



CHUNG & VANDER DOELEN
ENGINEERING LTD.

GEOTECHNICAL INVESTIGATION
PROPOSED 10-STOREY APARTMENT BUILDING
1 Dunbar Road North
Waterloo, Ontario

SUBMITTED TO:

2744668 Ontario Inc.
c/o 360 Pacifica Capital Corporation
700 -1130 Sherbrooke W
Montréal, QC Canada
H3A 2M8

ATTENTION:

Marie-Christine Pinard, VP Corporate Development



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August 30, 2024

File No.: 1548

2744668 Ontario Inc.
c/o 360 Pacifica Capital Corporation
700 -1130 Sherbrooke W
Montréal, QC
Canada
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Attention: Marie-Christine Pinard, VP Corporate Development

RE: Geotechnical Investigation
Proposed 10-Storey Apartment Building
1 Dunbar Road North, Waterloo, Ontario

We take pleasure in enclosing one (1) copy of our Geotechnical Investigation Report carried out at the above-referenced Site. Soil samples will be retained for a period of three (3) months and will thereafter be disposed of unless we are otherwise instructed.

If you have any questions or clarifications are required, please contact the undersigned at your convenience.

We thank you for giving us this opportunity to be of service to you.

Yours truly,

CHUNG & VANDER DOELEN ENGINEERING LTD.

Eric Y. Chung, M. Eng., P.Eng.
Principal Engineer

TABLE OF CONTENTS

	Page
Letter of Transmittal	i
Table of Contents	ii
List of Enclosures	iii
1.0 INTRODUCTION	1
2.0 FIELD WORK.....	1
3.0 LABORATORY TESTING	2
4.0 EXISTING SITE CONDITIONS.....	2
5.0 SUBSURFACE CONDITIONS.....	3
5.1 Topsoil/Pavement	3
5.2 Fill	3
5.3 Buried Topsoil	3
5.4 Silty Sand.....	4
5.5 Silt.....	4
5.6 Coarse Granular Deposits	4
5.7 Clayey Silt Till	5
5.8 Groundwater.....	5
6.0 DISCUSSION AND RECOMMENDATIONS.....	7
6.1 General	7
6.2 Two-Level Basement	7
6.3 Footing Foundations.....	8
6.4 Raft Foundation.....	8
6.5 Earthquake Considerations.....	9
6.6 Open Cut Excavation and Groundwater Control.....	9
6.7 Dewatering.....	10
6.8 Floor Slab Design Against Hydrostatic Pressure.....	11
6.9 Floor Slab Construction	11
6.10 Shored Excavation	12
6.11 Lateral Earth Pressure	13
6.12 Pavement Design and Construction	14
6.12.1 Access Driveways and Parking Areas	14
6.12.2 Pavement Above Underground Parking Garage.....	15
6.13 On Site Infiltration	16
6.14 Handling of Excess Soil	16
7.0 CLOSURE.....	17



LIST OF ENCLOSURES

Appendix A	Limitations of Report
Appendix B	Geotechnical Data from 2018 Investigation
Enclosure A	Soil Abbreviations and Terms Used on Record of Borehole Log Sheets
Enclosures 1 to 6	Borehole Log Sheets 1 to 6
Enclosures 7 to 9	Grain Size Distribution Charts
Appendix C	Geotechnical Data from 2023 Investigation
Enclosure A	Soil Abbreviations and Terms Used on Record of Borehole Log Sheets
Enclosures 1 to 4	Borehole Log Sheets 7 to 10
Enclosures 5 to 8	Grain Size Distribution Charts
Drawing No. 1	Borehole Location Plan



1.0 INTRODUCTION

CHUNG & VANDER DOELEN ENGINEERING LTD. (CVD) has been retained by 2744668 Ontario Inc. to update a geotechnical investigation report for the proposed 6 to 10-storey apartment building at 1 Dunbar Road North in Waterloo, Ontario. CVD carried out a geotechnical investigation at the site in 2018 and submitted a geotechnical report dated June 18, 2018. A supplementary geotechnical report dated December 3, 2023 was prepared due to the change of the building design from 1 level basement to 2.5 levels of basement in December 2023. The current geotechnical report is prepared for the redesign of the development to a 6 to 10-storey building with 2.5 levels of basement for underground parking.

The proposed building will have 158 units, 6 to 10 storeys high with a mechanical penthouse and 2.5 levels of basement for underground parking. The finished ground floor level has been established at elevation 331.54 m, the P2 level at elevation 325.54 m and the P2.5 level at 324.04 (1.5 m for the elevator pit). If the building or part of the building is to be supported by a raft foundation, the raft will likely be founded at elevation 322.04 m.

The purpose of this investigation was to determine the subsurface conditions at the site and, based on the findings, to make geotechnical recommendations for:

- Foundation design recommendations;
- Excavation condition;
- Groundwater control during and after construction;
- Slab-on-grade design;
- Backfilling recommendations;
- Foundation soil classification for seismic design per OBC 2012;
- Foundation and retaining wall design;
- Shoring design; and
- Pavement design

2.0 FIELD WORK

The initial investigation was performed on June 4 and 5, 2018 and consisted of six (6) boreholes, numbered 1 to 6, advanced to a depth of 11.13 m below ground surface. Two (2) monitoring wells were installed to measure the groundwater table.

The supplementary geotechnical investigation was performed between November 3 and 7, 2023 and consisted of advancing four (4) boreholes, numbered 7 to 10, to depths between 20.25 and 21.80 m below existing ground surface. One (1) monitoring well was installed at Borehole 8. The borehole locations are shown on Drawing 1, Borehole Location Plan.

The field work was carried out under the supervision of a member of our engineering team, who logged the boreholes in the field, effected the subsurface sampling, and monitored the groundwater conditions. Groundwater conditions were monitored during and at completion of each borehole.



The boreholes were advanced to the sampling depths using a track-mounted power auger drilling rig, equipped with continuous flight augers and standard soil sampling equipment.

Standard Penetration tests (SPTs) in accordance with ASTM Specification D1586 were carried out at frequent intervals of depth during the advancement of the boreholes. These test results are shown on the Borehole Log Sheets as Penetration Resistance or “N”-values. The undrained shear strength of the cohesive soil deposit was determined on the slightly disturbed SPT samples using a field pocket penetrometer. The compactness condition or consistency of the soil strata has been inferred from these test results.

The location and ground surface elevation of the boreholes were surveyed by CVD for the purpose of this report. The ground surface elevations were referenced to a temporary benchmark (TBM) which is shown on Drawing No. 1 and described below:

TBM: Top of eastern catch basin in road edge of southbound lan on Dunbar Road North, just north of the intersection with Erb Street West, as shown on Drawing No. 1

Elevation: 330.97 m (geodetic)

3.0 LABORATORY TESTING

Soil samples obtained from the in-situ tests were examined in the field and subsequently brought to our laboratory for visual and tactile examination to confirm field classification. Moisture content determination of all retrieved samples occurred.

In total, seven (7) grain size distribution analyses and one (1) Atterberg Limits test were performed on the major soil deposits to confirm field identification and to provide information on the soil hydraulic conductivity for the design of infiltration galleries.

4.0 EXISTING SITE CONDITIONS

The site consists of eight (8) adjoining properties, 1 and 5 Dunbar Road North and 142 to 154 Erb Street West in Waterloo. The site is currently occupied by 2-storey residential dwellings which have been boarded up and ready for demolition.

The site is located on the north side of Erb Street West between Roslin Avenue North and Dunbar Road North. These houses have asphalt/granular base driveways extending from the Erb Street West and Dunbar Road North to the houses/garages. The remainder of the properties are grass-covered with frequent mature trees.

The site grades generally decrease to the north and west, away from the corner of Dunbar Road North and Erb Street West towards to the northern property line in the backyards of the residential dwellings. The ground surface elevations at the borehole locations ranged between 329.41 and 331.42 m.



5.0 SUBSURFACE CONDITIONS

The subsurface conditions collected in 2018 are enclosed in Appendix B. The soil stratigraphy encountered in the six (6) boreholes advanced as part of the investigation are shown on the Borehole Log Sheets, Enclosures 1 to 6, inclusive. Boreholes 7 to 10 of the current supplementary investigation are attached as Enclosures 1 to 4 in Appendix C. The following sections provide descriptions of the major soil deposits encountered in the boreholes. Enclosure A provides explanations of the various soil abbreviations and terms used on the borehole log sheets.

The stratigraphic boundaries shown on the borehole logs are inferred from non-continuous sampling conducted during advancement of the borehole drilling procedures and, therefore, represent transitions between soil types rather than exact planes of geologic change. The subsurface conditions will vary between and beyond the borehole locations.

5.1 Topsoil/Pavement

Topsoil was encountered at ground surface at Boreholes 3, 5, 6, 7, 8, 9 and 10 and below the granular base pavement at Borehole 1 with measured thicknesses ranging between 75 and 300 mm.

Asphalt pavement was encountered at ground surface at Borehole 4 with a measured thickness of 50 mm. Granular base materials were contacted at surface at Boreholes 1 and 2 and below the asphalt at Borehole 4 with measured thicknesses ranging between 100 and 250 mm.

5.2 Fill

A layer of fill was encountered underlying the topsoil at Boreholes 1 and 5 to 10 and the pavement structure at Boreholes 2 and 4, which extended to depths between 0.97 and 2.45 m below ground surface. The fill materials varied in composition from silty sand to sandy silt with traces of gravel and clay. Traces of organics/topsoil were observed within the fill materials at all borehole locations.

The SPT “N”-values measured within the fill materials ranged from 1 to 8 blows per 300 mm of penetration, indicating a very loose to loose compactness condition. The measured water content of the samples collected ranged between 4 and 21%, thus indicating a moist moisture condition. The higher moisture contents reflect the presence of topsoil with the fill matrix.

5.3 Buried Topsoil

A layer of buried topsoil, 510± mm in thickness, was encountered underlying the fill materials at Borehole 6 and extended to a depth of 2.64 m below ground surface (elevation 327.77 m). Further, the bottom portion of the fill materials often contains buried topsoil.



5.4 Silty Sand

A deposit of silty sand was encountered at Borehole 5 underlying the fill materials and at Borehole 6 below the buried topsoil. The deposit extended to depths between 4.11 and 4.42 m below ground surface. The results of one (1) grain size distribution analysis from Borehole 5 are shown graphically on Enclosure 9.

SPT “N”-values measured within this deposit ranged from 4 blows to 11 blows per 300 mm of penetration, indicating a loose to compact compactness condition. The measured water content of the samples collected ranged between 4 and 11%, thus indicating a damp to moist moisture condition.

5.5 Silt

A deposit of silt was encountered at Borehole 6 below the silty sand deposit and extended to a depth of 5.18 m below ground surface. The silt deposit contained some sand and traces of gravel and clay.

The SPT “N”-values measured within this deposit ranged from 6 blows to 10 blows per 300 mm of penetration, indicating a loose to compact compactness condition. The measured water content of the samples collected from this deposit ranged between 11 and 20%, thus indicating a moist to wet moisture condition.

5.6 Coarse Granular Deposits

A major deposit of sand to sand and gravel was encountered at Borehole 3 below the topsoil, at Boreholes 1, 2, 4, and 7 to 10 below the fill materials, at Borehole 5 below the silty sand deposit and at Borehole 6 below the silt deposit. The coarse granular deposit extended to depths between 10.05 and 13.10 m below ground surface at Boreholes 3 and 6 to 10. Boreholes 1, 2, 4 and 5 were terminated within the sand deposit to a depth of 11.13 m below ground surface.

The coarse granular deposit contained sand to sand and gravel with trace to some and silt. Gravelly layers were observed throughout this stratum at random thicknesses and sequences. The results of two (2) grain size distribution analyses from Boreholes 1 and 3 are shown graphically on Enclosures 7 and 8, respectively in Appendix B. The results of three (3) grain size distribution analyses from Boreholes 7 to 9 are shown graphically on Enclosures 5 to 7 in Appendix C.

The SPT “N”-values measured within this deposit ranged from 7 blows to 63 blows per 300 mm of penetration, indicating a loose to very dense compactness condition. The measured water content of the samples collected from this deposit ranged between 1 and 23%, thus indicating a damp to saturated moisture condition.



5.7 Clayey Silt Till

A deposit of clayey silt till was encountered at Boreholes 3 and 6 to 10 below the sand to sand and gravel deposit and terminated within the clayey silt till deposit at respective depths between 11.13 and 21.8 m below ground surface. The clayey silt till deposit contained typically traces of sand and gravel with occasional to frequently silt seams and layers. Layers/seams of sand deposit were also encountered in the lower stratum of the till deposit. A typical grain size distribution from Borehole 10 is shown on Enclosure 8 in Appendix C.

SPT “N”-values measured within this deposit ranged from 14 blows to 61 blows per 300 mm. Undrained shear strength measured on slightly disturbed SPT samples using a pocket penetrometer were from 140 to over 250 kPa. Based on the “N”- values, measured shear strength and tactile examination, the clayey silt till exhibits a very stiff to hard consistency. The occasional lower “N”-values reflect saturated silt seams/layers within the till stratum.

The measured water content of the samples collected from this deposit ranged between 14 and 25%, thus indicating a moist moisture condition. An Atterberg Limits test yielded Liquid Limit at 33%, Plastic Limit at 17%, resulting a Plasticity Index of 16%, indicative of a clay of low plasticity (CL).

5.8 Groundwater

Groundwater conditions were monitored during and following completion of borehole sampling. Monitoring wells were installed at Boreholes 1, 6 and 8. The table below summarizes the water levels measured within the monitoring wells on three (3) different dates, with the latest taken on August 27, 2024:

Borehole No.	Ground Surface Elevation (m)	Date	Groundwater Depth (m)	Groundwater Elevation (m)
1	331.15	June 5, 2018	7.72	323.43
		November 27, 2023	7.58	323.57
		August 27, 2024	7.42	323.73
6	330.41	June 5, 2018	6.74	323.67
		November 27, 2023	6.64	323.77
		August 27, 2024	6.42	323.99
8	330.82	November 27, 2023	7.05	323.77
		August 27, 2024	6.94	323.88



Based on the observed groundwater levels, natural moisture contents and observations during borehole drilling and sampling, the groundwater is considered to lie at depths of $6.4\pm$ to $7.7\pm$ m below existing grades, corresponding to elevations between $323.43\pm$ and $323.99\pm$ m. It is likely that the groundwater table will be higher in the Spring and continue to recover from the effect of dewatering for the project at the corner of Erb Street West and Dietz Avenue North. The dewatering for this project was terminated approximately 6 months ago.

These groundwater levels indicate the groundwater table has a downward gradient towards the east. It is noted that the observed groundwater table will fluctuate seasonally and in response to major weather events.



6.0 DISCUSSION AND RECOMMENDATIONS

6.1 General

The proposed building will have 158 units, 6 to 10 storeys high with a mechanical penthouse and 2.5 levels of basement for underground parking. The finished ground floor level has been established at elevation 331.54 m, the P2 level at elevation 325.54 m and the P2.5 level at 324.04 (1.5 m for the elevator pit). If the building or part of the building is to be supported by a raft foundation, the raft will likely be founded at elevation 322.04 m.

