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GEOTECHNICAL REPORT

AT

**0TH SCUGOG LINE 6
PORT PERRY, ON**

PREPARED FOR:

**Wanlong Real Estate Development Ltd.
(Property Owner)**

October 3, 2025

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1. BACKGROUND

King EPCM (the Engineer) was retained by Wanlong Real Estate Development Ltd. (the Client) to carry out a geotechnical and hydrogeology investigation for a proposed residential sub-division at 0th Scugog Line 6, Township of Scugog, Regional Municipality of Durham, Ontario (the site).

The purpose of this report is to review the existing site conditions and recommendations for the design and construction of an industrial sub-division Blocks. This report details King EPCM's borehole drilling program, fieldwork and testing, development constraints mapping, and design recommendations.

This report was prepared for the Client, Wanlong Real Estate Development Ltd, for the property owners, and any related site-specific engineers, designers, and contractors. This report is considered an intellectual property of King EPCM, and third party use of this report, including reliance, in-part or full, is prohibited without written consent from King EPCM.

2. SITE DESCRIPTION

2.1.Site Location

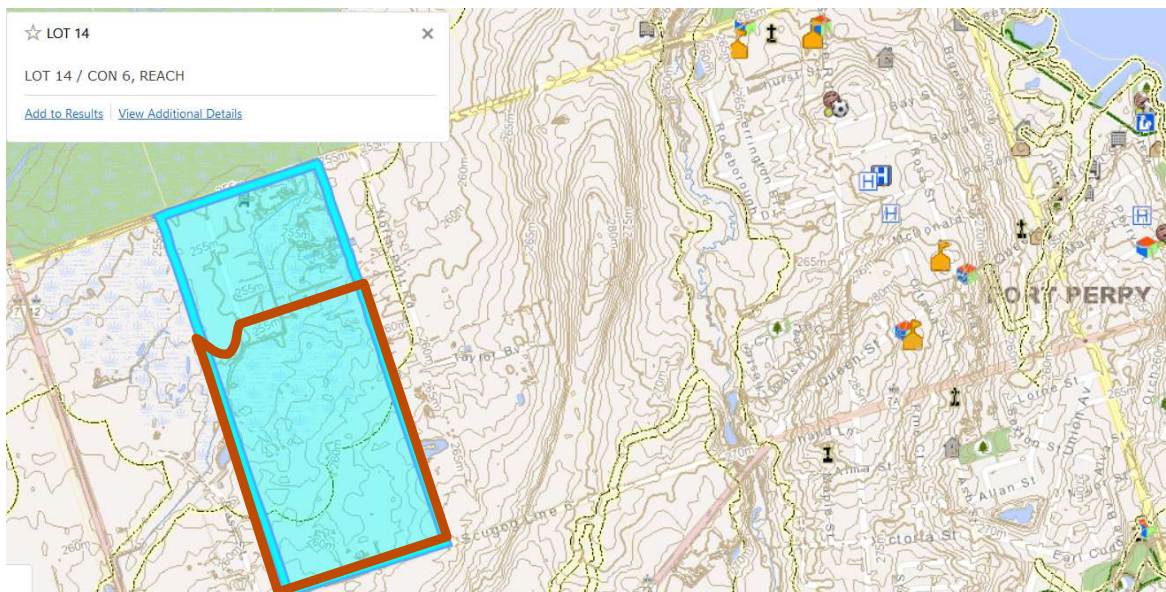


Figure 1 - 0th Scugog Line 6, Township of Scugog

The site is located at the municipal address of 0th Scugog Line 6, Township of Scugog, Regional Municipality of Durham. The site can also be referenced as:

Part of Lot 14, Concession 6, Township of Scugog
PIN: 26805-0606(LT)
Part 1 and 2 of Plan 40R18803

The site property is considered rural agricultural and non-developed, generally bound by Scugog Line 6 along the south and a natural wetland to the west. The property is generally considered shallowly grading to the northwest, with most of the property being agricultural row-crops.

2.2. Proposed Project

The purpose of this report is to provide review of existing geotechnical formations and provide recommendations on development constraints and other design information.

The project proposes an industrial sub-division, composed of twelve (12) industrial Blocks, each of which may be further severed into individual lots for future considerations.

See Appendix I for detailed Site Plans.

3. SURFACE INVESTIGATIONS

Surface investigation is separated into three parts:

- Topographic survey
- Site visit and field inspections
- Groundwater monitoring program

3.1. Topographic Survey

A topographic survey was conducted by Mandarin Surveyors Limited, dated November 1, 2022. In general, the survey shows the tree crowline to the west, road elevations, and shallow grading slopes ranging between 1.0% through to 2.5% towards the northwest. Refer to Appendix I for the topographic survey.

3.2. Site Visit and Field Inspections

Multiple site visits were conducted for field inspections of the subject property. As the property was roto-disc tilled by an agricultural tractor, the Engineer was able to review the surficial soil conditions. In general, the soil is largely composed of layers of silt and clay, with a small elevated hill of sand along the west-central area of the property.

Due to the silty clay soil for the majority of the property, infiltration is generally considered as “very slow” with significant surficial runoff into the wetlands and ponds at the west property boundary.

4. SUB-SURFACE INVESTIGATIONS

A total of thirteen (13) geotechnical boreholes were drilled at the subject property in December 2021.

4.1. BOREHOLE PROGRAM

Thirteen (13) geotechnical boreholes were drilled at the site, with the following locations: in total 13 boreholes were drilled at the site and all boreholes were converted to monitoring well. The location of all boreholes and monitoring well are shown in Appendix II.

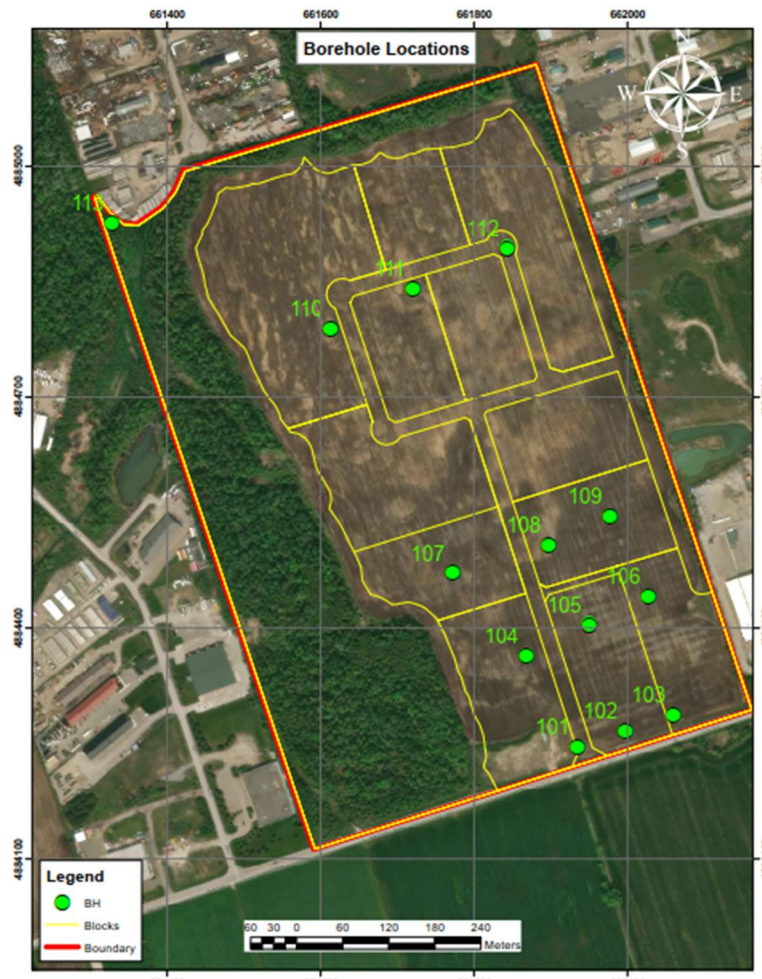


Figure 2, Drilled Boreholes and Installed Monitoring Wells Location

Table 1 - Borehole Program Summary

Borehole #	Date	Northing (UTM)	Easting (UTM)	Surface Elev (amsl)	Hole Depth (m)	Screen Elevations	Surface Soil type	Groundwater
101	06-Dec-2021	4,884,244.90	661,934.63	262.184	3.1	259.08-262.07	Clay	yes
102	07-Dec-2021	4,884,266.53	661,997	262.627	4	258.63-260.12	Clay	yes
103	07-Dec-2021	4,884,287.68	662,059.62	263.463	3.1	260.36-261.85	Clay	yes
104	08-Dec-2021	4,884,364.30	661,868	260.898	4	256.9-258.39	Clay	yes
105	09-Dec-2021	4,884,404.51	661,950	261.746	2.7	259.05-260.54	Clay	yes
106	15-Dec-2021	4,884,440.76	662,027	262.448	2.5	259.87-261.42	Clay	yes
107	08-Dec-2021	4,884,471.38	661,772	260.092	3.1	257-258.48	Clay	yes
108	09-dec-021	4,884,508.26	661,897.12	261.729	3	258.73-260.22	Clay	yes
109	09-Dec-2021	4,884,544.89	661,977	261.704	3	258.7-260.2	Clay	yes
110	14-Dec-2021	4,884,788.53	661,612.83	256.346	3.1	253.35-254.84	Sand	yes
111	14-Dec-2021	4,884,841.03	661,720.39	257.541	3.1	254.54-256.04	Sand	yes
112	14-Dec-2021	4,884,893.89	661,843	258.759	3	255.76-257.25	Clay	yes
113	13-Dec-2021	4,884,926.44	661,327.92	255.121	2.1	253-254.52	Silt	yes

Over the period of time, groundwater level was measured at different intervals to understand the fluxualtion in groundwater level with seasonal changes. Groundwater monitoring program data as below. This grounwater data as similar to Hydrogeology Report of this property.

Table 2 – Groundwater Review throughout 2021 and 2022 (= broken)*

Date		BH 101	BH 102	BH 103	BH 104	BH 105	BH 106	BH 107	BH 108	BH 109	BH 110	BH 111	BH 112	BH 113
December 2021	GW depth	0.4	3.5	2.2	1.8	2.2	2.2	2.2	2.4	2.8	1.0	1.0	1.5	0.7
	GW Level	261.784	259.127	261.263	259.098	259.546	260.248	257.892	259.329	258.904	255.346	256.541	257.259	254.421
March 30, 2022	GW depth	1.3	0.9	1.2	0.4	0.8	1.0	1.1	1.0	1.0	1.2	1.3	1.7	0.5
	GW Level	260.884	261.727	262.263	260.498	260.946	261.448	258.992	260.729	260.704	255.146	256.241	257.059	254.621
May 30, 2022	GW depth	-	-	-	-	-	-	-	-	-	1.25	1.58	-	1.35
	GW Level	-	-	-	-	-	-	-	-	-	255.096	255.961	-	253.771
June 22, 2022	GW depth	1.27	0.68	1.15	0.06	0.80	1.12	1.29	1.37	1.06	*	1.53	1.73	0.54
	GW Level	260.914	261.947	262.313	260.838	260.946	261.328	258.802	260.359	260.644	*	255.920	257.029	254.580

Over the 8 month groundwater monitoring program was carried out to identify the seasonal change in groundwater with different season. Maximum highest groundwater was recorded 262.263 m on March 30,2022.

