Geotechnical Investigation

Proposed 9-Story Residential Apartment
211 Clarence Street
Ottawa, Ontario

Prepared for:

Clarence Gate Holdings Inc.
1376 Bank Street, Unit 500
Ottawa, ON
K1H 7Y3

Attention: Alex Diaz

LRL File No.: 180647

July 2022

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1 INTRODUCTION

LRL Associates Ltd. (LRL) was retained by Clarence Gate Holdings Inc. to perform a geotechnical investigation for a new nine (9) story residential apartment complex to be located at 211 Clarence Street, Ottawa, Ontario.

The purpose of the investigation was to identify the subsurface conditions across the site by the completion of a limited 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 currently vacant, and is civically located at 211 Clarence Street, Ottawa ON. The location is presented in Figure 1 included in **Appendix A**. The lot is approximately rectangular in shape, having a surface area of about 285 m^2. The site is bounded by 212 Murray Street to the North, 215 Clarence Street to the East, Clarence Street to the South, and 309 Cumberland Street to the West. At the time of the investigation, the overgrown brush had recently been removed from site, and the topography is considered to be flat.

It is understood that development on this site will consist of construction of nine (9) storey apartment complex, having a footprint of 185 m^2. The complex will have a basement level, and serviced with municipal water and sewer systems.

3 PROCEDURE

The fieldwork for this investigation was carried out in conjunction with the Phase 2 Environmental Site Assessment (ESA) on July 8, 2022. Prior to the fieldwork, the site was cleared for the presence of any underground services and utilities. A total of two (2) boreholes, labelled BH1 and BH2, were drilled across the site to get a general understanding of the site's soil conditions. The approximate locations of the boreholes are shown in Figure 2 included in **Appendix A**.

The boreholes were advanced using a truck mount 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 8.23 and 8.87 m below ground surface (bgs) respectively. Upon completion, the boreholes were backfilled 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 collected from the boreholes were placed and sealed in plastic bags to prevent moisture loss. 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). A topographic survey was carried out to determine the ground surface elevations at the boring locations. A temporary site benchmark (TBM) was used for the survey, and taken as the top of the fire hydrant at 222 Clarence Street, and given an elevation of 100.00 m. The boreholes respective elevation is shown on the Borehole Logs attached in **Appendix B.**

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 this site is comprised of “Abandoned River Channel Deposits”, consisting of silt and silty clay; commonly including lenses of sand.

The subsurface conditions encountered in the boreholes were classified based on visual and tactile examination of the materials recovered from the boreholes and the results of in-situ laboratory testing. 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 at the boreholes are given in their respective 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 Fill

At the surface of both boring locations, a layer of fill material was encountered, and extended to depths of 1.50 and 1.70 m bgs in BH1 and BH2 respectively. This material can generally be described as sand mixed with some gravel and organic material, brown, and moist to dry. The recorded SPT “N” values of this deposit varied from 4 to 21, indicating the deposit is loose to compact. The natural moisture contents were found to range between 6 and 24%.

4.3 Silty Clay

Underlying the fill at both boring locations, a layer of silty clay was encountered and extended to a depth of 3.81 m bgs. The material had trace sand, grey, and moist. The recorded SPT "N" values of this deposit varied from 7 to 2, indicating the deposit is loose to compact. The natural moisture contents were found to be 33 and 38%.

4.4 Silt and Clay

Underlying the silty clay at both boring locations, a layer of silt and clay was encountered and extended to a depth of 6.70 (end of explorations) and 7.16 m bgs in BH1 and BH2 respectively. The material had trace sand, grey, and moist. The recorded SPT "N" values of this deposit varied from Weight of Hammer (WH) to 2, indicating the deposit is very soft. The natural moisture contents were found to be 50 and 57%.

4.5 Glacial Till

Underlying the silt and clay in BH2, a layer of glacial till was encountered and extended to a depth of 8.87 m bgs. (end of exploration depth). The material can be described as a mixture of silt and sand, with some gravel sized stone, grey, and moist. The SPT "N" value was found to be 58, indicating the material is very dense. The natural moisture content was determined to be 6%.

4.6 Laboratory Analysis

Two (2) soil samples were collected for laboratory gradation analyses. The gradation analyses comprised of sieve and hydrometer were conducted following the procedure **ASTM D422.** Details of laboratory analyses are reflected in **Table 1**.

Table 1: Gradation Analysis Summary

Sample Location	Depth (m)	Percent for Each Soil Gradation							Estimated Hydraulic Conductivity K (m/s)
		Gravel		Sand			Silt (%)	Clay (%)	
		Coarse (%)	Fine (%)	Coarse (%)	Medium (%)	Fine (%)			
BH1	2.3 – 2.9	0.0	0.0	0.0	0.1	8.4	57.4	34.1	1×10^{-7}
BH2	4.6-5.2	0.0	0.0	0.0	0.2	0.5	44.5	54.8	1×10^{-7}

Atterberg limits and moisture contents were conducted on two (2) split spoon soil sample Based on the test result, the values indicate that the subsoils contains inorganic clays of low plasticity.

These A summary of these values are provided below in **Table 2**.

Table 2: Summary of Atterberg Limits and Water Contents

Sample Location	Parameter					
	Depth (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Water Content (%)	USCS Group Symbol
BH1	2.3 – 2.9	41	18	23	33	CL
BH2	4.6 – 5.2	48	22	26	50	CL

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

4.7 Groundwater Conditions

Groundwater was carefully monitored during this field investigation. During drilling, no groundwater was encountered. Based on the moisture contents of the submitted samples, it is expected the static groundwater level is around 5 m bgs.