In general, the surficial topsoil and pavement structure were underlain by typically very loose to loose fill materials followed by loose to very dense granular deposit, which were then underlain by a very stiff to hard clayey silt till. At the northwest quadrant of the site (near Boreholes 5 and 6), loose fill, buried topsoil and loose native silty sand/silt extended to depths of $4.3\pm$ to $5.2\pm$ m (elevation $326.0\pm$ to $325.2\pm$ m) respectively.

Based on the observed groundwater levels, natural moisture contents and observations during borehole drilling and sampling, the groundwater is considered to lie at depths of $6.4\pm$ to $7.7\pm$ m below existing grades, corresponding to elevations between $323.43\pm$ and $323.99\pm$ m. It is likely that the groundwater table will be higher in the Spring and continue to recover from the effect of dewatering for the project at the corner of Erb Street West and Dietz Avenue North. The dewatering for this project was terminated approximately 6 months ago.

These groundwater levels indicate the groundwater table has a downward gradient towards the east. It is noted that the observed groundwater table will fluctuate seasonally and in response to major weather events. It is recommended that the groundwater table be monitored continuous until the startup of the construction as the groundwater table will have great influence on the need and method for dewatering.

6.2 Two-Level Basement

The groundwater table at the site exists at depths of $6.4\pm$ to $7.7\pm$ m below existing grades, corresponding to elevations between $323.43\pm$ and $323.99\pm$ m and lies in the sand to sand and gravel deposit. Therefore, the P2 basement floor of elevation 325.54 m will lie $1.5\pm$ m above the highest groundwater table. For the P2.5 (elevation 324.04 m), it will be near or below the highest water table recorded to date.

Based on the above, the P2.5 level will be at or below the groundwater table, the basement walls and floor slabs will have to be water-proofed. The P2.5 basement floor slabs will need to be structurally reinforced to withstand the hydrostatic pressure and may require to be anchored down dependent on the final structural design and analysis.

If any foundation excavations are made in the saturated granular deposits, the excavation will need to be pre-drained, and it will require a dewatering system in order to work in a “dry condition” and to maintain the integrity of the granular foundation soils from becoming “quick”.



There is insufficient space for open cut excavations based on the footprint of the proposed building on the site. Therefore, a shoring system will be required to support the excavation and not compromise the foundations of the bordering roadways and neighbouring properties.

Consideration should be given to installing a caisson wall to support the excavation side walls and to provide a positive cutoff of groundwater by toeing into the underlying clayey silt till. In this case, dewatering will only need to be conducted within the caisson wall cofferdam, and this will greatly reduce the need to handle large quantity of groundwater.

6.3 Footing Foundations

Conventional strip and spread footing foundations can be used to support the proposed building structures. Based on P2 at 325.54 m and P2.5 at 324.04 m, the footing founding level will be at or below $324.3 \pm$ m. Footings will be founded on compact to dense sand to sand and gravel and can be designed to a net soil bearing capacity of 300 kPa at SLS.

These soil bearing pressures can be achieved provided that the groundwater table is lowered to maintain the integrity of the sand/gravel deposits and the founding subgrade is undisturbed during construction. In addition, the footings should be founded below any topsoil or other deleterious materials on competent undisturbed soils. Spacing between adjacent footing steps should not be steeper than 10H to 7V.

The majority of the settlements will take place during construction and the first loading cycle of the building. The maximum total and differential settlements of footings designed to the above recommended soil bearing pressure are expected to be less than 25 and 20 mm, respectively, and these are considered tolerable for the structure being contemplated.

Exterior footings and footings in unheated portions of the building should be provided with a soil cover of not less than 1.2 m or equivalent synthetic thermal insulation for adequate frost protection. The founding subgrade soils must be protected from frost penetration during winter construction.

The footing excavations should be inspected by the geotechnical engineer to ensure adequate soil bearing and proper subgrade preparation.

6.4 Raft Foundation

It is understood that the proposed 6 to 10-storey building or a portion of it may need to be supported on a raft foundation. Based on supplied information, the raft will likely be founded $2 \pm$ m below the P2.5 basement floor, near elevation 322.04 m.

The raft soil subgrade will consist of compact to very dense sand to sand and gravel overlying very stiff to hard clayey silt till. If the entire building is supported by a raft foundation, the applied soil pressure would be approximately 144 kPa (12 kPa per floor, 10 storeys + 2 levels of underground parking). However, since the two-level basement will unload approximately 120 kPa of soil pressure ($20 \text{ kN/m}^3 \times 6$



m), the net increase in applied pressure would be $24 \pm$ kPa. This net applied pressure will produce less than 5 mm of settlement.

The following design and construction criteria are recommended:

- Modulus of vertical subgrade reaction of 20 MN/m^3 can be used for preliminary structural design of the raft foundation
- Design the structures to accommodate the relative movement between the residential tower and parking garage/ramp
- Remove any loose or soft soils exposed at the raft founding subgrade and replace such materials with lean concrete or engineered fill
- Place a 50 to 100 mm thick lean concrete working pad to facilitate placement of reinforcement steel and support the installation of waterproofing materials
- Groundwater must be properly controlled during the raft slab construction
- The factored Geotechnical Resistance at ULS is 900 kPa

It is recommended that the foundation excavations be inspected by the geotechnical engineer to ensure adequate soil bearing and proper subgrade preparation.

6.5 Earthquake Considerations

In accordance with The Ontario Building Code 2012 (OBC), the proposed structure should be designed to resist earthquake load and effects as per OBC Subsection 4.1.8.

Based on the anticipated condition of the engineered fill materials and the underlying soil condition encountered at the boreholes, the site can be classified as a Site Class C as per OBC Table 4.1.8.4.A (Page B4-24).

6.6 Open Cut Excavation and Groundwater Control

Excavations are expected to be in the order of $2.5 \pm$ to $8.5 \pm$ m deep for foundations, site servicing and basement construction. The excavations will penetrate topsoil, pavement structure, discontinuous very loose to compact fill layers, loose to dense granular deposits. Provided the groundwater is controlled/lowered below the excavation depths, these materials are considered to be Type 3 Soils in accordance with the latest Occupational Health and Safety Act.

Above the groundwater table, excavations in the Type 3 Soils are expected to remain stable during the construction period provided that side slopes are cut to 1H : 1V from the bottom of the excavation. Where seepage or perched groundwater is encountered, side slopes should be cut to more stable angles



of 3H : 1V. The side slopes should be suitably protected from erosion processes.

Above the groundwater table, rainwater or local perched groundwater can be controlled by pumping from filtered sump pits as and where required. It is recommended that excavation for the future development be done during the typically drier summer months when ground water conditions would be expected to lie at lower elevations.

Dewatering will be required for any excavations carried out below the groundwater table, as the granular soils will become “quick” and lose its integrity to support loads. Dewatering will be required for the footing and raft foundations under the P2.5 level as it will be located near or below the groundwater table. The groundwater level must be lowered and controlled to at least 600 mm below the excavation level to facilitate the excavation and construction of footing/raft foundations, and foundation walls to be carried out in the dry condition.

It is feasible/practical to lower the groundwater table to a depth of 0.6 m by pumping from local sump pits. More extensive pumping and/or pre-draining using pump wells or well points could be required if the excavation/founding depth is more than 0.6 m. It is recommended that CVD be retained to review the design grades and evaluate the need for dewatering.

In wet to saturated subgrade condition, it will be necessary to excavate below founding level and pour a 75 mm thick mud slab of lean concrete to protect the founding soil from disturbance during the installation of reinforcing steel bars and form work.

6.7 Dewatering

Dewatering will be required for the footing and raft foundations under the P2.5 level as it will be located near or below the groundwater table. The method of dewatering depends on how deep the excavation penetrate into the groundwater table.

A dewatering system must be installed to lower the groundwater table to at least 600 mm below the founding levels to enable construction to be carried out in a relatively dry condition, the granular subgrade soils are not disturbed by the hydrostatic pressure, and the lower water table sufficiently depressurized.

The objective of a properly installed and operated dewatering system, to be designed by the dewatering contractor, should:

- Lower the water table inside the excavation and intercept seepage which will emerge from the banks and the bottom of the excavation.
- Improve the stability of the bottom of the excavation to prevent disturbance due to hydrostatic pressure.
- Provide a reasonably dry working area in the bottom of the excavation.



- Provide for the collection and removal of surface runoff water and rainfall.

The dewatering system should be monitored to ensure that “silt” is not removed during pumping. It is noted that the selection of the appropriate dewatering system is the responsibility of the dewatering contractor. The dewatering system proposed by the dewatering contractor should be reviewed by the geotechnical engineer.

The dewatering system should be kept effective until backfilling to the foundations is completed and the weight of the structure is sufficient to resist hydrostatic pressure. The dewatering system should be decommissioned gradually.

A hydrogeological study will be required to determine the amount of groundwater to be pumped and support application to Ministry of Environment, Conservation and Parks (MECP) for an Environmental Activity and Sector Registry (EASR), or a Permit To Take Water (PTTW).

6.8 Floor Slab Design Against Hydrostatic Pressure

If the P2.5 basement floor level is below the groundwater table, the basement walls and floor slabs will have to be water-proofed. The basement floor slabs will need to be structurally reinforced to withstand the hydrostatic pressure and may require to be anchored down dependent on the final structural design and analysis. It is recommended that CVD be retained to review the finalized building designs.

6.9 Floor Slab Construction

The basement floor slab can be constructed as slab on grade on the native undisturbed sand to sand and gravel deposit, or on the 450 to 600 mm thick granular fill which will be placed between the top of the raft foundation and the slab on grade. The granular fill layer is intended to allow utilities to be buried between the slab on grade and the raft. It is recommended that the granular fill layer be consisted of clear crushed stone (9 mm size preferred for the ease of handling and installing utilities).

The clear crushed stone should be suitably compacted/densified to ensure settlement does not take place. At the time of floor slab construction, the exposed clear crushed stone subgrade should be proof-rolled with a heavy roller in conjunction with an inspection by the geotechnical engineer.

A modulus of subgrade reaction (k_s) of 80 MN/m³ may be used for the design of the floor slabs, considering the floor subgrade will consist of clear crushed stone, or 50 MN/m³ on the native sand to sand gravel deposit.

The floor slabs should be separated structurally from the columns and foundation walls. Sawcut control joints should be provided at regular spacing (less than 30 times the concrete slab thickness) and to depths between one-third to one-quarter of the slab thickness.

Care should be taken to ensure that the backfill against foundation walls, interior piers/columns and concrete pits are placed in thin layers and each layer compacted to at least 95% SPMDD. These types of



confined areas should be backfilled with excavated granular materials or imported granular soils such as OPSS Granular B Type I.

Moisture migration from the underlying soils through the concrete slab-on-grade will take place via “capillary action” and “diffusion” (due to vapour pressure differential). Although the Granular “A” layer will provide a capillary break, the low permeance of the concrete slab and floor coverings will result in 100% humidity under the concrete slab and, consequently, the moisture in the concrete will increase over time. The potential effect of the soil moisture should be considered in selecting the floor coverings. A vapour retarder material (such as a 15-mil poly, ASTM E-1745) can be placed to reduce soil moisture migration. Reference is made to ACI 302. For this project, the floor slab in the basement shall be provided with a vapour retarder in all living areas and enclosed areas (such as lobby, storage room, and utility rooms).

6.10 Shored Excavation

As excavation for the raft foundation is expected to be in the order of $8.5\pm$ m deep, a shoring system will be required for temporary excavation support during construction where sufficient space is not available for open cut excavations and to support the adjacent structures. Possible shoring supports include soldier pile and timber lagging system, caisson wall or soil nail retaining system with shotcrete facing.

The shoring system is generally designed and built by a specialized shoring contractor. The shoring system should be designed in accordance with the guidelines provided in the Canadian foundation Engineering Manual (CFEM) 5th Edition.

The shoring system will have to withstand the lateral earth pressure, the adjacent roadway, buried services and the traffic loads as well as the adjacent building structures. Frost pressures on the shoring system should be considered if the system is exposed to winter freezing condition. The shoring system should be monitored to ensure deflection and lateral movements are acceptable, and modifications made to the shoring system if deflection and lateral movements become a problem.

The following soil parameters may be used in the design of shoring. K_o (at rest condition) should be used where the shoring will need to support any existing building/structure.

Soil	Unit Weight (kN/m^3)	Friction Angle (ϕ°)	K_o	K_a	K_p
Fill Materials & Very Loose to Loose Native Granular Deposits	19	28	0.53	0.36	2.77
Compact to Very Dense Sand/Gravel	21	33	0.46	0.29	3.40
Stiff to Hard Clayey Silt Till	20	29	0.52	0.35	2.85



The shoring system can be supported by soil anchor tie-backs and/or raker footings. Soil anchors will provide an unobstructed open space for construction whereas raker supports will obstruct the forming and construction of footings and foundation walls.

If a soldier pile and timber lagging system is adopted, the augering/installation of the soldier piles and timber laggings, especially where they are located adjacent existing structures, should be carried out with caution such that the installation process will not cause future settlements to the adjacent existing structures. The geotechnical engineer should be retained to perform inspection during the installation.

6.11 Lateral Earth Pressure

Unbalanced foundation walls and any other soil retaining structures should be designed to resist the lateral earth pressure acting against these walls. The following formula may be used to calculate the unfactored earth pressure distribution. The factored resistance can be calculated by using a factor of 0.8.

$$P = K (\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2$$

Where:

P	=	lateral earth pressure, kPa
K	=	theoretical earth pressure coefficient (0.5 for level free-draining granular backfill)
γ	=	unit weight of retained soil, 20.0 kN/m ³
γ'	=	submerged unit weight of backfill, 10.2 kN/m ³
γ_w	=	unit weight of water, 9.8 kN/m ³
h_1	=	depth below top of backfill to water table, m
h_2	=	depth below water table to bottom of wall, m
q	=	surcharge, kPa

If free-draining granular material (OPSS Granular “B” Type I) is used as backfill and the water table is kept below the footing of the retaining wall or foundation wall, the hydrostatic pressure component can be ignored in the earth pressure calculation.

The backfill should be placed in thin layers and compacted to 95% SPMDD. Over-compaction adjacent to the foundation/retaining walls should be avoided. Compaction should be carried out with hand operated equipment within 1 m of the foundation wall or retaining wall. Weeping tiles leading to a frost-free outlet or weep holes should be installed to effect drainage behind the retaining wall.

The sliding resistance of the retaining wall footings should be checked. The unfactored horizontal resistance against sliding between cast-in-place concrete and the various soils can be calculated using the following unit weight and friction coefficient:



Soil	Unit Weight (kN/m ³)	Friction Coefficient
Well-compact Granular Backfill	21	0.40
Compact Sand, Silty Sand, Silt	20	0.30

6.12 Pavement Design and Construction

6.12.1 Access Driveways and Parking Areas

Existing topsoil, pavement structure and any deleterious materials should be excavated from the pavement areas. The excavated inorganic site materials can be reused to raise grades to the proposed subgrade level, if required. Based on the results of the field work, the predominant subgrade materials at the site will consist of fine-grained fill materials and native sand/silt soils.