4.2. STRATIGRAPHY & SOIL PHYSICAL PROPERTIES

In general, the stratigraphy can be described as the following:

- 0 – 0.3 topsoil / disturbed soils due to agricultural activities
- 0.3 – 1.5m USCS: CL, wet to damp brown clay
- 1.5 – 4m USCS: CL, wet gray clay
- Soil texture was physically identified during the investigation, additional sieve analysis was not performed on the soil samples.
- Certain areas may have a shallow layer of sandy soil on surface, but still wet clay at depths.
- Static cone penetrometer readings generally show 1000kPa of bearing capacity with less than 0.5cm of displacement and significant undrained shear strengths greater than 100kPa (insertion failure).
- Certain locations, such as the northwest area around BH110 shows significant plastic deformation from wet clays (such as unlimited plastic deformation at 1000kPa of cone penetrometer pressure)
- No foreign fill material was found over entire site, only topsoil and native clay encountered during the geotechnical investigation of this site.
- During the geotechnical investigation, there was not found or encountered coarse sand 3m below the ground surface.

4.3. IN-SITU INFILTRATION TESTING

Based on two separate field visits dated December 13 and 15, 2021, "field-saturated" hydraulic conductivity, K_{fs} , was achieved using the "Constant Head Well Permeameter" (CHWP) method. K_{fs101} was conducted at BH101 while K_{fs106} at BH106, K_{fs107} at BH107, and K_{fs112} at BH112 using ETC Slow Soils Pask Permeameter Apparatus. The "Constant Head Well Permeameter" (CHWP) method was described in Appendix III in detail.

It is understood that the in-situ infiltration test was not tested at the actual LID bottom, but based on sieve size analysis and borehole soil samples, it is in the Engineer's opinion as a geotechnical engineer that the soils perform similarly in hydrological infiltration potential.

The ETC Pask Permeameter is a convenient and easy to use apparatus for ponding a constant head of water in a well, and simultaneously measuring the flow into the soil. The K_{fs} was calculated as:

$$K_{fs101} = 7.5E-9 \text{ m/sec} = 7.5E-7 \text{ cm/sec}$$

$$K_{fs106} = 6.2E-9 \text{ m/sec} = 6.2E-7 \text{ cm/sec}$$

$$K_{fs107} = 4.0E-6 \text{ m/sec} = 4.0E-4 \text{ cm/sec}$$

$$K_{fs112} = 6.2E-9 \text{ m/sec} = 6.2E-7 \text{ cm/sec}$$

It should be noted that three tests (K_{fs101} , K_{fs106} , and K_{fs112}) indicate low permeability in clayey soils, while the fourth test (K_{fs107}) shows higher permeability due to the presence of a thick upper sandy layer within the massive clay soils.

The Kfs values were subsequently corrected for temperature ($t = 4^{\circ}\text{C}$ to 7°C).

$$K_{a101} = 7.07\text{E-}9 \text{ m/sec} = 7.07\text{E-}7 \text{ cm/sec}$$

$$K_{a106} = 6.04\text{E-}9 \text{ m/sec} = 6.04\text{E-}7 \text{ cm/sec}$$

$$K_{a107} = 3.77\text{E-}6 \text{ m/sec} = 3.77\text{E-}4 \text{ cm/sec}$$

$$K_{a112} = 5.84\text{E-}9 \text{ m/sec} = 5.84\text{E-}7 \text{ cm/sec}$$

Correlations between Perc Time (PT) and field-saturated hydraulic conductivity (K_{fs}) are often used in development of on-site water recycling and treatment facilities that operate by infiltration into unsaturated soil. Based on OMMAH (1997) interpolation, the measured infiltration rate may be interpolated as:

$$PT_{101} = 48.8 \text{ min / cm} \quad (\text{Infiltration Rate} = 12.3 \text{ mm/hour})$$

$$PT_{106} = 50.8 \text{ min / cm} \quad (\text{Infiltration Rate} = 11.8 \text{ mm/hour})$$

$$PT_{107} = 9.1 \text{ min / cm} \quad (\text{Infiltration Rate} = 66 \text{ mm/hour})$$

$$PT_{112} = 51.3 \text{ min / cm} \quad (\text{Infiltration Rate} = 11.7 \text{ mm/hour})$$

Considering that most of new Blocks under development are composed of clay materials and the substrate material of upper sandy layer composed of low permeability clay, like other parts of the site, the slower infiltration rates from PT_{101} , PT_{106} , and PT_{107} may be used as representative of the permeability of the site. Therefore, the engineer's opinion is to trust the values obtained from the OMMAH (1997), with an unfactored infiltration rate of 11.9 mm/hour.

For a conservative approach to infiltration speeds, the Wisconsin Department of Natural Resources (2004) method shall be used for the calculation of a factored design infiltration rate and the Engineer's opinion is that the factored engineering design infiltration rate is 4.8 mm/hour, with a safety factor of 2.5.

See Appendix III for more details, the calculations and graphs provided.

5. DESIGN RECOMMENDATIONS

5.1. GEOTECHNICAL MODEL

Based on the borehole information and the static cone penetration tests performed within each borehole, the following geotechnical model are stated:

- 0.5 – 1.5m native clays, moist to wet at depth, brown
- 1.5 – 3.0m native clays, wet, gray, stiff
- All soil type is define as per the soil properties at site, in depth sieve analysis wasnot carry out.
- The seasonal high groundwater level is estimated to range between 0.4 m and 1.0 m below grade, perched on top of the clay layer. During the groundwater monitoring program, the maximum groundwater level was recorded at 0.4 m below ground surface in BH102. Monitoring results indicate that, across the property, the seasonal groundwater fluctuation is generally between 0.4 m and 1.0 m below grade.
- In-situ shear vane was performed in each boreholes to understand the soil property.
- Minimum tested Undrained shear strength = 130kPa (for majority of property, except for areas around BH110)
- ULS and SLS for this property was calculated based on minimum tested undrained shear strength value of 130kPa, follow the CFEM for assessment of ULS and SLS.
- SLS = 150kPa (Canadian Foundation Engineering Manual use to assessment of SLS)
- ULS = 225kPa (Canadian Foundation Engineering Manual use to assessment of ULS)
- Durinf the geotechnical investigation, minimum noted undrained shear strength is 130kPa.
- Unit weight 21kN/m³, cohesion = 130kPa, phi = 0 degrees

Additional investigation for the area surrounding BH110 (proposed Block 10) is not required at this stage and will be carried out during future detailed design, due to soft soil was found in this area compare to other borehole datas.

Ultimate Bearing Capacity (Undrained Clay - $\phi = 0$)

According to Terzaghi's bearing capacity equation for undrained clay ($\phi = 0$):

$$q_{Ult} = C_u \times N_c$$

Where:

- $C_u = 130$ kPa (undrained cohesion)
- $N_c = 5.14$ (bearing capacity factor for $\phi = 0$)

$$q_{ultimate} = 130 \times 5.14 = 668.2 \text{ kPa}$$

Allowable Bearing Pressure (Serviceability Limit State - SLS)

$$q_{SLS} = q_{ult} / FS = 668.2 / 2.0 = 334.1 \text{ kPa}$$

However, considering settlement and conservative design for wet cohesive soils, a reduced SLS value of 150 kPa is recommended, as used in the main report.

Factored Ultimate Bearing Resistance (ULS)

$$q_{uls} = \phi (\text{resistance}) \times q_{\text{ultimate}}$$

Assuming ϕ resistance = 0.4 (typical for undrained cohesive soil):

$$q_{ULS} = 0.4 \times 668.2 = 267.3 \text{ kPa}$$

For conservatism and to match field behavior (soft zones near BH110), a ULS of 225 kPa is used in design recommendations.

5.2.POTENTIAL ISSUES DURING CONSTRUCTION

Based on the proposed site grading plan and road backfills, each industrial Block will be separately designed and most likely require foreign earth backfill. Significant amounts of backfill will be required, and adequate O.Reg 406/19 Excess Soil Fill management and compaction is required for each future industrial Block.

Additionally, the area surrounding BH110 (proposed Block 10) encountered severe plastic deformation and it is recommended for additional geotechnical investigations to determine allowable bearing capacity.

5.3.FROST PROTECTION

Based on the fine-grained soil conditions at the property and the relatively shallow depth to groundwater, the following footing recommendations are provided:

- In areas underlain by significant foreign fill, the bottom of footings should be placed at a minimum depth of 1.2 m below finished grade.
- In areas underlain by native soils, footings should extend to a depth of 1.5 m below finished grade. This additional embedment is recommended due to the close proximity of the seasonal high groundwater table to the ground surface, which may impact soil strength and long-term performance of the foundations.

5.4.PROPOSED FOUNDATIONS

At the time of preparing this report, the design loading requirements were not available. Based on the investigation of the native soils at the site, structural footings may be designed for a geotechnical bearing capacity of 150 kPa at the Serviceability Limit State (SLS) and 225 kPa at the Ultimate Limit State (ULS). No foreign fill was encountered during this investigation. However, if any foreign fill is identified during future or follow-up investigations, a geotechnical study will be carried out for those areas. Additional geotechnical investigation is also recommended for Block 10 during the detailed design stage to confirm suitable foundation parameters.

5.5.SETTLEMENT CONSIDERATIONS

In general, soils within the “stress influence zone” beneath all foundation elements of a proposed structure will be consolidated after an extended period of time. This is an important factor to realize, since the SLS is highly impacted by the potential for settlement.

The primary soil layer affected by the proposed foundation elements consists of dense, compacted, wet clay, with potential groundwater present between 0.5 m and 1.0 m below grade. Due to the nature of the wet clay, it is critical that excavations are not over-dug. Disturbed wet clay under high groundwater conditions generally has poor re-compaction and backfill characteristics.

Coarse sand was encountered in BH110 and BH111 at depths ranging from 0.7 m to 1.0 m below the surface. Areas with shallow groundwater, combined with thin lenses of coarse sand, may present flowing sand conditions and exhibit very low bearing capacity. Consequently, all foundations in these areas should be reviewed and approved by a qualified geotechnical engineer or a supervised geotechnical technician.

Low spots within excavations should be cover completely with concrete (after confirmation from structural engineer for rebar vertical positions), or backfilled with OPSS 1010 Granular B compacted to above 98% SPMDD.

5.6.SEISMIC LOADING

Using the information provided by the site investigation, the general soil profile comprises of “Very dense soil and soft rock – Site Class C” as defined by Table 4.1.8.4.A “Site Classification for Seismic Site Response” of the Ontario Building Code having an Undrained Shear Strength of greater than 100kPa.

5.7.OHSA SOIL TYPE & TRENCH SUPPORT

Using the information provided by the site investigation, the general soil profile comprises of “Type 2 Soil” as defined Occupational Health and Safety Act (OHSA) O.Reg 213/91, section 226 “Soil Types”.

Type 2 Soil is described as follows:

- Very stiff, dense. You can penetrate it with moderate difficulty by using a small sharp object but a pick can be driven in easily.
- Low to medium natural moisture content, medium degree of internal strength.
- Has a damp appearance after it’s excavated

The sides of a trench will remain vertical for several hours. After that, exposure to air and sunlight will cause tension cracks to appear. The soil will begin cracking and splaying into the trench.

Where personnel must enter a trench greater than 1.2m in depth, appropriate temporary shoring solutions must be installed. Possible temporary shoring solutions include an appropriate 1:1 gradient of excavation sloping, or the installation of a steel trench box.

