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REPORT ON

GEOTECHNICAL INVESTIGATION
PROPOSED COMMERCIAL BUILDINGS
151-159 WESCAR LANE
CITY OF OTTAWA, ONTARIO

Project # 230403

Submitted to:

Sunbelt Rentals Inc.
2489 Sheffield Road
Ottawa, Ontario
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June 14, 2023 – Revised December 6, 2023
Revised August 29, 2024

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RE: GEOTECHNICAL INVESTIGATION
PROPOSED COMMERCIAL DEVELOPMENT
151-159 WESCAR LANE
CITY OF OTTAWA, ONTARIO

1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for the above noted proposed commercial development to be located at 151 – 159 Wescar Lane, City of Ottawa, Ontario (see Key Plan, Figure 1).

The purpose of the investigation was to:

- Identify the subsurface conditions at the site by means of a limited number of boreholes;
- Based on the factual information obtained, provide recommendations and guidelines on the geotechnical engineering aspects of the project design; including bearing capacity and other construction considerations, which could influence design decisions.

2.0 BACKGROUND INFORMATION AND SITE GEOLOGY

2.1 Existing Conditions and Site Geology

The site is currently vacant. The site is bordered on the west and south by undeveloped lands and farmland, on the north by Cavanmore Road followed by residential development and on the east by Wescar Lane followed by commercial development.

Based on a review of the surficial geology map for the site area, it is expected that the site is generally underlain by coarse textured glaciomarine deposits consisting of sand, gravel, minor silt and clay and/or glacial till. A review of the bedrock geology map indicates that the bedrock underlying the site consists of limestone, dolostone, shale, arkose and sandstone of the Ottawa Group, Simcoe Group and Shadow Lake Formation.

2.2 Proposed Development

The site consists of about a 4.6 hectare (11.4 acres), irregular shaped property located southwest of the intersection of Cavanmore Road and Wescar Lane in the City of Ottawa, Ontario (see Key Plan, Figure 1).

Based on information provided for the development, it is proposed to construct two commercial buildings. The proposed commercial buildings will consist of the following:

- Building A: 3,342 square metres
- Building B: 1,128 square metres

Preliminary information provided by the client indicates that the proposed buildings will consist of one two-storey and one single-storey steel frame metal clad structure. The proposed buildings will be placed on conventional concrete spread footing foundations with a concrete slab-on-grade construction (no basement). The interior layout of the buildings are not known at this time, however, it is understood the interiors will consist mostly of warehouse space along with some associated office spaces. The proposed buildings will be provided with an asphaltic concrete surfaced access roadway and parking lot.

The proposed development will be serviced by private services including a drilled cased well, an onsite septic system and a stormwater management facility.

3.0 PROCEDURE

The field work for this investigation was carried out on May 29 and 30, 2023, at which time eleven (11) boreholes numbered BH1 to BH11 and one additional borehole labelled BH-STORM were put down at the site using a track mounted drill rig equipped with a hollow stem auger owned and operated by CCC Environment and Geotechnical Drilling of Ottawa, Ontario. Boreholes BH1 to BH4 and B9 were put down within the proposed building footprints. Boreholes BH5 to BH8, BH10 and BH11 were put down within the proposed parking lot area for pavement design purposes. Borehole BH-STORM was put down within the proposed stormwater pond for others, and its contents are not discussed in this report.

The subsurface soil conditions encountered at the boreholes were classified based on visual and tactile examination of the samples recovered (ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), standard penetration tests (ASTM D-1586 – Penetration Test and Split Barrel Sampling of Soils as well as laboratory test results on select samples. In situ vane shear testing (ASTM D-2573 Standard Test Method for Field Shear Test in Cohesive Soil) was not carried out as cohesive materials were not encountered. The soils were classified using the Unified Soil Classification System. Groundwater conditions at the boreholes and test pits were noted at the time of drilling. Groundwater was measured at a later date in a standpipe put down within one borehole (BH9). The boreholes were loosely backfilled with the excavated materials and auger cuttings upon completion of the fieldwork.

Three soil samples (BH3 – SS6 – 3.8 – 4.4 m, BH4 – SS11 – 7.6 – 8.2 m & BH9 – SS4 – 2.3 – 2.9 m) were submitted for Particle Size Analysis (ASTM D422), two soil samples (BH2 – SS8 – 5.2 – 5.8 m & BH4 – SS9 – 6.1 - 6.7 m) were submitted for sieve analysis (ASTM C136) and one soil sample (BH1 – SS4 – 2.3 – 2.9 m) was submitted for Atterberg Limits testing (ASTM D4318). The samples were selected based on depth and tactile examination to be representative of the various soil conditions encountered at the site.

Two samples of soil (BH2 – SS3 – 1.5 – 2.1 m & BH4 – SS3 – 1.5 – 2.1 m) were also delivered to a chemical laboratory for testing for any indication of potential soil sulphate attack and soil corrosion on buried concrete and steel.

A total of 52 soil samples recovered from the boreholes were also tested for moisture content (ASTM D2216).

The field work was supervised throughout by a member of our engineering staff who located the boreholes and test pits in the field, logged the boreholes and cared for the samples obtained. A description of the subsurface conditions encountered at the boreholes is given in the attached

Record of Borehole Sheets. The results of the laboratory testing of the soil samples are presented in the Laboratory Test Results section and Attachment B following the text in this report. The approximate locations of the boreholes are shown on the attached Site Plan, Figure 2.

4.0 SUBSURFACE CONDITIONS

4.1 General

As previously indicated, a description of the subsurface conditions encountered at the boreholes is provided in the attached Record of Borehole Sheets following the text of this report. The borehole logs indicate the subsurface conditions at the specific hole locations only. Boundaries between zones on the logs are often not distinct, but rather are transitional and have been interpreted. Subsurface conditions at locations other than borehole locations may vary from the conditions encountered at the boreholes.

The soil descriptions in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil involves judgement and Kollaard Associates Inc. does not guarantee descriptions as exact, but infers accuracy to the extent that is common in current geotechnical practice.

The groundwater conditions described in this report refer only to those observed at the location and on the date the observations were noted in the report and on the borehole logs. Groundwater conditions may vary seasonally, or may be affected by construction activities on or in the vicinity of the site.

The following is a brief overview of the subsurface conditions encountered at the boreholes.

4.2 Fill

Fill materials consisting of red brown, yellow brown or grey brown silty sand, fine to medium sand and/or sand and gravel were encountered from the surface at all boreholes. The fill materials extended to a depth of about 0.6 to 1.5 metres at the borehole locations. The fill materials were fully penetrated in boreholes BH1 to BH6 and BH8 to BH10. Boreholes BH7 and BH11 were terminated within the fill materials at a depth of about 1.5 metres.

4.3 Silt

Beneath the fill materials, a layer of grey brown to grey clayey silt with a trace to some sand was encountered in boreholes BH1 to BH6 and BH8 to BH10. The silt was encountered at depths ranging between 0.6 and 1.5 metres below the existing ground surface. The results of standard penetration tests completed within the silt gave N values of between 2 and 41 blows per 0.3 metres, indicating a very loose to dense state of compaction. The silt was fully penetrated in boreholes BH1 to BH4 and BH9, and had a thickness of between 1.7 and 5.9 metres. Boreholes BH5, BH6, BH8 and BH10 were terminated within the silt.

The results of two hydrometer tests (ASTM D422) on samples of soil (BH3 – SS6 – 3.8 – 4.4 m & BH9 – SS4 – 2.3 – 2.9 m) indicate the samples have the following:

Sample	Depth(metres)	% Gravel	% Sand	% Silt	% Clay
BH3 – SS6	3.8 – 4.4	0.0	15.4	57.6	27.0
BH9 – SS4	2.3 – 2.9	1.3	27.3	45.4	26.0

The results of Atterberg Limits tests and moisture content (ASTM D422) conducted on one soil sample (BH1 – SS4 – 2.3 – 2.9 m) of the silt are presented in the following table and in Attachment A at the end of the report. The tested silt sample classifies as low plasticity in accordance with the Unified Soil Classification System. The results of the laboratory testing are located in Attachment A.

Table I – Atterberg Limit and Water Content Results

Sample	Depth(metres)	LL (%)	PL (%)	PI (%)	W (%)
BH1-SS6	2.3 – 2.9	22.0	12.7	9.3	20.2

LL: Liquid Limit PL: Plastic Limit PI: Plasticity Index w: water content
CL: Inorganic Low Plastic Soils

The results are located in Attachment A. The response to concerns regarding the Atterberg Limit Test Results have also been included in Attachment A.

4.4 Sand

Beneath the silt, a layer of grey silty sand and/or fine to medium sand was encountered in boreholes BH1 to BH4 and BH9. The sand materials were encountered at depths ranging between 2.7 and 6.1 metres below the existing ground surface. The results of standard penetration tests completed within the sand gave N values of between 1 and 31 blows per 0.3 metres, indicating a very loose to dense state of compaction. The sand was fully penetrated in boreholes BH1 to BH4 and BH9, and had a thickness of between 0.6 and 2.0 metres.

The results of two sieve analysis tests (ASTM C136) on samples of soil (BH2 – SS8 – 5.2 – 5.8 m & BH4 – SS9 – 6.1 – 6.7 m) indicates the samples had a gravel content of 0 to 1.7 percent, a sand content of 48.8 to 78.1 percent, and a silt and clay content of 61.2 to 20.2 percent. The results are located in Attachment A.

4.5 Glacial Till

A deposit of grey silty sand with some gravel, cobbles, boulders and a trace of clay (glacial till) was encountered beneath the sand materials in boreholes BH1 to BH4 and BH9. The glacial till was encountered at depths ranging between 3.3 and 7.3 metres below the existing ground surface. The results of standard penetration tests completed in the glacial till gave N values of between 7 and 100 blows per 0.3 metres, indicating a loose to very dense state of compaction. Boreholes BH1 and BH4 were terminated within the glacial till at a depth of about 8.2 metres below the existing ground surface. Practical refusal on bedrock or large boulders was encountered within the glacial till at boreholes BH2, BH3 and BH9.

The results of a hydrometer test (ASTM D422) on a sample of soil (BH4 – SS11 – 7.6 – 8.2 m) indicates the sample has the following:

Sample	Depth(metres)	% Gravel	% Sand	% Silt	% Clay
BH4 – SS11	7.6 – 8.2	12.8	55.8	23.4	8.0

The results are located in Attachment A.

4.6 Potential Bedrock

Practical refusal on bedrock or large boulders was encountered in boreholes BH2, BH3 and BH9 at depths of about 7.6, 7.8 and 6.4 metres, respectively, below the existing ground surface.

4.7 Moisture Contents

A total of 52 soil samples were also tested for moisture content (ASTM D2216). The measured moisture contents of the fill materials ranged from 4 to 19 percent. The measured moisture contents of the silt material ranged from 16 to 32 percent. The measured moisture contents of the sand materials ranged from 20 to 29 percent. The measured moisture contents of the glacial till ranged from 7 to 24 percent. The results of the moisture content are included on the Record of Borehole sheets following the text of this report.

4.8 Groundwater

Some groundwater was encountered in boreholes BH1, BH2, BH3, BH4, BH6, BH7, BH9 and BH10 at the time of drilling on May 29, and May 30, 2023, at depths of about 3.0, 3.8, 3.0, 3.0, 1.2, 1.2, 0.8 and 1.3 metres, respectively, below the existing ground surface. Boreholes BH5, BH8 and BH11 were dry at the time of drilling on May 29 and May 30, 2023. Groundwater was measured in a standpipe installed within borehole BH9 at a depth of about 1.1 metres below the existing ground surface on June 14, 2023. Groundwater levels are expected to fluctuate seasonally. Higher groundwater levels are expected during wet periods of the year, such as early spring.

4.9 Corrosivity on Reinforcement and Sulphate Attack on Portland Cement

The results of the laboratory testing of two soil samples submitted for chemistry testing related to corrosivity are summarized in the following tables.

BH2 – SS3 – 1.5 – 2.1 m

Item	Threshold of Concern	Test Result	Comment
Chlorides (Cl)	Cl > 0.04 %	<0.0005	Negligible
pH	pH < 5.5	7.70	Negligible concern
Resistivity	R < 20,000 ohm-cm	10500	Mildly Corrosive
Sulphates (SO_4)	SO_4 > 0.1%	<0.0020	Negligible concern

BH4 – SS3 – 1.5 – 2.1 m

Item	Threshold of Concern	Test Result	Comment
Chlorides (Cl)	Cl > 0.04 %	<0.0005	Negligible
pH	pH < 5.5	7.69	Negligible concern
Resistivity	R < 20,000 ohm-cm	9430	Moderately Corrosive
Sulphates (SO_4)	SO_4 > 0.1%	<0.0020	Negligible concern

The results of the laboratory testing of a soil samples for sulphate gave percent sulphates of less than 0.0020. The National Research Council of Canada (NRC) recognizes four categories of potential sulphate attack of buried concrete based on percent sulphate in soil. From 0 to 0.10 percent the potential is negligible, from 0.10 to 0.20 percent the potential is mild but positive, from 0.20 to 0.50 percent the potential is considerable and 0.50 percent and greater the potential is severe. Based on the above, the soils are considered to have a negligible potential for sulphate attack on buried concrete materials and accordingly, conventional GU or MS Portland cement may be used in the construction of the proposed concrete elements.

The pH value for the soil samples was reported to be between 7.69 and 7.70, indicating a durable condition against corrosion. These values were evaluated using Table 2 of Building Research Establishment (BRE) Digest 362 (July 1991).The pH is greater than 5.5 indicating the concrete will not be exposed to attack from acids.

The chloride content of the samples was also compared with the threshold level and present negligible concrete corrosion potential.

Corrosivity Rating for soils ranges from extremely corrosive with a resistivity rating <1000 ohm-cm to non-corrosive with a resistivity of >20,000 ohm-cm as follows:

Soil Resistivity (ohm-cm)	Corrosivity Rating
> 20,000	non- corrosive
10,000 to 20,000	mildly corrosive
5,000 to 10,000	moderately corrosive
3,000 to 5,000	corrosive
1,000 to 3,000	highly corrosive
< 1,000	extremely corrosive

The soil resistivity was found to be between 9430 and 10500 ohm-cm for the samples analyzed making the soil mildly to moderately corrosive for buried steel. Increasing the specified strength and increasing concrete cover and adding air entrainment into any reinforced concrete in contact with the soil is recommended. Additional special protection, other than listed above, is not required for reinforcement steel within the concrete foundation walls.

Based on the chemical test results, Type GU General Use Hydraulic Cement may be used for this proposed development. Special protection in the form of air entrainment and minimum cover is required for reinforcement steel within the concrete walls.