The following flexible pavement structures for the access driveway(s) and potential parking areas not above the underground parking garage are recommended based on the results of grain size distribution, assumed CBR values, groundwater conditions, frost susceptibility of subgrade soils and traffic volume.

Component	Light Duty Pavement (mm)	Heavy Duty Pavement (mm)
Asphaltic Concrete HL3	40	40
Asphaltic Concrete HL8	50	50
Granular "A" Base	150	150
Granular "B" Sub-base	300	400

The pavement design considers that pavement construction will be carried out during the drier time of the year and that the subgrade is stable, not heaving under construction equipment traffic. If the subgrade is wet or unstable, additional granular sub-base may be required.

Prior to the placement of the granular base, the subgrade will be stripped of existing pavements, topsoil, and deleterious materials. The exposed subgrade should be thoroughly recompact with a heavy vibratory compactor and inspected by a qualified geotechnical inspector. Any soft spots encountered during the process should be excavated to the level of competent soil. The required grades can then be achieved by placing approved on-site soils in maximum 200 to 300 thick lifts which should be compacted to 95% SPMDD.

The base and sub-base materials should be produced in accordance with the current OPSS specifications and placed and uniformly compacted to at least 100% SPMDD. The asphaltic concrete should be placed and compacted in accordance with OPSS Form 310 and to at least 92% of the Marshall Density (MRD). Frequent in situ density testing by this office should be carried out to verify that the specified degree of



compaction is being achieved and maintained.

It should be noted that even well compacted trench backfill could settle for a period of time after construction. In this regard, the surface course of the asphaltic concrete should be placed at least one (1) year after trench backfill is completed to allow any minor settlements to occur within the trench backfill. The incomplete pavement structure may not be capable of supporting construction traffic. Consequently, minor repairs of the sub-base, base and asphaltic concrete may be required prior to paving with the base course and/or the surface course asphaltic concrete.

The prepared earth subgrade and final pavement surfaces should be graded to direct water runoff away from buildings, sidewalks, and other similar pertinent structures. Positive drainage outlets should be provided at all low points of the prepared earth subgrade, such as stub drains extended from the catch-basins.

6.12.2 Pavement Above Underground Parking Garage

It is understood that asphalt pavement may be constructed above the underground garage on concrete slab and the following pavement structure is recommended:

Component	Component Thickness (mm)
Superpave 12.5 Surface Course	45
Asphaltic Concrete HL4 Base Course	45
Granular “A” Base (less than 5% silt)	Variable

A water-proofing membrane should be installed above the concrete slab to prevent moisture migration into the underground parking level, protect the concrete slab and reinforcing steel rebar, and aid the drainage of infiltrated water from the Granular “A” base layer to area drains. The structural concrete slab should be sloped to direct water runoff to area drains.

Protection board should be installed above the waterproofing membrane in order protect it from damage and improve the durability and performance of the pavement structure.

The granular base thickness above the underground parking structure will be variable. The granular base materials should contain less than 5% silt and be uniformly compacted to at least 100% SPMDD. The prepared earth subgrade and final pavement surfaces should be graded to direct water runoff to area drains.



6.13 On Site Infiltration

It is understood that the potential for a storm water infiltration feature is to be considered at the site. It is noted that infiltration features should have the base located at least 1.0 m above the high groundwater table and that a minimum infiltration rate of 15 mm/hr is required.

Based on the results of grain size analyses and our past experience, the hydraulic conductivity and infiltration rate of the native inorganic soil types encountered at the boreholes are estimated and provided in the following table and may be used for storm water management purposes:

MATERIAL	PERMEABILITY (K) (cm/sec)	INFILTRATION RATE (mm/hr)
Sand, trace gravel to gravelly, trace silt	2×10^{-2}	100
Silty Sand	2×10^{-3}	40
Sand and Gravel	5×10^{-2}	150
Clayey Silt Till	1×10^{-6}	1

Considering the subsurface conditions encountered at the boreholes, at-source infiltration features are considered to be feasible within the native sand and gravel, sand and silty sand deposits throughout the site.

6.14 Handling of Excess Soil

Excess soil will be generated due to the proposed site works. The management of excess soil is now governed by Ontario Regulation 406/19. In accordance with the regulation, the Project Leader is responsible for the handling, storage, reuse, transportation, and removal of all soil. To support off-site removal, the following is required:

- Planning Documentation
 - Assessment of Past Use
 - Sampling and Analysis Plan
 - Excess Soil Characterization Report
 - Excess Soil Destination Report
- Tracking
- Registry
- Record Keeping

CVD can provide further assistance on this matter as the project develops.



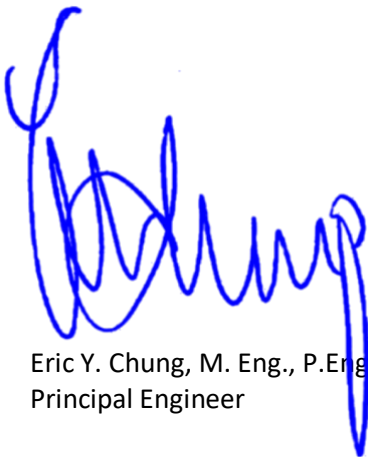
7.0 CLOSURE

The Limitations of Report, as quoted in Appendix A, is an integral part of this report.

We trust that the information presented in this report is complete within our terms of reference. If there are any further questions concerning this report, please do not hesitate to contact our office.

Yours truly,

CHUNG & VANDER DOELEN ENGINEERING LTD.



Eric Y. Chung, M. Eng., P.Eng.
Principal Engineer



APPENDIX A

LIMITATIONS OF REPORT



APPENDIX “A”

LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the testhole locations. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Soils Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes and their respective depths may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

The benchmark and elevations mentioned in this report were obtained strictly for use in the geotechnical design of the project and by this office only, and should not be used by any other parties for any other purposes.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. CHUNG & VANDER DOELEN ENGINEERING LIMITED accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

This report does not reflect the environmental issues or concerns unless otherwise stated in the report.



APPENDIX B

Geotechnical Data from 2018 Investigation



Soil Abbreviations and Terms Used on Record of Borehole Sheets

TERMINOLOGY DESCRIBING COMMON SOIL TYPES:

Topsoil	-	mixture of soil and humus capable of supporting vegetation
Peat	-	mixture of visible and invisible fragments of decayed organic matter
Till	-	unstratified glacial deposit which may range from clay to boulders
Fill	-	soil materials identified as being placed anthropologically

CLASSIFICATION (UNIFIED SYSTEM)

Clay	<0.002mm
Silt	0.002 to .075mm
Sand	0.075 to 4.75mm
	Fine 0.075 to 0.425 mm
	Medium 0.425 to 2.0 mm
	Coarse 2.0 to 4.75 mm
Gravel	4.75 to 75mm
	Fine 4.75 to 19 mm
	Coarse 19 to 75 mm
Cobbles	75 to 300mm
Boulders	>300mm

TERMINOLOGY

Soil Composition	% by Weight
"traces"	<10%
"some"(eg. some silt)	10-20%
Adjective (eg. sandy)	20-35%
"and"(eg. sand and gravel)	35-50%

Standard Penetration Resistance (SPT): Standard Penetration Resistance ('N' Values) refers to the number of blows required to advance a standard (ASTM D1586) 51 mm Ø (2 inch) split-spoon sampler by the use of a free falling, 63.5 Kg (140lbs) hammer. The number of blows from the drop weight is recorded for every 15 cm (6 inches). The hammer is dropped from a distance of 0.76m (30 inches) providing 474.5 Joules per blow. When the sampler is driven a total of 45 cm (18 inches) into the soil, the standard penetration index ('N' Value) is the total number of blows for the last 30 cm (12 inches).

Dynamic Cone Penetration Resistance (DCPT): Dynamic Cone Penetration Resistance is similar to a SPT with the 474.5 Joule/blow impulse provided by the free falling hammer where the split-spoon sampler is replaced by a 51 mm Ø, 60° conical point and the number of blows is recorded continuously for every 30 cm (12 inches).

COHESIVE SOILS CONSISTENCY

	(kPa)	(P.S.F.)	Nominal 'N' Value
Very Soft	<12	<250	0-2
Soft	12-25	250-500	2-4
Firm	25-50	500-1000	4-8
Stiff	50-100	1000-2000	8-15
Very Stiff	100-200	2000-4000	15-30
Hard	>200	>4000	>30

RELATIVE DENSITY OF COHESIONLESS SOIL

	'N' Value
Very Loose	0-4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

MOISTURE CONDITIONS:

Cohesive Soil
DTPL- Drier than plastic limit
APL- About plastic limit
WTPL- Wetter than plastic limit
MWTPL- Much wetter than plastic limit

Cohesionless Soil
Damp
Moist
Wet
Saturated

SAMPLE TYPES AND ADDITIONAL FIELD TESTS

SS	Split Spoon Sample (obtained from SPT)	GS	Grab Sample	PP	Pocket Penetrometer
AS	Auger Sample	BS	Bulk Sample	VANE	Peak & Remolded shear
		TW	Thin Wall Sample or Shelby Tube	DMT	Flat Plate Dilatometer

LABORATORY TESTS

SG	Specific Gravity	S	Sieve Analysis	W	Water Content
H	Hydrometer	P	Field Permeability	K	Lab Permeability
W_p	Plastic Limit	W_l	Liquid Limit	I_p	Plasticity Index
GSA	Grain Size Analysis	C	Consolidation	UNC	Unconfined compression



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Enclosure A

FILE No: G18555**BOREHOLE No. 1**Client: **1950512 Ontario Inc.**Project: **Proposed 6-Storey Apartment Building**Location: **142-154 Erb Street West, Waterloo, Ontario****EQUIPMENT DATA**Machine: **Diedrich D-50T**Method: **Hollow Stem Auger**Size: **108 mm I.D.**Date: **Jun 05 - 18 TO Jun 05 - 18**

SOIL LITHOLOGY				SAMPLE			SHEAR STRENGTH (kPa)				WATER CONTENT (%)			WELL DATA	DEPTH (m)	REMARKS
ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE	FIELD VANE: Peak ⊗ Rem. ×				W _p W W _L					
							LAB TEST: Unc. ■ P.P. □									
							PENETRATION RESISTANCE									
							20	40	60	80		10	20	30		
331.05 330.26	100 mm GRANULAR BASE															steel flushmount casing set in concrete
	100 mm TOPSOIL															
	very loose, dark brown	0.5														
	FILL, sand and silt to silty sand	1.0		1	SS	3										
	trace clay, trace topsoil/organics	1.5														
	moist	2.0		2	SS	1										
329.02 2.13	compact to dense	2.5		3	SS	24										
	brown	3.0														
	SAND	3.5		4	SS	21										
	trace to some silt	4.0														
	trace gravel	4.5														
	occ. silty seams	5.0		5	SS	17										bentonite seal/50 mm I.D. PVC riser
	damp to saturated	5.5														
		6.0														
		6.5		6	SS	34										
		7.0														
		7.5														
		8.0		7	SS	28										
		8.5														
		9.0														
		9.5		8	SS	28										
		10.0														
		10.5														
		11.0		9	SS	26										water level in monitoring well at a depth of 7.72 m on June 5, 2018
320.02 11.13	End of Borehole	11.5														water level in monitoring well at a depth of 7.42 m on August 27, 2024

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FILE No: G18555**BOREHOLE No. 2**Client: **1950512 Ontario Inc.**Project: **Proposed 6-Storey Apartment Building**Location: **142-154 Erb Street West, Waterloo, Ontario****EQUIPMENT DATA**

Machine: **Diedrich D-50T**
 Method: **Hollow Stem Auger**
 Size: **108 mm I.D.**
 Date: **Jun 04 - 18 TO Jun 04 - 18**

SOIL LITHOLOGY			SAMPLE			SHEAR STRENGTH (kPa)				WATER CONTENT (%)			WELL DATA	DEPTH (m)	REMARKS		
ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE	FIELD VANE: Peak ⊗ Rem. × LAB TEST: Unc. ■ P.P. □ 50 100 150 200				W _p W W _L						
							PENETRATION RESISTANCE STANDARD ● DYN. CONE ○ 20 40 60 80				10 20 30						
329.76 0.97	250 mm GRANULAR BASE																
	very loose, dark brown FILL, silty sand trace topsoil/organics moist very loose to dense brown SAND trace to some gravel trace to some silt damp to saturated ----- gravelly layer ----- ----- gravelly layer -----	0.5															
		1.0	1	SS	3												
		1.5															
		2.0	2	SS	8												
		2.5															
		3.0	3	SS	10												
		3.5															
		4.0	4	SS	11												
		4.5															
5.0	5	SS	20														
5.5																	
6.0																	
6.5																	
7.0																	
7.5																	
8.0																	
8.5																	
9.0																	
9.5																	
10.0																	
10.5																	
11.0																	
11.5																	
319.60 11.13	End of Borehole																

borehole cave-in and water level at depth of 6.25 m bgs upon completion of drilling

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FILE No: G18555**BOREHOLE No. 3**Client: **1950512 Ontario Inc.**Project: **Proposed 6-Storey Apartment Building**Location: **142-154 Erb Street West, Waterloo, Ontario****EQUIPMENT DATA**Machine: **Diedrich D-50T**Method: **Hollow Stem Auger**Size: **108 mm I.D.**Date: **Jun 05 - 18 TO Jun 05 - 18**

SOIL LITHOLOGY			SAMPLE			SHEAR STRENGTH (kPa)				WATER CONTENT (%)			WELL DATA	DEPTH (m)	REMARKS		
ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE	FIELD VANE: Peak ⊗ Rem. × LAB TEST: Unc. ■ P.P. □ 50 100 150 200				W _p W W _L						
							PENETRATION RESISTANCE STANDARD ● DYN. CONE ○ 20 40 60 80				10 20 30						
329.11 0.30	300 mm TOPSOIL	0.3															
	loose to dense brown SAND trace to some silt trace gravel occ. silty seams damp to saturated ----- gravelly layer -----	0.5															
		1.0		1	SS	7											
		1.5															
		2.0		2	SS	17											
		2.5															
		3.0															
		3.5		4	SS	26											
		4.0															
		4.5															
		5.0		5	SS	32											
		5.5															
		6.0															
		6.5		6	SS	25											
		7.0															
		7.5															
		8.0		7	SS	28											
8.5																	
9.0																	
9.5																	
10.0																	
319.20 10.21	hard, grey CLAYEY SILT trace sand moist	10.2															
318.28 11.13	End of Borehole	11.1		9	SS	46											
		11.5															

borehole cave-in at water level at depth of 5.94 m bgs upon completion of drilling

