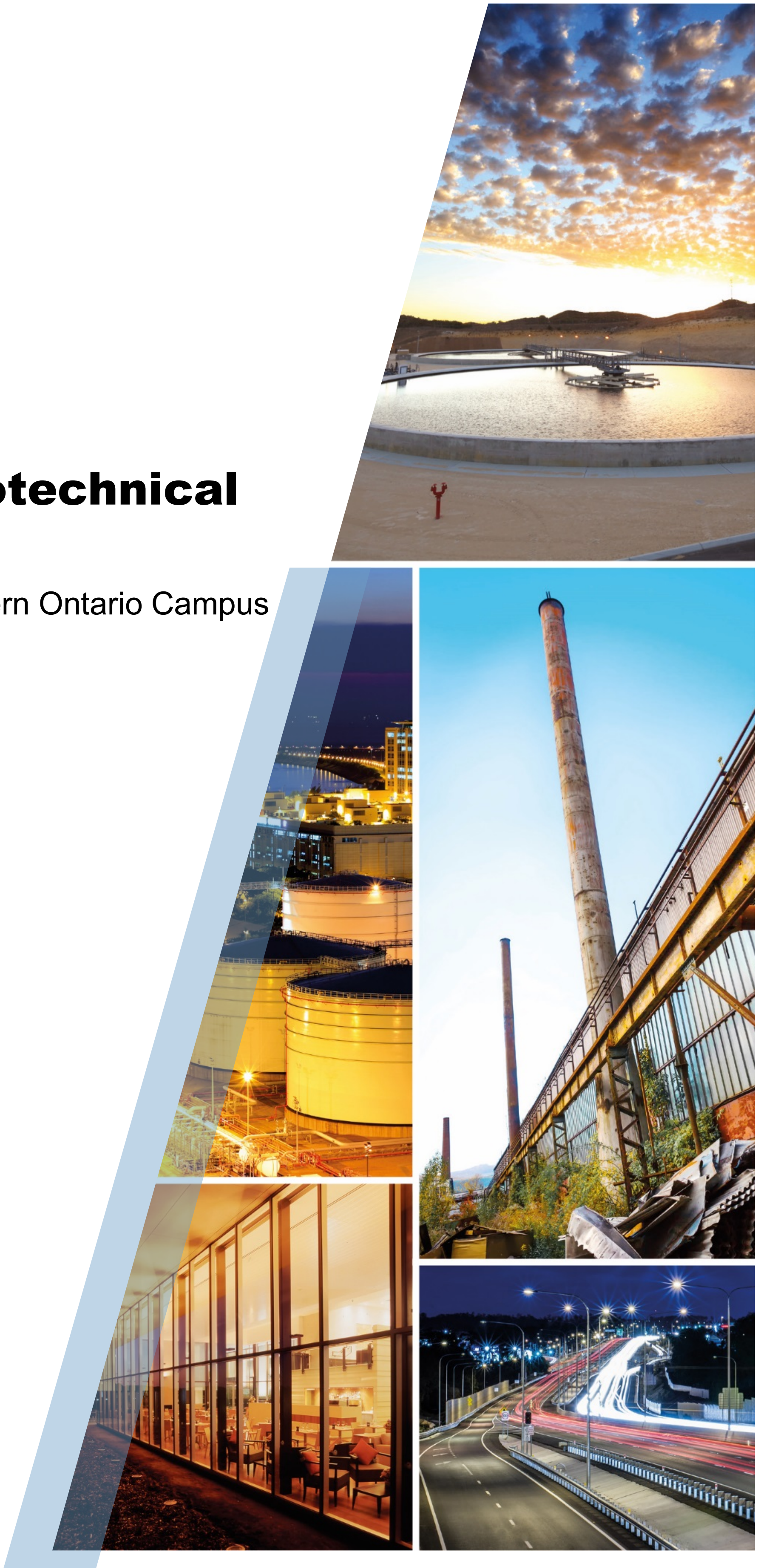
Preliminary Geotechnical Investigation

Children's Hospital of Eastern Ontario Campus
401 & 407 Smyth Road
Ottawa, Ontario

Infrastructure Ontario



Executive Summary

GHD Limited (GHD) has been retained by Ontario Infrastructure and Lands Corporation (“IO”) to carry out a preliminary geotechnical investigation for the proposed development at the Children’s Hospital of Eastern Ontario (CHEO) Campus located at 401 & 407 Smyth Road in Ottawa, Ontario. The proposed development will consist of constructing the 1Door4Care building that would be located in the southwestern portion of the CHEO’s Campus. The Site is currently developed with a parking lot and landscaped areas. The gross floor area of the proposed Children's Treatment Centre building, is approximatively 207,000 square-feet (19,230 square-metre). The preliminary development concept for the 1Door4Care building includes a multi-storey building with an underground basement. The anticipated development surrounding the building footprint may include parking, internal road network and underground utilities.

The geotechnical investigation was undertaken concurrently with an environmental and hydrogeological investigation. The drilling work consisted of advancing a total of fourteen (14) exploratory geotechnical boreholes and installing ten (10) shallow and deep monitoring wells. Select soil and rock core samples were collected and submitted for geotechnical laboratory testing.

One level of underground basement is anticipated for the proposed building. This would result in the foundation subgrade being approximately 3.0 metres below existing grade. Based on the boreholes data, the founding subgrade for the building at this depth will generally consist of dense silty sand or completely weathered shale bedrock. The proposed building can be supported on conventional spread and strip footings placed within the native silty sand or weathered shale bedrock. It is recommended that the building foundations be extended to the shale bedrock in order to avoid supporting the building foundations on two different types of materials (i.e. soil and bedrock) which could consequently result in excessive differential settlement. Raft (Mat) foundation may also be considered a feasible foundation option for this project, depending on the structural loads and the tolerable settlement. Depending on the structural loads, deep foundations such as cast-in-place concrete piles (caissons) socketed into the sound bedrock could be considered the foundation type best suited for supporting large structural loads due to the high load carrying capacity of the bedrock.

Swelling of the Georgian Bay shale bedrock is well documented and should be expected during and after construction. Any structures such as foundation walls and slabs that will be placed directly on the shale bedrock, should be designed for the full loads imparted by the swelling of the shale over the design life of the structures. Alternatively, the design for the foundation walls and slabs should incorporate measures to accommodate swelling such as a sufficient delay period after excavation or placement of compressible materials in order to mitigate the impact of the expected deformations.

The amount of seepage into excavations will depend on the depth of excavation relative to the groundwater level at the time of construction and the hydraulic conductivity of the excavated soils/bedrock. The measured groundwater levels within the installed monitoring wells were found to range from approximately 1.4 to 5.0 mBGS. It is expected that seepage rate into the excavation within the native silty sand deposits will be moderate to high. If the excavation is to be above the groundwater table, minor to moderate groundwater ingress can readily be handled by using installation of sumps and pumps at strategic locations at the base of excavation. If the excavation is to be extended to a greater depth and below local groundwater table, an active pre-construction dewatering system such as well points may be required depending on the depth and size of excavations. Please refer to the Hydrogeological Assessment Report prepared by GHD for this project under separate cover.

The possible presence of cobbles and boulders at this Site and their impact on the excavation should be clearly stated in the contract documents.

Footings subject to frost action should have a minimum soil cover of at least 1.8 m according to OPSD 3090.101 for Southern Ontario, or be protected using equivalent insulation.

Based on the results of this investigation and the results of an MASW survey conducted by GHD, the Site can be classified as Class 'B’ for seismic load calculations.

Qualified geotechnical personnel should inspect all stages of the proposed development. Specifically, they should ensure that the materials and conditions comply with this geotechnical investigation report. In addition, qualified geotechnical personnel should provide material testing services prior to and during foundation preparation and construction.

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1. Introduction

GHD Limited (GHD) has been retained by Ontario Infrastructure and Lands Corporation (“IO”) to carry out a preliminary geotechnical investigation for the proposed development at the Children’s Hospital of Eastern Ontario (CHEO) Campus located at 401 & 407 Smyth Road in Ottawa, Ontario (hereafter referred to as the Site). A Site Location Map is provided on Figure 1.

The proposed development will consist of constructing the 1Door4Care building that would be located in the southwestern portion of the CHEO’s Campus. The Site is currently developed with parking lot and landscaped areas. The gross floor area of the proposed building, as a Children's Treatment Centre, is approximatively 207,000 square-feet (19,230 square-metre). The preliminary development concept for the 1Door4Care building includes a multi-storey building with an underground basement. The anticipated development surrounding the building footprint may include parking, internal road network and underground utilities.

The GHD proposed scope of work included geotechnical, hydrogeological, and environmental components, as well as a Multi-Channel Analysis of Surface Waves (MASW) analysis) and a geophysical survey. The geotechnical investigation was undertaken concurrently with the environmental and hydrogeological investigations. This report comprises the geotechnical investigation and the geophysical survey as well as the results of the MASW analysis completed at the Site. The finding of the hydrogeological and environmental investigations will be presented under separate covers.

The geotechnical investigation for this Site included advancing a total of fourteen (14) geotechnical exploratory boreholes. The borehole locations are presented on Figure 2. In general, the objectives of the geotechnical investigation are as follows:

- Determine the subsurface soil/rock and groundwater at the borehole locations.
- Carry out laboratory testing on selected soil and rock core samples to assess geotechnical properties.
- Conduct multichannel analysis of surface waves (MASW) to evaluate soil shear wave velocity and define Site classification for seismic site response.
- Carry out laboratory chemical analysis on selected soil samples to assess soil potential for sulphate attack on construction concrete (class of exposure) and soil corrosivity on ductile cast iron elements.
- Complete geophysical Survey to determine the location of buried infrastructure, objects/elements or obstructions within the development area.
- Provide professional opinions and recommendations regarding the design and construction of proposed building foundations, floor slab, pavements, and to assess the anticipated construction conditions pertaining to excavation, backfilling, and groundwater control.

The preliminary geotechnical investigation was carried out in accordance with GHD’s work plan dated November 4, 2019, in response to a Request for Services issued by IO.

This report summarizes the activities and findings of the current preliminary geotechnical investigation.

2. Field and Laboratory Work Procedures

The field investigation protocols and methodologies undertaken for the present geotechnical investigation are presented below and were undertaken in general accordance with the guidelines provided in the “Site Investigation Guidelines for Due Diligence and Design Purposes Social and Civil Infrastructure Project” dated November 2018.

2.1 Safety Planning and Utility Clearances

Upon project initiation, a Site-specific Health and Safety Plan (HASP) was prepared for implementation during the field investigation program. The HASP presented the visually observed Site conditions and identified potential physical hazards to field personnel. Required personal protective equipment was also listed in the HASP. The HASP was reviewed by GHD’s field personnel prior to undertaking field activities and a copy of the HASP was maintained at the Site for the duration of the investigative work. Health and Safety requirements in the HASP were implemented during the field investigation program.

Prior to initiating the subsurface investigation activities, all applicable utility companies (gas, hydro, bell, network cables, pipeline and municipal sewers, etc.) were contacted. In addition, a private utility locator (Multiview Locates Inc.) was utilized to demarcate the location of the privately owned utilities within the area of the boreholes.

2.2 Borehole Advancement and Field Testing

Drilling activities for the geotechnical investigation were conducted during the period between November 26 and December 4, 2019 under the full-time supervision of an experienced GHD technical representative. The drilling activities consisted of the advancement of fourteen (14) exploratory geotechnical boreholes (denoted as MW1 to MW5, BH6 to BH8, MW9, MW10 and BH11 to BH14) to approximate depths varying between 2.3 and 11.4 metres below ground surface (mBGS). In addition, ten (10) shallow and deep monitoring wells were installed in some of the completed boreholes. The approximate locations of the drilled boreholes/wells are shown on Figure 2.

The drilling activities were conducted utilizing a track mounted conventional drilling rig, supplied and operated by a Ministry of the Environment, Conservation and Parks (MECP) licensed well driller (Profile Drilling).

Soil samples were generally collected every 0.75 m depth intervals and into the completely weathered shale bedrock. All sampling was conducted using a 50 millimetre (mm) outside diameter split spoon sampler in general accordance with the specifications of the Standard Penetration Test Method (ASTM D1586). The relative density or consistency of the subsurface soil layers were measured using the Standard Penetration Test (SPT) method, by counting the number of blows (‘N’) required to drive a conventional split barrel soil sampler 0.3 m depth.

Rock coring was subsequently carried out in three boreholes (MW2, MW3, and MW4) using diamond-drilling methods to confirm the presence of bedrock and to determine bedrock quality. Rock coring was carried out and extended to depths varying between approximately 5.7 and 7.3 m into the bedrock. Rock cores were obtained using a HQ sized core barrel, placed in core boxes, and visually examined and logged.

The supervising technician logged the borings and examined the soil/rock samples as they were obtained. The soil and rock core samples were transported to GHD's geotechnical laboratory where they were further reviewed by a senior geotechnical engineer. The detailed results of the examination are recorded on the borehole logs presented in Appendix A.

Upon completion of drilling activities, the ground elevations at the borehole locations were surveyed by J.D.BARNES Limited using a geodetic benchmark (BM) and the UTM Coordinate System (UTM-18 NAD83). A summary of the survey information is presented in the table below.

Borehole Identification	Location – UTM Coordinate System		Total Depth (mBGS)	Ground Elevation (mAMSL)
	Northing	Easting		
MW1	5027668.51	448936.95	5.5	82.53
MW2	5027646.04	448956.59	11.3	82.43
MW3	5027642.05	448935.55	11.4	81.58
MW4	5027621.96	448917.85	8.4	80.34
MW5	5027604.92	448917.81	3.1	80.54
BH6	5027626.34	448896.25	2.4	80.04
BH7	5027643.80	448912.47	2.4	80.40
BH8	5027623.43	448936.55	3.1	80.82
MW9	5027678.63	448898.49	3.8	80.52
MW10	5027644.57	448886.32	3.8	79.86
BH11	5027617.47	448987.18	2.5	81.32
BH12	5027580.89	448953.96	3.8	81.27
BH13	5027562.88	448996.61	2.4	81.37
BH14	5027560.88	448919.43	2.3	81.17

Notes:
mBGS: metres below ground surface
mAMSL: metres Above Mean Sea Level

These elevations should not be used for construction purposes.

2.3 Monitoring Well Installation

Ten (10) shallow and deep monitoring wells were installed in seven (7) select boreholes (MW1 to MW5, MW9, and MW10) for long term groundwater level monitoring and for the hydrological study. In boreholes MW2, MW3 and MW4 shallow and deep wells were installed in separate borings located adjacent to each other.

Each monitoring well was instrumented with a 50 mm diameter, Schedule 40 PVC screen and completed with 50 mm diameter PVC riser pipe and J-plug. A silica sand pack was placed in the annular space between the PVC screen pipe and the borehole annulus to approximately 0.3 m above the top of the screen. A bentonite seal and hole plug was installed in the remaining borehole annulus above the sand pack. A protective flushmount casing with a concrete collar was placed around each monitoring well. The well completion details for each monitoring well is presented on the borehole logs provided in Appendix A.

2.4 Soil Corrosivity Testing

Corrosivity testing was conducted on eleven (11) selected samples extracted from the drilled boreholes in accordance with ASTM and CSA Standards to assess the corrosion potential against ductile iron pipes and sulphate attack on concrete. The certificates of analysis associated with the corrosivity test results are provided in Appendix F and results are discussed in Section 5.5.

2.5 Organic Content Testing

An organic matter content test was carried out on eight (8) samples extracted from the drilled boreholes. The certificates of analysis associated with the organic content test results are provided in Appendix F and the results are discussed in Section 3.3.6.

2.6 Multi-channel Analysis of Surface Waves (MASW)

In order to measure the ground shear wave velocity at the proposed building location and define the Site classification for seismic site response, a multi-channel analysis of surface waves (MASW) was carried out by GHD along two (2) select investigated lines within the Site. The purpose of the MASW survey was to determine the seismic site class in accordance with the Ontario Building Code (OBC 2012) by measuring the average shear wave velocity within the upper 30+ m of the soil/rock profile directly under the assumed founding level of the proposed building.

The findings and the obtained results of the MASW survey are discussed in Section 4.8 and the related MASW report is provided in Appendix D.

2.7 Geophysical Survey

A geophysical survey was completed by Multiview Locates Inc. at the Site. The objective of this survey was to detect and map the presence of potential underground storage tanks or any buried metallic objects within the development area. The geophysical work consisted of an electromagnetic (EM31) survey and ground penetration radar (GPR). The geophysical survey report is provided in Appendix E.

2.8 Geotechnical Laboratory Testing

All geotechnical laboratory testing was completed in accordance with the latest editions of the ASTM standards. Geotechnical laboratory testing consisted of moisture content tests on all recovered soil samples, as well as grain size distribution analysis (sieve and hydrometer) on eleven (11) select soil samples. Atterberg Limit testing was also conducted on eight (8) soil samples selected for grain size analysis that exhibited plasticity to assess soil plasticity properties. Standard Proctor compaction test was conducted on seven (7) bulk samples collected from the auger cuttings obtained from the fill layers within the boreholes.

Laboratory uniaxial compressive strength (UCS) test was carried out on nine (9) select rock core samples. In addition, four (4) rock core samples were submitted to Western University for free swell test. The free swell tests are being carried out in an unconfined state such that the shale bedrock is free to swell in all directions.

Unit weight test was not carried out on soil samples due to the difficulty to obtain intact soil samples for testing. The collected soil samples were classified/described in general accordance with the ASTM D2487 - Standard Practice for Classification of Soils for engineering purposes (Unified Soil Classification System-USCS).

Geotechnical laboratory test results are discussed in Section 3.3. The results of moisture content determination tests, grain size analyses and Atterberg Limits are provided on the borehole logs in Appendix A. The gradation curves, plasticity charts, standard proctor, uniaxial compressive strength (UCS) tests,and free swell test results are provided in Appendix B.

3. Site Geology and Subsurface Conditions

3.1 Regional Geology

Based on the Quaternary Geology of Ontario map[1], the site is situated in an area of fluvial deposits consisting of gravel, sand, silt and clay deposited on modern flood plains. The Bedrock Geology of Ontario map[2], indicates the Site is underlain by the upper Ordovician aged shale of the Georgian Bay Formation and Blue Mountain/Billings Formations. The Georgian Bay Formation gradationally overlies the Blue Mountain Formation and consists of interbedded grey to dark grey shale and fossiliferous calcareous siltstone to limestone. In eastern Ontario the Blue Mountain Formation is equivalent to the Billings Formation and consists of dark blue-grey to brown to black shale with thin interbeds of limestone or calcareous siltstone. Review of the bedrock topography map and MECP well records for the Site, the depth to the bedrock surface is anticipated to range from 0.8 to 3.6 metres below ground surface or at elevations between 75 and 80 m.

