Geotechnical Investigation

Nepean Housing Infill Project
Dunbar Court
Ottawa, Ontario

Prepared for:

Nepean Housing Corporation
15 Kilbarron Road
Ottawa, Ontario
K2J 5B2

LRL File No.: 200013

March, 2020

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1 INTRODUCTION

LRL Associates Ltd. (LRL) was retained by Deborah Edwards on behalf of Nepean Housing Corporation to perform a geotechnical investigation for a proposed infill project, located at 28 Dunbar Court, Ottawa, Ontario.

The purpose of the investigation was to identify the subsurface conditions across the site by the completion of a borehole drilling program. Based on the visual and factual information obtained, this report will provide guidelines on the geotechnical engineering aspects of the design of the project, including construction considerations.

This report has been prepared in consideration of the terms and conditions noted above. Should there be any changes in the design features, which may relate to the geotechnical recommendations provided in the report, LRL should be advised in order to review the report recommendations.

2 SITE AND PROJECT DESCRIPTION

The site under investigation is Nepean Community Housing. The area of study was concentrated around the existing townhomes with corresponding units 14, 16, 18, and 20, located along Dunbar Court. At the time of the investigation, the site was snow covered. The general topography of the site is considered to be relatively flat. A play structure was observed north of the townhomes, and a grassy area located to the north east of the townhouse. Access to the site comes by way of Dunbar Court. The location is presented in Figure 1 included in **Appendix A**.

This development is an infill project; the existing townhomes will be demolished. A new three (3) storey apartment building, complete with community space, and fourteen (14) tenant parking spaces will be constructed. The apartment building will be serviced with municipal service.

3 PROCEDURE

The fieldwork for this investigation was carried out on February 20, 2020. Prior to the fieldwork, the site was cleared for the presence of any underground services and utilities. A total of three (3) boreholes were drilled onsite, at predetermined locations approved by the project's architect, and labelled BH1 through BH3. The approximate locations of the boreholes are shown in Figure 2 included in **Appendix A**.

The boreholes were advanced using a track mounted CME 75 drill rig equipped with 200 mm diameter continuous flight hollow stem auger supplied and operated by CCC Geotechnical and Environmental Drilling Ltd. A "two man" crew experienced with geotechnical drilling operated the drill rig and equipment.

Sampling of the overburden materials encountered in the boreholes was carried out at regular depth intervals using a 50.8 mm diameter drive open conventional spoon sampler in conjunction with standard penetration testing (SPT) "N" values. The SPT were conducted following the method **ASTM D1586** and the results of SPT, in terms of the number of blows per 0.3 m of split-spoon sampler penetration after first 0.15 m designated as "N" value.

The boreholes were advanced to depths of 6.7 and 9.7 m below ground surface (bgs). Upon completion, the boreholes were backfilled and compacted using the overburden cuttings. The fieldwork was supervised throughout by a member of our engineering staff who oversaw the drilling activities, cared for the samples obtained and logged the subsurface conditions encountered within each of the boreholes. All soil samples were transported back to our office for further evaluation. The recovered soil samples collected from the boreholes were classified based on visual examination of the materials recovered and the results of the in-situ testing.

Furthermore, all boreholes were located using a Garmin Etrex Legend GPS (Global Positioning System) receiver using NAD 83 datum (North American Datum). LRL's field personnel determined the existing grade elevations at the borehole locations through a topographic survey carried out using a temporary site bench mark (top of flange on fire hydrant west of the community mailbox, on west side of Dunbar Court), given an elevation of 100.00 m. Ground surface elevations of the boring locations are shown on their respective boreholes logs.

4 SUBSURFACE SOIL AND GROUNDWATER CONDITIONS

4.1 General

A review of local surficial geology maps provided by the Department of Energy, Mines and Resources Canada suggest that the surficial geology for this area is Fluvioglacial Deposits; consisting of gravel and sand, stratified, some till in the form of eskers and various ice contact deposits. Surface reworked into beaches in locations below the Champlain Sea marine limit.

The subsurface conditions encountered in the boreholes were classified based on visual and tactile examination of the materials recovered from the boreholes. The soil descriptions presented in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil were conducted according to the procedure **ASTM D2487** and judgement, and LRL does not guarantee descriptions as exact, but infers accuracy to the extent that is common in current geotechnical practice.

The subsurface soil conditions encountered are given in their respective borehole logs presented in **Appendix B**. A greater explanation of the information presented in the borehole logs can be found in **Appendix C** of this report. These logs indicate the subsurface conditions encountered at a specific test location only. Boundaries between zones on the logs are often not distinct, but are rather transitional and have been interpreted as such.

4.2 Topsoil

Topsoil having a thickness ranging between 200 and 300 mm was found at the surface of all boring locations.

This material was classified as topsoil based on colour and the presence of organic material and is intended as identification for geotechnical purposes only. It does not constitute a statement as to the suitability of this layer for cultivation and sustaining plant growth.

4.3 Fill

Underlying the topsoil in all boring locations, a layer of fill material was encountered, and extended to a depth of 1.45 m bgs. It can generally be described as a brown mixture of sand-silt-clay, some gravel sized stone, and moist. Standard Penetration Tests (SPT) were carried out in this layer, and the SPT "N" values were found ranging between 12 and 75. However, it should be noted that these "N" values reflect that the material was frozen at these depths, and not the state of compactness. The natural moisture contents were found to range between 4 and 13%.

4.4 Sand

Underlying the fill in all borehole locations, a deposit of sand was encountered, and extended to depths of 6.70 (BH1 and BH2) and 9.76 (BH3) m bgs. It can be described as having trace silt, brown, and moist. SPTs were carried out in this layer, and the "N" values were found ranging between 15 and 29, indicating this layer is compact. The natural moisture contents were found to be 4 and 23%.

Four (4) sand samples were collected for laboratory sieve analyses. The results are summarized below in **Table 1**.

Table 1: Sieve Analysis Summary

Sample Location	Depth (m)	Percent for Each Soil Gradation						Estimated Hydraulic Conductivity K (cm/s)
		Gravel		Sand			Fines	
		Coarse (%)	Fine (%)	Coarse (%)	Medium (%)	Fine (%)	Silt & Clay (%)	
BH1	1.5 – 2.1	0.0	0.0	0.0	2.9	91.3	5.8	2 x 10^{-5}
BH1	2.3 – 2.9	0.0	0.0	0.0	2.4	94.3	3.3	2 x 10^{-5}
BH2	3.1 – 3.7	0.0	0.0	0.0	3.6	93.4	3.0	2 x 10^{-5}
BH3	4.6 – 5.2	0.0	0.0	0.0	2.5	95.2	2.3	2 x 10^{-5}

The laboratory report can be found in **Appendix D** of this report.

4.5 Groundwater Conditions

Groundwater conditions were carefully monitored during the field investigation. During drilling, no water was encountered in BH1 and BH2. The soil samples became wet/saturated below about 7.6 m in BH3, indicating the presence of water.

Piezometers consisting of ¾" PVC pipe were installed in BH1 and BH2 to measure the static groundwater table. These piezometers were measured on March 4, 2020, and both pipes were found to be dry.

It should be noted that groundwater levels could fluctuate with seasonal weather conditions, (i.e.: rainfall, droughts, spring thawing) and due to construction activities at or near the vicinity of the site.

5 GEOTECHNICAL CONSIDERATIONS

This section of the report provides general geotechnical recommendations for the design aspect of the proposed development based on our interpretation of the information gathered from the borehole data performed at this site and from the project requirements.

5.1 Foundations

Based on the subsurface soil conditions established at this site, the footings for the proposed apartment building and community space shall be founded below the frost penetration depth, constructed on the native sand material. Therefore, all fill material, and any construction debris from the existing townhouse should be removed from the proposed structure's footprint down to the required founding depth.

5.2 Shallow Foundation

Conventional strip and column footings founded over the undisturbed native sand material may be designed using a maximum allowable bearing pressure of **100 kPa** for serviceability limit state **(SLS)** and **150 kPa** for ultimate limit state **(ULS)** factored bearing resistance. The factored ULS value includes the geotechnical resistance factor of 0.5.

In-situ field testing is recommended to check the strength and stability of the footings subgrade once the excavation is complete. Any incompetent subgrade areas as identified from in-situ testing must be sub-excavated and backfilled with approved structural fill consisting of Granular B Type II. Similarly, any soft or wet areas should also be sub-excavated and backfilled with approved structural fill only. Prior to placing the structural fill, the subgrade should be inspected and approved by a geotechnical engineer or qualified geotechnical personnel. The bearing pressure is contingent on the water level being 0.3 m below the underside footing elevation in order to have a stable and dry subgrade during construction.

