GROUNDWORK ENGINEERING LIMITED

Marco Polo 100 Design Challenge

GEOTECHNICAL REPORT

Fourth Street

Gananoque, Ontario

Prepared for:

Horizon Legacy

Project No: **GW-21050**

November 2021

GEOTECHNICAL • CIVIL • STORMWATER • ONSITE WASTEWATER

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Contents

1.0 Introduction

Groundwork Engineering Limited (**GEL**) was retained by Horizon Legacy (**Client**) to conduct a geotechnical investigation at Fourth Street, Gananoque, Ontario. This report has been prepared solely and exclusively for the Client for the purpose of providing geotechnical information for the proposed development of the construction of a six (6) unit residential development at Fourth Street, Gananoque.

2.0 Site and Project Description

The site is located at Fourth Street in Gananoque, Ontario (Figure 1).

Figure 1. Site Location

The intent of the investigation is to study and report on the subsurface soil and groundwater conditions in boreholes drilled at the site and to provide geotechnical engineering information for bearing capacity, site excavation, backfill, drainage, groundwater, pavement design and seismic site classification.

The scope of this geotechnical investigation included drilling six (6) boreholes, four (4) to 6.0 m depth and two (2) to 3.0 m depth or refusal whichever comes first. If rock is encountered the investigation will include one (1) 1.5 m deep rock core.

Environmental sampling is included within the scope of work for this investigation in order to establish preliminary excess soil management requirements.

3.0 Method of Investigation

3.1 General

Prior to drilling the boreholes, locates were obtained from the relevant authorities and utility providers. Underground utilities were marked and the borehole locations were selected to avoid the utilities while still being representative of the site.

Drilling of the boreholes was undertaken on October 18th, 2021 using a track mounted CME 55 drill rig. The boreholes were advanced using continuous flight augers. Six (6) boreholes were drilled, four (4) to 6 m depth and two (2) to 3.0 m. At each borehole location, soil samples were collected while performing the Standard Penetration Test (SPT) in general accordance with the procedure as described in American Society for Testing and Materials (ASTM) D1586. This consisted of freely dropping a 63.5 kg (140 lb) hammer from a vertical distance of 0.76 m (30 in), in order to drive a 51 mm (2 in) outer diameter split-barrel (split spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground a distance of 300 mm (12 in) was recorded as the SPT 'N' value, which correlates to the relative density of non-cohesive soils and is, in certain cases, indicative of the consistency of cohesive soils.

While examining split-spoon samples, pocket penetrometer tests were performed on representative clay samples. These readings provide an indication of the unconfined, undrained compressive strength of the clay.

Representative samples were packaged and labelled for laboratory sampling. After the drilling and excavation, sampling and logging was completed and the boreholes were backfilled using drill cuttings and bentonite pellets.

All field activities were performed under the constant supervision of GEL technical staff.

3.2 Borehole Locations

All borehole locations were laid out in the field by GEL. Borehole locations and elevations were collected by GEL with GPS survey equipment. The location of the boreholes can be seen on

the site plan provided in Appendix A. The following table summarizes the borehole ground surface elevations:

ID	Elevation (m)
BH1	85.19
BH2	84.02
BH3	83.08
BH4	84.09
BH5	85.61
BH6	86.33

Table 1. Borehole Surface Elevations

4.0 Subsurface Conditions

4.1 General

Details on the subsurface conditions encountered during the geotechnical investigation are presented on individual borehole logs attached to this report as Appendix B. The soil descriptions given in this report are based on current geotechnical practice as per the Canadian Foundation Engineering Manual, 4th Edition. The stratigraphic boundaries shown have been inferred from non-continuous samples and observations of drilling resistance and typically represent a transition from one soil type to another. These boundaries should not be interpreted to represent actual planes of geologic change. The subsurface conditions are confirmed at the borehole location only and will vary between and beyond the locations.

4.2 Fill (Moist)

Layers of moist fill ranging in thickness of 0.05 metres to 0.25 metres below ground surface (mbgs), was encountered in BH1, BH2, BH4 and BH6.

- BH1 from 0.00 to 0.25 mbgs (85.19 m – 84.94 m)
- BH2 from 0.00 to 0.25 mbgs (84.02 m – 83.77 m)
- BH4 from 0.00 to 0.05 mbgs (84.09 m – 84.04 m)
- BH6 from 0.00 to 0.18 mbgs (86.33 m – 86.15 m)

4.3 Light Brown Sand (Moist)

A layer of moist light brown sand with a thickness of 0.51 m, was encountered in BH1 and BH2.

- BH1 from 0.25 to 0.76 mbgs (84.94 m – 84.43 m)

- BH2 from 0.25 to 0.76 mbgs (83.77 m – 83.26 m)

The SPT ‘N’ value of this material was recorded as 11 to 16 blows per 300 mm of penetration indicating a compact consistency.

4.4 Light Brown Sand, Trace Gravel (Moist)

A layer of moist light brown sand, trace gravel with a thickness of 0.89 m, was encountered in BH1.

- BH1 from 0.76 to 1.65 mbgs (84.43 m – 83.54 m)

The SPT ‘N’ value of this material was recorded as 15 blows per 300 mm of penetration indicating a compact consistency.

4.5 Light Brown Sand and Gravel (Moist)

A layer of moist light brown sand and gravel with a thickness of 0.67 m, was encountered in BH2.

- BH2 from 0.76 to 2.05 mbgs (83.26 m – 81.97 m)

The SPT ‘N’ value of this material was recorded as 7 to 23 blows per 300 mm of penetration indicating a loose to compact consistency.

4.6 Brown Silty Clay, Trace Gravel, Trace Sand (Moist)

A layer of moist brown silty clay, trace gravel, trace sand with a thickness of 1.40 m, was encountered in BH1.

- BH1 from 1.65 to 3.05 mbgs (83.54 m – 82.14 m)

The SPT ‘N’ value of this material was recorded as 7 to 9 blows per 300 mm of penetration indicating a firm consistency.

4.7 Peat (Moist)

A layer of moist peat with a thickness of 0.34 m, was discovered in BH2.

- BH2 from 2.60 to 2.94 mbgs (81.42 m – 81.08 m)

4.8 Brown Silty Clay, Trace Sand (Moist)

A layer of moist brown silty clay, trace sand ranging in thickness from 0.11 m to 1.52 m, was encountered in BH2, BH4 and BH5.

- BH2 from 2.05 to 2.60 mbgs (81.97 m – 81.42 m) and from 2.94 to 3.05 mbgs (81.08 m – 80.97 m)
- BH4 from 0.05 to 0.76 mbgs (84.04 m – 83.33 m)
- BH5 from 3.05 to 4.57 mbgs (82.56 m – 81.04 m)

The SPT 'N' value of this material was recorded as 5 to 22 blows per 300 mm of penetration indicating a firm to very stiff consistency.

Pocket penetrometer readings taken of this material ranged from 3.43 kg/cm^2 to beyond the limit of the device. This indicates an undrained shear strength of 336 kPa to beyond 441 kPa.

4.9 Greyish-Brown Silty Clay, Trace Sand (Moist)

A layer of moist greyish brown silty clay, trace sand ranging in thickness of 0.76 m to 4.39 m, was discovered in BH3, BH4, BH5 and BH6.

- BH3 from 0.00 to 0.76 mbgs (83.08 m – 82.32 m)
- BH4 from 0.76 to 3.05 mbgs (83.33 m – 81.04 m)
- BH5 from 0.00 to 3.05 mbgs (85.61 m – 82.56 m)
- BH6 from 0.18 to 4.57 mbgs (86.15 m – 81.76 m)

The SPT 'N' value of this material was recorded as 2 to 21 blows per 300 mm of penetration indicating a soft to very stiff consistency.

Pocket penetrometer readings taken of this material ranged from 2.4 kg/cm^2 to beyond limit. This indicates an undrained shear strength of 235 kPa to beyond 441 kPa.

4.10 Greyish-Brown Silty Clay (Moist)

A layer of moist greyish brown silty clay, trace sand with a thickness of 1.53 m, was discovered in BH5 and BH6.

- BH5 from 4.57 to 6.10 mbgs (81.04 m - 79.51 m)
- BH6 from 4.57 to 6.10 mbgs (81.76 m – 80.23 m)

The SPT 'N' value of this material was recorded as 2 to 21 blows per 300 mm of penetration indicating a soft to very stiff consistency.

Pocket penetrometer readings taken of this material ranged from 1.0 kg/cm^2 to beyond limit. This indicates an undrained shear strength of 98 kPa to beyond 441 kPa.