In general, based on the above geological mapping, the subject Site is situated in an area of fluvial deposits consisting of gravel, sand, silt and clay soils followed by shale bedrock.

3.2 Site Stratigraphy

It should be noted that the subsurface conditions are confirmed at the borehole locations only, and may vary at other locations. The boundaries shown on the borehole logs represent an inferred transition between the various strata, rather than a precise plane of geological change. It must be understood that actual contacts between deposits will typically be gradational as a result of neutral geologic processes. Variation in the deposit boundaries from those described in the borehole logs must be anticipated. Therefore, design and construction equipment and procedures must be selected

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[1] Ministry of Northern Development and Mines – Quaternary Geology of Ontario – Southern Sheet – Map 2556.

[2] Ministry of Northern Development and Mines – Bedrock Geology of Ontario – Southern Sheet – Map 2544

to accommodate significant variations in the deposit boundaries. Details of the subsurface conditions are provided on the borehole logs presented in Appendix A.

The soil conditions observed in the boreholes advanced for this geotechnical investigation are generally consistent with the described geology of the region as presented in Section 3.1 of this report. The general stratigraphy at the Site consists of fill/disturbed soils underlain by silty sand deposits followed by bedrock. A brief description of each soil stratum is summarized below:

3.2.1 Ground Cover

Topsoil

A surficial layer of topsoil was encountered at the ground surface of boreholes MW1, MW2, MW3, and MW4, which were advanced within grassed areas. The thickness of the topsoil layer ranged from approximately 75 to 100 millimetres (mm). Classification of this material was based solely on visual and textural examination. It should be noted that the thickness of topsoil can vary between borehole locations.

Asphalt

Boreholes MW5, BH11, BH12, BH13, and BH14 have been drilled on the existing pavement of the parking areas and encountered an asphalt surface layer. The thickness of the asphalt ranged between 50 to 75 mm.

3.2.2 Fill / Disturbed Soil

Earth fill / disturbed soil was encountered in all boreholes at the ground surface or below the topsoil/asphalt, and extended to a depth varying from approximately 0.4 to 1.7 mBGS. The fill composition is in general heterogeneous, consisting of silty sand/sandy silt or sand and gravel. Rootlets, wood pieces and asphalt fragments were observed within the fill layer. Also, the upper portion of the fill layer was observed to be frozen.

SPT ‘N’ values obtained within the earth fill layer varied between 4 and 98 blows per 0.3 m of penetration, indicating a variable degree of compaction. The elevated blow counts is likely due the presence of gravel and cobbles within the fill layer or the frozen ground. Water content measurements obtained from extracted fill samples varied between 2 and 25 percent by weight. The low moisture content is likely due to the presence of gravel and cobble fragments within the tested fill samples and the high moisture content is likely due to the presence of clay and/or ice lenses within the tested fill samples.

Gradation analysis was completed on one selected sample of the fill layer. The results are presented in the borehole logs and are tabulated in Section 3.3.1. The gradation analysis curve is presented in Appendix B.

It is possible that the thickness and quality of the fill (presence of deleterious materials or organics) can vary between borehole locations.

3.2.3 Silty Sand

A silty sand deposit was encountered beneath the fill layer in all boreholes and extended to the bedrock surface. The silty sand deposit was found to contain gravel, clay and cobble fragments.

SPT ‘N’ values obtained within this deposit varied between 8 blows per 0.3 m of penetration and greater than 50 blows per 0.075 m of penetration (refusal), indicating a loose to very dense relative density, but generally compact to dense condition. The elevated blow counts/refusal is generally occurring near the bedrock surface.

The moisture content of the samples collected varied generally between 4 and 30 percent by weight. The low moisture content is likely due to the presence of gravel or shale and cobble fragments within the tested sand samples, and the high moisture content of 28 and 30 percent is likely due to the high percentage of clay within the silty sand deposit.

Gradation analysis was completed on ten selected samples of the silty sand deposit. The results are presented in the borehole logs and are tabulated in Section 3.3.1. The gradation analysis curves are presented in Appendix B. Atterberg limits tests were also performed on eight soil samples selected for grain size analysis that exhibited plasticity. The results are presented in the borehole logs and are tabulated in Section 3.3.2. The plasticity charts are presented in Appendix B.

3.2.4 Shale Bedrock

Bedrock was encountered in all boreholes at a depth of 0.9 to 3.8 mBGS. The shale bedrock was cored in three boreholes (MW2, MW3, and MW4) to verify the presence of bedrock and assess the bedrock quality. The boreholes within the completely weathered zones were advanced by auguring and SPT sampling for variable thicknesses, but generally less than 2 m before reaching auger refusal. From the recovered rock cores, the bedrock was visually identified as the Georgian Bay Formation. The shale was generally observed to be dark grey in color, thinly laminated, completely weathered at its surface and became gradually fresh with depth. This formation consists generally of a dark grey weak to moderately strong shale interbedded with light grey color strong to very strong limestone and siltstone layer.

Due to the method of investigation and the presence of completely weathered shale at the bedrock surface, the top of the bedrock profile cannot be accurately determined. However, the estimated depths to the completely weathered shale bedrock surface from augering and coring is listed in the following table:

Borehole Identification Number	Estimated Depth/Elevations of Bedrock Surface (mBGS/mAMSL)
MW1	3.8 / 78.7
MW2	3.8 / 78.6
MW3	3.1 / 78.6
MW4	1.5 / 78.8
MW5	1.7 / 78.8
BH6	0.9 / 79.2
BH7	1.5 / 78.9

Borehole Identification Number	Estimated Depth/Elevations of Bedrock Surface (mBGS/mAMSL)
BH8	1.5 / 79.3
MW9	2.0 / 78.5
MW10	2.3 / 77.6
BH11	1.5 / 79.8
BH12	2.3 / 79.0
BH13	1.1 / 80.3
BH14	1.0 / 80.1

Notes:

mBGS:	metres Below Ground Surface
mAMSL	metres Above Mean Sea Level

The Total Core Recovery (TCR) achieved with the HQ size core bit ranged from approximately 80 to 100% and the Solid Core Recovery (SCR) ranged from 59 to 100 %. The Rock Quality Designation (RQD) ranged from 0 to 100% with the lower values of RQD observed near the surface of the rock and percentages generally increased with depth. The RQD values are a general indicator of rock mass quality; however, in horizontally laminated sedimentary rock formation such as the Georgian Bay Formation, the RQD values may likely underestimate the quality of the rock.

Photographs of the Rock Core samples are presented in Appendix C.

Nine (9) rock core samples were submitted to the GHD geotechnical laboratory for Uniaxial Compressive Strength (UCS) testing. The results of UCS testing are tabulated in Section 3.3.4 and are also presented in Appendix B.

Time dependent deformation (i.e. swelling) of the Georgian Bay shale bedrock is well documented and should be expected during and after construction. Four (4) rock core samples were submitted to Western University for free swell test. The free swell tests are carried out in an unconfined state such that the shale bedrock is free to swell in all directions. Based on the data from the laboratory testing, the horizontal swelling potential ranges from 0 to 0.05 % log cycle of time, while vertical swelling potential ranges from 0.1 to 0.2 % log cycle of time.

Rock at depth is subjected to stresses resulting from the weight of the overlying strata and from locked in stresses of tectonic origin. If the stresses within the rock exceeded the strength of the rock, it will likely impact the behavior and stability of the excavation within the rock. It is well documented that the sedimentary rock formations in Southern Ontario, including the Georgian Bay Formation possess high horizontal stresses which generally exceed the vertical stress.

Based on previous experience, the Georgian Bay Formation could contain pockets of combustible gas. Even though during the present investigation there were no physical indications (e.g. bubbles in the drill water, odor in the rock cores) of the presence of gas in the boreholes advanced into the bedrock, monitoring of the gas should be carried out during construction.

3.3 Geotechnical Laboratory Test Results

3.3.1 Grain Size Distribution

Grain size analyses consisting of sieve and hydrometer testing were carried out on eleven (11) select soil samples extracted from the boreholes. The obtained results are reported in the borehole logs and are tabulated in the following table. The gradation analysis curves are presented in Appendix B.

Borehole Identification	Depth (mBGS)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Fines Silt & Clay (%)
MW1	1.5-2.1 & 2.3-2.9	26	58	11	5	16
MW2	1.5-2.1 & 2.3-2.9	32	48	13	7	20
MW3	0.8-1.4	43	52	5		5
MW3	2.3-2.9	16	59	17	8	25
MW4	0.8-1.4	11	59	20	10	30
MW5	0.9-1.2 & 1.5-1.7	8	62	20	10	30
MW7	0.8-1.4	3	54	30	13	43
BH8	0.8-1.4	8	59	22	11	33
MW9	0.8-1.4 & 1.5-2.0	14	53	20	13	33
MW10	0.8-1.4	26	47	18	9	27
BH12	0.8-1.4 & 1.5-2.1	18	52	19	11	30

Based on the gradation test results, the tested soil sample of fill/disturbed layer can be classified as sand with gravel and silt (sand and gravel), and the tested soil samples of the native deposit can be classified as silty sand with gravel.

3.3.2 Atterberg Limits

Atterberg limits test was conducted on eight (8) of the soil samples selected for grain size analysis. The obtained results are reported in the borehole logs and are tabulated in the following table. The test results are presented in the plasticity chart in Appendix B.

Borehole Identification	Depth (mBGS)	W	LL	PL	PI	Soil Description and Classification
MW3	2.3-2.9	11	31	21	10	Low Plasticity Inorganic Clay (CL)
MW4	0.8-1.4	15	20	20	9	Low Plasticity Inorganic Clay (CL)
MW5	0.9-1.7	9	29	17	12	Low Plasticity Inorganic Clay (CL)
BH7	0.8-1.4	7	30	22	8	Low Plasticity Inorganic Clay (CL)
BH8	0.8-1.4	10	24	19	5	Low Plasticity Inorganic Clay (CL-ML)
MW9	0.8-2.0	9	27	20	7	Low Plasticity Inorganic Clay (CL-ML)
MW10	0.8-1.4	9	24	21	3	Inorganic Silt (ML)
BH12	0.8-2.1	4	26	20	6	Low Plasticity Inorganic Clay (CL-ML)

Notes:

W:	Natural water content in percent
LL:	Liquid limit
PL:	Plastic limit
PI:	Plasticity index

Based on the gradation and Atterberg test results, the tested soil samples of the native deposit can be generally classified as silty sand that generally contains low plasticity clay.

3.3.3 Proctor Test

Seven (7) laboratory Standard Proctor compaction tests were conducted on bulk samples of the auger cuttings extracted from the surficial fill at the Site to determine the maximum dry density and optimum moisture content of the fill. The purpose of the testing was to assess the compactability during construction. The results are summarized below and are also provided in Appendix B.

Borehole Identification Number	Depth (mBGS)	*Maximum Dry Density (kg/m^3)*	Optimum Moisture Content (%)
MW1	0.0-0.6	2,067	9.5
MW3	0.0-0.6	2,062	8.4
MW5	0.0-0.6	2,057	10
BH6	0.0-0.6	2,086	7.1
BH12	0.0-0.6	2,250	6.8
BH13	0.0-0.6	2,143	8.7
BH14	0.0-0.6	2,178	7.6

The tested samples maximum dry density ranged between 2,057 and 2,250 kg/m^3 and the optimum moisture contents varied between 6.8 and 10 percent by weight. The measured in-situ moisture content of the tested samples varied between 5 and 12 percent indicating the fill material are generally within +/- 3 percent of the laboratory optimum for compaction.

3.3.4 Uniaxial Compressive Strength of Intact Rock Core

Laboratory uniaxial compressive strength (UCS) test was carried out on nine (9) selected rock samples extracted from the cores. The results of these tests are summarized below and are also presented in Appendix B.

Borehole Identification	Rock Type	Sample Depth (mBGS)	UCS (MPa)
MW2	Shale	5.13	35.9
MW2	Shale	7.67	31.4
MW2	Shale	9.70	24.4
MW3	Shale	6.28	28.4
MW3	Shale	7.83	33.5
MW3	Shale	10.27	35.4
MW4	Shale	3.26	41.8
MW4	Shale	6.38	28.5
MW4	Shale	7.58	30.5

Note:
MPa: Megapascal

Based on the results of the unconfined compressive strength test, the tested rock core samples may be generally classified in accordance with ISRM (International Society of Rock Mechanics) guidelines as moderately strong.

3.3.5 Free Swell Test

In order to estimate the time dependent horizontal and vertical free swell rates, four (4) rock core samples were submitted to Western University for free swell test. The free swell tests are carried out in an unconfined state such that the shale bedrock is free to swell in all directions. Based on the data from the laboratory testing, the horizontal swelling potential ranges from 0 to 0.05 % log cycle of time, while vertical swelling potential ranges from 0.1 to 0.2 % log cycle of time. The results of the free swell tests are presented in Appendix B.

3.3.6 Organic Content

The organic matter content test was carried out on eight (8) shallow samples from the fill layer and within the upper 0.6 m of boreholes. The results of these tests are summarized in the table below.

Borehole Number	MW1	MW2	MW3	MW5	BH6	BH12	BH13	BH14
Depth (mBGS)	0-0.6	0-0.6	0-0.6	0-0.6	0-0.6	0-0.6	0-0.6	0-0.6
Organic Matter by loss on ignition (%)	1.09	2.97	1.22	2.52	2.04	3.30	2.28	2.46

The organic content of the tested soil samples from the fill layer ranged between 1.09 and 3.30 percent by weight. The values are considered to be low and will not impact the reuse of this material as engineered fill or backfill in settlement sensitive areas provided it is free of deleterious materials.

The certificates of analysis associated with the soil samples organic content test results are provided in Appendix F.

3.4 Groundwater Conditions

As part of this geotechnical investigation, seven (7) shallow monitoring wells (MW1 to MW5, MW9 and MW10) were installed in select completed boreholes. Additionally, three (3) deep monitoring wells were installed adjacent to the shallow monitoring wells (MW2, MW3, and MW4). All boreholes appeared to be dry upon completion to their respective limits of investigation. The groundwater depths/elevations were measured on several occasions. A summary of the groundwater level measurements collected within the monitoring wells are presented in Table 1, and on the borehole logs provided in Appendix A. The depth to the groundwater table at this Site ranged between 1.4 to 5.0 mBGS and the elevation of the groundwater table varied between 77.2 and 78.8 m.

In the long term, seasonal fluctuations of the groundwater level should be expected. Perched water table condition could develop in the fill after heavy precipitation and/or during spring thaw.

4. Engineering Discussion and Assessment

4.1 General Geotechnical Evaluation

It is understood that the development will consist of constructing the proposed 1Door4Care building in the southwestern portion of the CHEO’s Campus. The Site is currently developed with parking lot and landscaped areas. The preliminary development concept for the 1Door4Care building includes a six-storey building with one level of underground basement. The surrounding area of the building footprint may include parking, internal road network and underground utilities. Further details of the proposed development activities at the Site are unknown to GHD and specific information with regard to founding depths below the ground surface, and footing/slab loading conditions were not available at the time of preparation of this report.

One level of underground basement is anticipated for the proposed building. This would result in the foundation subgrade being approximately 3.0 metres below existing grade. Based on the borehole data, the founding subgrade for the building at this depth will generally consist of dense silty sand or completely weathered shale bedrock. The proposed building can be supported on conventional spread and strip footings placed within the native silty sand or weathered shale bedrock. It is recommended that the building foundations be extended to the shale bedrock in order to avoid supporting the building foundations on two different types of materials (i.e. soil and bedrock) which could consequently result in excessive differential settlement. Raft (Mat) foundation may also be considered a feasible foundation option for this project, depending on the structural loads and the tolerable settlement. Depending on the structural loads, deep foundations such as cast-in-place concrete piles (caissons) socketed into the sound bedrock could be considered for supporting large structural loads due to the high load carrying capacity of the bedrock. For preliminary design purposes, recommendations are provided for spread and strip footings, raft foundation and cast-in-place concrete piles (caissons) to support the proposed structures. Please refer to Section 4.3 for more details.

Swelling of the Georgian Bay shale bedrock is well documented and should be expected during and after construction. Therefore, any structures such as foundation walls and slabs that will be placed directly on the shale bedrock, should be designed for the full loads imparted by the swelling of the shale over the design life of the structures. The design for the foundation walls and slabs should incorporate measures to accommodate swelling such as a sufficient delay period and/or after excavation placement of a compressible material in order to mitigate the impact of the expected deformations. If the construction schedule permits, the construction of foundation walls and slabs that will be in direct contact with the shale bedrock could be delayed to allow the majority of the rock swell to occur (typically four to six months between excavation and installation of the foundations wall or slabs).

The amount of seepage into excavations will depend on the depth of excavation relative to the groundwater level at the time of construction and the hydraulic conductivity of the excavated soils/bedrock. The measured groundwater levels within the installed monitoring wells were found to range from approximately 1.4 to 5.0 mBGS. It is expected that seepage rate into the excavation within the native silty sand deposits will be moderate to high. If the excavation is to be above the groundwater table, minor to moderate groundwater ingress can readily be handled by using installation of sumps and pumps at strategic locations at the base of excavation. If the excavation is to be extended to a greater depth and below local groundwater table, an active pre-construction dewatering system such as well points may be required depending on the depth and size of excavations. Please refer to the Hydrogeological Assessment Report prepared by GHD for this project under separate cover.

The possible presence of cobbles and boulders at this Site and their impact on the excavation should be clearly stated in the contract documents.

Footings subject to frost action should have a minimum soil cover of at least 1.8 m according to OPSD 3090.101 for Southern Ontario, or be protected using equivalent insulation.

The following sections provide additional comments and recommendations on the above topics as well as other geotechnical related design and construction issues.

4.2 Site Preparation and Grading

The ground cover and fill/disturbed materials at this Site extended to depths varying between approximately 0.4 and 1.7 mBGS. The fill/disturbed materials generally have low shear strength and observed to contain rootlets, wood pieces, and asphalt fragments. Also, the upper portion of the fill was observed to be in a frozen state.

The ground cover and any earth fill materials found to contain significant amounts of organics or deleterious materials should be removed prior to site grading activities and should not be used as backfill in settlement sensitive areas. The subgrade exposed after the removal of the unsuitable fill material will consist generally of native silty sand soils. The subgrade soils should be visually inspected, compacted if required, and proof rolled using heavy equipment. Any soft, or unacceptable areas should be sub-excavated, removed as directed by the Geotechnical Engineer and replaced with suitable clean earth fill materials or imported granular materials placed in thin layers (150 mm thick or less) and compacted to a minimum of 98 percent Standard Proctor Maximum Dry Density (SPMDD).

