2597237 Ontario Ltd.

Geotechnical Investigation

Type of Document
Final

Project Name
Proposed Residential Development
6102 Renaud Road
Ottawa, Ontario

Project Number
OTT-00246046-A0

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Date Submitted
August 28, 2019

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Executive Summary

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation recently completed for the proposed new residential development to be located at 6102 Renaud Road in the City of Ottawa, ON. The site location is shown on Figure 1. This work was authorized by Mr. Sael Nemorin of 2597237 Ontario Ltd.

The subject site is approximately 0.6 hectare (1.4 acres) in size and is currently occupied by buildings that will be demolished as part of the proposed development. It is our understanding that the proposed preliminary development plans consist of residential one to two storey wood frame type buildings (with or without basement) and a four-storey apartment building with one underground parking level.

The fieldwork for the geotechnical investigation was undertaken from April 16 to 18, 2018 and consisted of five (5) boreholes (Borehole Nos. 1 to 5) at the locations shown on the Borehole Location Plan, Figure 2. The boreholes were advanced to termination depths from 8.1 m to 11.6 m and dynamic cone refusal depths of 26.1 m and 27.0 m below existing grade. The fieldwork was supervised on a full-time basis by a representative from EXP.

The geotechnical investigation revealed the subsurface soil conditions at the site to comprise of a surficial topsoil layer and pavement structure underlain by fill, silty sand and an extensive compressible marine clay deposit. Groundwater level measurements ranged from 0.4 m to 1.4 m depths (Elevation 76.4 m to 75.4 m).

The subsurface soils are not considered to be liquefiable.

The site is classified as **Class D** for seismic site response in accordance with Table 4.1.8.4.A of the 2012 Ontario Building Code.

The site is underlain by a compressible marine clay prone to consolidation settlement if overstressed by loads imposed on it by site grade raise, foundations and groundwater lowering resulting in settlement of foundations. Based on a review of the engineering properties of the clay, it is considered that the maximum site grade raise may be up to 1.0 m when combined with a one to two storey building with or without a basement, supported by footings founded at a 1.0 m depth below existing grade and designed for a bearing pressure at serviceability limit state (SLS) of 96 kPa and factored geotechnical resistance at ultimate limit state (ULS) of 120 kPa. Settlements of the footings designed for the SLS value above and properly constructed are expected to be within the normally tolerated limits of 25 mm total and 19 mm differential movements.

For the proposed four-storey apartment building with one level underground parking and for other types of residential building configurations requiring higher bearing pressure values than indicated above in combination with a maximum 1.0 m grade raise, the buildings may be supported by footings, raft or pile foundations in combination with soil fill and light weight fill.

Since the bearing values of foundations supported by the marine clay depend on the magnitude of the site grade raise, it is recommended that once the grade raise of the site is known and the grading plan is available, EXP be contacted to provide more detailed foundation recommendations.

For the pile foundation option, an additional geotechnical investigation will be required to determine the depth to bedrock.

The lowest floor slabs of the one- to two-storey buildings with or without basement may be designed on slabs on grade. Perimeter drains for buildings without a basement will not be required provided the floor slab is set at least 150 mm above the final grade. Perimeter drains will be required for buildings with a basement. The need for underfloor drains will have to be assessed during detailed design.

Subsurface basement walls should be designed to resist static lateral earth pressure and dynamic lateral earth pressure during a seismic event.

The excavations at the site may be undertaken as open cut provided they meet the requirements of the Ontario Occupational Health and Safety Act (OHSA). Seepage of water is expected in the excavations and maybe handled by conventional sump-pump techniques. High capacity pumps may be required in zones of persistent seepage.

Based on the geotechnical investigation, the majority of material required for backfilling against subsurface walls, footings and service trenches would have to be imported and should conform to the OPSS requirements of Granular B Type II and Select Subgrade Material (SSM). On-site soils may be used as backfill in landscaped areas.

The pavement structure for light duty traffic areas may consist of 65 mm of asphaltic concrete underlain by 150 mm of OPSS 1010 Granular A base and 450 mm of OPSS 1010 Granular B Type II sub-base. The pavement structure for heavy duty traffic areas may consist of 90 mm of asphaltic concrete underlain by 150 mm of OPSS 1010 Granular A base and 600 mm of OPSS 1010 Granular B Type II sub-base.

Normal Portland cement may be used in the sub-surface concrete at this site. The subsurface soils are considered to be moderately to mildly corrosive to buried steel members/structures. Appropriate measures should be undertaken to protect buried steel elements from corrosion.

Tree planting restrictions and setbacks will require consultation with a landscape architect and should be in accordance with City of Ottawa guidelines and policy.

The above and other related considerations are discussed in greater detail in the main body of this report.

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1 Introduction

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation recently completed for the proposed new residential development to be located at 6102 Renaud Road in the City of Ottawa, Ontario. The site location is shown on Figure 1. This work was authorized by Mr. Sael Nemorin of 2597237 Ontario Ltd. on April 4, 2018.

The subject site is approximately 0.6 hectare (1.4 acres) in size and is currently occupied by buildings that will be demolished as part of the proposed development. It is our understanding that the proposed preliminary development plans consist of residential one to two storey wood frame type buildings (with or without basement) and a four-storey apartment building with one underground parking level.

EXP completed a Phase One Environmental Site Assessment (ESA) of the site and the results are presented in our report dated September 18, 2017. EXP completed a Phase Two ESA of the site and the results are presented in our report dated October 30, 2017.

The geotechnical investigation was undertaken to:

a) Establish the subsurface soil and groundwater conditions at the five (5) boreholes located on site and a review of the subsurface soil and groundwater conditions of boreholes from the Phase Two ESA;

b) Assess the potential for liquefaction of the subsurface soils during a seismic event and classify the site for seismic site response in accordance with the requirements of the 2012 Ontario Building Code (OBC);

c) Comment on grade-raise restrictions;

d) Make recommendations regarding the most suitable type of foundations, founding depth and bearing pressure at serviceability limit state (SLS) and factored geotechnical resistance at ultimate limit state (ULS) of the founding strata and comment on the anticipated total and differential settlements of the recommended foundation type;

e) Discuss slab-on-grade construction and permanent drainage system requirements;

f) Provide lateral earth pressure parameters for subsurface basement wall design;

g) Comment on excavation conditions and de-watering requirements during construction;

h) Provide comments regarding pipe bedding requirements;

i) Discuss backfilling requirements and suitability of on-site soils for backfilling purposes;

j) Comment on subsurface concrete requirements for buried concrete structures/members and corrosion potential of subsurface soils to buried metal structures/members;

k) Recommend pavement structures for the parking lots and access roads; and,

l) Provide recommendations for the planting of trees.

The comments and recommendations given in this report assume that the above-described design concept will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The result of this review may be a modification of

our recommendations or it may require additional field or laboratory work to check whether the changes are acceptable from a geotechnical viewpoint.

2 Phase Two ESA Information

A Phase Two Environmental Site Assessment (ESA) of the site was undertaken by EXP and the results are presented in the report titled, “Phase Two Environmental Site Assessment, 6102 Renaud Road, Ottawa, Ontario” dated October 30, 2017 (EXP Project No. OTT-00246046-A0).

The Phase Two ESA consists of four (4) boreholes located inside and outside the existing buildings on site. The borehole information indicates that below interior concrete slabs, the subsurface soil conditions consist of fill to a 1.8 m depth underlain by native silty clay. The boreholes terminated within the silty clay at 3.7 m to 4.8 m depths. The groundwater levels measured in the monitoring wells installed in the four (4) boreholes ranges from 1.5 m to 1.7 m depths (Elevation 76.9 m to 75.5 m).

3 Site Description

The site is located on the south side of Renaud Road and east of Saddleridge Drive in Ottawa, Ontario. The site is approximately 0.6 hectare (1.4 acres) in size and is occupied by a residential building in the north part and a commercial building in the south part of the site. The surrounding properties consist of residential development. The site location is shown in Figure 1.

Based on the approximate ground surface elevations of the boreholes ranging from Elevation 79.1 m near the front of the property along Renaud Road to Elevation 76.7 m at the rear of the property, the topography of the site is relatively flat.

4 Procedure

The fieldwork for the geotechnical investigation was undertaken from April 16 to 18, 2018 and consisted of five (5) boreholes (Borehole Nos. 1 to 5) at the locations shown on the Borehole Location Plan, Figure 2. The boreholes were advanced to termination depths from 8.1 m to 11.6 m and dynamic cone refusal depths of 26.1 m and 27.0 m below existing grade. The fieldwork was supervised on a full-time basis by a representative from EXP.

The borehole locations and geodetic elevations were estimated from the spot elevations provided on the survey plan titled, "Part of Lot 6, Concession 4 (Ottawa Front) Geographic Township of Gloucester, City of Ottawa", dated September 22, 2017 and prepared by Annis, O'Sullivan, Vollebekk Ltd. (AOV). Therefore, the ground surface elevations indicated on the borehole logs should be considered approximate. The borehole locations were cleared of private and public underground services, prior to the start of drilling operations.

The boreholes were drilled with a CME-55 truck-mounted drill rig equipped with continuous flight hollow-stem auger equipment. Standard penetration tests (ASTM 1586) were performed in all the boreholes at 0.75 m to 3.0 m depth intervals and soil samples retrieved by the split-barrel sampler. Relatively undisturbed thin-walled tube samples (Shelby tube samples) were retrieved at selected depth intervals within the clay. The undrained shear strength of the clay was measured by conducting penetrometer and in-situ vane tests at selected depth intervals. Borehole Nos. 1 and 4 were advanced by conducting dynamic cone penetration test (DCPT) from 10.1 m to cone refusal depth of 27.0 m in Borehole No. 1 and from 19.2 m to cone refusal depth of 26.1 m in Borehole No. 4.

Groundwater levels were measured in the open boreholes upon completion of drilling. In addition, 19 mm diameter slotted standpipes were installed in three boreholes for long-term monitoring of the groundwater levels. The standpipes were installed in accordance with EXP standard practice and their installation configuration is documented on the respective borehole log.

On completion of the fieldwork, all the soil samples were transported to the EXP laboratory located in the City of Ottawa. All the borehole samples were visually examined in the laboratory by a senior geotechnical engineer for textural classification. The engineer also assigned the laboratory testing, which consisted of performing the following tests in accordance with the American Society for Testing and Materials (ASTM).

Natural Moisture Content ..... 48 tests

Natural Unit Weight ..... 10 tests

Grain-Size Analysis ..... 2 tests

Atterberg Limits ..... 4 tests

pH, Sulphate Chlorides and Resistivity Analyses ..... 2 tests

Consolidation Tests ..... 2 tests

5 Subsurface Soil and Groundwater Conditions

A detailed description of the subsurface soil and groundwater conditions determined from the boreholes are given on the attached borehole logs, Figure Nos. 3 to 7.

The borehole logs and related information depict subsurface conditions only at the specific locations and times indicated. Subsurface conditions and water levels at other locations may differ from conditions at the locations where sampling was conducted. The passage of time also may result in changes in the conditions interpreted to exist at the locations where sampling was conducted. Boreholes were drilled to provide representation of subsurface conditions as part of a geotechnical exploration program and are not intended to provide evidence of potential environmental conditions.

It should be noted that the soil boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The “Notes on Sample Descriptions” preceding the borehole logs form an integral part of this report and should be read in conjunction with this report.

A review of the borehole logs indicates the following soil stratigraphy with depth and groundwater level measurements.

5.1 Topsoil

A 50 mm thick surficial topsoil layer was contacted in Borehole Nos. 3 and 4.

5.2 Pavement Structure

Borehole No. 1 is located within the existing paved driveway. The pavement structure consists of 50 mm thick asphaltic concrete underlain by 150 mm thick crushed limestone gravel layer.

5.3 Fill

Fill was surficially encountered in Borehole Nos. 2 and 5 and below the topsoil in Borehole Nos. 3 and 4. The fill extends to depths of 0.7 m and 0.9 m (Elevation 76.8 m to 76.0 m). The fill consists of a mixture of gravel, silty sand with topsoil, roots, rootlets and wood debris (Borehole No. 5). Based on the N-values of 4 to 21 from the Standard Penetration Test (SPT), the fill is in a loose to compact state. The natural moisture content of the fill is 15 percent to 27 percent.

5.4 Silty Sand

The fill in Borehole No. 1 is underlain by silty sand to a 2.2 m depth (Elevation 76.9 m). Based on N-values of 8 and 13 from the SPT, the silty sand is in a loose to compact state. The natural moisture content of the silty sand ranges from 18 percent to 27 percent.

The results of the grain-size analysis of one (1) sample of the silty sand is summarized in Table I. The grain-size distribution curve is shown in Figure 8.