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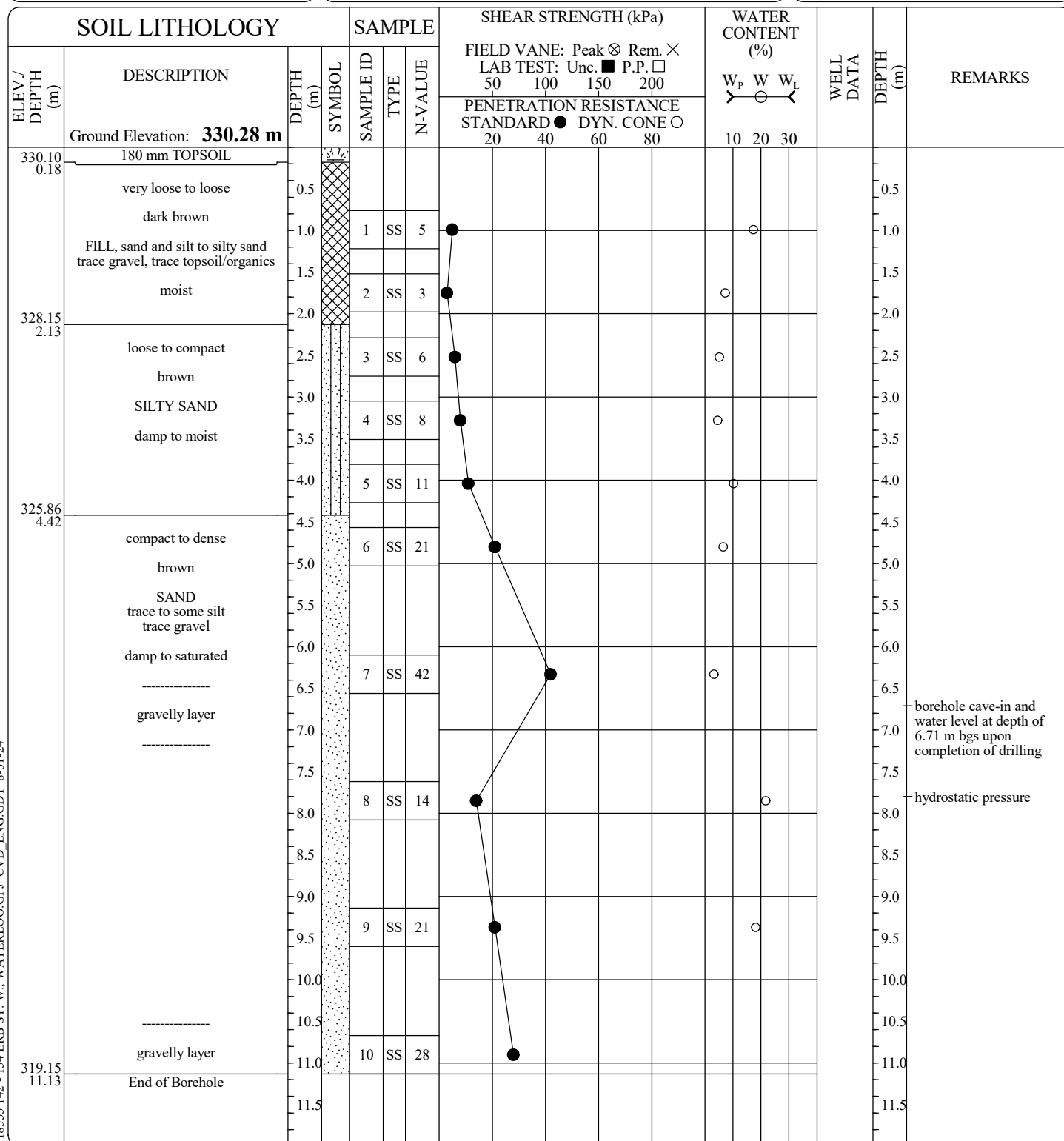
FILE No: G18555**BOREHOLE No. 4**Client: **1950512 Ontario Inc.**Project: **Proposed 6-Storey Apartment Building**Location: **142-154 Erb Street West, Waterloo, Ontario****EQUIPMENT DATA**Machine: **Diedrich D-50T**Method: **Hollow Stem Auger**Size: **108 mm I.D.**Date: **Jun 04 - 18 TO Jun 04 - 18**

SOIL LITHOLOGY				SAMPLE			SHEAR STRENGTH (kPa)				WATER CONTENT (%)			WELL DATA	DEPTH (m)	REMARKS
ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE	FIELD VANE: Peak ⊗ Rem. × LAB TEST: Unc. ■ P.P. □ 50 100 150 200				W _p W W _L					
							PENETRATION RESISTANCE				↗ ○ ↖					
							STANDARD ● DYN. CONE ○				10 20 30					
328.64 2.13	50 mm ASPHALT 200 mm GRANULAR BASE	0.5														
	very loose, dark brown	1.0		1	SS	4	●									
	FILL, sandy silt to silt sand trace gravel, trace clay, trace topsoil/organics	1.5														
	moist	2.0	2	SS	3	●										
	loose to very dense, brown SAND trace to some silt trace gravel damp to saturated ----- gravelly layer -----		2.5													
			3.0	3	SS	8	●									
			3.5													
			4.0	4	SS	12	●									
			4.5													
			5.0	5	SS	36	●									
		5.5														
		6.0														
		6.5	7	SS	53	●										
		7.0														
319.64 11.13	End of Borehole	7.5														borehole cave-in and water level at depth of 7.01 m bgs upon completion of drilling
		8.0	8	SS	30	●										
		8.5														
		9.0														
		9.5	9	SS	33	●										
		10.0														
		10.5														
		11.0	10	SS	37	●										
		11.5														

borehole cave-in and
water level at depth of
7.01 m bgs upon
completion of drillingPROJECT MANAGER: **EYC****CHUNG & VANDER DOELEN
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FILE No: G18555**BOREHOLE No. 5**Client: **1950512 Ontario Inc.**Project: **Proposed 6-Storey Apartment Building**Location: **142-154 Erb Street West, Waterloo, Ontario****EQUIPMENT DATA**

Machine: **Diedrich D-50T**
 Method: **Hollow Stem Auger**
 Size: **108 mm I.D.**
 Date: **Jun 04 - 18 TO Jun 04 - 18**

PROJECT MANAGER: **EYC**
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BOREHOLE No. 6



Location: **142-154 Erb Street West, Waterloo,
Ontario**

Machine: **Diedrich D-50T**
Method: **Hollow Stem Auger**
Size: **108 mm I.D.**
Date: **Jun 04 - 18 TO Jun 04 - 1**

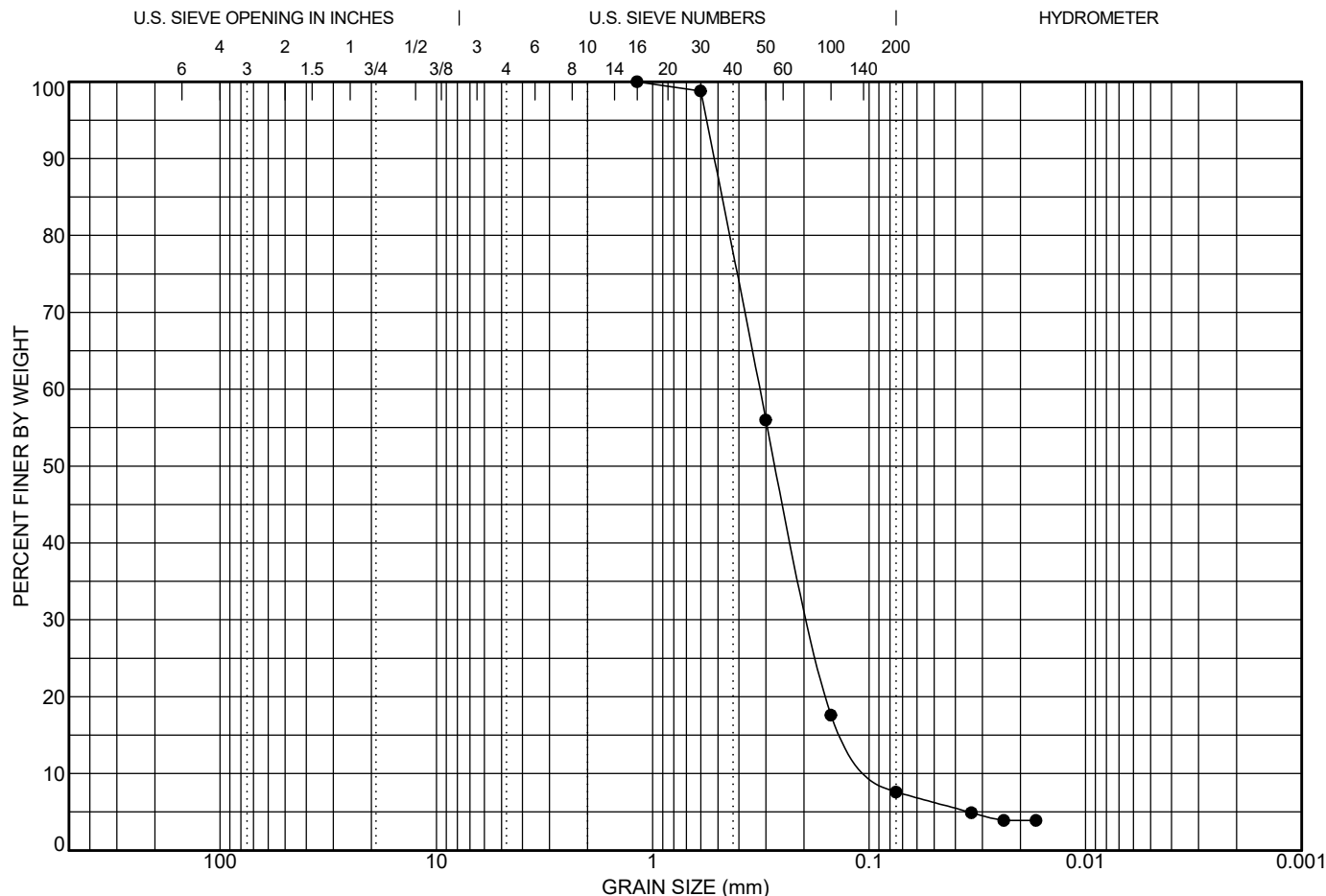
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CVD BOREHOLE (2017) G18555 142 - 154 ERB ST. W., WATERLOO.GPJ CVD ENG.GDT 8-31-24

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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

LL	PL	PI	Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
			1.24	3.61	1.18	0.32	0.188	0.089	0.0	92.4		7.6

Date: Jun. 11 - 2018
Client: 1950512 Ontario Inc.
Contractor:
Source:
Sampled From: BH 1 - SA 4, 3.05 m to 3.51 m depth
Sample No.: 1-4
Date Sampled: Jun. 05 - 2018
Sampled By: JV
Lab No.: 3201
Date Tested: Jun. 07 - 2018
Type of Material: Sand, trace silt

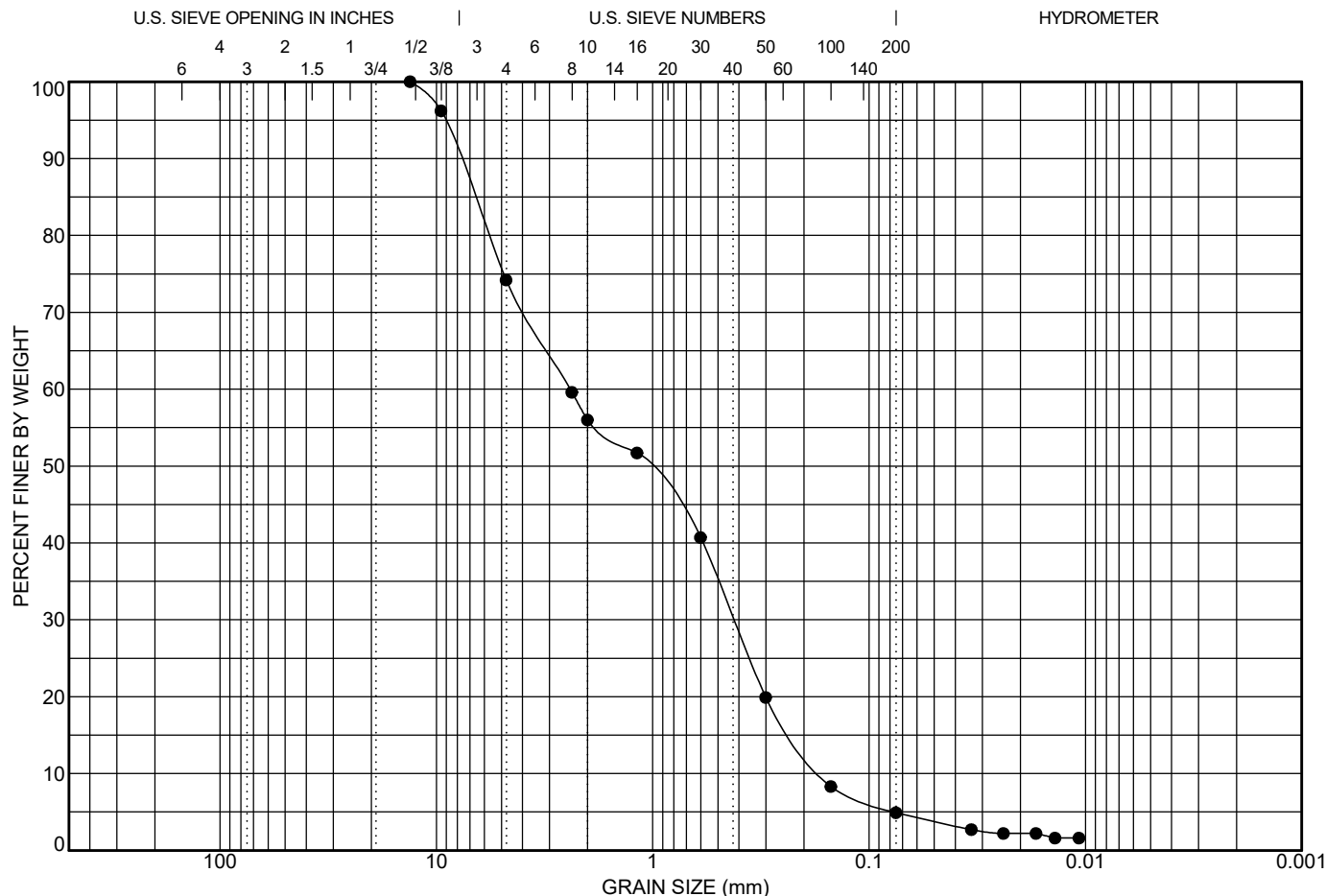
Sieve Size (mm)	Percent Passing	No Specifications



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GRAIN SIZE DISTRIBUTION

Project: Proposed 6-Storey Apartment Building
Location: 142-154 Erb Street West, Waterloo, Ontario
File No.: G18555
Enclosure No.: 7



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

LL	PL	PI	Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
			0.44	14.49	13.2	2.406	0.42	0.166	25.8	69.3	4.9	

Date: Jun. 11 - 2018
Client: 1950512 Ontario Inc.
Contractor:
Source:
Sampled From: BH 3 - SA 4, 3.05 m to 3.51 m depth
Sample No.: 3-4
Date Sampled: Jun. 05 - 2018
Sampled By: JV
Lab No.: 3202
Date Tested: Jun. 07 - 2018
Type of Material: Gravelly Sand, trace silt