4.11 Grey Silty Clay, Trace Sand (Moist)

Layers of moist grey silty clay, trace sand ranging in thickness of 1.53 m to 3.81 m, was encountered in BH3 and BH4.

- BH3 from 0.76 to 4.57 mbgs (82.32 m – 78.51 m)
- BH4 from 3.05 to 4.57 mbgs (81.04 m – 79.51 m)

The SPT 'N' value of this material was recorded as 2 to 21 blows per 300 mm of penetration indicating a soft to very stiff consistency.

Pocket penetrometer readings taken of this material ranged from 0.42 kg/cm^2 to beyond limit. This indicates an undrained shear strength of 41 kPa to beyond 441 kPa.

4.12 Grey Silty Clay (Moist)

A layer of moist grey silty clay with a thickness of 1.53 m was encountered in BH3 and BH4.

- BH3 from 4.57 to 6.10 mbgs (78.51 m – 76.98 m)
- BH4 from 4.57 to 6.10 mbgs (79.51 m – 77.99 m)

The SPT 'N' value of this material was recorded as 2 to 7 blows per 300 mm of penetration indicating a soft to very stiff consistency.

Pocket penetrometer readings taken of this material ranged from 1.48 kg/cm^2 to 1.87 kg/cm^2. This indicates an undrained shear strength of 145 kPa to 183 kPa.

4.13 Bedrock

Bedrock refusal was not encountered in all six (6) boreholes.

5.0 Groundwater

Groundwater was encountered during the investigation in two (2) boreholes; BH2 at 1.68 mbgs and BH3 at 1.22 mbgs.

Groundwater levels can fluctuate greatly and be located at different elevations depending on seasonal and atmospheric conditions – i.e. heavy rains, spring thaw, dry spells, etc.

6.0 Laboratory Results

Selective samples were collected in the field and transported to Malroz Engineering Inc. Kingston, Ontario laboratory for gradation and moisture content testing and Caduceon Environmental Laboratories Kingston, Ontario for chemical analysis in accordance with Ontario Regulation (O.Reg) 153. Visual soil classifications made in the field were verified by peer review in the lab.

6.1 Chemical Analysis

The samples were taken from BH2, BH4 and BH6 at a depth of between 1.52 mbgs to 2.29 mbgs was found to be slightly in exceedance of O.Reg 153 Table 1 Background Soil Site Condition Standards for Residential/Parkland/Institutional/Industrial/Commercial/Community Property Use. Slight exceedances were identified in Barium in BH4 and BH6, Sodium Adsorption Ratio in BH2 and PHC F4 (Gravimetric) in BH2. Barium is common in the shallow clay soils of this region. The higher sodium adsorption ratio reading is likely due to road salts.

The samples from BH2, BH4 and BH6 were found to meet criteria for Table 2 Full Depth Generic Site Condition Standards (medium and fine textured soils) in Potable Ground Water Condition Standards for Residential/Parkland/Institutional Property Use. Chemical analysis test results can be found in Appendix C.

Any excess fill that is required to be hauled off site must be disposed of at an appropriate receiving site.

6.2 Physical Analysis

Grain size testing was carried out on samples taken at 1.52 mbgs to 2.29 mbgs for BH4 and BH6. The sample tested from BH4 and BH6 was determined to be a silty clay, trace sand. Detailed results of the Grain Size analysis testing can be seen in Appendix D.

Atterberg Limits testing was conducted on samples from BH4 and BH6. The liquid limit for BH4 was determined to be 54.1 and the plastic limit 25.2. The resulting plasticity index is 28.9, indicating silty clay with high plasticity. The liquid limit for BH6 was determined to be 61.4 and the plastic limit 25.1. The resulting plasticity index is 36.2, indicating silty clay with very high plasticity. Detailed results of the Atterberg Limits can be seen in Appendix D.

Moisture content testing was carried out on samples from BH4 and BH6. The silty clay, trace sand of BH4 was found to have a moisture content of 29.6%. The clayey silt, trace sand of BH6 was found to have a moisture content of 34.2%. Detailed results of the Moisture Content Testing can be seen attached in Appendix E.

7.0 Seismic Hazard Site Classification

The Ontario Building Code 2012 (Code) stipulates the methodology for earthquake design analysis, as set out in Section 4.1.8. The determination of the type of analysis is predicated on the importance of the structure, the spectral response acceleration and the site classification. The parameters for determination of Site Classification for Seismic Site Response are set out in Table 4.1.4.4.A of the Code. The classification is based on the determination of the average shear velocity of the top 30 metres of the site stratigraphy, where shear wave velocity measurements have been taken or alternatively estimated on the basis of rational analysis of undrained shear strength or penetration resistance.

Based on the results of the boreholes taken the site designation for seismic analysis is best represented by Site Class C according to Table 4.1.8.4.A of the Code and National Building Code of Canada**.**

8.0 Discussion

The following discussion provides our interpretation of the geotechnical data obtained from the field investigation. The interpretation and discussion are specific to the design of excavations, pavement structure and storm sewer servicing.

Any comments made regarding the construction aspects are provided only in as much as they may impact design considerations. Contractors bidding on or undertaking work at the site should make their own assessment regarding the nature and adequacy of the factual information, as it affects their construction techniques, scheduling, equipment selection and the like.

Contractors should submit a detailed excavation, shoring, and dewatering plan for review prior to the start of construction. Construction stages should be clearly defined. Any required structural members and connection details should be clear and understood, and it should be ensured that any required inspections can be carried out easily in the field. All working drawings for temporary works should be prepared by a qualified professional engineer licensed in Ontario.

8.1 Dewatering

Good construction practices include diverting surface water away from excavations. This may be accomplished through the use of ditches and swales. To remove water that does enter excavations, the base of excavations should be shaped to drain to one or more sumps and pumped as required. Any water discharged from site should meet all applicable regulatory requirements including those related to erosion and sedimentation control.

8.2 Excavations

We recommend that all unsuitable materials (sod, root mat, topsoil, soils containing large

quantities of organic matter) be removed from below the footprint of structural fills to expose the existing clayey silt and silty clay.

After removal of the required materials, the exposed soil surface should be re-graded, compacted and inspected by qualified geotechnical personnel prior to any placement of fill or granular.

The existing clayey silt and silty clay is subject to disturbance under heavy construction traffic as well as changes in moisture conditions. Therefore excavation operations should be properly carried out and timed so as to avoid excessive reworking of the subsoils and minimize over excavation. A smooth edge bucket should be used for excavations to minimize soil disturbance.

All excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health & Safety Act (OHSA) and Regulations for Construction Projects. The OHSA regulations require that if workers must enter an excavation deeper than 1.2 m, the excavation must be suitably sloped and/or braced in accordance with the OHSA requirements. The soft to very stiff silty clay found on site can be considered as Type 3 soil. OHSA specifies maximum slope of the excavations for Type 3 soil from the bottom of the excavation to be 3 horizontal to 1 vertical.

Stockpiles of excavated materials must be kept from the edge of any excavation to avoid slope instability. It is therefore important to make sure to keep a distance from the edge at least equal to the depth of the excavation. This distance is also applicable for the passage of heavy machinery near excavations. This condition must be respected at all times unless specific studies are conducted for each case.

It is expected that excavations could be appropriately backslope within the limits of the property. However, a shoring system will be required if appropriate back sloping is not possible. Shoring systems must be designed by a professional engineer licensed in the province of Ontario, in accordance with relevant codes, standards and regulations such as the latest version of the Canadian Foundation Engineering Manual and the Ontario Occupational Health and Safety Act (OHSA) Regulations for Construction Projects. The system should be designed to resist full earth and hydrostatic pressures, as well as surcharges due to

construction and highway traffic loadings. The following parameters may be used in the shoring design:

Soil Type	Bulk Unit Weight (kN/m^3)	Angle of Internal Friction (deg.)	Coefficient of Lateral Earth Pressure		
			K_a	K_o	K_p
Silty Clay	19	28	0.37	0.54	2.60
Compacted Gran. 'A'	21.0	34	0.28	0.44	3.60
Compacted Gran. 'B' Type II	21.5	35	0.27	0.43	3.70

Table 2. Lateral Earth Pressure Parameters

8.3 Foundations

Conventional spread footings located on the firm to very stiff silty clay may be designed using a factored geotechnical resistance at Ultimate Limit States (ULS) of 225 kPa and a bearing resistance of 150 kPa at Serviceability Limit States (SLS). For this application the total settlement that can be expected under SLS conditions would be less than 25mm with differential settlements of less than 15mm.