The laboratory results are presented in Attachment B following this report.

5.0 GEOTECHNICAL GUIDELINES AND RECOMMENDATIONS

5.1 General

This section of the report provides engineering guidelines on the geotechnical design aspects of the project based on our interpretation of the information from the test holes and the project requirements. It is stressed that the information in the following sections is provided for the guidance of the designers and is intended for this project only. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction, and make their own interpretation of the factual data as it affects their construction techniques, schedule, safety and equipment capabilities.

The professional services for this project include only the geotechnical aspects of the subsurface conditions at this site. The presence or implications of possible surface and/or subsurface contamination resulting from previous uses or activities at this site or adjacent properties, and/or resulting from the introduction onto the site of materials from offsite sources are outside the terms of reference for this report.

5.2 Foundations for Proposed Commercial Buildings

It is understood that the proposed commercial buildings will consist of conventional concrete spread footing foundations complete with cast-in-place concrete foundation walls and concrete slab-on-grade construction and no basements.

As previously indicated, the subsurface conditions at the site encountered at the boreholes advanced during the investigation consisted of fill materials (silty sand, fine to medium sand and/or sand and gravel) overlying silt with a trace to some sand and clay, followed by silty sand and/or fine to medium sand over glacial till then bedrock. The allowable bearing pressure for any footings depends on the depth of the footings below original ground surface, the width of the footings, and the height above the original ground surface of any landscape grade raise adjacent to the foundations and the thickness of the soils deposit beneath the footings.

5.3 Subsurface Conditions at the Underside of Footing Level

It is expected that the subgrade immediately below the proposed footing level will consist of silt. Once the excavations for the foundations are complete, the exposed subgrade should be inspected by a qualified geotechnical person. Should the subgrade consist of loose silt, the subgrade should be sub-excavated to remove the loose material to a depth of 0.6 metres below the underside of footing elevation.

5.4 Foundation Excavation

The excavations for the foundation should be taken through any fill or otherwise deleterious material to bear on the native, undisturbed grey brown silt subgrade. The sides of the excavations should be sloped in accordance with the requirements of Ontario Regulation 213/91, s. 226 under the Occupational Health and Safety Act. According to the Act, the native soils at the site can be classified as Type 3 soil, however, this classification should be confirmed by qualified individuals as the site is excavated and if necessary, adjusted.

It is expected that the side slopes of the excavation will be stable in the short term provided the walls are sloped at 1H:1V through the fill materials and native silt to the bottom of the excavation and provided no excavated materials are stockpiled within 3 metres of the top of the excavations.

5.5 Conventional Spread Footing Foundations

The allowable bearing pressure for any footings depends on the depth of the footings below original ground surface, the width of the footings, and the height above the original ground surface of any landscape grade raise adjacent to the foundation.

For the proposed commercial buildings, a maximum allowable bearing pressure of 120 kilopascals using serviceability limit states design and a factored ultimate bearing resistance of 360 kilopascals using ultimate limit states design, may be used for the design of conventional strip footings or pad footings founded on the silt or on a suitably constructed engineered pad placed on the silt.

The maximum total and differential settlement of the footings are expected to be less than 25 millimetres and 20 millimetres, respectively, using the above allowable bearing pressure and resistance. There is no maximum grade raise associated with the above allowable bearing pressure.

The subgrade surface should be inspected and approved by geotechnical personnel prior to placement of any granulars.

5.6 Engineered Fill

Should the complete removal of all fill materials and any otherwise deleterious material result in a subgrade below the proposed founding level, any fill required to raise the footings for the proposed building to founding level should consist of granular material meeting Ontario Provincial Standards Specifications (OPSS) requirements for Granular A or Granular B Type II and should be compacted in maximum 300 millimetre thick loose lifts to 98 percent of the standard Proctor maximum dry density. It is considered that the engineered fill should be compacted using dynamic compaction with a large diameter vibratory steel drum roller or diesel plate compactor. If a diesel plate compactor is used, the lift thickness may need to be restricted to less than 300 mm to achieve proper compaction. Compaction should be verified by a suitable field compaction test method.

To allow the spread of load beneath the foundations, the engineered fill should extend out from the outside edges of the footings for a horizontal distance of 0.5 metres and then down and out at a slope of 1 horizontal to 1 vertical, or flatter. The excavations for the structure should be sized to accommodate this fill placement.

The first lift of engineered fill material should have a thickness of 300 millimetres in order to protect the subgrade during compaction. Should the subgrade surface consist of silt below the water table, a 4 ounce per square yard non woven geotextile fabric should be placed between the engineered fill and the silt subgrade. It is considered that the placement of a geotextile fabric between the engineered fill and the subgrade is not necessary where granular materials meeting the grading requirements for OPSS Granular A or Granular B Type I or Type II are placed on a silt subgrade above the normal ground water level. It is recommended that trucks are not used to place the engineered fill on the subgrade. The fill should be dumped at the edge of the excavation and moved into place with a tracked bulldozer or excavator.

The native soils at this site will be sensitive to disturbance from construction operations and from rainwater or snowmelt, and frost. In order to minimize disturbance, construction traffic operating directly on the subgrade should be kept to an absolute minimum and the subgrade should be protected from below freezing temperatures.

5.7 Frost Protection Requirements for Spread Footing Foundations

In general, all exterior foundation elements and those in any unheated parts of the proposed buildings should be provided with at least 1.5 metres of earth cover for frost protection purposes. Isolated, unheated foundation elements adjacent to surfaces, which are cleared of snow cover during winter months should be provided with a minimum 1.8 metres of earth cover for frost protection purposes.

5.8 Foundation Wall Backfill and Drainage

Provided the proposed finished floor surfaces are everywhere above the exterior finished grade, the granular materials beneath the proposed floor slabs are properly compacted and provided the exterior grade is adequately sloped away from the proposed buildings, no perimeter foundation drainage system is required.

Groundwater inflow from the native soils into the foundation excavations during construction, if any should be handled by pumping from sumps within the excavations.

The native soils encountered at this site are considered to be frost susceptible. As such, to prevent possible foundation frost jacking, the backfill against any unheated or insulated walls or isolated walls or piers should consist of free draining, non-frost susceptible material. If imported material is required, it should consist of sand or sand and gravel meeting OPSS Granular B Type I grading requirements.

Alternatively, foundations could be backfilled on the exterior with native material in conjunction with the use of an approved proprietary drainage layer system (such as Platon System Membrane) against the foundation wall. There is potential for possible frost jacking of the upper portion of some types of these drainage layer systems if frost susceptible material is used as backfill. To mitigate this potential, the upper approximately 0.6 metres of the foundation should be backfilled with non-frost susceptible granular material.

Where the granular backfill will ultimately support a pavement structure or walkway, it is suggested that the wall backfill material be compacted in 250 millimetre thick lifts to 95 percent of the standard Proctor dry density value. In that case any native material proposed for foundation backfill should be inspected and approved by the geotechnical engineer.

5.9 Slab on Grade Support

As stated above, it is expected that the proposed buildings will be founded on native silt or on an engineered pad placed on the native subgrade. For predictable performance of the proposed concrete floor slabs, all existing fill material and any otherwise deleterious material should be removed from below the proposed floor slab areas. The exposed native subgrade surface should then be inspected and approved by geotechnical personnel. Any soft areas evident should be subexcavated and replaced with suitable engineered fill.

The fill materials beneath the proposed concrete floor slab on grades should consist of a minimum of 150 millimetre thickness of crushed stone meeting OPSS Granular A immediately beneath the concrete floor slab followed by sand, or sand and gravel meeting the OPSS for Granular B Type I, or crushed stone meeting OPSS grading requirements for Granular B Type II, or other material approved by the Geotechnical Engineer. The fill materials should be compacted in maximum 300 millimetre thick lifts to at least 95 percent of the standard Proctor maximum dry density.

The slabs should be structurally independent from walls and columns, which are supported by the foundations. This is to reduce any structural distress that may occur as a result of differential soil movement. If it is intended to place any internal non-load bearing partitions directly on the slab-on-grades, such walls should also be structurally independent from other elements of the building founded on the conventional foundation system so that some relative vertical movement between the floor slabs and foundations can occur freely.

The concrete floor slabs should be saw cut at regular intervals to minimize random cracking of the slab due to shrinkage of the concrete. The saw cut depth should be about one quarter of the thickness of the slab. The crack control cuts should be placed at a grid spacing not exceeding the lesser of 25 times the slab thickness or 4.5 metres. The slabs should be cut as soon as it is possible to work on the slabs without damaging the surface of the slabs. Under slab drainage is not considered necessary provided that the floor slab levels are above the finished exterior ground surface level.

5.10 Ground Water in Excavation and Construction Dewatering

Groundwater was measured in boreholes BH1 to BH4, BH6, BH7, BH9 and BH10 at the time of drilling on May 29 and 30, 2023 at about 0.8 to 3.8 metres below the existing ground surface. Boreholes BH5, BH8 and BH11 were dry at the time of drilling. Water was measured in a standpipe placed within borehole BH9 at about 1.1 metres below the existing ground surface on June 14, 2023. It is expected that the proposed USF for the building foundations may be placed below the water level. As such, it is anticipated that there could be significant inflow into the excavation during construction of the foundation for the underground parking area. There is potential that a permit to take water PTTW may be required in accordance with MECP guidelines where construction dewatering may result in flows of more than 400,000 Litres/day. At minimum a registration on the Environmental Activity Sector Registry (EASR) as per O.Reg. 63/16 will be required.

5.11 Seismic Design for the Proposed Commercial Buildings

5.11.1 Seismic Site Classification Ontario Building Code

For seismic design purposes, in accordance with the 2012 OBC Section 4.1.8.4, Table 4.1.8.4.A., the site classification for seismic site response is Site Class D. The subsurface conditions below the proposed foundation design level consist of loose to compact silt with sand, loose to dense silty sand and loose to very dense glacial till followed by bedrock.

In accordance with the 2012 OBC Section 4.1.8.4, Table 4.1.8.4.A., the average properties of the top 30 metres will result in an average standard penetration resistance = $15 \leq N(60) \leq 50$. In addition there are no conditions in the profile where there are more than 3 m of soil with a plasticity index PI ≥ 20; or moisture content ≥ 40%; or undrained strength ≤ 25kPa.

5.11.1 National Building Code Seismic Hazard Calculation

The online 2015 National Building Code Seismic Hazard Calculation was used to verify the seismic conditions at the site. The design Peak Ground Acceleration (PGA) for the site was calculated as 0.250 with a 2% probability of exceedance in 50 years based on the interpolation of the 2015 National Building Code Seismic Hazard calculation. The seismic site classification for the site is indicated to be Seismic Site Class D. The results of the calculation are attached in Attachment C following the text of this report.

5.11.2 Potential for Soil Liquefaction

As previously indicated, the soils below the proposed foundations will consist of silt followed by sand over glacial till overlying bedrock at about 6.3 to greater than 8.2 metres below the existing ground surface. Consideration for the potential for soil liquefaction was determined by considering the ratio between the cyclic resistance ratio (CRR) and the cyclic stress ratio (CSR) for the soils between the proposed underside of footing level and the depth explored by standard penetration testing. CSR and CRR values are not computed for N'(60) > 30

For Building A
The average factor of safety against liquefaction for the soils assessed for an earthquake with a magnitude of 7.5 is 0.295 / 0.020 = 10.0

For Building B
The average factor of safety against liquefaction for the soils assessed for an earthquake with a magnitude of 7.5 is 0.179 / 0.022 = 8.15

The silt at the site has a clay content of 26 to 27 percent. Soils with a clay content of greater than 15 percent are not considered susceptible to liquefaction. At the depth and thickness present, the sand is not considered a concern for liquefaction. As such there is no risk to the buildings at the site resulting from seismic liquefaction.

6.0 ACCESS ROADWAY AND PARKING LOT PAVEMENTS

6.1 Subgrade Preparation

In preparation for pavement construction at this site any fill materials, soft, wet or deleterious materials should be removed from the proposed access roadway and parking lot area. The exposed subgrade surface should then be proof inspected and approved by geotechnical personnel. It is considered that the subgrade should consist of silt. Any soft or unacceptable areas evident should be subexcavated and replaced with suitable earth borrow material. The subgrade should be shaped and crowned to promote drainage of the roadway and parking area granulars. Following approval of the preparation of the subgrade, the pavement granulars may be placed.

For any areas of the site that require the subgrade to be raised to proposed roadway and parking area subgrade level, the material used should consist of OPSS select subgrade material or OPSS Granular B Type I or Type II. Materials used for raising the subgrade to proposed roadway and parking area subgrade level should be placed in maximum 300 millimetre thick loose lifts and be compacted to at least 95 percent of the standard Proctor maximum dry density using suitable compaction equipment.

6.2 Parking Area Structure

Based on the results of the boreholes, a layer of fill materials (silty sand, fine to medium sand, sand and gravel) overlying native silt was encountered. It is considered that the fill materials and any other deleterious materials should be removed within the proposed parking areas.

Following approval of the subgrade surface by geotechnical personnel, the granular material (engineered fill) consisting of granular crushed stone meeting OPSS grading requirements as described below.

Asphaltic Concrete Surfaced Areas
For pavement areas subject to cars and light trucks the pavement should consist of:

50 millimetres of Superpave 12.5 hot mix asphaltic concrete over
150 millimetres of OPSS Granular A base over
300 millimetres of OPSS Granular B, Type II subbase

(50 or 100 millimetre minus crushed stone)

Non-woven geotextile fabric (6 oz/sqy) such as Terrafix 360R or Thrace-Ling 150EX or approved alternative.

For pavement areas subject to heavy truck loading the pavement should consist of:

40 millimetres of Superpave 12.5 hot mix asphaltic concrete over
50 millimetres of Superpave 19 hot mix asphaltic concrete over
150 millimetres of OPSS Granular A base over
300 millimetres of OPSS Granular B, Type II subbase
(50 or 100 millimetre minus crushed stone)
Non-woven geotextile fabric (6 oz/sy) such as Terrafix 360R or Thrace-Ling 150EX or approved alternative.

Performance grade PG 58-34 asphaltic concrete should be specified. Compaction of the granular pavement materials should be carried out in maximum 300 millimetre thick loose lifts to 100 percent of the standard Proctor maximum dry density value using suitable vibratory compaction equipment.

The above pavement structures will be adequate on an acceptable subgrade, that is, one where any roadway fill has been adequately compacted. If the roadway subgrade is disturbed or wetted due to construction operations or precipitation, the granular thicknesses given above may not be adequate and it may be necessary to increase the thickness of the Granular B Type II subbase.

All areas marked “Concrete Surface” are to be designed by the structural engineer.