No piezometers were installed for long term water level observations.

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 in the vicinity of the site.

5 GEOTECHNICAL CONSIDERATIONS

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

This section will detail the specific requirements and limitations with regard to allowable foundation bearing pressure and depth, grade raise and size of the footings.

5.1 Foundations

Based on the subsurface soil conditions established at this site, it is recommended that the footings for the proposed building will be founded below the frost penetration depth, overlying the native silty clay. Therefore, all fill material, including incompetent native soil should be removed from the proposed footprint.

5.2 Shallow Foundation

Conventional strip and column footings founded over the undisturbed native silty clay may be designed using a maximum allowable bearing pressure of **90 kPa** for serviceability limit state **(SLS)** and **135 kPa** for ultimate limit state **(ULS)** factored bearing resistance. The factored ULS value includes the geotechnical resistance factor of 0.5. This bearing capacity assumes that no significant grade raise (ie: greater than 1.0 m) will be required, and that grades will tie into neighbouring properties. This bearing capacity allows for a strip footing maximum width of 2.5 m, and a pad footing maximum width of 5.0 m on any side.

In-situ field testing may be required to check the strength and stability of the footings subgrade. Any incompetent subgrade areas as identified from in-situ testing must be sub-excavated and backfilled with approved structural fill. Similarly, any soft or wet areas should also be sub-excavated and backfilled with approved structural fill only. Prior to placing any approved structural fill, the subgrade should be inspected and approved by 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

For foundations set over undisturbed native soil and where excavation below the underside of the footings is performed in order to reach a suitable founding stratum, consideration should also be given to support the footings on structural fill. The structural fill should be placed over undisturbed native soils in layers not exceeding 300 mm and compacted to 98% of its Standard Proctor Maximum Dry Density (SPMDD) within ±2% of its optimum moisture content. In order to allow the spread of load beneath the footings and to prevent undermining during construction, the structural fill should extend minimum 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. Furthermore, the structural fill must be tested to ensure that the specified compaction level is achieved.

5.4 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 3 below provides various material types and their respective earth pressure properties.

Table 3: 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
Silty Clay to Silt and Clay	17.5	25	0.52	0.41	2.46

5.5 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.

5.6 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.

5.7 Liquefaction Potential

As recommended in Canadian Foundation Engineering Manual 4th edition (*Bray et al. 2004)*, the following criteria can be used to determine liquefaction susceptibility of fine grained soils.

- $w/w_L \geq 0.85$ and $I_p \leq 12$: Susceptible to liquefaction or cyclic mobility
- $w/w_L \geq 0.8$ and $12 \leq I_p \leq 20$: Moderately susceptible to liquefaction or cyclic mobility
- $w/w_L < 0.8$ and $I_p \leq 20$: No liquefaction or cyclic mobility, but may undergo significant deformations if cyclic shear stress > static undrained shear strength.

Based on the above criteria, liquefaction is not a concern for this site.

5.8 Tree Planting Guidelines

Trees being planted onsite shall follow the document “Tree Planting in Sensitive Marine Clay Soils – 2017 Guidelines”.

In summary, small (7.5 m mature tree height) to medium (7.5 – 14 m mature tree height) size trees may be planted onsite provided they are set back a minimum of 4.5 m from the foundation if the following conditions are met:

- The USF is 2.1 m or greater below the lowest finished grade.
- A small tree must have a minimum of 25 m^3 of available soil volume, and a medium tree must be provided with a minimum of 30 m^3 of available soil volume as determined by a landscape architect.
- Foundation walls are reinforced with two (2) upper and two (2) lower 15M rebar.
- Grading surrounding the tree must promote draining to the tree root zone.

5.9 Frost Protection

All exterior footings for any heated structure exposed to frost conditions should have a minimum of 1.5 m of earth cover. Footings for any unheated structures, signage or lighting, and where snow will be cleared, 1.8 m of earth cover is required. 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 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 foundation frost jacking and 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 I, or a Select Subgrade Material (SSM).

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 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

Concrete slab-on-grade should rest over compacted, free draining and well graded structural fill only. Therefore, all organic or otherwise deleterious material shall be removed from the proposed building's footprint. The exposed undisturbed native subgrade should then be inspected and approved by a qualified geotechnical personnel.

Any underfloor fill needed to raise the general floor grade shall consist of OPSS Granular B Type II or I or SSM material or an approved equivalent, compacted to 95% of its SPMDD. The final lift shall be compacted to 98% of its SPMDD. A minimum 200 mm Granular A layer meeting the **OPSS 1010** shall be placed underneath the slab and compacted to 100% of its SPMDD.

It is also recommended that the area of extensive exterior slab-on-grade (sidewalks, ramp etc.) shall be constructed using Granular A base of thickness 150 mm with incorporating subdrain facilities. 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.

If any areas of the proposed building area are to remain unheated during the winter period, thermal protection of the slab on grade may be required. The “Guide for Concrete Floor and Slab Construction”, **ACI 302.1R-04** is recommended to follow for the design and construction of vapour retarders below the floor slab. Further details on the insulation requirements could be provided, if necessary.

5.13 Corrosion Potential and Cement Type

A soil sample was submitted to Paracel Laboratories Ltd. for chemical testing. The following **Table 4** below summarizes the results.