Alternatively, footings can be constructed on Engineered Fill Ontario Provincial Standard Specification (OPSS) Granular B Type II compacted to 100% Standard Proctor Maximum Dry Density (SPMDD) placed on the firm to stiff native silty clay using a factored geotechnical resistance at Ultimate Limit States (ULS) of 200 kPa and a bearing resistance of 135 kPa at Serviceability Limit States (SLS).

8.4 Frost Protection

A permanent soil cover of 1.5 m or its equivalent in thermal insulation is required for frost protection of all foundations at the Site. If thermal insulation is being considered, appropriate products and placement instructions are best obtained from individual manufacturers.

8.5 Slabs on Grade

Topsoil, organics, loose gravel and any fill must be removed from all areas to be developed as exterior slabs on grade. Up-fill may be required to achieve the required subgrade elevation beneath exterior concrete ramps, sidewalks or slabs on grade. On this basis any up-fill required should consist of Ontario Provincial Standard Specification (OPSS) Type II Granular "B" material placed and uniformly compacted in 200mm thick lifts to at least 98% Standard Proctor Maximum Dry Density (SPMDD).

Excavations within the building envelope should be backfilled with OPSS Type II Granular "B" material. Use of granular material as outlined above, however will not guarantee that settlement will not take place. All backfill within the building envelope should be placed in 200mm thick lifts with each lift uniformly compacted to at least 100% SPMDD. Excavations outside the building envelope under landscaped areas can be backfilled with native fill. Excavations outside the building envelope under paved areas should be backfilled with OPSS Type II Granular "B" material.

Irrespective of the structural design, the final construction beneath floor slabs on grade within building envelopes should consist of at least 150mm of well compacted (100% SPMDD) OPSS Granular "A" base material or clear crushed stone. For buildings where moisture control is critical, clear stone should be specified rather than Granular "A" and consideration should also be given to including a polyethylene sheet beneath the slab to help damp-proof the floors for such applications. The slabs should be free floating and should not be tied into the foundation walls or grade beams. Saw cut control joints should be incorporated into the slabs along column lines and at regular intervals to control shrinkage cracking. Interior load bearing walls should not be founded on the slab but on spread footings as outlined above.

The final construction beneath exterior concrete slabs on grade or sidewalks should consist of at least 150mm of well compacted (100% SPMDD) OPSS Granular "A" base material.

8.6 Engineered Fill

Engineered Fill application may be required on this project in order to provide a level base in cases of over-excavation.

For any fill operation to be considered Engineered Fill, the following criteria must be satisfied:

- Engineered Fill should consist of uniform, homogeneous material. The fill material should also be free of organics, deleterious materials (i.e., building debris such as bricks, metal etc.). Materials meeting Ontario Provincial Standard Specification (OPSS) Granular B Type I or II specifications would be considered a suitable Engineered Fill material;
- Prior to the placement of Engineered Fill, it must be evaluated for suitability in the Geotechnical Laboratory. Samples should be provided to the Geotechnical Engineer and submitted for Standard Proctor and grain size analysis;
- Engineered fill must be compactable, and of a suitable moisture content such that it is within +/- 2.0% of its optimum moisture content, as determined through laboratory testing;
- Engineered Fill must be placed under the continuous supervision of a Geotechnical Engineer or their designate;
- Each layer of material should be placed in maximum 0.2m lifts, and uniformly compacted with heavy compaction equipment suitable for the type of fill used, to 100% of its Standard Proctor Maximum Dry Density (SPMDD);
- Field density tests must be taken by the Geotechnical Engineer on each lift of Engineered Fill. Any Engineered Fill which is tested and found to be out of specification shall be either removed, reworked or retested; and
- Engineered fill placed underneath foundations must extend laterally a minimum of 1.5 D from the outside edge of footings, where D is the depth of Engineered Fill placed.

8.7 Pavements

8.7.1 Subgrade Considerations

Topsoil, loose gravel, and fill must be removed to subgrade elevations from all areas to be developed as parking areas and the surface must be proof-rolled prior to placement of granular sub-base.

8.7.2 Flexible Pavements

The long term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedure must be maintained to ensure that

uniform subgrade moisture and density conditions are maintained as much as practically possible and that the natural subgrade is not disturbed and weakened.

The following pavement component thicknesses are provided for the design of flexible pavements. Control of surface water is an important factor in achieving good pavement performance. Grading adjacent to pavement areas should be designed so that water is not allowed to pond adjacent to the outside edges of the pavement. The subgrade must be free of depressions and sloped (preferably at a minimum grade of two percent) to provide effective drainage toward subgrade drains. To intercept excess subsurface water within the pavement structure granular materials, perforated sub-drains with suitable outlets and catch basins should be installed below the pavement area's subgrade if adequate overland flow drainage is not provided (i.e. ditches and swales). The surface of the pavement should be properly graded to direct runoff water towards suitable drainage features.

In the following table "Light Duty Areas" refer to areas that are occupied by car parking and light traffic while "Heavy Duty Areas" refer to areas that experience heavy truck traffic, emergency routes, delivery routes, etc. Where asphalt paving areas are proposed the following component thicknesses should be adhered to:

Pavement Layer	Compaction Requirements	Light Duty Areas	Heavy Duty Areas
Surface Course HL3 (OPSS 1150) (PG58-34)	97% of Marshall Relative Density (OPSS 310)	50 mm	40 mm
Base Course HL8 (OPSS 1150) (PG58-34)	97% of Marshall Relative Density (OPSS 310)	-----	50 mm
Granular A Base	100% Standard Proctor Maximum Dry Density	150 mm	150 mm
Granular B Type II Sub-base (OPSS 1010)	100% Standard Proctor Maximum Dry Density	300 mm	300 mm

Table 3. Minimum Asphaltic Concrete Pavement Structure New Construction

8.8 Site Servicing

The bedding material for site services should consist of an approved free draining, well graded granular material (such as granular "A") compatible with the size, class and type of pipe and consistent with local standards as may be applicable. Care will be required to ensure that any

softened or disturbed soil is removed prior to placing pipe bedding. Bedding should be placed and uniformly compacted in 200 mm thick lifts and compacted to at least 95% of SPMDD (Standard Proctor Maximum Dry Density).

Selective reuse of the excavated soil as trench backfill may be feasible provided that any excessively wet or frozen material is excluded and that minor post construction settlement is tolerable. Excavated rock may be used as backfill provided that rock fragments are less than 150 mm in size in all directions.

All service trench backfill materials should be placed in 300 mm thick lifts with each lift uniformly compacted to at least 95% of SPMDD. The upper 1 m of backfill beneath any paved or hard standing areas should be uniformly compacted to at least 98% of SPMDD.

9.0 Statement of Qualifications 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 Groundwork Engineering Limited. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction, and make their own interpretation of the factual data as it affects their construction techniques, schedule, safety and equipment capabilities.

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

The recommendations provided in this report are based on subsurface data obtained at the specific test locations only. Boundaries between zones presented on the borehole logs are often not distinct but transitional and were interpreted. Experience indicates that the subsurface soil and groundwater conditions can vary significantly between and beyond the test locations.

For this reason, the recommendations given in this report are subject to a field verification of the subsurface soil conditions at the time of construction.