7.0 HYDRAULIC CONDUCTIVITY TESTING

Kollaard Associates Inc returned to the site on November 28 and 30, 2023 to complete two in-situ hydraulic conductivity assessments within the foot print of the proposed stormwater management infiltration trench (see Site Plan, Figure 1). The subsurface conditions consisted of about 1.5 metres of fill materials (fine to medium sand or sand and gravel) overlying clayey silt with a trace of sand.

A water level was taken from the standpipe installed in borehole BH9 prior to the fieldwork on November 30, 2023. Groundwater was measured at a depth of about 1.6 metres below the existing ground surface.

Two in-situ hydraulic conductivity tests were completed using a Guelph Permeameter within the area of the proposed storm infiltration area in the existing materials within 1.0 metres of the underside of the proposed infiltration trench. The existing soils at this level were described as red brown fine to medium sand fill. The results of the testing and associated calculations are included as Appendix D following this report.

The results of the calculations based on the in-situ hydraulic conductivity tests gave a coefficient of permeability of between 1.0 $*10^{-4}$ and 2.7 $*10^{-5}$ cm/s.

The following table obtained from the Low Impact Development Stormwater Management Planning and Design Guide - Appendix C produced by Credit Valley Conservation and Toronto and Region Conservation indicates the relationship between the Percolation Time, Coefficient of Permeability and Infiltration Rate.

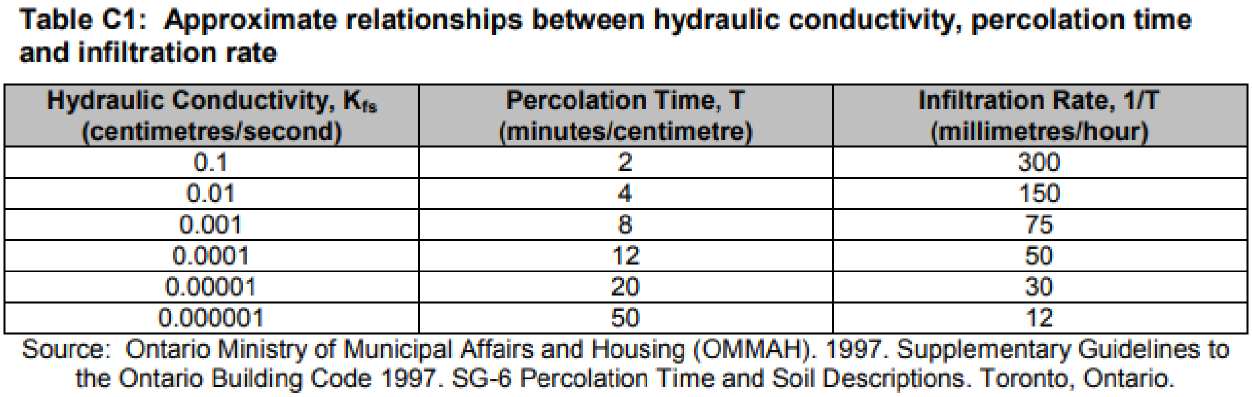


Table C1: Approximate relationships between hydraulic conductivity, percolation time and infiltration rate

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

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

From the above comparison, the existing soils within 1 metre of the bottom of the infiltration trenches would have an estimated infiltration rate of 30 to 50millimetres/hour.

8.0 CONSTRUCTION CONSIDERATIONS

It is suggested that the final design drawings for the project, including the proposed site grading plan, be reviewed by the geotechnical engineer to ensure that the guidelines provided in this report have been interpreted as intended.

The engagement of the services of the geotechnical consultant during construction is recommended to confirm that the subsurface conditions throughout the proposed development do not materially differ from those given in the report and that the construction activities do not adversely affect the intent of the design.

All foundation areas and any engineered fill areas for the proposed buildings should be inspected by Kollaard Associates Inc. to ensure that a suitable subgrade has been reached and properly prepared. The placing and compaction of any granular materials beneath the foundations should be inspected to ensure that the materials used conform to the grading and compaction specifications.

The subgrade for the access roadway and parking areas should be inspected and approved by geotechnical personnel. In situ density testing should be carried out on the roadway and parking area granular materials to ensure the materials meet the specifications from a compaction point of view.

The native silt at this site will be sensitive to disturbance from construction operations, from rainwater or snow melt and frost. In order to minimize disturbance, construction traffic operating directly on the subgrade should be kept to an absolute minimum and the subgrade should be protected from below freezing temperatures.

We trust this report provides sufficient information for your present purposes. If you have any questions concerning this report or if we may be of further services to you, please do not hesitate to contact our office.

Regards,
Kollaard Associates Inc.

Dean Tataryn

LICENSED PROFESSIONAL ENGINEER
Aug 29, 2024
S.E. deWit
100079612
PROVINCE OF ONTARIO

Dean Tataryn, B.E.S., EP.

Steve DeWit, P.Eng.

BOREHOLE BH01

PROJECT: Proposed Industrial Development
CLIENT: Sunbelt Rentals Inc
LOCATION:151 - 159 Wescar Lane
PENETRATION TEST HAMMER:63.5 kg, Drop, 0.76 mm

PROJECT NUMBER:230403
DATE OF BORING: 2023-05-29
SHEET:1 of 1
DATUM:GEODETIC

SOIL PROFILE			
DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)
Yellow brown fine to medium sand (FILL)	0.00	▩	120.72
Grey brown fine to medium sand (FILL)	0.76	▩	119.96
Grey CLAYEY SILT, trace sand	1.22	▥	119.50
Grey SILTY SAND	4.11		116.61
Grey fine to medium SAND	5.33		115.39
Grey silty sand, some gravel, cobbles, boulders, trace clay (GLACIAL TILL)	7.32		113.40
End of borehole in GLACIAL TILL	8.23		112.49

SAMPLES			MOISTURE CONTENT (%)
NUMBER	TYPE	BLOWS/0.3m	
1	SS	8	12
2	SS	26	19
3	SS	5	32
4	SS	7	20
5	SS	2	23
6	SS	11	17
7	SS	6	21
8	SS	21	20
9	SS	29	20
10	SS	9	25
11	SS	7	13

DEPTH SCALE (meters): 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0

UNDIST SHEAR STRENGTH x Cu. kPa x
REM SHEAR STRENGTH o Cu. kPa o
0 20 40 60 80 100

DYNAMIC CONE PENETRATION TEST
blows/300 mm
0 20 40 60 80 100

PIEZOMETER OR STANDPIPE INSTALLATION

Some groundwater observed at about 3.0 metres below the existing ground surface, May 29, 2023. ∇

DEPTH SCALE: 1 to 50
LOGGED: CI
BORING METHOD: Power Auger
AUGER TYPE: 200 mm Hollow Stem
CHECKED: SD

BOREHOLE BH02

PROJECT: Proposed Industrial Development
CLIENT: Sunbelt Rentals Inc
LOCATION: 151 - 159 Wescar Lane
PENETRATION TEST HAMMER: 63.5 kg, Drop, 0.76 mm

PROJECT NUMBER: 230403
DATE OF BORING: 2023-05-29
SHEET: 1 of 1
DATUM: GEODETIC

SOIL PROFILE			
DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)
Red brown fine to medium sand (FILL)	0.00		121.02
Grey silty clay (FILL)	0.30		120.72
Yellow brown fine to medium sand (FILL)	1.07		119.95
Grey brown CLAYEY SILT, trace sand	1.52		119.50
Grey CLAYEY SILT, trace sand	3.05		117.97
Grey fine to medium SAND	4.88		116.14
Grey SILTY SAND	5.64		115.38
Grey silty sand, some gravel, cobbles, boulders, trace clay (GLACIAL TILL)	6.10		114.92
Practical refusal on bedrock or large boulder	7.62		113.40

SAMPLES			MOISTURE CONTENT (%)
NUMBER	TYPE	BLOWS/0.3m	
1	SS	1	12
2	SS	6	15
3	SS	8	29
4	SS	9	21
5	SS	7	28
6	SS	9	20
7	SS	12	22
8	SS	1	22
9	SS	58	11
10	SS	16	13

DEPTH SCALE (meters): 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0

UNDIST SHEAR STRENGTH x Cu. kPa x
REM SHEAR STRENGTH o Cu. kPa o
0 20 40 60 80 100

DYNAMIC CONE PENETRATION TEST
blows/300 mm
0 20 40 60 80 100

PIEZOMETER OR STANDPIPE INSTALLATION

Some groundwater observed at about 3.8 metres below the existing ground surface, May 29, 2023.

∇

DEPTH SCALE: 1 to 50
LOGGED: CI

BORING METHOD: Power Auger
AUGER TYPE: 200 mm Hollow Stem
CHECKED: SD

BOREHOLE BH03

PROJECT: Proposed Industrial Development
CLIENT: Sunbelt Rentals Inc
LOCATION: 151 - 159 Wescar Lane
PENETRATION TEST HAMMER: 63.5 kg, Drop, 0.76 mm

PROJECT NUMBER: 230403
DATE OF BORING: 2023-05-29
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE				SAMPLES			UNDIST SHEAR STRENGTH x Cu. kPa x / REM SHEAR STRENGTH o Cu. kPa o	DYNAMIC CONE PENETRATION TEST blows/300 mm	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	NUMBER	TYPE	BLOWS/0.3m	0 20 40 60 80 100	0 20 40 60 80 100		
	Yellow brown silty sand (FILL)	0.00		122.42							
	Yellow brown sand and gravel (FILL)	0.30		122.12	1	SS	9			7	
1.0					2	SS	26			4	
	Grey brown CLAYEY SILT, trace sand	1.22		121.20							
2.0					3	SS	19			17	Some groundwater observed at about 3.0 metres below the existing ground surface, May 29, 2023. ▽
					4	SS	38			20	
3.0	Grey CLAYEY SILT, trace sand	3.05		119.37	5	SS	7			20	
4.0					6	SS	3			27	
5.0					7	SS	2			22	
					8	SS	3			19	
6.0	Grey SILTY SAND	5.79		116.63	9	SS	15			20	
7.0	Grey silty sand, some gravel, cobbles, boulders, trace clay (GLACIAL TILL)	7.01		115.41	10	SS	2			19	
					11	SS	100			24	
	Practical refusal on bedrock or large boulder	7.77		114.65							

DEPTH SCALE: 1 to 50

LOGGED: CI

BORING METHOD: Power Auger

AUGER TYPE: 200 mm Hollow Stem

CHECKED: SD

BOREHOLE BH04

PROJECT: Proposed Industrial Development
CLIENT: Sunbelt Rentals Inc
LOCATION: 151 - 159 Wescar Lane
PENETRATION TEST HAMMER: 63.5 kg, Drop, 0.76 mm

PROJECT NUMBER: 230403
DATE OF BORING: 2023-05-29
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	UNDIST SHEAR STRENGTH x Cu. kPa x / REM SHEAR STRENGTH o Cu. kPa o (0 20 40 60 80 100)	DYNAMIC CONE PENETRATION TEST blows/300 mm (0 20 40 60 80 100)	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	Yellow brown sand and gravel (FILL)	0.00		122.46	1	SS	11			4	
1.0					2	SS	18			4	
2.0	Grey brown CLAYEY SILT, trace sand	1.52		120.94	3	SS	15			23	
					4	SS	41			20	Some groundwater observed at about 3.0 metres below the existing ground surface, May 29, 2023. ∇
3.0	Grey CLAYEY SILT, trace sand	3.05		119.41	5	SS	26			16	
4.0					6	SS	5			28	
5.0					7	SS	6			25	
					8	SS	17			18	
6.0	Grey fine to medium SAND	6.10		116.36	9	SS	31			22	
7.0					10	SS	10			29	
	Grey silty sand, some gravel, cobbles, boulders, trace clay (GLACIAL TILL)	7.32		115.14							
8.0					11	SS	40			16	
	End of borehole in GLACIAL TILL	8.23		114.23							

DEPTH SCALE: 1 to 50

LOGGED: CI

BORING METHOD: Power Auger

AUGER TYPE: 200 mm Hollow Stem

CHECKED: SD

BOREHOLE BH05

PROJECT: Proposed Industrial Development
CLIENT: Sunbelt Rentals Inc
LOCATION: 151 - 159 Wescar Lane
PENETRATION TEST HAMMER: 63.5 kg, Drop, 0.76 mm

PROJECT NUMBER: 230403
DATE OF BORING: 2023-05-29
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE				SAMPLES			UNDIST SHEAR STRENGTH x Cu. kPa x REM SHEAR STRENGTH o Cu. kPa o 0 20 40 60 80 100	DYNAMIC CONE PENETRATION TEST blows/300 mm 0 20 40 60 80 100	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	NUMBER	TYPE	BLOWS/0.3m				
	Topsoil (FILL)	0.00	▨	121.81							
	Yellow brown silty sand (FILL)	0.10	▨	121.71							
1.0	Grey brown CLAYEY SILT, trace sand	0.61	▥	121.20							
	End of borehole in SILT	1.52		120.29							Borehole dry, May 29, 2023.

DEPTH SCALE: 1 to 50

LOGGED: CI

BORING METHOD: Power Auger

AUGER TYPE: 200 mm Hollow Stem

CHECKED: SD

BOREHOLE BH06

PROJECT: Proposed Industrial Development
CLIENT: Sunbelt Rentals Inc
LOCATION: 151 - 159 Wescar Lane
PENETRATION TEST HAMMER: 63.5 kg, Drop, 0.76 mm

PROJECT NUMBER: 230403
DATE OF BORING: 2023-05-29
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE				SAMPLES			UNDIST SHEAR STRENGTH x Cu. kPa x REM SHEAR STRENGTH o Cu. kPa o 0 20 40 60 80 100	DYNAMIC CONE PENETRATION TEST blows/300 mm 0 20 40 60 80 100	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	NUMBER	TYPE	BLOWS/0.3m				
1.0	Red brown silty sand (FILL)	0.00	▨	122.34							
	Grey brown CLAYEY SILT, trace sand	1.22	▥	121.12							∇
	End of borehole in SILT	1.52		120.82							

Some groundwater observed at about 1.2 metres below the existing ground surface, May 29, 2023.