Table 4: Results of Chemical Analysis

Sample Location	Depth (m)	pH	Sulphate (µg/g)	Chloride (µg/g)	Resistivity (Ohm.cm)
BH2	2.3-2.9	7.53	67	5	4,650

The above results revealed a measured sulphate concentration of 67 µg/g in the sample. Based on the CAN/CSA-A23.1 standards (Concrete Materials and Methods of Concrete Construction), a sulphate concentration of less than 1000 µg/g falls within the negligible category for sulphate attack on buried concrete. The test results from soil samples were below the noted threshold. As such, buried concrete for footings and foundations walls will not require any special additive to resist sulphate attack and the use of normal Portland cement is acceptable.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The soil resistivity was measured to be 4,650 ohm.cm, which falls between the “moderately corrosive” range for soil resistivity.

6 Excavation and Backfilling Requirements

6.1 Excavation

Most of the excavation being carried out will be through fill and native silty clay. Excavation must be carried out in accordance with 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. Therefore, shallow temporary excavations can be cut at 1 horizontal to 1 vertical (1H: 1V) for a fully drained excavation starting at the base of the excavation and as per requirements of the OHSA regulations.

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, some minor groundwater seepage or infiltration from the native soils into the shallow temporary excavations during construction may be expected. However, it is anticipated that pumping from open sumps should be sufficient to control groundwater inflow. Any groundwater seepage or infiltration entering the excavation should be removed from the excavation by pumping from sumps within the excavations. Surface water runoff into the excavation should be minimized and diverted away from the excavation if possible.

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 the takings of ground water and storm water for the purpose of dewatering construction projects range between 50,000 and 400,000 litres per day.

Based on the field investigation through localized borings, it is anticipated that pumping of groundwater will not exceed 50,000 litres per day. As such, no PTTW nor registration in the EASR is anticipated to be required for the construction of the proposed warehouse 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 silty clay. Alternately, underground services may be founded over properly prepared and approved structural fill, where excavation below the invert is required. 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 I 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 any pipes should conform to the manufacturers design requirements and to the detailed installations outlined in the Ontario Provincial Standard Specifications (OPSS) and any applicable standards or requirements.

If services are required to be founded below the groundwater table the native materials may be sensitive to disturbances and may also be susceptible to piping and scouring from water pressure at the base of the excavation. Therefore, special precautions should be taken in these areas to stabilize and confine the base of the excavation such as using recompression (thicker bedding) and/or dewatering methods (pre-pumping). In order to properly compact the bedding, the water table should be kept at least 300 mm below the base of the excavation at all time during the installation of any sewers and structures.

As an alternative to Granular A bedding and only where wet conditions are encountered, the use of “clear stone” bedding, such as 19 mm clear stone, **OPSS 1004**, may be considered only in conjunction with a suitable geotextile filter (such as terrafix 270R or approved equivalent). Without proper filtering, there may be entry of fines from native soils and trench backfill into the bedding, which could result in loss of support to the pipes and possible surface settlements. The sub-bedding, bedding and cover materials should be compacted in maximum 200 mm thick lifts to at least 95% of its SPMDD within ±2% of its optimum moisture content using suitable vibratory compaction equipment.

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 or I. 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 are 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 encountered overburden materials are considered to be frost susceptible and should not be used as backfill material directly against foundation walls or underneath unheated concrete slabs. However, these 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. Any imported material shall conform to OPSS Granular B – Type II or I, SSM or approved equivalent.

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. Any excavated materials proposed for reuse should be stockpiled in a manner to promote drying and should be inspected 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. 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 150 mm 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 300 mm.

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 structures 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.

The subgrade for the pavement areas and underground services should be inspected and approved by geotechnical personnel. In-situ density testing should be carried out on the pavement granular materials, pipe bedding and backfill to ensure the materials meet the specifications for required compaction.

If 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.

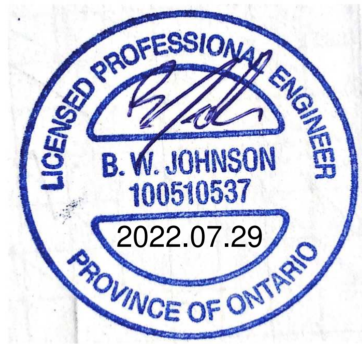
The professional services for this project include only the geotechnical aspects of the subsurface conditions at this site. The presence or implications of possible contamination resulting from previous uses or activities at this site or adjacent properties, and/or resulting from the introduction onto 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 boring locations only. Boundaries between zones presented on the borehole 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.



Brad Johnson, P.Eng.
Geotechnical Engineer

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APPENDIX A

Site and Borehole Location Plan

PROJECT

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
211 CLARENCE STREET
OTTAWA, ONTARIO