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

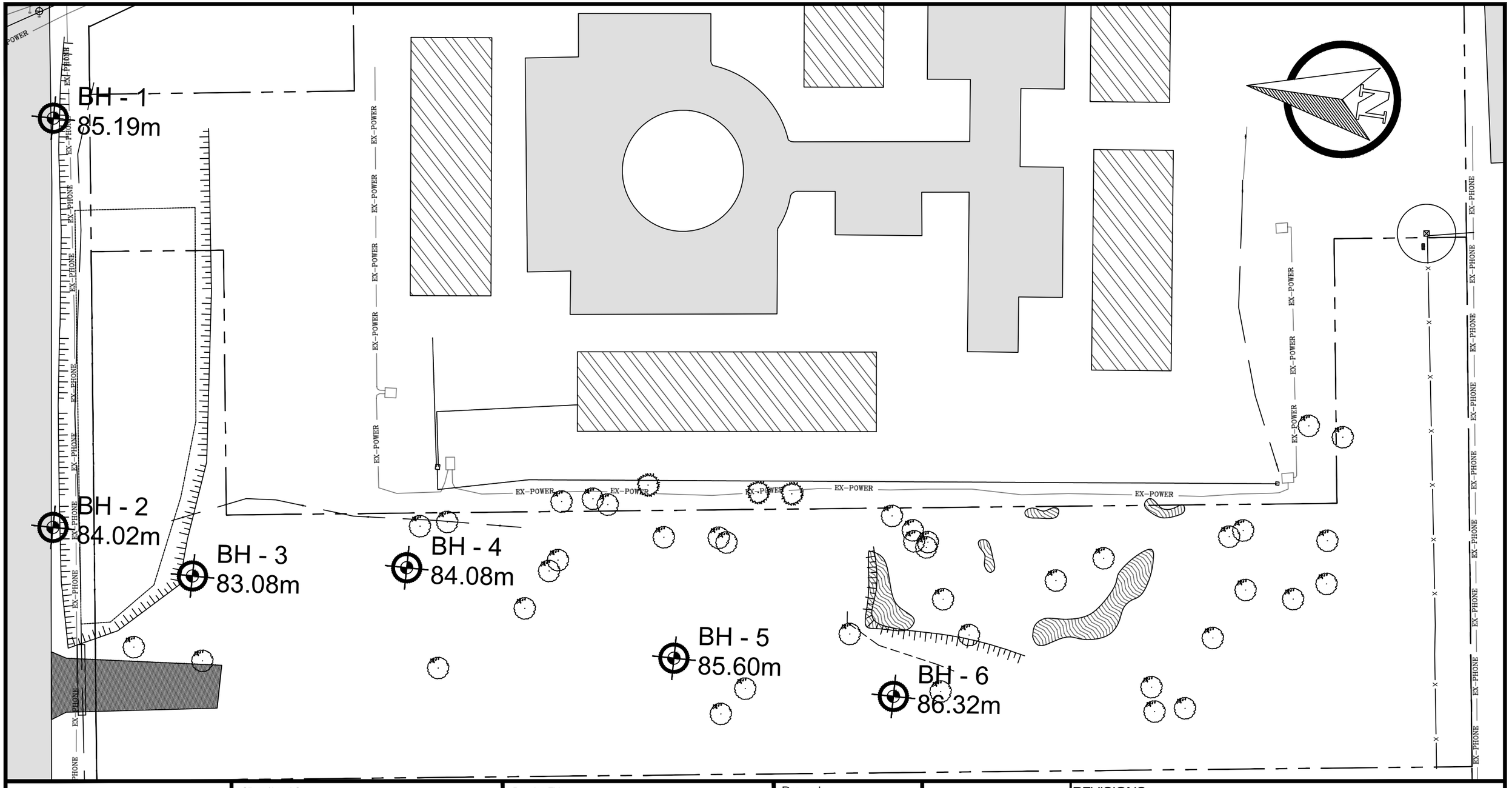
We trust this report provides sufficient information for your present purposes. If you have any questions concerning this report or if we may be of further service to you, please do not hesitate to contact the undersigned.

Martin Burger
M.Eng. P.Eng.

Groundwork Engineering Limited

Appendix A

Site Plan



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Client / Land Owner: HORIZON LEGACY

Project: MARCO POLO 100 DESIGN CHALLENGE

GANANOQUE ONTARIO

Drawing Title: BOREHOLE SITE PLAN

Project Number: GW-21050

Drawing Number: SK-BH MAP

SHEET 1 of 1

Drawn by: TF

Checked By: MB

Scale: 1:500

Date: OCT 26, 2021

REVISIONS

No.	Description	Date
1.	ISSUED FOR REPORT	2021/10/26

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Groundwork Engineering Limited

Appendix B

Borehole Logs

RECORD OF BORE HOLE No. 1

Groundwork Engineering Limited

PROJECT NUMBER:	GW - 21050	DRILLING LOCATION:	Shoulder of road	LOGGED BY:	RL
PROJECT CLIENT:	Horizon Legacy	DRILLING METHOD:	Hollow Stem Auger	COMPILED BY:	RL
PROJECT NAME:	Marco Polo 100 Design Challenge	DRILLING MACHINE:	CME55 Track Mounted	REVIEWED BY:	MB
PROJECT LOCATION:	Fourth Street, Gananoque, Ontario	DATE STARTED:	Oct. 18, 2021	DATE COMPLETED: Oct. 18, 2021	REVISION NO.: N/A

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING			
Lithology Plot	DESCRIPTION LOCAL GROUND SURFACE ELEVATION: 85.19	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	PenetrationTesting ○ SPT ● DCPT *Undrained Shear Strength (kPa) 20 40 60 80	▽ Water Content (%) 20 40 60 80 Liquid Limit (%) W_p W W_l Plastic Liquid 20 40 60 80	POCKET PENETROMETER kg/sq.cm	SHEAR VANE TEST N·m	COMMENTS
	Fill (Moist) 84.94	SS	1	57	11	0		○				No refusal No groundwater encountered
	Light Brown Sand (Moist) 84.43	SS	2									
	Light Brown Sand, Trace Gravel (Moist) 83.54	SS	1	47	15	1		○				
	Brown Silty Clay, Trace Gravel, Trace Sand (Moist)	SS	1	47	7	2		○				
		SS	2									
		SS	1	47	9	3		○				
	82.14 No Refusal					4						
						5						
						6						
						7						

RECORD OF BORE HOLE No. 2

Groundwork Engineering Limited

PROJECT NUMBER:	GW - 21050	DRILLING LOCATION:	Shoulder of road	LOGGED BY:	RL
PROJECT CLIENT:	Horizon Legacy	DRILLING METHOD:	Hollow Stem Auger	COMPILED BY:	RL
PROJECT NAME:	Marco Polo 100 Design Challenge	DRILLING MACHINE:	CME55 Track Mounted	REVIEWED BY:	MB
PROJECT LOCATION:	Fourth Street, Gananoque, Ontario	DATE STARTED:	Oct. 18, 2021	DATE COMPLETED: Oct. 18, 2021	REVISION NO.: N/A

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING			
Lithology Plot	DESCRIPTION LOCAL GROUND SURFACE ELEVATION: 84.02	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	PenetrationTesting ○ SPT ● DCPT *Undrained Shear Strength (kPa) 20 40 60 80	▽ Water Content (%) 20 40 60 80 Liquid Limit (%) W_P W W_L Plastic Liquid 20 40 60 80	POCKET PENETROMETER kg/sq.cm	SHEAR VANE TEST N·m	COMMENTS
	Fill (Moist) 83.77											No refusal Groundwater encountered at 1.68m below ground level
	Light Brown Sand (Moist) 83.26	SS SS	1 2	57	16							
	Light Brown Sand and Gravel (Moist) 81.97	SS SS	1 2	57	23	1						
	Brown Silty Clay, Trace Sand (Moist) 81.42	SS SS	1 2	37	7	2						
	Peat (Moist) 81.08	SS SS SS	1 2 3	57	5							
	Brown Silty Clay, Trace Sand (Moist) 80.97 No Refusal					3						
						4						
						5						
						6						
						7						

Groundwork Engineering Limited

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and requires interpretative assistance from a qualified Geotechnical Engineer. Also, Borehole information should be read in conjunction with the geotechnical report for which it was commisioned and the accompanying 'Notes to Record of Boreholes'.

Scale

RECORD OF BORE HOLE No. 3

Groundwork Engineering Limited

PROJECT NUMBER:	GW - 21050	DRILLING LOCATION:	Footprint of building	LOGGED BY:	RL
PROJECT CLIENT:	Horizon Legacy	DRILLING METHOD:	Hollow Stem Auger	COMPILED BY:	RL
PROJECT NAME:	Marco Polo 100 Design Challenge	DRILLING MACHINE:	CME55 Track Mounted	REVIEWED BY:	MB
PROJECT LOCATION:	Fourth Street, Gananoque, Ontario	DATE STARTED:	Oct. 18, 2021	DATE COMPLETED: Oct. 18, 2021	REVISION NO.: N/A

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING			
Lithology Plot	DESCRIPTION LOCAL GROUND SURFACE ELEVATION: 83.08	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	■ Hammer Blow Count 20 40 60 80 PenetrationTesting ○ SPT ● DCPT *Undrained Shear Strength (kPa) 20 40 60 80	▽ Water Content (%) 20 40 60 80 Liquid Limit (%) W_p W W_L Plastic Liquid 20 40 60 80	POCKET PENETROMETER kg/sq.cm	SHEAR VANE TEST N·m	COMMENTS
	Greyish-Brown Silty Clay, Trace Sand (Moist)	SS	1	100	2							No refusal Groundwater encountered at 1.22m below ground level
	82.32											
		SS	1	100	2	1					0.42	
		SS	1	100	2	2						
	Grey Silty Clay, Trace Sand (Moist)	SS	1	100	6						1.08	
		SS	1	100	5	3					1.58	
		SS	1	100	11	4					1.58	
	78.51											
		SS	1	100	7	5					1.48	
	Grey Silty Clay (Moist)	SS	1	100	7						1.72	
	76.98					6						
	No Refusal											
						7						