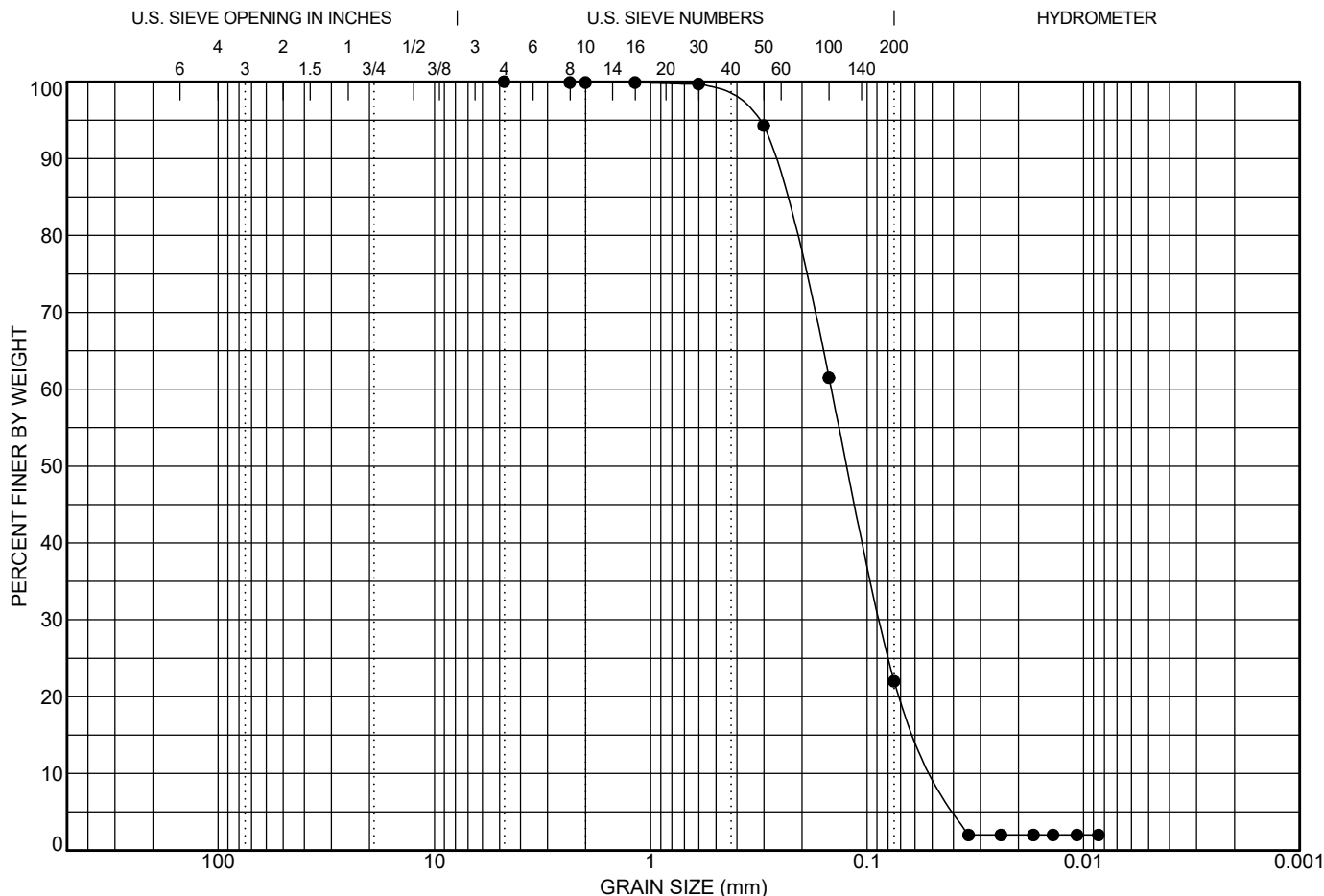
Sieve Size (mm)	Percent Passing	No Specifications



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GRAIN SIZE DISTRIBUTION

Project: Proposed 6-Storey Apartment Building
Location: 142-154 Erb Street West, Waterloo, Ontario
File No.: G18555
Enclosure No.: 8



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

LL	PL	PI	Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
			1.09	3.14	4.75	0.146	0.086	0.047	0.0	78.0	22.0	

Date: Jun. 11 - 2018
Client: 1950512 Ontario Inc.
Contractor:
Source:
Sampled From: BH 5 - SA 5, 3.81 m to 4.27 m depth
Sample No.: 5-5
Date Sampled: Jun. 04 - 2018
Sampled By: JV
Lab No.: 3203
Date Tested: Jun. 07 - 2018
Type of Material: Silty Sand

Sieve Size (mm)	Percent Passing	No Specifications



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 Fax: 519-742-7739
 e-mail: info@cvdengineering.com

GRAIN SIZE DISTRIBUTION

Project: Proposed 6-Storey Apartment Building
Location: 142-154 Erb Street West, Waterloo, Ontario
File No.: G18555
Enclosure No.: 9

APPENDIX C

Geotechnical Data from 2023 Investigation



Soil Abbreviations and Terms Used on Record of Borehole Sheets

TERMINOLOGY DESCRIBING COMMON SOIL TYPES:

Topsoil	-	mixture of soil and humus capable of supporting vegetation
Peat	-	mixture of visible and invisible fragments of decayed organic matter
Till	-	unstratified glacial deposit which may range from clay to boulders
Fill	-	soil materials identified as being placed anthropologically

CLASSIFICATION (UNIFIED SYSTEM)

Clay	<0.002mm
Silt	0.002 to .075mm
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	Fine 0.075 to 0.425 mm
	Medium 0.425 to 2.0 mm
	Coarse 2.0 to 4.75 mm
Gravel	4.75 to 75mm
	Fine 4.75 to 19 mm
	Coarse 19 to 75 mm
Cobbles	75 to 300mm
Boulders	>300mm

TERMINOLOGY

Soil Composition	% by Weight
"traces"	<10%
"some"(eg. some silt)	10-20%
Adjective (eg. sandy)	20-35%
"and"(eg. sand and gravel)	35-50%

Standard Penetration Resistance (SPT): Standard Penetration Resistance ('N' Values) refers to the number of blows required to advance a standard (ASTM D1586) 51 mm Ø (2 inch) split-spoon sampler by the use of a free falling, 63.5 Kg (140lbs) hammer. The number of blows from the drop weight is recorded for every 15 cm (6 inches). The hammer is dropped from a distance of 0.76m (30 inches) providing 474.5 Joules per blow. When the sampler is driven a total of 45 cm (18 inches) into the soil, the standard penetration index ('N' Value) is the total number of blows for the last 30 cm (12 inches).

Dynamic Cone Penetration Resistance (DCPT): Dynamic Cone Penetration Resistance is similar to a SPT with the 474.5 Joule/blow impulse provided by the free falling hammer where the split-spoon sampler is replaced by a 51 mm Ø, 60° conical point and the number of blows is recorded continuously for every 30 cm (12 inches).

COHESIVE SOILS CONSISTENCY

	(kPa)	(P.S.F.)	Nominal 'N' Value
Very Soft	<12	<250	0-2
Soft	12-25	250-500	2-4
Firm	25-50	500-1000	4-8
Stiff	50-100	1000-2000	8-15
Very Stiff	100-200	2000-4000	15-30
Hard	>200	>4000	>30

RELATIVE DENSITY OF COHESIONLESS SOIL

	'N' Value
Very Loose	0-4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

MOISTURE CONDITIONS:

Cohesive Soil
DTPL- Drier than plastic limit
APL- About plastic limit
WTPL- Wetter than plastic limit
MWTPL- Much wetter than plastic limit

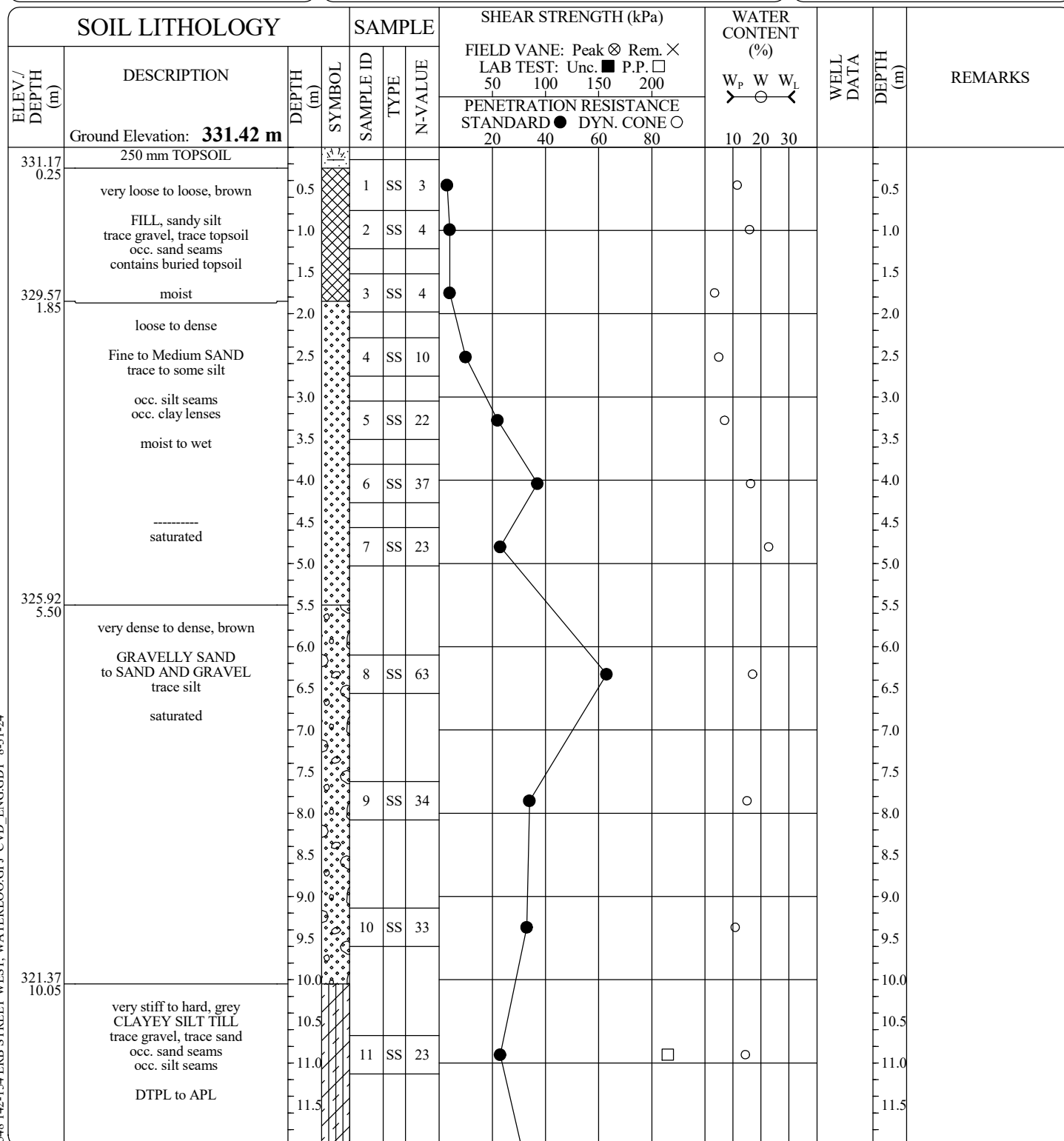
Cohesionless Soil
Damp
Moist
Wet
Saturated

