southwestern portion of Site due to the high water table conditions. LIDs should be designed by a competent stormwater engineer and were not incorporated into this assessment.

In-situ infiltration testing is proposed as a supplementary investigation to determine infiltration rates expected in specific areas of the Site and to aid the detailed design process of the LID measures.

The wastewater assessment indicates that the proposed development of 59 lot estate homes with private, on-site wastewater disposal, would result in a nitrate concentration of 8.52 mg/L at the property boundary, which is less than the Ontario Drinking Water Quality Standard of 10 mg/L. The proposed development is therefore expected to maintain acceptable nitrate concentrations at property boundaries.

Since the Site is situated within an HVA, Cambium recommends using the BMPs so as to avoid overland flow of any contaminants to the natural environment. There are no significant chemical or pathogen threats identified for the proposed land uses at the development.

11.0 Closing

We trust that the information in this submission meets your current requirements. If you have any questions regarding the contents of this report, please contact the undersigned.

Respectfully submitted,

Cambium Inc.

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2024-05-03

WY/mc/nh/sk

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12.0 References

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13.0 Standard Limitations

Limited Warranty

In performing work on behalf of a client, Cambium relies on its client to provide instructions on the scope of its retainer and, on that basis, Cambium determines the precise nature of the work to be performed. Cambium undertakes all work in accordance with applicable accepted industry practices and standards. Unless required under local laws, other than as expressly stated herein, no other warranties or conditions, either expressed or implied, are made regarding the services, work or reports provided.

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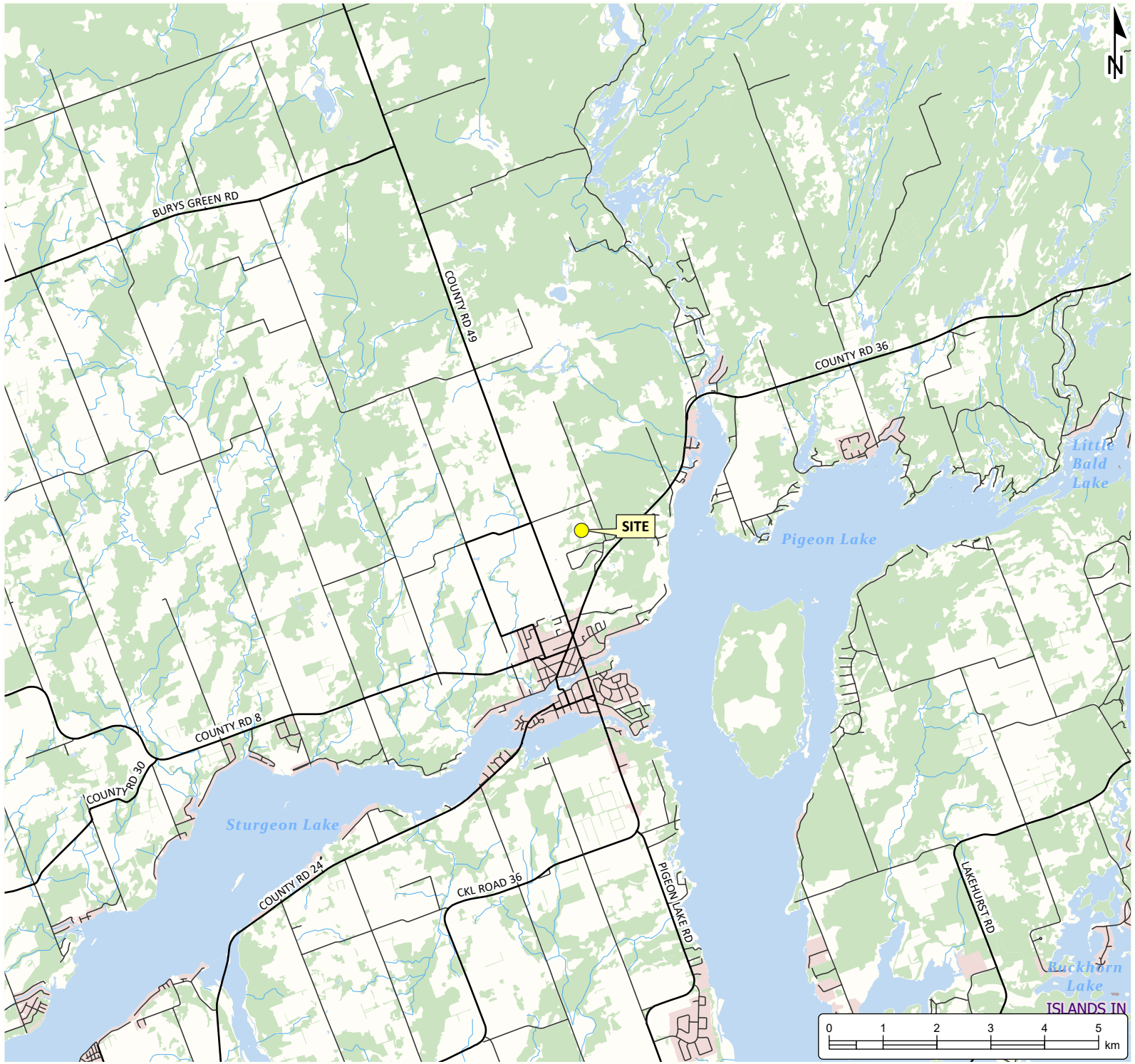
Appended Figures



HYDROGEOLOGICAL ASSESSMENT

JEFFERY HOMES
Pt. Lot 19, Conc. 19 - 168 County Road 49
Bobcaygeon, Ontario

LEGEND

- Highway
- Major Road
- Minor Road
- Railway
- Water Area
- Watercourse
- First Nations Reserve
- Provincial Park
- Wooded Area
- Built Up Area

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SITE LOCATION PLAN

Project No.: 17986-001		Date: December 2023	Rev.:
Scale: 1:100,000		Projection: NAD 1983 UTM Zone 17N	
Created by: DBB	Checked by: SK	Figure: 1	

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HYDROGEOLOGICAL ASSESSMENT

JEFFERY HOMES
Pt. Lot 19, Conc. 19 - 168 County Road 49
Bobcaygeon, Ontario

LEGEND

Site (approximate)

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SITE PLAN

Project No.: 17986-001		Date: December 2023 Rev.:	
Scale: 1:6,000		Projection: NAD 1983 UTM Zone 17N	
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HYDROGEOLOGICAL ASSESSMENT

JEFFERY HOMES
Pt. Lot 19, Conc. 19 - 168 County Road 49
Bobcaygeon, Ontario

LEGEND

- Borehole
- Monitoring Well
- Piezometer
- Site (approximate)

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BOREHOLE LOCATION PLAN

Project No.: 17986-001		Date: December 2023	Rev.:
Scale: 1:6,000		Projection: NAD 1983 UTM Zone 17N	
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HYDROGEOLOGICAL ASSESSMENT

JEFFERY HOMES
Pt. Lot 19, Conc. 19 - 168 County Road 49
Bobcaygeon, Ontario

LEGEND

- Benchmark
- Borehole
- Monitoring Well
- Piezometer
- Watercourse, Permanent
- Watercourse, Intermittent
- Groundwater Contour (2m interval)
- Site (approximate)

(293.93) Groundwater Elevation

(307.20) Well Screen Bottom (masl)

Groundwater Flow Direction

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GROUNDWATER ELEVATION PLAN

Project No.: 17986-001		Date: December 2023 Rev.:	
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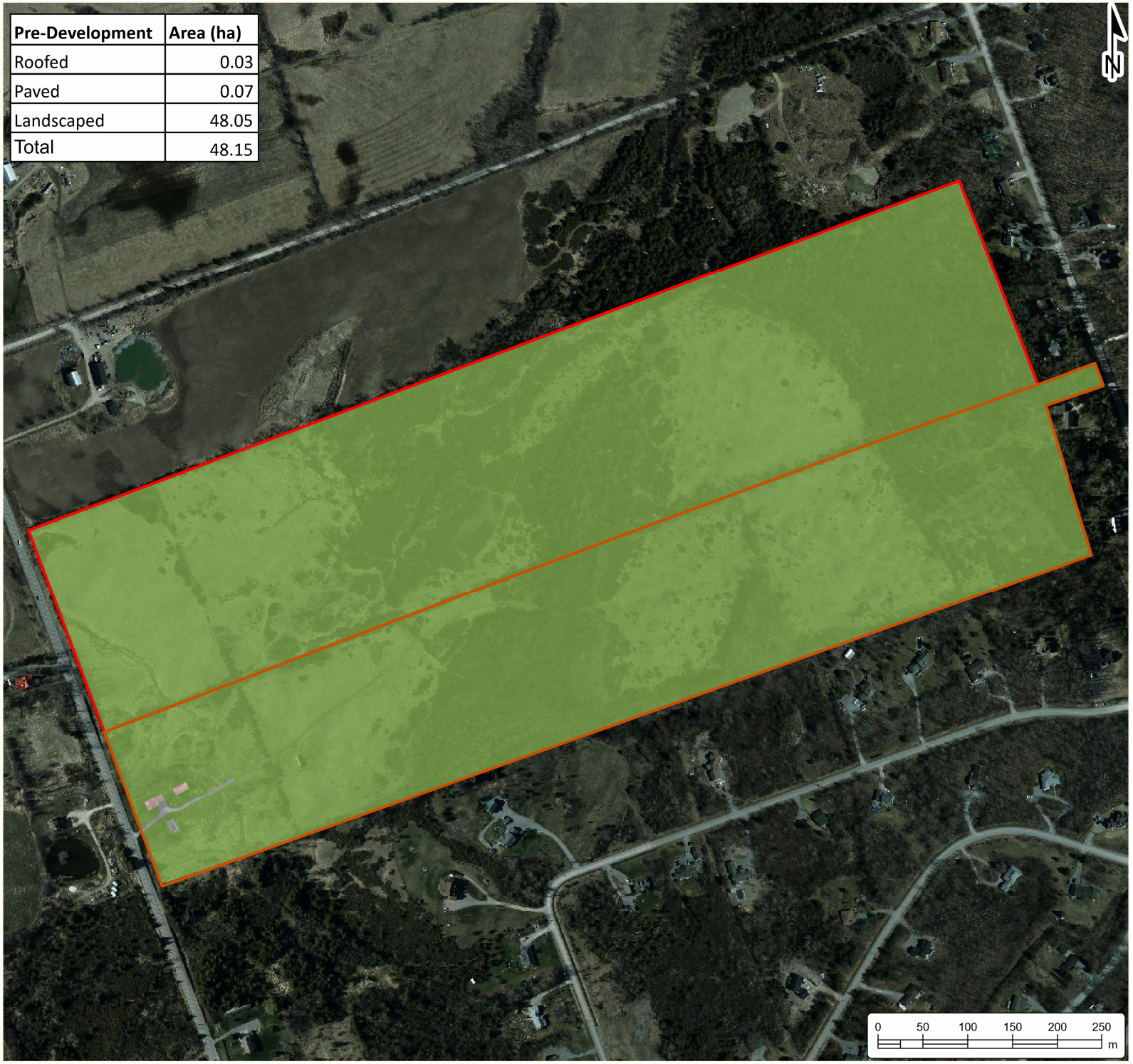
Pre-Development	Area (ha)
Roofed	0.03
Paved	0.07
Landscaped	48.05
Total	48.15



HYDROGEOLOGICAL ASSESSMENT

JEFFERY HOMES
Pt. Lot 19, Conc. 19 - 168 County Road 49
Bobcaygeon, Ontario

LEGEND

- Roofed
- Paved
- Landscaped
- Phase 2
- Phase 1

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PRE-DEVELOPMENT PLAN

Project No.: 17986-001		Date: April 2024 Rev.:	
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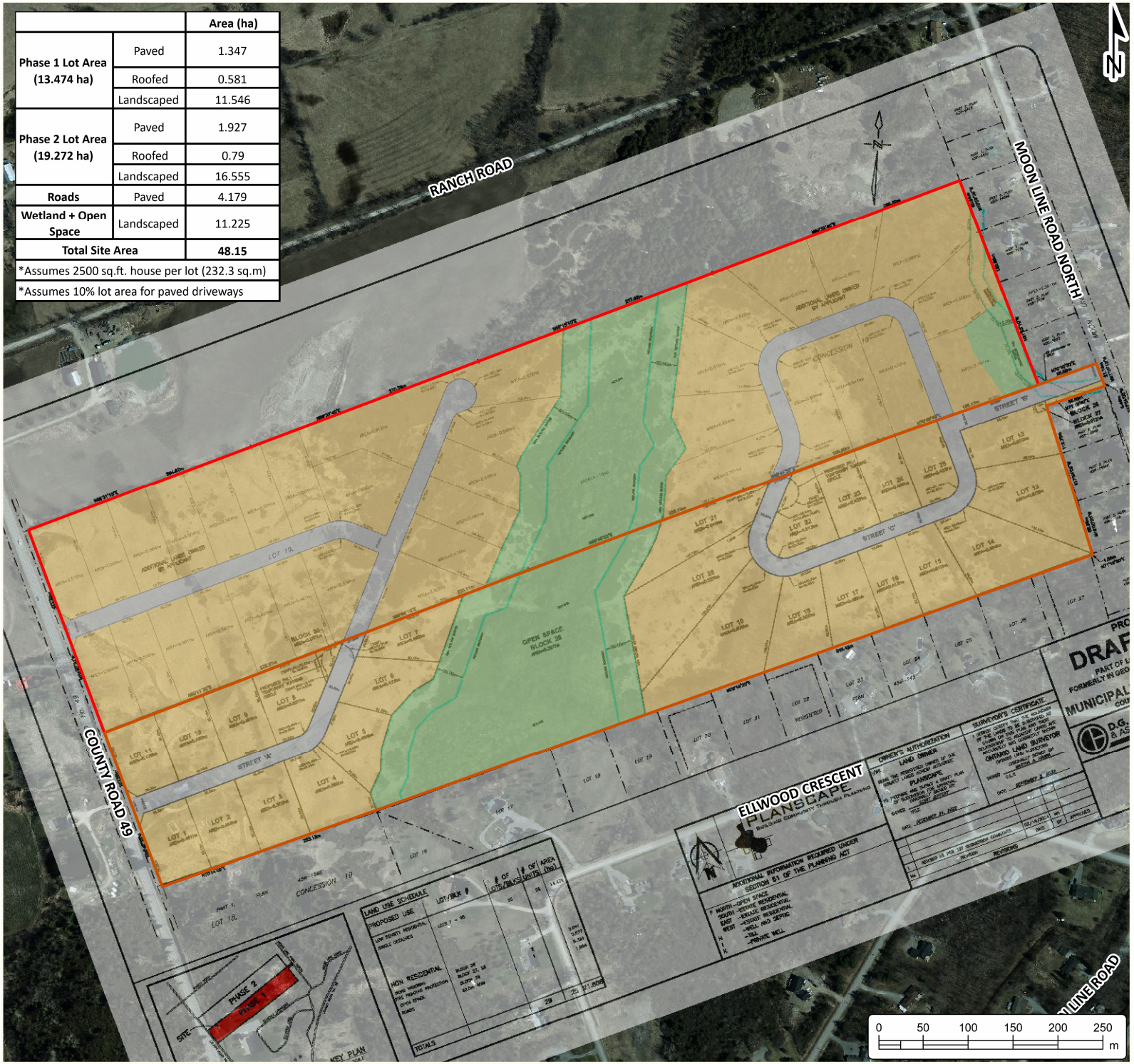
		Area (ha)
Phase 1 Lot Area (13.474 ha)	Paved	1.347
	Roofed	0.581
	Landscaped	11.546
Phase 2 Lot Area (19.272 ha)	Paved	1.927
	Roofed	0.79
	Landscaped	16.555
Roads	Paved	4.179
Wetland + Open Space	Landscaped	11.225
Total Site Area		48.15
*Assumes 2500 sq.ft. house per lot (232.3 sq.m)		
*Assumes 10% lot area for paved driveways		