RECORD OF BORE HOLE No. 4

Groundwork Engineering Limited

PROJECT NUMBER:	GW - 21050	DRILLING LOCATION:	Footing of building	LOGGED BY:	RL
PROJECT CLIENT:	Horizon Legacy	DRILLING METHOD:	Hollow Stem Auger	COMPILED BY:	RL
PROJECT NAME:	Marco Polo 100 Design Challenge	DRILLING MACHINE:	CME55 Track Mounted	REVIEWED BY:	MB
PROJECT LOCATION:	Fourth Street, Gananoque, Ontario	DATE STARTED:	Oct. 18, 2021 DATE COMPLETED: Oct. 18, 2021	REVISION NO.:	N/A

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING			
Lithology Plot	DESCRIPTION LOCAL GROUND SURFACE ELEVATION: 84.09	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	PenetrationTesting ○ SPT ● DCPT *Undrained Shear Strength (kPa) 20 40 60 80	▽ Water Content (%) 20 40 60 80 Liquid Limit (%) W_P W W_L Plastic Liquid 20 40 60 80	POCKET PENETROMETER kg/sq.cm	SHEAR VANE TEST N·m	COMMENTS
	Fill (Moist) 84.04											
	Brown Silty Clay, Trace Sand (Moist)	SS	1	63	8							No refusal No groundwater encountered "BL" = Beyond Limits (>4.5)
		SS	2									
	83.33											
	Greyish-Brown Silty Clay, Trace Sand (Moist)	SS	1	67	20	1						
		SS	1	100	21	2				BL		
		SS	1	100	21					BL		
	81.04					3						
	Grey SIlty Clay, Trace Sand (Moist)	SS	1	100	21					BL		
		SS	1	100	11	4				2.36		
	79.51											
	Grey SIlty Clay (Moist)	SS	1	100	2	5				1.87		
		SS	1	100	2							
	77.99					6						
	No Refusal											
						7						

Groundwork Engineering Limited

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Scale

RECORD OF BORE HOLE No. 5

Groundwork Engineering Limited

PROJECT NUMBER: GW - 21050 | DRILLING LOCATION: Footing of building | LOGGED BY: RI

PROJECT CLIENT: Horizon Legacy | DRILLING METHOD: Hollow Stem Auger | COMPILED BY: RL

PROJECT NAME: Marco Polo 100 Design Challenge | DRILLING MACHINE: CME55 Track Mounted | REVIEWED BY: MB

PROJECT LOCATION: Fourth Street, Gananoque, Ontario | DATE STARTED: Oct. 18, 2021 | DATE COMPLETED: Oct. 18, 2021 | REVISION NO.: N/A

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING			
Lithology Plot	DESCRIPTION LOCAL GROUND SURFACE ELEVATION: 85.61	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	PenetrationTesting ○ SPT ● DCPT *Undrained Shear Strength (kPa) 20 40 60 80	▽ Water Content (%) 20 40 60 80 Liquid Limit (%) W_P W W_L Plastic Liquid 20 40 60 80	POCKET PENETROMETER kg/sq.cm	SHEAR VANE TEST N·m	COMMENTS
		SS	1	100	7					2.70		No refusal No Groundwater encountered "BL" = Beyond Limits (>4.5)
		SS	1	73	19	1				BL		
	Greyish-Brown Silty Clay, Trace Sand (Moist)	SS	1	100	17	2				BL		
		SS	1	100	18					BL		
	82.56					3						
		SS	1	100	14					BL		
	Brown Silty Clay, Trace Sand (Moist)	SS	1	100	22	4				3.43		
	81.04											
		SS	1	100	6	5				1.77		
	Greyish-Brown Silty Clay (Moist)	SS	1	100	8					1.0		
	79.51					6						
	No Refusal											
						7						

Groundwork Engineering Limited

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and requires interpretative assistance from a qualified Geotechnical Engineer. Also, Borehole information should be read in conjunction with the geotechnical report for which it was commisioned and the accompanying 'Notes to Record of Boreholes'.

Scale

RECORD OF BORE HOLE No. 6

Groundwork Engineering Limited

PROJECT NUMBER: GW - 21050
PROJECT CLIENT: Horizon Legacy
PROJECT NAME: Marco Polo 100 Design Challenge
PROJECT LOCATION: Fourth Street, Gananoque, Ontario
DRILLING LOCATION: Footing of building
DRILLING METHOD: Hollow Stem Auger
DRILLING MACHINE: CME55 Track Mounted
DATE STARTED: Oct. 18, 2021 DATE COMPLETED: Oct. 18, 2021
LOGGED BY: RL
COMPILED BY: RL
REVIEWED BY: MB
REVISION NO.: N/A

LOCAL GROUND SURFACE ELEVATION: 86.33

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	FIELD TESTING: PenetrationTesting (SPT / DCPT) *Undrained Shear Strength (kPa)	LAB TESTING: Water Content (%) / Liquid Limit (%) / Plastic / Liquid	POCKET PENETROMETER kg/sq.cm	SHEAR VANE TEST N·m	COMMENTS
	Fill (Moist) 86.15											No refusal No groundwater encountered "BL" = Beyond Limits (>4.5)
		SS	1	63	8							
		SS	1	100	21	1				BL		
		SS	1	100	9	2				BL		
	Greyish-Brown Silty Clay, Trace Sand (Moist)	SS	1	100	13					3.42		
		SS	1	100	9	3				2.93		
		SS	1	100	14	4				2.4		
	81.76											
		SS	1	100	7	5				2.0		
	Greyish-Brown Silty Clay (Moist)											
		SS	1	100	6							
	80.23					6						
	No Refusal											
						7						

Groundwork Engineering Limited

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and requires interpretative assistance from a qualified Geotechnical Engineer. Also, Borehole information should be read in conjunction with the geotechnical report for which it was commisioned and the accompanying 'Notes to Record of Boreholes'.

Scale

Groundwork Engineering Limited

Appendix C

Caduceon : Chemical Analysis

Unit 640, 654 Norris Ct Kingston, ON K7P 2R9 www.groundengineer.ca

CADUCEON™ ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G103188 **REPORT No. B21-33926 (i)**

Report To:

Groundwork Engineering LTD
654 Norris Crt, Unit 640,
Kingston Ontario K7P 2R9 Canada
Attention: Martin Burger

Caduceon Environmental Laboratories
285 Dalton Ave
Kingston Ontario K7K 6Z1
Tel: 613-544-2001
Fax: 613-544-2770

DATE RECEIVED: 18-Oct-21
DATE REPORTED: 25-Oct-21
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: 21050-Marco Polo
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		BH2 Aux 5-7.5	BH4 Aux 5-7.5	BH6 Aux 5-7.5	
			Sample I.D.		B21-33926-1	B21-33926-2	B21-33926-3	
			Date Collected		18-Oct-21	18-Oct-21	18-Oct-21	
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
pH @25°C	pH Units		SM 4500H	21-Oct-21/O	7.36	7.40	7.21	
Conductivity @25°C	mS/cm	0.001	SM 2510B	21-Oct-21/O	0.253	0.271	0.257	
Sodium Adsorption Ratio	units		SM 3120	22-Oct-21/O	2.46	0.227	0.135	
Antimony	µg/g	0.5	EPA 6020	22-Oct-21/O	< 0.5	< 0.5	< 0.5	
Arsenic	µg/g	0.5	EPA 6020	22-Oct-21/O	2.5	4.2	4.3	
Barium	µg/g	1	EPA 6010	22-Oct-21/O	90	342	278	
Beryllium	µg/g	0.2	EPA 6010	22-Oct-21/O	0.4	1.1	1.0	
Boron	µg/g	0.5	EPA 6010	22-Oct-21/O	7.3	7.0	6.3	
Boron (HWS)	µg/g	0.02	MOE3470	22-Oct-21/O	0.06	0.06	0.10	
Cadmium	µg/g	0.5	EPA 6010	22-Oct-21/O	< 0.5	< 0.5	< 0.5	
Chromium	µg/g	1	EPA 6010	22-Oct-21/O	19	58	49	
Chromium (VI)	µg/g	0.2	EPA7196A	20-Oct-21/O	< 0.2	< 0.2	< 0.2	
Cobalt	µg/g	1	EPA 6010	22-Oct-21/O	7	21	17	
Copper	µg/g	1	EPA 6010	22-Oct-21/O	16	34	31	
Lead	µg/g	5	EPA 6010	22-Oct-21/O	27	12	11	
Mercury	µg/g	0.005	EPA 7471A	22-Oct-21/O	0.024	0.012	0.015	