Prior to pouring footings' concrete, the subgrade should be inspected and approved by a geotechnical engineer or a representative of geotechnical engineer.

5.3 Structural Fill

If excavation below the underside of the footing is performed, structural fill shall be placed to support the footings. The structural fill should be placed over undisturbed native soils in maximum lift thicknesses of 300 mm and compacted to 98% of its Standard Proctor Maximum Dry Density (SPMDD). In order to allow the spread of load beneath the footings and to prevent under mining during construction, the structural fill must extend 1.0 m beyond the outside edges of the footings and then outward and downward at 1 horizontal to 1 vertical profile (or flatter) over a distance equal to the depth of the structural fill below the footing. The recommended material to be used as structural fill to support the footings shall consist of imported granular material meeting Ontario Provincial Standards Specifications (OPSS) requirements for a Granular B Type II, or an approved equivalent material.

The structural fill must be tested to ensure that the specified compaction level was achieved.

5.4 Basement Construction

Basement floor slabs can be considered to rest either on undisturbed native material or approved structural fill. For bedding and to serve as moisture barrier underneath the basement floor slabs, a minimum of 200 mm thick layer of 19 mm clear stone meeting the **OPSS 1004** gradation requirements should be placed.

Buildings with basements located in a wet granular layer shall have an under-floor drainage system with invert located a minimum of 300 mm below the underside of basement slab installed. This shall be comprised of 100 mm diameter weeping tile pre-wrapped with geotextile knitted sock, embedded in a 150 mm layer of 19 mm clear stone. Installed in one direction below the slab and connected to sump/frost-free outlet of the exterior weeping tile from which water is pumped to the nearby ditches or storm sewer line, if available.

Proper moisture barrier with vapour retarder should be used for any slab on grade where the floor will be covered by moisture sensitive flooring materials/equipment.

5.5 Lateral Earth Pressure

The following equation should be used to estimate the intensity of the lateral earth pressure against any earth retaining structure/foundation walls.

$$P = K (\gamma h + q)$$

Where;

P = Earth pressure at depth h;

K = Appropriate coefficient of earth pressure;

γ = Unit weight of compacted backfill, adjacent to the wall;

h = Depth (below adjacent to the highest grade) at which P is calculated;

q = Intensity of any surcharge distributed uniformly over the backfill surface (usually surcharge from traffic, equipment or soil stockpiled and typically considered 10 kPa).

The coefficient of earth pressure at rest (K_0) should be used in the calculation of the earth pressure on the storm water manhole/basement walls, which are expected to be rather rigid and not to deflect.

The above expression assumes that perimeter drainage system prevents the build-up of any hydrostatic pressure behind the foundation wall.

Table 2 below provides various material types and their respective earth pressure properties.

Table 2: Material and Earth Pressure Properties

Type of Material	**Bulk Density (kN/m^3)**	**Friction Angle (Φ)**	**Pressure Coefficient**		
			At Rest (K_0)	**Active (K_A)**	**Passive (K_P)**
Granular A	23.0	34	0.44	0.28	3.53
Granular B Type I	20.0	31	0.49	0.32	3.12
Granular B Type II	23.0	32	0.47	0.31	3.25
Sand	19.0	31	0.49	0.32	3.12

5.6 Settlement

The estimated total settlement of the shallow foundations, designed using the recommended serviceability limit state capacity value, as well as other recommendations given above, will be less than 25 mm. The differential settlement between adjacent column footings is anticipated to be 15 mm or less.

5.7 Liquefaction

Compact, well graded sandy soils are not prone to liquefaction. Therefore, the potential for liquefaction is not a concern for this site.

5.8 Seismic

Based on the information of this geotechnical investigation and in accordance with the Ontario Building Code 2015 (Table 4.1.8.4.A.) and Canadian Foundation Engineering Manual (4th edition), the site can be classified for Seismic Site Response Site Class D.

The above classifications were recommended based on conventional method exercised for Site Classification for Seismic Site Response and in accordance with the generally accepted geotechnical engineering practice. It should be noted that a greater Seismic Site Class might be possible to achieve by carrying out a site specific Multichannel Analysis of Surface Waves (MASW) survey.

5.9 Frost Protection

All exterior footings located in any unheated portions of the proposed building should be protected against frost heaving by providing a minimum of 1.5 m of earth cover. Areas that are to be cleared of snow (i.e. sidewalks, paved areas, etc.) should be provided with at least 1.8 m of earth cover for frost protection purposes. Alternatively, the required frost protection could be provided using a combination of earth cover and extruded polystyrene insulation. Detailed guidelines for footing insulation frost protection can be provided upon request.

In the event that foundations are to be constructed during winter months, the foundation soils are required to be protected from freezing temperatures using suitable construction techniques. The base of all excavations should be insulated from freezing temperatures immediately upon exposure, until heat can be supplied to the building interior and the footings have sufficient soil cover to prevent freezing of the subgrade soils.

5.10 Foundation Drainage

A conventional, perforated corrugated polyethylene drainage pipe (100 mm minimum), pre-wrapped with geotextile knitted sock conforming to **OPSS 1840** should be embedded in a 300 mm layer of 19 mm clear crushed stone and set adjacent to the perimeter footings. The drainage pipe should be connected positively to a suitable outlet, such as a sump pit or storm sewer.

In order to minimize ponding of water adjacent to the foundation walls, roof water should be controlled by a roof drainage system that directs water away from the building to prevent ponding of water adjacent to the foundation wall. The exterior grade should be sloped away from the building to promote water drainage away from the foundation walls.

5.11 Foundation Walls Backfill (Shallow Foundations)

To prevent possible lateral loading, the backfill material against any foundation walls, grade beams, isolated walls, or piers should consist of free draining, non-frost susceptible material such as sand or sand and gravel meeting OPSS Granular B Type II or equivalent grading requirements.

The foundation wall backfill should be compacted to minimum 95% of its SPMDD using light compaction equipment, where no loads will be set over top. The compaction shall be increased to 98% of its SPMDD under walkways, slabs or paved areas close to the foundation or any retaining walls. Backfilling against foundation walls should be carried out on both sides of the wall at the same time where applicable.

5.12 Slab-on-grade Construction

For predictable performance for a slab-on-grade, it should rest over undisturbed competent native soil or structural fill only. Therefore, all organic or otherwise deleterious material shall be removed from the buildings' footprint. The exposed native subgrade surface should then be inspected and approved by geotechnical personnel.

Any underfloor fill needed to raise the general floor grade shall consist of OPSS Granular B Type II material or an approved equivalent, compacted to 95% of its SPMDD. The final lift shall be compacted to 98% of its SPMDD. A 200 mm thick layer of Granular A meeting the **OPSS 1010** shall be placed underneath the slab and compacted to 100% of its SPMDD. Alternatively, if wet condition persists, 200 mm thickness of 19 mm clear stone meeting the **OPSS 1004** requirements shall be used instead of Granular A.

It is also recommended that any area of extensive exterior slab-on-grade (sidewalks, ramp etc.) shall be constructed using Granular A base of minimum thickness 150 mm. The modulus of subgrade reaction (ks) for the design of the slabs set over competent native soil/structural fill is **24 MPa/m.**

In order to further minimize and control cracking, the floor slab shall be provided with wire or fibre mesh reinforcement and construction or control joints. The construction or control joints should be spaced equal distance in both directions and should not exceed 4.5 m. The wire or fibre mesh reinforcement shall be carried out through the joints.

6 EXCAVATION AND BACKFILLING REQUIREMENTS

6.1 Excavation

It is anticipated that the depth of excavation for the building or any proposed services will not extend below 1.8 – 2.4 m. Excavation must be carried-out in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects.

According to the Ontario's Occupational Health and Safety Act (OHSA), O. Reg. 213/91 and its amendments, the surficial overburden expected to be excavated into at this site can be classified as Type 3 for fully drained excavations. Therefore, shallow temporary excavations in the overburden soil can be cut at 1 horizontal to 1 vertical, for a fully drained excavation starting from the base of the excavation and as per requirements of the OHSA regulations.

In the event that the aforementioned slopes are not possible to achieve due to space restrictions, the excavation shall be shored according to OHSA O. Reg. 213/91 and its amendments. Refer to the parameters provided in **Table 2** in **Section *5.5*** for use in the design of any shoring structures.