HYDROGEOLOGICAL ASSESSMENT

JEFFERY HOMES

Pt. Lot 19, Conc. 19 - 168 County Road 49
Bobcaygeon, Ontario

LEGEND

- Developable Lot
- Paved
- Landscaped
- Phase 2
- Phase 1

***Note there are not any houses proposed on the plan, so the areas for paved and roofed in the residential lots are assumed values for the houses and the driveways.**

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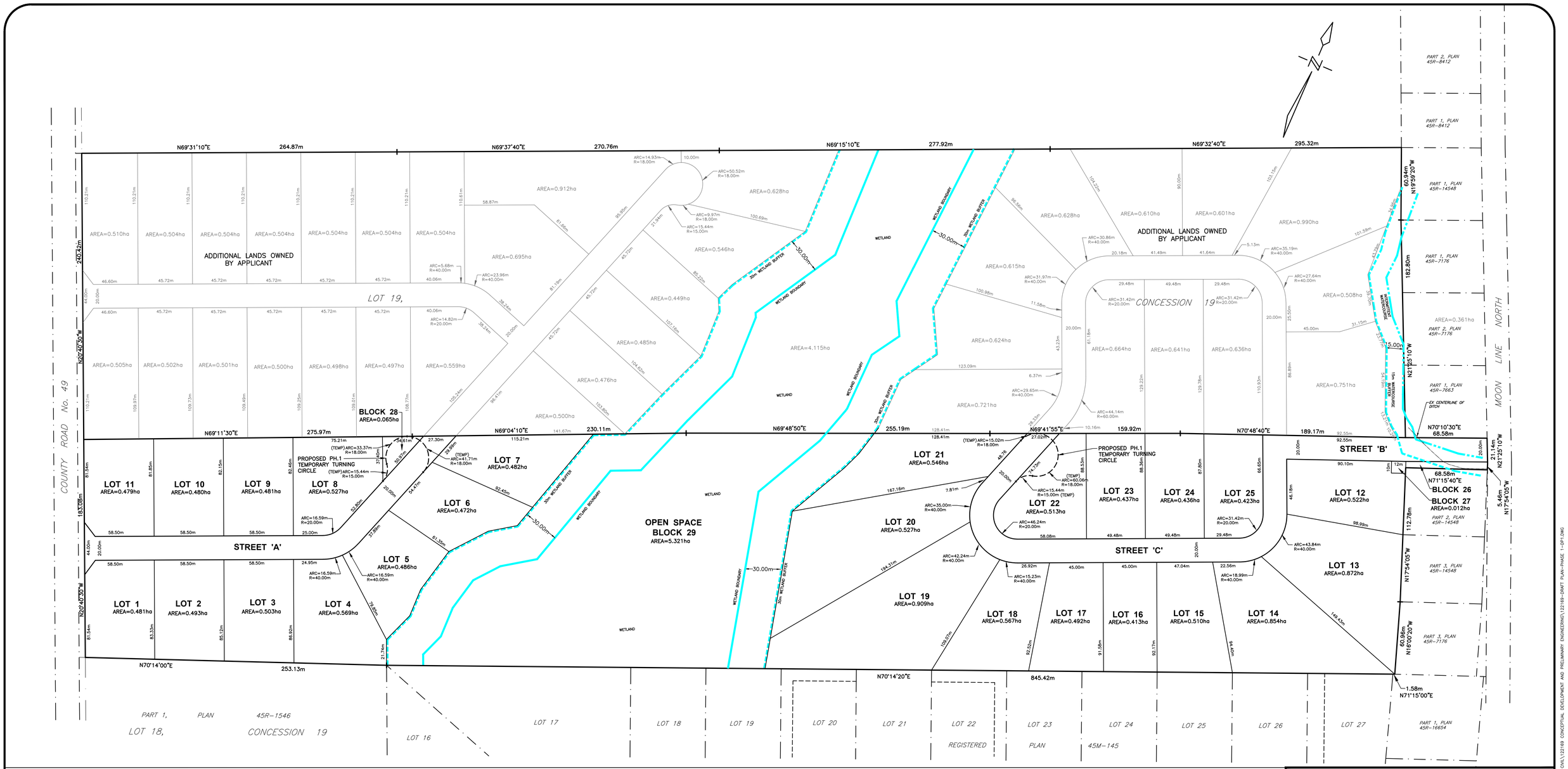
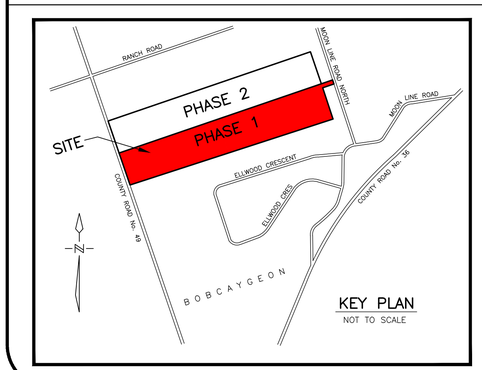
POST-DEVELOPMENT PLAN

Project No.: 17986-001		Date: December 2023	Rev.:
Scale: 1:6,000		Projection: NAD 1983 UTM Zone 17N	
Created by: DBB	Checked by: SK	Figure: 6	

Appendix A

Proposed Development Plan and Land Information





LAND USE SCHEDULE

PROPOSED USE	LOT/BLK #	# OF LOTS/BLKS	# OF UNITS	AREA (ha)
LOW DENSITY RESIDENTIAL				
SINGLE DETACHED	LOTS 1 – 25	25	25	14.475
NON RESIDENTIAL				
ROAD WIDENING	BLOCK 26	1		0.041
FIRE FIGHTING PROTECTION	BLOCK 27, 28	2		0.077
OPEN SPACE	BLOCK 29	1		5.321
ROADS	20.0m ROW			1.894
TOTALS		29	25	21.808

PLANSCAPE
BUILDING COMMUNITY THROUGH PLANNING

ADDITIONAL INFORMATION REQUIRED UNDER SECTION 51 OF THE PLANNING ACT

F NORTH –OPEN SPACE
SOUTH –ESTATE RESIDENTIAL
EAST –ESTATE RESIDENTIAL
WEST –ESTATE RESIDENTIAL
H –WELL AND SEPTIC
I –TILL
K –PRIVATE WELL

OWNER'S AUTHORIZATION

I/WE LAND OWNER
BEING THE REGISTERED OWNER OF THE SUBJECT LANDS HEREBY AUTHORIZE
PLANSCAPE
TO PREPARE AND SUBMIT A DRAFT PLAN OF SUBDIVISION FOR APPROVAL
SIGNED *ORIGINALLY SIGNED BY: SCOTT JEFFERY*
TITLE
DATE *DECEMBER 21, 2022*

SURVEYOR'S CERTIFICATE

I HEREBY CERTIFY THAT THE BOUNDARY OF THE LANDS TO BE SUBDIVIDED AS SHOWN ON THIS PLAN AND THEIR RELATIONSHIP TO ADJACENT LANDS ARE ACCURATELY AND CORRECTLY SHOWN
ONTARIO LAND SURVEYOR
ONTARIO LAND SURVEYORS
SIGNED *ORIGINALLY SIGNED BY: MARYNA A. HANNA*
O.L.S
DATE *SEPTEMBER 2, 2022*

No.	REVISION	DATE	BY	APPROVED
1.	REVISED AS PER 1ST SUBMISSION COMMENTS	03/18/2024	MH	

REVISIONS

PROPOSED
DRAFT PLAN

PART OF LOT 19, CONCESSION 19
FORMERLY IN GEOGRAPHIC TOWNSHIP OF HARVEY
NOW IN THE
MUNICIPALITY OF TRENT LAKES
COUNTY OF PETERBOROUGH

D.G. BIDDLE & ASSOCIATES
CONSULTING ENGINEERS & PLANNERS
96 King Street East
Oshawa, Ontario, L1H 1B6
Phone: 905-576-8500
info@dgbiddle.com
dgbiddle.com

SCALE: 1:1500
DRAWN BY: B.B.
DESIGN BY: M.J.H.
CHECKED BY: M.B.C.
PLOT DATE: 05/04/2024

122169

DP-1

X:\STAFF\JOB FILES\122000\122169 JEFFERY - BOBCAYGEON\122169 DRAWINGS CIVIL\122169 CONCEPTUAL DEVELOPMENT AND PRELIMINARY ENGINEERING\122169-DRAFT PLAN-PHASE 1-DP1.DWG