Michelle Dubien
Lab Manager

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill,B-Barrie
Uncertainty values available upon request

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G103188 **REPORT No. B21-33926 (i)**

Report To:

Groundwork Engineering LTD
654 Norris Crt, Unit 640,
Kingston Ontario K7P 2R9 Canada
Attention: Martin Burger

Caduceon Environmental Laboratories
285 Dalton Ave
Kingston Ontario K7K 6Z1
Tel: 613-544-2001
Fax: 613-544-2770

DATE RECEIVED: 18-Oct-21
DATE REPORTED: 25-Oct-21
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: 21050-Marco Polo
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		BH2 Aux 5-7.5	BH4 Aux 5-7.5	BH6 Aux 5-7.5	
			Sample I.D.		B21-33926-1	B21-33926-2	B21-33926-3	
			Date Collected		18-Oct-21	18-Oct-21	18-Oct-21	
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Molybdenum	µg/g	1	EPA 6010	22-Oct-21/O	< 1	< 1	< 1	
Nickel	µg/g	1	EPA 6010	22-Oct-21/O	11	44	37	
Selenium	µg/g	0.5	EPA 6020	22-Oct-21/O	0.6	0.9	1.0	
Silver	µg/g	0.2	EPA 6020	22-Oct-21/O	< 0.2	< 0.2	< 0.2	
Thallium	µg/g	0.1	EPA 6020	22-Oct-21/O	0.1	0.3	0.2	
Uranium	µg/g	0.1	EPA 6020	22-Oct-21/O	0.5	0.6	0.5	
Vanadium	µg/g	1	EPA 6010	22-Oct-21/O	25	76	64	
Zinc	µg/g	3	EPA 6010	22-Oct-21/O	45	93	78	

µg/g = micrograms per gram (parts per million) and is equal to mg/Kg
F1 C6-C10 hydrocarbons in µg/g, (F1-btex if requested)
F2 C10-C16 hydrocarbons in µg/g, (F2-napth if requested)
F3 C16-C34 hydrocarbons in µg/g, (F3-pah if requested)
F4 C34-C50 hydrocarbons in µg/g
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
Any deviations from the method are noted and reported for any particular sample.
nC6 and nC10 response factor is within 30% of response factor for toluene:
nC10,nC16 and nC34 response factors within 10% of each other:
C50 response factors within 70% of nC10+nC16+nC34 average:
Linearity is within 15%:
All results expressed on a dry weight basis.
Unless otherwise noted all chromatograms returned to baseline by the retention time of nC50.

Unless otherwise noted all extraction, analysis, QC requirements and limits for holding time were met.
If analyzed for F4 and F4G they are not to be summed but the greater of the two numbers are to be used in application to the CWS PHC
QC will be made available upon request.

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill,B-Barrie
Uncertainty values available upon request

Michelle Dubien
Lab Manager

CADUCEON ENVIRONMENTAL LABORATORIES
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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G103188 **REPORT No. B21-33926 (ii)**

Report To:

Groundwork Engineering LTD
654 Norris Crt, Unit 640,
Kingston Ontario K7P 2R9 Canada
Attention: Martin Burger

Caduceon Environmental Laboratories
285 Dalton Ave
Kingston Ontario K7K 6Z1
Tel: 613-544-2001
Fax: 613-544-2770

DATE RECEIVED: 18-Oct-21
DATE REPORTED: 25-Oct-21
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: 21050-Marco Polo
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		BH2 Aux 5-7.5	BH4 Aux 5-7.5	BH6 Aux 5-7.5	
			Sample I.D.		B21-33926-1	B21-33926-2	B21-33926-3	
			Date Collected		18-Oct-21	18-Oct-21	18-Oct-21	
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Benzene	µg/g	0.02	EPA 8260	20-Oct-21/R	< 0.02	< 0.02	< 0.02	
Toluene	µg/g	0.2	EPA 8260	20-Oct-21/R	< 0.2	< 0.2	< 0.2	
Ethylbenzene	µg/g	0.05	EPA 8260	20-Oct-21/R	< 0.05	< 0.05	< 0.05	
Xylene, m,p-	µg/g	0.03	EPA 8260	20-Oct-21/R	< 0.03	< 0.03	< 0.03	
Xylene, o-	µg/g	0.03	EPA 8260	20-Oct-21/R	< 0.03	< 0.03	< 0.03	
Xylene, m,p,o-	µg/g	0.03	EPA 8260	20-Oct-21/R	< 0.03	< 0.03	< 0.03	
PHC F1 (C6-C10)	µg/g	10	CWS Tier 1	20-Oct-21/R	< 10	< 10	< 10	
PHC F2 (>C10-C16)	µg/g	5	CWS Tier 1	21-Oct-21/K	< 5	< 5	< 5	
PHC F3 (>C16-C34)	µg/g	10	CWS Tier 1	21-Oct-21/K	48	16	11	
PHC F4 (>C34-C50)	µg/g	10	CWS Tier 1	21-Oct-21/K	56 [1]	< 10	< 10	
PHC F4 (Gravimetric)	µg/g	50	CWS Tier 1	22-Oct-21/K	540			
% moisture	%			20-Oct-21/R	9.4	19.3	17.2	

1. Note: Chromat did not return to baseline F4G required

µg/g = micrograms per gram (parts per million) and is equal to mg/Kg
F1 C6-C10 hydrocarbons in µg/g, (F1-btex if requested)
F2 C10-C16 hydrocarbons in µg/g, (F2-napth if requested)
F3 C16-C34 hydrocarbons in µg/g, (F3-pah if requested)
F4 C34-C50 hydrocarbons in µg/g
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
Any deviations from the method are noted and reported for any particular sample.
nC6 and nC10 response factor is within 30% of response factor for toluene:
nC10,nC16 and nC34 response factors within 10% of each other:
C50 response factors within 70% of nC10+nC16+nC34 average:
Linearity is within 15%:
All results expressed on a dry weight basis.
Unless otherwise noted all chromatograms returned to baseline by the retention time of nC50.

Unless otherwise noted all extraction, analysis, QC requirements and limits for holding time were met.
If analyzed for F4 and F4G they are not to be summed but the greater of the two numbers are to be used in application to the CWS PHC
QC will be made available upon request.

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill,B-Barrie
Uncertainty values available upon request

Michelle Dubien
Lab Manager

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G103188 **REPORT No. B21-33926 (iii)**

Report To:

Groundwork Engineering LTD
654 Norris Crt, Unit 640,
Kingston Ontario K7P 2R9 Canada
Attention: Martin Burger

Caduceon Environmental Laboratories
285 Dalton Ave
Kingston Ontario K7K 6Z1
Tel: 613-544-2001
Fax: 613-544-2770

DATE RECEIVED: 18-Oct-21
DATE REPORTED: 25-Oct-21
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: 21050-Marco Polo
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		BH2 Aux 5-7.5	BH4 Aux 5-7.5	BH6 Aux 5-7.5	
			Sample I.D.		B21-33926-1	B21-33926-2	B21-33926-3	
			Date Collected		18-Oct-21	18-Oct-21	18-Oct-21	
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Acenaphthene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Acenaphthylene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Anthracene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Benzo(a)anthracene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Benzo(a)pyrene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Benzo(b)fluoranthene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Benzo(b+k)fluoranthene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Benzo(g,h,i)perylene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Benzo(k)fluoranthene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Chrysene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Dibenzo(a,h)anthracene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Fluoranthene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Fluorene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Indeno(1,2,3,-cd)pyrene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Methylnaphthalene,1-	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Methylnaphthalene,2-	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	

Michelle Dubien
Lab Manager

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill,B-Barrie
Uncertainty values available upon request

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CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G103188 **REPORT No. B21-33926 (iii)**

Report To:

Groundwork Engineering LTD
654 Norris Crt, Unit 640,
Kingston Ontario K7P 2R9 Canada
Attention: Martin Burger

Caduceon Environmental Laboratories
285 Dalton Ave
Kingston Ontario K7K 6Z1
Tel: 613-544-2001
Fax: 613-544-2770

DATE RECEIVED: 18-Oct-21
DATE REPORTED: 25-Oct-21
SAMPLE MATRIX: Soil

JOB/PROJECT NO.: 21050-Marco Polo
P.O. NUMBER:
WATERWORKS NO.