LRL

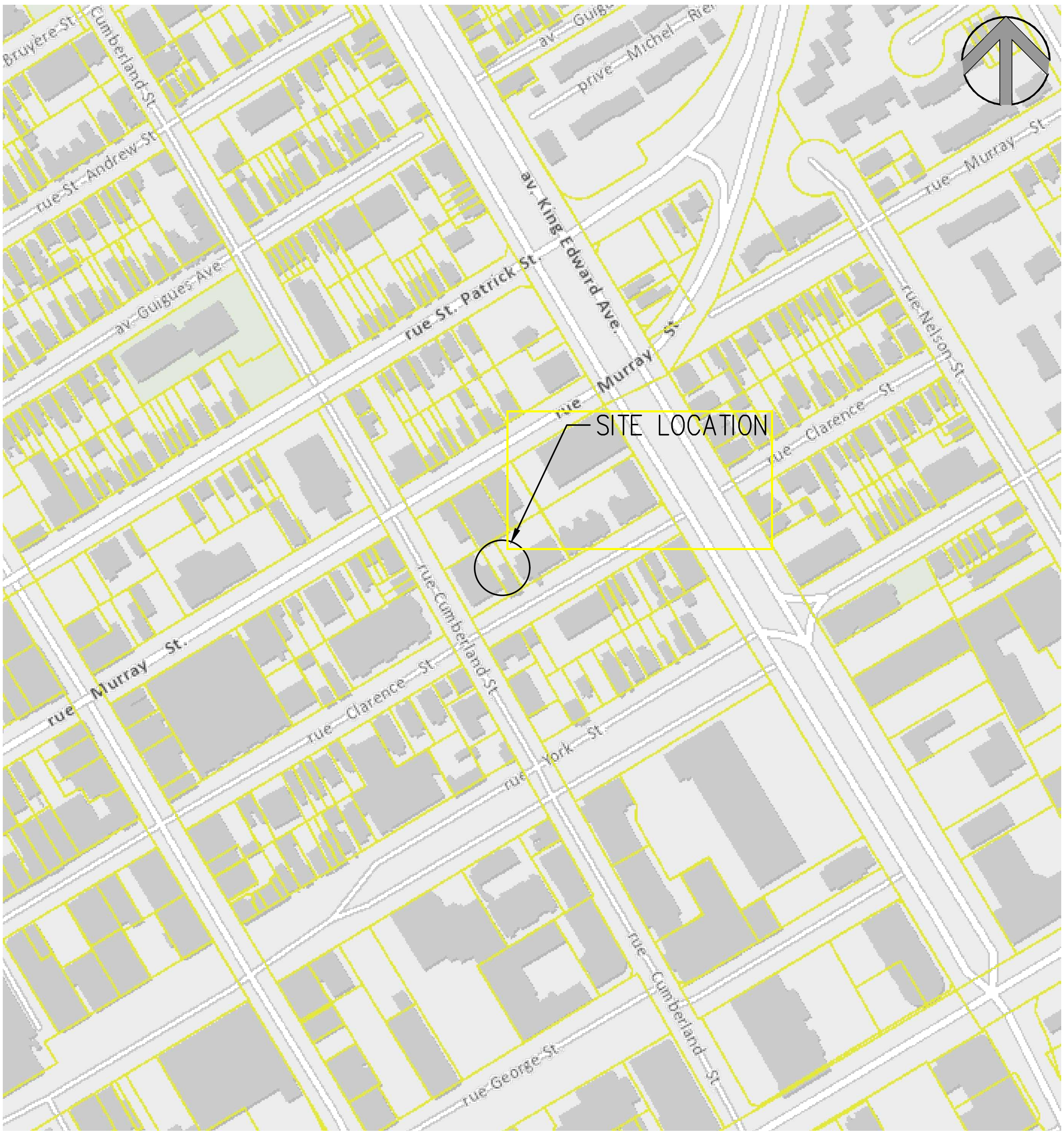
ENGINEERING | INGÉNIERIE

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

DRAWING TITLE

SITE LOCATION
SOURCE: GEOOTTAWA

CLIENT	DATE	PROJECT	
CLARENCE GATE HOLDINGS INC.	JULY 2022	180647	FIGURE 1



ENGINEERING | INGÉNIERIE

5430 Canotek Road | Ottawa, ON, K1J 9G2
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PROJECT

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
211 CLARENCE STREET
OTTAWA, ONTARIO

DRAWING TITLE

BOREHOLE LOCATION
SOURCE: GOOGLE SATELITE VIEW

CLIENT	DATE	PROJECT	
CLARENCE GATE HOLDINGS INC.	JULY 2022	180647	FIGURE 2

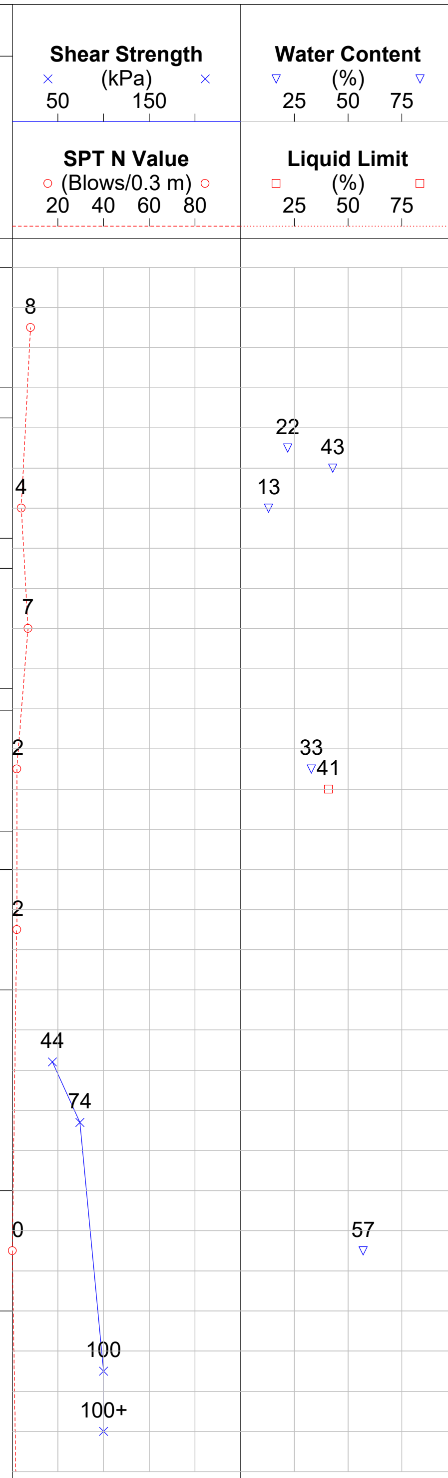
APPENDIX B
Borehole Logs

Borehole Log: BH1

Project No.: 180647
Project: Proposed 9-Storey Residential Building
Client: Clarence Gate Holdings Inc.
Location: 211 Clarence Street, Ottawa ON
Date: July 7, 2022
Field Personnel: GM
Driller: CCC Geotech and Enviro Drilling
Drilling Equipment: Truck Mount CME 850
Drilling Method: Hollow Stew Auger