Kawartha Conservation Public Property Mapping Tool

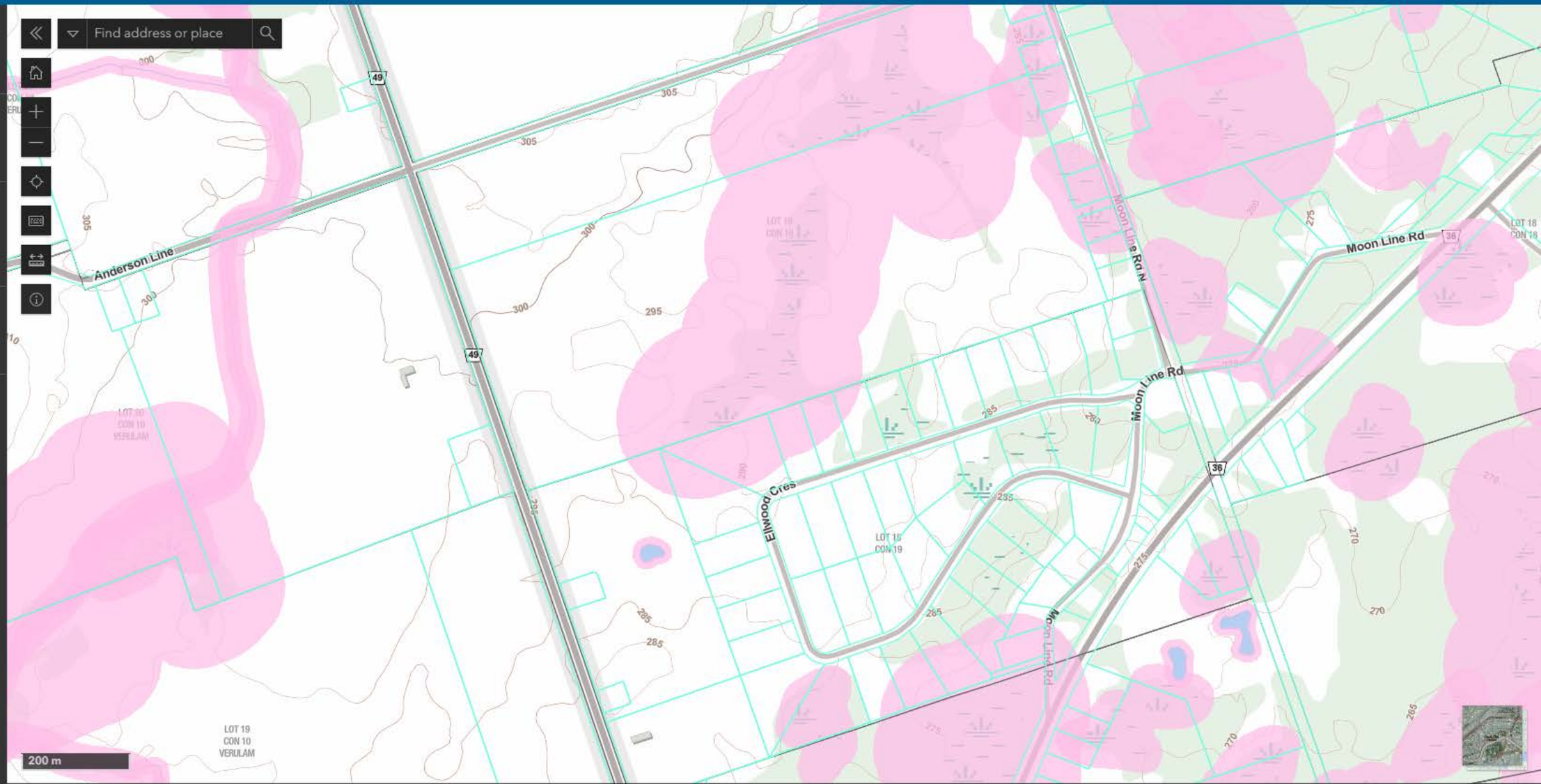
KRCA Assessment Parcels

KRCA_LIO_LotFabric

KRCA_RegulatedAreaBoundary

Wellhead Protection Area

Surface Water Intake Protection Zone



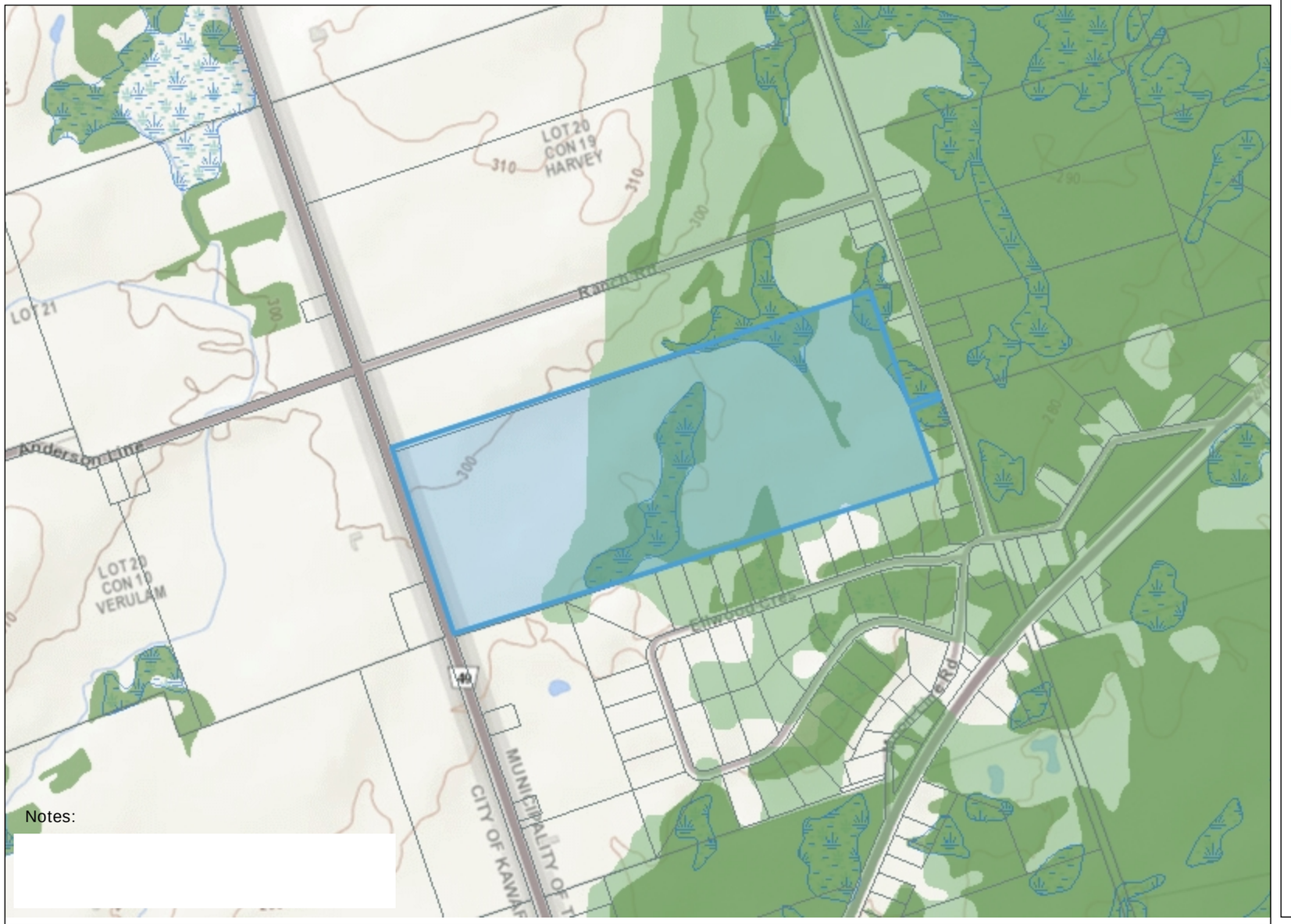
Ontario

Ministry of Natural Resources and Forestry

Make-a-Map: Natural Heritage Areas

Natural Heritage Areas Map

Map created:11/10/2023



Notes:

Legend

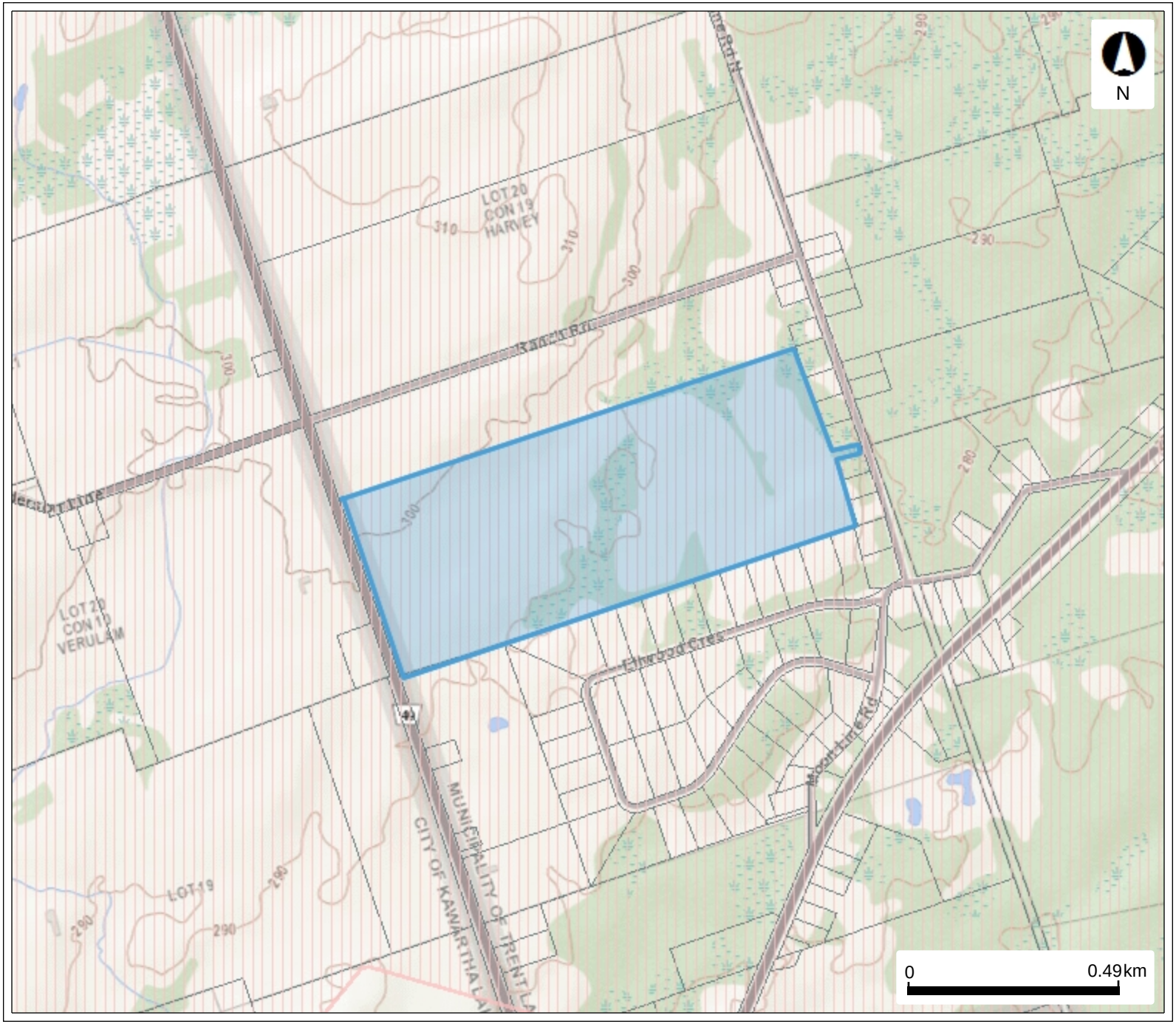
- Assessment Parcel
- Evaluated Wetland
- Provincially Significant/considérée d'importance provinciale
- Non-Provincially Significant/non considérée d'importance provinciale
- Unevaluated Wetland
- Woodland
- Natural Heritage System

0.7 0 0.33 0.7 Kilometres

Absence of a feature in the map does not mean they do not exist in this area.

This map should not be relied on as a precise indicator of routes or locations, nor as a guide to navigation. The Ontario Ministry of Natural Resources and Forestry(OMNRF) shall not be liable in any way for the use of, or reliance upon, this map or any information on this map.

Source Protection Information Atlas Map



Legend

- Highly Vulnerable Aquifers
- Assessment Parcel

This map should not be relied on as a precise indicator of routes or locations, nor as a guide to navigation. The Ontario Ministry of Environment, Conservation and Parks (MECP) shall not be liable in any way for the use or any information on this map. of, or reliance upon, this map.

Ontario

Map Created: 11/10/2023
Map Center: 44.56425 N, -78.54321 W

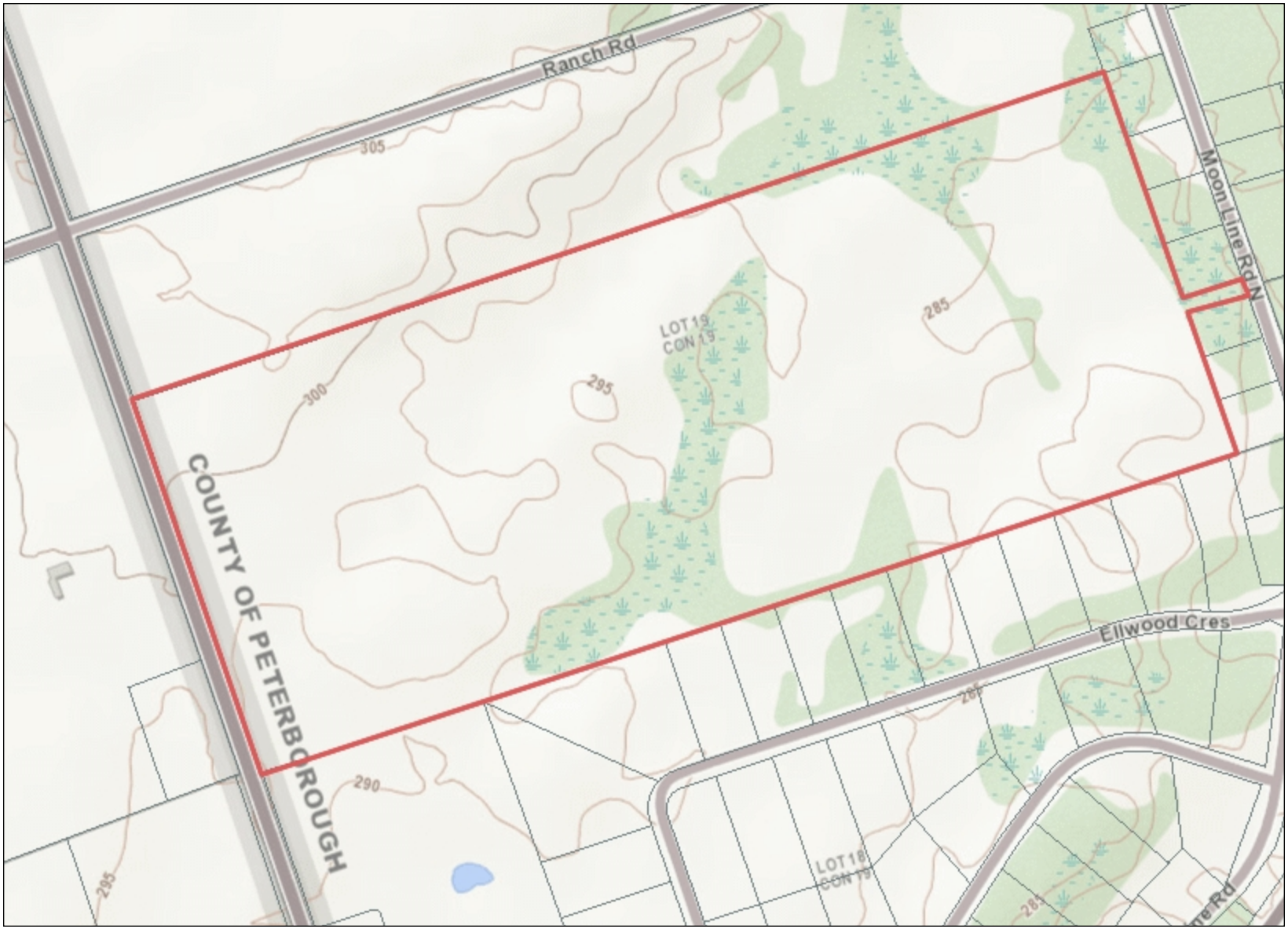
Ontario

MINISTRY OF NATURAL RESOURCES AND FORESTRY

Make a Topographic Map

Topo map

Notes:



Legend

- Building as Symbol
- Building to Scale
- Airport
- Heliport \ Hospital Heliport
- Seaplane Base
- Ferry Route
- Trail
- Bruce Trail
- Greenbelt Route
- Rideau Trail
- Trans Canada Trail
- Voyageur Trail
- Waterfront Trail
- Railway \ Train Station
- Railway with Bridge
- Railway with Tunnel
- Road (Major → Minor)
- Winter Road
- Road with Bridge
- Road with Tunnel
- Primary, Kings or 400 Series Highway
- Secondary Highway
- Tertiary Highway
- District, County, Regional or Municipal Road
- Toll Highway
- One Way Road
- Road with Permanent Blocked Passage
- Road with Address Ranges
- Hydro Line, Communication Line or Unknown Transmission Line
- Natural Gas Pipeline, Water Pipeline or Unknown Pipeline
- Spot Height
- Index Contour
- Contour
- Wooded Area
- Wetland
- Waterbody
- Waterbody Elevation
- Watercourse
- Falls
- Rapids
- Rapids \ Falls
- Rapids
- Rocks
- Lock Gate
- Dam \ Hydro Wall
- Dam \ Hydro Wall
- Provincial \ State Boundary
- International Boundary
- Upper Tier \ District Municipal Boundary
- Lower Tier \ Single Tier Municipal Boundary
- Lot Line
- Indian Reserve
- Provincial Park
- National Park
- Conservation Reserve
- Military Lands

0 0.3 km

Projection: Web Mercator

Appendix B
Borehole Logs

CAMBIUM
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Log of Borehole: BH101-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 25, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 694675.16 E, 4937141.01 N	**Elevation:**	302.80 masl

SUBSURFACE PROFILE			SAMPLE								
Elevation (m) / Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
303 / 0		TOPSOIL: 75mm thick layer of topsoil	1A	SS					Cap	Small cobble throughout
		CLAYEY SILT: Brown, clayey silt, some sand, trace gravel, drier than plastic limit, soft	1B	SS	25	2			Pipe; Bentonite Plug	Water level measured at 0.44 mbgs on Nov. 10, 2023
302 / 1		TILL: Light brown, gravelly silty sand, trace clay, moist to wet, compact	2	SS	50	15				
301 / 2			3	SS	42	15			Sand Pack	Groundwater first encountered at 2.29 mbgs
		TILL: Grey, silty gravel and sand, trace clay, wet, dense	4	SS	70	43			PVC Screen	Water level upon completion at 2.44 mbgs
300 / 3		-becomes very dense	5	SS	100	50/75			Cap	SS4 GSA: 34% gravel 34% sand 25% silt 7% clay
		Borehole terminated at 3.12 mbgs after auger refusal on presumed bedrock or large boulders								Borehole open upon completion
299 / 4										
298 / 5										

Logged By: J. Riseling **Input By:** J. Riseling

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Kingston
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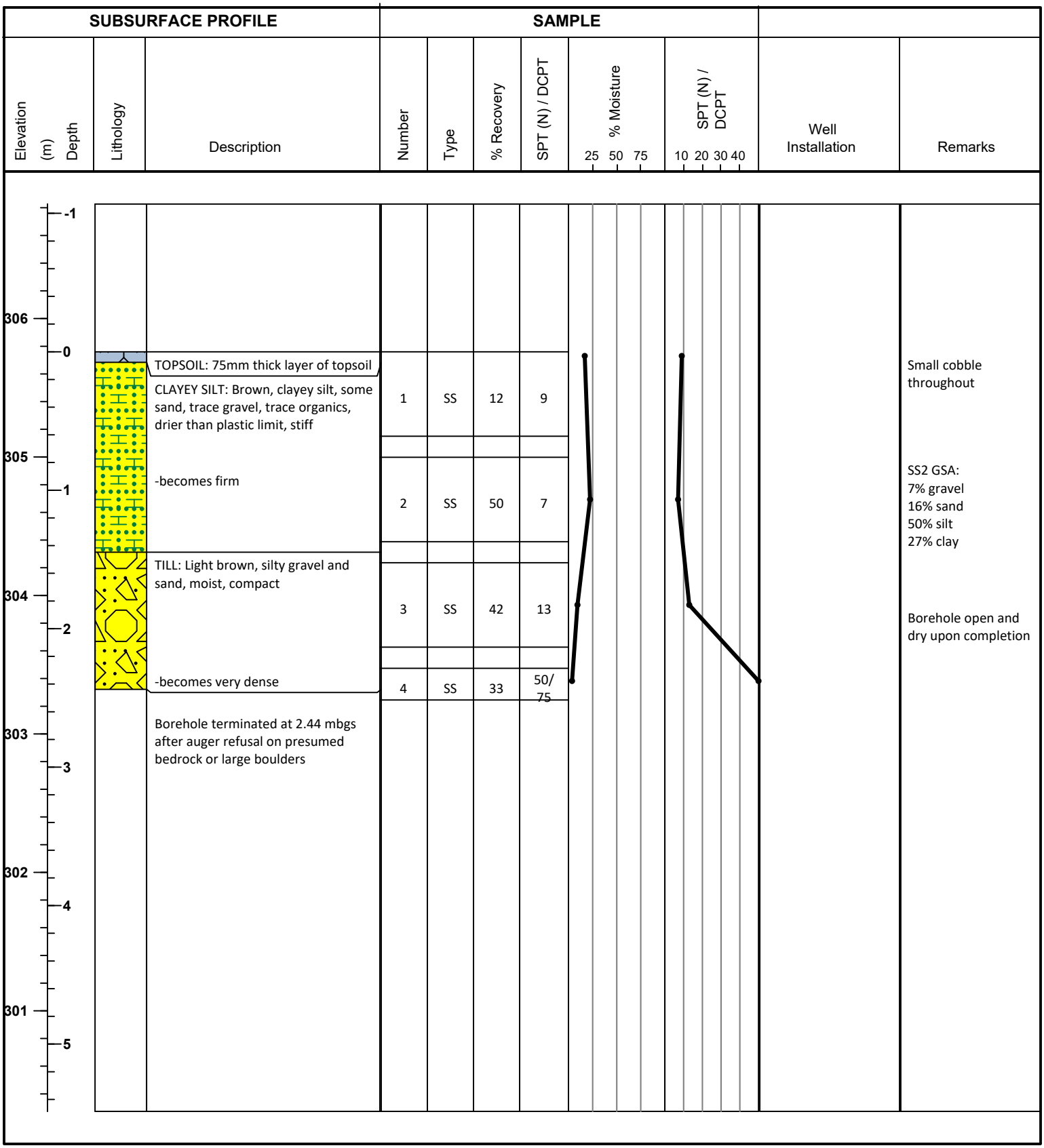
Log of Borehole: BH102-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 25, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 694793.84 E, 4937195.17 N	**Elevation:**	305.76 masl



Logged By:	J. Riseling	**Input By:**	J. Riseling

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Kingston
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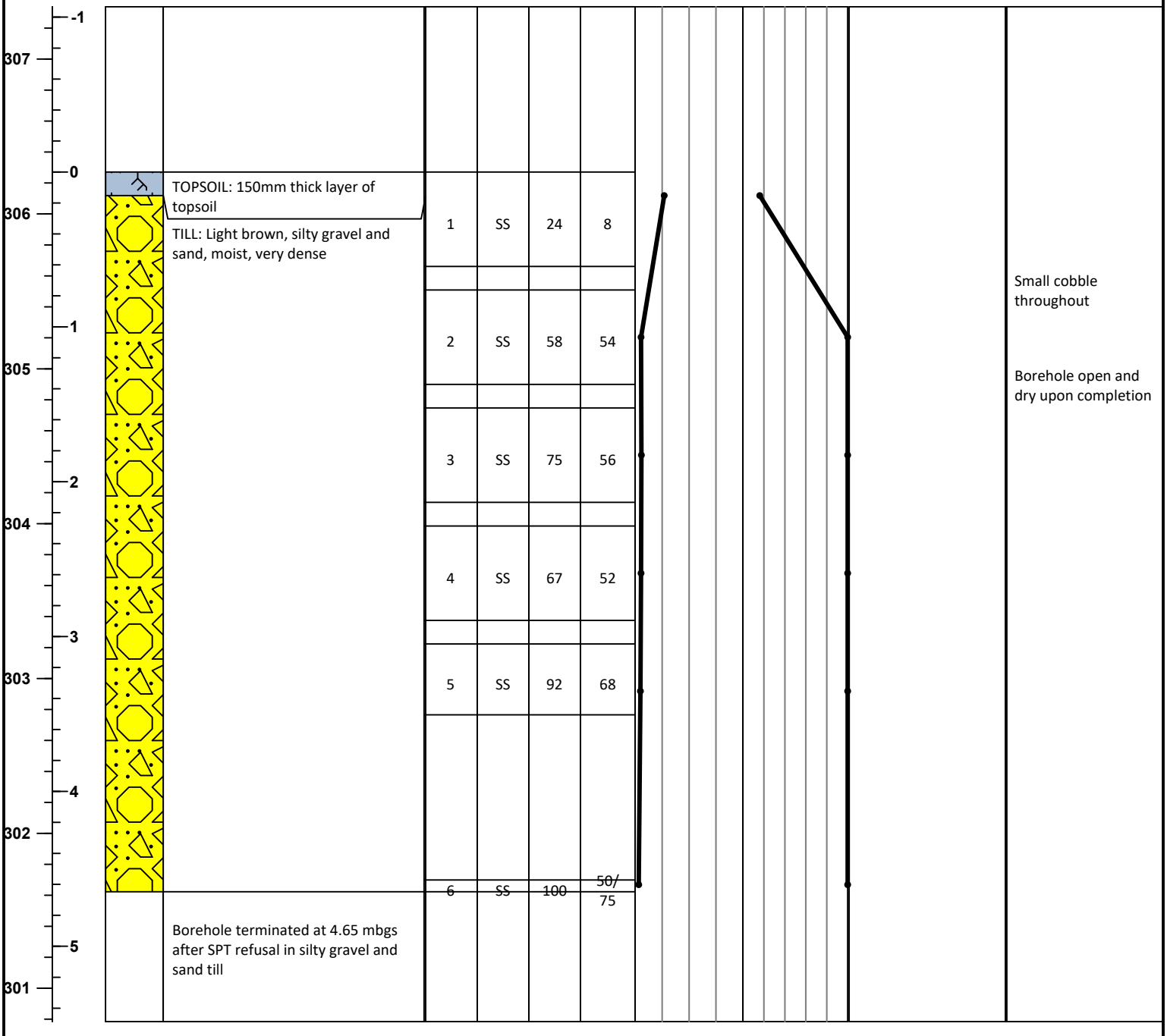
Log of Borehole: BH103-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 25, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 694882.12 E, 4937290.56 N	**Elevation:**	306.27 masl

SUBSURFACE PROFILE			SAMPLE								
Elevation (m) / Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
306.27 / 0		TOPSOIL: 150mm thick layer of topsoil	1	SS	24	8				Small cobble throughout
		TILL: Light brown, silty gravel and sand, moist, very dense	2	SS	58	54				Borehole open and dry upon completion
			3	SS	75	56				
			4	SS	67	52				
			5	SS	92	68				
301.77 / 4.65		Borehole terminated at 4.65 mbgs after SPT refusal in silty gravel and sand till	6	SS	100	50/75				



Logged By: J. Riseling **Input By:** J. Riseling

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Log of Borehole: BH104-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 25, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 695029.52 E, 4937418.20 N	**Elevation:**	302.35 masl

Elevation (m) / Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
303 / -1										
302 / 0		TOPSOIL: 150mm thick layer of topsoil								
		TILL: Light brown, sandy silty gravel, some clay, moist, compact	1	SS	25	6				
301 / 1			2	SS	75	12				Small cobble throughout
			3	SS	25	11				Borehole open and dry upon completion
300 / 2		-becomes moist to wet	4	SS	75	19				
299 / 3		-becomes very dense	5	SS	0	50/150				
298 / 4		-becomes grey	6	SS	100	50/50				
297 / 5		Borehole terminated at 4.62 mbgs after SPT refusal in sandy silty gravel till								

Logged By: J. Riseling **Input By:** J. Riseling

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Log of Borehole: BH105-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 25, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 695220.03 E, 4937348.23 N	**Elevation:**	300.32 masl

Elevation (m)	Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
301	-1										
300	0		TOPSOIL: 200mm thick layer of topsoil	1A	SS	58	8				
			TILL: Brown, sandy silty gravel, some clay, moist, loose	1B	SS						
299	1		-becomes dense	2	SS	25	37				Small cobble throughout
298	2			3	SS	75	31				SS3 GSA: 39% gravel 28% sand 23% silt 10% clay
297	3		-becomes very dense	4	SS	100	50/125				Borehole open and dry upon completion
				5	SS	100	50/150				
296	4			6	SS	25	50/100				
295	5		Borehole terminated at 4.67 mbgs after SPT refusal in sandy silty gravel till								

Logged By: J. Riseling **Input By:** J. Riseling

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Log of Borehole: BH106-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 26, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 695333.16 E, 4937462.64 N	**Elevation:**	298.73 masl

Elevation (m)	Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
299	0		TOPSOIL: 200mm thick layer of topsoil	1	SS	33	7				Small cobble throughout
			TILL: Light brown, gravelly silty sand, trace clay, moist, dense	2	SS	42	49				Borehole open and dry upon completion
298	1			3	SS	83	41				
			-becomes very dense	4	SS	67	59				
297	2			5	SS	33	50/75				
				6	SS	80	50/100				
296	3										
295	4										
294	5		Borehole terminated at 4.82 mbgs after SPT refusal in gravelly silty sand till								

Logged By: J. Riseling **Input By:** J. Riseling

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Log of Borehole: BH107-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 26, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 695513.31 E, 4937433.93 N	**Elevation:**	296.44 masl

SUBSURFACE PROFILE			SAMPLE								
Elevation (m) / Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
297 / -1										
296 / 0		TOPSOIL: 250mm thick layer of topsoil	1	SS	42	6				Small cobble throughout
		TILL: Light brown, gravelly silty sand, trace clay, moist, very dense	2	SS	96	83				
295 / 1			3	SS	50	50/100				Borehole open and dry upon completion
294 / 2			4	SS	100	80				
293 / 3			5	SS	55	50/125				
292 / 4			6	SS	67	50/75				
291 / 5		Borehole terminated at 4.80 mbgs after SPT refusal in gravelly silty sand till								