5.8.BACKFILL

Compaction of fill surrounding the outside of any foundation element or during the construction of the roadway should be compacted to at least 98% of the material's Standard Proctor Maximum Dry Density (SPMDD) within 1.0m of the final subgrade elevation, and then compacted to 100% SPMDD up to final grade. Compaction should be completed in multiple layers, using an appropriately sized steel vibrating roller machine. Smaller vibratory compacting machines must compact thinner layers (and thus more total layers), while larger machines allow for thicker layers of compaction. Small, confined locations not suitable for roller machines must be compacted by hand-held compaction equipment, such as jumping-jack style compactor. Small-scale asphalt compaction plates are not suitable for compaction of local clay soils.

5.9.DRIVEWAY DESIGN

In consideration to the sub-surface investigation, the main subgrade soil would be primarily composed of disturbed agricultural topsoil & moist – wet clay. After appropriate stripping of organic topsoil and compaction of native clays, it is expected that significant earthworks and grading will be required for the proposed municipal driveways and private driveways.

Using Township of Scugog's 2003 Design Criteria and Standard Details, Section B 4.00 Pavement Design and investigation summary, the Engineer has determined the following characteristics of the native sub-grade soils and industrial sub-division municipal roads:

Table 3 – Pavement Design Overview

Parameter	Typical Design / Requirement	Observed / Site Characteristic
Subgrade Soil	Compacted native clay suitable for foundation and pavement support	Disturbed agricultural topsoil overlying moist to wet clay; requires stripping and compaction
Sieve Analysis	N/A	100% of soil passes 0.075 mm (No. 200) sieve for BH101–BH112 at depths ≥ 0.5 m; classified as fine-grained soil
Frost Susceptibility	N/A	Soil is generally non-plastic silty clay and is frost-susceptible
Drainage	Designed with biofiltration swales and underdrains	Existing industrial collector road includes two biofiltration swales with cloth-wrapped perforated underdrains; grading directs surface water to swales
Traffic Volume	Low to moderate, with occasional heavy loads	Subdivision generally experiences low traffic frequency with occasional heavy industrial loads
Pavement / Driveway Composition	40 mm HL3 asphalt surface, 75 mm HL8 asphalt base,	Granular B recommended as OPSS 1010 Type II virgin material; use of recycled concrete

Parameter	Typical Design / Requirement	Observed / Site Characteristic
	150 mm Granular "A", 300 mm Granular "B"	Granular B would require additional thickness and compaction

It is recommended that Granular B to be used shall be OPSS 1010 Granular B Type II, virgin materials. Alternative concrete recycle Granular B shall be considered by the Engineer, but generally require additional thicknesses and additional compaction effort by the construction crew.

6. ON-SITE SANITARY SEWAGE

Based on the results from Section 4.3 In-situ Infiltration Testing, the native soil characteristic of most boreholes (except for BH107) all have an average septic T-time of 50.4min/cm. This generally means that the dense clay drains very slowly, and requires:

- Class IV-B septic system (alternative treatment units) combined with Shallow Buried Trench for reduced footprints
- Large septic bed footprints using traditional septic design methods with filter mantle
- Durham Region Health Departments also requires an additional septic reserve area, equal to each designed septic bed footprint
- Additional septic design requirements that must be checked on a case-by-case basis is OBC 8.7.3.2 (1) (e), where the bottom of absorption trench must be at minimum 900mm higher than the high groundwater table, rock (bedrock), or soil with percolation time more than 50 minutes / cm.

In summary, the Engineer believes that the current site soil condition is conducive to on-site sanitary sewage systems, as described in OBC Section 8, but exercises that significant caution is required due to the extremely low infiltration rate.

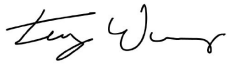
Significant foreign fill within each future industrial Block may significantly change the soil infiltration values and should be further evaluated at an individual Block or Lot level.

7. SUMMARY

The geotechnical aspects of the final design drawings and specifications should be reviewed by King EPCM prior to tendering and construction, and to confirm that the intent of this report has been met. During construction, full-time engineered fill monitoring and sufficient foundation inspections, subgrade inspections, in-situ density tests and materials testing should be carried out. As the main soil type for the proposed foundation elements will be within stiff clay (native) or foreign soil fill, appropriate and consistent tests must be carried out to ensure uniformity of soil, and to ensure that settlement is appropriately controlled.

King EPCM appreciates the opportunity to be of service for this project, and trusts that this report provides sufficient geotechnical engineering information for a detailed design of the project. King EPCM looks forward to providing continued service during the construction stage. Please do not hesitate to contact King EPCM at any time if there are any questions regarding this project.

Sincerely,



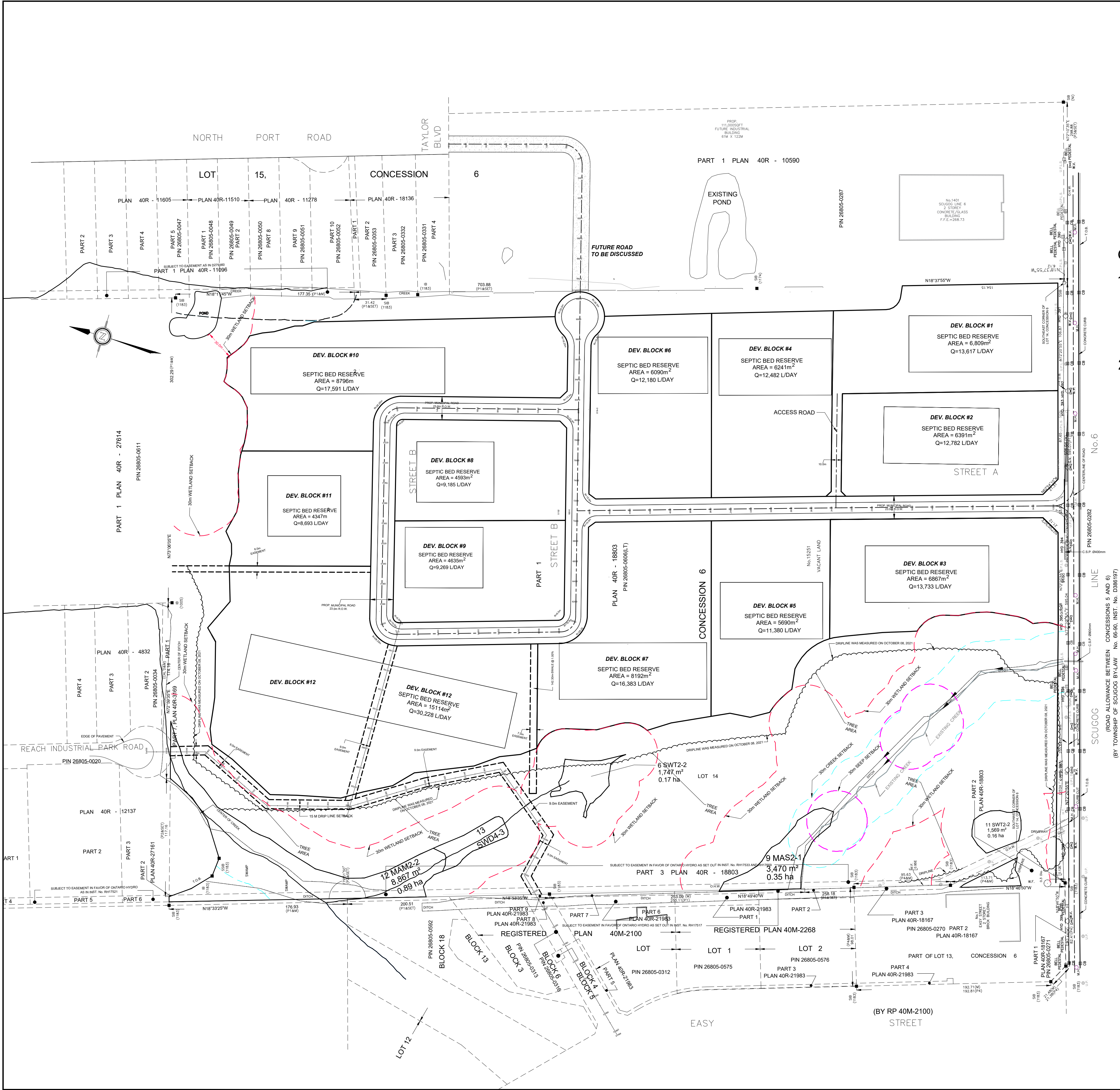
Tony Wang, P. Eng
Principal Engineer



8. REFERENCES

1. **Ontario Regulation 406/19: On-Site and Excess Soil Management**, under the Environmental Protection Act, Ministry of the Environment, Conservation and Parks (MECP), Ontario.
2. **Ontario Building Code (OBC), 2012**, including all amendments up to the date of this report – specifically Part 8 (Sewage Systems) and Part 4 (Structural Design).
3. **Canadian Foundation Engineering Manual**, 4th Edition, Canadian Geotechnical Society, 2006.
4. **Township of Scugog Design Criteria and Standard Details**, Section B: Roadway and Pavement Design, 2003.
5. **Occupational Health and Safety Act (OHSA) O. Reg. 213/91**, Construction Projects – Section 226, Soil Types.
6. **OMMAH (1997)** – Ontario Ministry of Municipal Affairs and Housing. “Design Guidelines for Sewage Systems”.
7. **Wisconsin Department of Natural Resources (2004)** – "Infiltration Standards – Technical Support Document".
8. **ASTM D2487/D2488** – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System – USCS).

APPENDIX I – SITE PLAN AND TOPOGRAPHIC SURVEY

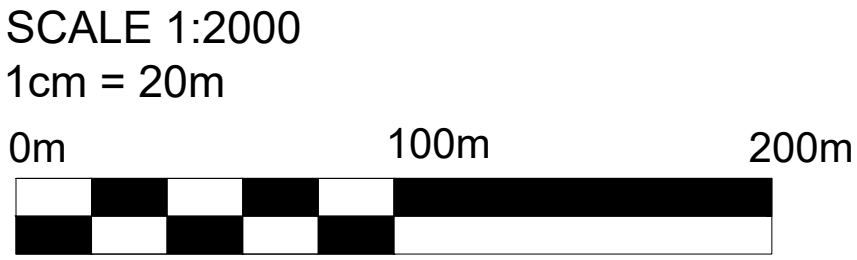


- LEGEND:
- PROPERTY BOUNDARY
 - BLOCK BOUNDARY
 - DRIPLINE
 - 30 M WETLAND SETBACK
 - 30 M CREEK SETBACK
 - 30 M SEEP SETBACK
 - VEGETATION COMMUNITY
 - WATERCOURSE/DRAINAGE, OHN

- GENERAL NOTE:
- SITE SURVEYS WERE CONDUCTED BY "MANDARIN SURVEYORS LIMITED" ON NOV. 01, 2021 AND "A.R.(SANDY) WAKELING SURVEYING TECHNICAL SERVICES" ON AUG. 17, 2021
 - NATURAL HERITAGE INFORMATION (DEVELOPABLE AREA) WAS CONDUCTED BY "GHD" ON NOV 28, 2024.