			Client I.D.		BH2 Aux 5-7.5	BH4 Aux 5-7.5	BH6 Aux 5-7.5	
			Sample I.D.		B21-33926-1	B21-33926-2	B21-33926-3	
			Date Collected		18-Oct-21	18-Oct-21	18-Oct-21	
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Methylnaphthalene 2-(1-)	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Naphthalene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Phenanthrene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	
Pyrene	µg/g	0.05	EPA 8270	22-Oct-21/K	< 0.05	< 0.05	< 0.05	

µg/g = micrograms per gram (parts per million) and is equal to mg/Kg
F1 C6-C10 hydrocarbons in µg/g, (F1-btex if requested)
F2 C10-C16 hydrocarbons in µg/g, (F2-napth if requested)
F3 C16-C34 hydrocarbons in µg/g, (F3-pah if requested)
F4 C34-C50 hydrocarbons in µg/g
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
Any deviations from the method are noted and reported for any particular sample.
nC6 and nC10 response factor is within 30% of response factor for toluene:
nC10,nC16 and nC34 response factors within 10% of each other:
C50 response factors within 70% of nC10+nC16+nC34 average:
Linearity is within 15%:
All results expressed on a dry weight basis.
Unless otherwise noted all chromatograms returned to baseline by the retention time of nC50.

Unless otherwise noted all extraction, analysis, QC requirements and limits for holding time were met.
If analyzed for F4 and F4G they are not to be summed but the greater of the two numbers are to be used in application to the CWS PHC
QC will be made available upon request.

R.L. = Reporting Limit
Site Analyzed: K-Kingston, W-Windsor, O-Ottawa, R-Richmond Hill,B-Barrie
Uncertainty values available upon request

Michelle Dubien
Lab Manager

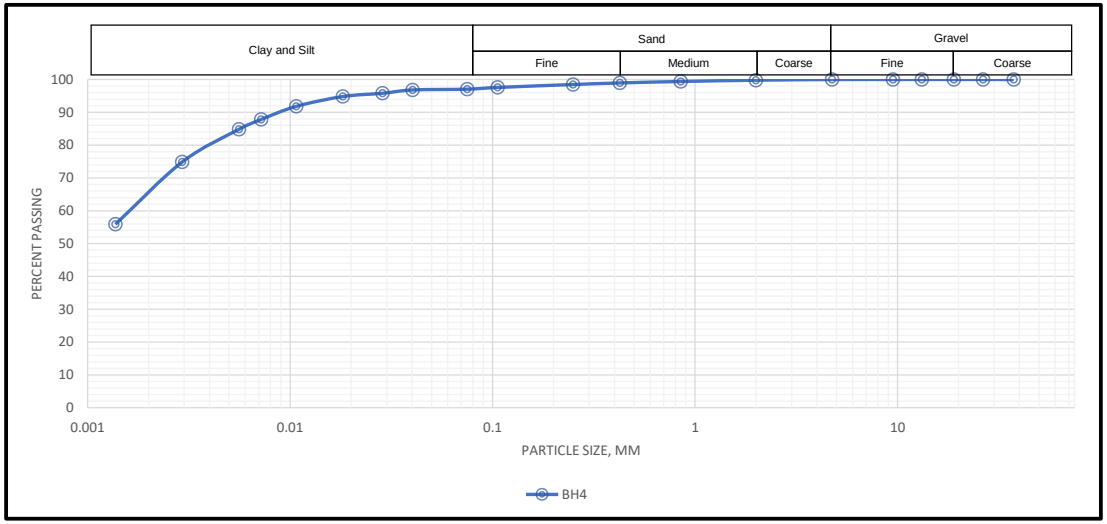
Groundwork Engineering Limited

Appendix D

Malroz : Grain Size Analysis & Atterberg Limits

Malroz Engineering Inc. Laboratory
745 Development Drive Unit 4B
Kingston, ON, K7M 4W6

Particle Size Analysis (LS-702)



Clay (%)	Silt (%)	Sand (%)	Gravel (%)
66	31	3	0
silty CLAY, trace sand			

Lab No.: 228A
Client Ref.: 21050
Client: Groundwork Engineering
Location : -
Sample: BH4
Depth: 5' - 7.5'

Notes:

Tested: JS
Date: 2021-10-25

Validated: Matt Storms
Date: 2021-10-27

Supplementary Data:

Volume of bulb, V_B (cm^3)	57	Specific Gravity, GS (assumed):	2.7
Length of Bulb, L_2 (cm)	13.60	Dispersing Agent (g/L):	40
Scale Dimension, h_s (cm/Div.)	0.18	Area of Cylinder, A (cm^2)	28.3
Maximum Particle Size (mm):	0.85	0' to Top of Bulb, L_1 (cm)	11.0

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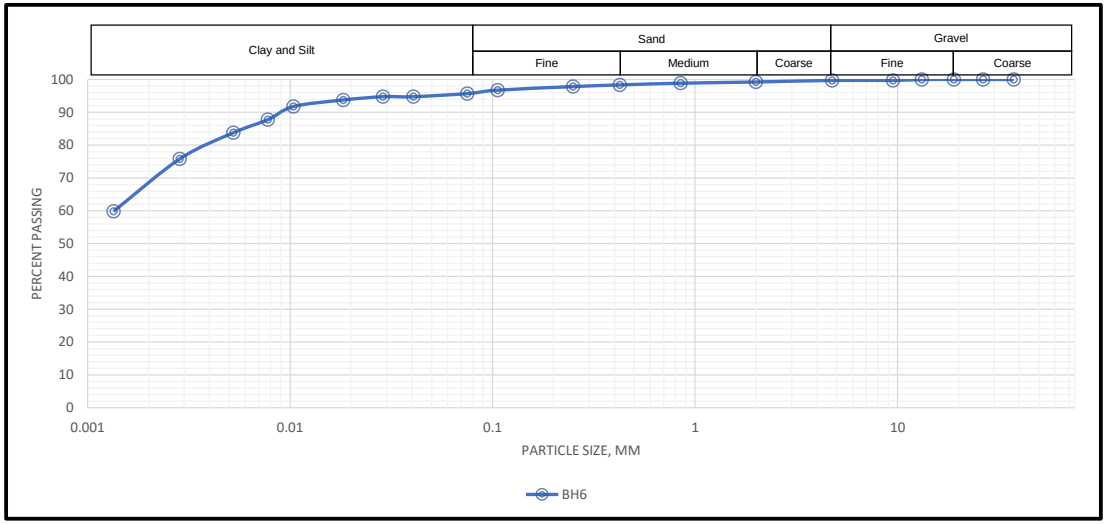
Particle Size Analysis (LS-702)



Clay (%)	Silt (%)	Sand (%)	Gravel (%)
69	27	4	0
silty CLAY, trace sand			

Lab No.: 228B
Client Ref.: 21050
Client: Groundwork Engineering
Location : -
Sample: BH6
Depth: 5' - 7.5'

Notes:

Tested: JS
Date: 2021-10-25

Validated: Matt Stamm
Date: 2021-10-27

Supplementary Data:

Volume of bulb, V_B (cm^3)	57	Specific Gravity, GS (assumed):	2.7
Length of Bulb, L_2 (cm)	13.60	Dispersing Agent (g/L):	40
Scale Dimension, h_s (cm/Div.)	0.18	Area of Cylinder, A (cm^2)	28.3
Maximum Particle Size (mm):	0.85	0' to Top of Bulb, L_1 (cm)	11.0

Malroz Engineering Inc. Laboratory
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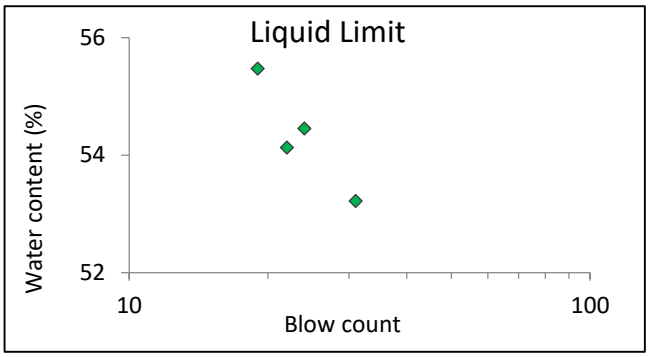
Atterberg Limits Test Summary (LS 703/704)