Table I: Summary of Results from Grain-size Analysis – Silty Sand Sample				
Borehole - Sample No.	Depth (Elevation) (m)	Grain Size Analysis (%)		
		Gravel	Sand	Fines (Silt and Clay)
BH 1 - SS3	1.5 – 2.1 (77.6 – 77.0)	0	80	20

Based on a review of the results from the grain-size analysis, the soil may be described as a silty sand (SM) in accordance with the Unified Soil Classification System (USCS).

5.5 Clay

Sensitive marine clay was contacted beneath the fill and silty sand at 0.7 m to 0.9 m depths (Elevation 76.8 m to 76.0 m) in the five (5) boreholes. The clay consists of an upper desiccated brown crust underlain by grey clay.

5.5.1 *Brown Clay (Desiccated Crust)*

The brown clay crust was contacted in Borehole Nos. 2 to 5 and was not present in Borehole No. 1. The upper crust extends to depths ranging from 2.1 to 3.0 m (Elevation 75.3 m to 74.2 m). The clay crust is approximately 1.4 m to 2.1 m thick. The undrained shear strength of the crust is 82 kPa to 192 kPa indicating a stiff to very stiff consistency. The sensitivity values of the clay are 4.9 and 7.2, indicating the sensitivity of the clay may be described as sensitive. The natural moisture content and unit weight of the crust are 23 percent to 60 percent and 16.9 kN/m^3 to 19.0 kN/m^3 respectively. Grain-size analysis and Atterberg limit determination of two (2) samples of the brown clay crust are summarized in Tables II and III. The grain-size distribution curve is shown in Figure 9.

Table II: Summary of Results from Grain-size Analysis – Brown Clay Sample				
Borehole No. - Sample No.	Depth (Elevation) (m)	Grain Size Analysis (%)		
		Gravel	Sand	Fines (Silt and Clay)
BH2 – SS2	0.8 – 1.4 (76.7 – 76.1)	0	2	98

Table III: Summary of Atterberg Limit Results – Brown Clay Sample					
Borehole No. - Sample No.	Depth (Elevation) (m)	Atterberg Limit Results (%)			
		w_n	LL	PL	PI
BH4 – SS2	0.8 – 1.4 (75.9 – 75.3)	45	72	29	43
W_n: Natural Moisture Content; **LL**: Liquid Limit; **PL:** Plastic Limit; **PI**: Plasticity Index (1): Refer to Casagrande Plasticity Chart (1932).					

Based on a review of the results from the grain-size analysis and the Atterberg limits, the soil may be classified as a high plastic clay (CH), in accordance with the Unified Soil Classification System (USCS).

5.5.2 *Grey Clay*

The silty sand in Borehole No. 1 and the brown clay crust in Borehole Nos. 2 to 5 are underlain by the grey clay contacted at 2.1 m to 3.0 m depths (Elevation 76.9 m to 74.2 m). The undrained shear strength of the clay ranges from 29 kPa to 86 kPa with one measurement of 115 kPa at 14.6 m (Elevation 62.1 m) in Borehole No. 4. The grey clay has a weaker zone in the upper 1.0 m in Borehole Nos. 2 and 3, as indicated by the lowest measured undrained shear strength values of 29 kPa and 34 kPa. Based on the undrained shear strength measurements, the clay has a firm to stiff consistency with a very stiff zone at 14.6 m depth (Elevation 62.1 m) in Borehole No. 4. The sensitivity values of 4.6 to 18 indicate the clay has a sensitivity that may be described a sensitive to quick. The silty clay has a moisture content of 35 percent to 88 percent and a natural unit weight measured from one sample of 17.9 kN/m^3.

Atterberg limit values of the clay are summarized in Table IV.

Table IV: Summary of Atterberg Limit Results – Grey Clay Samples					
Borehole No. - Sample No.	Depth (Elevation) (m)	Atterberg Limit Results (%)			
		w_n	LL	PL	PI
BH3 – SS6	3.8 – 4.4 (73.6 – 72.4)	82	59	27	32
BH4 – SS8	6.1 – 6.7 (70.6 – 70.0)	78	59	25	34
BH4 – SS11	10.7 – 11.3 (66.0 – 65.4)	76	60	30	30
W_n: Natural Moisture Content; **LL**: Liquid Limit; **PL:** Plastic Limit; **PI**: Plasticity Index (1): Refer to Casagrande Plasticity Chart (1932).					

Based on a review of the results from the Atterberg limits, the soil may be classified as a high plastic clay (CH), in accordance with the USCS.

One-dimensional oedometer (consolidation) test was conducted on two (2) thin walled tube samples of the grey clay and the results are summarized in Table V. The stress versus void ratio curves are shown in Figures 10 and 11.

Table V: One-Dimensional Oedometer (Consolidation) Test Results on Grey Clay Samples										
Borehole - Sample No.	**Depth (Elevation) (m)**	**σ'_{v0} (kPa)**	**w_c (%)**	**γ (kN/m^3)**	**σ'_p (kPa)**	**e_o**	**c_r**	**c_c**	**OCR**	**OC**
BH 1-ST8	6.1-6.7 (73.0 – 72.4)	68	84	14.9	150	2.322	0.037	2.80	2.2	82
BH 5-ST6	3.8-4.4 (73.4 – 72.8)	47	81	15.1	110	2.229	0.034	2.66	2.3	63

σ'_{v0} = estimated effective overburden pressure (kPa); w_c: natural moisture content (%), γ: estimated natural unit weight (kN/m^3) σ'_p = pre-consolidation pressure (kPa), e_o = initial void ratio; c_r = re-compression index; c_c = compression index; OCR = Over consolidation ratio; OC= over-consolidation pressure (kPa);

(1) - estimated σ'_{v0} based on May 7, 2018 groundwater level measurements.

Based on a review of the consolidation test results, the over consolidation ratio is 2.2 and 2.3 indicating the clay is over consolidated.

5.6 Inferred Boulders and Bedrock

Boulders within glacial till and bedrock are inferred at cone refusal depths of 26.1 m and 27.0 m (Elevation 52.1 m and 50.6 m) in Borehole Nos. 1 and 4. Review of published geology maps indicate the bedrock is limestone of the Ottawa formation.

5.7 Groundwater

The groundwater level measurements taken several days following the completion of drilling in the standpipes installed in selected boreholes are summarized in Table VI.

Table VI: Summary of Groundwater Levels in Boreholes					
Borehole No.	**Ground Surface Elevation (m)**	**Drill Date**	**Date of Groundwater Level Measurement (Number of Days After Drilling)**	**Depth of Groundwater Level Below Ground Surface (m)**	**Elevation of Groundwater Level (m)**
3	76.81	April 17, 2018	May 7, 2018 (20 days)	0.4	76.4
4	76.67	April 17, 2018	May 7, 2018 (20 days)	1.3	75.4
5	77.18	April 18, 2018	May 7, 2018 (19 days)	1.4	75.8

A review of Table VI indicates that the groundwater level ranges from 0.4 m to 1.4 m depths (Elevation 76.4 m to 75.4 m).

Water levels were determined in the boreholes at the times and under the conditions stated in the scope of services. Note that fluctuations in the level of groundwater may occur due to a seasonal variation such as

precipitation, snowmelt, rainfall activities, and other factors not evident at the time of measurement and therefore may be at a higher level during wet weather periods.

6 Liquefaction Potential and Seismic Site Classification

6.1 Liquefaction Potential

Based on the findings from this geotechnical investigation, it is recommended the proposed buildings be supported by footings founded on the compact zone of the silty sand and on the stiff to very stiff clay.

The compact zone of the silty sand is not considered liquefiable.

As indicated in Section 5.5 of this report, the liquid limit of the brown and grey silty clay from four (4) tested samples ranges from 59 percent to 72 percent and the plasticity index ranges from 30 percent to 43 percent. Based on the results of the Atterberg limits and natural moisture contents, the brown and grey clay are not susceptible to liquefaction during a seismic event as per Bray et. al. (2004) criteria for fine-grained soils, shown in Figure 12.

6.2 Seismic Site Classification

The subsoil information at this site has been examined in relation to Section 4.1.8.4 of the 2012 Ontario Building Code (OBC). The average shear-wave velocity value of the clay, inferred glacial till and bedrock to a 30-m depth was estimated.

The shear-wave velocity value of the clay deposit was correlated to the undrained shear strength values (Su) using the Dickenson, S.E. (1994)[1] formula:

$$Vs(m/s) = 23.Su^{0.475}$$

The shear-wave velocity value of the inferred glacial till was correlated to the standard penetration test values using Imai and Tonouchi2 (1982) formula:

$$Vs(m/s) = 91.7\ N^{0.26}$$

The shear-wave velocity of the inferred bedrock was assumed as 360 m/s.

The average shear-wave velocity to 30 m depth was estimated at 221 m/s. On this basis, the site may be classified as Class D for seismic site response in accordance with Table 4.1.8.4 A of the 2012 OBC.

[1] Dickenson, S.E. (1994), "Dynamic Response of Soft and Deep Cohesive Soils during the Loma Prieta Earthquake".
2 Imai, T, and K Tonouchi (1982). Correlation of N value with S-wave velocity and shear modulus, Proc., 2nd European Symp. on Penetration Testing, Amsterdam, pp. 67–72.

7 Grade Raise Restrictions

The site is underlain by a sensitive marine clay deposit consisting of a brown clay crust of limited thickness underlain by a grey clay which weakens with depth to a minimum value and thereafter increases with depth. The marine clay deposit is prone to consolidation settlement if overstressed by loads imposed on it by site grade raise, foundations, and by groundwater level lowering following construction. Overstressing of the clay stratum may result in its consolidation and subsequent settlement of foundations, which may exceed the tolerable limits of the structure resulting in cracking of the structure.

Based on a review of the engineering properties of the clay, it is considered that the site grade raise may be 1.0 m in conjunction with the footings designed as per Section 9 of this report. An allowance for groundwater lowering was not required as part of the review, since the proposed footings will be at or above the measured groundwater level in the clay and measures are employed in new service trenches to minimize the permanent lowering of the groundwater level at the site (use of clay seals), as recommended in Sections 12 and 14.

8 Site Grading Operations

As part of the site preparation, the site grading within the footprint of the proposed buildings and paved areas should consist of the excavation and removal of all topsoil, paved surfaces, fill and any organic stained soils from the site. Any soft/loose areas identified in the interior of the building footprint should be excavated and replaced with Ontario Provincial Standard Specification (OPSS 1010 as amended by SSP110S13) Granular B Type II compacted to 98 percent standard Proctor maximum dry density (SPMDD).

It may be possible to leave some of the existing fill and silty sand in-place in the parking lot/access road areas, pending further evaluation in the field during construction and acceptability from an environmental perspective. For budgeting purposes, the contractor should assume that all the existing fill material will be required to be removed and replaced with imported granular material from the area of the proposed building and parking lot/access road areas.

Following approval of the exposed subgrade, the grades beneath the floor slabs may be raised to the underside of the 300 mm thick clear stone layer, by the placement of engineered fill consisting of OPSS 1010 Granular B Type II placed in 300 mm thick lifts and each lift compacted to 98 percent of the SPMDD.

For the proposed parking and access road areas, the site grades may be raised to the design subgrade level by the placement of OPSS 1010 select subgrade material (SSM) compacted to 95 percent of the SPMDD.

In-place density tests should be performed on each lift of placed material to ensure that it has been compacted to the project specifications.

9 Foundation Considerations

The investigation has revealed that for the maximum permissible grade raise of 1.0 m, the geotechnical conditions at the site are suitable for the construction of residential one- to two-storey wood-frame type structures with or without a basement supported by conventional strip and spread footings designed for the limit state bearing pressure values indicated below.

For the proposed four-storey apartment building with one level underground parking and other types of residential building configurations requiring higher bearing pressure values than indicated below in combination with a maximum 1.0 m grade raise, the buildings may be supported by footings, raft or pile foundations in combination with soil fill and light weight fill.

Since the bearing values of foundations supported by the marine clay depend on the magnitude of the site grade raise, it is recommended that once the grade raise of the site is known and the grading plan is available, EXP be contacted to provide more detailed foundation recommendations.

For the pile foundation option, an additional geotechnical investigation will be required to determine the depth to bedrock.

9.1 Footings

The one- to two-storey wood-frame type buildings with a basement and 1.0 m grade raise may be supported by maximum 1.0 m wide strip and 3 m by 3 m square pad footings founded on the compact zone of the silty sand and stiff to very stiff clay at a maximum depth of 1.0 m below existing grade and designed for a bearing pressure at serviceability limit state (SLS) of 96 kPa and a factored geotechnical resistance at ultimate limit state (ULS) of 120 kPa. The factored ULS value includes a resistance factor of 0.5 in accordance with the 2006 Canadian Foundation Engineering Manual (CFEM). The above SLS value is considered valid, provided the site grade raise of 1.0 m is respected.