Any excavated material stockpiled near an excavation or trench should be stored at a distance equal to or greater than the depth of the excavation/trench and construction equipment traffic should be limited near open excavation.

6.2 Groundwater Control

Based on the subsurface conditions encountered at this site, groundwater seepage or infiltration into the temporary excavations during construction is expected to be minor in nature, if any. This will be able to be controlled by pumping with sump pumps. Surface water runoff into the excavation should be minimized and diverted away from the excavation.

A permit to take water (PTTW) is required from Ministry of Environment and Climate Change (MOECC), Ontario Reg. 387/04, if more than 400,000 litres per day of groundwater will be pumped during a construction period less than 30 days. Registration in the Environmental Activity and Sector Registry (EASR) is required when water takings range between 50,000 and 400,000 litres per day.

The actual amount of groundwater inflow into open excavations will depend on several factors such as the contractor's schedule, rate of excavation, the size of excavation, depth below the groundwater level, and at the time of year which the excavation is executed. It is expected that pumping rates will be less than 50,000 litres per day. As such, EASR registration is not required for the construction at this site.

6.3 Pipe Bedding Requirements

It is anticipated that any underground services required as part of this project will be founded over properly prepared and approved structural fill. Consequently all organic material should be removed down to a suitable bearing layer. Any sub-excavation of disturbed soil should be removed and replaced with a Granular B Type II or approved equivalent, laid in loose lifts of thickness not exceeding 300 mm and compacted to 95% of its SPMDD. Bedding, thickness of cover material and compaction requirements for watermains and sewer pipes should conform to the manufacturer's design requirements and to the detailed installations outlined in the Ontario Provincial Standard Specifications (OPSS) or any other applicable standards.

6.4 Trench Backfill

All service trenches should be backfilled using compactable material, free of organics, debris and large cobbles or boulders. Acceptable native materials (if encountered and where possible) should be used as backfill between the roadway subgrade level and the depth of seasonal frost penetrations (i.e. 1.8 m below finished grade) in order to reduce the potential for differential frost heaving between the new excavated trench and the adjacent section of roadway. Where native backfill is used, it should match the native materials exposed on the trench walls. Backfill below the zone of seasonal frost penetration could consist of either acceptable native material or imported granular material conforming to OPSS Granular B Type II. Any boulders larger than 150 mm in size should not be used as trench backfill.

To minimize future settlement of the backfill and achieve an acceptable subgrade for the roadway, the trench should be compacted in maximum 300 mm thick lifts to at least 95% of its SPMDD. The specified density may be reduced where the trench backfill is not located within or in close proximity to existing roadways or any other structures.

For trenches carried out in existing paved areas, transitions should be constructed to ensure that proper compaction is achieved between any new pavement structure and the existing pavement structure to minimize potential future differential settlement between the existing and new pavement structure. The transition should start at the subgrade level and extend to the underside of the asphaltic concrete level (if any) at a 1 horizontal to 1 vertical slope. This is especially important where trench boxes are used and where no side slopes is provided to the excavation. Where asphaltic concrete is present, it should be cut back to a minimum of 150 mm from the edge of the excavation to allow for proper compaction between the new and existing pavement structures.

7 REUSE OF ON-SITE SOILS

The existing surficial overburden materials consists mostly of fill material. This material is considered to be frost susceptible and should not be used as backfill material directly against foundation walls or underneath unheated concrete slabs. However, it could be reused as general backfill material (service trenches, general landscaping/backfilling) if it can be compacted according to the specifications outlined herein at the time of construction and found free from any waste, organics and debris.

It should be noted that the adequacy of any material for reuse as backfill will depend on its water content at the time of its use and on the weather conditions prevailing prior to and during that time. Therefore, all excavated materials to be reused shall be stockpiled in a manner that will prevent any significant changes in their moisture content, especially during wet conditions, and approved for reuse by a geotechnical engineer.

8 PAVEMENT REINSTATEMENT

There are no access roads or municipal streets proposed to be constructed as part of this project. There will only be driveway(s) for the residential units. However, there may be some street reinstatement from connecting to the municipal services.

The reinstatement of any pavement structure within the existing street should be conducted as recommended in **Section 6.4** and the pavement structure should be reinstated to match at minimum what already exists.

Where the existing asphaltic concrete surface of a roadway is affected by the excavating process, the damaged zones should be saw cut and any damaged or loose pieces of asphaltic concrete should be removed down to the binder course or its entire depth, where only one layer exist. The existing base should be scarified and proof-rolled with any soft areas excavated and replaced to the proper level with OPSS Granular A. Where two layers of asphalt exist on an access lane, the surface course should be grinded over a width of 150mm to allow the new surface course to overlap the binder layer and not create one straight vertical joint. On existing streets, the overlap should be increased to 300mm.

9 INSPECTION SERVICES

The engagement of the services of the geotechnical consultant during construction is recommended to confirm that the subsurface conditions throughout the proposed site 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 footing areas and any structural fill areas for the proposed dwelling should be inspected by LRL to ensure that a suitable subgrade has been reached and properly prepared. The placing and compaction of any granular materials beneath the foundations and slab-on-grade should be inspected to ensure that the materials used conform to the grading and compaction specifications.

If the footings are to be constructed during winter season, the footing subgrade should be protected from freezing temperatures using suitable construction techniques.

10 REPORT CONDITIONS AND LIMITATIONS

It is stressed that the information presented in this report is provided for the guidance of the designers and is intended for this project only. The use of this report as a construction document or its use by a third party beyond the client specifically listed in the report is neither intended nor authorized by LRL Associates Ltd. 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 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 off-site sources are outside the terms of reference for this report.

The recommendations provided in this report are based on subsurface data obtained at the specific test pit locations only. Boundaries between zones presented on the test pit logs are often not distinct but transitional and were interpreted. Experience indicates that the subsurface soil and groundwater conditions can vary significantly between and beyond the test locations. For this reason, the recommendations given in this report are subject to a field verification of the subsurface soil conditions at the time of construction.

The recommendations are applicable only to the project described in this report. Any changes to the project will require a review by LRL Associates Ltd., to ensure compatibility with the recommendations contained in this project.

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 the undersigned.

Yours truly,
LRL Associates Ltd.

LICENSED PROFESSIONAL ENGINEER
March 6, 2020
B. W. JOHNSON
100510537
PROVINCE OF ONTARIO

Brad Johnson, P. Eng.
Geotechnical Engineer

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APPENDIX A

Site and Borehole Location Plan

LRL
ENGINEERING | INGÉNIERIE
5430 Canotek Road | Ottawa, ON, K1J 9G2
www.lrl.ca | (613) 842-3434

PROJECT

GEOTECHNICAL INVESTIGATION
NEPEAN HOUSING INFILL PROJECT
28 DUNBAR COURT
OTTAWA, ONTARIO

DRAWING TITLE

SITE LOCATION
SOURCE: GEO-OTTAWA

CLIENT

NEPEAN HOUSING CORPORATION

DATE

MARCH 2020

PROJECT

200013

FIGURE 1

LRL
ENGINEERING | INGÉNIERIE
5430 Canotek Road | Ottawa, ON, K1J 9G2
www.lrl.ca | (613) 842-3434

PROJECT
GEOTECHNICAL INVESTIGATION
NEPEAN HOUSING INFILL PROJECT
28 DUNBAR COURT
OTTAWA, ONTARIO

DRAWING TITLE
BOREHOLE LOCATION
SOURCE: Imagery 2020 Google, Digital Globe Map Data