Logged By: J. Riseling **Input By:** J. Riseling

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Log of Borehole: BH108-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 26, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 695459.31 E, 4937561.77 N	**Elevation:**	297.97 masl

Elevation (m)	Depth	Description	Number	Type	% Recovery	SPT (N) / DCPT	Well Installation	Remarks
299	-1						Cap	
298	0	TOPSOIL: 150mm thick layer of topsoil	1A	SS	42	9		
		TILL: Light brown, gravelly silty sand, trace clay, moist, loose	1B	SS				Small cobble throughout
297	1	-becomes dense	2	SS	67	49	Pipe Bentonite Plug	
		-becomes very dense	3	SS	58	69		SS3 GSA: 32% gravel 41% sand 20% silt 7% clay
296	2		4	SS	0	50/75		Borehole open and dry upon completion
295	3		5	SS	50	50/50	Sand Pack PVC Screen	Monitoring well was found dry on Nov. 10, 2023
294	4		6	SS	67	50/150	Cap	
293	5	Borehole terminated at 4.72 mbgs after SPT refusal in gravelly silty sand till						

Logged By: J. Riseling **Input By:** J. Riseling

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Log of Borehole: BH109-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 26, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 695333.74 E, 4937710.50 N	**Elevation:**	300.40 masl

Elevation (m) / Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
301 / -1										
300 / 0		TOPSOIL: 200mm thick layer of topsoil	1A	SS	50	10			Cap	
		TILL: Light brown, gravelly silty sand, trace clay, moist, compact	1B	SS						Small cobble throughout
299 / -1		-becomes dense	2	SS	33	42			Pipe Bentonite Plug	Borehole open and dry upon completion
298 / -2		-becomes very dense	3	SS	75	53				
			4	SS	100	77				SS4 GSA: 33% gravel 35% sand 23% silt 9% clay
297 / -3			5	SS	67	50/150			Sand Pack PVC Screen	Monitoring well was found dry on Nov. 10, 2023
296 / -4			6	SS	100	50/125			Cap	
295 / -5		Borehole terminated at 4.85 mbgs after SPT refusal in gravelly silty sand till								

Logged By: J. Riseling **Input By:** J. Riseling

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Log of Borehole: BH110-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 26, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 695259.48 E, 4937570.87 N	**Elevation:**	300.35 masl

Elevation (m) / Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
301 / -1										
300 / 0		TOPSOIL: 75mm thick layer of topsoil	1A	SS						
		TILL: Light brown, gravelly silty sand, trace clay, moist, loose	1B	SS	46	6				Small cobble throughout
299 / -1		-becomes dense	2	SS	33	37				Borehole open and dry upon completion
298 / -2			3	SS	83	35				
		-becomes very dense	4	SS	67	50/ 75				
297 / -3			5	SS	100	50/ 100				
296 / -4			6	SS	88	50/ 250				
295 / -5		Borehole terminated at 4.98 mbgs after SPT refusal in gravelly silty sand till								

Logged By: J. Riseling **Input By:** J. Riseling

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Log of Borehole: BH111-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 27, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 694825.61 E, 4937424.12 N	**Elevation:**	305.05 masl

Elevation (m)	Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
306	-1										
305	0		TOPSOIL: 200mm thick layer of topsoil	1	SS	38	8				
			TILL: Light brown, sandy silty gravel, some clay, moist, loose								Small cobble throughout
304	1		-becomes compact	2	SS	33	18				Borehole open and dry upon completion
303	2			3	SS	12	24				
				4	SS	55	26				
302	3		-becomes very dense	5	SS	0	50/50				
			Borehole terminated at 3.35 mbgs after auger refusal on presumed bedrock or large boulder								
301	4										
300	5										

Logged By: J. Riseling **Input By:** J. Riseling

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Log of Borehole: BH112-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 27, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 694713.62 E, 4937533.65 N	**Elevation:**	314.53 masl

SUBSURFACE PROFILE			SAMPLE								
Elevation (m) / Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
315 / 0		TOPSOIL: 150mm thick layer of topsoil	1A	SS	75	11				
314 / 1		TILL: Light brown, sandy silty gravel, some clay, moist, compact	1B	SS						
		-becomes dense	2	SS	67	49				Small cobble throughout
313 / 2			3	SS	83	41				SS3 GSA: 34% gravel 29% sand 26% silt 11% clay
312 / 3		-becomes very dense	4	SS	0	50/ 225				
			5	SS	100	50/ 75				Borehole open and dry upon completion
311 / 4										
310 / 5		Borehole terminated at 4.80 mbgs after SPT refusal in sandy silty gravel till	6	SS	67	50/ 75				

Logged By: J. Riseling **Input By:** J. Riseling

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Kingston
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Log of Borehole: BH113-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 27, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 694578.13 E, 4937436.09 N	**Elevation:**	311.71 masl

SUBSURFACE PROFILE			SAMPLE								
Elevation (m) / Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
312 / 0		TOPSOIL: 150mm thick layer of topsoil	1A	SS					Cap	
		TILL: Light brown, sandy silty gravel, some clay, moist, loose	1B	SS	33	7				
311 / 1		-becomes compact	2	SS	36	23			Pipe Bentonite Plug	Small cobble throughout Borehole open and dry upon completion
310 / 2			3	SS	50	22				
309 / 3		-becomes very dense	4	SS	33	50/ 225				
			5	SS	0	50/ 100			Sand Pack PVC Screen	Water level measured at 3.94 mbgs on Nov. 10, 2023
308 / 4										
307 / 5		Borehole terminated at 4.60 mbgs after SPT refusal in sandy silty gravel till	6	SS	100	50/ 25			Cap	

Logged By: J. Riseling **Input By:** J. Riseling

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Log of Borehole: BH114-23

Client:	Jeffrey Homes	**Project Name:**	GEO - 168 County Road 49, Bobcaygeon	**Project No.:**	17986-002
Contractor:	Landshark	**Method:**	Hollow Stem Auger	**Date Completed:**	October 27, 2023
Location:	168 County Road 49, Bobcaygeon	**UTM:**	17T 694694.37 E, 4937341.31 N	**Elevation:**	307.63 masl

SUBSURFACE PROFILE			SAMPLE								
Elevation (m) / Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
308 / 0		TOPSOIL: 200mm thick layer of topsoil	1	SS	33	4				Small cobble throughout
		TILL: Light brown, sandy silty gravel, some clay, moist, loose								
307 / 1		-becomes compact	2	SS	50	21				Borehole open and dry upon completion
306 / 2		-becomes dense	3	SS	21	32				
		-becomes very dense	4	SS	20	50/125				
305 / 3			5	SS	0	50/50				
304 / 4		Borehole terminated at 3.66 mbgs after auger refusal on presumed bedrock or large boulder								
303 / 5										

Logged By: J. Riseling **Input By:** J. Riseling

Appendix C
Grain Size Analysis

Grain Size Distribution Chart

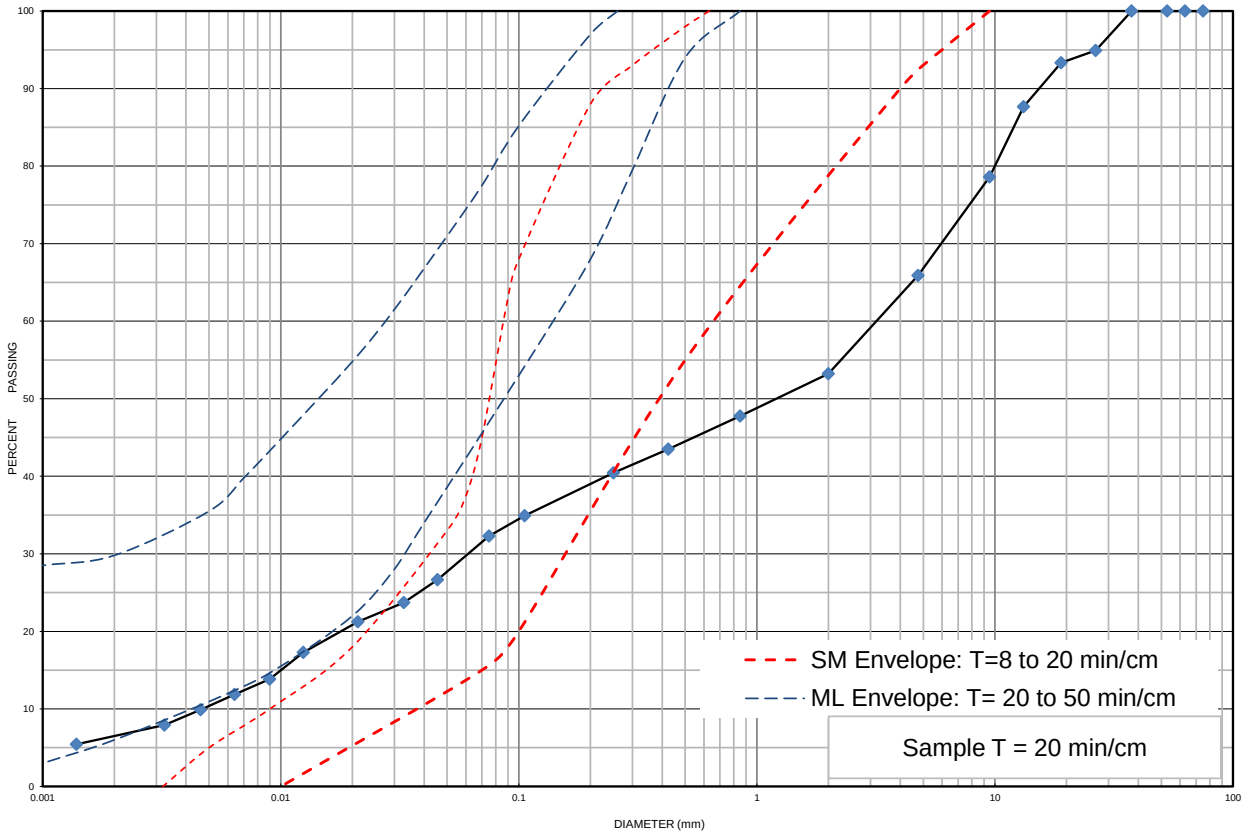
Project Number: *17986-002* **Client:** *Jeffery Homes*

Project Name: *Pt. Lot 19, Conc. 19 - Bobcaygeon Development*

Sample Date: *October 25-27, 2023* **Sampled By:** *Josh Riseling - Cambium Inc.*

Location: *BH 101-23 SS 4* **Depth:** *2.3 m to 2.9 m* **Lab Sample No:** *S-23-1845*

UNIFIED SOIL CLASSIFICATION SYSTEM					
CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDERS
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 101-23	SS 4	2.3 m to 2.9 m	34	34	25	7	7.5

Description	Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Silty Gravel and Sand trace Clay	SM	3.2500	0.0610	0.0047	691.49	0.24

Additional information availabe upon request

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Grain Size Distribution Chart

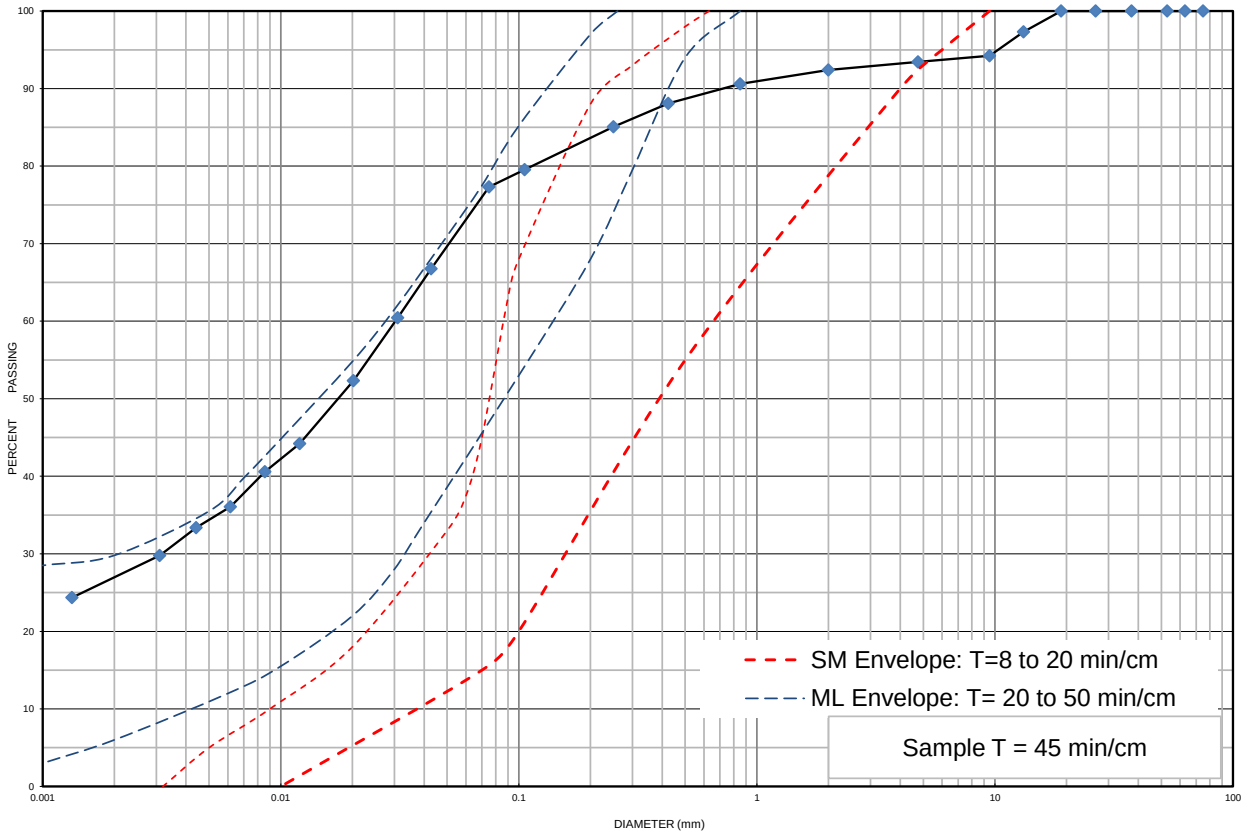
Project Number: *17986-002* **Client:** *Jeffery Homes*