The clean earth fill/disturbed soils and native soils encountered at the Site may be suitable for reuse as backfill to raise site grades (where required) or to be used as backfill against foundations or as trench backfill during installation of buried services, provided the material is free of deleterious materials and is within the optimum moisture content. Based on the standard proctor testing results, the fill soils are generally near their optimum water content for compaction. If the fill and native soils are to be reused as structural fill, it should be anticipated that reworking of the soils will be necessary to facilitate compaction through drying or slight wetting, and use of sheep's-foot roller compactors. It is believed that any bedrock generated during excavation may not be suitable for reuse as a backfill, because of the difficulties associated with breaking the rock fragments down, moisture conditioning and compaction.

Installation of engineered fill, where required, must be continuously monitored on a full-time basis by qualified geotechnical personnel.

4.3 Foundations

Structural foundation at the Site can consist of conventional spread/strip footings or mat foundation founded on native soils or weathered shale bedrock or deep foundations supported on sound bedrock. The common practice for the Serviceability Limit State (SLS) design of most structure and building foundations is to limit the total and differential foundation settlements to 25 mm and 15 mm, respectively. Other serviceability criteria for the proposed building may be determined by the structural engineer considering tolerable settlement that would not restrict the use or operation of the facilities.

The foundation design options are presented in more detail below:

4.3.1 Conventional Spread/Strip Footings

One level of underground parking is anticipated for the proposed building. This would result in the foundation subgrade being approximately 3.0 metres below existing grade. Based on the boreholes data, the founding subgrade for the building at this depth will generally consist of dense silty sand or weathered shale bedrock. It is recommended that the building foundations be extended to the shale bedrock in order to avoid supporting the building foundations on two different types of materials (i.e. soil and bedrock) which could consequently result in excessive differential settlement. For the purpose of preliminary design, spread and strip foundations placed on the weathered shale bedrock at depths between 0.9 and 3.8 mBGS can be designed for a factored geotechnical resistance at Ultimate Limit State (ULS) of 800 kPa, and a geotechnical reaction at Serviceability Limit State (SLS) of 600 kPa. The recommended bearing capacity is for footing dimension of less than 3.0 metres and subject to an engineering inspection and approval by qualified geotechnical engineer for all bearing surfaces. If larger footing dimensions are required, the geotechnical engineer should be consulted.

Footings subject to frost action should have a minimum soil cover of at least 1.8 m according to OPSD 3090.101 for Southern Ontario, or equivalent insulation.

During construction, the foundation subgrade should be protected from inclement weather, excessive drying, and ingress of free water.

The contractor should be prepared to deal with cobbles and boulders that may exist within the overburden during construction.

4.3.2 Raft (Mat) Foundation

A raft/mat foundation (concrete pad/structural slab) can be considered to support the proposed structure with attention to the following recommendations. The structural slab (mat/raft) should be extended to minimum depths between 0.9 and 3.8 mBGS to be placed within the weathered shale bedrock.

For the design of a raft foundation placed on weathered shale bedrock, the modulus of vertical subgrade reaction can be taken as k_v = 80 MPa/m for a 0.3 m x 0.3 m square plate. For the design of a rectangular mat foundation of width “b” (m), the modulus of subgrade reaction (k_{vb}) can be calculated using the following equation:

$$K_{vb} = k_v/b\ [(m + 0.15)/1.5m]$$

where;

k_{vb}= modulus of subgrade reaction for actual footing dimension b
k_v= modulus of subgrade reaction (for a 0.3m x 0.3m square plate)
b= width of the raft (m)
L= length of raft (m)
m= L/b

The modulus of subgrade reaction will be used by the structural engineers to model the deformation and stiffness response of the raft on soil to assess the suitability of this foundation option.

The exposed foundation grade on which the proposed mat will be supported should be inspected and approved by a geotechnical engineer prior to the construction of the foundations.

4.3.3 Deep Foundation

As an alternative foundation option, the proposed building can be supported on deep foundations (cast-in-place concrete caissons) that transfer the foundation loads to the sound bedrock. The caissons should be socketed at least 0.3 m into the sound bedrock. The bedrock was cored at three borehole locations (MW3, MW4, and MW5) within the proposed building footprint. Based on the data obtained from the cored boreholes, the estimated depth to sound bedrock at this Site is approximately 5.0 to 6.0 mBGS or between elevation of 75 and 76 m. For caissons socketed nominally (0.3 m) into sound bedrock, preliminary design may be based on an end-bearing factored axial geotechnical resistance at ULS of 4.0 Magapascal (MPa). SLS resistances do not apply, since the SLS resistance for 25 mm of settlement is greater than the factored axial geotechnical resistance at ULS.

It should be noted that the base of any caisson excavations must be cleaned of loose rock or soil debris prior to concreting.

Temporary casing will be required when drilling through the wet overburden (wet sandy soils) to prevent sloughing and groundwater infiltration. The Contractor should determine the appropriate groundwater control measures in accordance with their equipment and methods to facilitate the caisson installations.

The caisson installation should be carried out under full time inspection by GHD from the ground surface, to verify that a competent bearing surface has been established at each caisson unit. The bearing surface of each caisson should be evaluated by visual examination of the auger cuttings during auguring, particularly at the caisson base, observation of the progress of drilling operations and comparison of the observations and depth/elevation of each caisson with the information presented on the borehole reports.

All pile caps and other structure foundations should be provided with a minimum of 1.8 m of soil cover for frost protection.

The deep foundations should be constructed in accordance with OPSS 903.

4.4 Time Dependent Rock Deformation

Rock deformation around any excavation extending into the bedrock will occur as both an initial elastic relaxation and as a time dependent deformation. Typically, the initial elastic movement will begin to occur immediately upon excavation. The time dependent deformation is composed of two phenomena (creep/stress relaxation and swelling).

Creep/stress relaxation will start to occur as soon as the stresses are relaxed around the excavation and continue over time. The swelling potential is highly variable since it depends on the stress state within the rock mass, groundwater conditions, calcite content and rock composition.

Swelling of the Georgian Bay shale bedrock is well documented and should be expected during and after excavation/construction. In order to estimate the time dependent horizontal and vertical free swell rates, four (4) rock core samples were submitted to Western University for free swell test. Based on the data from the laboratory testing, the underground basement slab and the foundation wall, and any structure in direct contact with the shale bedrock should be designed for horizontal free swell rates of approximately 0 to 0.05 % log cycle of time and vertical free swell rates of approximately 0.1 to 0.2 % log cycle of time.

If sufficient delays (typically four to six months) between excavation and the construction of foundation walls or slab on grade that will be in direct contact with shale bedrock are not possible, then the foundation walls and the slab on grade will need to be designed for the full loads imparted by the swelling of the shale over the design life of the structures or a compressible materials would need to be incorporated into the foundation walls and slab design. The results of the free swell tests will give an indication of the maximum swell rates in vertical and horizontal directions that can be used for the design.

4.5 Underground Basement Slab

The underground basement slab for the one level basement is expected to be founded at approximately 3.0 mBGS. The founding soils at this depth are expected to comprise of dense native silty sand and/or weathered shale bedrock. As mentioned above in Section 4.4, the bedrock at this site has a potential to swell which could consequently cause the slab to heave unevenly. Therefore, the slab should be designed as a structural slab (connected to the footings) to resist the full loads imparted by the swelling of the shale over the design life of the slab. Alternatively, the design for the slab should incorporate measures to accommodate swelling such as a sufficient delay period and/or placing compressible materials between the bedrock and granular base for the slab in order to mitigate the impact of the expected deformations.

A qualified geotechnical engineer should review the condition of the subgrade beneath the proposed underground parking slab at the time of construction.

The floor slab should be placed on a 200 mm thick layer of well-graded granular base material consisting of 19 mm clear stone or crusher run limestone (or equivalent). For the structural design of the concrete slab-on-grade, a combined modulus of subgrade / granular base reaction coefficient (k) of 25 MPa/m can be used.

Due to the anticipated relatively shallow groundwater table at this Site, a subfloor drainage system and waterproofing membrane will be required beneath the slab. Recommendations for subfloor drainage can be provided on review of building plans. The purpose of the subfloor drainage system is primarily to prevent a build-up of hydrostatic pressure below the floor slab so that the slab does not need to be designed to resist hydrostatic load. The drainage system must be designed to collect and dispose of groundwater at a rate sufficient to prevent build-up of hydrostatic pressure. The purpose of placing a waterproofing membrane below the slab is to minimize potential for seepage of groundwater through the slab and keep the underground basement dry. If a permanent subfloor drainage system is provided, then the slab does not need to be designed to resist hydrostatic pressure.

As an alternative to a permanent subfloor drainage system, the basement can be supported on raft (mat) foundation (structural slab) and designed as a water tight tank. This will eliminate the need to install and maintain the subfloor drains, but is otherwise likely to be more costly. This will also protect the slab from uneven heave that may occur as a result of bedrock swelling.

4.6 Foundation Wall

As mentioned above in Section 4.4, the bedrock at this site has a potential to swell which could consequently result in additional stresses on the foundation wall. Therefore, the portion of the wall extending into the bedrock should be designed to resist the full loads imparted by the swelling of the shale over the design life of the foundation wall. Alternatively, the design for the wall should incorporate measures to accommodate swelling such as a sufficient delay period and/or placing compressible materials between the bedrock and the wall in order to mitigate the impact of the expected deformations.

A perimeter wall drainage system will need to be installed for the proposed building, where a basement is to be constructed (below grade space), to collect groundwater from within the surficial earth fill and native soil layers. A perimeter drainage system consisting of Terrafix Terradrain™ 200, Mirafi Miradrain™ 5000, and/or similar products is recommended. A waterproofing membrane such as Mirafi Miradri™ and/or similar product compatible with the drainage system is also recommended. The perimeter drainage system should be provided with a collector pipe at the base of the foundation wall that drains to a sump pit and discharges to a positive outlet such as the municipal storm sewer. If a perimeter drainage system is provided, then the basement walls will not need to be designed to resist hydrostatic pressures.

The grade surrounding the foundation walls should be sloped (minimum of 3%) to minimize ponding of water on the ground surface and to provide positive drainage away from the foundation wall.

4.7 Lateral Earth Pressures

Structures subject to unbalanced earth pressures such as foundation walls, shoring systems, retaining walls and other similar structures should be designed to resist the lateral earth pressures. If required and depending on the type of shoring used during construction, the temporary shoring system for excavation support can be designed for the lateral earth pressures given in Sections 26.8, 26.9, and 26.10 of the Canadian Foundation Engineering Manual (CFEM) - 4th Edition. Surcharge loads and hydrostatic pressures should be considered as appropriate. The following table below summarizes the recommended soil parameters to be used for lateral earth pressure calculations at this Site:

Soil Type	Bulk Unit Weight	Effective Angle of Internal Friction (º)	Coefficient of Lateral Earth Pressure		
	γ (kN/m^3)	ϕ’	K_a	K_o	K_p
Fill / disturbed soil	18	25°	0.40	0.58	2.46
Silty Sand	20	30°	0.33	0.50	3.00
Bedrock	26	N/A	N/A	N/A	N/A

If movement sensitive services exist close to the shoring, the lateral pressure should be computed using the coefficient of earth pressure at rest, K_{0}.

4.8 Seismic Site Classification

The latest Ontario Building Code (OBC) requires the assignment of a Seismic Site Class for calculations of earthquake design forces and the structural design based on a two percent probability of exceedance in 50 years. According to the latest OBC, the Seismic Site Class is a function of soil profile, and is based on the average properties of the subsoil strata to a depth of 30 m below the ground surface. The OBC provides the following three methods to obtain the average properties for the top 30 m of the subsoil strata:

- Average shear wave velocity.
- Average Standard Penetration Test (SPT) values (uncorrected for overburden).
- Average undrained shear strength.

Based on the results of this investigation and MASW report provided in Appendix D, the Site can be classified as **Class 'B’** for seismic load calculations subjected to code requirements.

4.9 Pavement Design

The following provides recommendations for new pavement structure for the design of potential driveways and at grade parking areas, if required.

4.9.1 Subgrade Preparation

Earth fill was encountered at the ground surface or immediately beneath the ground cover (i.e. asphalt, topsoil) in all boreholes. The ground earth fill extended to depths between 0.4 and 1.7

mBGS. The removal of the existing fill to its full depth for pavement structure may not be necessary. The existing earth fill may be suitable to support pavements for the potential driveways and at grade parking areas provided the upper 0.5 m of the existing fill beneath the proposed subgrade levels are removed and grades raised to design levels using engineered fill. The excavated fill materials can be reused as engineered fill provided it is free of any deleterious materials.

It is recommended that any subgrade comprising of existing fill be inspected for obvious soft/loose areas and presence of deleterious materials. Should such areas be found, GHD can provide appropriate advice for replacement of the material and addressing local weak areas at that time.

Engineered fill to raise the grade can consist of select excavated fill provided it is free of any deleterious materials. The fill should be placed in large areas where it can be compacted by a heavy roller. Any fill placed to increase or level the grade must be compacted to a minimum 98 percent of its SPMDD in lifts not exceeding 150 mm. In-situ density testing to monitor the effectiveness of the compaction equipment in achieving the required densities is also recommended.

The most severe loading conditions on pavement areas and the subgrade may occur during construction. Consequently, special provisions such as end dumping and forward spreading of sub-base fills, restricted construction lanes, and half-loads during paving may be required, especially if construction is carried out during inclement weather conditions.

4.9.2 Recommended Pavement Structure

The following asphaltic concrete and granular pavement thickness may be used for the design of the potential driveways and at grade parking areas. The pavement designs include a Heavy Duty for driveways and a Light Duty for parking areas.

Pavement Layer	Compaction Requirements	Light Duty Pavement Design	Heavy Duty Pavement Design
Surface Course Asphaltic Concrete HL3 (OPSS 1150)	91% to 96.5% Maximum Relative Density (OPSS 310)	40 mm	40 mm
Base Course Asphaltic Concrete HL8 (OPSS 1150)	92% to 97.5% Maximum Relative Density (OPSS 310)	50 mm	60 mm
Base Course: Granular ‘A’ or 19mm Crusher Run (OPSS1010)	100% Standard Proctor Maximum Dry Density	150 mm	150 mm
Sub-base Course: Granular B or 50mm Crusher Run (OPSS1010)	98% Standard Proctor Maximum Dry Density	250 mm	350 mm

If pavement construction occurs in wet inclement weather it may be necessary to provide additional subgrade support for construction traffic by increasing the thickness of the granular sub-base.

4.9.3 Drainage

Grading adjacent to pavement areas should be designed so that water is not allowed to pond adjacent to the outside edges of the pavement. Also, the pavement subgrade should be free of depressions and sloped (preferably at a minimum grade of two percent) to provide effective drainage toward the edge of pavement and toward catchbasins. A subdrain should be placed in the up gradient direction of all catchbasins to allow for any water ponded on the subgrade surface to drain. The subdrain should be a 150 mm diameter perforated pipe, 3 m long, placed in a 0.3 m by 0.3 m trench notched into the subgrade, and backfilled with granular materials.

5. Construction Considerations

5.1 Excavation and Temporary Shoring

The Occupational Health and Safety Act (OHSA) regulations require that if workmen must enter an unsupported excavation deeper than 1.2 m, the excavation must be suitably sloped and/or braced in accordance with the OHSA requirements. OHSA specifies maximum slope of the excavations for four broad soil types as summarized in the following table:

Soil Type	Base of Slope	Maximum Slope Inclination
1	Within 1.2 m of bottom	1 horizontal to 1 vertical
2	Within 1.2 m of bottom of trench	1 horizontal to 1 vertical
3	From bottom of excavation	1 horizontal to 1 vertical
4	From bottom of excavation	3 horizontal to 1 vertical

Trench and basement excavations should be carried out in strict conformance to the current Occupational Health and Safety Act (OHSA). For the purpose of interpreting the act, the fill and native soils within the Site above the groundwater table can be classified as Type 3 soils. If affected by groundwater seepage, the fill and native soils can be considered as Type 4 soils. The highest number soil type identified in an excavation must govern the excavation slopes from top to bottom of the excavation.

If the above recommended excavation side slopes cannot be maintained due to lack of space or any other reason, the excavation side walls must be supported by an engineered shoring system. The shoring system should be designed in accordance with Canadian Engineering Foundation Manual (4th Edition) and the OHSA Regulations for Construction Projects.

If a shoring system is selected to support the excavation walls, it is recommended that the expertise of an experienced shoring contractor be retained during selection of a shoring approach. It is also recommended that the shoring system required to stabilize the excavation sidewalls during construction be developed by the general and shoring contractors. Further recommendations for shoring may be required depending on the type of shoring system selected for this project.

It is anticipated that shallow foundation and utility excavations within the overburden can be made with conventional equipment. Cobbles and boulders should be expected within the overburden, and the contract should allow for the removal of construction cobbles and boulders.

If the excavation extends to the underlying shale bedrock, the bedrock may be removed with a larger excavator equipped with a ‘V’ shaped bucket equipped with a ripper and/or hoe ram. Excavation into the bedrock can be carried out at or near vertical faces. The bedrock exposed in the excavation may degrade as it is exposed or if it becomes wet. As such, the bedrock may ravel over time if it is not protected. It recommended that exposed bedrock be protected (i.e. applying shotcrete) from weathering or deterioration if the excavation is to be left open for a long period of time. The selection of the excavation equipment to be used into the bedrock is the contractor's responsibility.

Blasting may not be permitted by the municipality and rock excavation may be carried out using mechanical equipment as stated above. However, blasting may be carried out in compliance with existing provincial environmental guideline limits with respect to ground and air vibration. The blasting operations should be carried out by an experienced contractor and ensuring that the ground and air vibration levels produced during blasting operations are within the recommended provincial guideline limits. The selection and implementation of this excavation option (blasting) is the contractor's responsibility. Vibration monitoring of the adjacent utilities and structures is recommended during excavation, if blasting option is selected.

5.2 Temporary Ground Water Control

The amount of seepage into excavations will depend on the depth of excavation relative to the groundwater level at the time of construction and the hydraulic conductivity of the excavated soils. The measured groundwater levels within the installed monitoring wells were found to range from approximately 1.4 to 5.0 mBGS. It is expected that seepage rate into the excavation within the native deposit (i.e. silty sand) will be moderate to high. If the excavation is to be above the groundwater table, minor to moderate groundwater ingress can readily be handled by using installation of sumps and pumps at strategic locations at the base of excavation. If the excavation is to be extended to a greater depth and below local groundwater table, an active pre-construction dewatering system such as well points may be required depending on the depth and size of excavations. It is noted that groundwater seepage into the excavation may be most pronounced near the interface between the overburden and the bedrock and through the upper fractured zone of the bedrock. Vertical excavations through the bedrock may require some kind of protection (i.e. shotcrete) to assure safety and stability of the walls that may also greatly reduce the rates of water seepage into the excavations. Please refer to the Hydrogeological Assessment Report prepared by GHD for this project under separate cover.