DEPTH SCALE: 1 to 50
LOGGED: CI

BORING METHOD: Power Auger
AUGER TYPE: 200 mm Hollow Stem
CHECKED: SD

BOREHOLE BH07

PROJECT: Proposed Industrial Development
CLIENT: Sunbelt Rentals Inc
LOCATION: 151 - 159 Wescar Lane
PENETRATION TEST HAMMER: 63.5 kg, Drop, 0.76 mm

PROJECT NUMBER: 230403
DATE OF BORING: 2023-05-29
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE				SAMPLES			UNDIST SHEAR STRENGTH x Cu. kPa x	DYNAMIC CONE PENETRATION TEST	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	NUMBER	TYPE	BLOWS/0.3m	REM SHEAR STRENGTH o Cu. kPa o 0 20 40 60 80 100	blows/300 mm 0 20 40 60 80 100		
1.0	Yellow brown sand and gravel (FILL)	0.00	▨	122.06							∇
	End of borehole in FILL	1.52		120.54							Some groundwater observed at about 1.2 metres below the existing ground surface, May 29, 2023.

DEPTH SCALE: 1 to 50

LOGGED: CI

BORING METHOD: Power Auger

AUGER TYPE: 200 mm Hollow Stem

CHECKED: SD

BOREHOLE BH08

PROJECT: Proposed Industrial Development
CLIENT: Sunbelt Rentals Inc
LOCATION:151 - 159 Wescar Lane
PENETRATION TEST HAMMER:63.5 kg, Drop, 0.76 mm

PROJECT NUMBER:230403
DATE OF BORING: 2023-05-30
SHEET:1 of 1
DATUM:GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE				SAMPLES			UNDIST SHEAR STRENGTH x Cu. kPa x	DYNAMIC CONE PENETRATION TEST	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	NUMBER	TYPE	BLOWS/0.3m	REM SHEAR STRENGTH o Cu. kPa o 0 20 40 60 80 100	blows/300 mm 0 20 40 60 80 100		
	Red brown silty sand (FILL)	0.00	▨	121.09							
1.0	Grey brown CLAYEY SILT, trace sand	0.61	▥	120.48							
	End of borehole in SILT	1.52		119.57							Borehole dry, May 30, 2023.

DEPTH SCALE: 1 to 50

LOGGED: CI

BORING METHOD: Power Auger

AUGER TYPE: 200 mm Hollow Stem

CHECKED: SD

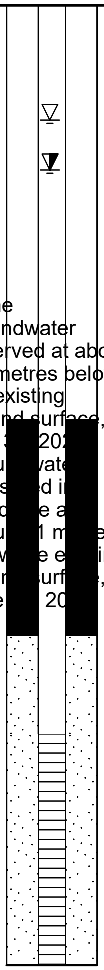
BOREHOLE BH09

PROJECT: Proposed Industrial Development
CLIENT: Sunbelt Rentals Inc
LOCATION:151 - 159 Wescar Lane
PENETRATION TEST HAMMER:63.5 kg, Drop, 0.76 mm

PROJECT NUMBER:230403
DATE OF BORING: 2023-05-30
SHEET:1 of 1
DATUM:GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	UNDIST SHEAR STRENGTH x Cu. kPa x / REM SHEAR STRENGTH o Cu. kPa o (0 20 40 60 80 100)	DYNAMIC CONE PENETRATION TEST blows/300 mm (0 20 40 60 80 100)	MOISTURE CONTENT (%)
	Yellow brown silty sand (FILL)	0.00		120.98	1	SS	7			11
	Yellow brown fine to medium sand (FILL)	0.40		120.58						
1.0	Grey brown fine to medium sand (FILL)	0.61		120.37						
	Grey brown CLAYEY SILT, trace sand	1.07		119.91	2	SS	2			25
2.0	Grey CLAYEY SILT, trace sand	1.52		119.46	3	SS	4			27
					4	SS	8			29
3.0	Grey SILTY SAND	2.74		118.24						
	Grey silty sand, some gravel, cobbles, boulders, trace clay (GLACIAL TILL)	3.35		117.63	5	SS	18			24
4.0					6	SS	14			13
5.0					7	SS	23			7
6.0					8	SS	84			7
					9	SS	100			9
	Practical refusal on bedrock or large boulder	6.35		114.63						

PIEZOMETER OR STANDPIPE INSTALLATION



Some groundwater observed at about 0.8 metres below the existing ground surface, May 3[illegible] 202[illegible]. Groundwater measured in standpipe at about [illegible]1 metres below the existing ground surface, June [illegible] 20[illegible].

DEPTH SCALE: 1 to 50

LOGGED: CI

BORING METHOD: Power Auger

AUGER TYPE: 200 mm Hollow Stem

CHECKED: SD

BOREHOLE BH10

PROJECT: Proposed Industrial Development
CLIENT: Sunbelt Rentals Inc
LOCATION:151 - 159 Wescar Lane
PENETRATION TEST HAMMER:63.5 kg, Drop, 0.76 mm

PROJECT NUMBER:230403
DATE OF BORING: 2023-05-30
SHEET:1 of 1
DATUM:GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE				SAMPLES			UNDIST SHEAR STRENGTH x Cu. kPa x / REM SHEAR STRENGTH o Cu. kPa o	DYNAMIC CONE PENETRATION TEST blows/300 mm	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	NUMBER	TYPE	BLOWS/0.3m	0 20 40 60 80 100	0 20 40 60 80 100		
1.0	Red brown fine to medium sand (FILL)	0.00	▨	121.42							
	Grey brown CLAYEY SILT, trace sand	1.00	▥	120.42							∇
	End of borehole in SILT	1.52		119.90							

Some groundwater observed at about 1.3 metres below the existing ground surface, May 30, 2023.

DEPTH SCALE: 1 to 50

LOGGED: CI

BORING METHOD: Power Auger

AUGER TYPE: 200 mm Hollow Stem

CHECKED: SD

BOREHOLE BH11

PROJECT: Proposed Industrial Development
CLIENT: Sunbelt Rentals Inc
LOCATION: 151 - 159 Wescar Lane
PENETRATION TEST HAMMER: 63.5 kg, Drop, 0.76 mm

PROJECT NUMBER: 230403
DATE OF BORING: 2023-05-30
SHEET: 1 of 1
DATUM: GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE				SAMPLES			UNDIST SHEAR STRENGTH x Cu. kPa x REM SHEAR STRENGTH o Cu. kPa o 0 20 40 60 80 100	DYNAMIC CONE PENETRATION TEST blows/300 mm 0 20 40 60 80 100	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	NUMBER	TYPE	BLOWS/0.3m				
	Red brown silty sand (FILL)	0.00	▨	120.96							
1.0			▨								
	End of borehole in FILL	1.52		119.44							Borehole dry, May 30, 2023.

DEPTH SCALE: 1 to 50

LOGGED: CI

BORING METHOD: Power Auger

AUGER TYPE: 200 mm Hollow Stem

CHECKED: SD

BOREHOLE BH-STORM

PROJECT: Proposed Industrial Development
CLIENT: Sunbelt Rentals Inc
LOCATION:151 - 159 Wescar Lane
PENETRATION TEST HAMMER:

PROJECT NUMBER:230403
DATE OF BORING: 2023-05-30
SHEET:1 of 1
DATUM:GEODETIC

DEPTH SCALE (meters)	SOIL PROFILE				SAMPLES			UNDIST SHEAR STRENGTH x Cu. kPa x	DYNAMIC CONE PENETRATION TEST	MOISTURE CONTENT (%)	PIEZOMETER OR STANDPIPE INSTALLATION
	DESCRIPTION	DEPTH (m)	STRATA PLOT	ELEV. (m)	NUMBER	TYPE	BLOWS/0.3m	REM SHEAR STRENGTH o Cu. kPa o 0 20 40 60 80 100	blows/300 mm 0 20 40 60 80 100		
	Red brown fine to medium sand (FILL)	0.00	▩								
	Grey brown fine to medium sand (FILL)	0.15	▩		1	SS	5				
1.0			▩		2	SS	8				∇
	Grey brown sand and gravel (FILL)	1.07	▩								
	Grey brown CLAYEY SILT, trace sand	1.52	▥		3	SS	7				
2.0			▥								Some groundwater osberved at about 1.1 metres below the existing ground surface, May 30, 2023.
			▥		4	SS	7				
3.0			▥								
	End of borehole in SILT	3.05									

DEPTH SCALE: 1 to 50

LOGGED: CI

BORING METHOD: Power Auger

AUGER TYPE: 200 mm Hollow Stem

CHECKED: SD

LIST OF ABBREVIATIONS AND TERMINOLOGY

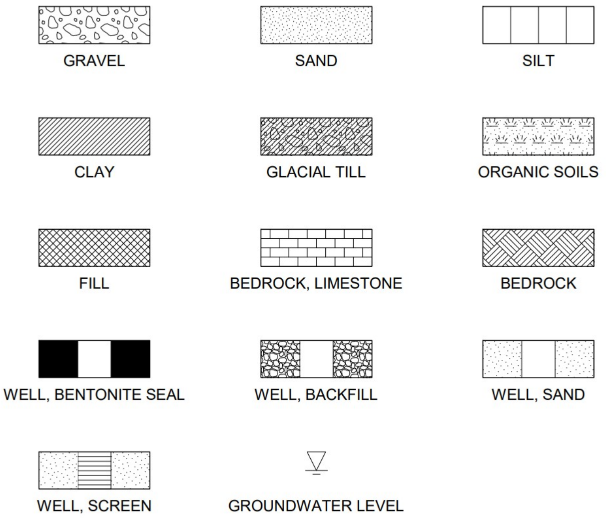
SAMPLE TYPES	
AS	Auger Sample
CS	Chunk Sample
DO	Drive Open
MS	Manual Sample
RC	Rock Core
SS	Split Spoon Sample
TO	Thin-Walled Open Shelby Tube
WS	Wash Sample

PENETRATION RESISTANCE

Standard Penetration Resistance (N)
The number of blows by a 63.5 kg hammer dropped 760 millimeters required to drive a 50 mm drive open sampler for a distance of 300 mm.

Dynamic Penetration Resistance
The number of blows by a 63.5 kg hammer dropped 760 mm to drive a 50 mm diameter, 60° cone attached to 'A' size drill rods for a distance of 300 mm.

WH	Sampler advanced by static weight of hammer and drill rods.
WR	Sampler advanced by static weight of drill rods.
PH	Sampler advanced by hydraulic pressure from drill rig.
PM	Sampler advanced by manual pressure.



SOIL DESCRIPTIONS

Relative Density	'N' Value
Very Loose	0 – 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	>50

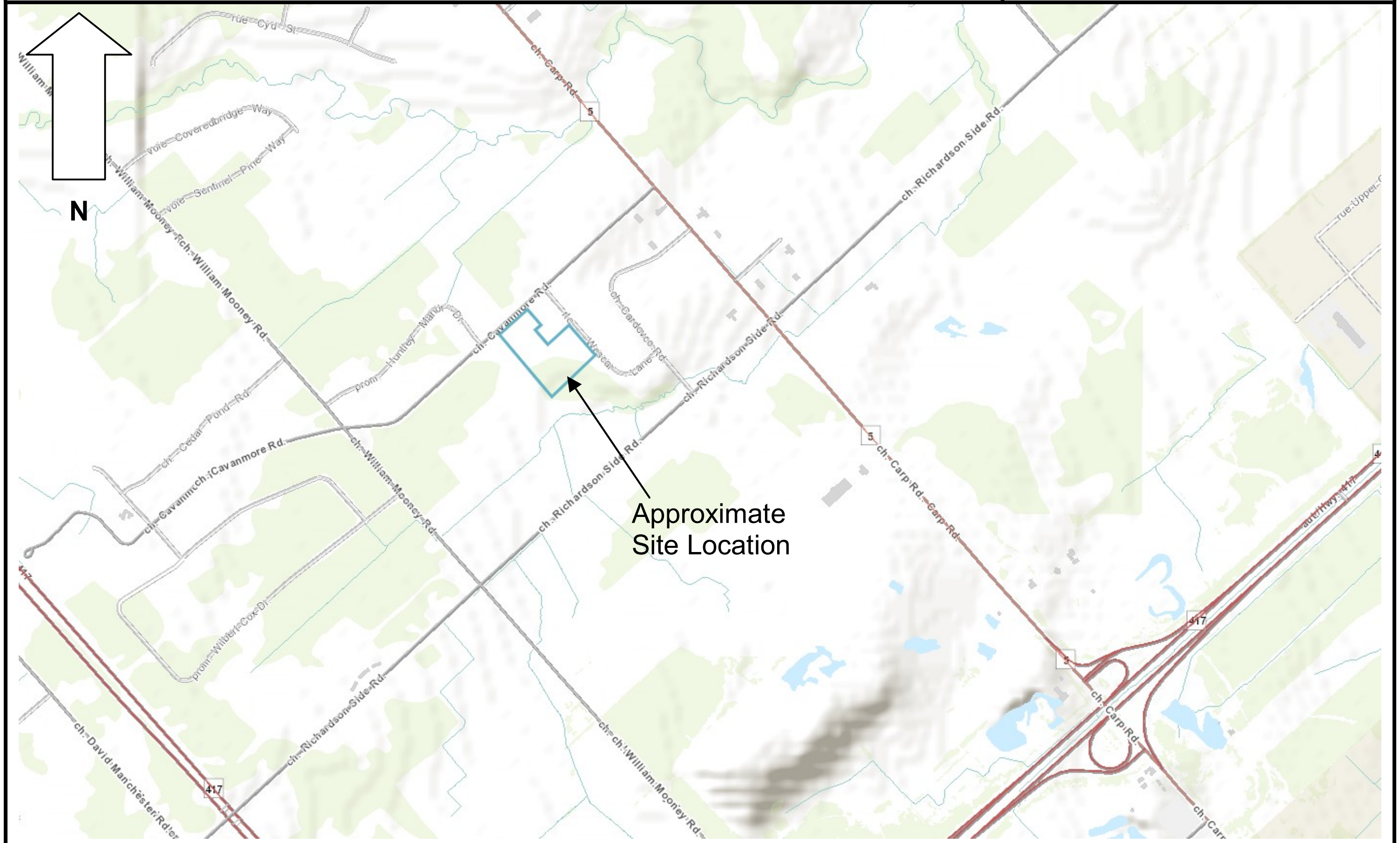
Consistency	Cu, kPa
Very Soft	0 – 12
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	>100

LIST OF COMMON SYMBOLS	
Cu	Undrained Shear Strength
e	Void Ratio
Cc	Compression Index
Cv	Coefficient of Consolidation
k	Coefficient of Permeability
PI	Plasticity Index
n	Porosity
u	Pore Pressure
W	Moisture Content
LL	Liquid Limit
PL	Plastic Limit
r	Unit Weight of Soil
y	Unit Weight of Submerged Soil
cr	Normal Stress

SOIL TESTS	
C	Consolidation Test
H	Hydrometer Analysis
M	Sieve Analysis
MH	Sieve and Hydrometer Analysis
U	Unconfined Compression Test
Q	Undrained Triaxial Test
VA	Field Vane, Undisturbed and Remolded Shear Strength