TABLE: BLOCK AREA INFORMATION

BLOCK	AREA (m2)
1	23,226
2	21,803
3	23,477
4	21,914
5	20,027
6	21,626
7	29,100
8	16,770
9	16,926
10	31,392
11	15,476
12	53,562
ROADS	32,799



ACCEPTED TO BE IN ACCORDANCE WITH THE TOWNSHIP OF SCUGOG STANDARDS. THIS ACCEPTANCE IS NOT TO BE CONSTRUED AS VERIFICATION OF ENGINEERING CONTENT

APPROVED

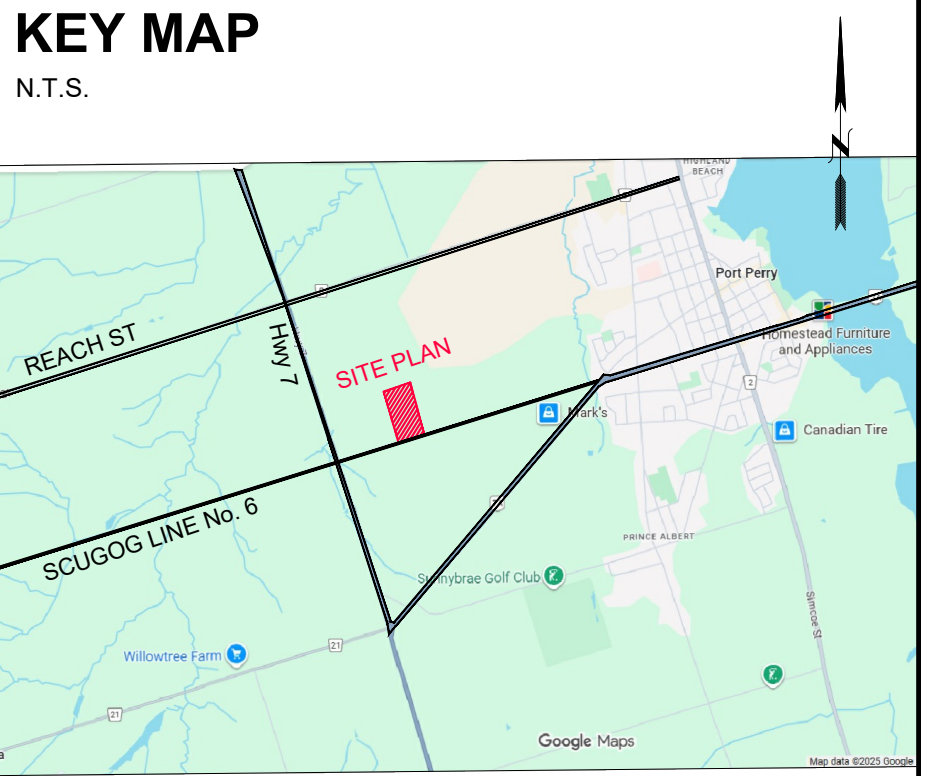
TOWNSHIP ENGINEER

DATE

DEPARTMENT OF WORKS
REGIONAL MUNICIPALITY OF DURHAM

DATE

REVISIONS				
No.		DATE	BY	APPROVED
V32	ISSUED FOR PERMITS	SEPT 23, 2024	KL	
V33	ISSUED FOR PERMITS	DEC 06, 2024	KL	
V34	ISSUED FOR PERMITS	MAY 2, 2025	SL	
V37	ISSUED FOR PERMITS	OCT 15, 2025	PR	



PROJECT NAME:

SCUGOG LINE 6 INDUSTRIAL BLOCK
SUB-DIVISION DEVELOPMENT

CORPORATION OF THE
TOWNSHIP OF SCUGOG

PROJECT LOCATION

SCUGOG LINE 6, PORT PERRY, ON
PART-1, PLAN 40R - 18803

CONSULTANTS NAME

KING E P C M
3780 14th Ave., Unit 211
Markham, ON, L3R 9Y5
www.KingEPCM.com
647-459-5647

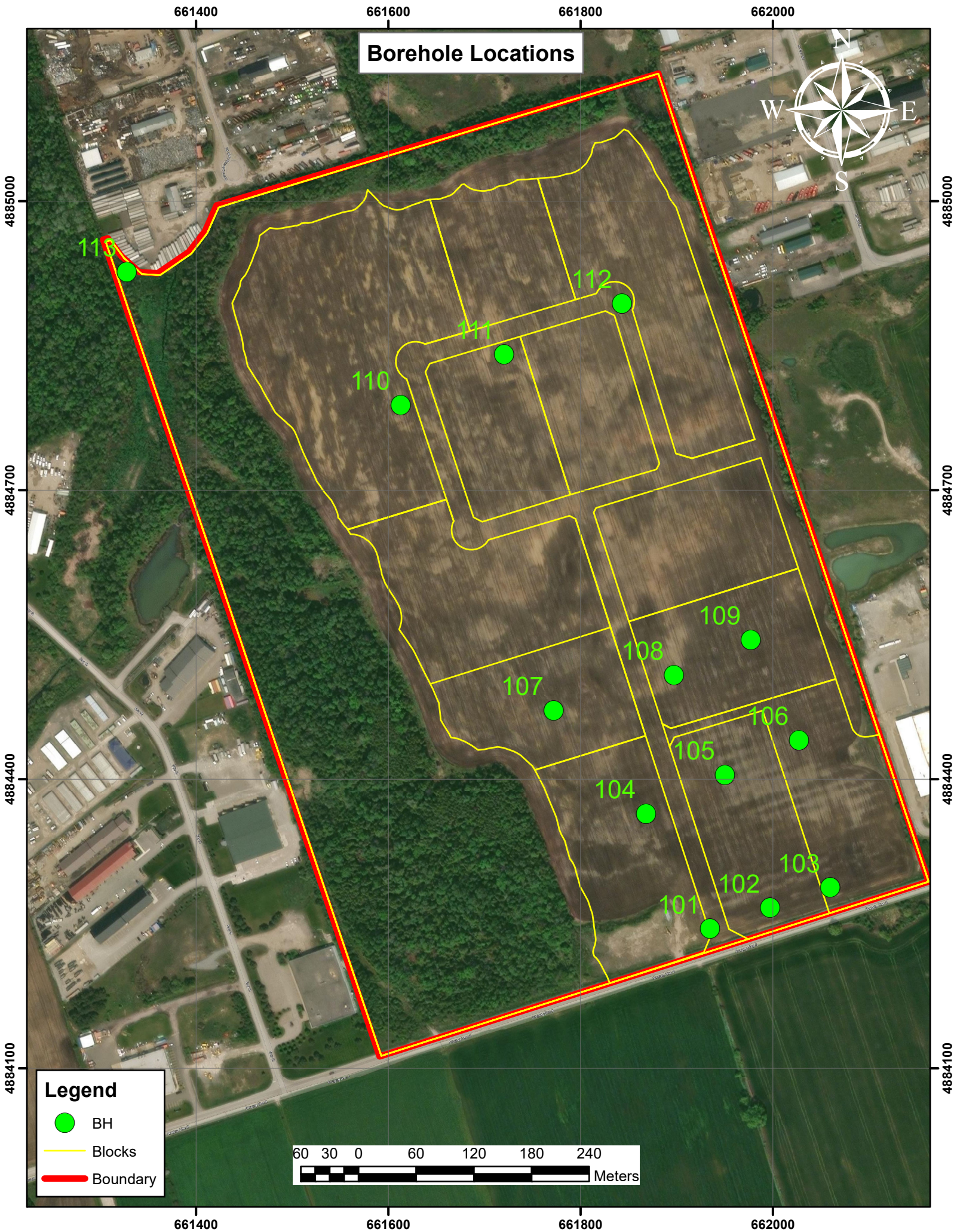
STAMP
LICENSED PROFESSIONAL ENGINEER
A. Samadi
100569767
2025.10.27
PROVINCE OF ONTARIO

SCALE:
SCALE 1:2000
DRAWN BY:
DESIGNED BY:
CHECKED BY:
DATE:

PROJECT NO.
S-S-2022-01
DRAWING NO.
EGR 1.1
SITE PLAN

KL/SL/PR
KL
TW
OCT 15, 2025

APPENDIX II – BOREHOLE DRILL LOG

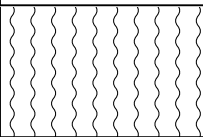
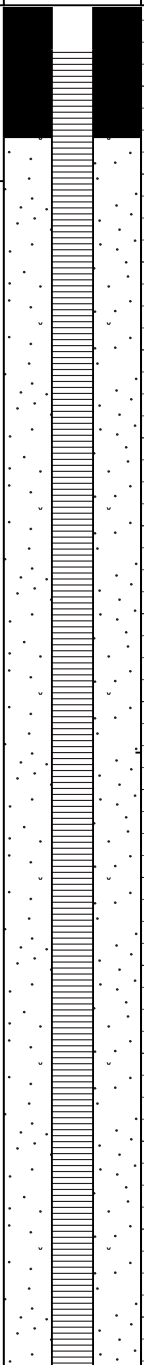
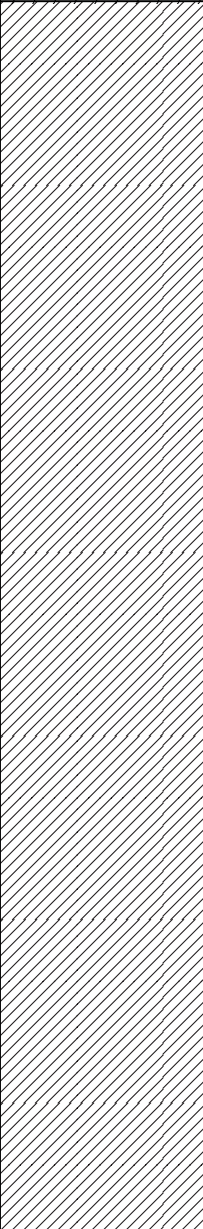


GROUNDWATER MONITORING Well BH101

PROJECT NUMBER	DRILLING COMPANY King EPCM	COORDINATES 4884,244,899N, 661,934,627E
PROJECT NAME	DRILLER Pincheng Zhao, Yung Chong	COORD SYS UTM-17
CLIENT	DRILL RIG	SURFACE ELEVATION 262.184 AMSL
ADDRESS 1401 Scugog Line 6, Port Perry	DRILLING METHOD Continuous Flight Auger	WELL TOC None
DRILLING DATE 12/06/2021	TOTAL DEPTH 3.1 m	LOGGED BY Pincheng Zhao
LICENCE NO. C-7691	DIAMETER 1.5 inch	CHECKED BY Tony Wang, P Eng, Principal Engineer

COMPLETION **CASING** 1.25 inch **SCREEN** 1.25 inch

COMMENTS Southeast corner of the dwelling

Depth (m)	Graphic Log	USCS SAMPLES	Material Description	Additional Observations	Well Installation	Elevation (m)
0.2			Topsoil			262.1
0.4			USCS: CL, lean clay, damp to wet depths	Groundwater measured at 0.4 m deep when drilling		261.8
0.6						261.6
0.8						261.4
1						261.2
1.2						261
1.4						260.8
1.6						260.6
1.8						260.4
2						260.2
2.2						260
2.4						259.8
2.6						259.6
2.8						259.4
3						259.2
			Termination Depth at: 3.1 m			259

Disclaimer

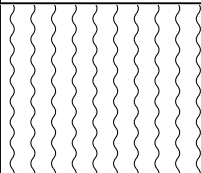
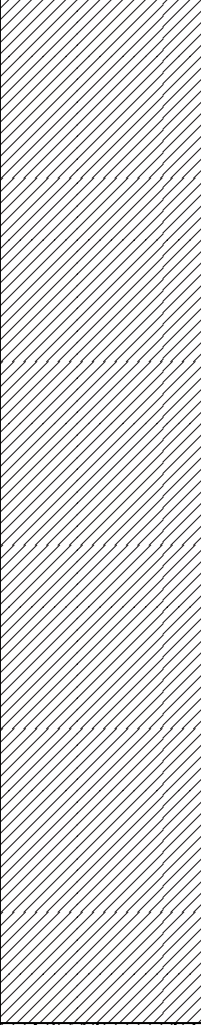
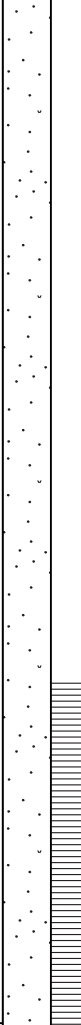
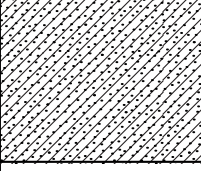
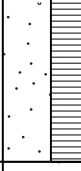
Page 1 of 1