SUBSURFACE PROFILE / SAMPLE DATA

Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)
Ground Surface	99.52				
FILL sand mixed with gravel and organic material, loose, brown, dry to moist.	0.00		SS1	8	46
			SS2	4	58
SILTY CLAY trace sand, grey, moist, firm to soft.	98.02 / 1.50		SS3	7	92
			SS4	2	100
			SS5	2	100
SILT AND CLAY trace sand, grey, moist, very soft.	95.71 / 3.81				
			SS6	WH	100



Monitoring Well Details

Easting: 446073 m
Northing: 5031056 m
Site Datum: TBM - Top of Fire Hydrant at 222 Clarence (100.00 m)
Groundsurface Elevation: 99.522 m
Top of Riser Elev.: NA
Hole Diameter: 200 mm
Monitoring Well Diameter: N/A

NOTES:

Borehole Log (continued): BH1

Project No.: 180647
Project: Proposed 9-Storey Residential Building
Client: Clarence Gate Holdings Inc.
Location: 211 Clarence Street, Ottawa ON
Date: July 7, 2022
Field Personnel: GM
Driller: CCC Geotech and Enviro Drilling
Drilling Equipment: Truck Mount CME 850
Drilling Method: Hollow Stew Auger

Depth (ft)	Depth (m)	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)	SPT N Value (Blows/0.3 m)	Monitoring Well Details
20–22			92.82	SS	SS7	2	88	2	
22		End of Borehole	6.70						

Chart headings: Shear Strength (kPa) 50 150; Water Content (%) 25 50 75; SPT N Value (Blows/0.3 m) 20 40 60 80; Liquid Limit (%) 25 50 75

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

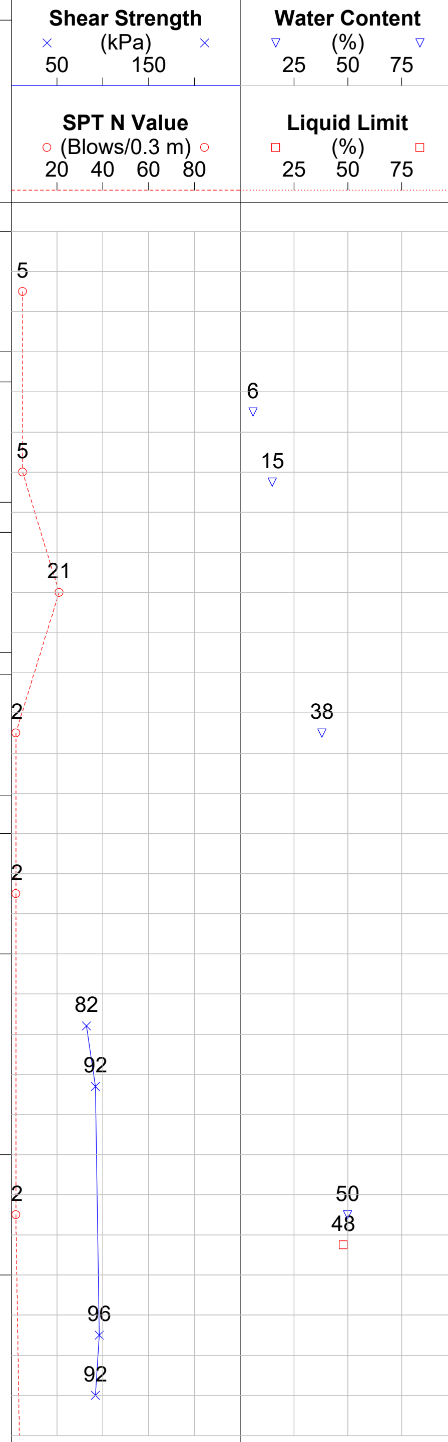
NOTES

Borehole Log: BH2

Project No.: 180647
Project: Proposed 9-Storey Residential Building
Client: Clarence Gate Holdings Inc.
Location: 211 Clarence Street, Ottawa ON
Date: July 7, 2022
Field Personnel: GM

Driller: CCC Geotech and Enviro Drilling **Drilling Equipment:** Truck Mount CME 850 **Drilling Method:** Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA					Monitoring Well Details
Depth	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)	
0 ft / 0 m	Ground Surface	99.37					
	FILL sand mixed with gravel and organic material, loose, brown, dry to moist.	0.00	⧗	SS1	5	50	
			⧗	SS2	5	25	
	SILTY CLAY trace sand, grey, moist, very stiff to soft.	97.67 1.70	⧗	SS3	21	46	
			⧗	SS4	2	100	
			⧗	SS5	2	100	
	SILT AND CLAY trace sand, grey, moist, very soft.	95.56 3.81					
			⧗	SS6	2	100	



Easting: 446079 m **Northing:** 5031066 m

Site Datum: TBM - Top of Fire Hydrant at 222 Clarence (100.00 m)

Groundsurface Elevation: 99.372 m **Top of Riser Elev.:** NA

Hole Diameter: 200 mm **Monitoring Well Diameter:** N/A

NOTES:

Borehole Log (continued): BH2

Project No.: 180647
Project: Proposed 9-Storey Residential Building
Client: Clarence Gate Holdings Inc.
Location: 211 Clarence Street, Ottawa ON
Date: July 7, 2022
Field Personnel: GM
Driller: CCC Geotech and Enviro Drilling
Drilling Equipment: Truck Mount CME 850
Drilling Method: Hollow Stew Auger

SUBSURFACE PROFILE		SAMPLE DATA							
Depth (ft / m)	Soil Description	Elev./Depth (m)	Type	Sample Number	N or RQD	Recovery (%)	Shear Strength (kPa) 50 150 / SPT N Value (Blows/0.3 m) 20 40 60 80	Water Content (%) 25 50 75 / Liquid Limit (%) 25 50 75	Monitoring Well Details
20–22				SS7	4	58	4		
23 / 7		92.21 7.16							
24–28 / 8	**GLACIAL TILL** silt-sand, some gravel sized stone, grey, moist, very dense.			SS8	58	42	58	6	
29 / 9		90.50 8.87							
29–39 / 9–11	End of Borehole Borehole terminated after practical auger refusal								

NOTES

APPENDIX C

Symbols and Terms used in Borehole Logs

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

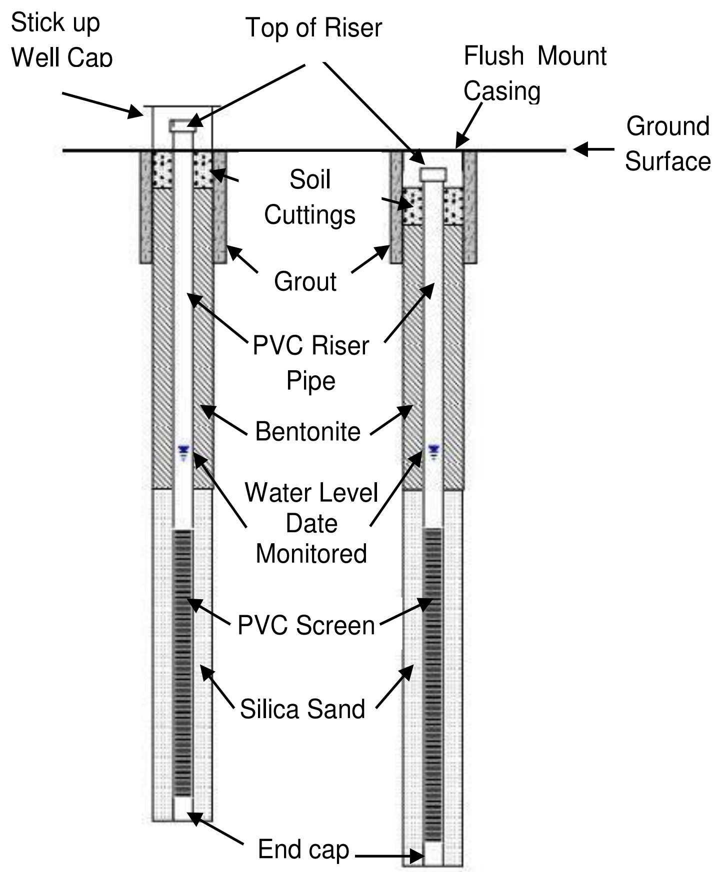
Rock Quality Designation (RQD) is a rough measure of the degree of jointing or fracture in a rock mas. The RQD is calculated as the cumulative length of rock pieces recovered having lengths of 100 mm or more divided by the length of coring. The qualitative description of the bedrock based on RQD is given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

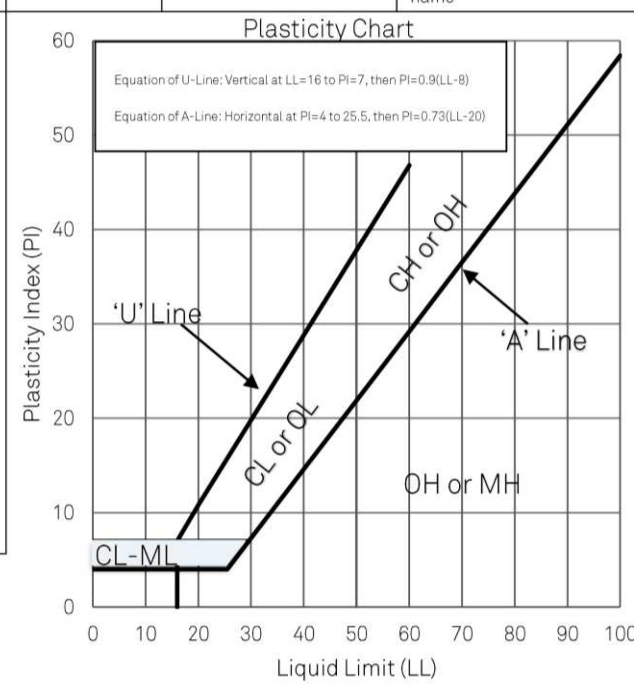
4. General Monitoring Well Data



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
			GC	Clayey gravel			Atterberg limits on or above "A" line and PI > 7	If fines are organic add "with orgnic fines" to group name
	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
			SC	Clayey sand			Atterberg limits on or above "A" line and PI > 7	If fines are organic add "with orgnic fines" to group name
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.	Plasticity Chart		
			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