KEY PLAN

FIGURE 1

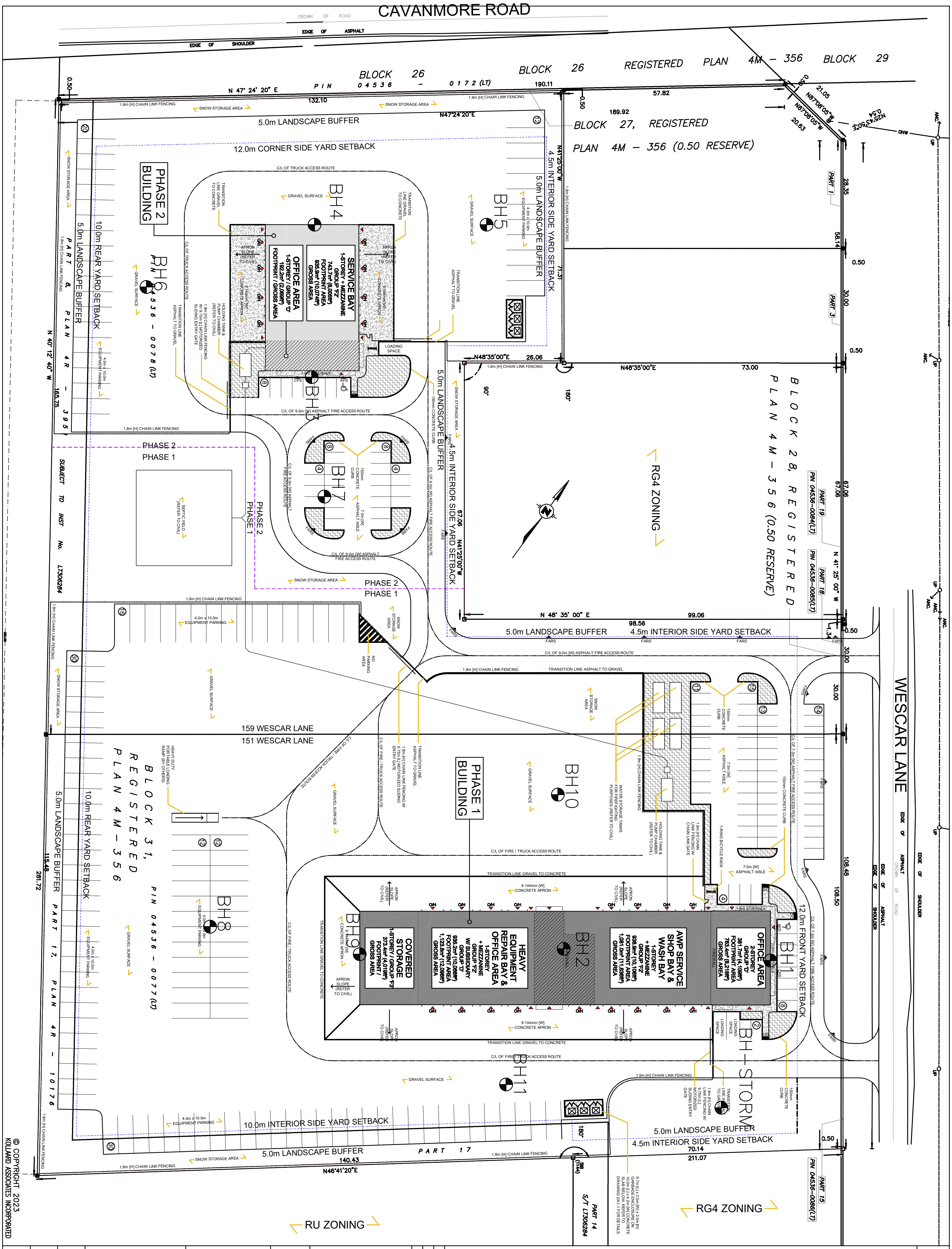


NOT TO SCALE

Kollaard Associates
Engineers

Project No. 230403

Date June 2023



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KOLLAARD ASSOCIATES INCORPORATED

DRAWING NUMBER:
SITE PLAN, FIGURE 2

LEGEND:
BH1 ● APPROXIMATE BOREHOLE LOCATION

REFERENCE: PLAN SUPPLIED BY SUNBELT RENTALS INC

SPECIAL NOTE: THIS DRAWING TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING REPORT.

REV.	NAME	DATE	DESCRIPTION

Kollaard Associates
Engineers

P.O. BOX 189, 210 PRESCOTT ST
KEMPTVILLE ONTARIO
K0G 1J0 FAX (613) 258-0475
http://www.kollaard.ca
(613) 860-0923
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CLIENT:
SUNBELT RENTALS INC.

PROJECT:
GEOTECHNICAL INVESTIGATION FOR PROPOSED COMMERCIAL DEVELOPMENT

LOCATION:
151-159 WESCAR LANE
OTTAWA, ONTARIO

DESIGNED BY: --
DATE: JUNE 14, 2023
DRAWN BY: DT
SCALE: N.T.S
KOLLAARD FILE NUMBER: 230403

ATTACHMENT A

Laboratory Test Results for Physical Properties

Moisture Content

LS - 701 / ASTM D 2216

PROJECT NO.: 230403	DATE SAMPLED: May 29 & 30, 2023	DATE TESTED: May 31, 2023
CLIENT: Sunbelt Rentals Inc	DATE RECEIVED:	TESTED BY: CI
LOCATION: 151 - 159 Wescar Lane	DATE REQUESTED:	FILE NO.:

METHOD A ■ METHOD B ☐

Water Content Recorded to +/- 1%			Water Content Recorded to +/- 0.1%		
Sieve Size, mm	Specimen Mass	Balance Readability, g	Sieve Size, mm	Specimen Mass	Balance Readability, g
75.0	5 kg	10	75.0	5 kg	10
37.5	1 kg	10	37.5	1 kg	10
19	250 g	0.1	19	250 g	0.1
9.5	50 g	0.1	9.5	50 g	0.1
4.75	20 g	0.1	4.75	20 g	0.1
2.00	20 g	0.1	2.00	20 g	0.1

ASTM D 2216 TABLE 1

Bore Hole:	BH1	BH1	BH1	BH1	BH1	BH1	BH1	BH1	BH1
Sample No.:	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9
Depth:	0-0.6	0.8-1.4	1.5-2.1	2.3-2.9	3.0-3.6	3.8-4.4	4.5-5.2	5.3-5.9	6.1-6.7
Tare No.:	1	2	3	4	5	6	7	8	9
Tare +Wet Soil (gms)	80.64	99.13	82.10	89.69	87.86	78.69	110.95	100.81	105.69
Tare + Dry Soil (gms)	74.48	86.90	67.13	78.00	75.33	70.11	95.66	87.31	91.62
Mass of Water (gms)	6.16	12.23	14.97	11.69	12.53	8.58	15.29	13.50	14.07
Mass of Tare (gms)	20.92	20.93	20.96	20.96	20.93	20.94	21.13	21.11	21.43
Mass of Solids (gms)	53.56	65.97	46.17	57.04	54.40	49.17	74.53	66.20	70.19
WATER CONTENT (%)	12	19	32	20	23	17	21	20	20
Drying Tempterature (ºC), if other than 110 ±5ºC									

Bore Hole:	BH1	BH1	BH2	BH2	BH2	BH2	BH2	BH2	BH2
Sample No.:	SS10	SS11	SS1	SS2	SS3	SS4	SS5	SS6	SS7
Depth:	6.9-7.5	7.6-8.2	0-0.6	0.8-1.4	1.5-2.1	2.3-2.9	3.0-3.6	3.8-4.4	4.5-5.2
Tare No.:	10	11	12	13	14	15	16	17	18
Tare +Wet Soil (gms)	106.24	115.78	78.84	93.33	103.92	87.54	102.70	93.42	112.06
Tare + Dry Soil (gms)	89.22	105.19	72.83	83.89	85.24	75.96	84.88	81.33	95.62
Mass of Water (gms)	17.02	10.59	6.01	9.44	18.68	11.58	17.82	12.09	16.44
Mass of Tare (gms)	21.02	20.91	20.94	20.95	20.84	21.05	20.94	20.87	20.96
Mass of Solids (gms)	68.20	84.28	51.89	62.94	64.40	54.91	63.94	60.46	74.66
WATER CONTENT (%)	25	13	12	15	29	21	28	20	22
Drying Tempterature (ºC), if other than 110 ±5ºC									

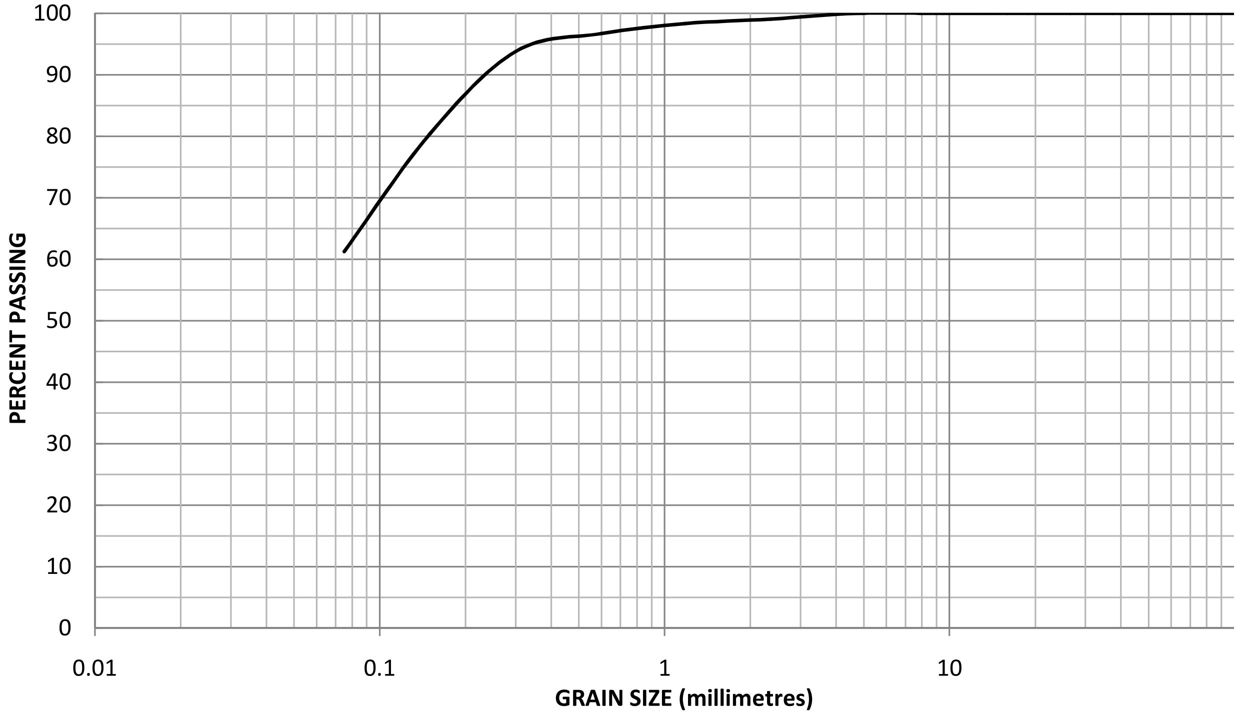
Bore Hole:	BH2	BH2	BH2	BH3	BH3	BH3	BH3	BH3	BH3
Sample No.:	SS8	SS9	SS10	SS1	SS2	SS3	SS4	SS5	SS6
Depth:	5.3-5.9	6.1-6.7	6.9-7.5	0-0.6	0.8-1.4	1.5-2.1	2.3-2.9	3.0-3.6	3.8-4.4
Tare No.:	19	20	21	22	23	24	25	26	27
Tare +Wet Soil (gms)	95.67	89.07	109.45	87.67	88.31	102.03	81.41	112.57	89.42
Tare + Dry Soil (gms)	81.97	82.29	99.60	83.31	85.62	90.34	71.26	97.19	75.00
Mass of Water (gms)	13.70	6.78	9.85	4.36	2.69	11.69	10.15	15.38	14.42
Mass of Tare (gms)	21.05	21.12	20.99	20.99	21.05	21.02	20.92	21.01	20.98
Mass of Solids (gms)	60.92	61.17	78.61	62.32	64.57	69.32	50.34	76.18	54.02
WATER CONTENT (%)	22	11	13	7	4	17	20	20	27
Drying Tempterature (ºC), if other than 110 ±5ºC									

Bore Hole:	BH3	BH3	BH3	BH3	BH3	BH4	BH4	BH4	BH4
Sample No.:	SS7	SS8	SS9	SS10	SS11	SS1	SS2	SS3	SS4
Depth:	4.5-5.2	5.3-5.9	6.1-6.7	6.9-7.5	7.6-8.2	0-0.6	0.8-1.4	1.5-2.1	2.3-2.9
Tare No.:	28	29	30	31	32	33	34	35	36
Tare +Wet Soil (gms)	89.59	96.85	110.73	96.21	102.62	77.86	92.68	79.82	79.46
Tare + Dry Soil (gms)	77.42	84.46	95.62	84.20	86.83	75.56	90.08	68.62	69.88
Mass of Water (gms)	12.17	12.39	15.11	12.01	15.79	2.30	2.60	11.20	9.58
Mass of Tare (gms)	20.91	20.91	20.99	20.88	20.95	21.03	20.98	20.95	20.90
Mass of Solids (gms)	56.51	63.55	74.63	63.32	65.88	54.53	69.10	47.67	48.98
WATER CONTENT (%)	22	19	20	19	24	4	4	23	20
Drying Tempterature (ºC), if other than 110 ±5ºC									

Bore Hole:	BH4	BH4	BH4	BH4	BH4	BH4	BH4	BH9	BH9
Sample No.:	SS5	SS6	SS7	SS8	SS9	SS10	SS11	SS1	SS2
Depth:	3.0-3.6	3.8-4.4	4.5-5.2	5.3-5.9	6.1-6.7	6.9-7.5	7.6-8.2	0-0.6	0.8-1.4
Tare No.:	37	38	39	40	41	42	43	44	45
Tare +Wet Soil (gms)	94.51	88.84	91.91	78.48	92.17	88.77	99.04	75.79	72.02
Tare + Dry Soil (gms)	84.19	74.05	77.85	69.57	79.28	73.45	88.48	70.20	61.85
Mass of Water (gms)	10.32	14.79	14.06	8.91	12.89	15.32	10.56	5.59	10.17
Mass of Tare (gms)	21.08	20.94	20.87	21.03	20.95	20.81	21.01	20.89	20.95
Mass of Solids (gms)	63.11	53.11	56.98	48.54	58.33	52.64	67.47	49.31	40.90
WATER CONTENT (%)	16	28	25	18	22	29	16	11	25
Drying Tempterature (ºC), if other than 110 ±5ºC									