Settlements of the footings designed for the SLS value above and properly constructed are expected to be within the normally tolerated limits of 25 mm total and 19 mm differential movements.

In areas where the founding soil is the silty sand (Borehole No. 1), the footing excavation will need to extend to the compact zone of the silty sand contacted at approximately 1.8 m depth (Elevation 77.3 m). The sub-excavated area may be backfilled with lean concrete or engineered fill compacted to 100 percent SPMDD.

The footings should be kept at the maximum 1.0 m depth below existing grade, to minimize overstressing the weaker zone of the underlying grey clay and excavations below the measured groundwater level.

All the footing beds should be examined by a geotechnical engineer to ensure that the founding surfaces are capable of supporting the design bearing pressure at SLS and that the footing beds have been properly prepared.

A minimum of 1.5 m of earth cover should be provided to the exterior foundations of heated structures to protect them from damage due to frost penetration. The frost cover should be increased to 2.1 m for unheated structures if snow will not be removed from their vicinity and to 2.4 m if snow will be removed

from the vicinity of the structure. When earth cover is less than the minimum required, an equivalent combination of earth cover and rigid insulation (such as Styrofoam HI-40) or rigid insulation alone should be provided. EXP can provide additional comments in this regard, if required.

The footings should be reinforced, and nominal reinforcing steel should be provided in the basement walls to minimize cracking. For guidance, the reinforcement in the basement walls may consist of a minimum of two upper and two lower 15M-size reinforcing bar sizes. The required reinforcing detail for the footings and basement walls will need to be determined by the structural engineer.

It should be noted that the surface of the clay is susceptible to disturbance due to movement of workers and construction equipment especially if the excavations are undertaken during wet weather periods. It is therefore considered that depending on the weather conditions prevailing at the time of construction, footing beds may have to be covered with a mud slab to prevent disturbance to the clay subgrade.

The depth to the native silty sand and clay may vary from that indicated on the borehole logs due to the presence of the existing buildings on site. For example, the fill thickness and depth to native silty sand and clay may be deeper than shown on the borehole logs at locations close to and/or within the footprint of existing buildings and underground service trenches. The boreholes from the Phase Two ESA indicate the fill extends to 1.8 m depth below existing grade. Therefore, it is recommended that once the existing buildings have been demolished and foundations, foundation walls and floor slabs have been removed, additional boreholes be undertaken within the footprints of the existing buildings to determine the subsurface conditions, suitable founding soil conditions and depths for footings, the groundwater level, bearing pressure at SLS and factored geotechnical resistance at ULS, excavation and dewatering requirements.

9.2 General Comment

The recommended bearing pressure at SLS and factored geotechnical resistances at ULS have been calculated by EXP from the borehole information for the design stage only. The investigation and comments are necessarily on-going as new information of underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field monitoring provided by an experienced geotechnical engineer to validate the information for use during the construction stage.

10 Floor Slab and Drainage Requirements

The floor slabs of the buildings may be constructed as slabs-on-grade provided they are set on a bed of well-packed 19 mm clear stone at least 300 mm thick placed on native soil or on well compacted engineered fill prepared as indicated in Section 8 of the report. The clear stone would prevent the capillary rise of moisture from the sub-soil to the floor slab. Adequate saw cuts should be provided in the floor slabs to control cracking.

Perimeter drains are not required for buildings with no basement, provided the floor slab is set at least 150 mm higher than the surrounding finished grade. For buildings with a basement, perimeter drains will be required as discussed in Section 11.

The need for underfloor drains for buildings with and without basements will have to be assessed once the slab elevation is available and compared with the elevation of the prevailing groundwater level.

The finished exterior grade should be sloped away from the buildings at an inclination of at least two percent to prevent ponding of surface water close to the exterior walls.

11 Subsurface Walls

The subsurface basement walls should be backfilled with free draining material, such as OPSS 1010 Granular B Type II and equipped with a perimeter drainage system to prevent the buildup of hydrostatic pressure behind the walls. The walls will be subjected to lateral static and dynamic (seismic) earth forces. The expressions below assume free draining backfill material, a perimeter drainage system, level backfill surface behind the wall and vertical face on the back side of the wall.

For design purposes, the lateral static earth thrust against the subsurface walls may be computed from the following equation:

$$P = K_0 h (\tfrac{1}{2} \gamma h + q)$$

where P = lateral earth thrust acting on the subsurface wall; kN/m

K_0 = lateral earth pressure coefficient for 'at rest' condition for Granular B Type II backfill material = 0.50

γ = unit weight of free draining granular backfill; Granular B Type II = 22 kN/m^3

h = depth of point of interest below top of backfill, m

q = surcharge load, kPa

The lateral seismic thrust may be computed from the equation given below:

$$\Delta P_e = \gamma H^2 \frac{a_h}{g} F_b$$

where ΔP_e = dynamic thrust in kN/m of wall

H = height of wall, m

γ = unit weight of backfill material = 22 kN/m^3

$\frac{a_h}{g}$ = seismic coefficient = 0.309 (refer to 2015 National Building Code Seismic Hazard Calculation shown in Appendix A)

F_b = thrust factor = 1.0

The dynamic thrust does not take into account the surcharge load. The resultant force acts approximately at 0.63H above the base of the wall.

All subsurface basement walls should be properly damp-proofed.

12 Pipe Bedding Requirements

It is recommended that the bedding for the underground services including material specifications, thickness of cover material and compaction requirements conform to City of Ottawa requirements and/or Ontario Provincial Standard Specification and Drawings (OPSS and OPSD).

Due to the presence of the sand and clay and high groundwater level, it is recommended the pipe bedding consist of 300 mm thick OPSS 1010 Granular B Type II sub-bedding material overlain by 150 mm thick OPSS 1010 Granular A bedding material. The bedding materials should be compacted to at least 95 percent SPMDD.

The bedding thickness may be further increased in areas where the sand and clay subgrade become disturbed. Trench base stabilization techniques, such as removal of loose/soft material, placement of crushed stone sub-bedding (Granular B Type II), completely wrapped in a non-woven geotextile, may also be used if trench base disturbance becomes a problem in wet or soft areas.

If the backfill for the service trenches will consist of granular fill, clay seals should be installed in the service trenches at select intervals as per City of Ottawa Drawing No. S8. The seals should be 1 m wide, extend over the entire trench width and from the bottom of the trench to the underside of the pavement structure. The clay should be compacted to 95 percent SPMDD. The purpose of the clay seals is to prevent the permanent lowering of the groundwater level.

13 Excavations and De-Watering Requirements

13.1 Excavations

Excavations for the construction of the proposed structures and installation of the underground services assuming a site grade raise of 1.0 m are anticipated to extend to a 2.0 m depth below existing grade. The excavations are expected to extend through the silty sand and into the clay. The excavations are anticipated to be up to 1.6 m below the groundwater level.

Upon completion of the demolition and removal of the existing buildings and their floor slabs, foundation walls and footings, the soils at the site may be excavated with conventional mechanical equipment capable of removing possible debris within the existing fill.

The excavations at the site may be undertaken as open cut provided they meet the requirements of the Ontario Occupational Health and Safety Act (OHSA). The overall soils are classified as Type 3 and must be cut back at 1H:1V from the bottom of the excavation. For excavations that extend below the groundwater level, the side slopes should be cut back at 2H:1V to H:1V from the bottom of the excavation. If space restrictions prevent open cut excavations, such as for underground service trenches, the excavations may be undertaken within the confines of a prefabricated support system (trench box) or engineered support system designed and installed in accordance with the above noted regulation.

Excavations up to a 2.0 m depth below existing grade are not expected to experience base-heave type failure.

The silty sand and clay stratum at the site are susceptible to disturbance due to the movement of construction equipment, and personnel on its surface. It is therefore recommended that the excavation at the site should be undertaken by equipment that does not travel on the excavated surface, such as a gradall or mechanical shovel. It is anticipated that temporary granular roads may be required to gain access to the site.

Many geologic materials deteriorate rapidly upon exposure to meteorological elements. Unless otherwise specifically indicated in this report, walls and floors of excavations must be protected from moisture, desiccation, and frost action throughout the course of construction.

13.2 De-Watering Requirements

Seepage of the surface and subsurface water into the excavations is anticipated. However, it should be possible to collect water entering the excavations at low points and to remove it by conventional pumping techniques. In areas of high infiltration or in areas where more permeable soil layers may exist (such as the silty sand) a higher seepage rate should be anticipated. Therefore, the need for high capacity pumps to keep the excavation dry should not be ignored.

It has been assumed that the maximum excavation depth at the site will be approximately 2.0 m and would necessitate groundwater removal from the site. It is noteworthy to mention that new legislation came into force in Ontario on March 29, 2016 to regulate groundwater takings for construction dewatering purposes. Prior to March 29, 2016, a Category 2 Permit to Take Water (PTTW) was required from the Ontario Ministry

of the Environment and Climate Change (MOECC) for groundwater takings related to construction dewatering, where taking volumes in excess of 50 m^3/day, but less than 400 m^3/day, and the taking duration was no more than 30 consecutive days. The new legislation replaces the Category 2 PTTW for construction dewatering with a new process under the Environmental Activity and Sector Registry (EASR). The EASR is an on-line registry, which allows persons engaged in prescribed activities, such as water takings, to register with the MOECC instead of applying for a PTTW.

To be eligible for the new EASR process, the construction dewatering taking must be less than 400 m^3/day under normal conditions. The water taking can be groundwater, storm water, or a combination of both. It should be noted that the 30-consecutive day limit on the water taking under the old Category 2 PTTW process has been removed in the new EASR process. Also, it should be noted that the EASR process requires two technical studies be prepared by a Qualified Person, prior to any water taking. These studies include a Water Taking Report, which provides assurance that the taking will not cause any unacceptable impacts, and a Discharge Plan, which provides assurance that the discharge will not result in any adverse impacts to the environment. A significant advantage of the new EASR process over the former Category 2 PTTW process, is that the groundwater taking may begin immediately after completing the on-line registration of the taking and paying the applicable fee, assuming the accompanying technical studies have been completed. The former PTTW process typically took more than 90 days, which had the potential to impact construction schedules. EXP can provide assistance during the EASR/PTTW process, if required.

Although this investigation has estimated the groundwater levels at the time of the fieldwork, and commented on dewatering and general construction problems, conditions may be present which are difficult to establish from standard boring and excavating techniques and which may affect the type and nature of dewatering procedures used by the contractor in practice. These conditions include local and seasonal fluctuations in the groundwater table, erratic changes in the soil profile, thin layers of soil with large or small permeabilities compared with the soil mass, etc. Only carefully controlled tests using pumped wells and observation wells will yield the quantitative data on groundwater volumes and pressures that are necessary to adequately engineer construction dewatering systems.

14 Backfilling Requirements and Suitability of On-Site Soils for Backfilling Purposes

The on-site soils to be excavated are anticipated to consist of a granular fill, silty sand, brown clay (desiccated crust) and grey clay. Select portions of the granular fill, silty sand and brown clay (desiccated crust) from above the groundwater level may be used in service trenches outside the building area, subject to further examination and testing during the early stages of construction. These soils are moisture sensitive and should be protected from the effects of weather if stockpiled on site. The brown and grey clay below the groundwater level are considered too wet to achieve the required degree of compaction. Therefore, these soils may be used for general grading purposes in landscaped areas, provided the moisture content of these soils is lowered by air-drying in the sun.

It is anticipated that the majority of the material required for backfilling purposes or as subgrade fill for the project would have to be imported and should preferably conform to the following specification:

- Engineered fill under slabs-on-grade - OPSS 1010 Granular B Type II placed in 300 mm thick lifts and each lift compacted to 98 percent of the SPMDD.
- Backfill in services trenches inside buildings – OPSS 1010 Granular B Type II placed in 300 mm thick lifts and each lift compacted to 98 percent of the SPMDD.
- Trench backfill and subgrade fill in parking area and access roadways – OPSS 1010 Select Subgrade Material (SSM) placed in 300 mm thick lifts and each lift compacted to 95 percent of the SPMDD. To minimize settlement of the pavement structure over services trenches, the trench backfill material within the frost zone should match the existing material along the trench walls to minimize differential frost heaving of the subgrade soil, provided this material is compactible. Other wise, frost tapers may be required.

As previously indicated, if the backfill for the service trenches will consist of granular fill, clay seals should be installed in the service trenches at select intervals as per City of Ottawa Drawing No. S8. The seals should be 1 m wide, extend over the entire trench width and from the bottom of the trench to the underside of the pavement structure. The clay should be compacted to 95 percent SPMDD. The purpose of the clay seals is to minimize the permanent lowering of the groundwater level.