GROUNDWATER MONITORING Well BH102

PROJECT NUMBER	DRILLING COMPANY King EPCM	COORDINATES 4884,266,525N, 661,996,529E
PROJECT NAME	DRILLER Pincheng Zhao, Yung Chong	COORD SYS UTM-17
CLIENT	DRILL RIG	SURFACE ELEVATION 262.627 AMSL
ADDRESS 1401 Scugog Line 6, Port Perry	DRILLING METHOD Continuous Flight Auger	WELL TOC None
DRILLING DATE 12/07/2021	TOTAL DEPTH 4 m	LOGGED BY Pincheng Zhao
LICENCE NO. C-7691	DIAMETER 1.5 inch	CHECKED BY Tony Wang, P Eng, Principal Engineer

COMPLETION **CASING** 1.25 inch **SCREEN** 1.25 inch

COMMENTS South of the dwelling

Depth (m)	Graphic Log	USCS SAMPLES	Material Description	Additional Observations	Well Installation BH101	Elevation (m)
0.2			Topsoil			262.6
0.4						262.4
0.6						262.2
0.8			USCS: CL, brown damp clay			262
1.0						261.8
1.2						261.6
1.4						261.4
1.6						261.2
1.8						261
2.0						260.8
2.2						260.6
2.4						260.4
2.6						260.2
2.8						260
3.0						259.8
3.2						259.6
3.4						259.4
3.6						259.2
3.8			USCS: CL, grey wet clay	Groundwater measured at 3.5 m deep when drilling		259
4.0			Termination Depth at: 4 m			258.6

Disclaimer

Page 1 of 1

GROUNDWATER MONITORING Well BH103

PROJECT NUMBER	DRILLING COMPANY King EPCM	COORDINATES 4884,287,682N, 662,059,624E
PROJECT NAME	DRILLER Pincheng Zhao, Yung Chong	COORD SYS UTM-17
CLIENT	DRILL RIG	SURFACE ELEVATION 263.463 AMSL
ADDRESS 1401 Scugog Line 6, Port Perry	DRILLING METHOD Continuous Flight Auger	WELL TOC None
DRILLING DATE 12/07/2021	TOTAL DEPTH 3.1 m	LOGGED BY Pincheng Zhao
LICENCE NO. C-7691	DIAMETER 1.5 inch	CHECKED BY Tony Wang, P Eng, Principal Engineer

COMPLETION **CASING** 1.25 inch **SCREEN** 1.25 inch

COMMENTS Southwest of the dwelling

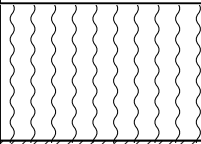
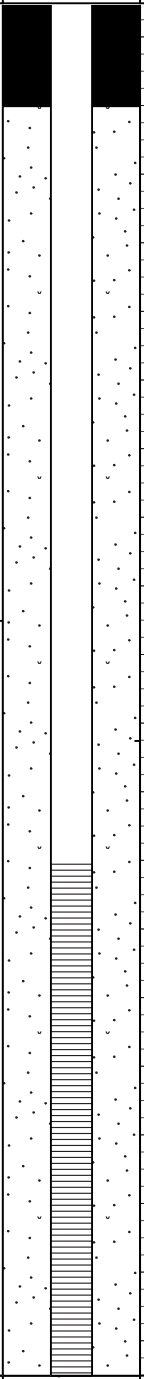
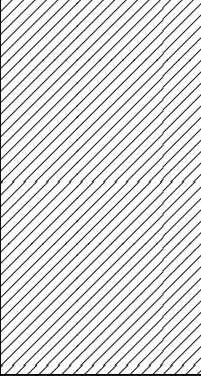
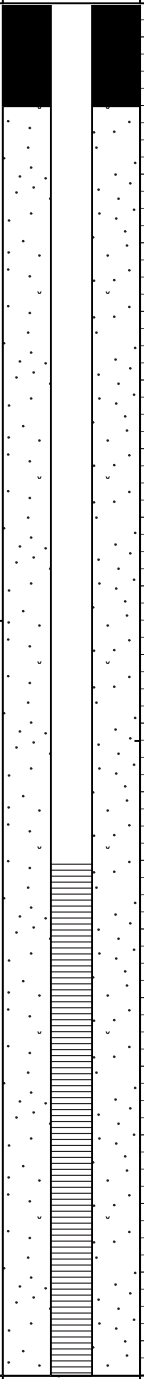
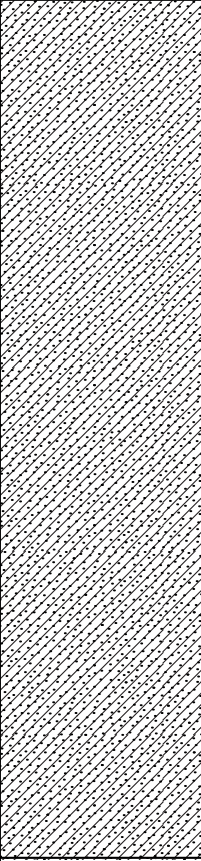
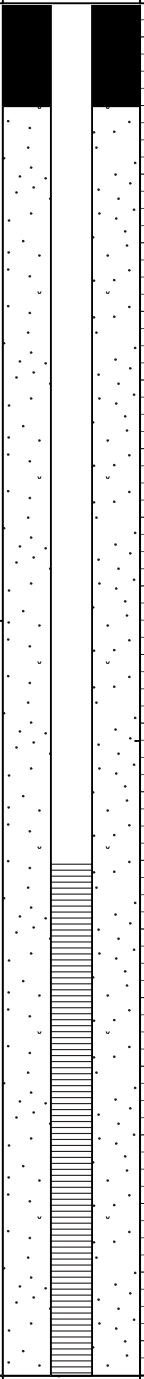
Depth (m)	Graphic Log	USCS SAMPLES	Material Description	Additional Observations	Well Installation	Elevation (m)
0.2			Topsoil			263.4
0.4						263.2
0.6			USCS: CL, brown damp clay			263
0.8						262.8
1						262.6
1.2						262.4
1.4						262.2
1.6						262
1.8						261.8
2			USCS: CL, grey wet clay			261.6
2.2				Groundwater measured at 2.2 m deep when drilling		261.4
2.4						261.2
2.6						261
2.8						260.8
3						260.6
			Termination Depth at: 3.1 m			260.4

GROUNDWATER MONITORING Well BH104

PROJECT NUMBER	DRILLING COMPANY King EPCM	COORDINATES 4884,364,300N, 661,867,534E
PROJECT NAME	DRILLER Pincheng Zhao, Yung Chong	COORD SYS UTM-17
CLIENT	DRILL RIG	SURFACE ELEVATION 260.898 AMSL
ADDRESS 1401 Scugog Line 6, Port Perry	DRILLING METHOD Continuous Flight Auger	WELL TOC None
DRILLING DATE 12/08/2021	TOTAL DEPTH 4 m	LOGGED BY Pincheng Zhao
LICENCE NO. C-7691	DIAMETER 1.5 inch	CHECKED BY Tony Wang, P Eng, Principal Engineer

COMPLETION **CASING** 1.25 inch **SCREEN** 1.25 inch

COMMENTS Southeast of the dwelling

Depth (m)	Graphic Log	USCS SAMPLES	Material Description	Additional Observations	Well Installation	Elevation (m)
0.2			Topsoil			260.8
0.4						260.6
0.6			USCS: CL, brown damp clay			260.4
0.8						260.2
1.0						260
1.2						259.8
1.4			USCS:CL, grey wet clay			259.6
1.6						259.4
1.8						259.2
2.0				Groundwater measured at 1.8 m deep when drilling		259
2.2						258.8
2.4						258.6
2.6						258.4
2.8						258.2
3.0						258
3.2						257.8
3.4						257.6
3.6						257.4
3.8						257.2
4.0			Termination Depth at: 4 m			257

Disclaimer

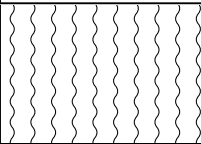
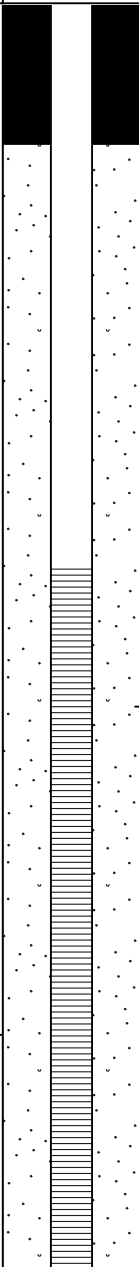
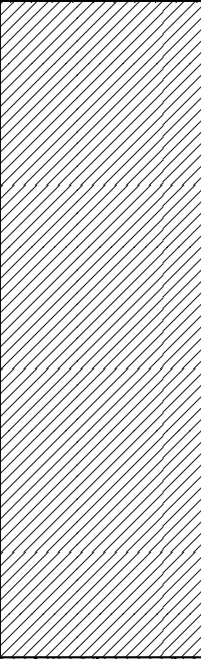
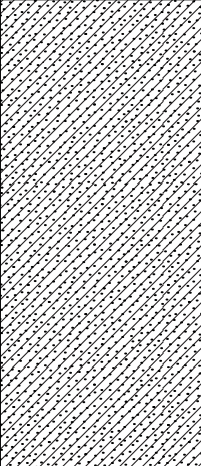
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GROUNDWATER MONITORING Well BH105

PROJECT NUMBER	DRILLING COMPANY King EPCM	COORDINATES 4884,404,509N, 661,950,440E
PROJECT NAME	DRILLER Pincheng Zhao, Yung Chong	COORD SYS UTM-17
CLIENT	DRILL RIG	SURFACE ELEVATION 261.746 AMSL
ADDRESS 1401 Scugog Line 6, Port Perry	DRILLING METHOD Continuous Flight Auger	WELL TOC None
DRILLING DATE 12/09/2021	TOTAL DEPTH 2.7 m	LOGGED BY Pincheng Zhao
LICENCE NO. C-7691	DIAMETER 1.5 inch	CHECKED BY Tony Wang, P Eng, Principal Engineer