CLIENT
NEPEAN HOUSING CORPORATION

DATE
MARCH 2020

PROJECT
200013

FIGURE 2

APPENDIX B

Borehole Logs

Borehole Log: BH1

Project No.: 200013

Project: Nepean Housing Infill Project

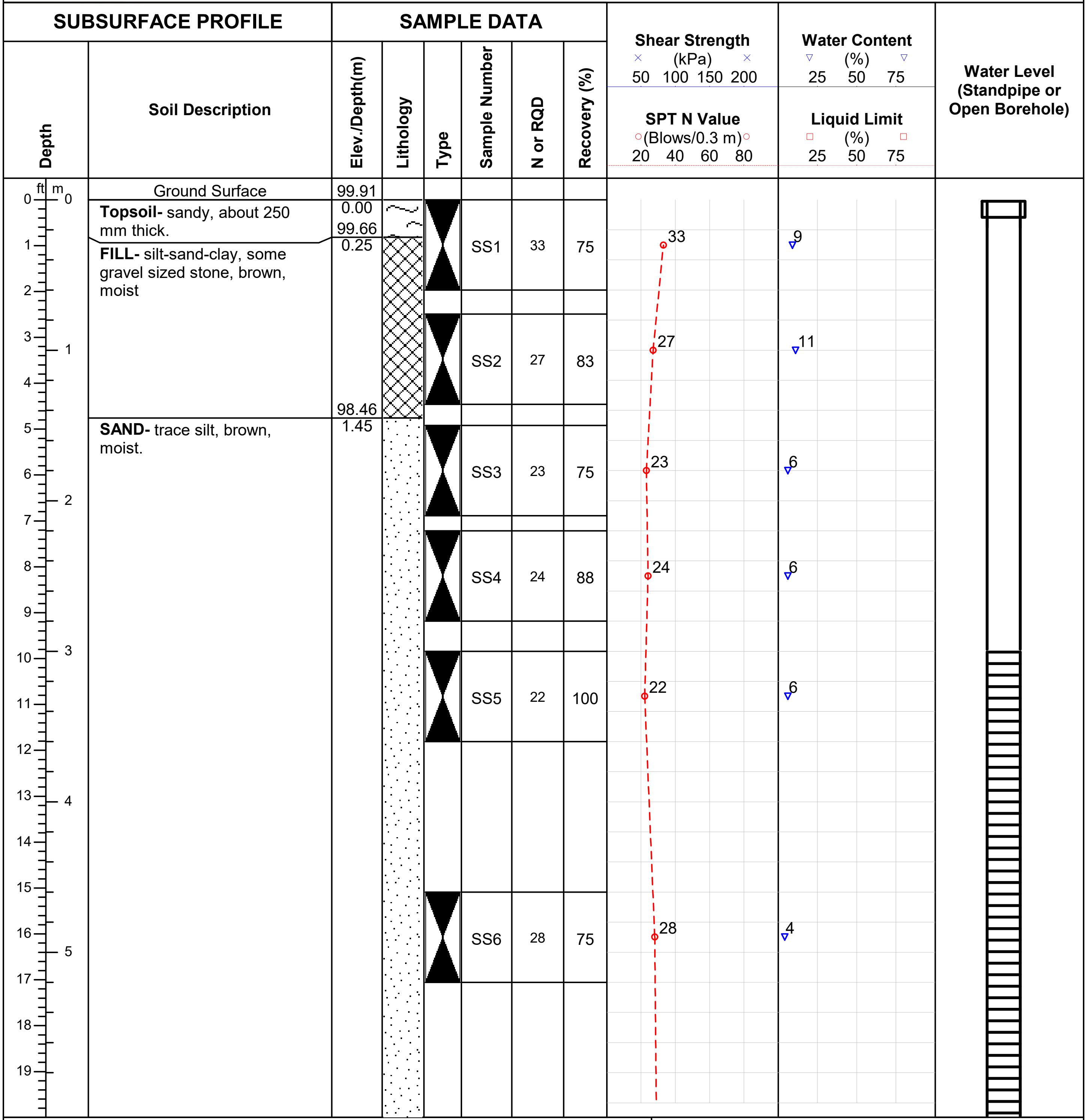
Client: Nepean Housing Corporation

Location: 28 Dunbar Court, Ottawa ON

Date: February 20, 2020

Field Personnel: BJ

Driller: CCC Geotech and Enviro Drilling Ltd. **Drilling Equipment:** Track Mount CME 75 **Drilling Method:** Hollow Stem Auger



Soil Description	Elev./Depth(m)
Ground Surface	99.91
Topsoil- sandy, about 250 mm thick.	0.00
FILL- silt-sand-clay, some gravel sized stone, brown, moist	99.66 0.25
SAND- trace silt, brown, moist.	98.46 1.45

Sample Number	N or RQD	Recovery (%)	SPT N Value	Water Content (%)
SS1	33	75	33	9
SS2	27	83	27	11
SS3	23	75	23	6
SS4	24	88	24	6
SS5	22	100	22	6
SS6	28	75	28	4

Easting: 439099 m **Northing:** 5019317 m

Site Datum: Top of Flange of Fire Hydrant - West of Community Mailbox (100.00 m)

Groundsurface Elevation: 99.912 m **Top of Riser Elev.:** 100.988 m

Hole Diameter: 200 mm

NOTES:

-Piezometer was measured on March 4, 2020 to determine water level. Piezometer was found to be dry.

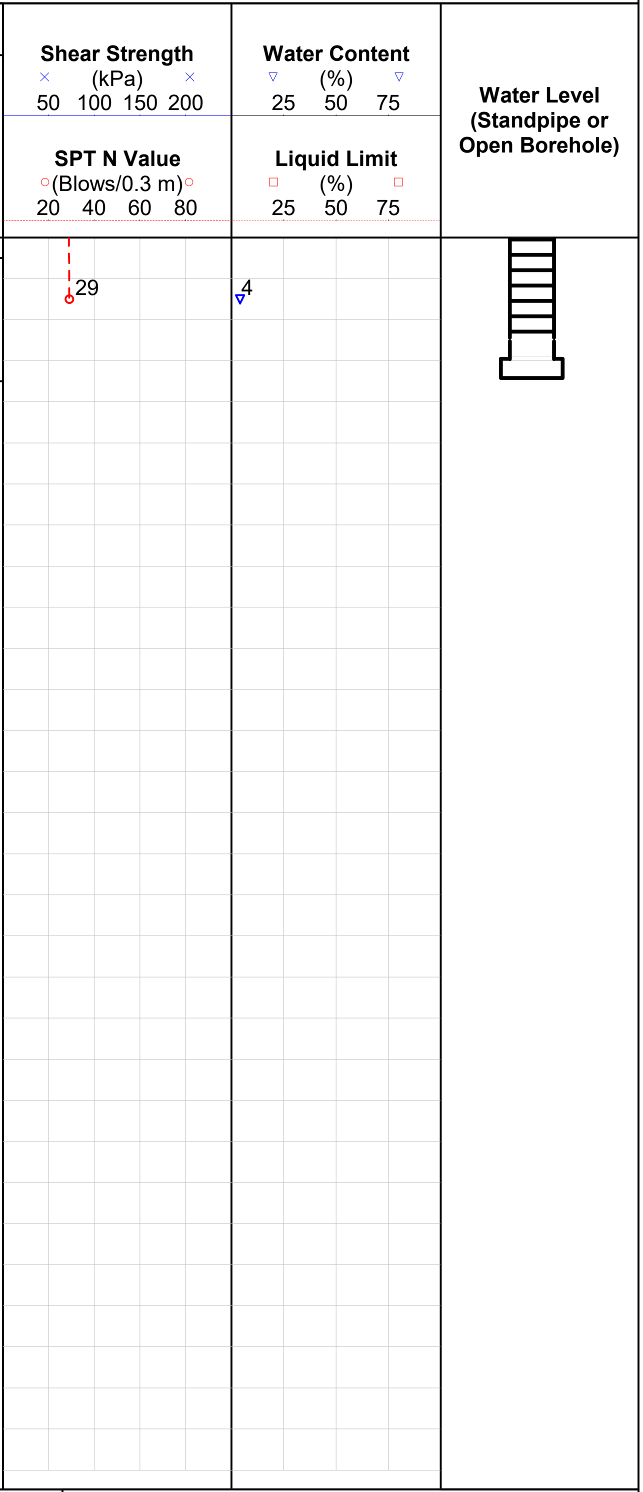
-The "N" values for SS1 and SS2 indicate the soil is frozen, not the state of compactness.

Borehole Log: BH1

Project No.: 200013
Project: Nepean Housing Infill Project
Client: Nepean Housing Corporation
Location: 28 Dunbar Court, Ottawa ON
Date: February 20, 2020
Field Personnel: BJ
Driller: CCC Geotech and Enviro Drilling Ltd.
Drilling Equipment: Track Mount CME 75
Drilling Method: Hollow Stem Auger

SUBSURFACE PROFILE		SAMPLE DATA					
Depth	Soil Description	Elev./Depth(m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)
20–22		93.21 6.70			SS7	29	100
22	End of Borehole						

Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39 (ft); 7, 8, 9, 10, 11 (m)



Easting: 439099 m
Northing: 5019317 m

Site Datum: Top of Flange of Fire Hydrant - West of Community Mailbox (100.00 m)

Groundsurface Elevation: 99.912 m
Top of Riser Elev.: 100.988 m

Hole Diameter: 200 mm

NOTES:

-Piezometer was measured on March 4, 2020 to determine water level. Piezometer was found to be dry.