15 Pavement Structures

Pavement structures for the surface parking areas and access roads are given on Table VII below for the anticipated engineered fill subgrade used to raise the site grades and for the native silty sand and clay subgrades. The pavement structures are based upon the assumption that the subgrade will be properly prepared and assumes a functional design life of 15 to 18 years. The proposed functional design life represents the number of years to the first rehabilitation, assuming regular maintenance is carried out.

Table VII: Recommended Pavement Structure Thicknesses

Pavement Layer	Compaction Requirements	Computed Pavement Structure	
		Light Duty Traffic (Parking Lots - Cars Only)	Heavy Duty (Parking Lots and Access Roads)
Asphaltic Concrete (PG 58-34)	92-97% MRD	65 mm HL3/SP12.5 mm/ Cat.B	40 mm HL3/SP12.5 Cat. B 50 mm HL8/SP 19 Cat. B
OPSS 1010 Granular A Base (crushed limestone)	100% SPMDD	150 mm	150 mm
OPSS 1010 Granular B Type II Sub-base	100% SPMDD	450 mm	600 mm

Notes:

1. SPMDD denotes standard Proctor maximum dry density, ASTM, D-698-12e2.
2. MRD denotes Maximum Relative Density, ASTM D2041.

The upper 300 mm of the subgrade fill must be compacted to 98% SPMDD.

Additional comments on the construction of the parking lot and access roads are as follows:

1. As part of the subgrade preparation, the proposed parking areas and access roads should be stripped of topsoil and other obviously unsuitable material. Fill required to raise the grades to design elevations should conform to requirement as per Section 8 and should be placed and compacted to 95 percent of the SPMDD. The subgrade should be properly shaped, crowned, then proofrolled with a heavy vibratory roller in the full-time presence of a representative of this office. Any soft or spongy subgrade areas detected should be sub excavated and properly replaced with suitable approved backfill compacted to 95 percent SPMDD (ASTM D698-12e2).
2. The long-term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure that uniform subgrade moisture and density conditions are achieved. The need for adequate drainage cannot be over-emphasized. Subdrains should be installed on both sides of the access road(s). Subdrains must be installed in the proposed parking area at low points and should be continuous between catchbasins to intercept excess surface and subsurface moisture and to prevent subgrade softening. This will ensure no water collects in the granular course, which could result in pavement failure during the spring thaw. The location and extent of subdrains required within the paved areas should be reviewed by this office in conjunction with the proposed site grading.

3. To minimize the problems of differential movement between the pavement and catchbasins/manhole due to frost action, the backfill around the structures should consist of free-draining granular preferably conforming to OPSS Granular B Type II material. Weep holes should be provided in the catchbasins/manholes to facilitate drainage of any water that may accumulate in the granular fill.
4. The most severe loading conditions on light-duty pavement areas and the subgrade may occur during construction. Consequently, special provisions such as restricted lanes, half-loads during paving, temporary construction roadways, etc., may be required, especially if construction is carried out during unfavorable weather.
5. The finished pavement surface should be free of depressions and should be sloped (preferably at a minimum cross fall of 2 percent) to provide effective surface drainage towards catch basins. Surface water should not be allowed to pond adjacent to the outside edges of paved areas.
6. Relatively weaker subgrade may develop over service trenches at subgrade level. These areas may require the use of thicker/coarser sub-base material and the use of a geotextile at the subgrade level. If this is the case, it is recommended that additional 150 mm of granular sub-base, OPSS Granular B Type II, should be provided in these areas, in addition to the use of a geotextile at the subgrade level.
7. The granular materials used for pavement construction should conform to Ontario Provincial Standard Specifications (OPSS 1010) for Granular A and Granular B Type II and should be compacted to 100 percent of the SPMDD.

The asphaltic concrete used and its placement should meet OPSS 1150 or 1151 requirements. It should be compacted from 92 percent to 97 percent of the MRD (ASTM D2041). Asphalt placement should be in accordance with OPSS 310 and OPSS 313.

It is recommended that EXP be retained to review the final pavement structure design and drainage plans prior to construction to ensure they are consistent with the recommendations of this report.

16 Corrosion Potential of Subsurface Soils

Chemical tests limited to pH, sulphate, chloride and resistivity tests were performed on two (2) selected soil samples. The results are shown on Table No. VIII. The Certificate of Analysis is included in Appendix B.

Table VIII: Results of pH, Sulphate, Chloride and Resistivity Tests on Soil Samples

Borehole No. - Sample No.	Depth (Elevation) (m)	Soil	pH	Sulphate (%)	Chloride Content (%)	Resistivity (ohm-cm)
			<5	>0.1 %	>0.04 %	
BH 1 – SS4	2.3 – 2.9 (76.8 – 76.2)	Grey Clay	7.54	0.0025	0.0051	6170
BH 4 – SS3	1.5 – 2.1 (75.2 – 74.6)	Brown Clay	7.05	0.0122	0.0054	4270

The results indicate a soil with a sulphate content of less than 0.1 percent. This concentration of sulphate in the soil would have a negligible potential of sulphate attack on subsurface concrete. The concrete should be designed in accordance with CSA A.23.1-14. However, the concrete should be dense, well compacted and cured.

The results of the resistivity tests indicate that the soil is moderately to mildly corrosive to buried steel elements. Appropriate measures should be undertaken to protect buried steel elements from corrosion.

17 Tree Planting Restrictions

The brown clay crust extends to depths ranging from 2.1 m to 3.0 m (Elevation 75.3 m to 74.2 m) in Borehole Nos. 2 to 5.

Based on the City of Ottawa document titled, “Tree Planting in Sensitive Marine Clay Soils – 2017 Guidelines,” the modified plasticity index of the brown clay was estimated at 43 percent indicating the brown clay crust has a high potential for soil volume change.

The grey clay was contacted beneath the silty sand in Borehole No. 1. The modified plasticity index of the grey clay is estimated at 32 percent indicating the grey clay has a medium potential for soil volume change.

In accordance with the above referenced 2017 guidelines, for high potential volume change soil types, the tree planting restrictions and setbacks from structures should follow the 2005 clay soil policy.

For medium potential volume change soil types, the tree planting restrictions and setbacks from structures should follow the above noted 2017 guidelines.

A landscape architect should be consulted to ensure the applicable tree planting restrictions and setbacks for the development of this site are in accordance with the applicable City of Ottawa guideline and policy.

18 Additional Comment

The depth to the native silty sand and clay may vary from that indicated on the borehole logs due to presence of the existing buildings on site. For example, the fill thickness and depth to native silty sand and clay may be deeper than shown on the borehole logs at locations close to and/or within the footprint of existing buildings and underground service trenches. The boreholes from the Phase Two ESA indicate the fill extends to 1.8 m depth below existing grade. Therefore, it is recommended that once the existing buildings have been demolished and foundations, foundation walls and floor slabs have been removed, additional boreholes be undertaken within the footprints of the existing buildings to determine the subsurface conditions, suitable founding soil conditions and depths for footings, the groundwater level, bearing pressure at SLS and factored geotechnical resistance at ULS, excavation and dewatering requirements.

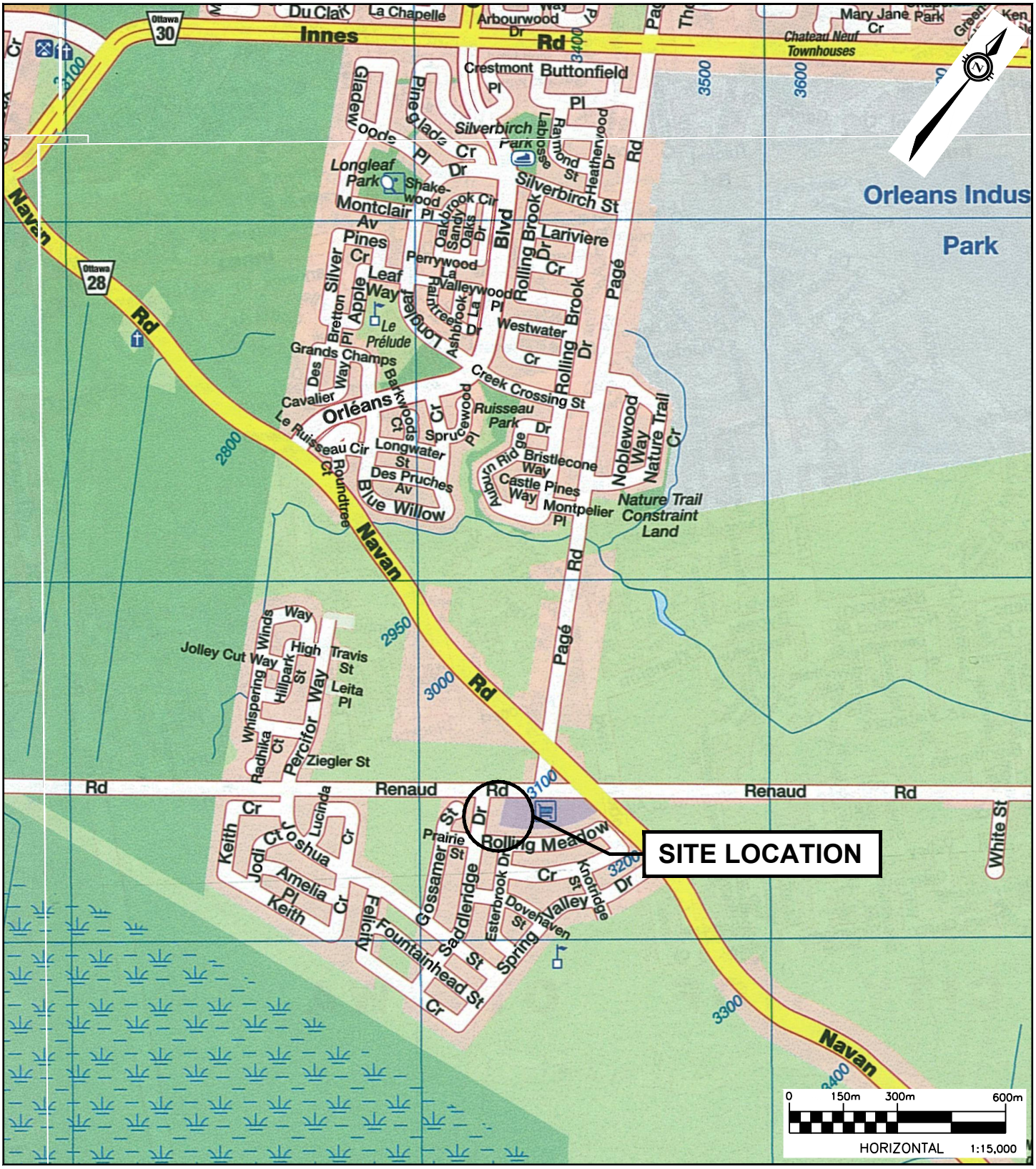
19 General Comments

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

The information contained in this report is not intended to reflect on environmental aspects of the soils. Reference is made to the Phase One and Two ESA reports regarding the environmental aspects of the soils.