Project Name: *Pt. Lot 19, Conc. 19 - Bobcaygeon Development*

Sample Date: *October 25-27, 2023* **Sampled By:** *Josh Riseling - Cambium Inc.*

Location: *BH 102-23 SS 2* **Depth:** *0.8 m to 1.4 m* **Lab Sample No:** *S-23-1846*

UNIFIED SOIL CLASSIFICATION SYSTEM					
CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDERS
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 102-23	SS 2	0.8 m to 1.4 m	7	16	50	27	22.3

Description	Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Clayey Silt some Sand trace Gravel	ML	0.0300	0.0032	-	-	-

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Grain Size Distribution Chart

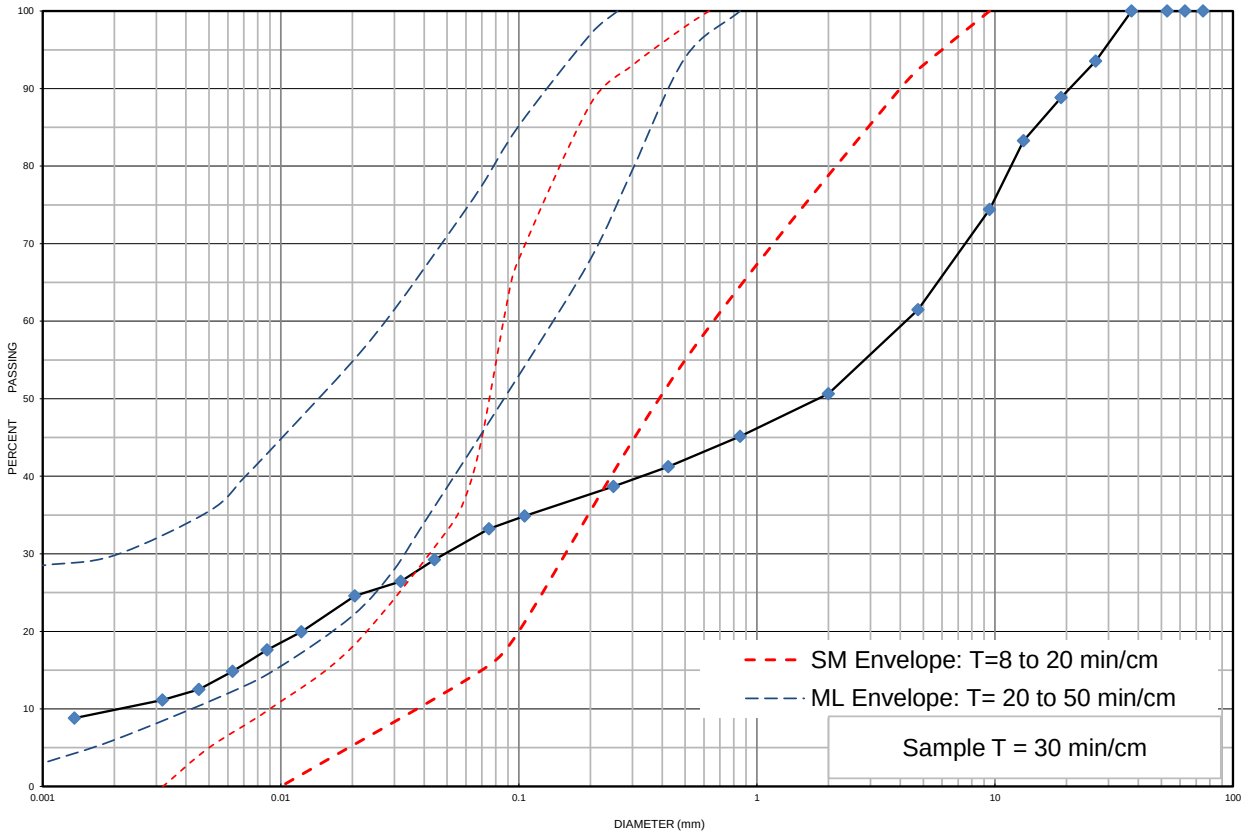
Project Number: *17986-002* **Client:** *Jeffery Homes*

Project Name: *Pt. Lot 19, Conc. 19 - Bobcaygeon Development*

Sample Date: *October 25-27, 2023* **Sampled By:** *Josh Riseling - Cambium Inc.*

Location: *BH 105-23 SS 3* **Depth:** *1.5 m to 2.1 m* **Lab Sample No:** *S-23-1847*

UNIFIED SOIL CLASSIFICATION SYSTEM					
CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDERS
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 105-23	SS 3	1.5 m to 2.1 m	39	28	23	10	6.2

Description	Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Sandy Silty Gravel some Clay	SM	4.200	0.050	0.002	2100.00	0.30

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Grain Size Distribution Chart

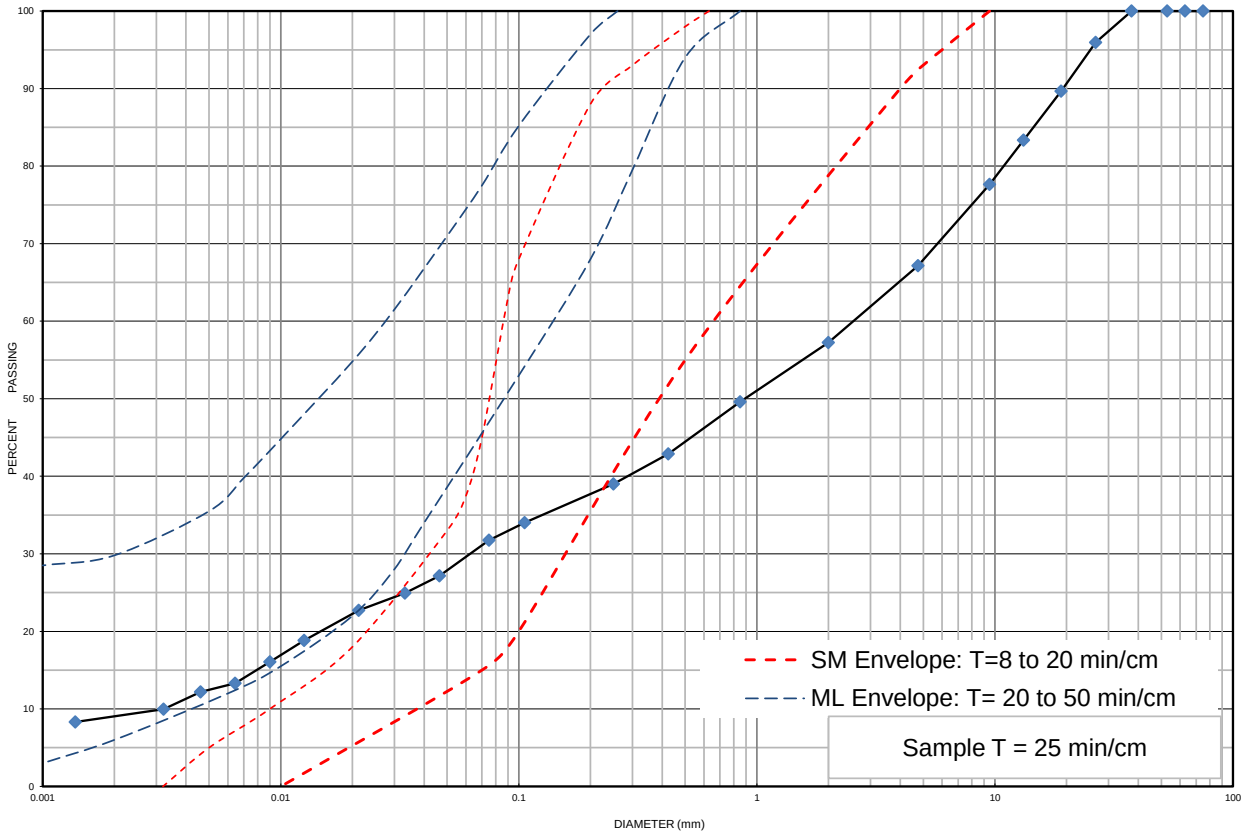
Project Number: *17986-002* **Client:** *Jeffery Homes*

Project Name: *Pt. Lot 19, Conc. 19 - Bobcaygeon Development*

Sample Date: *October 25-27, 2023* **Sampled By:** *Josh Riseling - Cambium Inc.*

Location: *BH 109-23 SS 4* **Depth:** *2.3 m to 2.9 m* **Lab Sample No:** *S-23-1849*

UNIFIED SOIL CLASSIFICATION SYSTEM					
CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDERS
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 109-23	SS 4	2.3 m to 2.9 m	33	35	23	9	5.5

Description	Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Gravelly Silty Sand trace Clay	SM	2.6000	0.0620	0.0031	838.71	0.48

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Grain Size Distribution Chart

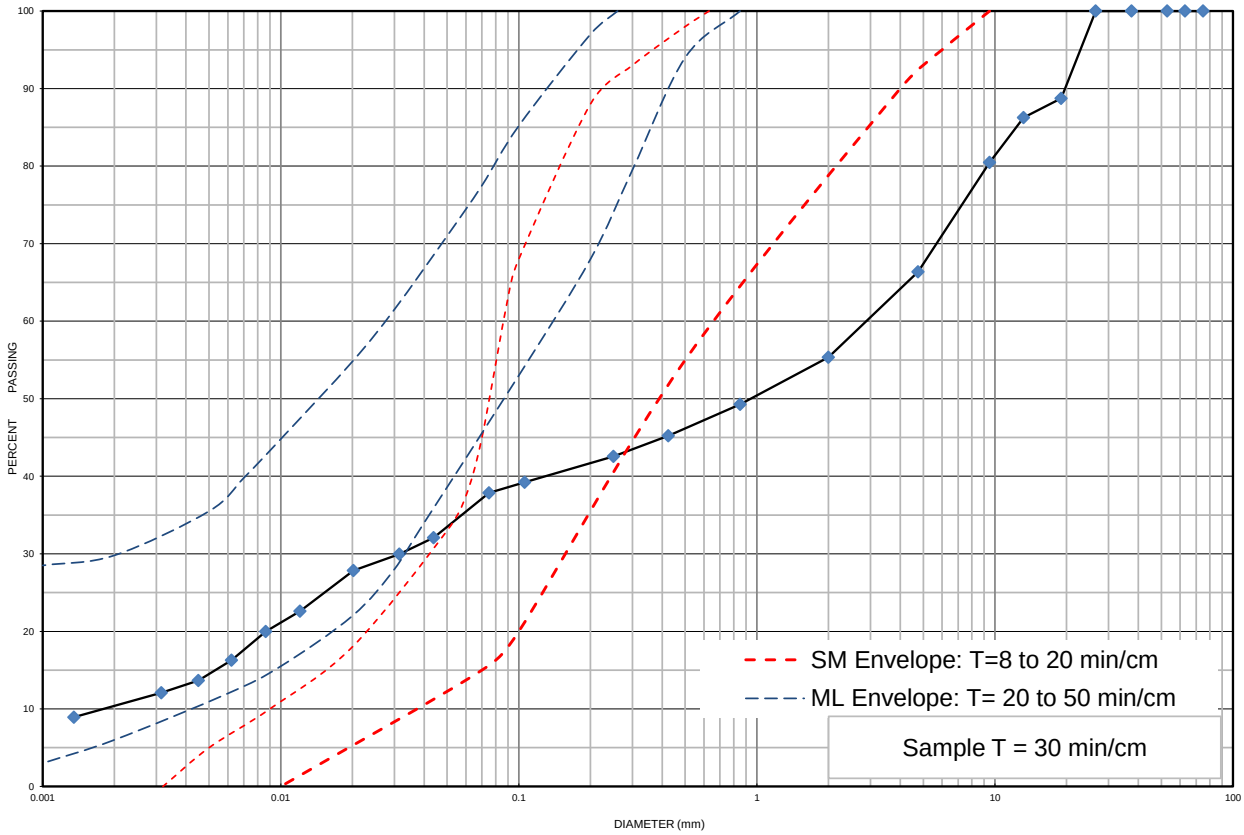
Project Number: *17986-002* **Client:** *Jeffery Homes*

Project Name: *Pt. Lot 19, Conc. 19 - Bobcaygeon Development*

Sample Date: *October 25-27, 2023* **Sampled By:** *Josh Riseling - Cambium Inc.*

Location: *BH 112-23 SS 3* **Depth:** *1.5 m to 2.1 m* **Lab Sample No:** *S-23-1850*

UNIFIED SOIL CLASSIFICATION SYSTEM					
CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDERS
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 112-23	SS 3	1.5 m to 2.1 m	34	29	26	11	6.8

Description	Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Sandy Silty Gravel some Clay	SM	2.9500	0.0330	0.0019	1552.63	0.19