It is recommended that the groundwater level be maintained at least 0.5 m below the base of excavation to provide dry and stable/safe condition. A dewatering specialist should be consulted to determine the most appropriate measures to be undertaken to sufficiently lower the groundwater table below the lowest excavation depth. The possibility of settlement from the dewatering should be part of the methodology considerations. The contract document should indicate that the selection of dewatering measures is the sole responsibility of the contactor.

5.3 Suitability of On-Site Soils

The ground cover and any earth fill materials found to contain significant amounts of organics or deleterious materials should be removed and should not be used as backfill materials.

The earth fill/disturbed soils and native soils encountered at the Site may be suitable for reuse as backfill to raise site grades (where required) or to be used as backfill against foundations or as trench backfill during installation of buried services, provided the material is free of organic material or other deleterious materials and is within the optimum moisture content. Based on the standard proctor testing results, the fill soils are generally near their optimum water content for compaction.

Based on the organic test results, it should be expected that some of the fill materials at this site will contain variable amounts of organic matter. Topsoil and organic materials should not be used as a backfill but can be used for landscaping purposes or removed off-site. Also, all oversized cobbles and boulders should be removed from the backfill materials.

It should be anticipated that reworking of the soils will be necessary to facilitate compaction through drying, wetting and use of smooth roller compactors. Control of moisture content during placement and compaction will also be essential for maintaining adequate compaction. If any materials are found to be wet, they may be left aside to dry, or mixed with drier material that is to be used as backfill. All backfill materials should be placed in thin layers (150 mm thick or less) and compacted by a heavy smooth type roller to 98 percent SPMDD.

It is believed that the bedrock generated at the Site may not be reused as a backfill, because of the difficulties associated with breaking the rock fragments down, moisture conditioning and compaction.

All backfill operations and materials should be inspected and tested by qualified geotechnical personnel to confirm that proper material is utilized and that adequate compaction is attained.

5.4 Site Servicing

The native soils encountered at the Site are considered suitable to support proposed Site services. Consideration could also be given to installing Site services within the existing fill, subject to an engineering inspection and approval by qualified geotechnical engineer for all bearing surfaces. The suitability of the subgrade to provide adequate support for buried services must be verified and confirmed on site by qualified geotechnical personnel experienced in such works.

The subgrade soils used to support the service pipes, should be visually inspected. Wet, loose or otherwise unsuitable fills should be sub-excavated and replaced with bedding materials or clean fills compacted to minimum of 95% SPMDD.

The bedding for trenched (open cut) services should consist of well graded materials meeting City of Ottawa specifications. The bedding should have a minimum thickness of 150 mm below the pipe and 300 mm above and adjacent to the pipe and should comply with the City of Ottawa Standards. The bedding and cover materials should be compacted to a minimum of 95 percent SPMDD to provide support and protection to the service pipes.

Where wet conditions are encountered, the use of 'clear stone' bedding (such as 19 mm clear stone, OPSS 1004) may be considered, only in conjunction with a suitable geotextile filter. Without proper filtering, there may be entry of fines from the existing fill or native soils and trench backfill into the bedding. This loss of fine soil particles could result in loss of support to the pipes and possible surface settlements.

5.5 Soil Corrosivity Potential

Corrosivity testing was conducted on eleven (11) select samples extracted from boreholes MW1, MW2, MW3, MW4, MW4, MW5, BH6, BH7, BH8, MW9, and BH12 in accordance with ASTM and CSA Standards. The results were compared with CSA A23.1 Standards to determine the potential of sulphate attack on concrete and with the American Water Works Association (AWWA) C105 to assess soil corrosivity potential of ductile iron pipes and fittings. Corrosivity testing as described by the American Water Works Association (AWWA) includes soil resistivity, pH, sulphide indication, redox potential, and moisture content. Points are assigned to the sample based on the results of the test. A soil that has a total point score of 10 or more is considered to be potentially corrosive to ductile iron pipe. The potential for sulphate attack on concrete (class of exposure) is determined using Table 3 provided in CSA A23.1. All samples were placed into laboratory-supplied containers, labeled and submitted under chain-of-custody protocol to AGAT. Analytical results received from the laboratory are provided in Appendix F.

The following table summarizes the laboratory test results for the eleven (11) soil samples collected from the boreholes to assess soil potential for sulphate attack on concrete structures:

Borehole No.	Sample Depth (m)	Sulphate (%)	Class of Exposure (Ref. Table 3 of CSA A23.1)	Potential for Sulphate Attack (Ref. Table 3 of CSA A23.1)	Cementing Materials to be used (Ref. Table 3 of CSA A23.1)
MW1	0.8 - 2.1	0.02	Below S-3	Negligible	Not specified
MW1	3.8 – 4.4	0.1	S-3	Moderate	MS or HS
MW2	2.3 – 2.9	0.013	Below S-3	Negligible	Not specified
MW3	2.3 -2.9	0.0286	Below S-3	Negligible	Not specified
MW4	0.8 – 1.4	0.0096	Below S-3	Negligible	Not specified
MW5	2.3 – 2.6	0.0337	Below S-3	Negligible	Not specified
BH6	0.8 – 1.6	0.0272	Below S-3	Negligible	Not specified
BH7	1.5 – 1.7	0.0365	Below S-3	Negligible	Not specified
BH8	1.5 – 1.7	0.0225	Below S-3	Negligible	Not specified
MW9	1.5 – 2.4	0.0124	Below S-3	Negligible	Not specified
BH12	1.5 – 2.4	0.0130	Below S-3	Negligible	Not specified

In general, the results of sulphate ion content analysis indicate that the majority of the tested soil/rock samples contain low levels of sulphate ion, which are below the class of exposure levels outlined in CSA A23.1 with the exception of one sample (MW1) from the weathered shale bedrock. Based on the results, special cement mixtures such as moderate sulphate-resistant cement (MS) or high-sulphate cement (HS) will likely be required to provide protection against sulphate attack.

In regards to soil corrosivity potential against ductile iron pipes and fittings, it is noted that sulphide analysis presented in AWWA is a qualitative test where a positive, trace, or negative determination is based on the presence of bubbles as a result of a chemical reaction. Such testing has not been conducted as AGAT defines sulfides concentration that is unrelated to the scale provided by AWWA. As a result, it was assumed that the result was positive and a maximum score of 3.5 was selected (most conservative assumption). Also, for moisture content determination, the value obtained from the conducted laboratory tests were used for this analysis and soil poor drainage condition has been considered to obtain more conservative values. The table below summarizes the ANSI/AWWA rating of the tested soil/rock samples on their potential for corrosion towards buried ductile cast iron pipes/fittings. A score of ten (10) points or more indicates the soil is corrosive to ductile iron pipes and protection will be needed.

Borehole No.	Sample Depth (m)	Parameters				Total Points	Corrosivity Potential
		Resistivity (ohm/cm)	pH	Redox Potential (mV)	Moisture (%)		
MW1	0.8 - 2.1	2240	7.87	269	9	7.5	No
MW1	3.8 – 4.4	746	7.78	241	6	15.5	Yes
MW2	2.3 – 2.9	1310	7.78	223	30	15.5	Yes
MW3	2.3 -2.9	625	7.88	234	11	15.5	Yes
MW4	0.8 – 1.4	2170	8.29	179	15	7.5	No
MW5	2.3 – 2.6	649	9.21	173	5	18.5	Yes
BH6	0.8 – 1.6	855	8.54	180	6	18.5	Yes
BH7	1.5 – 1.7	1370	8.01	203	4	15.5	Yes
BH8	1.5 – 1.7	893	8.62	206	5	18.5	Yes
MW9	1.5 – 2.4	1750	7.95	205	9	16.5	Yes
BH12	1.5 – 2.4	709	8.81	212	11	18.5	Yes

Based on the results obtained for the samples submitted, the total points ranged from 7.5 to 18.5. These results indicate that special provisions will be required for corrosion protection of any metallic pipe components at this Site.

6. Limitations of the Investigation

This report is intended solely for Ontario Infrastructure and Lands Corporation and their designer and is prohibited for use by others without GHD’s prior written consent. This report is considered GHD’s professional work product and shall remain the sole property of GHD. Any unauthorized reuse, redistribution of or reliance on the report shall be at the Client and recipient’s sole risk, without liability to GHD. No portion of this report may be used as a separate entity; it is to be read in its entirety and shall include all supporting drawings and appendices.

The recommendations made in this report are in accordance with our present understanding of the project, the current site use, ground surface elevation and conditions, and are based on the work scope approved by the Client and described in the report. The services were performed in a manner consistent with that level of care and skill ordinarily exercised by members of geotechnical engineering professions currently practicing under similar conditions in the same locality. No other representations, and no warranties or representations of any kind, either expressed or implied, are made. 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.

All details of design and construction are rarely known at the time of completion of a geotechnical study. The recommendations and comments made in the study report are based on our subsurface investigation and resulting understanding of the project, as defined at the time of the study. We should be retained to review our recommendations when the drawings and specifications are complete. Without this review, GHD will not be liable for any misunderstanding of our recommendations or their application and adaptation into the final design.

By issuing this report, GHD is the geotechnical engineer of record. It is recommended that GHD be retained during construction of all foundations and during earthwork operations to confirm the conditions of the subsoil are actually similar to those observed during our study. The intent of this requirement is to verify that conditions encountered during construction are consistent with the findings in the report and that inherent knowledge developed as part of our study is correctly carried forward to the construction phases.

It is important to emphasize that a soil investigation is, in fact, a random sampling of a site and the comments included in this report are based on the results obtained at the test locations only. The subsurface conditions confirmed at the test locations may vary at other locations. The subsurface conditions can also be significantly modified by the construction activities on site (e.g., excavation, dewatering and drainage, blasting, pile driving, etc.). These conditions can also be modified by exposure of soils or bedrock to humidity, dry periods or frost. Soil and groundwater conditions between and beyond the test locations may differ both horizontally and vertically from those encountered at the test locations and conditions may become apparent during construction which could not be detected or anticipated at the time of our investigation. Should any conditions at the site be encountered which differ from those found at the test locations, we request that we be notified immediately in order to permit a reassessment of our recommendations. If changed conditions are identified during construction, no matter how minor, the recommendations in this report shall be considered invalid until sufficient review and written assessment of said conditions by GHD is completed.

All of Which is Respectfully Submitted,

GHD

Ahmed Sorour

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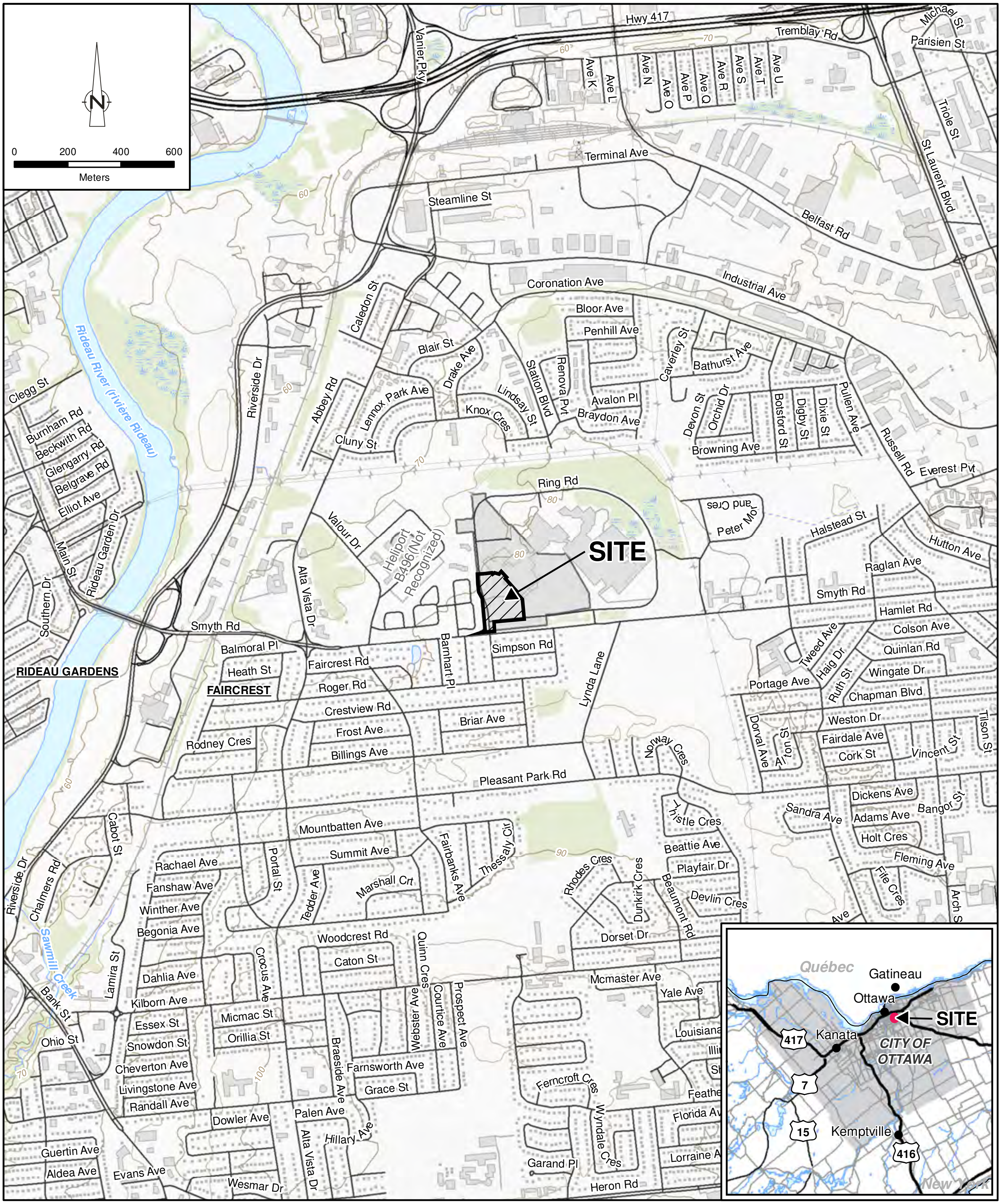
Karl Roechner, P. Eng.

Figures



Source: MNRF NRVIS, 2018. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2019

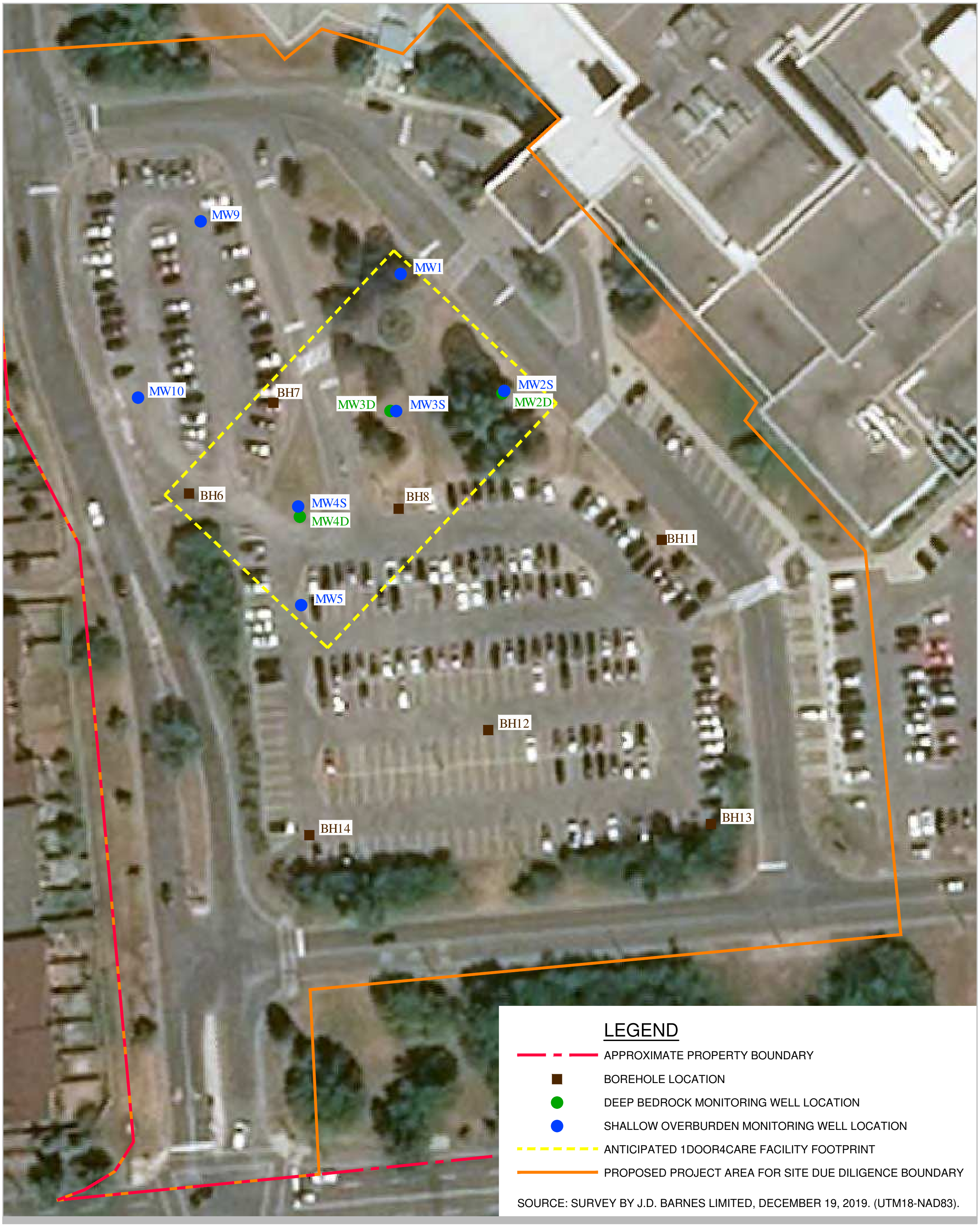
CHILDREN'S HOSPITAL OF EASTERN ONTARIO CAMPUS
401 & 407 SMYTH ROAD, OTTAWA, ONTARIO PHASE ONE
PROPOSED 1DOOR4CARE FACILITY

11205379-01
Nov 19, 2019

SITE LOCATION MAP

FIGURE 1

GIS File: Q:\GIS\PROJECTS\11205000s\11205379\Layouts\001\11205379-01(001)GIS-WA001.mxd



SOURCE: SURVEY BY J.D. BARNES LIMITED, DECEMBER 19, 2019. (UTM18-NAD83).