We trust that the information contained in this report will be satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Figures



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scale 1:15 000	PROJECT: 2597237 ONTARIO LTD. 6102 RENAUD ROAD, OTTAWA, ON	project no. OTT-00246046-A0
date MAY 2018		design S.P. / checked I.T.
drawn by J.R.	TITLE: SITE LOCATION PLAN	FIG 1

Filename: r:\240000\246000\246046-a0 6102 renaud rd\246046-ge.dwg
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Last Plotted: 5/8/2018 9:42:16 AM
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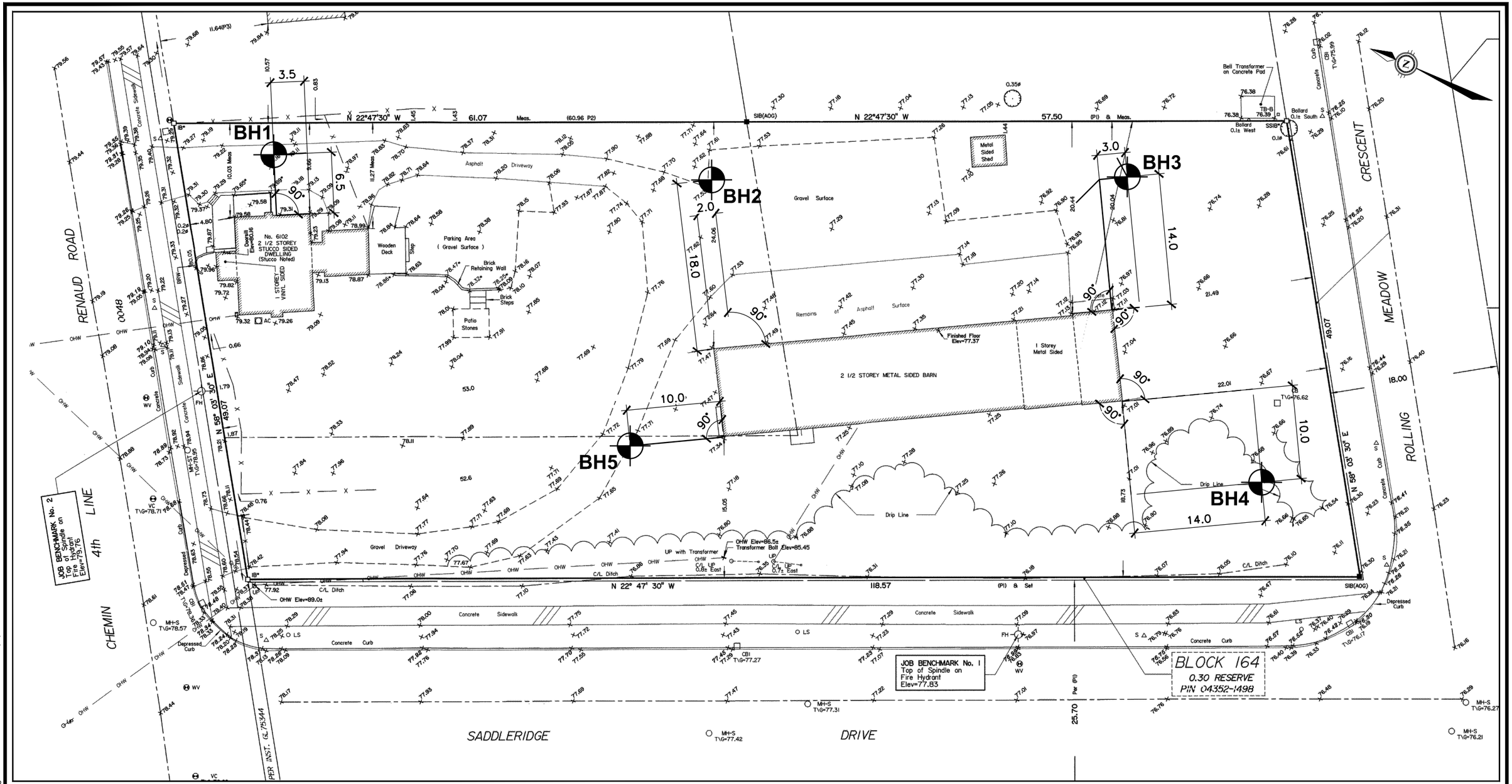

NOTES :

1. THE BOUNDARIES AND SOIL TYPES HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES THEY ARE ASSUMED AND MAY BE SUBJECT TO CONSIDERABLE ERROR.
2. SOIL SAMPLES WILL BE RETAINED IN STORAGE FOR THREE MONTHS AND THEN DESTROYED UNLESS THE CLIENT ADVISES THAT AN EXTENDED TIME PERIOD IS REQUIRED.
3. TOPSOIL QUANTITIES SHOULD NOT BE ESTABLISHED FROM THE INFORMATION PROVIDED AT THE BOREHOLE LOCATIONS.
4. BOREHOLE ELEVATIONS SHOULD NOT BE USED TO DESIGN BUILDING(S) OR FLOOR SLABS OR PARKING LOT(S) GRADES.
5. THIS DRAWING FORMS PART OF THE REPORT PROJECT NUMBER AS REFERENCED AND SHOULD BE USED ONLY IN CONJUNCTION WITH THIS REPORT.
6. SURVEY PLAN PREPARED BY ANNIS, O'SULLIVAN, VOLLEBEKK LTD. JOB N°.18260-17 UTOPIA, DATED SEPTEMBER 1ST, 2017.

LEGEND :

BH1 — PROPOSED BOREHOLE NUMBER & LOCATION

NOTE : ALL UNITS IN METRIC

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scale 1:400	PROJECT: 259727 ONTARIO LTD. PROPOSED RESIDENTIAL PROPERTY 6102 RENAUD ROAD, OTTAWA, ON	project no. OTT-00246046-A0
date MAY 2018		
drawn by J.R.	TITLE: BOREHOLE LOCATION PLAN	FIG 2

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Notes On Sample Descriptions

1. All sample descriptions included in this report follow the Canadian Foundations Engineering Manual soil classification system. This system follows the standard proposed by the International Societv for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by **exp** Services Inc. also follow the same system. Different classification systems may be used by others; one such system is the Unified Soil Classification. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		

0.002 0.006 0.02 0.06 0.2 0.6 2.0 6.0 20 60 200

EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

UNIFIED SOIL CLASSIFICATION

2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc., none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Log of Borehole BH 1

Project No: OTT-00246046-A0

Project: Geotechnical Investigation - Proposed Residential Development

Location: 6102 Renaud Road, Ottawa, ON.

Date Drilled: 'April 18, 2018

Drill Type: CME-55 Truck Mount Drill Rig

Datum: Approximate Elevation

Logged by: ML Checked by: SMP

Figure No. 3

Page. 1 of 3

Split Spoon Sample
Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Shear Strength by Vane Test
Combustible Vapour Reading
Natural Moisture Content
Atterberg Limits
Undrained Triaxial at % Strain at Failure
Shear Strength by Penetrometer Test

GWL	SYMBOL	SOIL DESCRIPTION	Approximate Elevation m	Depth
		ASPHALTIC CONCRETE ~50 mm	79.11	
		FILL ~ 150 mm Crushed limestone, grey, moist	79.0 78.8	
		SILTY SAND Oxidized stains, brown, moist, (loose to compact)		
		CLAY Sensitive to extra-sensitive, grey, wet, (firm to stiff)	76.9	
▼			74.91	

Standard Penetration Test N Value (20, 40, 60, 80)
Shear Strength kPa (50, 100, 150, 200)
Combustible Vapour Reading (ppm) (250, 500, 750)
Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20, 40, 60)
SAMPLES
Natural Unit Wt. kN/m³

Depth 0: 9
Depth 1: 8
Depth 2: 13
Hammer Weight
Depth 3: 77, s=9.1
Hammer Weight
Hammer Weight, s=8.0
Depth 4: 38, 82
Hammer Weight, s=10
Depth 5: 36
Depth 6: 36, s=6.0
Depth 7: 62, s=6.9
Hammer Weight
Depth 8: 67, s=7.0
Hammer Weight
Depth 9: 77, s=4.6

Continued Next Page

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion of drilling.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00246046-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	4.2	8.2

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

LOG OF BOREHOLE BH LOGS - 246046 - 6102 RENAUD ROAD.GPJ TROW OTTAWA.GDT 5/14/18

Log of Borehole BH 1

Project No: OTT-00246046-A0

Project: Geotechnical Investigation - Proposed Residential Development

Figure No. 3

GWL	SYMBOL	SOIL DESCRIPTION	Approximate Elevation m	Depth	Standard Penetration Test N Value (20 40 60 80) / Shear Strength kPa (50 100 150 200)	Combustible Vapour Reading (ppm) (250 500 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20 40 60)	SAMPLES	Natural Unit Wt. kN/m³
		Dynamic Cone Penetration Test (DCPT) conducted from 10.1 m to Cone Refusal Depth of 27.0 m.	69.11 69.0	10 11 12 13 14 15 16 17 18 19 20 21 22				

Continued Next Page

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion of drilling.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00246046-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	4.2	8.2

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 1

Project No: OTT-00246046-A0

Project: Geotechnical Investigation - Proposed Residential Development

Figure No. 3

GWL	SYMBOL	SOIL DESCRIPTION	Approximate Elevation m	Depth	Standard Penetration Test N Value (20 40 60 80) / Shear Strength kPa (50 100 150 200)	Combustible Vapour Reading (ppm) (250 500 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20 40 60)	SAMPLES	Natural Unit Wt. kN/m³
		Dynamic Cone Penetration Test (DCPT) conducted from 10.1 m to Cone Refusal Depth of 27.0 m. *(continued)*	57.11	22				
				23				
				24				
				25				
				26				
			52.1	27				
		Cone Refusal at 27.0 m Depth						

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion of drilling.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00246046-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	4.2	8.2

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 2

Project No: OTT-00246046-A0

Project: Geotechnical Investigation - Proposed Residential Development

Location: 6102 Renaud Road, Ottawa, ON.

Figure No. 4

Page. 1 of 1

Date Drilled: 'April 16, 2018

Drill Type: CME-55 Truck Mount Drill Rig

Datum: Approximate Elevation

Logged by: AN Checked by: SMP

Split Spoon Sample
Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Shear Strength by Vane Test

Combustible Vapour Reading
Natural Moisture Content
Atterberg Limits
Undrained Triaxial at % Strain at Failure
Shear Strength by Penetrometer Test

GWL	SYMBOL	SOIL DESCRIPTION	Approximate Elevation m	Depth	Natural Unit Wt. kN/m³
		FILL ~ 150 mm Crushed limestone, grey, moist	77.53 77.3	0	
		FILL Mixture of crushed limestone gravel and silty sand, grey and brown, wet	76.8		
		CLAY Sensitive, brown, moist, (stiff to very stiff)		1	17.6 17.1
			75.3	2	
		CLAY Extra-sensitive, grey, wet, (firm to stiff)		3	
				5	
				6	
				7	
			69.4	8	
		Borehole Terminated at 8.1 m depth			

Standard Penetration Test N Value: 20 40 60 80
Shear Strength kPa: 50 100 150 200
Combustible Vapour Reading (ppm): 250 500 750
Natural Moisture Content % / Atterberg Limits (% Dry Weight): 20 40 60
SAMPLES

Depth 0: 77.3 m; 77.53 m
Depth 1: 4; 192
Depth 2: 2; 82; s=4.9
Depth 3: 1; 34; s=14.0; Hammer Weight; 83
Depth 4: 43; s=9.0; Hammer Weight
Depth 5: 58; s=12.0; Hammer Weight
Depth 6: 68; s=13.0; Hammer Weight
Depth 7: 67; s=9.3; Hammer Weight; 82
Depth 8: 67; s=14.0; 69.4 m

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion of drilling.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00246046-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion		

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 3

Project No: OTT-00246046-A0

Project: Geotechnical Investigation - Proposed Residential Development

Location: 6102 Renaud Road, Ottawa, ON.

Date Drilled: 'April 17, 2018

Drill Type: CME-55 Truck Mount Drill Rig

Datum: Approximate Elevation

Logged by: AN Checked by: SMP

Figure No. 5

Page. 1 of 1

Split Spoon Sample
Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Shear Strength by Vane Test
Combustible Vapour Reading
Natural Moisture Content
Atterberg Limits
Undrained Triaxial at % Strain at Failure
Shear Strength by Penetrometer Test

GWL	SYMBOL	SOIL DESCRIPTION	Approximate Elevation m	Depth	Natural Unit Wt. kN/m³
		TOPSOIL ~ 50 mm	76.81	0	
		FILL Mixture of gravel, silty sand, topsoil and roots, brown and black, wet, (loose)	76.7		
		CLAY Brown, moist, (very stiff)	76.41		
			76.1		
		CLAY High plasticity, sensitive to extra-sensitive, grey, wet, (firm to stiff)	74.7	2	16.9
		Borehole Terminated at 8.5 m Depth	68.3	8	15.8

Standard Penetration Test N Value: 20, 40, 60, 80

Shear Strength (kPa): 50, 100, 150, 200

Combustible Vapour Reading (ppm): 250, 500, 750

Natural Moisture Content % / Atterberg Limits (% Dry Weight): 20, 40, 60

SAMPLES

Observed values: 4; 5; 192; 2; 144; 58; s=12.0; Hammer Weight; 29; s=12.0; Hammer Weight; 88; 38; s=16.0; Hammer Weight; 82; 43; s=9.0; 53; s=8.8; Hammer Weight; 67; s=8.7; Hammer Weight; 67; s=5.6

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe piezometer installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00246046-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	5.2	7.3
20 days	0.4	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 4

Project No: OTT-00246046-A0

Project: Geotechnical Investigation - Proposed Residential Development

Location: 6102 Renaud Road, Ottawa, ON.