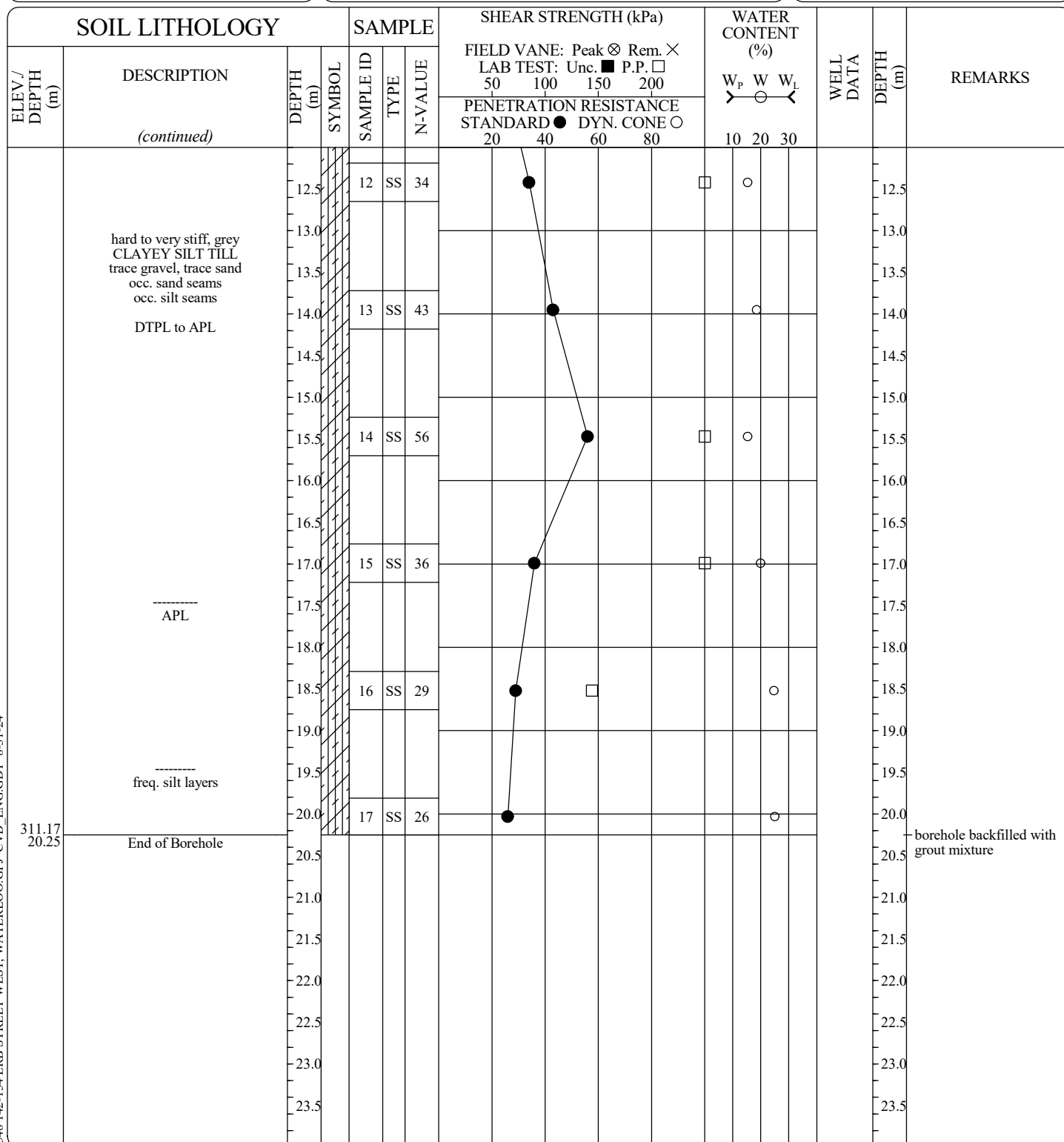
SAMPLE TYPES AND ADDITIONAL FIELD TESTS

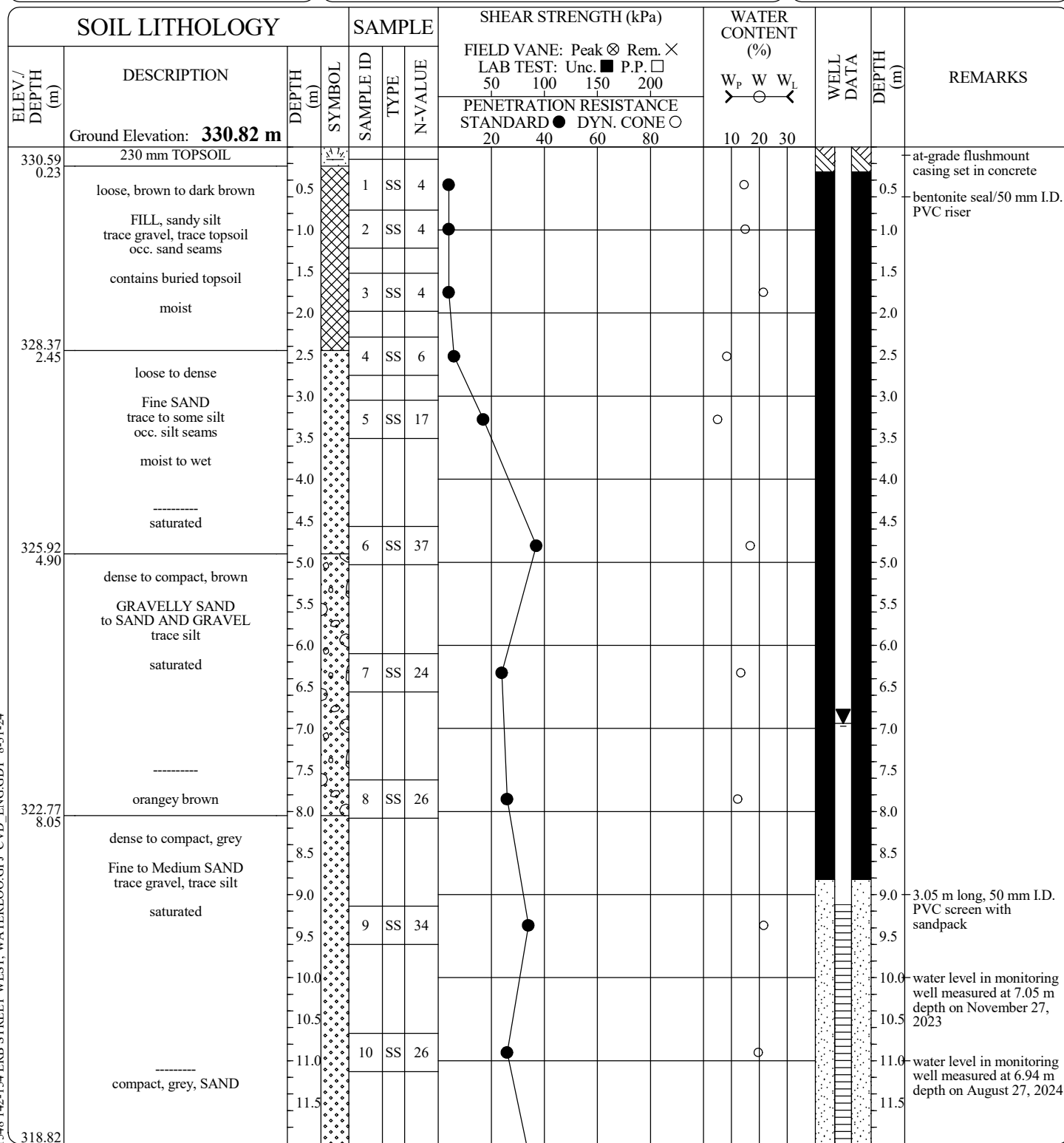
SS	Split Spoon Sample (obtained from SPT)	GS	Grab Sample	PP	Pocket Penetrometer
AS	Auger Sample	BS	Bulk Sample	VANE	Peak & Remolded shear
		TW	Thin Wall Sample or Shelby Tube	DMT	Flat Plate Dilatometer

LABORATORY TESTS

SG	Specific Gravity	S	Sieve Analysis	W	Water Content
H	Hydrometer	P	Field Permeability	K	Lab Permeability
W_p	Plastic Limit	W_l	Liquid Limit	I_p	Plasticity Index
GSA	Grain Size Analysis	C	Consolidation	UNC	Unconfined compression

FILE No: 1548**BOREHOLE No. 7**Client: **2744668 Ontario Inc.**Project: **Supplementary Geotechnical Investigation**Location: **142-154 Erb Street West, Waterloo, Ontario****EQUIPMENT DATA**Machine: **Diedrich D70**Method: **HSA/Mud Rotary**Size: **108 mm I.D.**Date: **Nov 06 - 23 TO Nov 06 - 23**PROJECT MANAGER: **EYC****CHUNG & VANDER DOELEN
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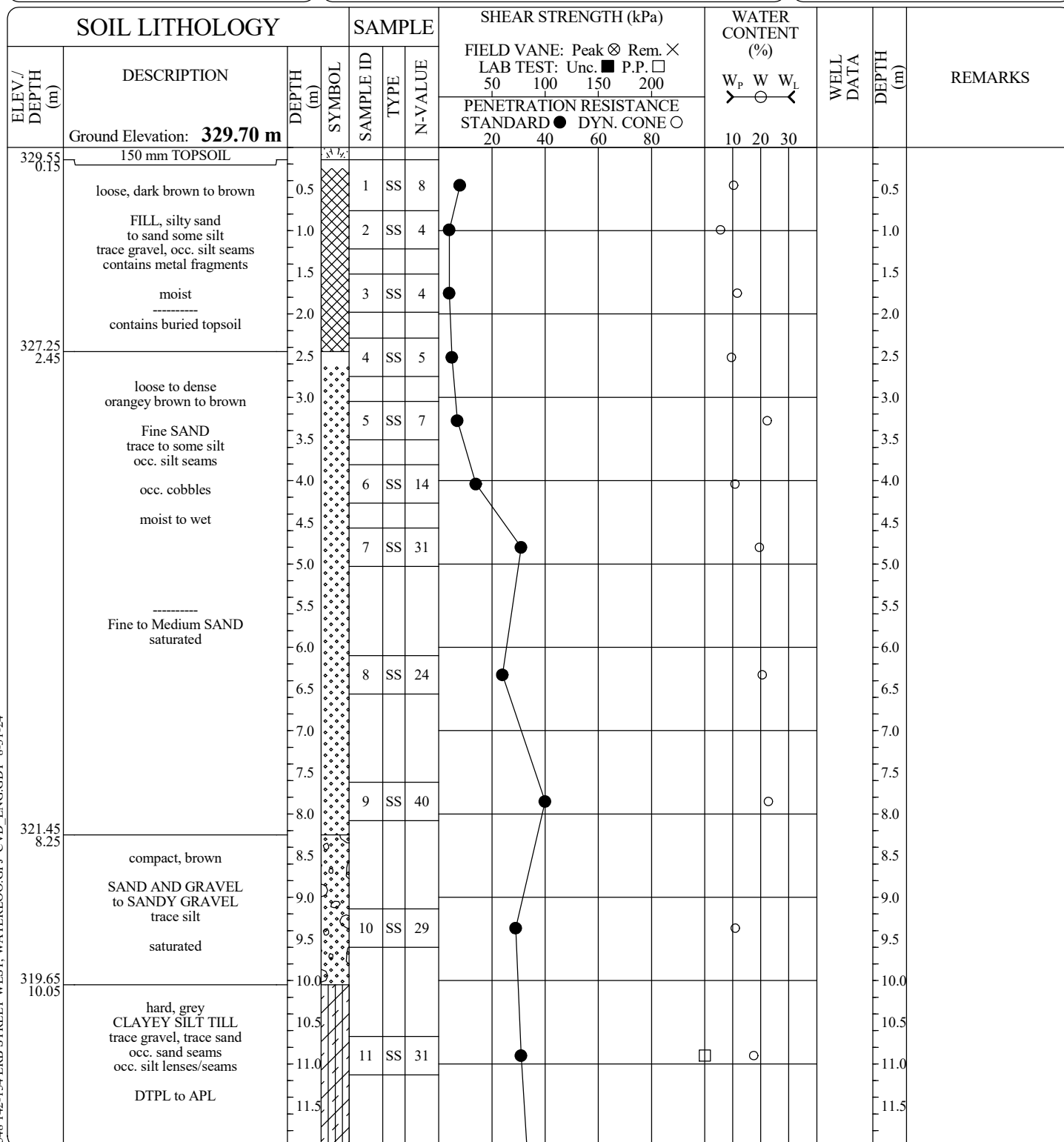
FILE No: 1548**BOREHOLE No. 7**Client: **2744668 Ontario Inc.**Project: **Supplementary Geotechnical Investigation**Location: **142-154 Erb Street West, Waterloo, Ontario****EQUIPMENT DATA**Machine: **Diedrich D70**Method: **HSA/Mud Rotary**Size: **108 mm I.D.**Date: **Nov 06 - 23 TO Nov 06 - 23**PROJECT MANAGER: **EYC****CHUNG & VANDER DOELEN
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 Kitchener, Ontario N2H 5E1
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FILE No: 1548**BOREHOLE No. 8**Client: **2744668 Ontario Inc.**Project: **Supplementary Geotechnical Investigation**Location: **142-154 Erb Street West, Waterloo, Ontario****EQUIPMENT DATA**Machine: **Diedrich D70**Method: **HSA/Mud Rotary**Size: **108 mm I.D.**Date: **Nov 06 - 23 TO Nov 07 - 23**PROJECT MANAGER: **EYC****CHUNG & VANDER DOELEN
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FILE No: 1548**BOREHOLE No. 8**Client: **2744668 Ontario Inc.**Project: **Supplementary Geotechnical Investigation**Location: **142-154 Erb Street West, Waterloo, Ontario****EQUIPMENT DATA**Machine: **Diedrich D70**Method: **HSA/Mud Rotary**Size: **108 mm I.D.**Date: **Nov 06 - 23 TO Nov 07 - 23**

SOIL LITHOLOGY				SAMPLE			SHEAR STRENGTH (kPa)				WATER CONTENT (%)			WELL DATA	DEPTH (m)	REMARKS	
ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE	FIELD VANE: Peak ⊗ Rem. × LAB TEST: Unc. ■ P.P. □				PENETRATION RESISTANCE STANDARD ● DYN. CONE ○						W _p W W _L
							20	40	60	80	10	20	30				
12.00	hard, grey CLAYEY SILT TILL trace gravel, trace sand occ. sand lenses/seams occ. silt seams DTPL to APL ----- APL -- End of Borehole	12.5		11	SS	36	●					□	○				sandpack bottom
13.0																	grout backfill
13.5																	
14.0		12	SS	35	●				□		○						
14.5																	
15.0																	
15.5		13	SS	35	●					□		○					
16.0																	
16.5																	
17.0		14	SS	50	●					□		○					
17.5																	
18.0																	
18.5		15	SS	61	●						□		○				
19.0																	
19.5																	
20.0	16	SS	14	●					□			○					
310.57 20.25		20.5															
		21.0															
		21.5															
		22.0															
		22.5															
		23.0															
		23.5															