-The "N" values for SS1 and SS2 indicate the soil is frozen, not the state of compactness.

Borehole Log: BH3

Project No.: 200013

Project: Nepean Housing Infill Project

Client: Nepean Housing Corporation

Location: 28 Dunbar Court, Ottawa ON

Date: February 20, 2020

Field Personnel: BJ

Driller: CCC Geotech and Enviro Drilling Ltd.

Drilling Equipment: Track Mount CME 75

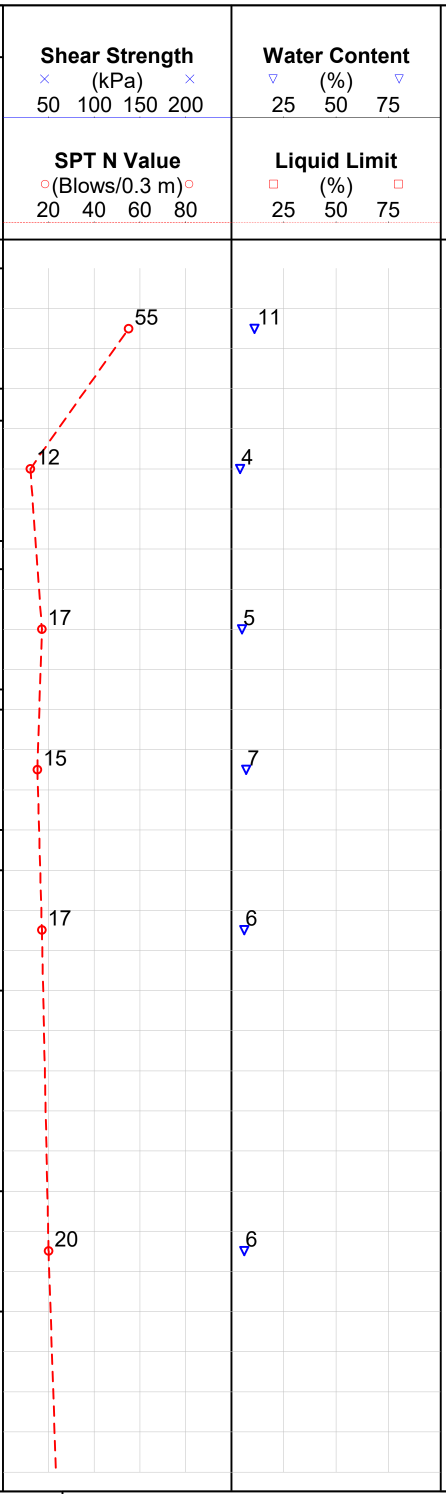
Drilling Method: Hollow Stem Auger

SUBSURFACE PROFILE

Soil Description	Elev./Depth(m)
Ground Surface	99.19
Topsoil- sandy, about 300 mm thick.	0.00
FILL- silt-sand-clay, some gravel sized stone, brown, moist	98.89 0.30
SAND- trace silt, brown, moist.	97.74 1.45

SAMPLE DATA

Type	Sample Number	N or RQD	Recovery (%)
⧗	SS1	55	79
⧗	SS2	12	71
⧗	SS3	17	83
⧗	SS4	15	75
⧗	SS5	17	79
⧗	SS6	20	75



Water Level (Standpipe or Open Borehole)

Easting: 439118 m

Northing: 5019326 m

Site Datum: Top of Flange of Fire Hydrant - West of Community Mailbox (100.00 m)

Groundsurface Elevation: 99.193 m

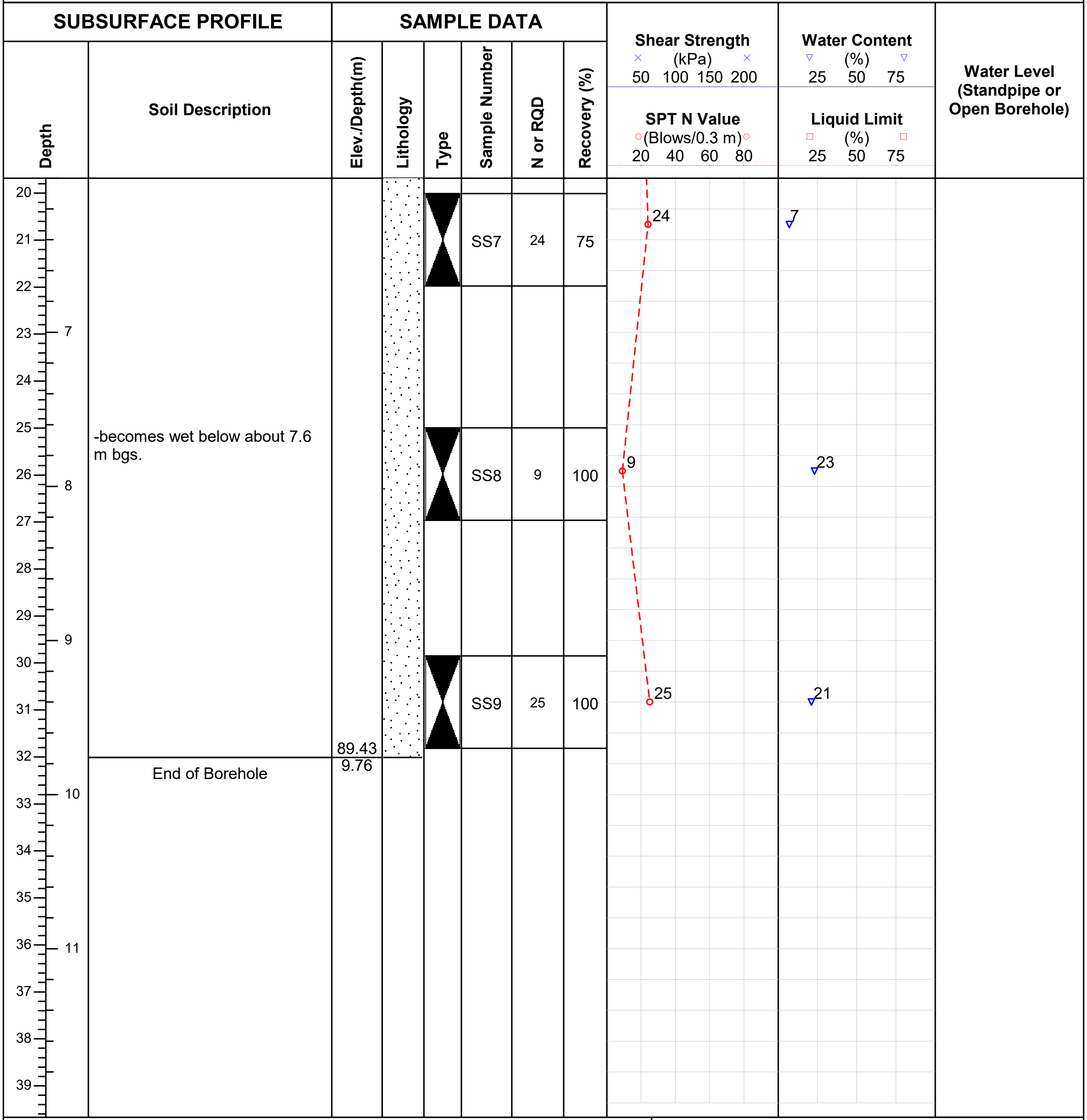
Top of Riser Elev.: 100.578 m

Hole Diameter: 200 mm

NOTES:
-The "N" value for SS1 indicate the soil is frozen, not the state of compactness.