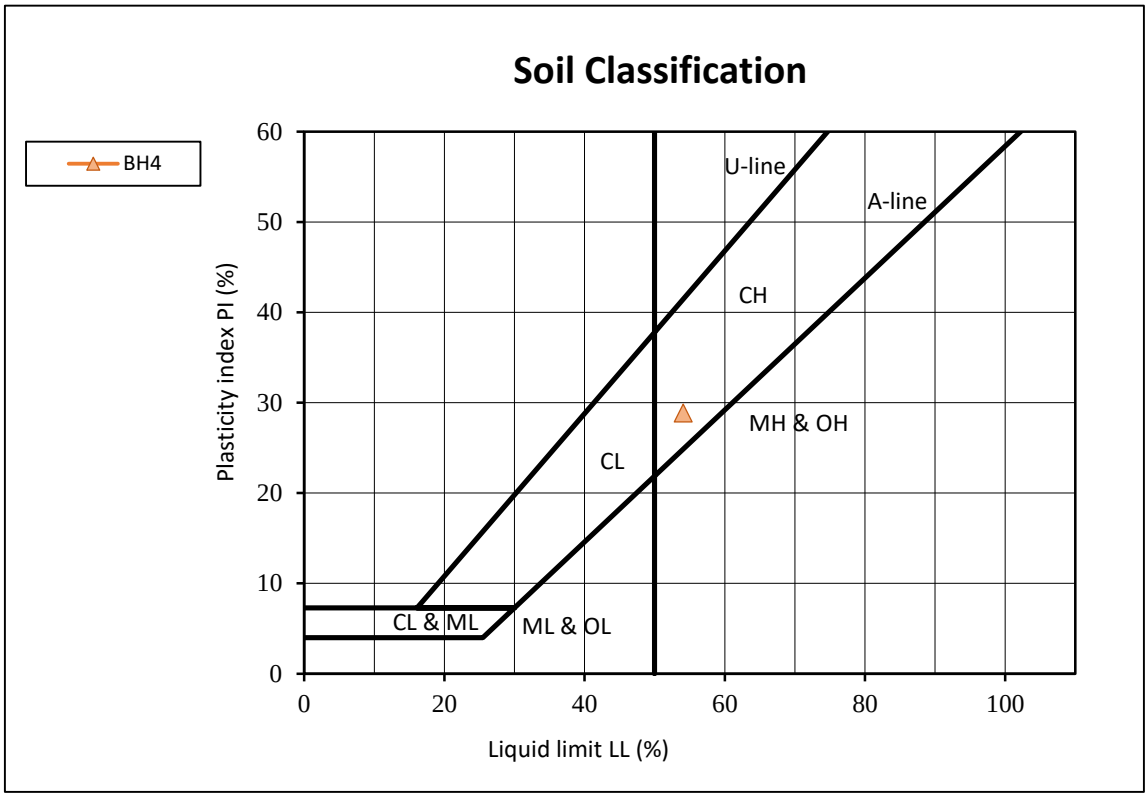
Client: Groundwork Engineering
Project No.: 1152
Client Ref.: 21050
BH: BH4
Depth: 5' - 7.5'
Sample: BH4

Lab No. 228C
Tested By: JS
Date Tested: 26-Oct-21

Atterberg Limits

Liquid Limit	**54.1%**
Plastic Limit	**25.2%**
Plasticity Index	**28.9%**





Validated By:

Date: 2021-10-27

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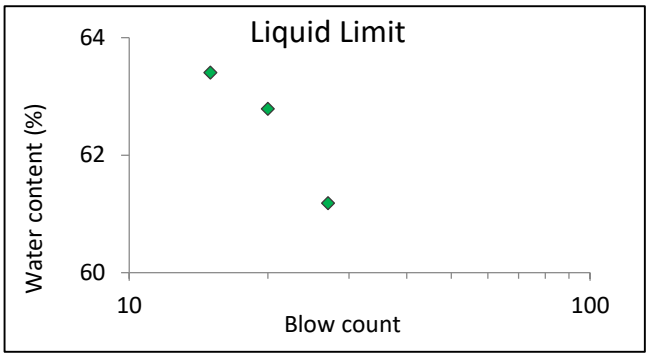
Atterberg Limits Test Summary (LS 703/704)

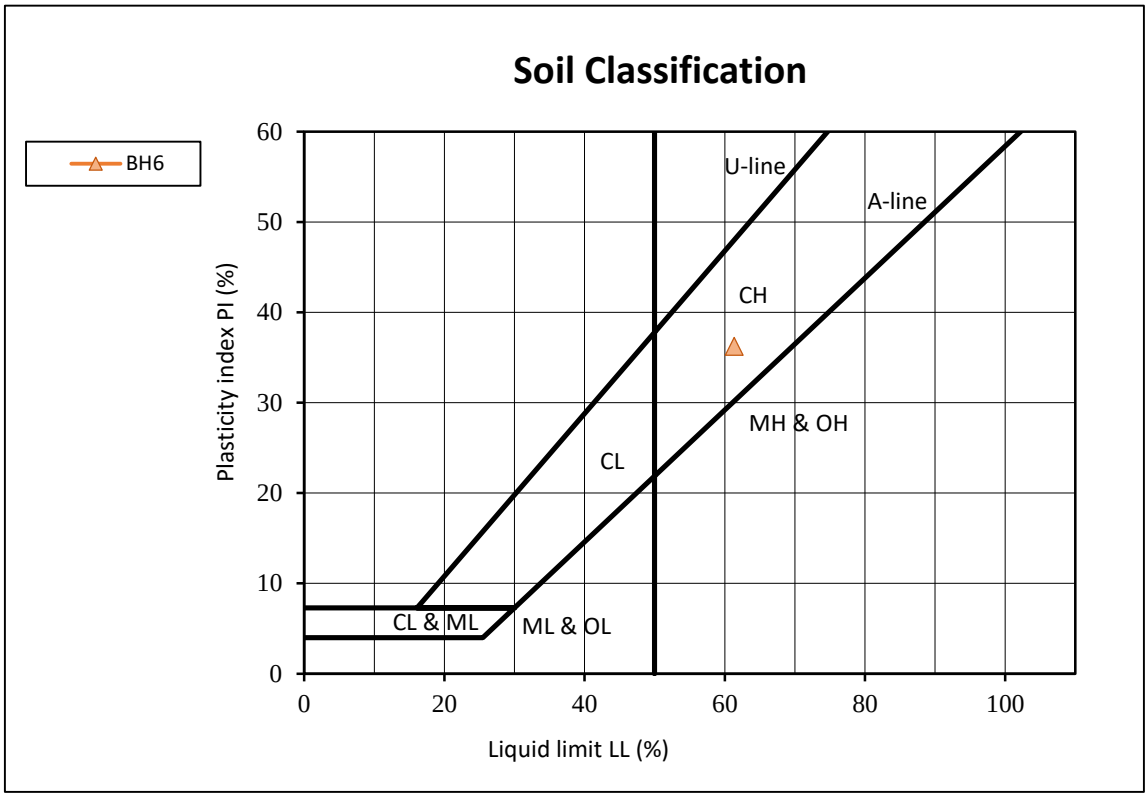
Client: Groundwork Engineering
Project No.: 1152
Client Ref.: 21050
BH: BH6
Depth: 5' - 7.5'
Sample: BH6

Lab No. 228D
Tested By: JS
Date Tested: 26-Oct-21

Atterberg Limits

Liquid Limit	**61.4%**
Plastic Limit	**25.1%**
Plasticity Index	**36.2%**





Validated By:

Date: 2021-10-27

Groundwork Engineering Limited

Appendix E

Malroz : Moisture Content

Malroz Engineering Inc. Laboratory
745 Development Drive Unit 4B
Kingston, ON, K7M 4W6

Moisture Content (D2216)

Client: Groundwork
Client Ref.: 21050
Sample: -
Depth: 5'-7.5'
Location: -

Lab No.: 228
Date: 27-Oct-21
Tested By: JS

Borehole No.	Depth	Tare Weight (g)	Tare + Wet Soil (g)	Tare + Dry Soil (g)	Moisture (g)	Dry Soil (g)	Wet Soil (g)	Moisture Content (%)
4	5'-7.5'	163.8	309.9	276.5	33.4	112.7	146.1	**29.6**
6	5'-7.5'	248.7	454.5	402.0	52.5	153.3	205.8	**34.2**

Validated:

Date: 27-Oct-21