Date Drilled: 'April 17, 2018

Drill Type: CME-55 Truck Mount Drill Rig

Datum: Approximate Elevation

Logged by: AN Checked by: SMP

Figure No. 6

Page. 1 of 3

Split Spoon Sample
Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Shear Strength by Vane Test
Combustible Vapour Reading
Natural Moisture Content
Atterberg Limits
Undrained Triaxial at % Strain at Failure
Shear Strength by Penetrometer Test

GWL	SYMBOL	SOIL DESCRIPTION	Approximate Elevation m	Depth	Natural Unit Wt. kN/m³
		TOPSOIL ~ 50 mm	76.67 / 76.6	0	
		FILL Mixture of crushed limestone gravel, silty sand, topsoil and rootlets, black, moist, (compact)	76.0		
		CLAY High plasticity, brown, moist, (very stiff)	75.37	1	18.3
					19.0
		CLAY High plasticity, sensitive to quick, grey, wet, (firm to very stiff)	74.6	2	
				3	
				5	
				6	
				7	
				8	
				9	
				10	

Standard Penetration Test N Value: 20 40 60 80

Shear Strength kPa: 50 100 150 200

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % / Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Observations:
- 18
- 7, 168
- 4, 120
- 67, s=7.0, Hammer Weight
- 38, s=8.0, Hammer Weight
- 43, s=6.0, Hammer Weight
- 43, s=18.0
- 48, s=10.0
- Hammer Weight
- 58, s=12.0, Hammer Weight
- 62, s=8.7
- 67, s=9.3

82

Continued Next Page

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe piezometer installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00246046-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	2.3	
20 days	1.3	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 4

Project No: OTT-00246046-A0

Project: Geotechnical Investigation - Proposed Residential Development

Figure No. 6

GWL	SYMBOL	SOIL DESCRIPTION	Approximate Elevation m	Depth	Standard Penetration Test N Value (20 40 60 80) / Shear Strength kPa (50 100 150 200)	Combustible Vapour Reading (ppm) (250 500 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20 40 60)	SAMPLES	Natural Unit Wt. kN/m³
		CLAY High plasticity, sensitive to quick, grey, wet, (firm to very stiff) *(continued)*	66.67	10				
				11	Hammer Weight; 82; s=6.8			
				12				
				13	86; s=7.2			
				14	Hammer Weight; 115; s=9.6			
				15				
				16	Hammer Weight; 86; s=7.2			
				18	Hammer Weight; 77; s=5.3			
				19	Hammer Weight; 86; s=9.0			
		Dynamic Cone Penetration Test (DCPT) conducted from 19.2 m to Cone Refusal Depth of 26.1 m.	57.5	20				
				21				
				22				

Continued Next Page

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe piezometer installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00246046-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	2.3	
20 days	1.3	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 4

Project No: OTT-00246046-A0

Project: Geotechnical Investigation - Proposed Residential Development

Figure No. 6

GWL	SYMBOL	SOIL DESCRIPTION	Approximate Elevation m	Depth	Standard Penetration Test N Value (20 40 60 80) / Shear Strength kPa (50 100 150 200)	Combustible Vapour Reading (ppm) (250 500 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20 40 60)	SAMPLES	Natural Unit Wt. kN/m³
		Dynamic Cone Penetration Test (DCPT) conducted from 19.2 m to Cone Refusal Depth of 26.1 m. *(continued)*	54.67	22				
				23				
				24				
				25				
			50.6	26				
		Cone Refusal at 26.1 m Depth						

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe piezometer installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00246046-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	2.3	
20 days	1.3	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 5

Project No: OTT-00246046-A0

Project: Geotechnical Investigation - Proposed Residential Development

Location: 6102 Renaud Road, Ottawa, ON.

Figure No. 7

Page. 1 of 2

Date Drilled: 'April 18, 2018

Drill Type: CME-55 Truck Mount Drill Rig

Datum: Approximate Elevation

Logged by: ML Checked by: SMP

Split Spoon Sample
Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Shear Strength by Vane Test

Combustible Vapour Reading
Natural Moisture Content
Atterberg Limits
Undrained Triaxial at % Strain at Failure
Shear Strength by Penetrometer Test

SOIL DESCRIPTION	Approximate Elevation m
FILL ~ 150 mm Crushed limestone, grey, wet	77.18 77.0
FILL Mixture of gravel, silty sand, clay, topsoil and wood debris, brown and black, moist, (loose to compact)	76.3
CLAY Sensitive, brown, moist, (stiff to very stiff)	75.78
CLAY Sensitive to extra-senstive, grey, wet, (firm to stiff)	74.2

Depth (m): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Standard Penetration Test N Value (20, 40, 60, 80) / Shear Strength (50, 100, 150, 200 kPa)

21, 5, >120, 6, 86, s=7.2, 2, 53, s=14.7, 43, s=9.0, 38, s=8.0, Hammer Weight, 36, s=6.0, Hammer Weight, 53, s=8.8, Hammer Weight, 62, s=8.7, Hammer Weight, 67, s=7.0

Combustible Vapour Reading (ppm) (250, 500, 750) / Natural Moisture Content % Atterberg Limits (% Dry Weight) (20, 40, 60)

SAMPLES: 87, 84

Natural Unit Wt. kN/m³: 17.8

Continued Next Page

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe piezometer installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00246046-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	3.6	10.1
19 days	1.4	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 5

Project No: OTT-00246046-A0

Project: Geotechnical Investigation - Proposed Residential Development

Figure No. 7

GWL	SYMBOL	SOIL DESCRIPTION	Approximate Elevation m	Depth	Standard Penetration Test N Value (20 40 60 80) / Shear Strength kPa (50 100 150 200)	Combustible Vapour Reading (ppm) (250 500 750) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (20 40 60)	SAMPLES	Natural Unit Wt. kN/m³
		CLAY Sensitive to extra-senstive, grey, wet, (firm to stiff) *(continued)*	67.18	10				
					Hammer Weight			
				11				
			65.6		67 s=5.6			
		Borehole Terminated at 11.6 m Depth						

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe piezometer installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00246046-A0

WATER LEVEL RECORDS

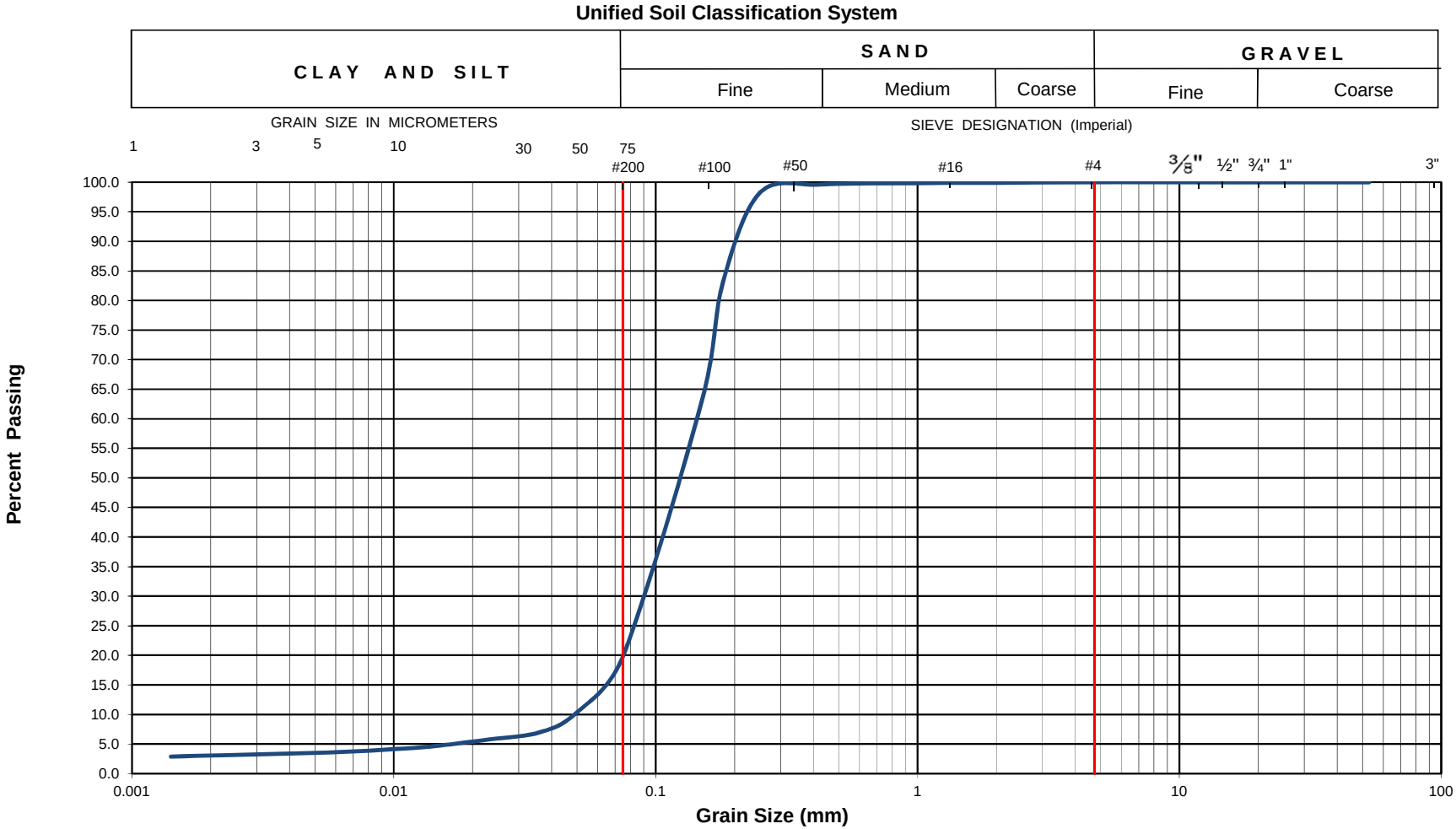
Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	3.6	10.1
19 days	1.4	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

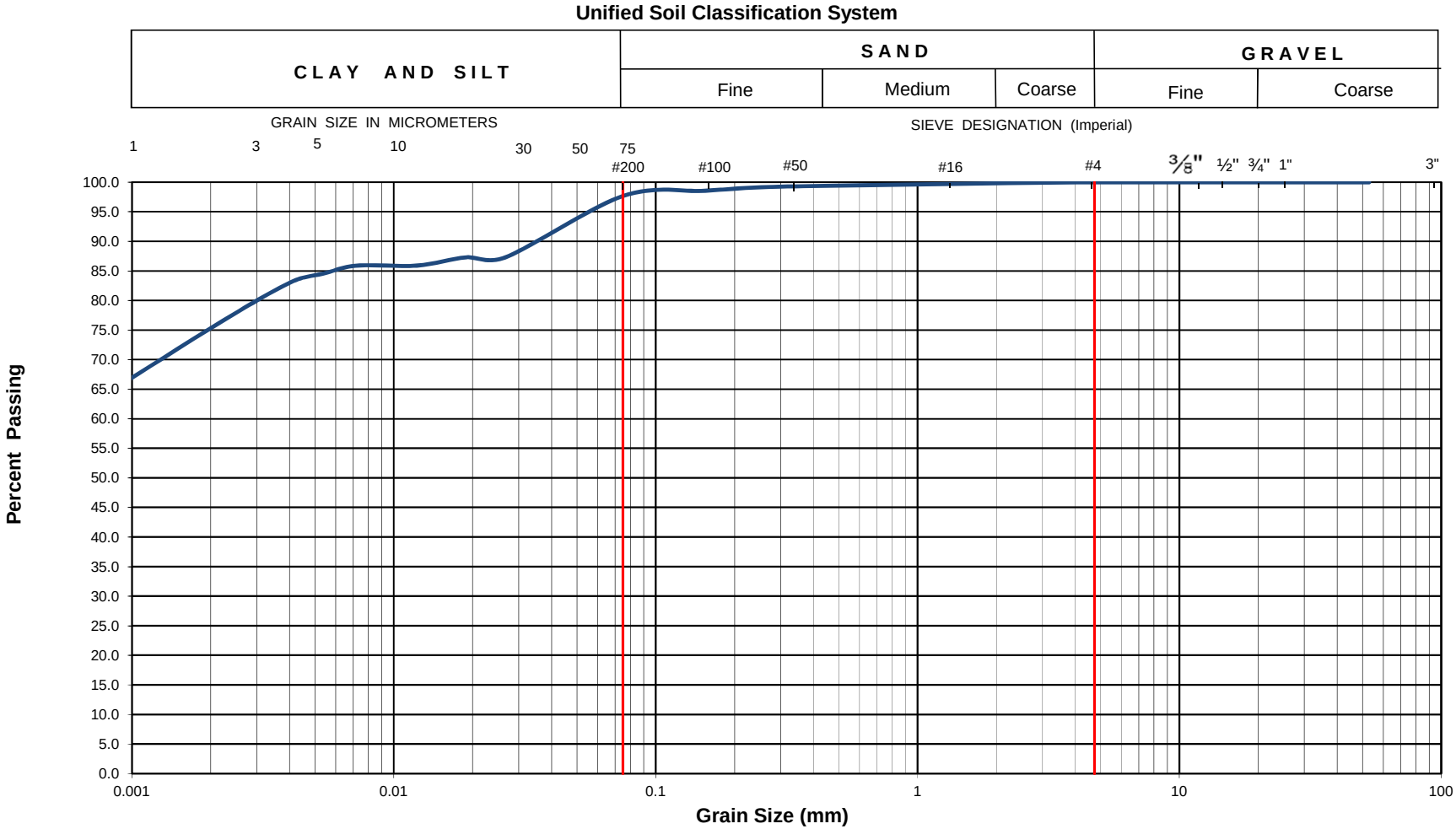
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-00246046 - A0**	**Project Name :**	**Geotechnical Investigation - Proposed Residential Development**						
Client :	**2597237 Ontario Ltd.**	**Project Location :**	**6102 Renaud Road, Ottawa, ON.**						
Date Sampled :	**April 18, 2018**	**Borehole No:**	**BH1**	**Sample No.:**	**SS3**	**Depth (m) :**	**1.5-2.1**		
Sample Description :		**% Silt and Clay**	**20**	**% Sand**	**80**	**% Gravel**	**0**	**Figure :**	**8**
Sample Description :		**Silty Sand (SM)**							