Borehole Log: BH3

Project No.: 200013
Project: Nepean Housing Infill Project
Client: Nepean Housing Corporation
Location: 28 Dunbar Court, Ottawa ON
Date: February 20, 2020
Field Personnel: BJ
Driller: CCC Geotech and Enviro Drilling Ltd.
Drilling Equipment: Track Mount CME 75
Drilling Method: Hollow Stem Auger



Soil Description	Elev./Depth(m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)	SPT N Value	Water Content (%)
				SS7	24	75	24	7
-becomes wet below about 7.6 m bgs.				SS8	9	100	9	23
	89.43 9.76			SS9	25	100	25	21
End of Borehole								

Easting: 439118 m
Northing: 5019326 m

Site Datum: Top of Flange of Fire Hydrant - West of Community Mailbox (100.00 m)

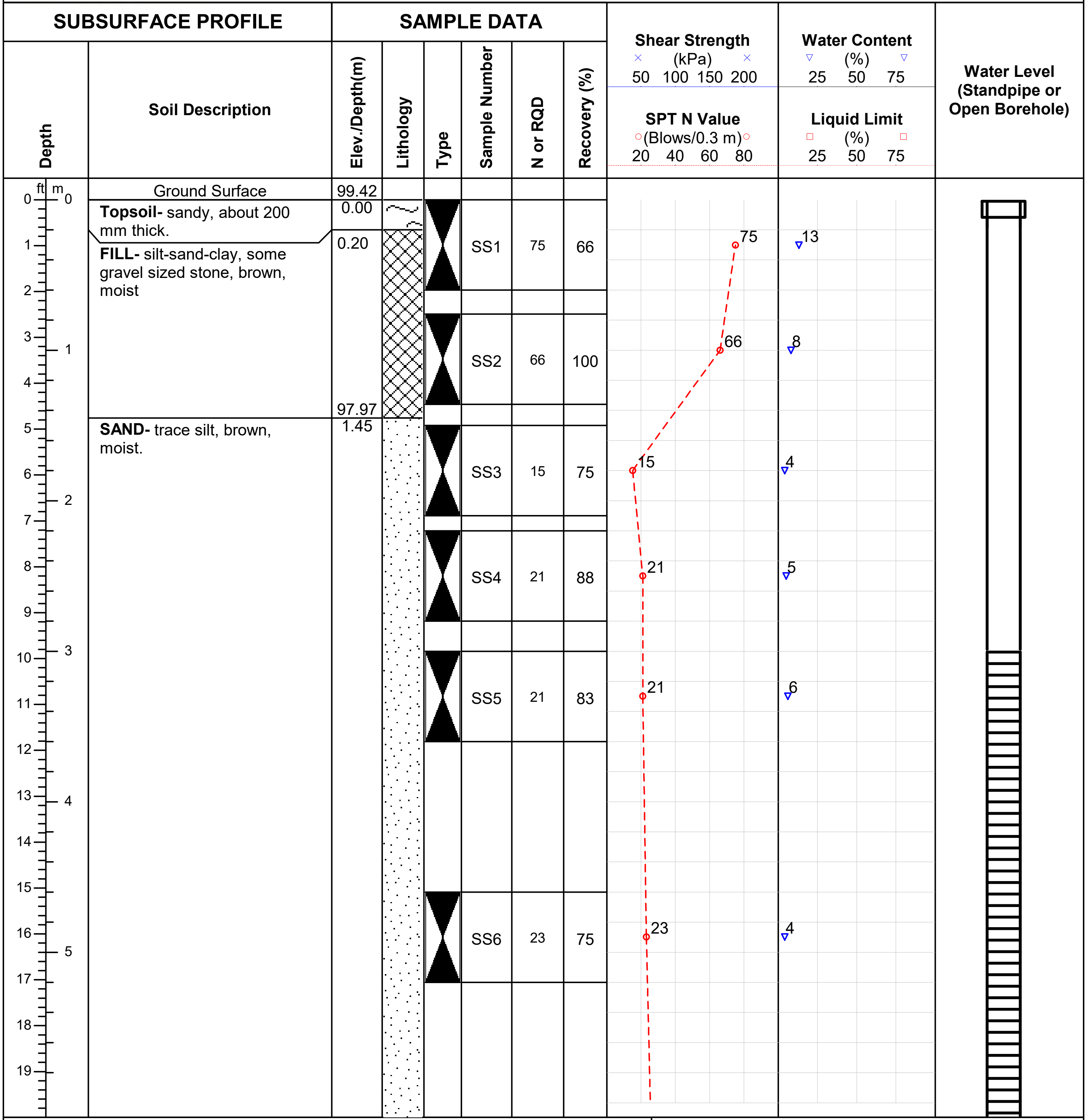
Groundsurface Elevation: 99.193 m
Top of Riser Elev.: 100.578 m

Hole Diameter: 200 mm

NOTES:
-The "N" value for SS1 indicate the soil is frozen, not the state of compactness.

Borehole Log: BH2

Project No.: 200013
Project: Nepean Housing Infill Project
Client: Nepean Housing Corporation
Location: 28 Dunbar Court, Ottawa ON
Date: February 20, 2020
Field Personnel: BJ
Driller: CCC Geotech and Enviro Drilling Ltd.
Drilling Equipment: Track Mount CME 75
Drilling Method: Hollow Stem Auger



Soil Description	Elev./Depth(m)	Sample Number	N or RQD	Recovery (%)
Ground Surface	99.42			
Topsoil- sandy, about 200 mm thick.	0.00			
FILL- silt-sand-clay, some gravel sized stone, brown, moist	0.20	SS1	75	66
		SS2	66	100
SAND- trace silt, brown, moist.	97.97 1.45	SS3	15	75
		SS4	21	88
		SS5	21	83
		SS6	23	75

Easting: 439126 m
Northing: 5019316 m
Site Datum: Top of Flange of Fire Hydrant - West of Community Mailbox (100.00 m)
Groundsurface Elevation: 99.419 m
Top of Riser Elev.: 100.688 m
Hole Diameter: 200 mm

NOTES:
-Piezometer was measured on March 4, 2020 to determine water level. Piezometer was found to be dry.

-The "N" values for SS1 and SS2 indicate the soil is frozen, not the state of compactness.