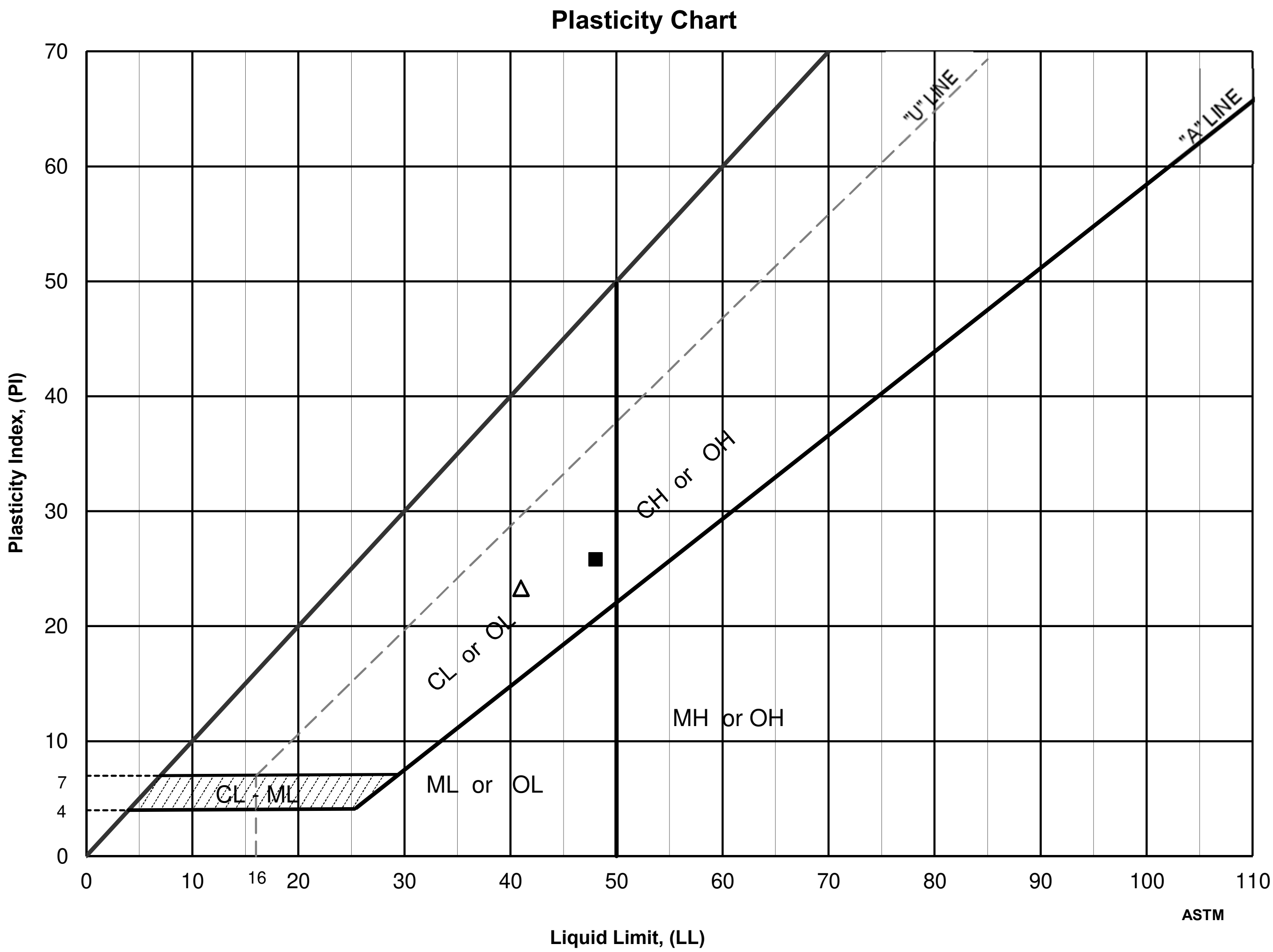
Laboratory Results

LRL Associates Ltd.

PLASTICITY INDEX

ASTM D 4318 / LS-703/704

Client:	Clarence Gate Holdings Inc.	**File No.:**	180647
Project:	Geotechnical Investigation	**Report No.:**	1
Location:	211 Clarence Street, Ottawa, ON.	**Date:**	July 7, 2022