0 10 20 30m

Coordinate System:
UTM ZONE 18 NAD83
METRES

N

PROPOSED 1DOOR4CARE FACILITY
CHILDREN'S HOSPITAL OF
EASTERN ONTARIO CAMPUS
401 & 407 SMYTH ROAD, OTTAWA, ONTARIO

SITE PLAN AND
INVESTIGATIVE LOCATIONS

Project No. **11205379**
Date **January 2020**

FIGURE 2

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Plot Date: 23 January 2020 3:11 PM

Source: Microsoft Product Screen Shot(s) Reprinted with permission from Microsoft Corporation, Accessed: 2019

Tables

Table 1

Summary of Groundwater Level Measurements
Preliminary Geotechnical Investigation
Children’s Hospital of Eastern Ontario Campus
401 Smyth Road, Ottawa, Ontario

Well ID	Ground Elevation(1)	Top of Riser Elevation(1)	Groundwater Elevation December 5, 2019			Groundwater Elevation December 13, 2019			Groundwater Elevation January 15, 2020		
	(mBGS)	(mAMSL)	(mBTOR)	(mBGS)	(mAMSL)	(mBTOR)	(mBGS)	(mAMSL)	(mBTOR)	(mBGS)	(mAMSL)
Shallow Monitoring Wells											
MW1	82.53	82.40	4.91	5.04	77.49	4.93	5.05	77.48	4.88	5.01	77.52
MW2S	82.43	82.34	Dry	Dry	Dry	4.52	4.61	77.82	4.45	4.54	77.89
MW3S	81.58	81.53	3.71	3.75	77.82	3.78	3.82	77.75	3.67	3.71	77.86
MW4S	80.27	80.13	Dry	Dry	Dry	1.30	1.44	78.83	Ice	Ice	Ice
MW5	80.54	80.41	Dry	Dry	Dry	2.29	2.42	78.12	1.71	1.84	78.70
MW9	80.52	80.37	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
MW10	79.86	79.75	2.34	2.34	77.41	2.38	2.38	77.37	Blocked	Blocked	Blocked
Deep Monitoring Wells											
MW2D	82.43	82.33	4.87	4.98	77.46	4.89	5.00	77.44	4.84	4.95	77.49
MW3D	81.58	81.50	4.20	4.27	77.30	4.29	4.36	77.21	4.30	4.37	77.20
MW4D	80.34	80.20	2.95	3.09	77.25	2.98	3.12	77.22	Ice	Ice	Ice

Notes:

(1)

mAMSL	metres Above Mean Sea Level.
mBGS	metres Below Ground Surface.
mBTOR	metres Below Top of Riser.

Appendices

Appendix A
Record of Borehole Logs

REFERENCE No.: 11205379

ENCLOSURE No.: 1

BOREHOLE No.: **MW1**

ELEVATION: 82.53 m

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

DATE (START): 26 November 2019

DATE (FINISH): 26 November 2019

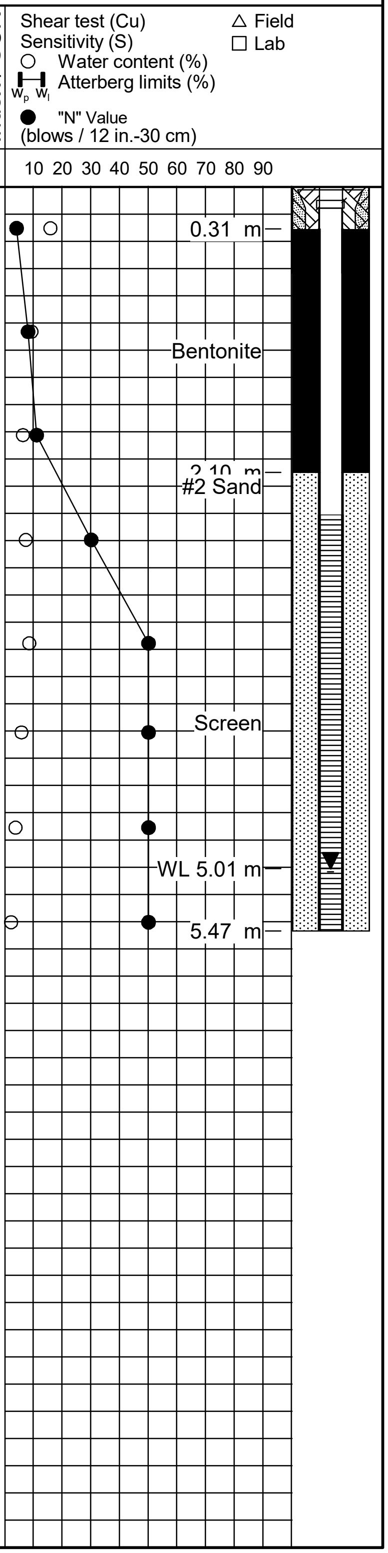
LEGEND

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- ◫ RC - ROCK CORE
- ▼ - WATER LEVEL

Depth (Metres)	Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery TCR (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR (N)
	82.53	GROUND SURFACE					
0.08	82.46	TOPSOIL : 75 mm					
		FILL : SILTY SAND, some gravel, asphalt fragments, wood pieces, brown, moist, loose cobble fragments	SS1	58	16	1-1-3-10	4
			SS2	50	9	4-4-4-6	8
1.52	81.01	NATIVE : SM-SILTY SAND with gravel, cobble fragments, grey, moist, compact Gravel : 26%, Sand : 58%, Silt : 11%, Clay : 5% cobble fragments	SS3	62	6	5-4-7-32	11
			SS4	67	7	22-16-14-11	30
		very dense	SS5	67	8	6-17-33-23	50
3.81	78.72	SHALE, completely weathered, grey	SS6	75	6	17-32-50/ 100mm	50+
			SS7	55	4	39-50/ 125mm	50+
			SS8	20	2	50/ 125mm	50+
5.47	77.06						

END OF BOREHOLE :

NOTE :
- End of Borehole at 5.47 m bgs
- Borehole was dry upon completion
- 50 mm diameter monitoring well installed at 5.47 m bgs
- Groundwater level measured at 5.04 m bgs on December 5, 2019
- Groundwater level measured at 5.05 m bgs on December 13, 2019
- Groundwater level measured at 5.01 m bgs on January 15, 2020
- bgs donates 'below ground surface'



REFERENCE No.: 11205379

ENCLOSURE No.: 2

BOREHOLE No.: MW2

ELEVATION: 82.43 m

BOREHOLE REPORT

Page: 1 of 2

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

DATE (START): 26 November 2019

DATE (FINISH): 27 November 2019

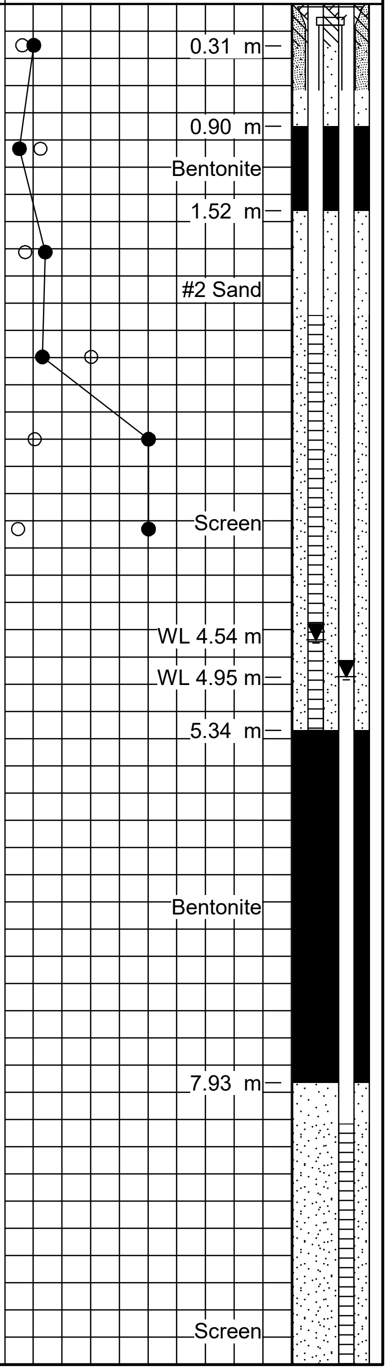
LEGEND

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- ◫ RC - ROCK CORE
- ▼ - WATER LEVEL

Depth (Metres)	Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK
	82.43	GROUND SURFACE
0.08	82.35	TOPSOIL : 75 mm
		FILL : SANDY SILT, some gravel, brown, moist, compact loose
1.52	80.91	NATIVE : SM-SILTY SAND with gravel, cobble fragments, brown, moist, compact Gravel : 32%, Sand : 48%, Silt : 13%, Clay : 7% clay pocket very dense
3.81	78.62	SHALE, completely weathered, grey Auger refusal
4.12	78.31	SHALE-BEDROCK, clay seams, laminated, interbeds of limestone/siltstone (hard layers), highly weathered to fresh, weak to moderately strong, grey

Type and Number	Recovery TCR (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR (N)
SS1	54	6	4-5-5-7	10
SS2	67	12	4-2-3-3	5
SS3	67	7	6-6-8-6	14
SS4	67	30	13-5-8-8	13
SS5	75	10	26-50/ 150mm	50+
SS6	17	5	50/ 100mm	50+
RC1	90	--	15	59
RC2	80	--	0	80
RC3	97	--	79	95
RC4	98	--	98	98
RC5	99	--	99	99

Shear test (Cu) △ Field
Sensitivity (S) ☐ Lab
○ Water content (%)
W_p W_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)



SOIL LOG WITH GRAPH+WELL 11205379 - REVISED.GPJ INSPEC_SOL.GDT 17/1/20

REFERENCE No.: 11205379 ENCLOSURE No.: 2

BOREHOLE No.: **MW2**
ELEVATION: 82.43 m

BOREHOLE REPORT

Page: 2 of 2

CLIENT: Infrastructure Ontario (I.O.)
PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus
LOCATION: 401 Smyth Road, Ottawa, Ontario
DESCRIBED BY: R. V. Tillaart CHECKED BY: A. Sorour
DATE (START): 26 November 2019 DATE (FINISH): 27 November 2019

LEGEND

☒	SS	- SPLIT SPOON
▨	ST	- SHELBY TUBE
◫	RC	- ROCK CORE
▼		- WATER LEVEL

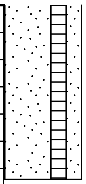
Shear test (Cu) △ Field
Sensitivity (S) ☐ Lab
○ Water content (%)
W_p W_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)

Depth Feet	Depth Metres	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR
		82.43		GROUND SURFACE			%			N
33–37	11.28	71.15				RC6	95	--	88	88

Feet: 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65

Metres: 11.0 11.28 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0

10 20 30 40 50 60 70 80 90



END OF BOREHOLE :

NOTE :

- End of Borehole at 11.28 m bgs
- Borehole was dry upon completion
- Rock coring from 4.12 m bgs
- 50 mm diameter shallow and deep monitoring wells installed at 5.34 m and 11.28 m bgs respectively

Shallow Monitoring Well

- Borehole was dry on December 5, 2019
- Groundwater level measured at 4.61 m bgs on December 13, 2019
- Groundwater level measured at 4.54 m bgs on January 15, 2020

Deep Monitoring Well

- Groundwater level measured at 4.98 m bgs on December 5, 2019
- Groundwater level measured at 5.00 m bgs on December 13, 2019
- Groundwater level measured at 4.95 m bgs on January 15, 2020
- bgs donates 'below ground surface'
- shallow and deep monitoring wells installed in separate holes adjacent to each other
- No methane gas was detected during drilling/coring

REFERENCE No.: 11205379

ENCLOSURE No.: 3

BOREHOLE No.: MW3

ELEVATION: 81.58 m

BOREHOLE REPORT

Page: 1 of 2

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

DATE (START): 28 November 2019

DATE (FINISH): 29 November 2019

LEGEND

☒ SS - SPLIT SPOON

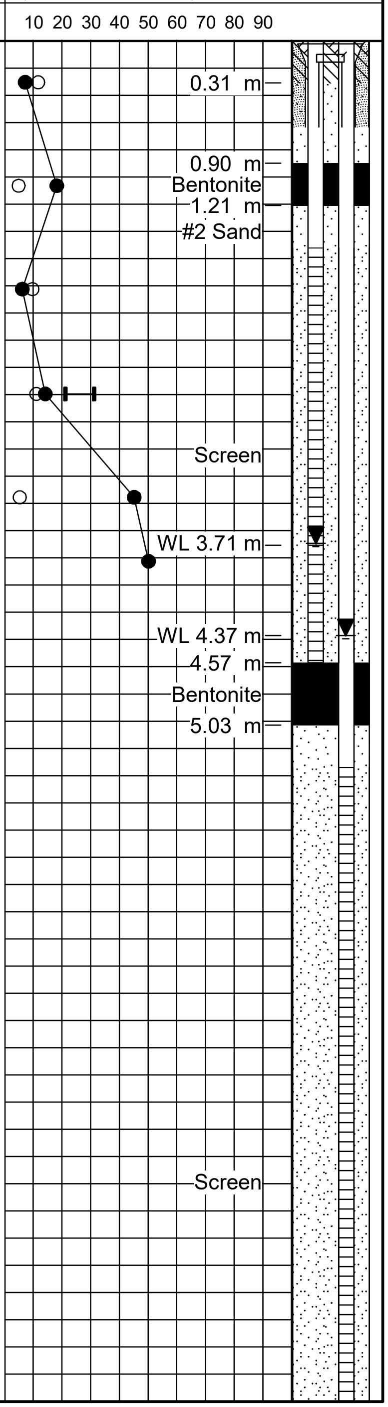
▨ ST - SHELBY TUBE

◨ RC - ROCK CORE

▼ - WATER LEVEL

Depth (Metres)	Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery TCR	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR
	81.58	GROUND SURFACE		%			N
0.10	81.48	TOPSOIL : 100 mm					
		FILL : SANDY SILT, trace gravel, trace rootlets, wood pieces, grey/brown, frozen, loose	SS1	50	12	5-3-4-4	7
0.76	80.82	SAND and GRAVEL, brown, moist, compact Gravel : 43%, Sand : 52%, Clay & Silt (Fines) : 5%	SS2	46	5	5-9-9-5	18
1.70	79.88	NATIVE : SM-SILTY SAND with gravel, cobble fragments, brown/grey, moist, loose to compact Gravel : 16%, Sand : 59%, Silt : 17%, Clay : 8%	SS3	50	10	3-2-4-4	6
			SS4	42	11	5-5-9-14	14
3.05	78.53	SHALE, completely weathered, grey	SS5	33	5	14-17-28-20	45
		no recovery	SS6	0	--	50/ 25mm	50+
4.11	77.47	SHALE-BEDROCK, laminated, interbeds of limestone/siltstone (hard layers), highly weathered to fresh, weak to moderately strong, grey	RC1	80	--	71	74
			RC2	99	--	86	99
			RC3	100	--	96	99
			RC4	100	--	100	100

Shear test (Cu)
Sensitivity (S)
○ Water content (%)
W_p W_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)
△ Field
☐ Lab



REFERENCE No.: 11205379

ENCLOSURE No.: 3

BOREHOLE No.: **MW3**

ELEVATION: 81.58 m

BOREHOLE REPORT

Page: 2 of 2

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

DATE (START): 28 November 2019

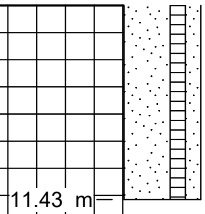
DATE (FINISH): 29 November 2019

LEGEND

☒	SS	- SPLIT SPOON
▨	ST	- SHELBY TUBE
◫	RC	- ROCK CORE
▼		- WATER LEVEL

Shear test (Cu) △ Field
Sensitivity (S) ☐ Lab
○ Water content (%)
W_p W_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)

Depth Feet	Depth Metres	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR %	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR N	10 20 30 40 50 60 70 80 90
		81.58		GROUND SURFACE							
33			▨		◫						
34			▨		◫						
35			▨		◫	RC5	100	--	86	89	
36	11.0		▨		◫						
37			▨		◫						
	11.43	70.15									
38				**END OF BOREHOLE :**							
39	12.0										
40											
41											
42											
43	13.0										
44											
45											
46	14.0										
47											
48											
49	15.0										
50											
51											
52	16.0										
53											
54											
55											
56	17.0										
57											
58											
59	18.0										
60											
61											
62	19.0										
63											
64											
65											



NOTE :

- End of Borehole at 11.43 m bgs
- Borehole was dry upon completion
- Rock coring from 4.11 m bgs
- 50 mm diameter shallow and deep monitoring wells installed at 4.57 m and 11.43 m bgs respectively

Shallow Monitoring Well

- Groundwater level measured at 3.75 m bgs on December 5, 2019
- Groundwater level measured at 3.82 m bgs on December 13, 2019
- Groundwater level measured at 3.71 m bgs on January 15, 2020

Deep Monitoring Well

- Groundwater level measured at 4.98 m bgs on December 5, 2019
- Groundwater level measured at 5.00 m bgs on December 13, 2019
- Groundwater level measured at 4.95 m bgs on January 15, 2020
- bgs donates 'below ground surface'
- shallow and deep monitoring wells installed in separate holes adjacent to each other
- No methane gas was detected during drilling/coring

REFERENCE No.: 11205379 ENCLOSURE No.: 4

BOREHOLE No.: **MW4**

ELEVATION: 80.34 m

BOREHOLE REPORT

Page: 1 of 2

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart CHECKED BY: A. Sorour

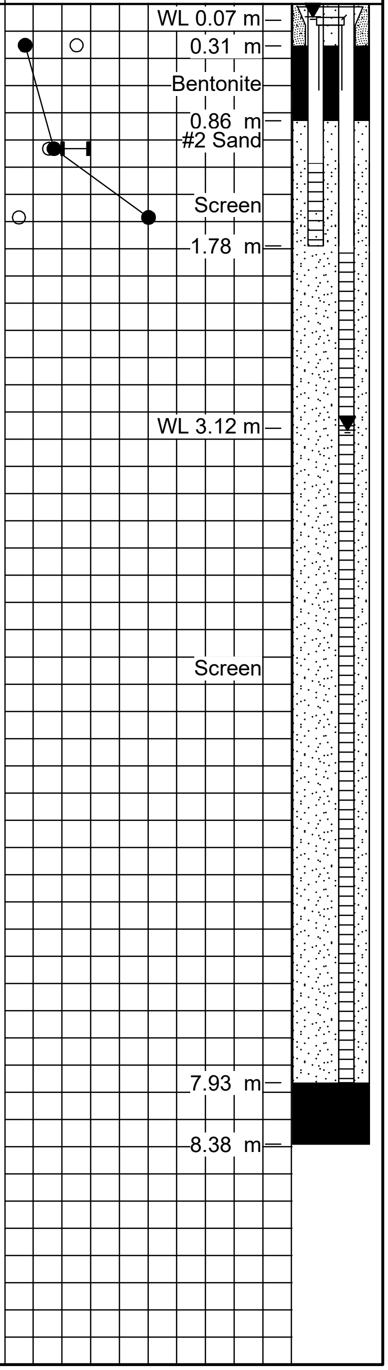
DATE (START): 2 December 2019 DATE (FINISH): 3 December 2019