Bore Hole:	BH9	BH9	BH9	BH9	BH9	BH9	BH9		
Sample No.:	SS3	SS4	SS5	SS6	SS7	SS8	SS9		
Depth:	1.5-2.1	2.3-2.9	3.0-3.6	3.8-4.4	4.5-5.2	5.3-5.9	6.1-6.7		
Tare No.:	46	47	48	1	2	3	4		
Tare +Wet Soil (gms)	81.31	81.98	87.50	92.66	92.40	80.15	85.30		
Tare + Dry Soil (gms)	68.60	68.25	74.40	84.59	87.83	76.22	79.83		
Mass of Water (gms)	12.71	13.73	13.10	8.07	4.57	3.93	5.47		
Mass of Tare (gms)	20.89	21.13	20.93	20.92	20.95	20.92	20.94		
Mass of Solids (gms)	47.71	47.12	53.47	63.67	66.88	55.30	58.89		
WATER CONTENT (%)	27	29	24	13	7	7	9		
Drying Tempterature (ºC), if other than 110 ±5ºC									

GRAIN SIZE DISTRIBUTION ANALYSIS	FIGURE 1



SIEVE SIZE (mm)	76.2	53	26.5	19.0	16	13.2	9.5	4.75	2.36	1.180	0.600	0.300	0.15	0.075
SAMPLE PASSING			100.0	100.0	100.0	100.0	100.0	100.0	99.1	98.4	96.7	93.8	80.5	61.2

CLIENT: Sunbelt Rentals Inc

PROJECT: 151-159 Wescar Lane

OUR REF.: 230403

TYPE OF MATERIAL: Sandy Silt

INTENDED USE:

DATE SAMPLED: May 29, 2023

DATE TESTED: June 1, 2023

SOURCE: BH2-SS8

SAMPLE NO: 1

REMARKS:

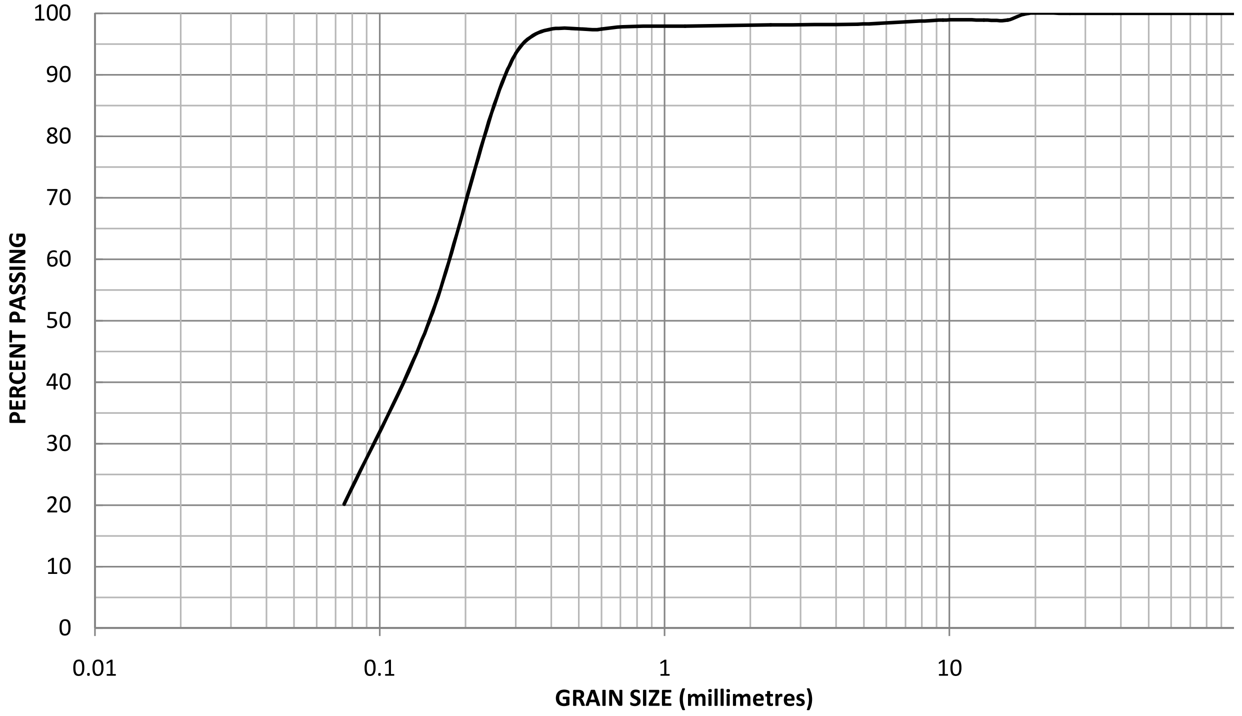
Kollaard Associates
Engineers
210 Prescott Street
Box 189
Kemptville, ON K0G 1J0
(613) 860-0923, www.kollaard.ca

Tested by: Ashlea Keevil-McKirdy

Issued by: Dean Tataryn, B.E.S., EP

Date: June 6, 2023

GRAIN SIZE DISTRIBUTION ANALYSIS	FIGURE 2



SIEVE SIZE (mm)	76.2	53	26.5	19.0	16	13.2	9.5	4.75	2.36	1.180	0.600	0.300	0.15	0.075
SAMPLE PASSING			100.0	100.0	98.9	98.9	98.9	98.3	98.1	97.9	97.5	93.5	50.2	20.2

CLIENT: Sunbelt Rentals Inc

PROJECT: 151-159 Wescar Lane

OUR REF.: 230403

TYPE OF MATERIAL: Sandy Silt

INTENDED USE:

DATE SAMPLED: May 29, 2023

DATE TESTED: June 1, 2023

SOURCE: BH4-SS9

SAMPLE NO: 2

REMARKS:

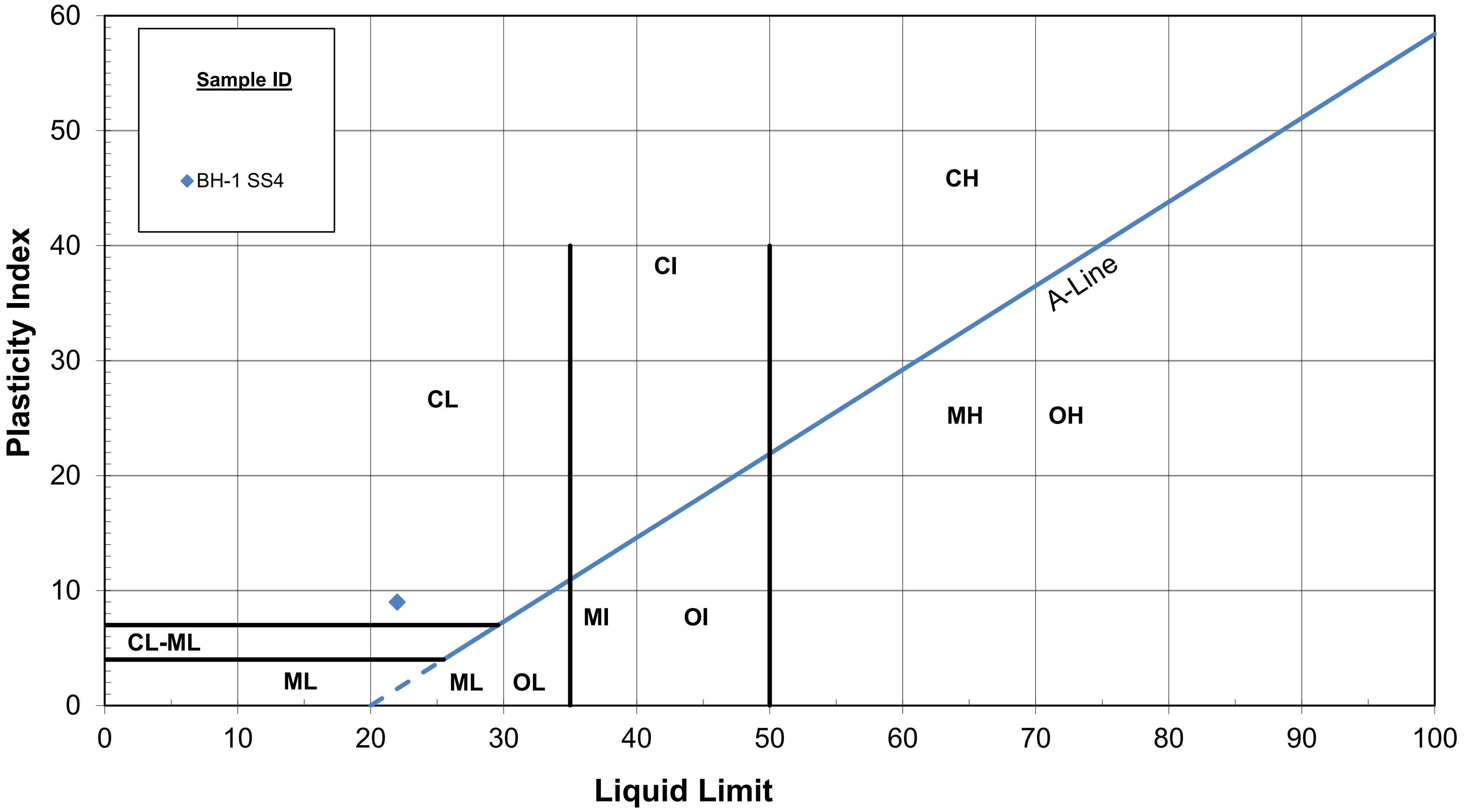
Kollaard Associates
Engineers
210 Prescott Street
Box 189
Kemptville, ON K0G 1J0
(613) 860-0923, www.kollaard.ca

Tested by: Ashlea Keevil-McKirdy

Issued by:

Dean Tataryn, B.E.S., EP

Date: June 6, 2023



Kollaard Associates, File #230403

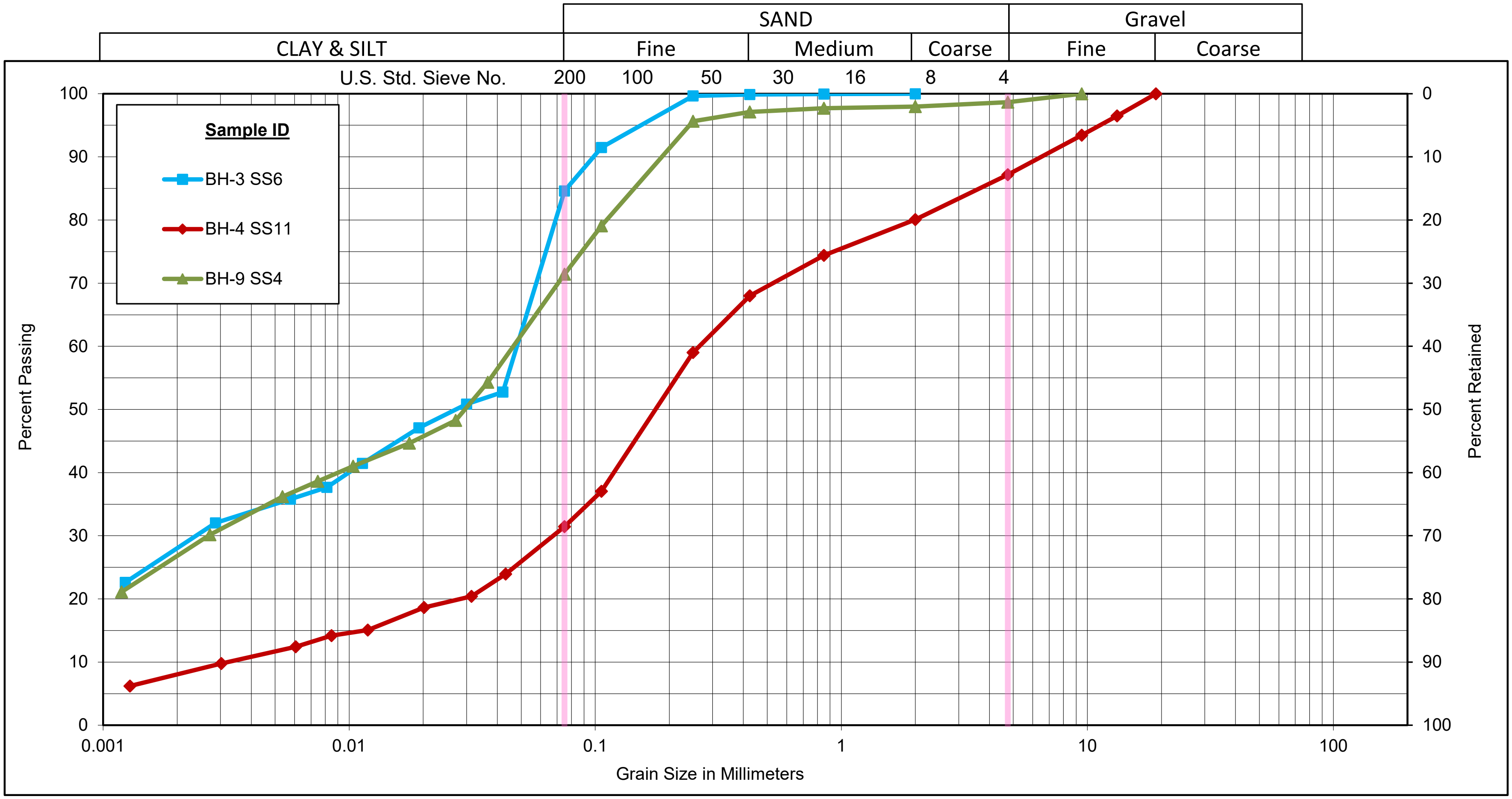
151-159 Wescas Lane

PLASTICITY CHART

Figure No.

Project No. 122410003

Unified Soil Classification System



Sample ID	Depth	% Gravel	% Sand	% Silt	% Clay
BH-3 SS6	12'6"-14'6"	0.0	15.4	57.6	27.0
BH-4 SS11	25'-27'	12.8	55.8	23.4	8.0
BH-9 SS4	7'6"-9'6"	1.3	27.3	45.4	26.0

Stantec

GRAIN SIZE DISTRIBUTION

Kollaard Associates, File #230403
151-159 Wescas Lane

Figure No.