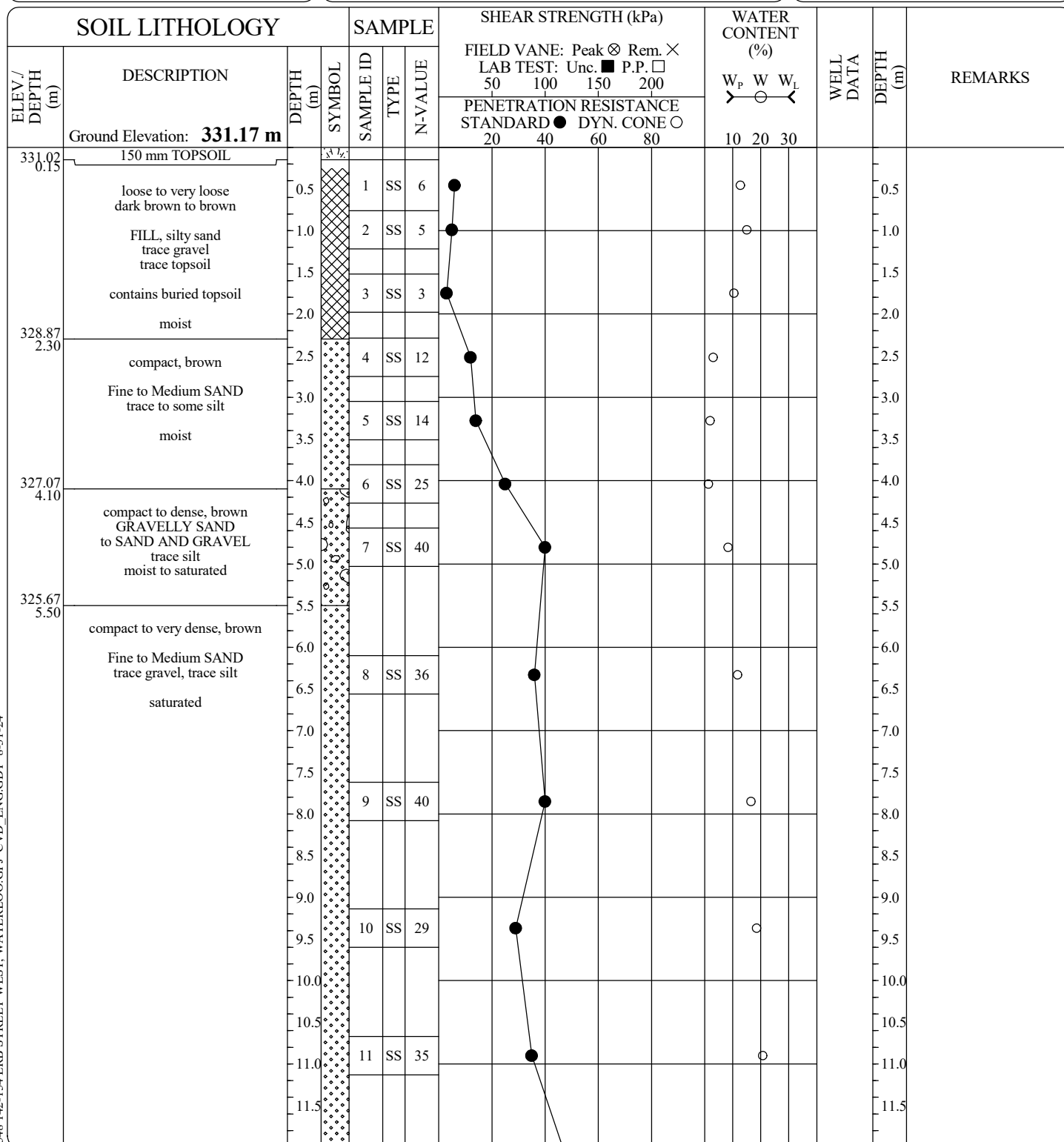
PROJECT MANAGER: **EYC****CHUNG & VANDER DOELEN
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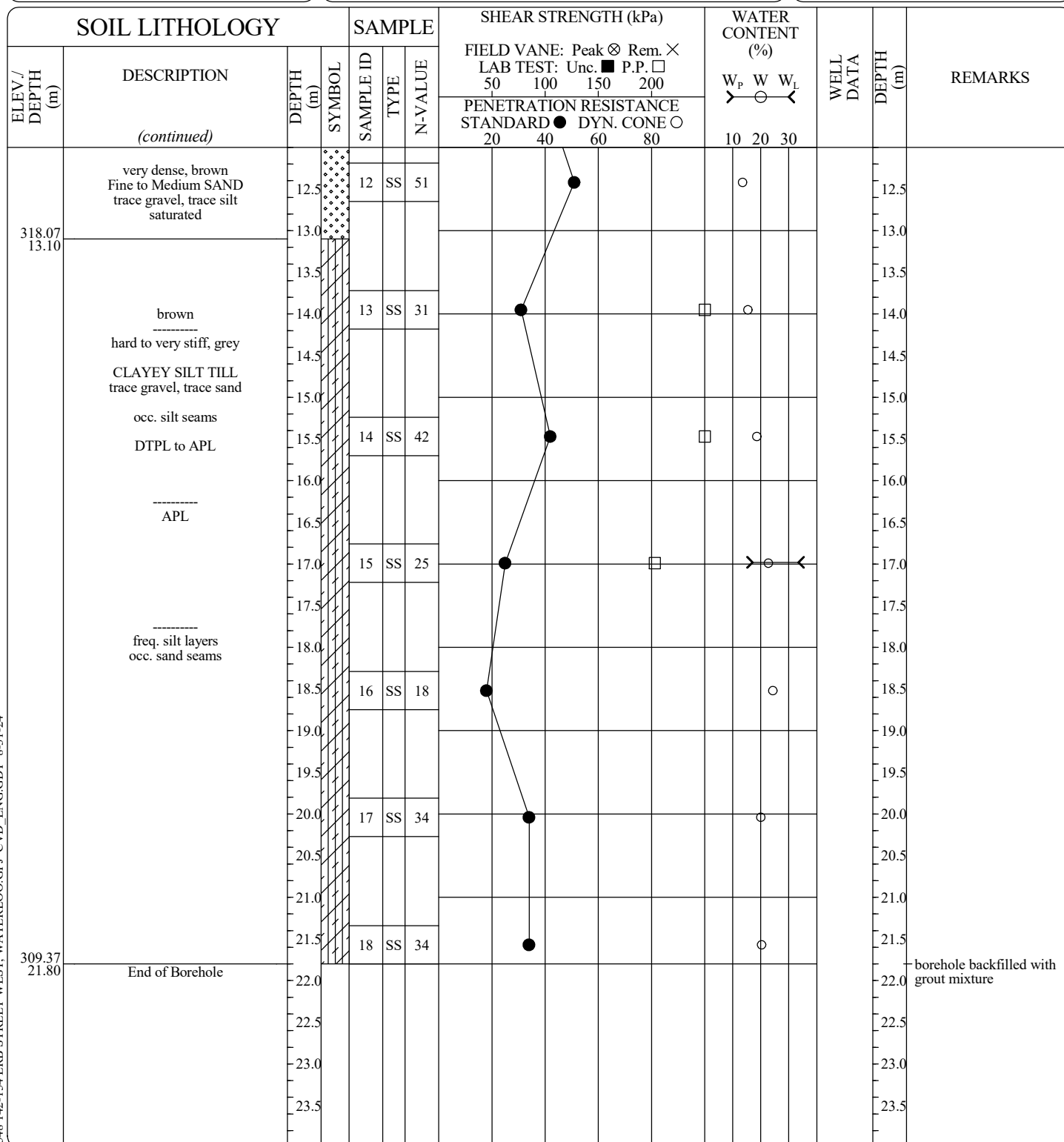
FILE No: 1548**BOREHOLE No. 9**Client: **2744668 Ontario Inc.**Project: **Supplementary Geotechnical Investigation**Location: **142-154 Erb Street West, Waterloo, Ontario****EQUIPMENT DATA**Machine: **Diedrich D70**Method: **HSA/Mud Rotary**Size: **108 mm I.D.**Date: **Nov 07 - 23 TO Nov 08 - 23**PROJECT MANAGER: **EYC****CHUNG & VANDER DOELEN
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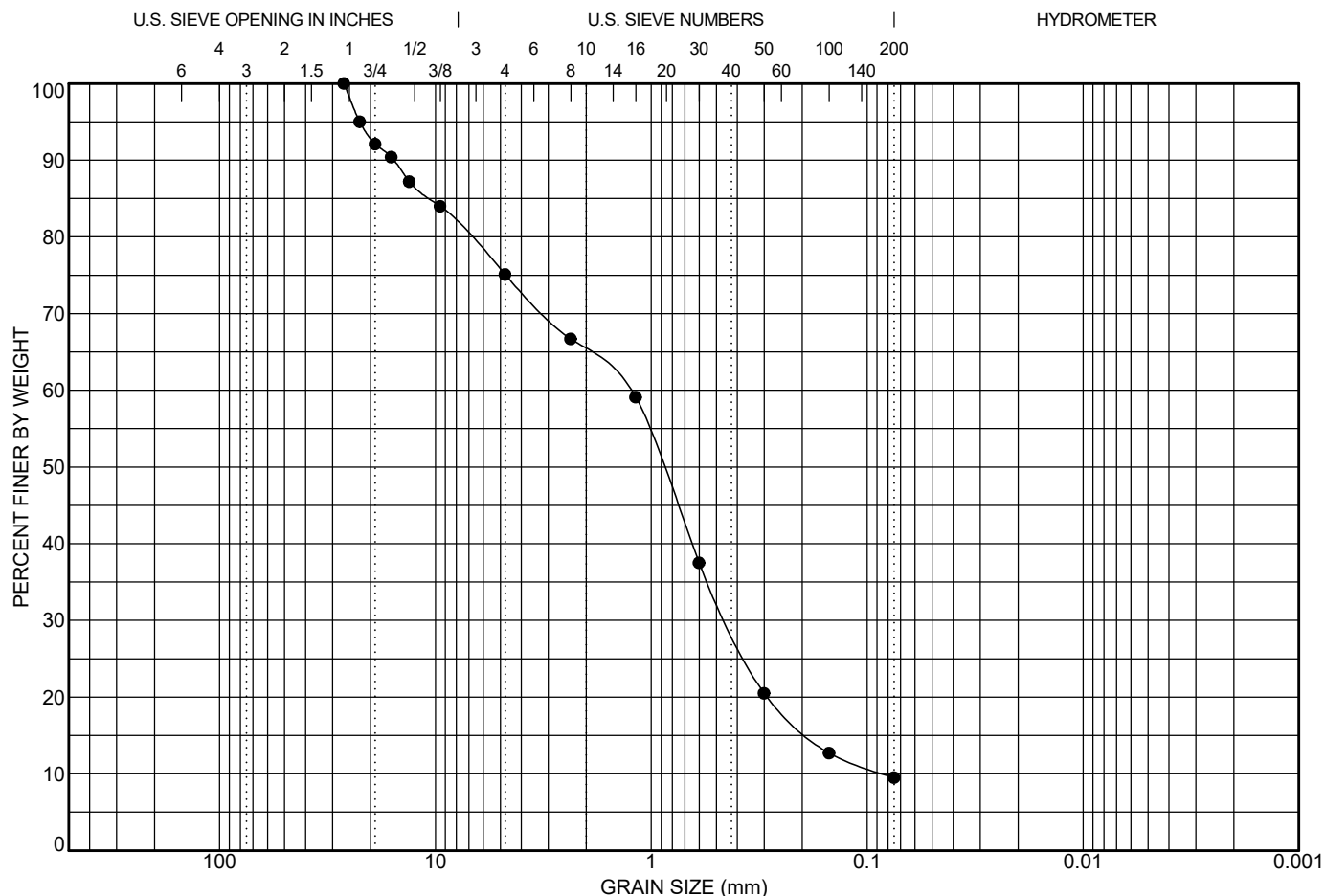
FILE No: 1548**BOREHOLE No. 9**Client: **2744668 Ontario Inc.**Project: **Supplementary Geotechnical Investigation**Location: **142-154 Erb Street West, Waterloo, Ontario****EQUIPMENT DATA**Machine: **Diedrich D70**Method: **HSA/Mud Rotary**Size: **108 mm I.D.**Date: **Nov 07 - 23 TO Nov 08 - 23**

SOIL LITHOLOGY				SAMPLE			SHEAR STRENGTH (kPa)				WATER CONTENT (%)			WELL DATA	DEPTH (m)	REMARKS		
ELEV./ DEPTH (m)	DESCRIPTION	DEPTH (m)	SYMBOL	SAMPLE ID	TYPE	N-VALUE	FIELD VANE: Peak ⊗ Rem. × LAB TEST: Unc. ■ P.P. □				W _P W W _L							
							PENETRATION RESISTANCE STANDARD ● DYN. CONE ○				↗ ○ ↖							
							20	40	60	80	10	20	30					
309.45 20.25	hard, grey CLAYEY SILT TILL trace gravel, trace sand occ. sand seams occ. silt lenses/seams DTPL to APL ----- APL ----- freq. silt seams ----- freq. sand and silt layers	12.5		12	SS	34		●					□	○		12.5	borehole backfilled with grout mixture	
		13.0																13.0
		13.5																13.5
		14.0		13	SS	50		□	●						○			14.0
		14.5																14.5
		15.0																15.0
		15.5		14	SS	47		■	●						○			15.5
		16.0																16.0
		16.5																16.5
		17.0		15	SS	54			●						○			17.0
		17.5																17.5
		18.0																18.0
	18.5		16	SS	58			●						○		18.5		
	19.0															19.0		
	19.5															19.5		
	20.0		17	SS	54			●						○		20.0		
	End of Borehole																	

PROJECT MANAGER: **EYC****CHUNG & VANDER DOELEN
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FILE No: 1548**BOREHOLE No. 10**Client: **2744668 Ontario Inc.**Project: **Supplementary Geotechnical Investigation**Location: **142-154 Erb Street West, Waterloo, Ontario****EQUIPMENT DATA**Machine: **Diedrich D70**Method: **HSA/Mud Rotary**Size: **108 mm I.D.**Date: **Nov 03 - 23 TO Nov 03 - 23**PROJECT MANAGER: **EYC****CHUNG & VANDER DOELEN
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FILE No: 1548**BOREHOLE No. 10**Client: **2744668 Ontario Inc.**Project: **Supplementary Geotechnical Investigation**Location: **142-154 Erb Street West, Waterloo, Ontario****EQUIPMENT DATA**Machine: **Diedrich D70**Method: **HSA/Mud Rotary**Size: **108 mm I.D.**Date: **Nov 03 - 23 TO Nov 03 - 23**PROJECT MANAGER: **EYC****CHUNG & VANDER DOELEN
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COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

LL	PL	PI	Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
			1.82	15.33	26.5	1.281	0.442	0.084	24.9	65.6	9.5	

Date: Dec. 01 - 2023
Client: 2744668 Ontario Inc.
Contractor:
Source:
Sampled From: BH 7 - SA 8, 6.10 to 6.55 m depth
Sample No.: 7-8
Date Sampled: Nov. 06 - 2023
Sampled By: YC
Lab No.: 1593
Date Tested: Nov. 29 - 2023
Type of Material: Gravelly Sand, trace silt

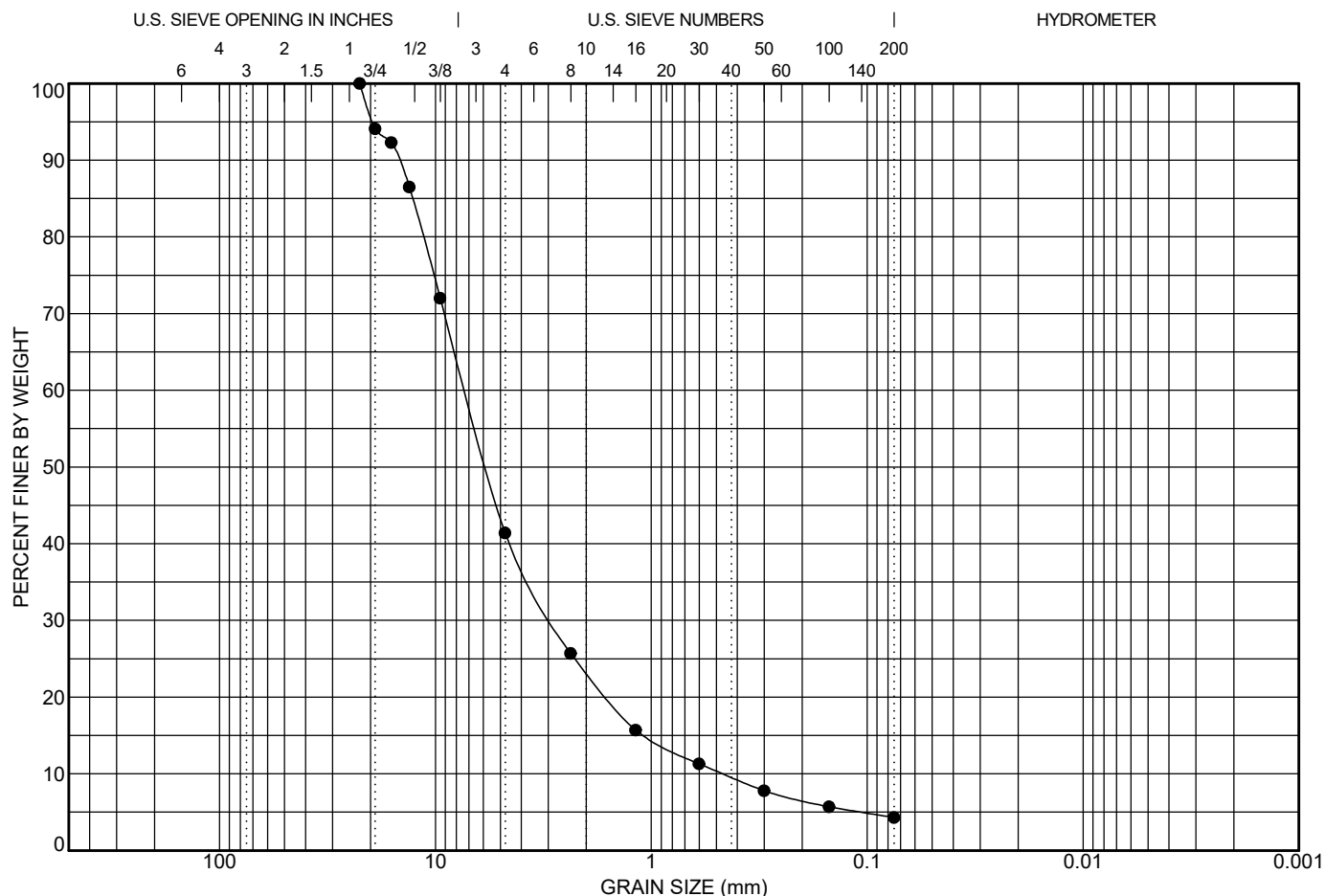
Sieve Size (mm)	Percent Passing	No Specifications