LEGEND

☒	SS	- SPLIT SPOON
▨	ST	- SHELBY TUBE
◫	RC	- ROCK CORE
▼		- WATER LEVEL

Shear test (Cu) △ Field
Sensitivity (S) ☐ Lab
○ Water content (%)
w_p w_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)

Depth (Metres)	Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery TCR (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR (N)
	80.34	GROUND SURFACE					
0.08	80.26	TOPSOIL : 75 mm					
		FILL : SILTY CLAY, trace sand and gravel, brown, frozen, firm, moist	SS1	50	25	4-3-4-4	7
0.76	79.58	NATIVE : SM-SILTY SAND, some clay and gravel, brown, moist, compact Gravel : 11%, Sand : 59%, SIlt : 20%, Clay : 10%	SS2	58	15	4-7-10-25	17
1.52	78.82	SHALE, completely weathered, grey	SS3	100	5	50/ 100mm	50+
		auger refusal					
2.69	77.65	SHALE-BEDROCK, laminated, interbeds of limestone/siltstone (hard layers), highly weathered to fresh, weak to moderately strong, grey	RC1	88	--	39	85
			RC2	100	--	78	100
			RC3	99	--	83	99
			RC4	100	--	100	100
8.38	71.96						



END OF BOREHOLE :

NOTE :

- End of Borehole at 8.38 m bgs
- Borehole was dry upon completion
- Rock coring from 2.69 m bgs
- 50 mm diameter shallow and deep monitoring wells installed at 1.78 m and

REFERENCE No.: 11205379

ENCLOSURE No.: 4

BOREHOLE No.: **MW4**

ELEVATION: 80.34 m

BOREHOLE REPORT

Page: 2 of 2

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

DATE (START): 2 December 2019

DATE (FINISH): 3 December 2019

LEGEND

☒	SS	- SPLIT SPOON
▨	ST	- SHELBY TUBE
◨	RC	- ROCK CORE
▼		- WATER LEVEL

Depth		Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR	Shear test (Cu) △ Field Sensitivity (S) ☐ Lab ○ Water content (%) w_p ├─┤ w_l Atterberg limits (%) ● "N" Value (blows / 12 in.-30 cm)
Feet	Metres	80.34		GROUND SURFACE			%			N	10 20 30 40 50 60 70 80 90
33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65	11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0			- 7.93 m bgs respectively **Shallow Monitoring Well** - Borehole was dry on December 5, 2019 - Groundwater level measured at 0.07 m bgs on December 13, 2019 **Deep Monitoring Well** - Groundwater level measured at 3.09 m bgs on December 5, 2019 - Groundwater level measured at 3.12 m bgs on December 13, 2019 - bgs donates 'below ground surface' - shallow and deep monitoring wells installed in separate holes adjacent to each other - No methane gas was detected during drilling/coring							

REFERENCE No.: 11205379

ENCLOSURE No.: 5

BOREHOLE No.: **MW5**

ELEVATION: 80.54 m

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

DATE (START): 4 December 2019

DATE (FINISH): 4 December 2019

LEGEND

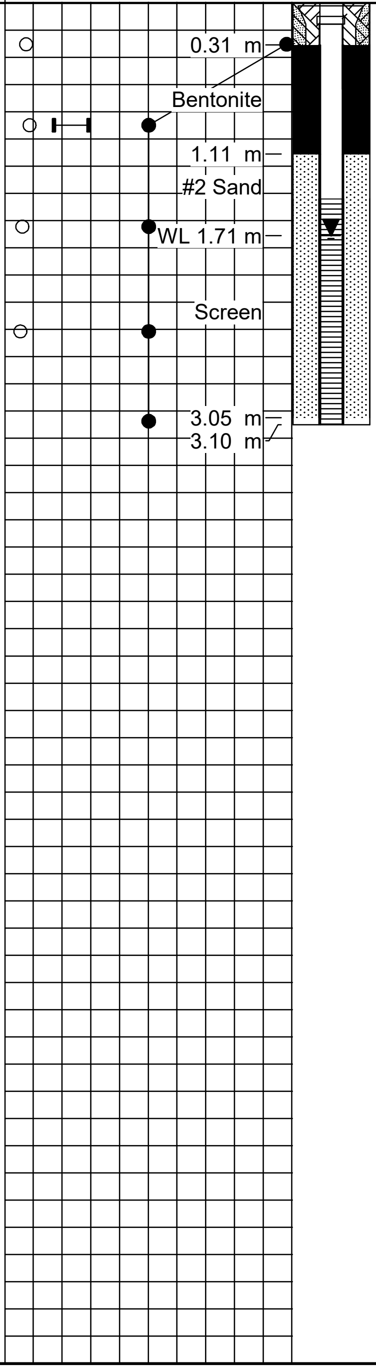
- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- ◫ RC - ROCK CORE
- ▼ - WATER LEVEL

Shear test (Cu) △ Field
Sensitivity (S) ☐ Lab
○ Water content (%)
w_p w_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)

Depth (Metres)	Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery TCR (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR (N)
	80.54	GROUND SURFACE					
0.05	80.49	ASPHALT : 50 mm					
		FILL : SAND and GRAVEL, grey/brown, frozen, very dense	SS1	67	7	65-85-13-16	98
0.91	79.63	NATIVE : SM-SILTY SAND, grey/brown, moist, very dense Gravel : 8%, Sand : 62%, Silt : 20%, Clay : 10%	SS2	46	9	16-50/ 125mm	50+
1.70	78.84	SHALE, completely weathered, grey	SS3	41	6	25-50/ 100mm	50+
			SS4	40	5	9-50/ 100mm	50+
		no recovery	SS5	0	--	50/ 50mm	50+
3.10	77.44	**END OF BOREHOLE :**					

Depth scale: Feet 1–32; Metres 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0

NOTE :
- End of Borehole at 3.10 m bgs
- Borehole was dry upon completion
- 50 mm diameter monitoring well installed at 3.05 m bgs
- Borehole was dry on December 5, 2019
- Groundwater level measured at 2.29 m bgs on December 13, 2019
- Groundwater level measured at 1.71 m bgs on January 15, 2020
- bgs donates 'below ground surface'



REFERENCE No.: 11205379

ENCLOSURE No.: 6

BOREHOLE No.: BH6

ELEVATION: 80.04 m

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

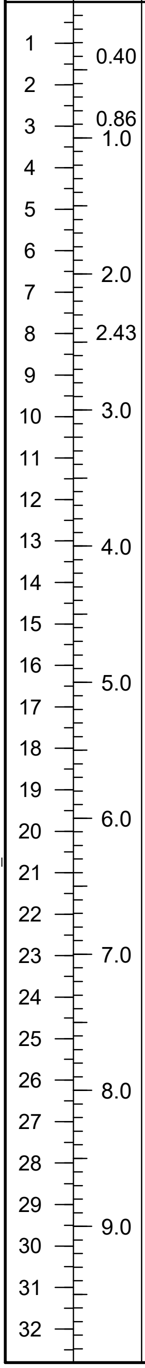
DATE (START): 2 December 2019

DATE (FINISH): 2 December 2019

LEGEND

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- ◧ RC - ROCK CORE
- ▼ - WATER LEVEL

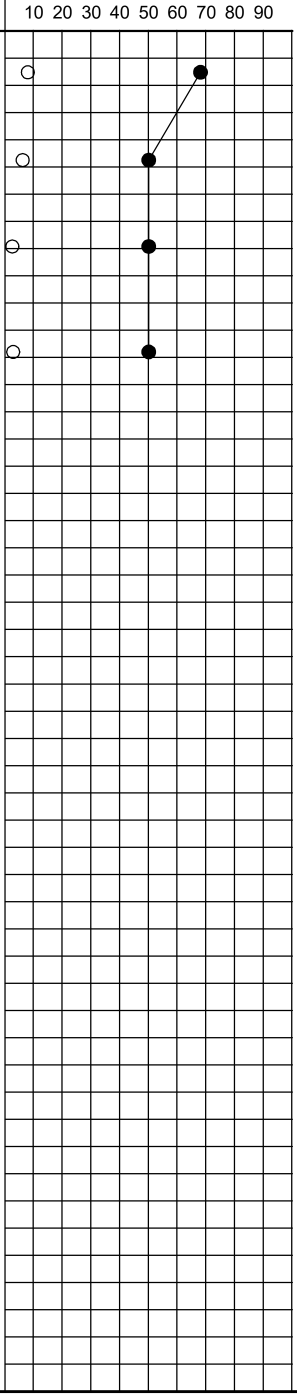
Depth (Metres)	Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR (N)
	80.04	GROUND SURFACE						
0.40	79.64	FILL : SAND and GRAVEL, grey, frozen, very dense	☒	SS1	75	8	49-50-18-6	68
0.86	79.18	NATIVE : SM-SILTY SAND, some clay, grey/brown, moist, very dense	☒	SS2	50	6	12-46-50/ 75mm	50+
		SHALE, completely weathered, grey	☒	SS3	20	3	50/ 125mm	50+
2.43	77.61		☒	SS4	20	3	50/ 125mm	50+



END OF BOREHOLE :

NOTE :
- End of Borehole at 2.43 m bgs
- Borehole was dry upon completion
- bgs donates 'below ground surface'

Shear test (Cu) △ Field
Sensitivity (S) ☐ Lab
○ Water content (%)
⊢⊣ Atterberg limits (%) w_p w_l
● "N" Value (blows / 12 in.-30 cm)



REFERENCE No.: 11205379

ENCLOSURE No.: 7

BOREHOLE No.: **BH7**

ELEVATION: 80.40 m

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

DATE (START): 29 November 2019

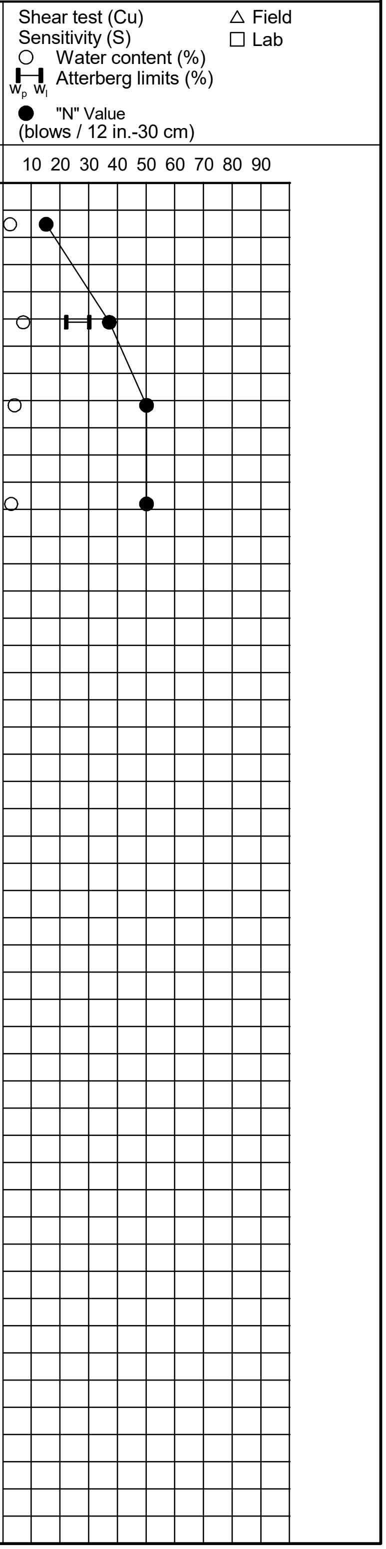
DATE (FINISH): 29 November 2019

LEGEND

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- ▯ RC - ROCK CORE
- ▼ - WATER LEVEL

Depth (Metres)	Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR (N)
	80.40	GROUND SURFACE						
		FILL : SAND and GRAVEL, cobble fragments, grey, moist, compact	☒	SS1	58	2	5-7-8-5	15
0.76	79.64	NATIVE : SM-SILTY SAND, some clay, grey/brown, moist, dense Gravel : 3%, Sand : 54%, Silt : 30%, Clay : 13%	☒	SS2	55	7	4-15-22-50/ 75mm	37
1.52	78.88	SHALE, completely weathered, grey	☒	SS3	46	4	38-50/ 125mm	50+
			☒	SS4	21	3	50/ 125mm	50+
2.43	77.97	**END OF BOREHOLE :**						

NOTE :
- End of Borehole at 2.43 m bgs
- Borehole was dry upon completion
- bgs donates 'below ground surface'



SOIL LOG WITH GRAPH+WELL 11205379 - REVISED.GPJ INSPEC_SOL.GDT 17/1/20

REFERENCE No.: 11205379

ENCLOSURE No.: 8

BOREHOLE No.: BH8

ELEVATION: 80.82 m

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

DATE (START): 2 December 2019

DATE (FINISH): 2 December 2019

LEGEND

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- ◫ RC - ROCK CORE
- ▼ - WATER LEVEL

Depth Feet	Depth Metres	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR %	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR N
		80.82		GROUND SURFACE						
1			☒	FILL : SAND with gravel, trace organics, grey, moist, compact	☒	SS1	50	9	6-4-5-6	9
3	0.76	80.06		NATIVE : SM-SILTY SAND, grey/brown, moist, compact Gravel : 8%, Sand : 59%, Silt : 22%, Clay : 11%	☒	SS2	75	10	2-5-6-45	11
5	1.52	79.30		SHALE, completely weathered, grey	☒	SS3	41	5	40-50/ 100mm	50+
8					☒	SS4	12	2	50/ 75mm	50+
10	3.13	77.69			☒	SS5	12	5	50/ 75mm	50+

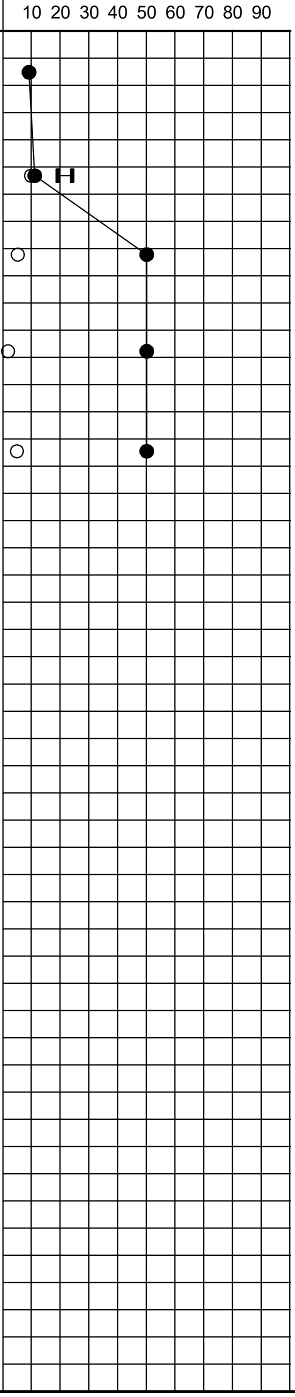
Feet: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

Metres: 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0

END OF BOREHOLE :

NOTE :
- End of Borehole at 3.13 m bgs
- Borehole was dry upon completion
- bgs donates 'below ground surface'

Shear test (Cu) △ Field
Sensitivity (S) ☐ Lab
○ Water content (%)
Atterberg limits (%) W_p W_l
● "N" Value (blows / 12 in.-30 cm)



REFERENCE No.: 11205379

ENCLOSURE No.: 9

BOREHOLE No.: **MW9**

ELEVATION: 80.52 m

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

DATE (START): 3 December 2019

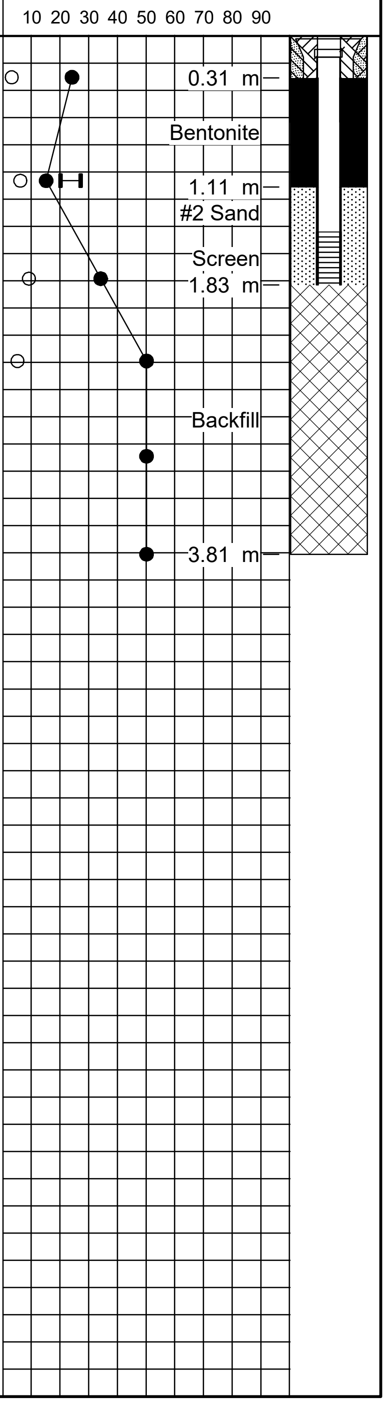
DATE (FINISH): 3 December 2019

LEGEND

☒	SS	- SPLIT SPOON
▨	ST	- SHELBY TUBE
◫	RC	- ROCK CORE
▼		- WATER LEVEL

Depth Feet	Depth Metres	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR
		80.52		GROUND SURFACE			%			N
				FILL : SAND and GRAVEL, grey, moist, compact	☒	SS1	58	3	24-18-6-4	24
	0.76	79.76		NATIVE : SM-SILTY SAND, some clay and gravel, cobble fragments, brown, moist, compact to dense Gravel : 14%, Sand : 53%, Silt : 20%, Clay : 13%	☒	SS2	58	6	4-8-7-17	15
					☒	SS3	76	9	7-8-26-50/ 75mm	34
	1.98	78.54		SHALE, completely weathered, grey	☒	SS4	100	5	49-50/ 50mm	50+
				no recovery	☒	SS5	0	--	50/ 50mm	50+
	3.81	76.71				SS6	0	--	50/ 0mm	50+