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-00246046 - A0**	**Project Name :**	**Geotechnical Investigation - Proposed Residential Development**						
Client :	**2597237 Ontario Ltd.**	**Project Location :**	**6102 Renaud Road, Ottawa, ON.**						
Date Sampled :	**April 16, 2018**	**Borehole No:**	**BH2**	**Sample No.:**	**SS2**	**Depth (m) :**	**0.8-1.4**		
Sample Description :		**% Silt and Clay**	**98**	**% Sand**	**2**	**% Gravel**	**0**	**Figure :**	**9**
Sample Description :		**Clay (CH)**							

Englobe

One-Dimensional Consolidation Properties of Soils Using Incremental Loading

ASTM D 2435 - Taylor Method

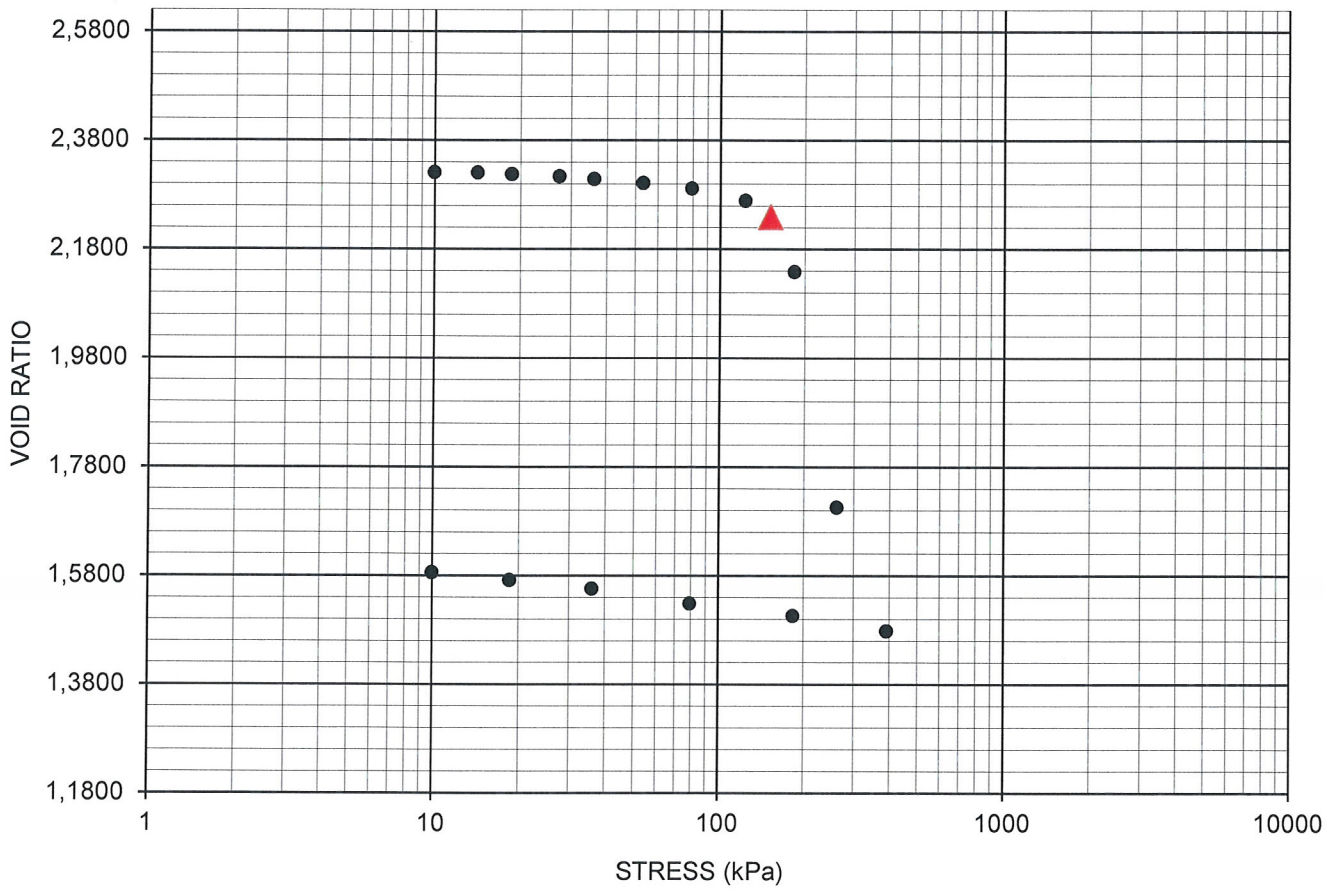
Client: Y/Project: OTT-00246046-A0 **Date :** 2018-04-24

Project : EXP Ontario **Our file No. :** P-0011703-6-01

Boring No. : BH-1, ST-8 **Sample No. :** 12 **Depth (m) :** 6,3 to 6,4m

Hydrostatic stress at the test (date) : Provided by ☐ the client ☐ Englobe

STRESS vs VOID RATIO CURVE



Geotechnical Characteristics of Soils :

Initial void ratio (e_o) :	2,322	Recompression index (C_r) :	0,037
Initial water content (w) :	84,0%	Virgin compression index (C_c) :	2,80
Initial humid unit weight (γ_h) :	14,9 kN/m³	Initial effective stress (σ'_v) :	68 kPa
Initial saturation degree (S_r) :	99,5%	Preconsolidation pressure (σ'_p):	150 kPa
		Overconsolidation deviation ($\Delta\sigma$) :	82 kPa

Coefficient of consolidation Cv	2,14E-01 m2/j	at	79	kPa
Coefficient of consolidation Cv	6,74E-02 m2/j	at	183	kPa

Remarks : The sampling and transportation of the sample were carried out by a client's representative. The initial effective stress has been provided by the client.

Prepared by :

A. Bouadma

Adlane Bouadma, jr Eng

Verified by :

Famakhan Fainke, Eng

Englobe

One-Dimensional Consolidation Properties of Soils Using Incremental Loading

ASTM D 2435 - Taylor Method

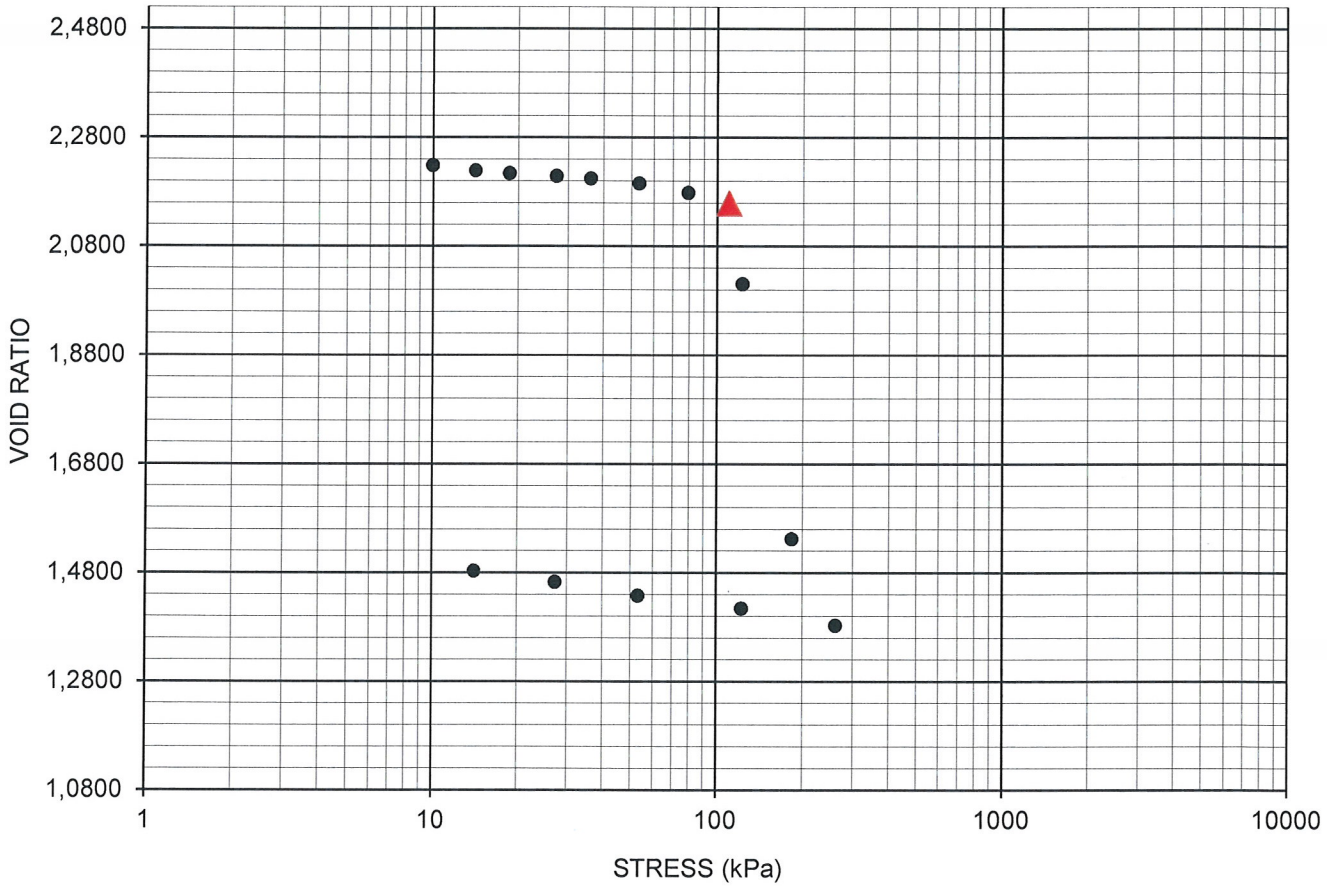
Client: Y/Project: OTT-00246046-A0 **Date :** 2018-04-26

Project : EXP Ontario **Our file No. :** P-0011703-6-01

Boring No. : BH-5, ST-6 **Sample No. :** 13 **Depth (m) :** 4,2 à 4,3m

Hydrostatic stress at the test (date) : Provided by ☐ the client ☐ Englobe

STRESS vs VOID RATIO CURVE



Geotechnical Characteristics of Soils :

Initial void ratio (e_o) :	2,229	Recompression index (C_r) :	0,034
Initial water content (w) :	81,0%	Virgin compression index (C_c) :	2,66
Initial humid unit weight (γ_h) :	15,1 kN/m³	Initial effective stress (σ'_v) :	47 kPa
Initial saturation degree (S_r) :	99,9%	Preconsolidation pressure (σ'_p):	110 kPa
		Overconsolidation deviation ($\Delta\sigma$) :	63 kPa