Borehole Log: BH2

Project No.: 200013

Project: Nepean Housing Infill Project

Client: Nepean Housing Corporation

Location: 28 Dunbar Court, Ottawa ON

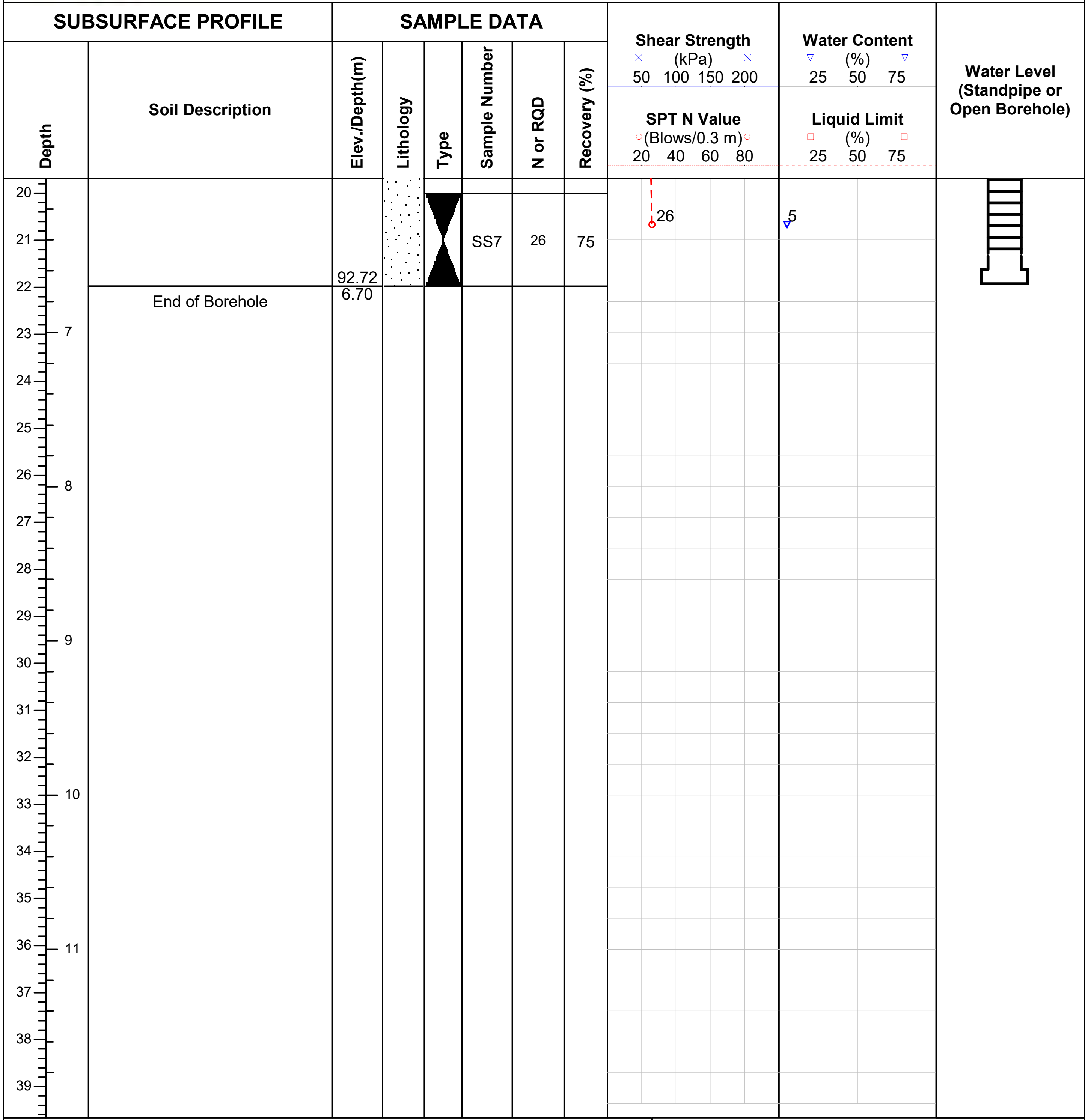
Date: February 20, 2020

Field Personnel: BJ

Driller: CCC Geotech and Enviro Drilling Ltd.

Drilling Equipment: Track Mount CME 75

Drilling Method: Hollow Stem Auger



Soil Description	Elev./Depth(m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)
	92.72 6.70			SS7	26	75
End of Borehole						

Easting: 439126 m

Northing: 5019316 m

Site Datum: Top of Flange of Fire Hydrant - West of Community Mailbox (100.00 m)

Groundsurface Elevation: 99.419 m

Top of Riser Elev.: 100.688 m

Hole Diameter: 200 mm

NOTES:

-Piezometer was measured on March 4, 2020 to determine water level. Piezometer was found to be dry.

-The "N" values for SS1 and SS2 indicate the soil is frozen, not the state of compactness.

APPENDIX C

Symbols and Terms used in Borehole Logs

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Symbols and Terms Used on Borehole and Test Pit Logs

1. Soil Description

The soil descriptions presented in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil involves some judgement and LRL Associates Ltd. does not guarantee descriptions as exact, but infers accuracy to the extent that is common in current geotechnical practice. Boundaries between zones on the logs are often not distinct but transitional and were interpreted.

a. Proportion

The proportion of each constituent part, as defined by the grain size distribution, is denoted by the following terms:

Term	Proportions
“trace”	1% to 10%
“some”	10% to 20%
prefix (i.e. “sandy” silt)	20% to 35%
“and” (i.e. sand “and” gravel)	35% to 50%

b. Compactness and Consistency

The state of compactness of granular soils is defined on the basis of the Standard Penetration Number (N) as per ASTM D-1586. It corresponds to the number of blows required to drive 300 mm of the split spoon sampler using a metal drop hammer that has a weight of 62.5 kg and free fall distance of 760 mm. For a 600 mm long split spoon, the blow counts are recorded for every 150 mm. The “N” value is obtained by adding the number of blows from the 2nd and 3rd count. Technical refusal indicates a number of blows greater than 50.

The consistency of clayey or cohesive soils is based on the shear strength of the soil, as determined by field vane tests and by a visual and tactile assessment of the soil strength.

The state of compactness of granular soils is defined by the following terms:

State of Compactness Granular Soils	Standard Penetration Number “N”	Relative Density (%)
Very loose	0 – 4	<15
Loose	4 – 10	15 – 35
Compact	10 - 30	35 – 65
Dense	30 - 50	65 - 85
Very dense	> 50	> 85

The consistency of cohesive soils is defined by the following terms:

Consistency Cohesive Soils	Undrained Shear Strength (C_u) (kPa)	Standard Penetration Number “N”
Very soft	<12.5	<2
Soft	12.5 - 25	2 - 4
Firm	25 - 50	4 - 8
Stiff	50 - 100	8 - 15
Very stiff	100 - 200	15 - 30
Hard	>200	>30

c. Field Moisture Condition

Description (ASTM D2488)	Criteria
Dry	Absence of moisture, dusty, dry to touch.
Moist	Dump, but not visible water.
Wet	Visible, free water, usually soil is below water table.

2. Sample Data

a. Elevation depth

This is a reference to the geodesic elevation of the soil or to a benchmark of an arbitrary elevation at the location of the borehole or test pit. The depth of geological boundaries is measured from ground surface.

b. Type

Symbol	Type	Letter Code
⌇	Auger	AU
⧗	Split Spoon	SS
‖	Shelby Tube	ST
⦀	Rock Core	RC

c. Sample Number

Each sample taken from the borehole is numbered in the field as shown in this column.

LETTER CODE (as above) – Sample Number.

d. Recovery (%)

For soil samples this is the percentage of the recovered sample obtained versus the length sampled. In the case of rock, the percentage is the length of rock core recovered compared to the length of the drill run.

3. Rock Description

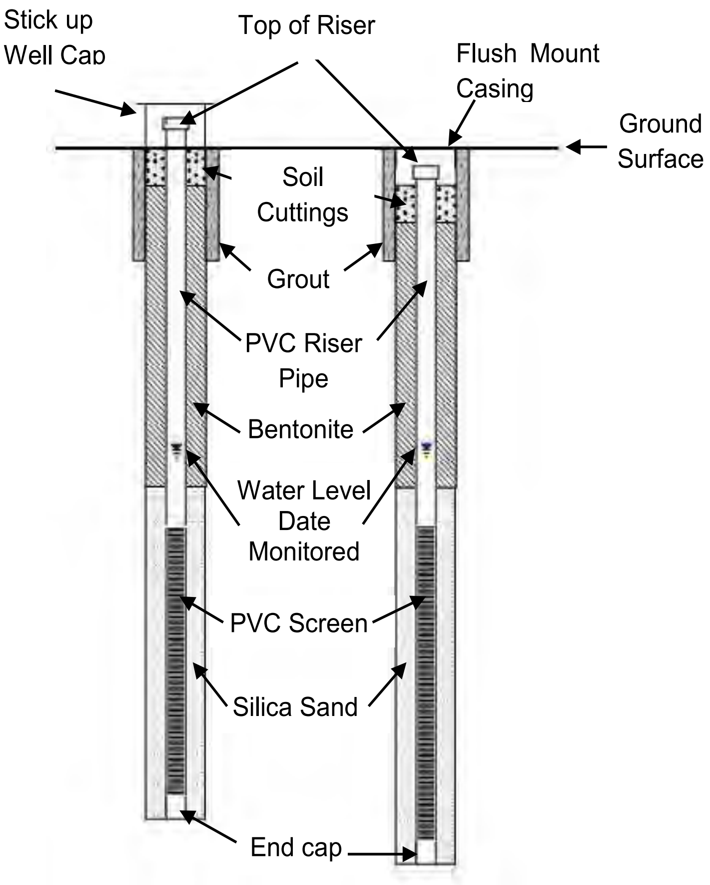
Rock Quality Designation (RQD) is a rough measure of the degree of jointing or fracture in a rock mas. The RQD is calculated as the cumulative length of rock pieces recovered having lengths of 100 mm or more divided by the length of coring. The qualitative description of the bedrock based on RQD is given below.

Rock Quality Designation (RQD) (%)	Description of Rock Quality
0 –25	Very poor
25 – 50	Poor
50 – 75	Fair
75 – 90	Good
90 – 100	Excellent

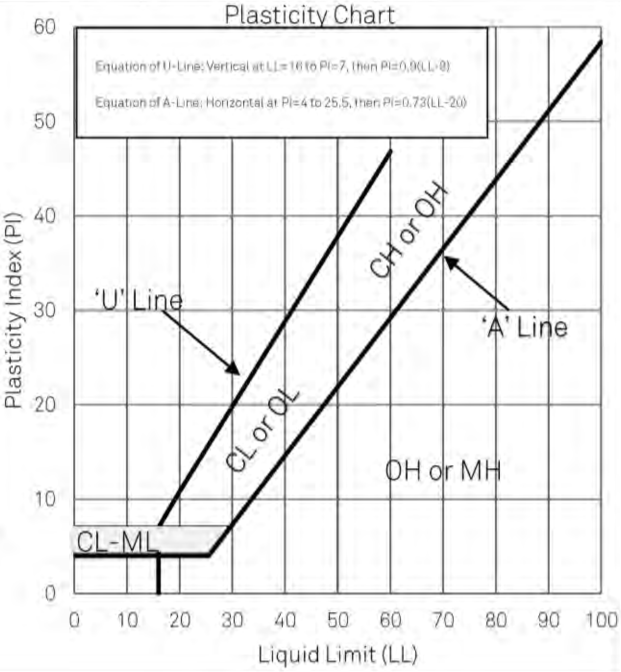
Strength classification of rock is presented below.