Project No. 122410003

Stantec

Particle-Size Analysis of Soils

LS702

AASHTO T88

PROJECT DETAILS

Client:	**Kollaard Associates, File #230403**	Project No.:	**122410003**
Project:	**151-159 Wescas Lane**	Test Method:	**LS702**
Material Type:	**Soil**	Sampled By:	**Kollaard Associates**
Source:	**BH-3**	Date Sampled:	**June 2, 2023**
Sample No.:	**SS6**	Tested By:	**Brian Prevost**
Sample Depth	**12'6"-14'6"**	Date Tested:	**June 9, 2023**

WASH TEST DATA

Oven Dry Mass In Hydrometer Analysis (g)	51.94
Sample Weight after Hydrometer and Wash (g)	8.34
Percent Passing No. 200 Sieve (%)	**83.9**
Percent Passing Corrected (%)	**83.94**

PERCENT LOSS IN SIEVE

Sample Weight Before Sieve (g)	**203.10**
Sample Weight After Sieve (g)	**203.00**
Percent Loss in Sieve (%)	**0.05**

SOIL INFORMATION

Liquid Limit (LL)		
Plasticity Index (PI)		
Soil Classification		
Specific Gravity (G_s)	2.750	
Sg. Correction Factor (α)	0.978	
Mass of Dispersing Agent/Litre	40	g

CALCULATION OF DRY SOIL MASS

Oven Dried Mass (W_o), (g)	149.30
Air Dried Mass (W_a), (g)	150.49
Hygroscopic Corr. Factor ($F=W_o/W_a$)	0.9921
Air Dried Mass in Analysis (M_a), (g)	52.35
Oven Dried Mass in Analysis (M_o), (g)	51.94
Percent Passing 2.0 mm Sieve (P_{10}), (%)	100.00
Sample Represented (W), (g)	51.94

SIEVE ANALYSIS

Sieve Size mm	Cum. Wt. Retained	Percent Passing
75.0		100.0
63.0		100.0
53.0		100.0
37.5		100.0
26.5		100.0
19.0		100.0
13.2		100.0
9.5		100.0
4.75		100.0
2.00	0.0	100.0
Total (C + F)[1]	203.00	
0.850	0.03	99.94
0.425	0.07	99.87
0.250	0.18	99.65
0.106	4.43	91.47
0.075	7.99	84.62
PAN	8.34	

Note 1: (C + F) = Coarse + Fine

HYDROMETER DETAILS

Volume of Bulb (V_B), (cm^3)	63.0
Length of Bulb (L_2), (cm)	14.47
Length from '0' Reading to Top of Bulb (L_1), (cm)	10.29
Scale Dimension (h_s), (cm/Div)	0.155
Cross-Sectional Area of Cylinder (A), (cm^2)	27.25
Meniscus Correction (H_m), (g/L)	1.0

START TIME 9:23 AM

HYDROMETER ANALYSIS

Date	Time	Elapsed Time T Mins	H_s Divisions g/L	H_c Divisions g/L	Temperature T_c °C	Corrected Reading $R = H_s - H_c$ g/L	Percent Passing P %	L cm	η Poise	K	Diameter D mm
09-Jun-23	9:24 AM	1	35.0	7.0	23.0	28.0	52.75	10.78904	9.39251	0.012818	0.04210
09-Jun-23	9:25 AM	2	34.0	7.0	23.0	27.0	50.86	10.94404	9.39251	0.012818	0.02999
09-Jun-23	9:28 AM	5	32.0	7.0	23.0	25.0	47.10	11.25404	9.39251	0.012818	0.01923
09-Jun-23	9:38 AM	15	29.0	7.0	23.0	22.0	41.44	11.71904	9.39251	0.012818	0.01133
09-Jun-23	9:53 AM	30	27.0	7.0	23.0	20.0	37.68	12.02904	9.39251	0.012818	0.00812
09-Jun-23	10:23 AM	60	26.0	7.0	23.0	19.0	35.79	12.18404	9.39251	0.012818	0.00578
09-Jun-23	1:33 PM	250	24.0	7.0	23.0	17.0	32.0246	12.49404	9.39251	0.012818	0.00287
10-Jun-23	9:23 AM	1440	19.0	7.0	23.0	12.0	22.6056	13.26904	9.39251	0.012818	0.00123

Remarks:

Reviewed By: Brian Prevost

Date: June 12, 2023

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Stantec

Particle-Size Analysis of Soils

LS702

AASHTO T88

PROJECT DETAILS

Client:	**Kollaard Associates, File #230403**	Project No.:	**122410003**
Project:	**151-159 Wescas Lane**	Test Method:	**LS702**
Material Type:	**Soil**	Sampled By:	**Kollaard Associates**
Source:	**BH-4**	Date Sampled:	**June 2, 2023**
Sample No.:	**SS11**	Tested By:	**Brian Prevost**
Sample Depth	**25'-27'**	Date Tested:	**June 9, 2023**

WASH TEST DATA

Oven Dry Mass In Hydrometer Analysis (g)	88.35
Sample Weight after Hydrometer and Wash (g)	54.48
Percent Passing No. 200 Sieve (%)	**38.3**
Percent Passing Corrected (%)	**30.70**

PERCENT LOSS IN SIEVE

Sample Weight Before Sieve (g)	**960.50**
Sample Weight After Sieve (g)	**959.30**
Percent Loss in Sieve (%)	**0.12**

SOIL INFORMATION

Liquid Limit (LL)		
Plasticity Index (PI)		
Soil Classification		
Specific Gravity (G_s)	2.750	
Sg. Correction Factor (α)	0.978	
Mass of Dispersing Agent/Litre	24	g

CALCULATION OF DRY SOIL MASS

Oven Dried Mass (W_o), (g)	190.00
Air Dried Mass (W_a), (g)	190.61
Hygroscopic Corr. Factor ($F=W_o/W_a$)	0.9968
Air Dried Mass in Analysis (M_a), (g)	88.63
Oven Dried Mass in Analysis (M_o), (g)	88.35
Percent Passing 2.0 mm Sieve (P_{10}), (%)	80.08
Sample Represented (W), (g)	110.32

SIEVE ANALYSIS

Sieve Size mm	**Cum. Wt. Retained**	**Percent Passing**
75.0		100.0
63.0		100.0
53.0		100.0
37.5		100.0
26.5		100.0
19.0	0.0	100.0
13.2	33.6	96.5
9.5	63.1	93.4
4.75	123.2	87.2
2.00	191.3	80.1
Total (C + F)[1]	959.30	
0.850	6.27	74.40
0.425	13.33	68.00
0.250	23.23	59.03
0.106	47.49	37.04
0.075	53.67	31.43
PAN	54.46	

Note 1: (C + F) = Coarse + Fine

HYDROMETER DETAILS

Volume of Bulb (V_B), (cm^3)	63.0
Length of Bulb (L_2), (cm)	14.47
Length from '0' Reading to Top of Bulb (L_1), (cm)	10.29
Scale Dimension (h_s), (cm/Div)	0.155
Cross-Sectional Area of Cylinder (A), (cm^2)	27.25
Meniscus Correction (H_m), (g/L)	1.0

START TIME 9:45 AM

HYDROMETER ANALYSIS

Date	Time	Elapsed Time T Mins	H_s Divisions g/L	H_c Divisions g/L	Temperature T_c °C	Corrected Reading $R = H_s - H_c$ g/L	Percent Passing P %	L cm	η Poise	K	Diameter D mm
9-Jun-23	9:46 AM	1	31.0	4.0	23.0	27.0	23.95	11.40904	9.39251	0.012818	0.04330
9-Jun-23	9:47 AM	2	27.0	4.0	23.0	23.0	20.40	12.02904	9.39251	0.012818	0.03144
9-Jun-23	9:50 AM	5	25.0	4.0	23.0	21.0	18.62	12.33904	9.39251	0.012818	0.02014
9-Jun-23	10:00 AM	15	21.0	4.0	23.0	17.0	15.08	12.95904	9.39251	0.012818	0.01191
9-Jun-23	10:15 AM	30	20.0	4.0	23	16.0	14.19	13.11404	9.39251	0.012818	0.00848
9-Jun-23	10:45 AM	60	18.0	4.0	23.0	14.0	12.42	13.42404	9.39251	0.012818	0.00606
9-Jun-23	1:55 PM	250	15.0	4.0	23	11.0	9.76	13.88904	9.39251	0.012818	0.00302
10-Jun-23	9:45 AM	1440	11.0	4.0	23	7.0	6.21	14.50904	9.39251	0.012818	0.00129

Remarks:

Reviewed By:

Date: June 12, 2023

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Stantec

Particle-Size Analysis of Soils

LS702

AASHTO T88

PROJECT DETAILS

Client:	**Kollaard Associates, File #230403**	Project No.:	**122410003**
Project:	**151-159 Wescas Lane**	Test Method:	**LS702**
Material Type:	**Soil**	Sampled By:	**Kollaard Associates**
Source:	**BH-9**	Date Sampled:	**June 2, 2023**
Sample No.:	**SS4**	Tested By:	**Brian Prevost**
Sample Depth	**7'6"-9'6"**	Date Tested:	**June 9, 2023**

WASH TEST DATA

Oven Dry Mass In Hydrometer Analysis (g)	79.42
Sample Weight after Hydrometer and Wash (g)	22.50
Percent Passing No. 200 Sieve (%)	**71.7**
Percent Passing Corrected (%)	**70.21**

PERCENT LOSS IN SIEVE

Sample Weight Before Sieve (g)	**334.00**
Sample Weight After Sieve (g)	**333.60**
Percent Loss in Sieve (%)	**0.12**

SOIL INFORMATION

Liquid Limit (LL)		
Plasticity Index (PI)		
Soil Classification		
Specific Gravity (G_s)	2.750	
Sg. Correction Factor (α)	0.978	
Mass of Dispersing Agent/Litre	40	g

CALCULATION OF DRY SOIL MASS

Oven Dried Mass (W_o), (g)	244.84
Air Dried Mass (W_a), (g)	246.75
Hygroscopic Corr. Factor ($F=W_o/W_a$)	0.9923
Air Dried Mass in Analysis (M_a), (g)	80.04
Oven Dried Mass in Analysis (M_o), (g)	79.42
Percent Passing 2.0 mm Sieve (P_{10}), (%)	97.96
Sample Represented (W), (g)	81.07

SIEVE ANALYSIS

Sieve Size mm	**Cum. Wt. Retained**	**Percent Passing**
75.0		100.0
63.0		100.0
53.0		100.0
37.5		100.0
26.5		100.0
19.0		100.0
13.2		100.0
9.5	0.0	100.0
4.75	4.5	98.7
2.00	6.8	98.0
Total (C + F)[1]	333.60	
0.850	0.20	97.72
0.425	0.69	97.11
0.250	1.87	95.66
0.106	15.30	79.09
0.075	21.52	71.42
PAN	22.50	

Note 1: (C + F) = Coarse + Fine

HYDROMETER DETAILS

Volume of Bulb (V_B), (cm^3)	63.0
Length of Bulb (L_2), (cm)	14.47
Length from '0' Reading to Top of Bulb (L_1), (cm)	10.29
Scale Dimension (h_s), (cm/Div)	0.155
Cross-Sectional Area of Cylinder (A), (cm^2)	27.2
Meniscus Correction (H_m), (g/L)	1.0

START TIME 9:11 AM

HYDROMETER ANALYSIS

Date	Time	Elapsed Time T Mins	H_s Divisions g/L	H_c Divisions g/L	Temperature T_c °C	Corrected Reading $R = H_s - H_c$ g/L	Percent Passing P %	L cm	η Poise	K	Diameter D mm
9-Jun-23	9:12 AM	1	52.0	7.0	23.0	45.0	54.31	8.15191	9.39251	0.012818	0.03660
9-Jun-23	9:13 AM	2	47.0	7.0	23.0	40.0	48.27	8.92691	9.39251	0.012818	0.02708
9-Jun-23	9:16 AM	5	44.0	7.0	23.0	37.0	44.65	9.39191	9.39251	0.012818	0.01757
9-Jun-23	9:26 AM	15	41.0	7.0	23.0	34.0	41.03	9.85691	9.39251	0.012818	0.01039
9-Jun-23	9:41 AM	30	39.0	7.0	23	32.0	38.62	10.16691	9.39251	0.012818	0.00746
9-Jun-23	10:11 AM	60	37.0	7.0	23.0	30.0	36.20	10.47691	9.39251	0.012818	0.00536
9-Jun-23	1:21 PM	250	32.0	7.0	23	25.0	30.17	11.25191	9.39251	0.012818	0.00272
10-Jun-23	9:11 AM	1440	24.5	7.0	23	17.5	21.12	12.41441	9.39251	0.012818	0.00119

Remarks:

Reviewed By: Brian Prevost

Date: June 12, 2023

V:\01216\active\laboratory_standing_offers\2023-Laboratory Standing Offers\122410003 Kollaard Associates\June 5, Three Hyd_One Limit_MCs, Kollaard #230403\Hydrometer-Lab Standing Offers.xlsx

Stantec

Stantec Consulting Ltd.
2781 Lancaster Rd, Suite 100 A&B, Ottawa ON K1B 1A7

June 12, 2023
File: 122410003

Client: Kollaard Associates Engineers., File #230403

Reference: ASTM D4318 Atterberg Limit & D2216 Moisture Content
151-159 Wescas Lane

The following table summarizes Atterberg Limit & Moisture Contents results.

Source	Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
BH-1 SS4	20.2	22.0	12.7	9.3
BH-3 SS6	25.0			
BH-4 SS11	9.2			
BH-9 SS4	24.1			

Sincerely,

Stantec Consulting Ltd.

Brian Prevost

Brian Prevost
For: Laboratory Supervisor
Tel: 613-738-6075
Fax: 613-722-2799
brian.prevost@stantec.com

Attachments: Plasticity Chart

Kollaard Associates
Engineers

210 Prescott Street, Unit 1
P.O. Box 189
Kemptville, Ontario K0G 1J0

Civil • Geotechnical •
Structural • Environmental •
Hydrogeology

(613) 860-0923

FAX: (613) 258-0475

August 29, 2024

230403

Sunbelt Rentals Inc.
2849 Sheffield Road
Ottawa, Ontario
K1B 3V6

Re: RESPONSE TO CITY OF OTTAWA OUTSTANDING GEOTECHNICAL COMMENT

This memo provides our response to an outstanding comment from the City of Ottawa's review regarding the geotechnical report dated June 14, 2023 by Kollaard Associates Inc., Project 230403, for the proposed commercial development at 151-159 Wescar Lane, Stittsville, City of Ottawa, Ontario.

- ***Original Comment - The MC is close to the LL; please discuss.***

Original Response - The results of the Atterberg Limit testing was incorrectly reported as CH: Inorganic High Plastic Soils and should have been reported as CL: Inorganic clays of low to medium plasticity. Kollaard Associates has revised the report to reflect the change.