COMPLETION **CASING** 1.25 inch **SCREEN** 1.25 inch

COMMENTS Middle of the field

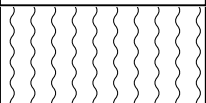
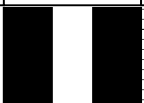
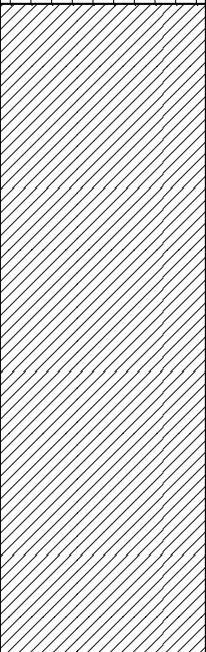
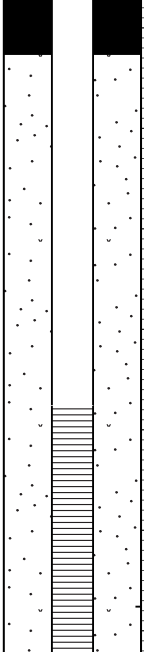
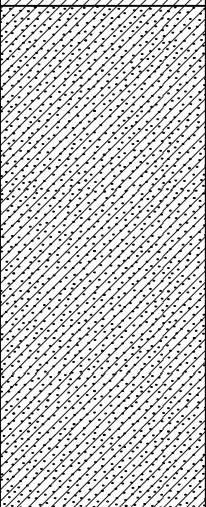
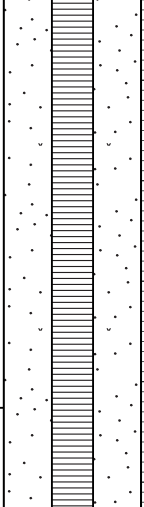
Depth (m)	Graphic Log	USCS SAMPLES	Material Description	Additional Observations	Well Installation	Elevation (m)
0.2			Topsoil			261.6
0.4			USCS: CL, brown damp clay			261.4
0.6						261.2
0.8						261
1						260.8
1.2						260.6
1.4						260.4
1.6						260.2
1.8			USCS: CL, grey wet clay			260
2						259.8
2.2				Groundwater measured at 2.2 m deep when drilling		259.6
2.4						259.4
2.6						259.2
2.8			Termination Depth at: 2.7 m	Bearing capacity tested at 2.7m deep is 1200 KPa at without displacement		259
						258.8

GROUNDWATER MONITORING Well BH106

PROJECT NUMBER	DRILLING COMPANY King EPCM	COORDINATES 4884,440,761N, 662,026,623E
PROJECT NAME	DRILLER Pincheng Zhao, Yung Chong	COORD SYS UTM-17
CLIENT	DRILL RIG	SURFACE ELEVATION 262.448 AMSL
ADDRESS 1401 Scugog Line 6, Port Perry	DRILLING METHOD Continuous Flight Auger	WELL TOC None
DRILLING DATE 12/15/2021	TOTAL DEPTH 2.5 m	LOGGED BY Pincheng Zhao
LICENCE NO. C-7691	DIAMETER 1.5 inch	CHECKED BY Tony Wang, P Eng, Principal Engineer

COMPLETION	CASING 1.25 inch	SCREEN 1.25 inch
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COMMENTS Middle of the field

Depth (m)	Graphic Log	USCS SAMPLES	Material Description	Additional Observations	Well Installation	Elevation (m)
0.2			Topsoil			262.4
0.2			USCS: CL, damp grey clay			262.2
0.4						262
0.6						261.8
0.8						261.6
1						261.4
1.2						261.2
1.4						261
1.6			USCS: CL, wet grey clay			260.8
1.8						260.6
2						260.4
2.2						260.2
2.4				Groundwater measured at 2.2 m deep when drilling		260
2.6			Termination Depth at: 2.5 m			259.8

GROUNDWATER MONITORING Well BH107

PROJECT NUMBER	DRILLING COMPANY King EPCM	COORDINATES 4884,471,381N, 661,771,905E
PROJECT NAME	DRILLER Pincheng Zhao, Yung Chong	COORD SYS UTM-17
CLIENT	DRILL RIG	SURFACE ELEVATION 260.092 AMSL
ADDRESS 1401 Scugog Line 6, Port Perry	DRILLING METHOD Continuous Flight Auger	WELL TOC None
DRILLING DATE 12/08/2021	TOTAL DEPTH 3.1 m	LOGGED BY Pincheng Zhao
LICENCE NO. C-7691	DIAMETER 1.5 inch	CHECKED BY Tony Wang, P Eng, Principal Engineer

COMPLETION **CASING** 1.25 inch **SCREEN** 1.25 inch

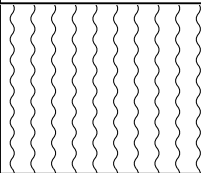
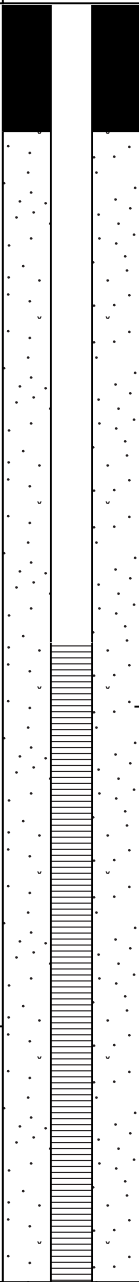
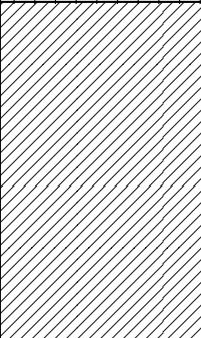
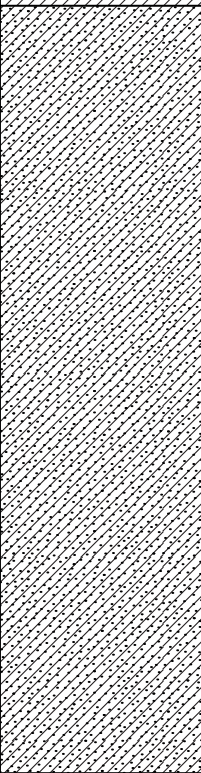
COMMENTS East of the dwelling

Depth (m)	Graphic Log	USCS SAMPLES	Material Description	Additional Observations	Well Installation	Elevation (m)
0.2			Topsoil			260
0.4			USCS: CL, brown damp clay			259.8
0.6						259.6
0.8						259.4
1						259.2
1.2						259
1.4						258.8
1.6						258.6
1.8						258.4
2			USCS: CL, grey wet clay			258.2
2.2				Groundwater measured at 2.2 m deep when drilling		258
2.4						257.8
2.6						257.6
2.8						257.4
3						257.2
			Termination Depth at: 3.1 m			257

PROJECT NUMBER	DRILLING COMPANY King EPCM	COORDINATES 4884,508,262N, 661,897,120E
PROJECT NAME	DRILLER Pincheng Zhao, Yung Chong	COORD SYS UTM-17
CLIENT	DRILL RIG	SURFACE ELEVATION 261.729 AMSL
ADDRESS 1401 Scugog Line 6, Port Perry	DRILLING METHOD Continuous Flight Auger	WELL TOC None
DRILLING DATE 12/09/2021	TOTAL DEPTH 3 m	LOGGED BY Pincheng Zhao
LICENCE NO. C-7691	DIAMETER 1.5 inch	CHECKED BY Tony Wang, P Eng, Principal Engineer

COMPLETION	CASING 1.25 inch	SCREEN 1.25 inch
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COMMENTS Middle of the field

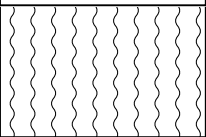
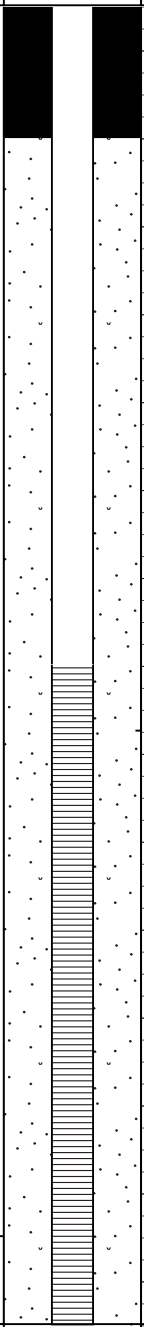
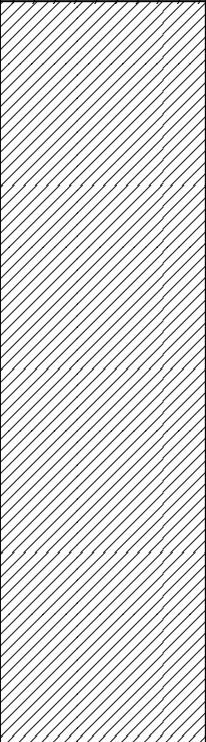
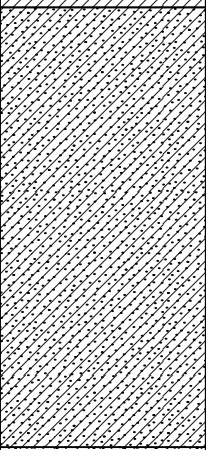
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0.2			Topsoil			261.6
0.4			USCS: CL, damp grey clay			261.4
0.6						261.2
0.8						261
1						260.8
1.2			USCS: CL, wet grey clay			260.6
1.4						260.4
1.6						260.2
1.8						260
2						259.8
2.2						259.6
2.4				Groundwater measured at 2.4 m deep when drilling		259.4
2.6						259.2
2.8						259
3			Termination Depth at: 3 m	Bearing capacity tested at 3m deep is 1000 KPa at without displacement		258.8
3.2						258.6

GROUNDWATER MONITORING Well BH109

PROJECT NUMBER	DRILLING COMPANY King EPCM	COORDINATES 4884,544,885N, 661,976,834E
PROJECT NAME	DRILLER Pincheng Zhao, Yung Chong	COORD SYS UTM-17
CLIENT	DRILL RIG	SURFACE ELEVATION 261.704 AMSL
ADDRESS 1401 Scugog Line 6, Port Perry	DRILLING METHOD Continuous Flight Auger	WELL TOC None
DRILLING DATE 12/09/2021	TOTAL DEPTH 3 m	LOGGED BY Pincheng Zhao
LICENCE NO. C-7691	DIAMETER 1.5 inch	CHECKED BY Tony Wang, P Eng, Principal Engineer

COMPLETION **CASING** 1.25 inch **SCREEN** 1.25 inch

COMMENTS Middle & west of the field

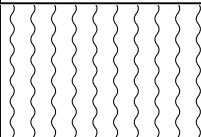
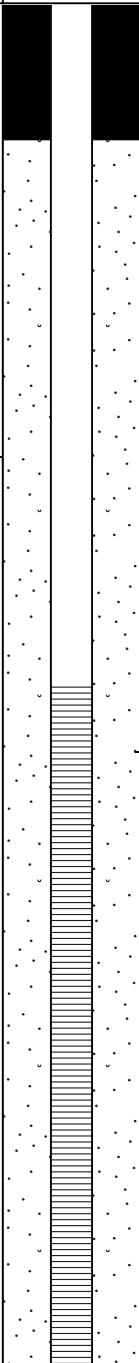
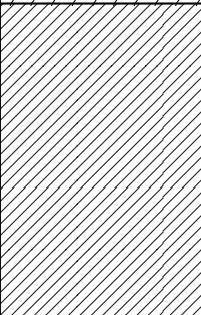
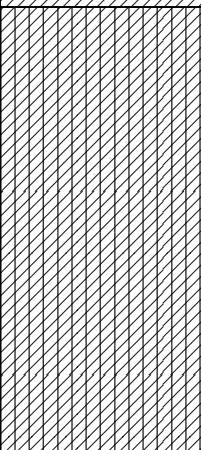
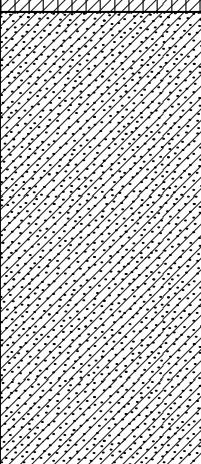
Depth (m)	Graphic Log	USCS SAMPLES	Material Description	Additional Observations	Well Installation	Elevation (m)
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0.4			USCS: CL, damp grey clay			261.4
0.6						261.2
0.8						261
1						260.8
1.2						260.6
1.4						260.4
1.6						260.2
1.8						260
2						259.8
2.2			USCS: CL, wet grey clay			259.6
2.4						259.4
2.6						259.2
2.8				Groundwater measured at 2.8 m deep when drilling		259
3			Termination Depth at: 3 m	Bearing capacity tested at 3m deep is 1200 KPa at 40mm displacement		258.8
						258.6