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Appendix D

AquiferTest Pro Results

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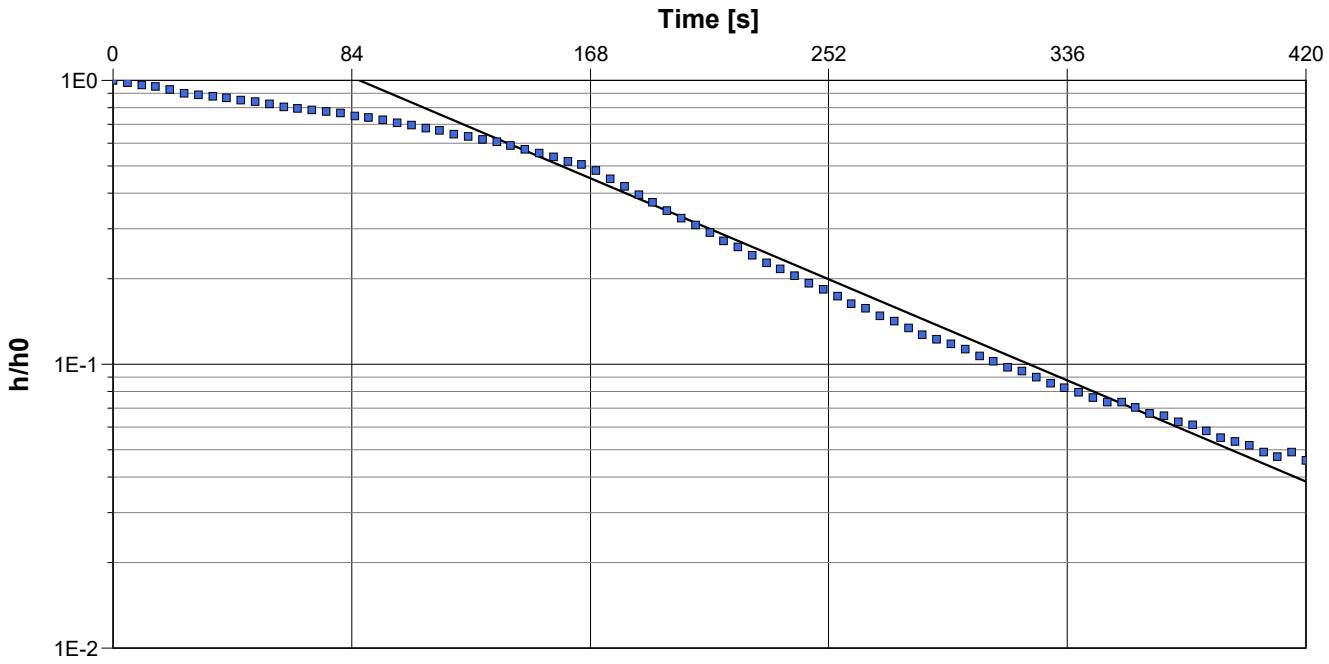
Slug Test Analysis Report

Project: 168 County Road 49, Bobcaygeon

Number: 17986-002

Client: Jeffrey Homes

Location: Bobcaygeon, ON	Slug Test: Slug Test 1	Test Well: MW101-23
Test Conducted by: J. Munro		Test Date: 11/10/2023
Analysis Performed by: W. Young	Hvorslev	Analysis Date: 11/13/2023
Aquifer Thickness: 2.44 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW101-23	8.38×10^{-6}	

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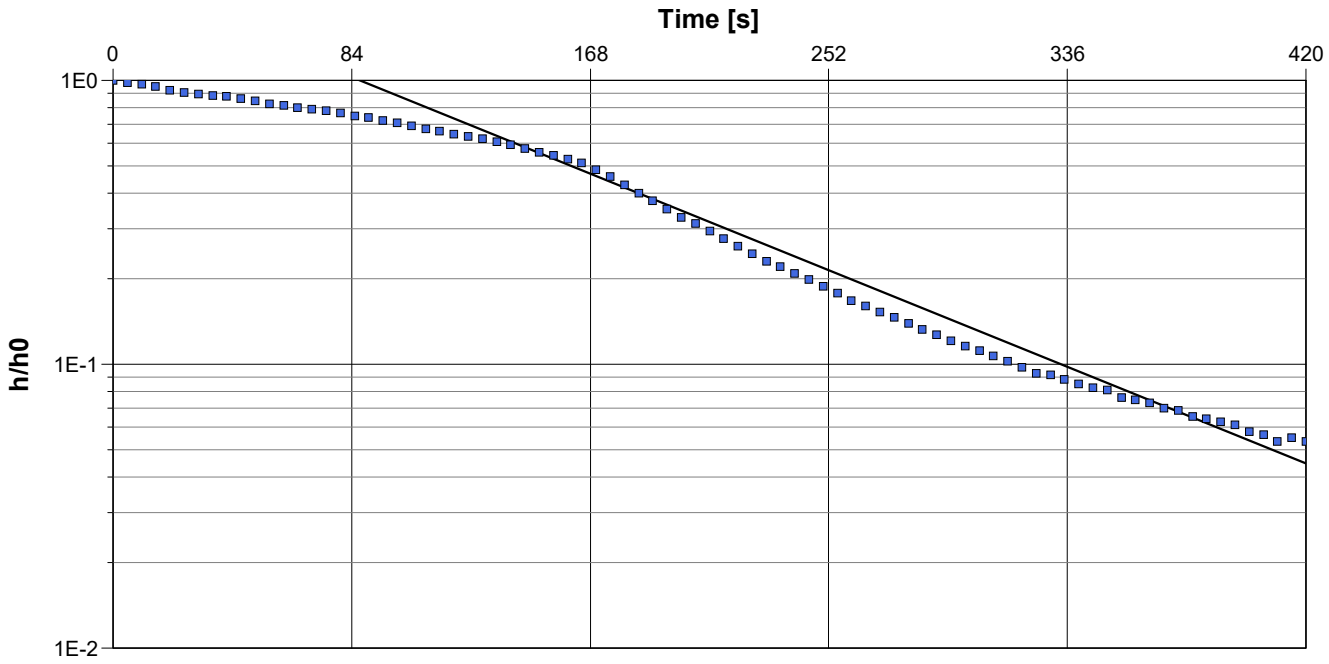
Slug Test Analysis Report

Project: 168 County Road 49, Bobcaygeon

Number: 17986-002

Client: Jeffrey Homes

Location: Bobcaygeon, ON	Slug Test: Slug Test 2	Test Well: MW101-23
Test Conducted by: J.Munro		Test Date: 11/10/2023
Analysis Performed by: W. Young	Hvorslev	Analysis Date: 11/13/2023
Aquifer Thickness: 2.44 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW101-23	8.00×10^{-6}	

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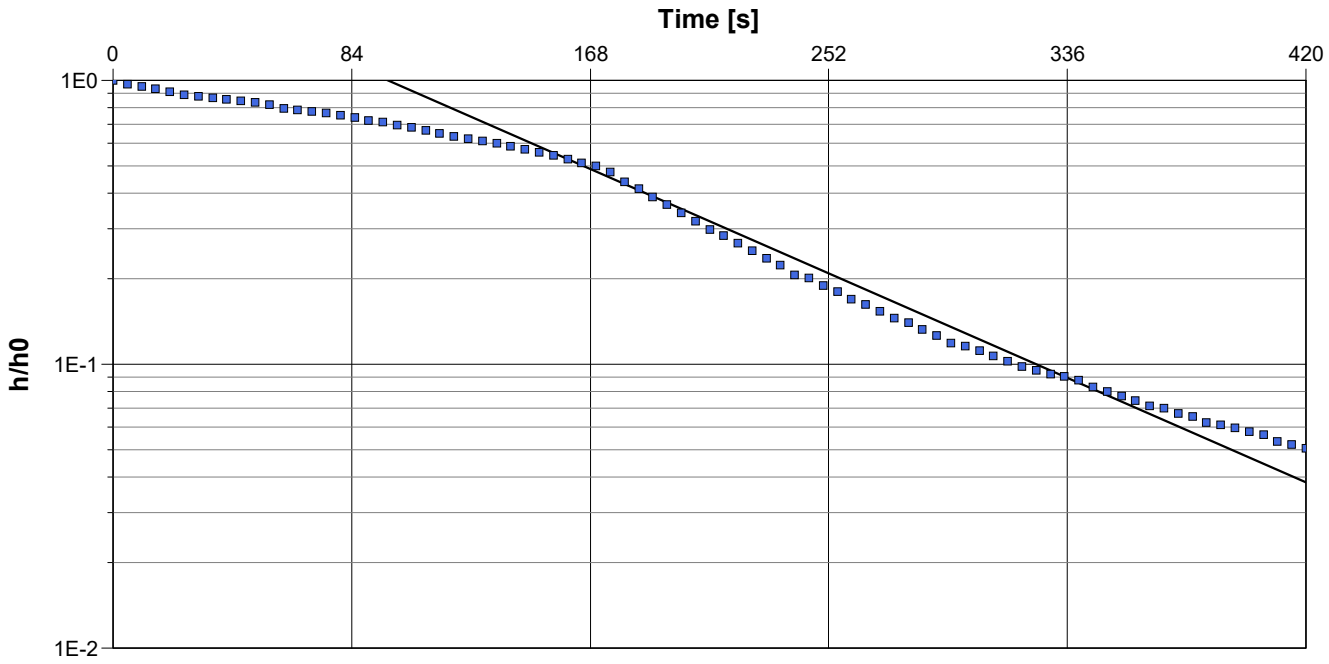
Slug Test Analysis Report

Project: 168 County Road 49, Bobcaygeon

Number: 17986-002

Client: Jeffrey Homes

Location: Bobcaygeon, ON	Slug Test: Slug Test 3	Test Well: MW101-23
Test Conducted by: J. Munro		Test Date: 11/10/2023
Analysis Performed by: W. Young	Hvorslev	Analysis Date: 11/13/2023
Aquifer Thickness: 2.44 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW101-23	8.64×10^{-6}	

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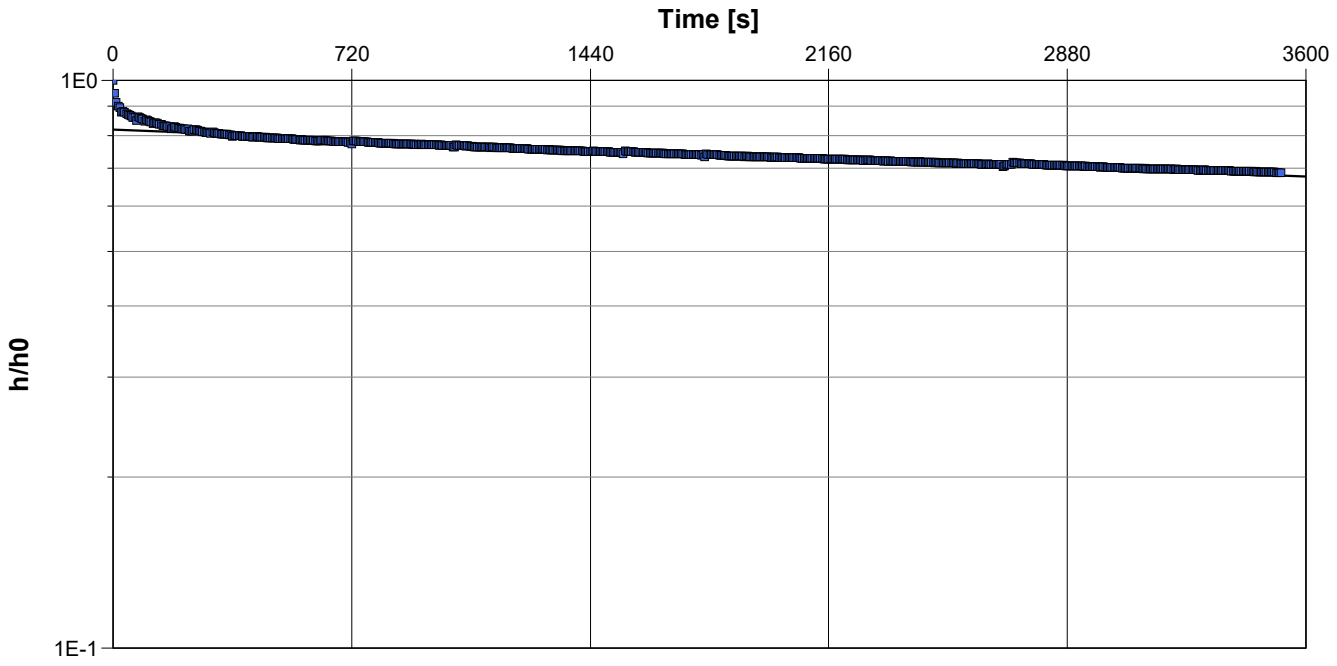
Slug Test Analysis Report

Project: 168 County Road 49, Bobcaygeon

Number: 17986-002

Client: Jeffrey Homes

Location: Bobcaygeon, ON	Slug Test: Slug Test 1	Test Well: MW113-23
Test Conducted by: J, Munro		Test Date: 11/10/2023
Analysis Performed by: W. Young	Hvorslev	Analysis Date: 11/13/2023
Aquifer Thickness: 0.58 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW113-23	4.51×10^{-8}	

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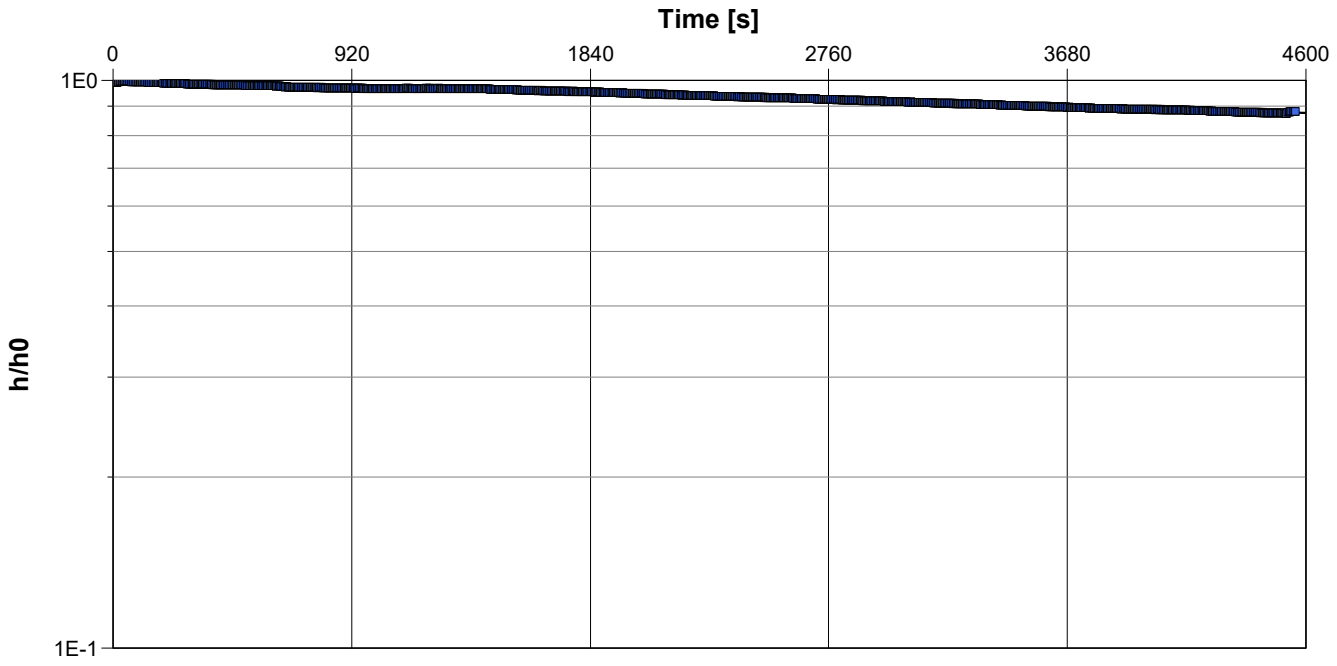
Slug Test Analysis Report