- ***(City02): OUTSTANDING. Thank you for the revised information, however I'm not sure that answers the question. The concern is that that the liquid limit (LL) of 22% shown in Table 1 is very close to the moisture content 20.2% (MC/WC). (Ref: Table 1, page 8 of 55). The City is always wary of unstable soils, and we'll need a bit more discussion of what impact this might have on the development.***

A review of the laboratory test results including both the hydrometer test results and the Atterberg Limits test results indicate that the soils in question consist of a Low Plastic Clayey Silt.
The Atterberg Limit test results were as follows:

Table I – Atterberg Limit and Water Content Results

Sample	Depth(metres)	LL (%)	PL (%)	PI (%)	W (%)
BH1-SS6	2.3 – 2.9	22.0	12.7	9.3	20.2

It is noted that the no in-situ shear tests were completed during the test hole drilling program as the soils encountered represented as non-cohesive materials. In-situ shear testing is reserved for cohesive materials.

Atterberg limits tests establish the moisture contents at which fine grained clay and silt soils transition between solid, semi-solid, plastic and liquid states. The Liquidity Index LI of a soil is calculated as the (Natural Water Content MC – Plastic Limit PL) / Plasticity Index. PI The Plasticity Index is calculated as the Liquid Limit – the Plastic Limit. As the MC approaches the LL, the LI will approach 1. As the LI approached 1 the soil is closer to being in its liquid state and is more prone to liquefaction under seismic conditions and more prone to shrinkage and shrinkage related settlement. Liquefaction results in bearing failures or excessive settlement.

With respect to shrinkage:

Because the soil consists of clayey silt rather than a marine deposited sensitive silty clay, the soil is not particularly susceptible to shrinkage as a result of decreasing moisture content. The clay content is not sufficient to cause expansion and contraction due to changing moisture contents. This is common knowledge as indicated by the City of Ottawa's own Tree Planting in Sensitive Marine Clays Soils – 2017 Guidelines.

With respect to potential for liquefaction:

For the soil tested, the LI is equal to (20.2 – 12.7)/9.3 = 0.806. This indicates that the soil is approaching the state at which it is susceptible to liquefaction.
From 6.6.3.2(6) of the Canadian Foundation Engineering Manual, soils having a MC/LL of > 0.85 and a PI of < 12 are potentially susceptible to liquefaction or cyclic mobility. The soil tested has a MR/LL of 0.92 and a PI of 9.3. As such it is susceptible to liquefaction

From 6.6.1 of the CFEM
The following factors influence the liquefaction potential of a given site:
1. Soil type: saturated granular soils, especially fine loose sands and reclaimed soils, with poor drainage conditions are susceptible to liquefaction. -
2. Relative density: loose sands are more susceptible to liquefaction, e.g., sand with Dr > 80% is not likely to liquefy.
3. Confining pressure: the confining pressure increases the resistance to liquefaction.

Section 5.11.2 of the geotechnical report discusses the potential for soil liquefaction under seismic conditions. The results of the calculations presented in this section indicate that the soils present at the site are of sufficiently density such that they are not susceptible to liquefaction.

There are no large slopes present at the site. As such issues related to slope instability due to potential liquefaction of the soils within a slope are also not a concern at the site.

As such, the close proximity of the natural water content of the soil tested to the liquid limit does not indicate that the soils present will potentially be unstable or that there is any risk present at the site due to unstable soils or liquefaction of the soils.

We trust that this report provides sufficient information for your present purposes. If you have any questions concerning this information or if we can be of further assistance to you, please do not hesitate to contact our office.

Yours truly,
Kollaard Associates Inc.

Dean Tataryn

29.AUG.2024
S.E. deWit
100079612

Dean Tataryn, B.E.S., EP.

Steve deWit, P.Eng.

ATTACHMENT B

Laboratory Test Results for Chemical Properties

CERTIFICATE OF ANALYSIS

Work Order	: **WT2316184**	Page	: 1 of 3
Client	: **Kollaard Associates Inc.**	Laboratory	: Waterloo - Environmental
Contact	: Dean Tataryn	Account Manager	: Costas Farassoglou
Address	: 210 Prescott Street Unit 1 Kemptville ON Canada K0G1J0	Address	: 60 Northland Road, Unit 1 Waterloo ON Canada N2V 2B8
Telephone	: 613 860 0923	Telephone	: 613 225 8279
Project	: 230403	Date Samples Received	: 07-Jun-2023 11:40
PO	: ----	Date Analysis Commenced	: 08-Jun-2023
C-O-C number	: ----	Issue Date	: 13-Jun-2023 17:32
Sampler	: ----		
Site	: ----		
Quote number	: SOA 2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Jon Fisher	Production Manager, Environmental	Inorganics, Waterloo, Ontario

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances

LOR: Limit of Reporting (detection limit).

Unit	*Description*
µS/cm	microsiemens per centimetre
mg/kg	milligrams per kilogram
ohm cm	ohm centimetres (resistivity)
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Soil/Solid**

(Matrix: **Soil/Solid**)

				Client sample ID	**BH2-SS3**	**BH4-SS3**	----	----	----
				Client sampling date / time	29-May-2023 10:00	29-May-2023 13:00	----	----	----
Analyte	*CAS Number*	*Method/Lab*	*LOR*	*Unit*	**WT2316184-001**	**WT2316184-002**	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
Conductivity (1:2 leachate)	----	E100-L/WT	5.00	µS/cm	95.5	106	----	----	----
pH (1:2 soil:CaCl2-aq)	----	E108A/WT	0.10	pH units	7.70	7.69	----	----	----
Resistivity	----	EC100R/WT	100	ohm cm	10500	9430	----	----	----
Leachable Anions & Nutrients									
Chloride, soluble ion content	16887-00-6	E236.Cl/WT	5.0	mg/kg	<5.0	<5.0	----	----	----
Sulfate, soluble ion content	14808-79-8	E236.SO4/WT	20	mg/kg	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any result qualifiers detected.

Please refer to the Accreditation section for an explanation of analyte accreditations.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
(lab use only)

COC Number: 17 -

Page of

Report To Contact and company name below will appear on the final report

Company: Kollaard Associates (27196)
Contact: Dean Tataryn
Phone: 613.860.0923, ext.225
Company address below will appear on the final report
Street: 210 Prescott Street, Unit 1 P.O. Box 189
City/Province: Kemptville, Ontario
Postal Code: K0G 1J0

Invoice To
Same as Report To ☐ YES ☐ NO
Copy of Invoice with Report ☐ YES ☐ NO
Company:
Contact:

Project Information
ALS Account # / Quote #: Q71021
Job #: 230403
PO / AFE:
LSD:

ALS Lab Work Order # (lab use only): WT2316184

Report Format / Distribution
Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)
Quality Control (QC) Report with Report ☐ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☐ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax dean@kollaard.ca
Email 2
Email 3

Invoice Distribution
Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax ~~[illegible]@kollaard.ca~~ admin@kollaard.ca
Email 2

Oil and Gas Required Fields (client use)
AFE/Cost Center: PO#
Major/Minor Code: Routing Code:
Requisitioner:
Location:

ALS Contact: Melanie M. Sampler:

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may appl
Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply
PRIORITY (Business Days)
4 day [P4-20%] ☐
3 day [P3-25%] ☐
2 day [P2-50%] ☐
EMERGENCY
1 Business day [E1 - 100%]
Same Day, Weekend or Statutory holiday [E2 -200%
(Laboratory opening fees may apply)]
Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm
For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request
Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Corrosivity (KOLLAARD-CORR-WT)	VOC, F1-F4 (VOC-R511 F1-F4-WT)	Metals & Inorganics (R511-Inorganics)	PAH (PAH-511-WT)	BTEX / F1-F4	SAMPLES ON HOLD	Sample is hazardous (please provide further detail
	BH2-SS3	May 29, 2023	10:00	SOIL	X						
	BH4-SS3	May 29, 2023	11:00	SOIL	X						

Environmental Division
Waterloo
Work Order Reference
WT2316184
Telephone : +1 519 886 6910

Drinking Water (DW) Samples[1] (client use)
Are samples taken from a Regulated DW System?
☐ YES ☐ NO
Are samples for human consumption/ use?
☐ YES ☐ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)
Frozen ☐ SIF Observations Yes ☐ No
Ice Packs ☐ Ice Cubes ☑ Custody seal intact Yes ☐ No
Cooling Initiated ☐
INITIAL COOLER TEMPERATURES °C: 7.1
FINAL COOLER TEMPERATURES °C: 9.6

SHIPMENT RELEASE (client use)
Released by: Date: June 7 2023 Time:

INITIAL SHIPMENT RECEPTION (lab use only)
Received by: LR Date: 06/07/23 Time: 11:40

FINAL SHIPMENT RECEPTION (lab use only)
Received by: AB Date: June 8 /23 Time: 9:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

[1] If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

ATTACHMENT C

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

Site: 45.292N 75.981W **User File Reference:** 151 - 159 Wescar Lane 2023-06-05 15:16 UT

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.394	0.211	0.124	0.037
Sa (0.1)	0.465	0.260	0.160	0.053
Sa (0.2)	0.390	0.224	0.141	0.049
Sa (0.3)	0.298	0.173	0.110	0.039
Sa (0.5)	0.213	0.125	0.080	0.029
Sa (1.0)	0.107	0.064	0.041	0.014
Sa (2.0)	0.052	0.030	0.019	0.006
Sa (5.0)	0.014	0.008	0.004	0.001
Sa (10.0)	0.005	0.003	0.002	0.001
PGA (g)	0.250	0.142	0.088	0.028
PGV (m/s)	0.177	0.100	0.062	0.019

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" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. 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.**

References

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

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
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

Natural Resources Canada Ressources naturelles Canada

Canada

ATTACHMENT D

Hydraulic Conductivity Calculations

Guelph Permeameter Test

Location 151 - 159 Wescar Lane **Date:** 2023-11-28

Investigator CI

Depth of Hole (cm) 25 **Hole Diameter (cm)** 6

Reservoir Used During Test (Select One) Combined (X)

Reservoir Constant Used 35.31

Single/First Head Test

Water Level in Well (cm) 15

[t] Time (mins.)	Δt (mins.)	Water Level in Reservoir (cm)	∆h (cm)	Rate of change ∆h/∆t (cm/min)
0		5.5		
2	2	5.7	0.2	0.1
4	2	6	0.3	0.15
6	2	6.2	0.2	0.1
8.5	2.5	6.6	0.4	0.16
10.5	2	6.8	0.2	0.1
12.5	2	7	0.2	0.1
14.5	2	7.2	0.2	0.1

Guelph Permeameter Test

Location 151 - 159 Wescar Lane **Date:** 2023-11-30
Investigator Isaac Bacon
Depth of Hole (cm) 28 **Hole Diameter (cm)** 6
Reservoir Used During Test (Select One Combined (X)
Reservoir Constant Used 35.31

Single/First Head Test

Water Level in Well (cm) 20

[t] Time (mins.)	Δt (mins.)	Water Level in Reservoir (cm)	∆h (cm)	Rate of change ∆h/∆t (cm/min)
0		5.5		
1	1	6.3	0.8	0.8
2	1	6.8	0.5	0.5
3	1	7.5	0.7	0.7
4	1	8.2	0.7	0.7
5	1	8.8	0.6	0.6
6	1	9.3	0.5	0.5
7	1	10	0.7	0.7
8	1	10.6	0.6	0.6
9	1	11.2	0.6	0.6
10	1	11.7	0.5	0.5
11	1	12.3	0.6	0.6
12	1	13.0	0.7	0.7
13	1	13.5	0.5	0.5
14	1	14.1	0.6	0.6
15	1	14.7	0.6	0.6
16	1	15.3	0.6	0.6
17	1	15.8	0.5	0.5
18	1	16.3	0.5	0.5
19	1	16.8	0.5	0.5
20	1	17.3	0.5	0.5

SoilMoisture
Soil Hydrology Instruments for Research Since 1955

Guelph Permeameter Calculations

🟩 **Input**
🟧 **Result**

Single Head Method - Nov 28, 2023

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): 35.22
Enter water Head Height ("H" in cm): 15
Enter the Borehole Radius ("a" in cm): 6

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.1000
* "R" = three values in a row with matching Δh/Δt

Res Type	35.22
H	15
a	6
H/a	2.5
a*	0.12
C0.01	1.033
C0.04	1.085
C0.12	1.063
C0.36	1.063
C	1.063
R	0.100
Q	0.059
pi	3.142

α*= 0.12 cm^{-1}

C = 1.062625
Q = 0.0587

K$_{fs}$ = 2.69E-05 *cm/sec*
1.61E-03 *cm/min*
2.69E-07 *m/sec*
6.35E-04 *inch/min*
1.06E-05 *inch/sec*

Φ$_m$ = 2.24E-04 *cm^2/min*

Single Head Method - Nov 30, 2023

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): 35.22
Enter water Head Height ("H" in cm): 20
Enter the Borehole Radius ("a" in cm): 6

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.5000
* "R" = three values in a row with matching Δh/Δt

Res Type	35.22
H	20
a	6
H/a	3.33333
a*	0.12
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.28754
R	0.500
Q	0.2935
pi	3.1415

α*= 0.12 cm^{-1}

C = 1.287543
Q = 0.2935

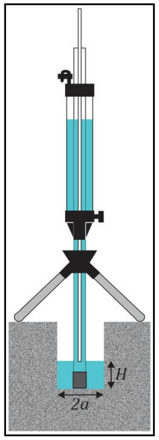
K$_{fs}$ = 1.02E-04 *cm/sec*
6.12E-03 *cm/min*
1.02E-06 *m/ses*
2.41E-03 *inch/min*
4.01E-05 *inch/sec*

Φ$_m$ = 8.50E-04 *cm^2/min*

Average

K$_{fs}$ = 6.44E-05 *cm/sec*
3.87E-03 *cm/min*
6.44E-07 *m/s*
1.52E-03 *inch/min*
2.54E-05 *inch/sec*

Φ$_m$ = 5.37E-04 *cm^2/min*



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(\mathrm{cm}^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121\left(H_2/a\right)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091\left(H_1/a\right)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091\left(H_2/a\right)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093\left(H_2/a\right)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093\left(H_2/a\right)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi\left(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $G_2 = \frac{H_1 C_2}{\pi\left(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $K_{fs} = G_2 Q_2 - G_1 Q_1$ $G_3 = \frac{(2H_2^2 + a^2 C_2)C_1}{2\pi\left(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $G_4 = \frac{(2H_1^2 + a^2 C_1)C_2}{2\pi\left(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $\Phi_m = G_3 Q_1 - G_4 Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	