GROUNDWATER MONITORING Well BH110

PROJECT NUMBER	DRILLING COMPANY King EPCM	COORDINATES 4884,788,529N, 661,612,830E
PROJECT NAME	DRILLER Pincheng Zhao, Yung Chong	COORD SYS UTM-17
CLIENT	DRILL RIG	SURFACE ELEVATION 256.346 AMSL
ADDRESS 1401 Scugog Line 6, Port Perry	DRILLING METHOD Continuous Flight Auger	WELL TOC None
DRILLING DATE 12/14/2021	TOTAL DEPTH 3.1 m	LOGGED BY Pincheng Zhao
LICENCE NO. C-7691	DIAMETER 1.5 inch	CHECKED BY Tony Wang, P Eng, Principal Engineer

COMPLETION **CASING** 1.25 inch **SCREEN** 1.25 inch

COMMENTS Northeast corner of the field

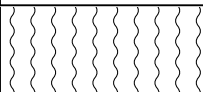
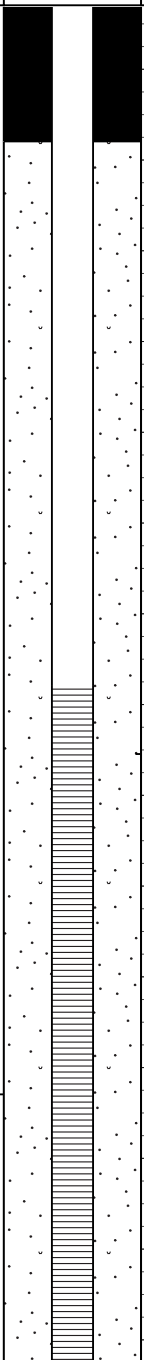
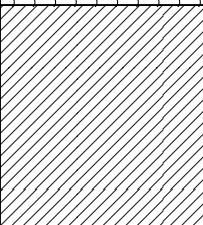
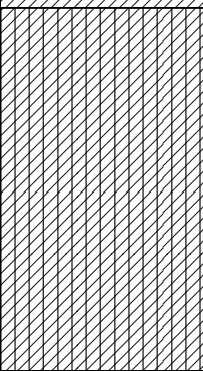
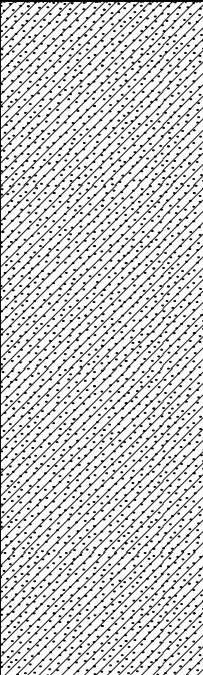
Depth (m)	Graphic Log	USCS SAMPLES	Material Description	Additional Observations	Well Installation	Elevation (m)
0.2			Topsoil			256.2
0.4			USCS: dark yellow sand			256
0.6						255.8
0.8						255.6
1						255.4
1.2			USCS: CL, grey damp clay	Groundwater measured at 1 m deep when drilling		255.2
1.4						255
1.6						254.8
1.8						254.6
2						254.4
2.2			USCS: CL, grey wet clay			254.2
2.4						254
2.6						253.8
2.8						253.6
3			Termination Depth at: 3m	Bearing capacity tested at 3m deep is 1000 KPa at less than 40cm displacement		253.4

GROUNDWATER MONITORING Well BH111

PROJECT NUMBER	DRILLING COMPANY King EPCM	COORDINATES 4884,841,025N, 661,720,391E
PROJECT NAME	DRILLER Pincheng Zhao, Yung Chong	COORD SYS UTM-17
CLIENT	DRILL RIG	SURFACE ELEVATION 257.541 AMSL
ADDRESS 1401 Scugog Line 6, Port Perry	DRILLING METHOD Continuous Flight Auger	WELL TOC None
DRILLING DATE 12/14/2021	TOTAL DEPTH 3.1 m	LOGGED BY Pincheng Zhao
LICENCE NO. C-7691	DIAMETER 1.5 inch	CHECKED BY Tony Wang, P Eng, Principal Engineer

COMPLETION **CASING** 1.25 inch **SCREEN** 1.25 inch

COMMENTS North and middle location of the field

Depth (m)	Graphic Log	USCS SAMPLES	Material Description	Additional Observations	Well Installation	Elevation (m)
0.2			Topsoil			257.4
0.4			USCS: dark yellow sand			257.2
0.6						257
0.8			USCS: CL, grey damp clay			256.8
1.0						256.6
1.2						256.4
1.4						256.2
1.6			USCS: CL, grey wet clay			256
1.8						255.8
2.0						255.6
2.2						255.4
2.4						255.2
2.6				Groundwater measured at 1 m deep when drilling		255
2.8						254.8
3.0			Termination Depth at: 3m	Bearing capacity tested at 3m deep is 1600 KPa at no displacement		254.6

GROUNDWATER MONITORING Well BH112

PROJECT NUMBER	DRILLING COMPANY King EPCM	COORDINATES 4884,893,893N, 661,842,834E
PROJECT NAME	DRILLER Pincheng Zhao, Yung Chong	COORD SYS UTM-17
CLIENT	DRILL RIG	SURFACE ELEVATION 258.759 AMSL
ADDRESS 1401 Scugog Line 6, Port Perry	DRILLING METHOD Continuous Flight Auger	WELL TOC None
DRILLING DATE 12/14/2021	TOTAL DEPTH 3 m	LOGGED BY Pincheng Zhao
LICENCE NO. C-7691	DIAMETER 1.5 inch	CHECKED BY Tony Wang, P Eng, Principal Engineer

COMPLETION **CASING** 1.25 inch **SCREEN** 1.25 inch

COMMENTS North and middle location of the field

Depth (m)	Graphic Log	USCS SAMPLES	Material Description	Additional Observations	Well Installation	Elevation (m)
0.2			Topsoil			258.6
0.4			USCS: CL, grey damp clay			258.4
0.6						258.2
0.8						258
1						257.8
1.2						257.6
1.4						257.4
1.6			USCS: CL, grey wet clay	Groundwater measured at 1.5 m deep when drilling		257.2
1.8						257
2						256.8
2.2						256.6
2.4						256.4
2.6						256.2
2.8						256
3			Termination Depth at: 3m	Bearing capacity tested at 3m deep is 1700 KPa at no displacement		255.8

Disclaimer

Page 1 of 1

GROUNDWATER MONITORING Well BH113

PROJECT NUMBER	DRILLING COMPANY King EPCM	COORDINATES 4884,926,436N, 661,327,919E
PROJECT NAME	DRILLER Pincheng Zhao, Yung Chong	COORD SYS UTM-17
CLIENT	DRILL RIG	SURFACE ELEVATION 255.121 AMSL
ADDRESS 1401 Scugog Line 6, Port Perry	DRILLING METHOD Continuous Flight Auger	WELL TOC None
DRILLING DATE 12/13/2021	TOTAL DEPTH 2.1 m	LOGGED BY Pincheng Zhao
LICENCE NO. C-7691	DIAMETER 1.5 inch	CHECKED BY Tony Wang, P Eng, Principal Engineer

COMPLETION **CASING** 1.25 inch **SCREEN** 1.25 inch

COMMENTS Northeast of the dwelling near the swamp

Depth (m)	Graphic Log	USCS SAMPLES	Material Description	Additional Observations	Well Installation	Elevation (m)
0.1			Topsoil			255.1
0.2						255.0
0.3						254.9
0.4			USCS: ML, Silt of low plasticity	Groundwater measured at 0.7 m deep when drilling		254.8
0.5						254.7
0.6						254.6
0.7						254.5
0.8						254.4
0.9						254.3
1.0						254.2
1.1						254.1
1.2						254.0
1.3						253.9
1.4						253.8
1.5						253.7
1.6						253.6
1.7						253.5
1.8						253.4
1.9						253.3
2.0						253.2
2.1						253.1
2.1			Termination Depth at: 2.1 m			253.0

APPENDIX III – IN-SITU INFILTRATION CALCULATIONS

In-situ Measurement of Field Saturated Hydraulic Conductivity

1. Field Permeability Test

The "Constant Head Well Permeameter" (CHWP) method (Reynolds, 1993; Elrick and Reynolds, 1986) is based on the observation that when a constant height or "head" of water is ponded in a borehole or "well" augured into unsaturated soil, a "bulb" of field-saturated soil is gradually established around the base of the well. The K_{fs} value achieved through this method can be less than or equal to half of K_s (Saturated hydraulic conductivity) due to partial blocking of soil pores by air bubbles and it is preferred over K_s in the design of on-site stormwater LID infiltration design, because drainage through the soil should be designed to occur at less than complete soil saturation.

The in-situ measurements were done by the ETC Slow Soils Pask Permeameter, is an extended single-head analysis method and calculations procedure used here are based on the work of W.D. Reynolds and D.E. Elrick formerly of the University of Guelph, Ontario, Canada.

The ETC Pask Permeameter is a convenient and easy to use apparatus for ponding a constant head of water in a well, and simultaneously measuring the flow into the soil. The rate of fall (R) of the water level in the permeameter reservoir and reservoir cross-sectional area (X) allows determination of quasi steady water flow I_{rate} (Q) into the soil (i.e $Q = XR$). K_{fs} is then calculated using Equation 1 (Reynolds, 1993):

$$K_{fs} = CQ / [2\pi H^2 + C\pi a^2 + (2\pi H/\alpha^*)] \quad (\text{Eq. 1})$$

In which:

K_{fs} = the calculated permeability from the field test

Table 1. Parameters used

Parameter	Description	BH			
		101	106	107	112
Soil Texture Factor (α^*) in cm^{-1}	Most structured and medium textured materials; including structured clayey and loamy soils, as well as unstructured medium single-grain sands (0.12) and Compacted, structureless, clayey materials such as landfill caps and liners, lacustrine or marine sediments (0.01).	0.01	0.01	0.12	0.01
R in cm/min	Quasi steady state (constant) rate of fall of water in permeameter reservoir (Measured in the site)	0.03	0.025	3.1	0.025
μ_k/μ_a	Temperature Correction Factor	0.942	0.974	0.942	0.942
C	Shape factor	1.27	1.27	1.36	1.27

X in cm ²	Cross-sectional area of permeameter reservoir	12.80
H in cm	Height of air inlet hole from bottom of the test hole	15
a in cm	Well hole radius	4.15

Based on data described in the above table and using Pask Permeameter ETC Quick Field Reference Tables for Standard Soils, the K_{fs} was calculated as:

$$K_{fs101} = 7.5E-9 \text{ m/sec} = 7.5E-7 \text{ cm/sec}$$

$$K_{fs106} = 6.2E-9 \text{ m/sec} = 6.2E-7 \text{ cm/sec}$$

$$K_{fs107} = 4.0E-6 \text{ m/sec} = 4.0E-4 \text{ cm/sec}$$

$$K_{fs112} = 6.2E-9 \text{ m/sec} = 6.2E-7 \text{ cm/sec}$$

It should be noted that the third test (K_{fs107}) has a higher permeability than the other tests due to the location of the well bottom in the sandy layer.