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 Fax: 519-742-7739
 e-mail: info@cvdengineering.com

GRAIN SIZE DISTRIBUTION

Project: Supplementary Geotechnical Investigation
Location: 142-154 Erb Street West, Waterloo, Ontario
File No.: 1548
Enclosure No.: 5



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

LL	PL	PI	Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
			2.43	15.61	22.4	7.239	2.858	0.464	58.6	37.1	4.3	

Date: Dec. 01 - 2023
Client: 2744668 Ontario Inc.
Contractor:
Source:
Sampled From: BH 8 - SA 8, 7.60 to 8.05 m depth
Sample No.: 8-8
Date Sampled: Nov. 07 - 2023
Sampled By: YC
Lab No.: 1594
Date Tested: Nov. 29 - 2023
Type of Material: Sand and Gravel, trace silt

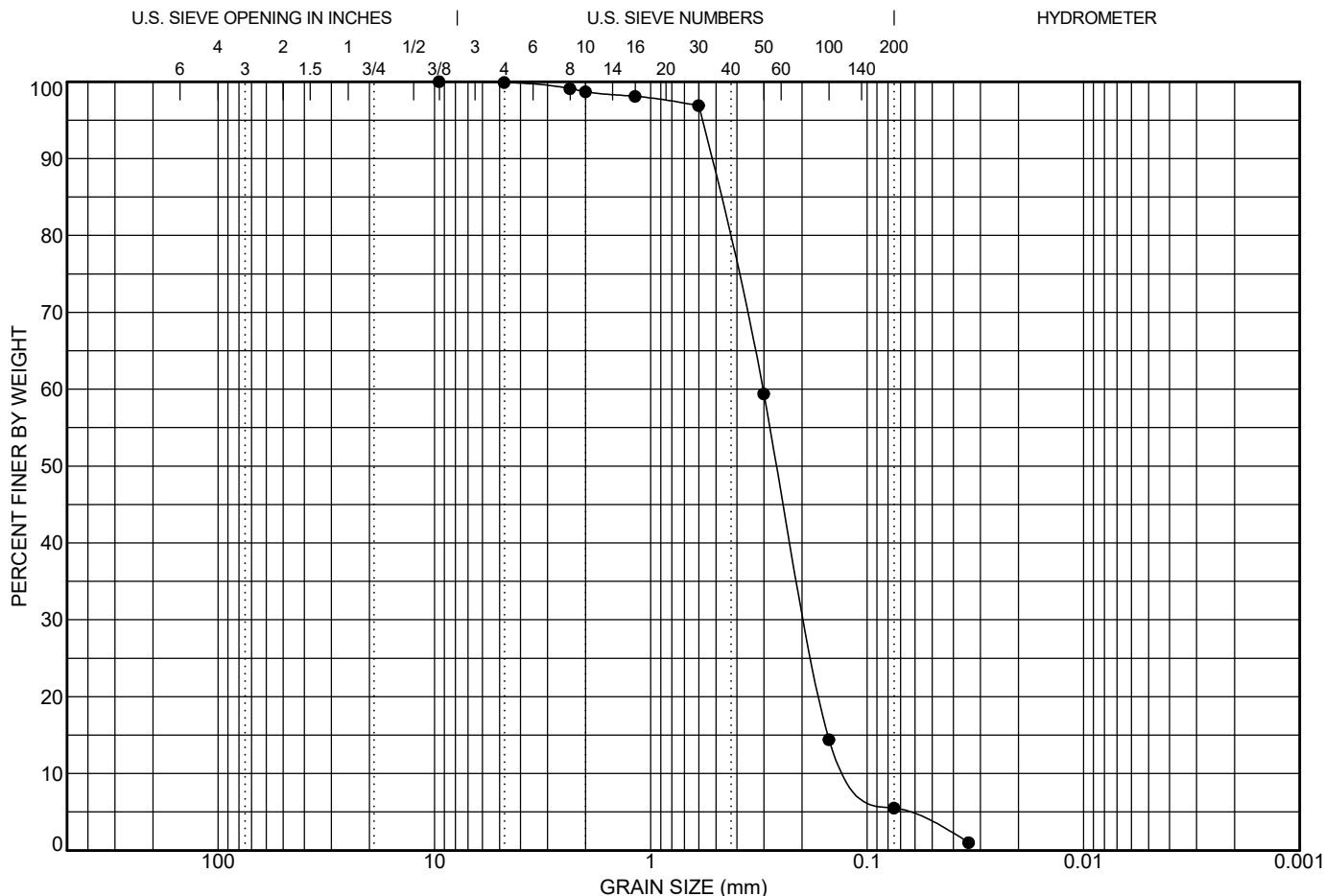
Sieve Size (mm)	Percent Passing	No Specifications



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GRAIN SIZE DISTRIBUTION

Project: Supplementary Geotechnical Investigation
Location: 142-154 Erb Street West, Waterloo, Ontario
File No.: 1548
Enclosure No.: 6



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

LL	PL	PI	Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
			1.13	2.85	9.5	0.303	0.191	0.106	0.1	94.4	5.5	

Date: Dec. 01 - 2023
Client: 2744668 Ontario Inc.
Contractor:
Source:
Sampled From: BH 9 - SA 8, 6.10 to 6.55 m depth
Sample No.: 9-8
Date Sampled: Nov. 07 - 2023
Sampled By: YC
Lab No.: 1595
Date Tested: Nov. 29 - 2023
Type of Material: Fine to Medium Sand, trace silt

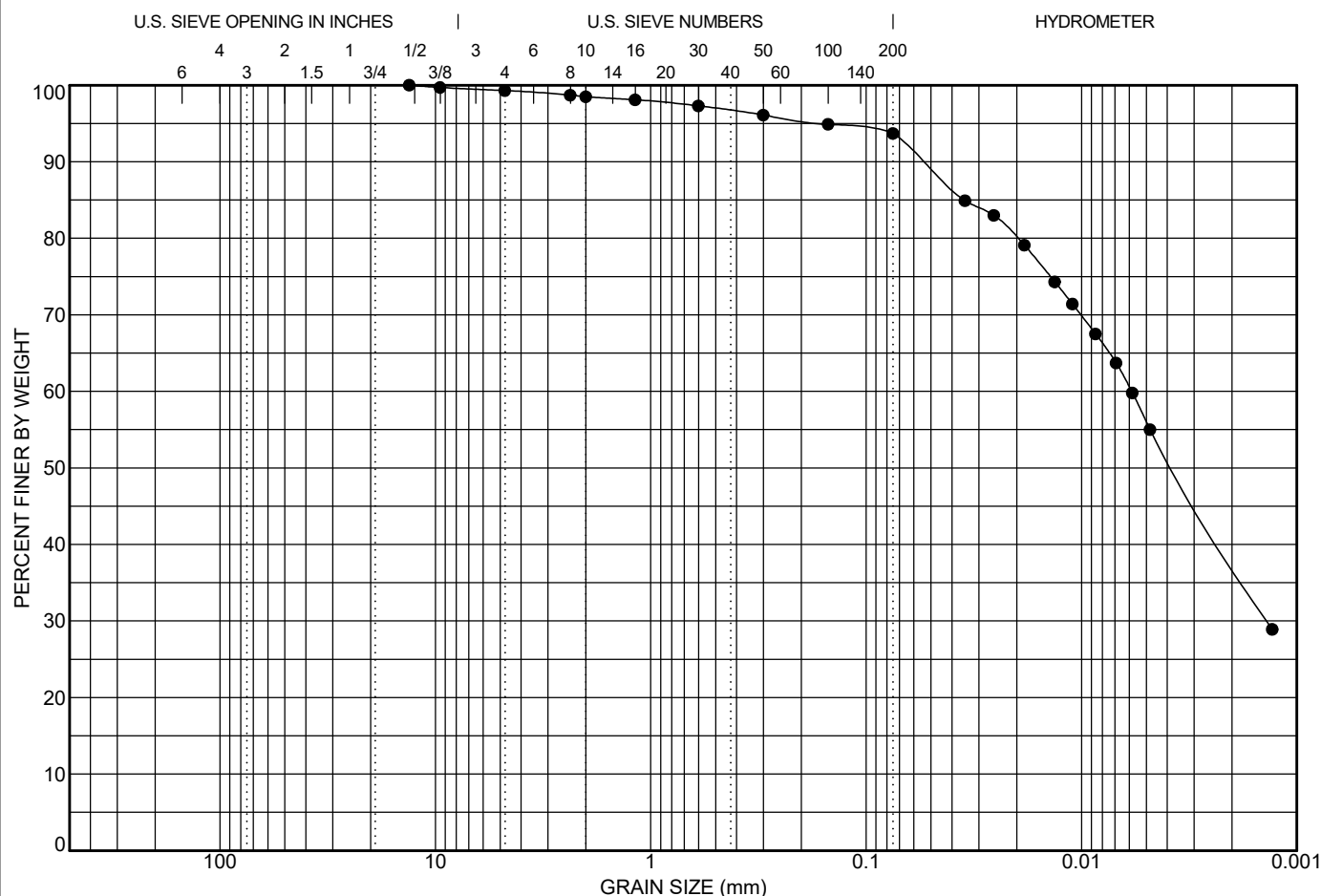
Sieve Size (mm)	Percent Passing	No Specifications



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GRAIN SIZE DISTRIBUTION

Project: Supplementary Geotechnical Investigation
Location: 142-154 Erb Street West, Waterloo, Ontario
File No.: 1548
Enclosure No.: 7



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

LL	PL	PI	Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
33.5	17.1				13.2	0.006	0.001		0.7	5.6	93.7	

Date:	Dec. 01 - 2023
Client:	2744668 Ontario Inc.
Contractor:	
Source:	
Sampled From:	BH 10 - SA 15, 16.75 to 17.20 m depth
Sample No.:	10-15
Date Sampled:	Nov. 03 - 2023
Sampled By:	YC
Lab No.:	1596
Date Tested:	Nov. 29 - 2023
Type of Material:	Clayey Silt Till, trace sand

Sieve Size (mm)	Percent Passing	No Specifications



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GRAIN SIZE DISTRIBUTION

Project: Supplementary Geotechnical Investigation

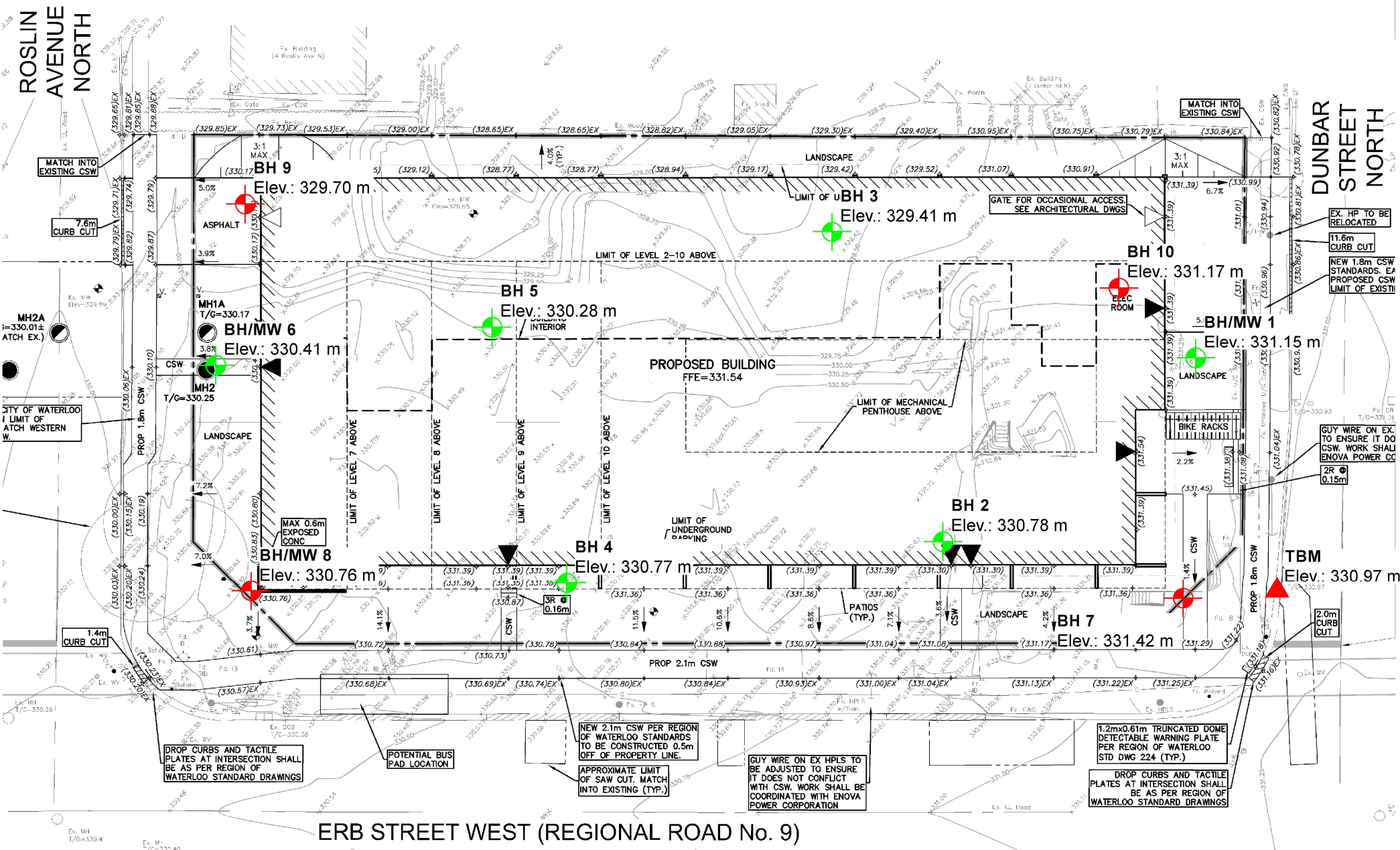
Location: 142-154 Erb Street West, Waterloo, Ontario

File No.: 1548

Enclosure No.: 8

DRAWING





KEY PLAN SOURCE: Key Map

- LEGEND**
- TBM: Top of catch basin in road edge of southbound lane on Dunbar Road North, just north of the intersection with Erb Street West Elev.: 300.97 m (Geodetic)
 - Borehole Location - 2018 Investigation
 - Borehole Location - 2023 Investigation

Elev. Ref.: The borehole locations and associated ground surface elevations were surveyed using a Network RTK Global Navigation Satellite System (GNSS) Receiver. The survey data was collected using UTM Zone 17N Projection, NAD83(CSRS)v7-2010 datum and Canada Geoid Model HT2_2010v70 (CGVD28).

BOREHOLE LOCATION PLAN

Proposed 6-Storey Residential Building

142-154 Erb Street West & 5 Dunbar Road North
Waterloo, Ontario



CHUNG & VANDER DOELEN
ENGINEERING LTD.

311 VICTORIA STREET NORTH
KITCHENER / ONTARIO / N2H 5E1 / 519-742-8979

Drawn By: JR	Date: August 2024	File No.: 1548
Checked By: EYC	Scale: N.T.S.	Drawing No.: 1