Shear test (Cu) △ Field
Sensitivity (S) ☐ Lab
○ Water content (%)
W_p W_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)



END OF BOREHOLE :

NOTE :
- End of Borehole at 3.81 m bgs
- Borehole was dry upon completion
- 50mm diameter monitoring well installed at 1.83 m bgs
- Borehole was dry on December 5, 2019
- Borehole was dry on December 13, 2019
- Borehole was dry on January 15, 2020
- bgs donates 'below ground surface'

REFERENCE No.: 11205379 ENCLOSURE No.: 10

GHD

BOREHOLE No.: **MW10**
ELEVATION: 79.86 m

BOREHOLE REPORT

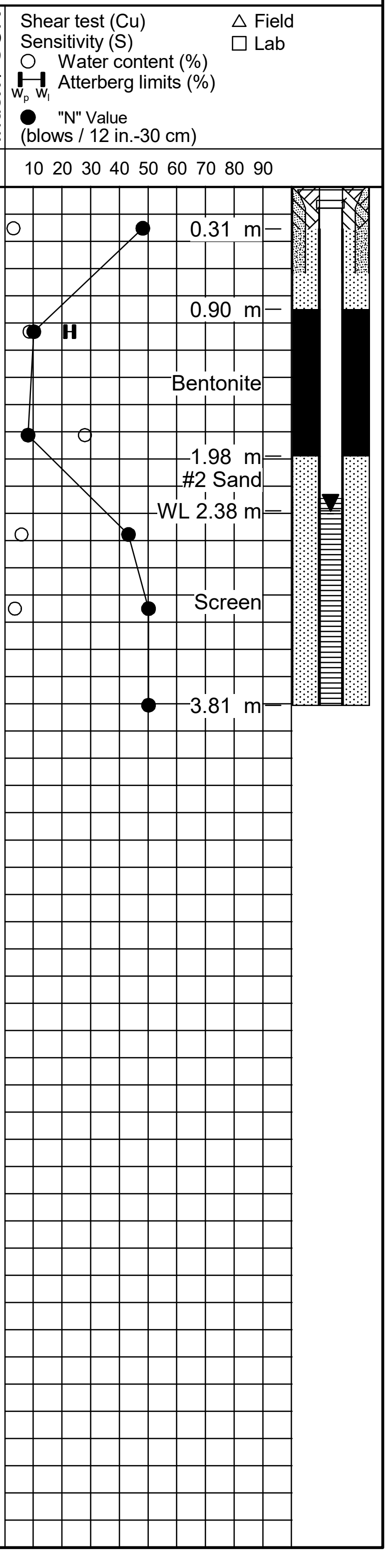
Page: 1 of 1

CLIENT: Infrastructure Ontario (I.O.)
PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus
LOCATION: 401 Smyth Road, Ottawa, Ontario
DESCRIBED BY: R. V. Tillaart CHECKED BY: A. Sorour
DATE (START): 2 December 2019 DATE (FINISH): 2 December 2019

LEGEND

☒ SS - SPLIT SPOON
▨ ST - SHELBY TUBE
◫ RC - ROCK CORE
▼ - WATER LEVEL

Depth (Metres)	Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR (N)
	79.86	GROUND SURFACE						
		FILL : SAND and GRAVEL, grey, frozen, dense	☒	SS1	58	3	24-37-11-3	48
0.76	79.10	NATIVE : SM-SILTY SAND with gravel, grey/brown, moist, compact/loose Gravel : 26%, Sand : 47%, Silt : 18%, Clay : 9% clay pocket	☒	SS2	42	9	5-3-7-10	10
			☒	SS3	42	28	2-3-5-7	8
2.29	77.57	SHALE, completely weathered, grey	☒	SS4	57	6	45-6-37-50/ 125mm	43
			☒	SS5	16	3	50/ 100mm	50+
3.81	76.05			SS6	0	--	50/ 50mm	50+



END OF BOREHOLE :

NOTE :
- End of Borehole at 3.81 m bgs
- Borehole was dry upon completion
- 50mm diameter monitoring well installed at 3.81 m bgs
- Groundwater level measured at 2.34 m bgs on December 5, 2019
- Groundwater level measured at 2.38 m bgs on December 13, 2019
- bgs donates 'below ground surface'

REFERENCE No.: 11205379

ENCLOSURE No.: 11

BOREHOLE No.: **BH11**

ELEVATION: 81.32 m

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

DATE (START): 4 December 2019

DATE (FINISH): 4 December 2019

LEGEND

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- ◫ RC - ROCK CORE
- ▼ - WATER LEVEL

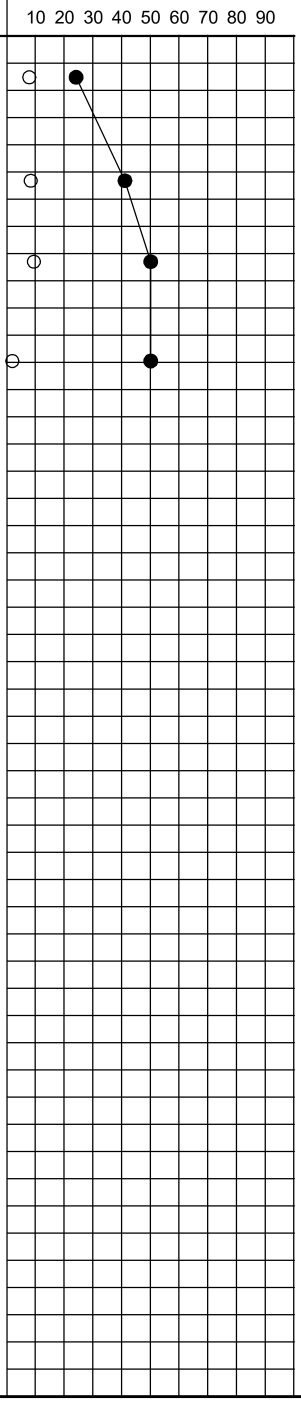
Depth (Metres)	Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR (N)
	81.32	GROUND SURFACE						
0.08	81.24	ASPHALT : 75 mm						
		FILL : SAND and GRAVEL, brown, frozen, compact	☒	SS1	67	8	16-17-7-5	24
0.76	80.56	NATIVE : SM-SILTY SAND, some clay, brown/grey, moist, dense	☒	SS2	55	8	16-17-24-32	41
1.52	79.80	SHALE, completely weathered, grey	☒	SS3	36	9	20--50/ 125mm	50+
			☒	SS4	33	2	30-50/ 50mm	50+
2.49	78.83							

END OF BOREHOLE :

NOTE :

- End of Borehole at 2.49 m bgs
- Borehole was dry upon completion
- bgs donates 'below ground surface'

Shear test (Cu) △ Field
Sensitivity (S) ☐ Lab
○ Water content (%)
Atterberg limits (%) W_p W_l
● "N" Value (blows / 12 in.-30 cm)



REFERENCE No.: 11205379

ENCLOSURE No.: 12

BOREHOLE No.: **BH12**

ELEVATION: 81.27 m

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

DATE (START): 4 December 2019

DATE (FINISH): 4 December 2019

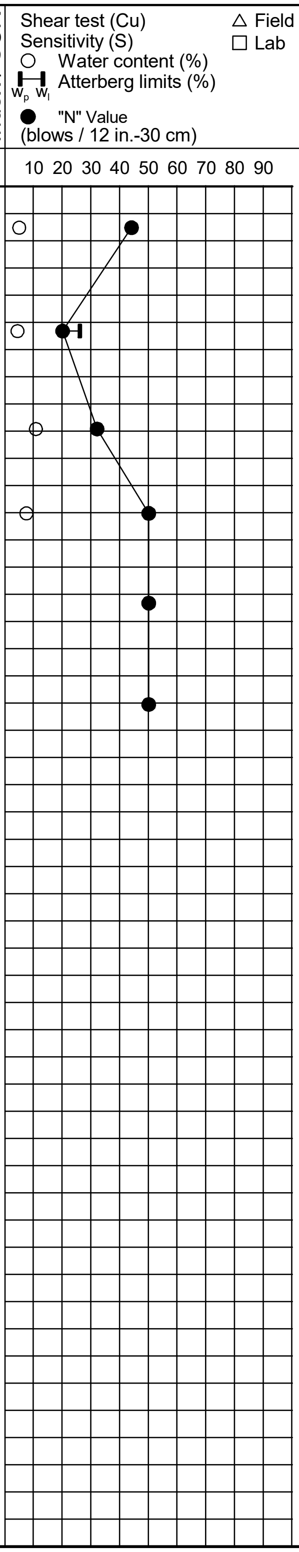
LEGEND

☒	SS	- SPLIT SPOON
▨	ST	- SHELBY TUBE
◫	RC	- ROCK CORE
▼		- WATER LEVEL

Depth (Metres)	Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR (N)
	81.27	GROUND SURFACE						
0.08	81.19	ASPHALT : 75 mm						
		FILL : SAND and GRAVEL, brown, moist, dense	☒	SS1	58	5	25-30-14-8	44
0.84	80.43	NATIVE : SM-SILTY SAND with gravel, some clay, brown/grey, moist, compact to dense Gravel : 18%, Sand : 52%, Silt : 19%, Clay : 11%	☒	SS2	75	4	3-5-15-33	20
			☒	SS3	76	11	7-15-17-50/ 75mm	32
2.29	78.98	SHALE, completely weathered, grey	☒	SS4	38	7	38-50/ 75mm	50+
				SS5	0	--	50/ 25mm	50+
3.81	77.46			SS6	0	--	50/ 0mm	50+

END OF BOREHOLE :

NOTE :
- End of Borehole at 3.81 m bgs
- Borehole was dry upon completion
- bgs donates 'below ground surface'



REFERENCE No.: 11205379

ENCLOSURE No.: 13

BOREHOLE No.: BH13

ELEVATION: 81.37 m

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

DATE (START): 4 December 2019

DATE (FINISH): 4 December 2019

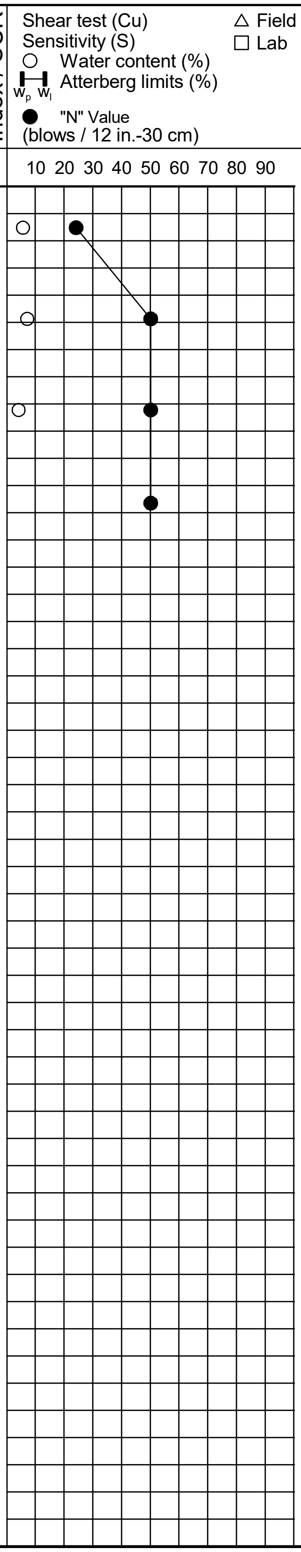
LEGEND

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- ◫ RC - ROCK CORE
- ▼ - WATER LEVEL

Depth (Metres)	Elevation (m)	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery TCR (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR (N)
	81.37	GROUND SURFACE					
0.08	81.29	ASPHALT : 75 mm					
		FILL : SAND and GRAVEL, brown, frozen, compact	SS1	83	6	16-12-12-9	24
0.76	80.61	NATIVE : SM-SILTY SAND, some clay, brown/grey, moist, very dense	SS2	71	7	10-12-50/ 125mm	50+
1.07	80.30	SHALE, completely weathered, grey					
			SS3	33	4	15-50/ 100mm	50+
2.37	79.00		SS4	12	--	50/ 75mm	50+

END OF BOREHOLE :

NOTE :
- End of Borehole at 2.37 m bgs
- Borehole was dry upon completion
- bgs donates 'below ground surface'



REFERENCE No.: 11205379

ENCLOSURE No.: 15

GHD

BOREHOLE No.: **BH14**

ELEVATION: 81.17 m

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Infrastructure Ontario (I.O.)

PROJECT: Preliminary Geotechnical Investigation - Children's Hospital of Eastern Ontario Campus

LOCATION: 401 Smyth Road, Ottawa, Ontario

DESCRIBED BY: R. V. Tillaart

CHECKED BY: A. Sorour

DATE (START): 4 December 2019

DATE (FINISH): 4 December 2019

LEGEND

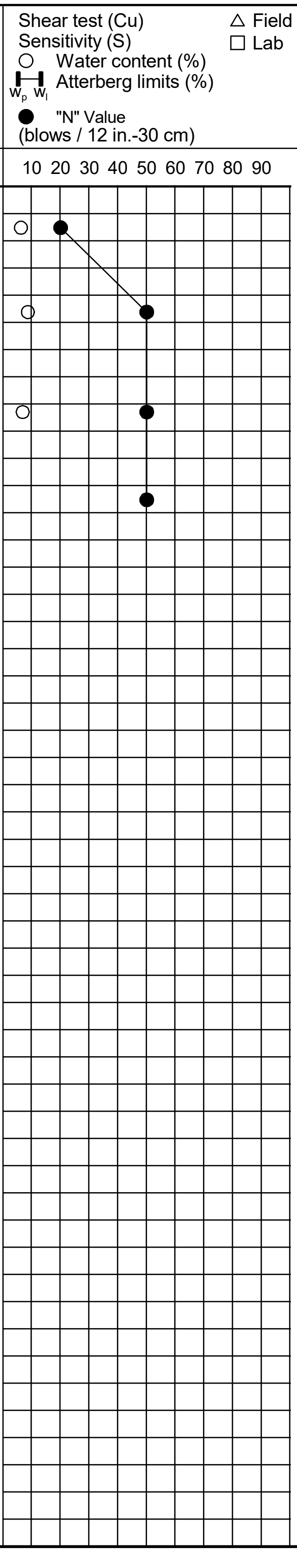
☒ SS - SPLIT SPOON

▨ ST - SHELBY TUBE

◫ RC - ROCK CORE

▼ - WATER LEVEL

Depth (Metres)	Elevation (m)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery TCR (%)	Moisture Content	Blows per 6 in. / 15 cm or RQD	Penetration Index / SCR (N)
	81.17		GROUND SURFACE						
0.08	81.09		ASPHALT : 75 mm						
			FILL : SAND and GRAVEL, brown, frozen, compact	☒	SS1	83	6	29-14-6-2	20
0.81	80.36		NATIVE : SM-SILTY SAND, some clay, brown/grey, moist, very dense	☒	SS2	100	9	15-36-50/ 25mm	50+
1.01	80.16		SHALE, completely weathered, grey	☒	SS3	45	7	36-50/ 125mm	50+
2.32	78.85		no recovery		SS4	0	--	50/ 25mm	50+



END OF BOREHOLE :

NOTE :

- End of Borehole at 2.32 m bgs
- Borehole was dry upon completion
- bgs donates 'below ground surface'

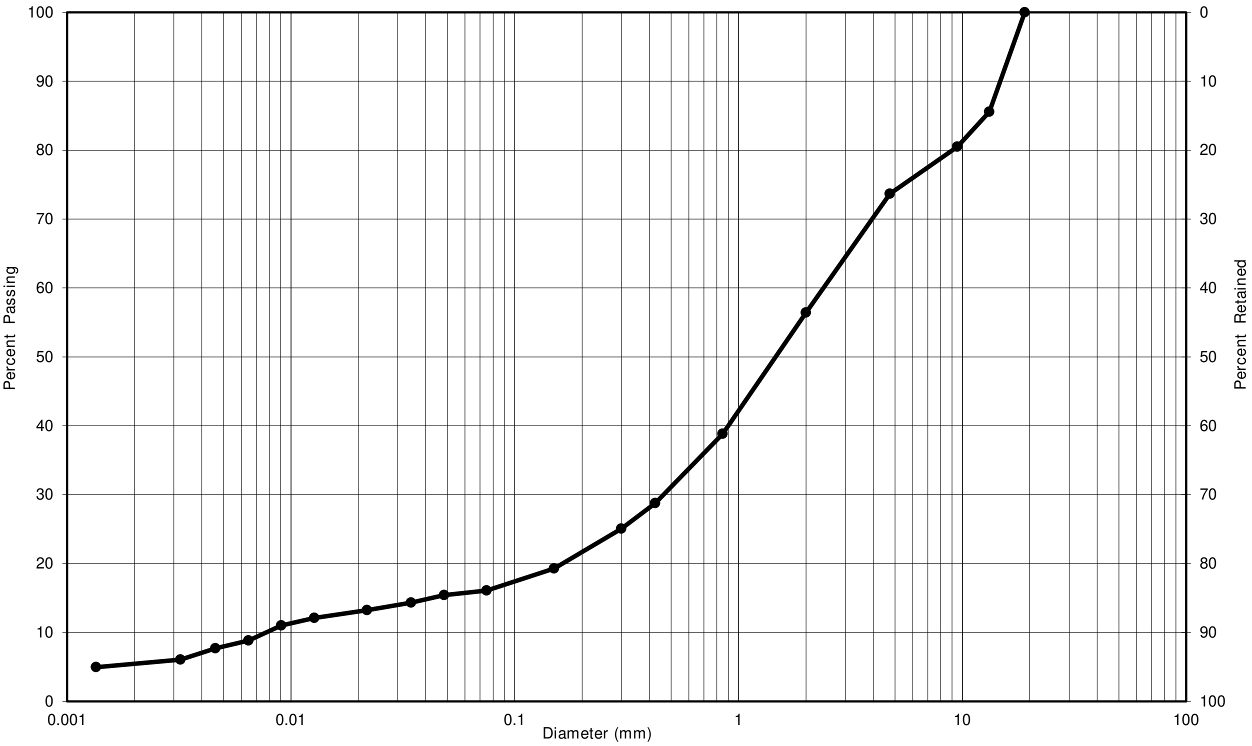
Appendix B
Geotechnical Laboratory Test Results

Appendix B1

Grain Size Distribution Results

Particle-Size Analysis of Soils
ASTM D422 (Geotechnical)

Client:	Infrastructure Ontario (IO)	Lab No.:	G2256
Project, Site:	Geotechnical Investigation - Childrens Hospital of Eastern Ontario, Ottawa, ON	Project No.:	11205379
Borehole No.:	MW1	Sample No.:	SS3 + SS4
Depth:	1.5m-2.1m / 2.3m - 2.9m	Enclosure:	