Strength Classification	Range of Unconfined Compressive Strength (MPa)
Extremely weak	< 1
Very weak	1 – 5
Weak	5 – 25
Medium strong	25 – 50
Strong	50 – 100
Very strong	100 – 250
Extremely strong	> 250

4. General Monitoring Well Data



5. Classification of Soils for Engineering Purposes (ASTM D2487)
(United Soil Classification System)

Major divisions			Group Symbol	Typical Names	Classification Criteria			
Coarse-grained soils More than 50% retained on No. 200 sieve* (>0.075 mm)	Gravels More than 50% of coarse fraction retained on No. 4 sieve(4.75 mm)	Clean gravels <5% fines	GW	Well-graded gravel	If 15% sand add "with sand" to group name.	Classification on basis of percentage of fines: Less than 5% pass No. 200 sieve - GW, GP, SW, SP More than 12% pass No. 200 sieve - GM, GC, SM, SC 5 to 12% pass No. 200 sieve - Borderline classifications, use of dual symbols	$C_u = \frac{D_{60}}{D_{10}} \geq 4$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravel			Not meeting either Cu or Cc criteria for GW	
		Gravels with >12% fines	GM	Silty gravel			Atterberg limits below "A" line or PI less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols If fines are organic add "with orgnic fines" to group name
			GC	Clayey gravel			Atterberg limits on or above "A" line and PI > 7	
	Sands 50% or more of coarse fraction passes No. 4 sieve(<4.75 mm)	Clean sands <5% fines	SW	Well-graded sand	If 15% gravel add "with gravel to group name		$C_u = \frac{D_{60}}{D_{10}} \geq 6$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sand			Not meeting either Cu or C ccriteria for SW	
		Sands with >12% fines	SM	Silty sand			Atterberg limits below "A" line or PI less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols If fines are organic add "with orgnic fines" to group name
			SC	Clayey sand			Atterberg limits on or above "A" line and PI > 7	
Fine-grained soils50% or more passes No. 200 sieve* (<0.075 mm)	Silts and Clays Liquid Limit <50%	Inorganic	ML	Silt	If 15 to 29% coarse-grained, add "with sand" or "with gravel" as appropriate. If >30% coarse-grained, add "sandy" or "gravelly" as appropriate. Class as organic when oven dried liquid limit is <75% of undried liquid limit.			
			CL	Lean Clay -low plasticity				
		Organic	OL	Organic clay or silt (Clay plots above 'A' Line)				
	Silts and Clays Liquid Limit >50%	Inorganic	MH	Elastic silt				
			CH	Fat Clay -high plasticity				
		Organic	OH	Organic clay or silt (Clay plots above 'A' Line)				
	Highly Organic Soils		PT	Peat, muck and other highly organic soils				

APPENDIX D

Laboratory Results

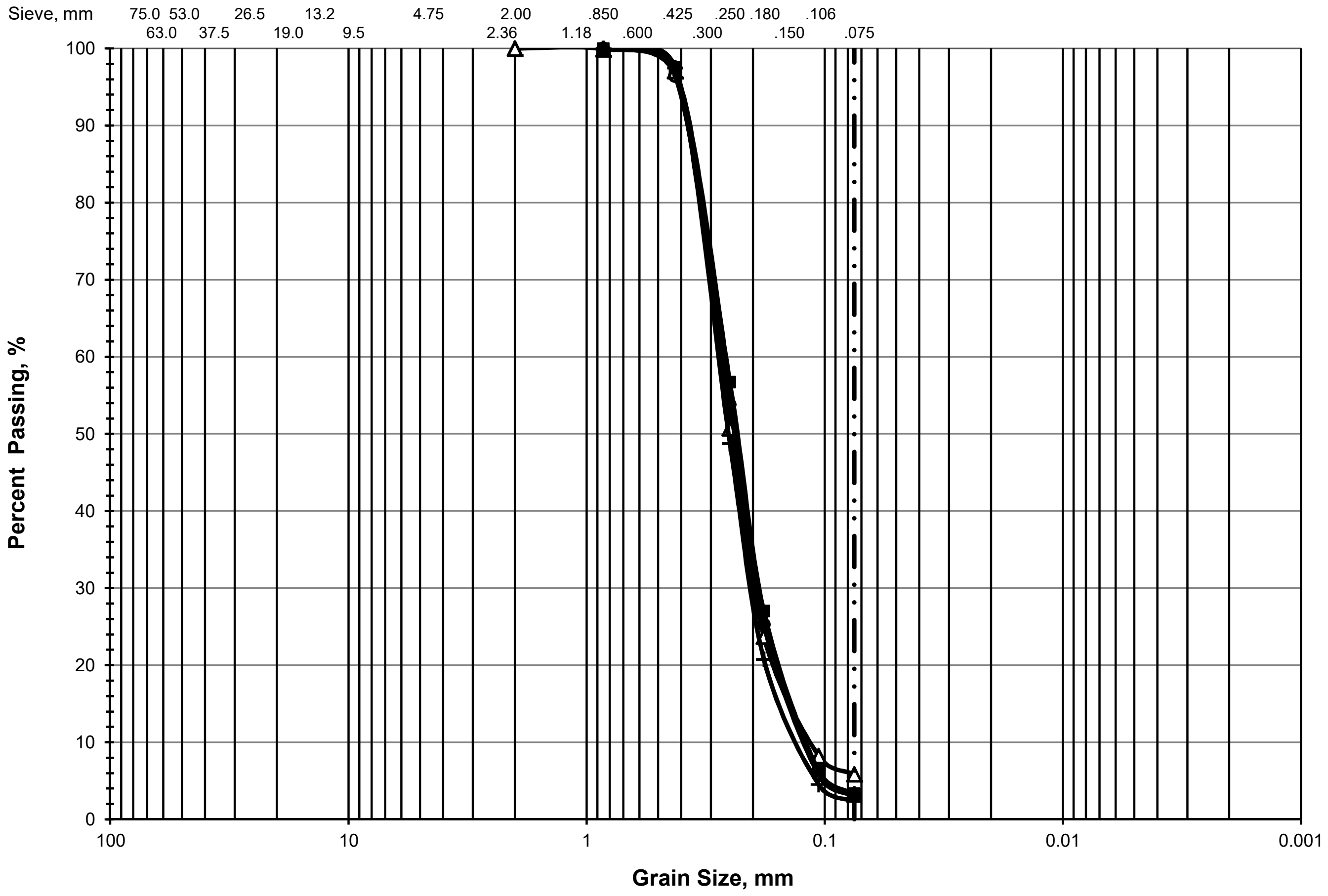
LRL Associates Ltd.

PARTICLE SIZE ANALYSIS

ASTM D 422 / LS-702

Client: Nepean Housing Corporation
Project: Geotechnical Investigation
Location: 28 Dunbar Court, Ottawa, ON.

File No.: 200013
Report No.: 1
Date: February 20, 2020



Unified Soil Classification System

	> 75 mm	% GRAVEL		% SAND			% FINES
		Coarse	Fine	Coarse	Medium	Fine	Silt & Clay
△	0.0	0.0	0.0	0.0	2.9	91.3	5.8
■	0.0	0.0	0.0	0.0	2.4	94.3	3.3
○	0.0	0.0	0.0	0.0	3.6	93.4	3.0
+	0.0	0.0	0.0	0.0	2.5	95.2	2.3

	Location	Sample	Depth, m	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
△	BH 1	SS-3	1.52 - 2.13	0.2851	0.2482	0.1963	0.1383	0.1144	1.2	2.5
■	BH 1	SS-4	2.29 - 2.90	0.2640	0.2341	0.1870	0.1371	0.1192	1.1	2.2
○	BH 2	SS-5	3.05 - 3.66	0.2754	0.2406	0.1915	0.1411	0.1221	1.1	2.3
+	BH 3	SS-5	4.57 - 5.18	0.2904	0.2545	0.2031	0.1536	0.1309	1.1	2.2