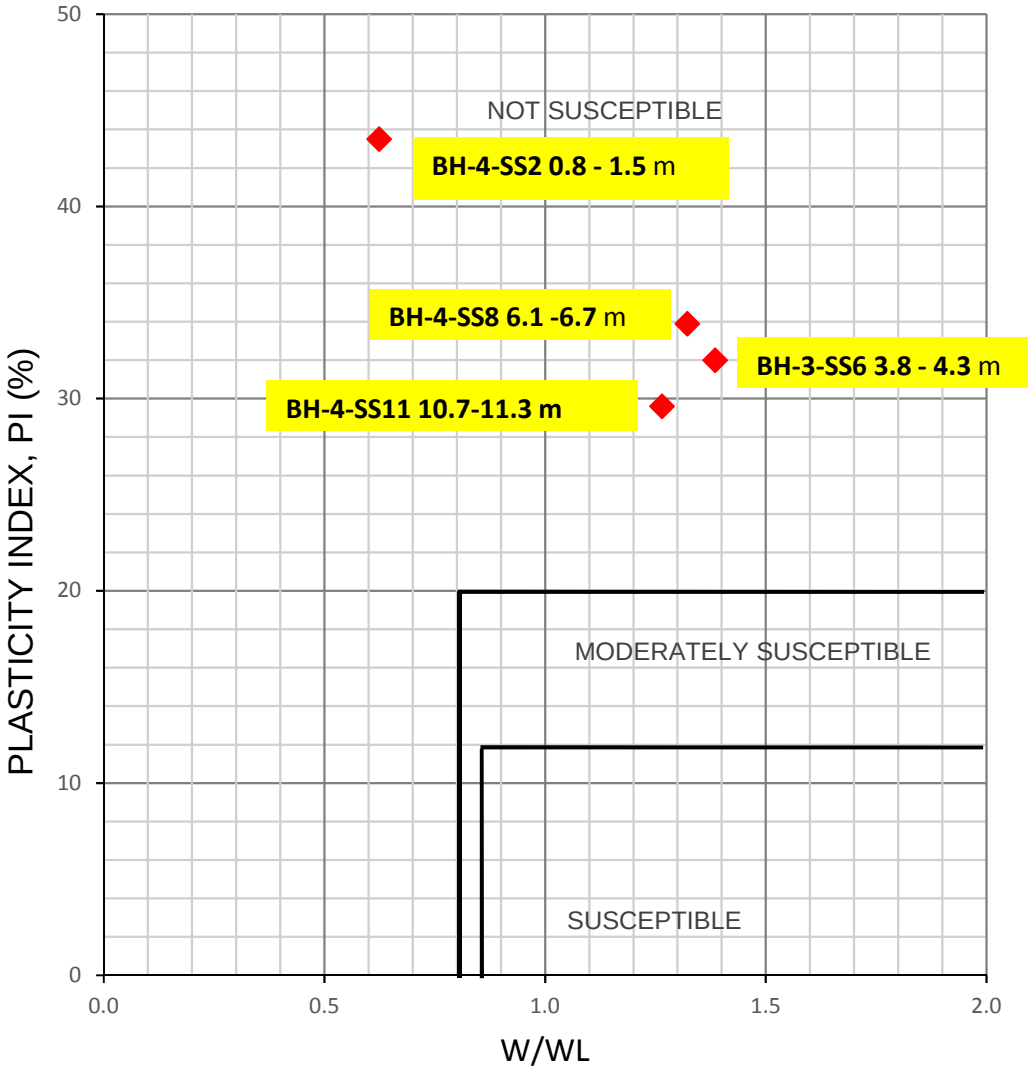
Coefficient of consolidation Cv	2,19E-01 m2/j	at	53	kPa
Coefficient of consolidation Cv	9,52E-02 m2/j	at	122	kPa

Remarks : The sampling and transportation of the sample were carried out by a client's representative. The initial effective stress has been provided by the client.

Prepared by : A. Bouadma

Adlane Bouadma, jr Eng

Verified by : Famakhan Fainke, Eng



BRAY ET AL. (2004) CRITERIA FOR LIQUEFACTION ASSESSMENT OF FINE GRAINED SOILS

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scale: N.T.S.	CLIENT: 2597237 Ontario Ltd.	project no. OTT-0024606-A0
date: May 2018	TITLE: Proposed Residential Subdivision - 6102 Renaud Road, Ottawa, ON.	FIG 12
drawn by: M.L.		

Appendix A: 2015 National Building Code Seismic Hazard Calculation

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

April 26, 2018

Site: 45.4292 N, 75.518 W User File Reference: 6102 Renaud Road, Ottawa, ON.

Requested by: , EXP Services Inc.

National Building Code ground motions: 2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.05)	Sa(0.1)	**Sa(0.2)**	Sa(0.3)	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**Sa(5.0)**	**Sa(10.0)**	**PGA (g)**	**PGV (m/s)**
0.501	0.581	**0.482**	0.363	**0.255**	**0.125**	**0.059**	**0.015**	**0.0055**	**0.309**	**0.211**

Notes. Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC 2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are specified in **bold** font. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. ***These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.05)	0.047	0.164	0.276
Sa(0.1)	0.065	0.204	0.331
Sa(0.2)	0.058	0.174	0.278
Sa(0.3)	0.046	0.133	0.211
Sa(0.5)	0.032	0.093	0.148
Sa(1.0)	0.016	0.046	0.073
Sa(2.0)	0.0062	0.021	0.034
Sa(5.0)	0.0013	0.0048	0.0084
Sa(10.0)	0.0006	0.0019	0.0032
PGA	0.035	0.110	0.179
PGV	0.022	0.072	0.118

References

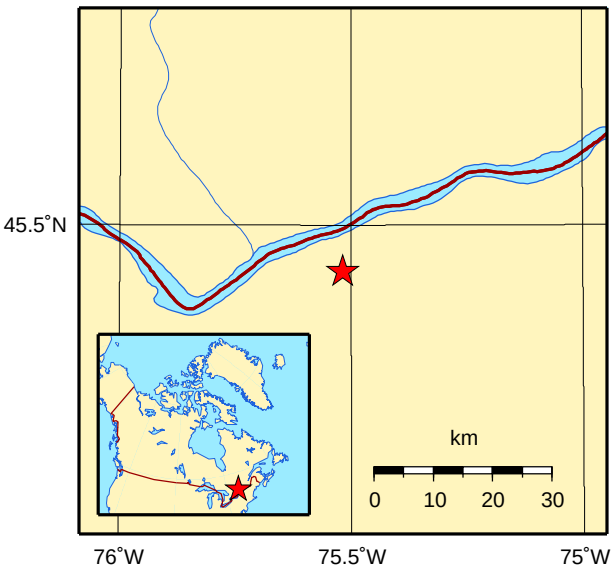
National Building Code of Canada 2015 NRCC no. 56190;
Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

User's Guide - NBC 2015, Structural Commentaries NRCC no. xxxxxx (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français



Natural Resources Canada Ressources naturelles Canada

Canada

Appendix B: AGAT Certificate of Analysis

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: **EXP SERVICES INC**
2650 QUEENSVIEW DRIVE, UNIT 100
OTTAWA, ON K2B8H6
(613) 688-1899

ATTENTION TO: **Susan Potyondy**

PROJECT: **OTT-246046**

AGAT WORK ORDER: **18Z331542**

SOIL ANALYSIS REVIEWED BY: **Amanjot Bhela, Inorganic Coordinator**

DATE REPORTED: **Apr 27, 2018**

PAGES (INCLUDING COVER): **5**

VERSION*: **1**

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Member of: Association of Professional Engineers and Geoscientists of Alberta (APEGA)
Western Enviro-Agricultural Laboratory Association (WEALA)
Environmental Services Association of Alberta (ESAA)

AGAT Laboratories is accredited to ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA) and/or Standards Council of Canada (SCC) for specific tests listed on the scope of accreditation. AGAT Laboratories (Mississauga) is also accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) for specific drinking water tests. Accreditations are location and parameter specific. A complete listing of parameters for each location is available from www.cala.ca and/or www.scc.ca. The tests in this report may not necessarily be included in the scope of accreditation.

Results relate only to the items tested and to all the items tested
All reportable information as specified by ISO 17025:2005 is available from AGAT Laboratories upon request

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 18Z331542

PROJECT: OTT-246046

CLIENT NAME: EXP SERVICES INC

ATTENTION TO: Susan Potyondy

SAMPLING SITE:6102 Renaud Road

SAMPLED BY:exp

Inorganic Chemistry (Soil)

DATE RECEIVED: 2018-04-23 **DATE REPORTED: 2018-04-26**

				BH1 SS4 7.	
		SAMPLE DESCRIPTION:		5'-9.5'	BH4 SS3 5'-7'
		SAMPLE TYPE:		Soil	Soil
		DATE SAMPLED:		2018-04-18	2018-04-18
Parameter	**Unit**	**G / S**	**RDL**	**9195398**	**9195399**
pH, 2:1 CaCl2 Extraction	pH Units			7.54	7.05
Chloride (2:1)	µg/g		2	51	54
Sulphate (2:1)	µg/g		2	25	122
Resistivity (2:1)	ohm.cm		1	6170	4270

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9195398-9195399 EC/Resistivity, Chloride and Sulphate were determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio.

Certified By: Amanjot Bhela

Results relate only to the items tested and to all the items tested

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: EXP SERVICES INC

PROJECT: OTT-246046

SAMPLING SITE:6102 Renaud Road

AGAT WORK ORDER: 18Z331542

ATTENTION TO: Susan Potyondy

SAMPLED BY:exp

Soil Analysis

RPT Date:			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Inorganic Chemistry (Soil)															
pH, 2:1 CaCl2 Extraction	9195564		7.58	7.54	0.5%	NA	99%	80%	120%						
Chloride (2:1)	9194146		623	584	6.5%	< 2	107%	70%	130%	103%	70%	130%	101%	70%	130%
Sulphate (2:1)	9194146		34	33	3.0%	< 2	97%	70%	130%	102%	70%	130%	100%	70%	130%

Comments: NA signifies Not Applicable.
Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Certified By: Amanjot Bhela

AGAT Laboratories is accredited to ISO/IEC 17025 by the Canadian Association for Laboratory Accreditation Inc. (CALA) and/or Standards Council of Canada (SCC) for specific tests listed on the scope of accreditation. AGAT Laboratories (Mississauga) is also accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) for specific drinking water tests. Accreditations are location and parameter specific. A complete listing of parameters for each location is available from www.cala.ca and/or www.scc.ca. The tests in this report may not necessarily be included in the scope of accreditation.

Results relate only to the items tested and to all the items tested

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http://www.agatlabs.com

Method Summary

CLIENT NAME: EXP SERVICES INC

AGAT WORK ORDER: 18Z331542

PROJECT: OTT-246046

ATTENTION TO: Susan Potyondy

SAMPLING SITE:6102 Renaud Road

SAMPLED BY:exp

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
pH, 2:1 CaCl2 Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	EC METER

Results relate only to the items tested and to all the items tested

AGAT Laboratories

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Laboratory Use Only

Work Order #: 1823315 42

Cooler Quantity: one - no ice.

Arrival Temperatures: 12.5 | 12.2 | 12.1

Custody Seal Intact: ☐ Yes ☐ No ☐ N/A

Notes:

Report Information:

Company: Exp Services
Contact: Susan Potyondy
Address: 100-2650 Queensview Drive
Ottawa ON, K2B 8H6
Phone: 613-688-1899 Fax:
Reports to be sent to:
1. Email: susan.potyondy@exp.com
2. Email:

Regulatory Requirements: ☐ No Regulatory Requirement

(Please check all applicable boxes)

☐ Regulation 153/04
Table (indicate one): ☐ Ind/Com ☐ Res/Park ☐ Agriculture
Soil Texture (Check One): ☐ Coarse ☐ Fine

☐ Sewer Use
☐ Sanitary
☐ Storm
Region (Indicate One): ☐ MISA

☐ Regulation 558
☐ CCME
☐ Prov. Water Quality Objectives (PWQO)
☐ Other (Indicate One)

Is this submission for a **Record of Site Condition?** ☐ Yes ☐ No

Report Guideline on Certificate of Analysis ☐ Yes ☐ No

Turnaround Time (TAT) Required:

Regular TAT ☐ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CPM

Project Information:

Project: OTT-246046
Site Location: 6102 Renaud Road
Sampled By: exp
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☒ No ☐

Company:
Contact:
Address:
Email:

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI (Y/N)	Metals and Inorganics (O. Reg 153; ☐ All Metals ☐ 153 Metals (excl. Hydrides) ☐ Hydride Metals ☐ 153 Metals (incl. Hydrides))	ORPs: ☐ B-HWS ☐ Cl ☐ CN ☐ Cr^{6+} ☐ EC ☐ FOC ☐ Hg ☐ pH ☐ SAR	Full Metals Scan	Regulation/Custom Metals	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_2+NO_3	Volatiles: ☐ VOC ☐ BTEX ☐ THM	PHCs F1 - F4	ABNs	PAHs	PCBs: ☐ Total ☐ Aroclors	Organochlorine Pesticides	TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B/aP ☐ PCBs	Sewer Use	pH	Sulphates	Chlorides	Electro Resistivity	
BH 1 SS4 7.5'-9.5'	Ap 18/18																		✓	✓	✓	✓		
BH 4 SS3 5'-7'	Ap 17/18																		✓	✓	✓	✓		

Samples Relinquished By (Print Name and Sign)	Date	Time	Samples Received By (Print Name and Sign)	Date	Time
Ryan DiGiuseppe	Ap 23/18	11:30	[illegible]	23-Apr-18	11h39
Samples Relinquished By (Print Name and Sign): Bron FedEx	23-Apr-18	16h00	Samples Received By (Print Name and Sign):		
Samples Relinquished By (Print Name and Sign):			Samples Received By (Print Name and Sign):		

Page 1 of 1

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Date Issued: February 22, 2017

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