Project: 168 County Road 49, Bobcaygeon

Number: 17986-002

Client: Jeffrey Homes

Location: Bobcaygeon, ON	Slug Test: Slug Test 2	Test Well: MW113-23
Test Conducted by: J. Munro		Test Date: 11/10/2023
Analysis Performed by: W. Young	Hvorslev	Analysis Date: 11/13/2023
Aquifer Thickness: 0.58 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW113-23	2.45×10^{-8}	

Appendix E
Water Balance Calculations

Water Balance Calculations

Part of Lot 19, Concession 19, Township of Galway-Cavendish and Harvey, County of Peterborough

THORNTHWAITE-TYPE MONTHLY WATER-BALANCE MODEL

modified from Dingman 2015: Box 6-8 (pg 299) using ET model of Hamon (1963)

		Input Data				Computed Values							
											Surplus	342	mm/yr
Weather Station Location:	**Peterborough Trent U**					**Latitude:**	**44.2**	**degree**					
Solar Declination (degree)	-20.6	-12.6	-1.5	10.0	19.0	23.1	21.0	13.4	2.6	-9.0	-18.5	-23.0	
DayLength (hr)*	9.1	10.3	11.8	13.3	14.6	15.3	14.9	13.8	12.3	10.8	9.5	8.7	
Available Water Storage Capacity		0.18	m/m		**Root Depth**	1500	mm			**SOILmax**	270.0	mm	

MONTHLY WATER BALANCE DATA

Temperatures in C, water-balance terms in mm.

Month:	J	F	M	A	M	J	J	A	S	O	N	D	Year
TEMPERATURE (T)	-8.4	-6.5	-1.3	6.3	12.8	18.0	20.7	19.4	15.0	8.4	2.4	-4.0	
PRECIPITATION (P)	57.3	48.8	56.5	66.4	88.7	83.0	73.6	87.0	92.4	77.0	85.5	66.0	882
RAIN	22.4	23.1	34.0	60.9	88.7	83.0	73.6	87.0	92.4	75.7	73.3	35.0	749
SNOW	35	26	23	6	0	0	0	0	0	1	12	31	133
MELT FACTOR (F)	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.40	0.00	
PACK	73	99	121	0	0	0	0	0	0	0	7	38	
MELT	0	0	0	127	0	0	0	0	0	1	5	0	133
INPUT (W)	22	23	34	188	89	83	74	87	92	77	78	35	882
POTENTIAL ET (PET)	0	0	0	41	70	97	115	98	65	39	22	0	548
NET INPUT (ΔW)	22	23	34	147	19	-14	-41	-11	27	38	56	35	
SOIL MOISTURE (SOIL)	270	270	270	270	270	256	220	211	238	270	270	270	
ΔSOIL	0	0	0	0	0	-14	-36	-9	27	32	0	0	0
ET	0	0	0	41	70	97	110	96	65	39	22	0	540
SURPLUS=W-ET-DSOIL	22	23	34	147	19	0	0	0	0	6	56	35	342

Notes:

Precipitation, Rain, Temperature, and Latitude are inputted parameters

SOILmax = available water storage capacity * root depth

m = month

D = Day length (hrs) $=2*\cos^{-1}(-\tan(\text{Latitude})*\tan(\text{Declination}))/0.2618$ [calculation is in radians]

$SNOW_m = P_m - RAIN_m$

$F_m = 0$ if $T_m <= 0^\circ C$; $F_m = 0.167*T_m$ if $0^\circ C < T_m < 6^\circ C$; $F_m = 1$ if $T_m >= 6^\circ C$

$PACK_m = (1-F_m)*(SNOW_m+PACK_{m-1})$

$MELT = F_m*(SNOW_m+PACK_{m-1})$

$W_m = RAIN_m+MELT_m$.

PET = 0 if $T_m<0$; otherwise $PET = 2.98*0.611*\exp(17.3*T_m/(T_m+237))/(T_m+237.2)*$Number of days in month [Hamon ET model (1963)]

$\Delta W_m = W_m - PET_m$

$SOIL = \min\{[\Delta W_m+SOIL_{m-1}], SOILmax\}$, if $\Delta Wm>0$; otherwise $SOIL = SOIL_{m-1} * \exp(\Delta W/SOILmax)$

$\Delta SOIL = SOIL_{m-1} - SOIL_m$

ET = PET if W_m > PET; otherwise, $ET = W_m - \Delta SOIL$

Pre- and Post-Development Water Balance Calculations

Part of Lot 19, Concession 19, Township of Galway-Cavendish and Harvey, County of Peterborough

1 Climate Information

Precipitation	882	mm/yr
Actual Evapotranspiration	540	mm/yr
Water Surplus	342	mm/yr

2 Infiltration Rates

Table 2 Approach - Infiltration factors	
Topography: Rolling hills	0.2
Soil Type: Till(Combination of sand,silt and gravel)	0.3
Cover: Cultivated land/Woodland	0.15
Total Infiltration Factor	**0.65**

Infiltration (Water Surplus * Infiltration Factor)	**222**	mm/yr
Run-off (Water Surplus - Infiltration)	**120**	mm/yr

Table 3 Approach - Typical Recharge Rates		
Coarse Sand and Gravel	>250	mm/yr
Fine to medium sand	200-250	mm/yr
Silty sand to sandy silt	150-200	mm/yr
Silt	125-150	mm/yr
Clayey Silt	100- 125	mm/yr
Clay	<100	mm/yr

Site development area is underlain predominantly by a glacial till sand, silt and gravel combination

Based on the above, the recharge rate is typically	150-200	mm/yr

3 Pre-Development Property Statistics	**ha**	**m^2**
Total Paved Area	0.07	700
Total Roof Area	0.03	300
Total Landscape Area	48.05	480,500
Total	**48.15**	**481,500**

4 Post-Development Property Statistics	**ha**	**m^2**
Total Paved Area	7.45	74,540
Total Roof Area	1.37	13,710
Total Landscape Area	39.33	393,260
Total	**48.15**	**481,510**

Pre- and Post-Development Water Balance Calculations

Part of Lot 19, Concession 19, Township of Galway-Cavendish and Harvey, County of Peterborough

5 Pre-Development Water Balance

Land Use		Area (m^2)	Precipitation (m^3)	Evapotranspiration (m^3)	Infiltration (m^3)	Run-off (m^3)
Impervious Areas	Paved Area	700	617	62	-	556
	Roof Area	300	265	26	-	238
Pervious Areas	Landscape Area	480,500	423,801	259,470	106,815	57,516
	Totals	481,500	424,683	259,558	106,815	58,310
Assuming no infiltration occurring in paved and roof areas, and 10% of precipitation to be evaporated from paved and roof areas.						

6 Post-Development Water Balance

Land Use		Area (m^2)	Precipitation (m^3)	Evapotranspiration (m^3)	Infiltration (m^3)	Run-off (m^3)
Impervious Areas	Paved Area	74,540	65,744	6,574	-	59,170
	Roof Area	13,710	12,092	1,209	-	10,883
Pervious Areas	Landscape Area	393,260	346,855	212,360	87,422	47,073
	Totals	481,510	424,692	220,144	87,422	117,126
Assuming no infiltration occurring in paved and roof areas, and 10% of precipitation to be evaporated from paved and roof areas.						

7 Comparision of Pre- and Post -Development

	Precipitation (m^3)	Evapotranspiration (m^3)	Infiltration (m^3)	Run-off (m^3)
Pre-Development	424,683	259,558	106,815	58,310
Post-Development	424,692	220,144	87,422	117,126
Change in Volume	9	- 39,414	- 19,393	58,816
Change in %	0	- 15	- 18	101

8 Requirement for Infiltration of Roof Run-off

Volume of Pre-Development Infiltration (m^3/yr)	106,815
Volume of Post-Development Infiltration (m^3/yr)	87,422
Deficit from Pre to Post Development Infiltration (m^3/yr)	19,393
Percentage of Roof Runoff required to match the pre-development infiltration (%)	178

Appendix F

Nitrate Mass Balance Calculations

Water Balance Calculations

Part of Lot 19, Concession 19, Township of Galway-Cavendish and Harvey, County of Peterborough

THORNTHWAITE-TYPE MONTHLY WATER-BALANCE MODEL

modified from Dingman 2015: Box 6-8 (pg 299) using ET model of Hamon (1963)

	Input Data	Computed Values										
										Surplus	**342**	**mm/yr**
Weather Station Location:	**Peterborough Trent U**				**Latitude:**	**44.2**	**degree**					
Solar Declination (degree)	-20.6	-12.6	-1.5	10.0	19.0	23.1	21.0	13.4	2.6	-9.0	-18.5	-23.0
DayLength (hr)*	9.1	10.3	11.8	13.3	14.6	15.3	14.9	13.8	12.3	10.8	9.5	8.7
Available Water Storage Capacity	0.18	m/m	**Root Depth**	1500	mm	**SOILmax**	270.0	mm				

MONTHLY WATER BALANCE DATA

Temperatures in C, water-balance terms in mm.

Month:	J	F	M	A	M	J	J	A	S	O	N	D	Year
TEMPERATURE (T)	-8.4	-6.5	-1.3	6.3	12.8	18.0	20.7	19.4	15.0	8.4	2.4	-4.0	
PRECIPITATION (P)	57.3	48.8	56.5	66.4	88.7	83.0	73.6	87.0	92.4	77.0	85.5	66.0	882
RAIN	22.4	23.1	34.0	60.9	88.7	83.0	73.6	87.0	92.4	75.7	73.3	35.0	749
SNOW	35	26	23	6	0	0	0	0	0	1	12	31	133
MELT FACTOR (F)	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.40	0.00	
PACK	73	99	121	0	0	0	0	0	0	0	7	38	
MELT	0	0	0	127	0	0	0	0	0	1	5	0	133
INPUT (W)	22	23	34	188	89	83	74	87	92	77	78	35	882
POTENTIAL ET (PET)	0	0	0	41	70	97	115	98	65	39	22	0	548
NET INPUT (ΔW)	22	23	34	147	19	-14	-41	-11	27	38	56	35	
SOIL MOISTURE (SOIL)	270	270	270	270	270	256	220	211	238	270	270	270	
ΔSOIL	0	0	0	0	0	-14	-36	-9	27	32	0	0	0
ET	0	0	0	41	70	97	110	96	65	39	22	0	540
SURPLUS=W-ET-DSOIL	22	23	34	147	19	0	0	0	0	6	56	35	342

Notes:

Precipitation, Rain, Temperature, and Latitude are inputted parameters

SOILmax = available water storage capacity * root depth

m = month

D = Day length (hrs) $=2*\cos^{-1}(-\tan(\text{Latitude})*\tan(\text{Declination}))/0.2618$ [calculation is in radians]

$SNOW_m = P_m - RAIN_m$

$F_m = 0$ if $T_m <= 0^oC$; $F_m = 0.167*T_m$ if $0^oC<T_m<6^oC$; $F_m = 1$ if $T_m>=6^oC$

$PACK_m = (1-F_m)*(SNOW_m+PACK_{m-1})$

$MELT = F_m*(SNOW_m+PACK_{m-1})$

$W_m = RAIN_m+MELT_m$.

PET = 0 if $T_m<0$; otherwise $PET = 2.98*0.611*\exp(17.3*T_m/(T_m+237))/(T_m+237.2)*$Number of days in month [Hamon ET model (1963)]

$\Delta W_m = W_m - PET_m$

$SOIL = \min\{[\Delta W_m+SOIL_{m-1}], SOILmax\}$, if $\Delta Wm>0$; otherwise $SOIL = SOIL_{m-1} * \exp(\Delta W/SOILmax)$

$\Delta SOIL = SOIL_{m-1} - SOIL_m$

ET = PET if W_m > PET; otherwise, $ET=W_m-\Delta SOIL$

CAMBIUM

Nitrate Attenuation

Calculations for Subdivision Developments

Input Data	Computed Values

Areas	Total
LOT AREA (m^2)	362100
BLDG FOOTPRINT (m^2)	0
ROAD AREA (m^2)	0
Avaible Infiltration Area (m^2)	362100

Surplus water

0.342	m/yr
0.000937	m/day
339.4125	m^3/day

Infiltration Factor

Rolling	0.2
Silt, sand,gravel till	0.3
Woodland/Cultivated	0.15
Total	0.65

Infiltrated water

0.000609	m/day
220.6181	m^3/day

Runoff 118.7944 m^3/day

PREDICTED NITRATE CONCENTRATIONS

Combined Concentrations at Property Boundaries

1 Lot	2 Lots	59 Lots
1000	2000	59000
40	40	40
220618.1	220618.1	220618.1
0.1	0.1	0.1
221618.1	222618.1	279618.1
0.28	**0.46**	**8.52**