And then the temperature corrected permeability would be calculated using equation 2 as follows:

$$K_a = K_{fs} \times \mu_k / \mu_a \quad (\text{Eq. 2})$$

In which:

K_a = corrected permeability adjusted for design temperature conditions

Then using the temperature correction factor (for $t=4^\circ\text{C} - 7^\circ\text{C}$) from the manual:

$$K_{a101} = 7.07E-9 \text{ m/sec} = 7.07E-7 \text{ cm/sec}$$

$$K_{a106} = 6.04E-9 \text{ m/sec} = 6.04E-7 \text{ cm/sec}$$

$$K_{a107} = 3.77E-6 \text{ m/sec} = 3.77E-4 \text{ cm/sec}$$

$$K_{a112} = 5.84E-9 \text{ m/sec} = 5.84E-7 \text{ cm/sec}$$

The field permeability data sheet is in the following.

2. Percolation time/infiltration rate for design (Reynolds et al., 2015)

Correlations between Perc Time (PT) and field-saturated hydraulic conductivity (K_{fs}) are often used in development of on-site water recycling and treatment facilities that operate by infiltration into unsaturated soil. The physically based PT versus K_{fs} expression in Reynolds et al. (2015) for cylindrical test holes in unsaturated soil can be simplified to Eq. 3.

$$PT = \frac{\Delta t}{\Delta H} = m K_{fs}^{-1} \quad (\text{Eq. 3})$$

Where:

$$m = \frac{\bar{c}a^2}{\left[2\bar{H}^2 + \bar{c}a^2 + \frac{2\bar{H}[1 - \exp(\alpha\psi_a)]}{\alpha} \right]}; 0 < m < 1 \quad (\text{Eq. 4})$$

And a is test hole radius, $\bar{H}$ is average water level (ponding depth) in the test hole over time interval, Δt , ψ_a is the antecedent or background pore water pressure head in the soil surrounding the test hole, α may be viewed as the “integrally correct” slope of the soil’s unsaturated hydraulic conductivity versus pore water pressure head relationship, $K(\psi)$ and $\bar{C}$ is a “shape function” (Reynolds et al., 2015).

Conversion of CHWP K_{fs}/k_a to equivalent Perc Time, PT for this site using $m= 5.39E-06$ (moderate capillarity category) and $m= 1.05E-06$ (very strong category):

$$PT_{101} = mK_{a101}^{-1} = \frac{(1.05E-6)}{(7.07E-9)} = 148.6 \text{ min/cm} \quad (\text{Infiltration Rate} = 4.04 \text{ mm/hour})$$

$$PT_{106} = mK_{a106}^{-1} = \frac{(1.05E-6)}{(6.04E-9)} = 173.9 \text{ min/cm} \quad (\text{Infiltration Rate} = 3.45 \text{ mm/hour})$$

$$PT_{107} = mK_{a107}^{-1} = \frac{(5.39E-6)}{(3.77E-6)} = 1.43 \text{ min/cm} \quad (\text{Infiltration Rate} = 419.4 \text{ mm/hour})$$

$$PT_{112} = mK_{a112}^{-1} = \frac{(1.05E-6)}{(5.84E-9)} = 179.8 \text{ min/cm} \quad (\text{Infiltration Rate} = 3.34 \text{ mm/hour})$$

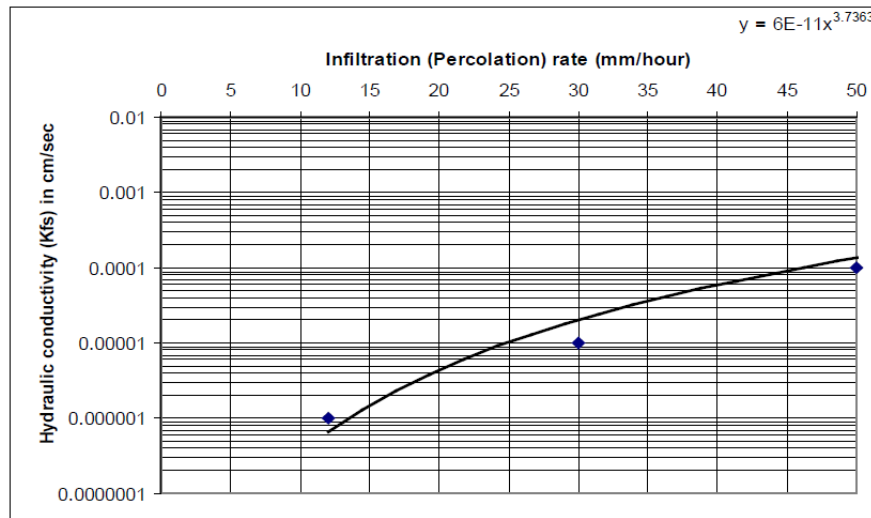
3. Percolation time/infiltration rate for design (OMMAH, 1997)

Despite the newer academic papers published by Reynolds et al. (2015), TRCA and other Conservation Authorities often still review design of infiltration basins based on historic trends. Below are two TRCA (2012) design criteria that describe the relationship between K_{fs} , PT, and infiltration rates, based on the 1997 (OMMAH) supplementary guidelines to OBC (1997).

Table 2. Approximate relationships between hydraulic conductivity, percolation time and infiltration rate

Hydraulic Conductivity, K_{fs} (centimetres/second)	Percolation Time, T (minutes/centimetre)	Infiltration Rate, 1/T (millimetres/hour)
0.1	2	300
0.01	4	150
0.001	8	75
0.0001	12	50
0.00001	20	30
0.000001	50	12

Source: Ontario Ministry of Municipal Affairs and Housing (OMMAH). 1997. *Supplementary Guidelines to the Ontario Building Code 1997. SG-6 Percolation Time and Soil Descriptions*. Toronto, Ontario.



Source: Ontario Ministry of Municipal Affairs and Housing (OMMAH). 1997. Supplementary Guidelines to the Ontario Building Code 1997. SG-6 Percolation Time and Soil Descriptions. Toronto, Ontario.

Figure 1. Approximate relationship between infiltration rate and hydraulic conductivity

Based on OMMAH interpolation from Table 2 and Figure 1 above, the measured K_{fs} may be interpolated as:

$$PT_{101} = 48.8 \text{ min / cm} \quad (\text{Infiltration Rate} = 12.3 \text{ mm/hour})$$

$$PT_{106} = 50.8 \text{ min / cm} \quad (\text{Infiltration Rate} = 11.8 \text{ mm/hour})$$

$$PT_{107} = 9.1 \text{ min / cm} \quad (\text{Infiltration Rate} = 66 \text{ mm/hour})$$

$$PT_{112} = 51.3 \text{ min / cm} \quad (\text{Infiltration Rate} = 11.7 \text{ mm/hour})$$

Although the results for three slow soils (BH101, BH106 & BH112) are almost similar with a slight difference (5 percent difference), but when comparing the OMMAH result with that obtained by Reynolds et al. (2015) formula ($PT = 1.43 - 179.8 \text{ min/cm}$), the two methods of conversion are completely different results and it seems that the values of the first method have underestimated the infiltration rate and Perc Time. As per the TRCA Stormwater Management Criteria guideline, the engineer's opinion is to trust to the value obtained from the second method (OMMAH, 1997) which was proposed by TRCA to convert measured hydraulic conductivity to percolation time and/or infiltration rate. Therefore, the engineer's opinion is to trust the values obtained from the second method (OMMAH, 1997), with an unfactored infiltration rate = 11.7-66 mm/hour.

The slower infiltration rates from PT₁₀₁, PT₁₀₆, and PT₁₀₇ may be used as representative of the permeability of the site.

4. Factored Engineering Design Infiltration Rate (Wisconsin Department of Natural Resources, 2004)

For a conservative approach to infiltration speeds, the Wisconsin Department of Natural Resources (2004) method shall be used for the calculation of a factored design infiltration rate. The overall massive soil formation is compacted clay soils, except in the middle part which was loam (ML), with an unfactored infiltration rate = 66 mm/hour in contrast to the rest of the site with an average of 11.9 mm/hour. However, the infiltration rate used to design an infiltration BMP must incorporate a safety correction factor that compensates for potential reductions in soil permeability due to compaction or smearing during construction, gradual accumulation of fine sediments over the lifespan of the BMP and uncertainty in measured values when less permeable soil horizons exist within 1.5 meters below the proposed bottom elevation of the BMP. As discussed above, the predominant soil material of this site is composed of clay (CL) to a depth of more than 3 meters, which has low permeability.

Based on borehole data, the soil layer remains consistent of CL soil types, including the soil layers 1.5 meters below the proposed bottom of the BMP, except in the middle part composed of ML. This means that based on the below Table 3, the measured infiltration rate should be divided by a safety correction factor to calculate the design infiltration rate. Thus the mean infiltration rate measured at the proposed bottom elevation of the BMP is 11.9 mm/hour, and the mean infiltration rate measured in the slowest underlying soil horizon is 4.8 mm/hour, and the ratio of infiltration rates is 2.5.

Table 3. Safety correction factors for calculating design infiltration rates

Ratio of Mean Measured Infiltration Rates ¹	Safety Correction Factor ²
≤ 1	2.5
1.1 to 4.0	3.5
4.1 to 8.0	4.5
8.1 to 16.0	6.5
16.1 or greater	8.5

Source: Wisconsin Department of Natural Resources. 2004. Conservation Practice Standards. Site Evaluation for Stormwater Infiltration (1002). Madison, WI.

Notes:

1. Ratio is determined by dividing the geometric mean measured infiltration rate at the proposed bottom elevation of the BMP by the geometric mean measured infiltration rate of the least permeable soil horizon within 1.5 metres below the proposed bottom elevation of the BMP.
2. The design infiltration rate is calculated by dividing the geometric mean measured infiltration rate at the proposed bottom elevation of the BMP by the safety correction factor.

**Engineering
Technologies
Canada Ltd.**

OWNER'S NAME:

SITE LOCATION: 1401 Scugog Line 6, Port Perry

PID #:

TEST PIT #: BH101

TECHNICIAN: Pincheng Zhao, Young Chong

DATE: 2021/12/13

WEATHER/TEMPERATURE: Sunny, 4-7°C

FIELD PERMEABILITY TEST #:

D – reservoir diameter (cm)	8.25	Soil Texture	Clay
d – well hole diameter (cm)	8.3	Soil Structure	Strongly Compacted
H – height of water in well (cm)	15	α^* (cm-1)	0.01
Depth below ground surface (cm)	38	C – Factor	1.27

[illegible]



WEATHER/TEMPERATURE: Raining, 5°C

D – reservoir diameter (cm)	8.25	Soil Texture	Clay
d – well hole diameter (cm)	8.3	Soil Structure	Strongly Compacted
H – height of water in well (cm)	15	α^* (cm-1)	0.01
Depth below ground surface (cm)	38	C – Factor	1.27

[illegible]



WEATHER/TEMPERATURE: Sunny, 4-7°C

D – reservoir diameter (cm)	8.25	Soil Texture	Loam
d – well hole diameter (cm)	8.3	Soil Structure	Moderate Blocky
H – height of water in well (cm)	15	α* (cm-1)	0.12
Depth below ground surface (cm)	50	C – Factor	1.36

[illegible]



WEATHER/TEMPERATURE: Raining, 5°C

D – reservoir diameter (cm)	8.25	Soil Texture	Clay
d – well hole diameter (cm)	8.3	Soil Structure	Strongly Compacted
H – height of water in well (cm)	15	α^* (cm-1)	0.01
Depth below ground surface (cm)	38	C – Factor	1.27

[illegible]