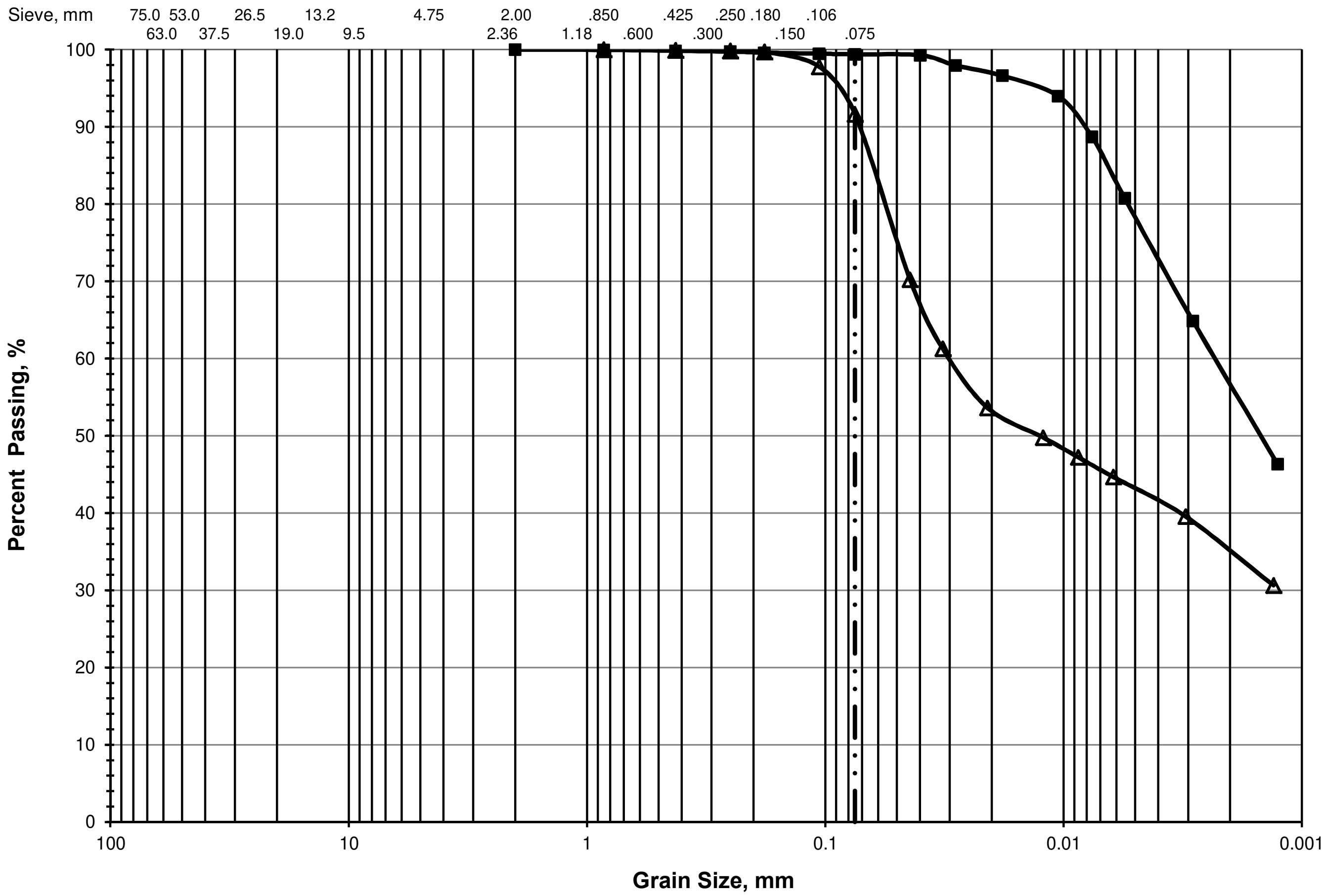
	Location	Sample	Depth, m	Moisture Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Activity Number	USCS
△	BH1	SS-4	2.29 - 2.90	33	41	18	23	0.66	n/d	CL
■	BH2	SS-6	4.57 - 5.18	50	48	22	26	1.06	n/d	CL

LRL Associates Ltd.

PARTICLE SIZE ANALYSIS

ASTM D 422 / LS-702

Client:	Clarence Gate Holdings Inc.	**File No.:**	180647
Project:	Geotechnical Investigation	**Report No.:**	2
Location:	211 Clarence Street, Ottawa, ON.	**Date:**	July 7, 2022



Unified Soil Classification System

	> 75 mm	% GRAVEL		% SAND			% FINES	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
△	0.0	0.0	0.0	0.0	0.1	8.4	57.4	34.1
■	0.0	0.0	0.0	0.0	0.2	0.5	44.5	54.8

	Location	Sample	Depth, m	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
△	BH 1	SS-4	2.29 - 2090	0.0303	0.0127					
■	BH 2	SS-6	4.57 - 5.18	0.0024	0.0016					

300 - 2319 St. Laurent Blvd
Ottawa, ON, K1G 4J8
1-800-749-1947
www.paracellabs.com

Certificate of Analysis

LRL Associates Ltd.

5430 Canotek Road
Ottawa, ON K1J 9G2
Attn: Brad Johnson

Client PO:
Project: 180647
Custody: 69107

Report Date: 29-Jul-2022
Order Date: 18-Jul-2022

Order #: 2230023

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
2230023-01	BH2 7.5-9.5'

Approved By:

Dale Robertson, BSc
Laboratory Director

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	28-Jul-22	28-Jul-22
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	19-Jul-22	20-Jul-22
Resistivity	EPA 120.1 - probe, water extraction	22-Jul-22	22-Jul-22
Solids, %	Gravimetric, calculation	19-Jul-22	19-Jul-22

Certificate of Analysis

Client: **LRL Associates Ltd.**

Client PO:

Report Date: 29-Jul-2022

Order Date: 18-Jul-2022

Project Description: 180647

	Client ID:	BH2 7.5-9.5'	-	-	-
	Sample Date:	07-Jul-22 09:00	-	-	-
	Sample ID:	2230023-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	71.3	-	-	-
General Inorganics					
pH	0.05 pH Units	7.53	-	-	-
Resistivity	0.10 Ohm.m	46.5	-	-	-
Anions					
Chloride	5 ug/g dry	5 [1]	-	-	-
Sulphate	5 ug/g dry	67 [1]	-	-	-

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
General Inorganics									
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis

Client: LRL Associates Ltd.

Client PO:

Report Date: 29-Jul-2022

Order Date: 18-Jul-2022

Project Description: 180647

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
General Inorganics									
pH	7.51	0.05	pH Units	7.50			0.1	2.3	
Resistivity	9.85	0.10	Ohm.m	9.83			0.2	20	
Physical Characteristics									
% Solids	77.3	0.1	% by Wt.	77.2			0.0	25	

Qualifier Notes:

Sample Qualifiers :

1 : Subcontracted analysis - Testmark.

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.
NC: Not Calculated