Silty Clay	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty Sand with Gravel, Trace Clay	26	58	16

Remarks: Silt-size particles (0.074 to 0.002 mm): 11%, Clay-size particles (<0.002 mm): 5%

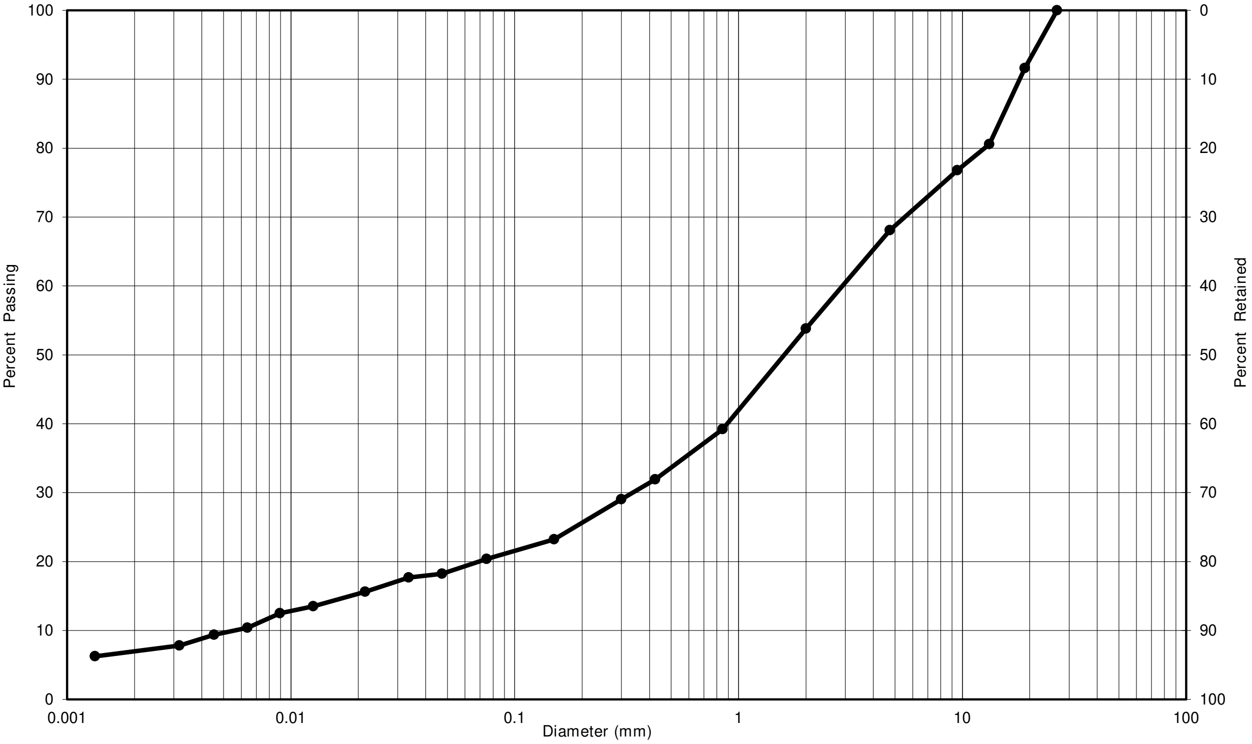
Gravel 26%, Sand 58%, Silt 11%, Clay 5%

Performed by:	Riddhee Panchal	Date:	December 16, 2019
Verified by:	Raj Kadia, C.E.T.	Date:	December 27, 2019

Particle-Size Analysis of Soils
ASTM D422 (Geotechnical)

Client:	Infrastructure Ontario (IO)	Lab No.:	G2256
Project, Site:	Geotechnical Investigation - Childrens Hospital of Eastern Ontario, Ottawa, ON	Project No.:	11205379

Borehole No.:	MW2	Sample No.:	SS3 + SS4
Depth:	1.5m-2.1m / 2.3m - 2.9m	Enclosure:	



Silty Clay	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty Sand with Gravel, Trace Clay	32	48	20

Remarks: Silt-size particles (0.074 to 0.002 mm): 13%, Clay-size particles (<0.002 mm): 7%

Gravel 32%, Sand 48%, Silt 13%, Clay 7%

Performed by:	Riddhee Panchal	Date:	December 16, 2019
Verified by:	Raj Kadia, C.E.T.	Date:	December 27, 2019

Particle-Size Analysis of Soils
ASTM D422 (Geotechnical)

Client: Infrastructure Ontario (IO)

Lab No.: G2256

Project, Site: Geotechnical Investigation - Childrens Hospital of Eastern Ontario, Ottawa, ON

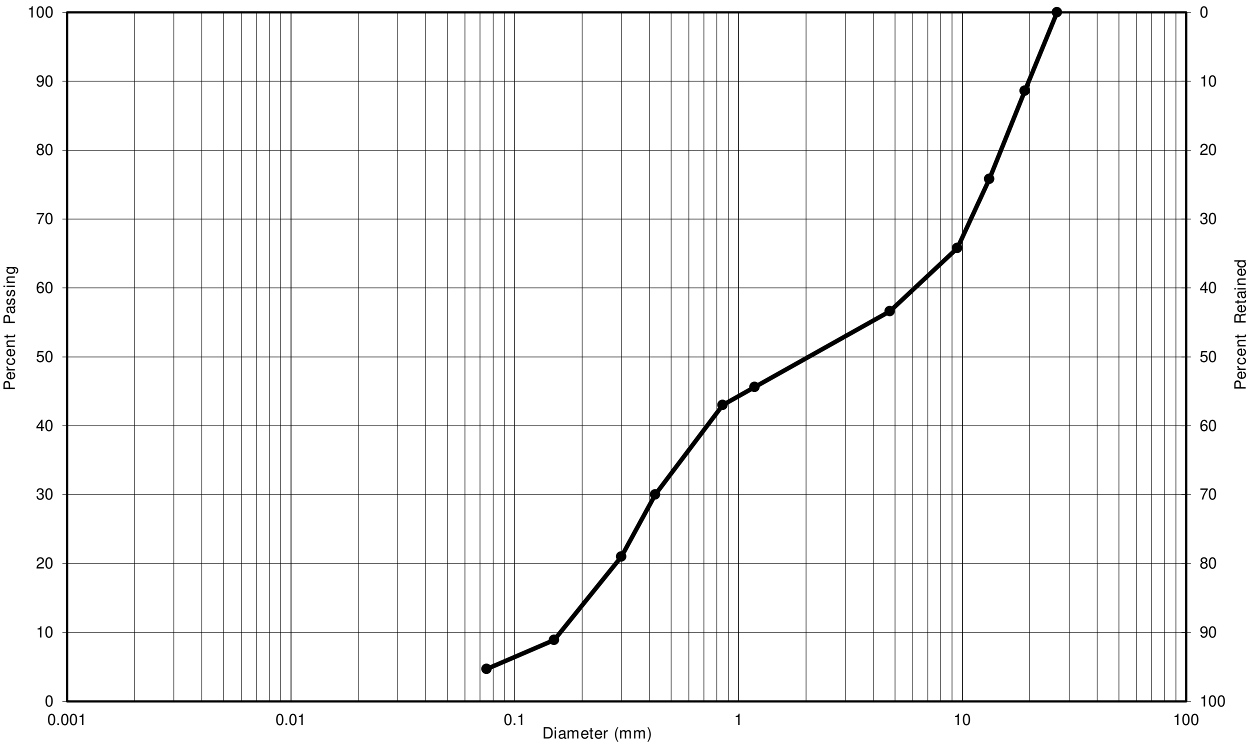
Project No.: 11205379

Borehole No.: MW3

Sample No.: SS2

Depth: 0.8m - 1.4m

Enclosure:



Silty Clay	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Sand with Gravel and Silt	43	52	5

Remarks:

Gravel 43%, Sand 52%, Silt 5%

Performed by: Riddhee Panchal

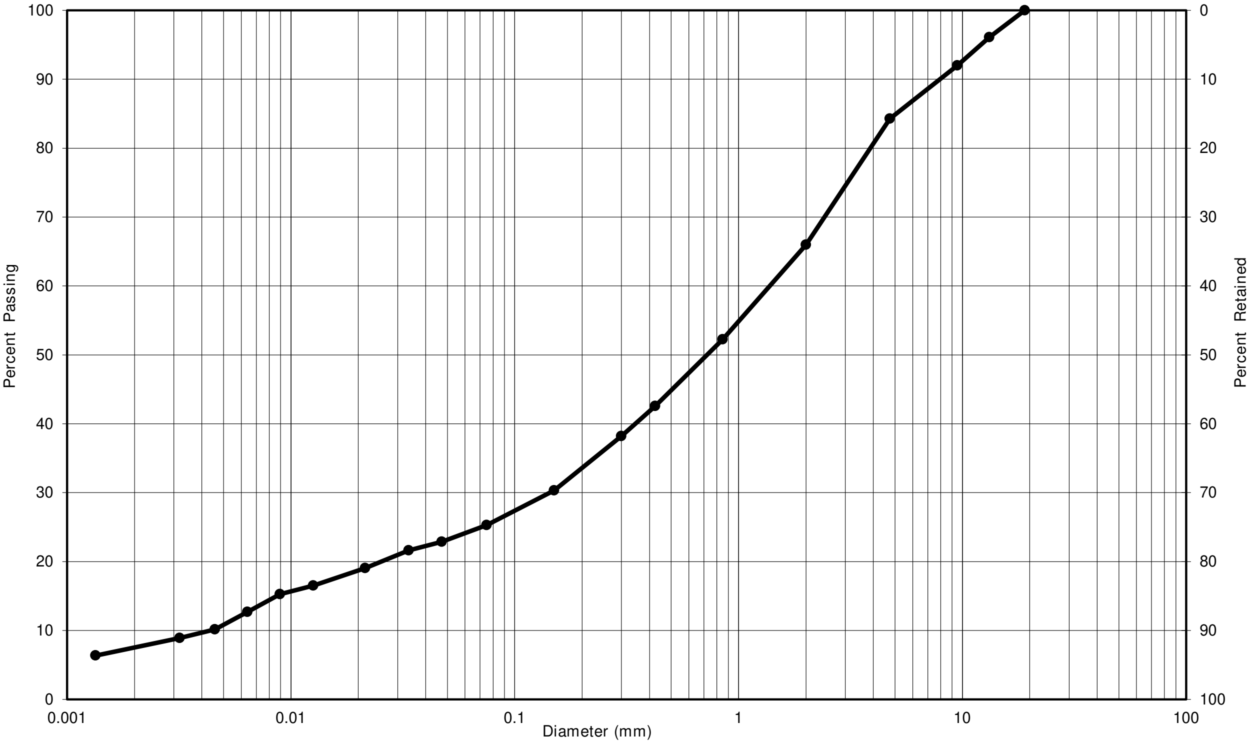
Date: December 16, 2019

Verified by: Raj Kadia, C.E.T.

Date: December 31, 2019

Particle-Size Analysis of Soils
ASTM D422 (Geotechnical)

Client:	Infrastructure Ontario (IO)	Lab No.:	G2256
Project, Site:	Geotechnical Investigation - Childrens Hospital of Eastern Ontario, Ottawa, ON	Project No.:	11205379
Borehole No.:	MW3	Sample No.:	SS4
Depth:	2.3m - 2.9m	Enclosure:	



Silty Clay	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty Sand with Gravel, Trace Clay	16	59	25

Remarks: Silt-size particles (0.074 to 0.002 mm): 17%, Clay-size particles (<0.002 mm): 8%

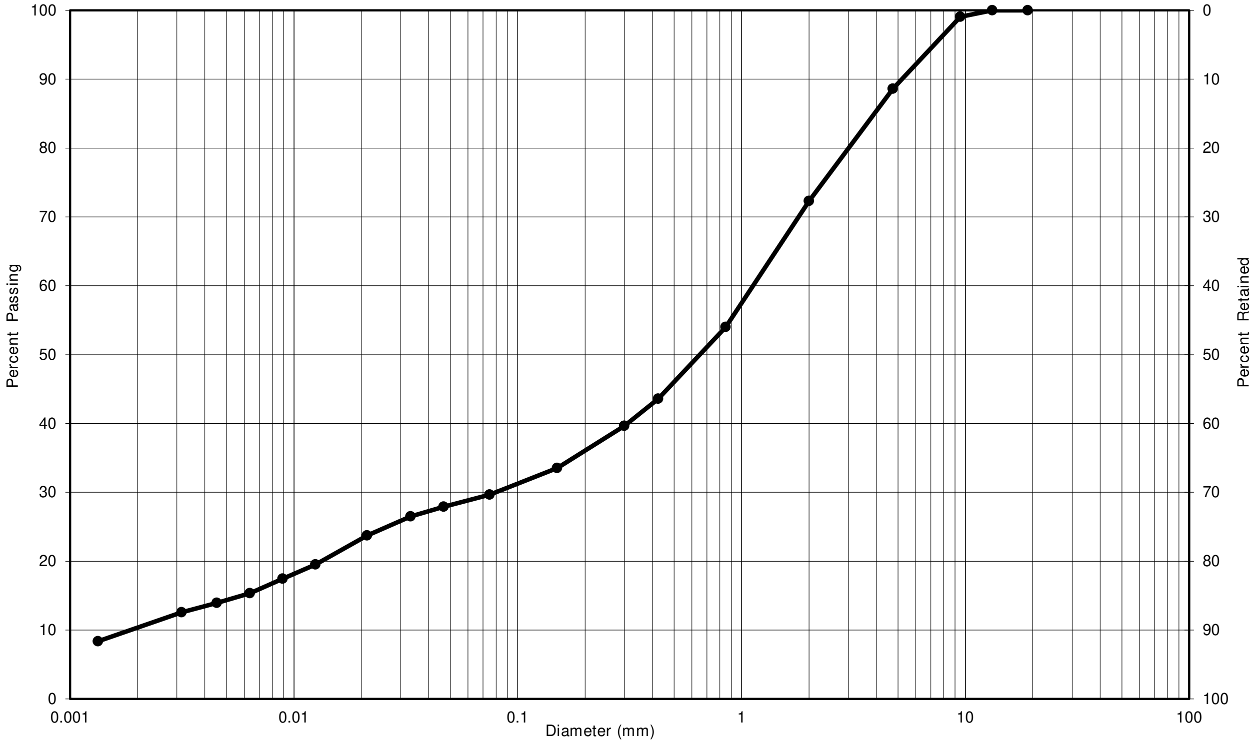
Gravel 16%, Sand 59%, Silt 17%, Clay 8%

Performed by:	Riddhee Panchal	Date:	December 16, 2019
Verified by:	Raj Kadia, C.E.T.	Date:	December 27, 2019

Particle-Size Analysis of Soils
ASTM D422 (Geotechnical)

Client:	Infrastructure Ontario (IO)	Lab No.:	G2256
Project, Site:	Geotechnical Investigation - Childrens Hospital of Eastern Ontario, Ottawa, ON	Project No.:	11205379

Borehole No.:	MW4	Sample No.:	SS2
Depth:	0.8m-1.4m	Enclosure:	



Silty Clay	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty Sand, Some Gravel, Trace Clay	11	59	30

Remarks: Silt-size particles (0.074 to 0.002 mm): 20%, Clay-size particles (<0.002 mm): 10%

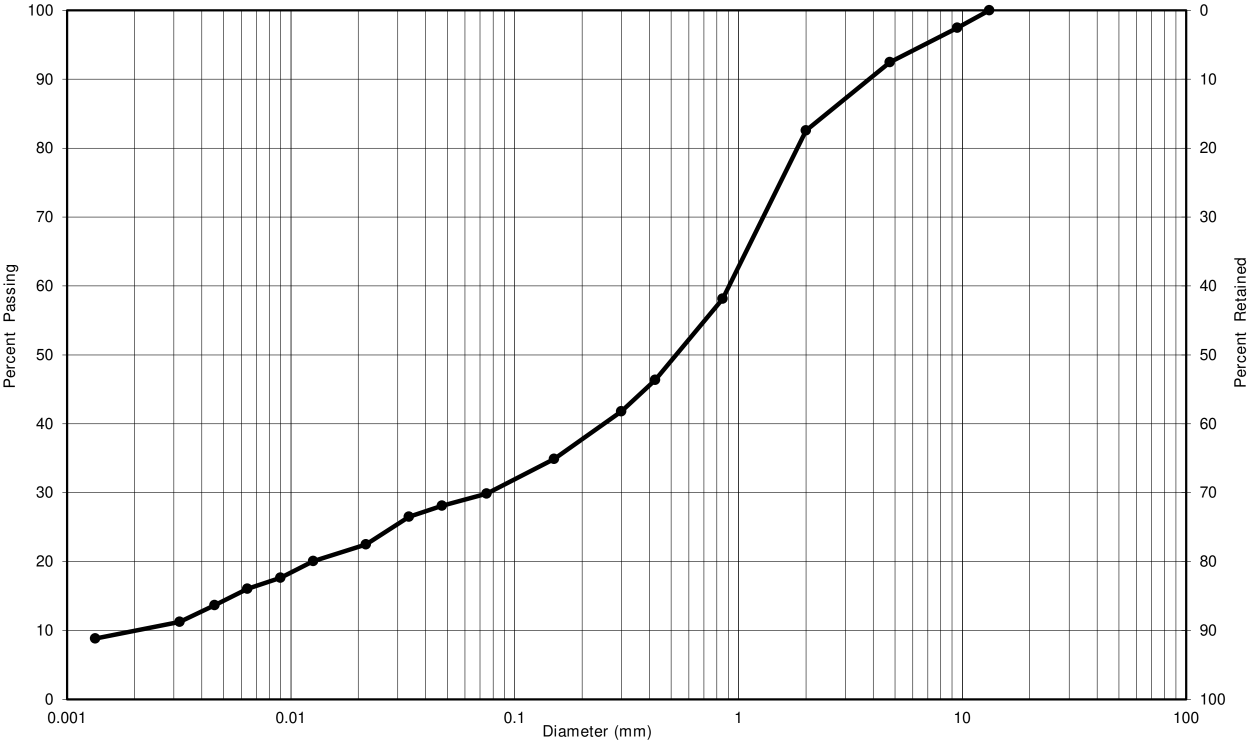
Gravel 11%, Sand 59%, Silt 20%, Clay 10%

Performed by:	Riddhee Panchal	Date:	December 16, 2019
Verified by:	Raj Kadia, C.E.T.	Date:	December 27, 2019

Particle-Size Analysis of Soils
ASTM D422 (Geotechnical)

Client:	Infrastructure Ontario (IO)	Lab No.:	G2256
Project, Site:	Geotechnical Investigation - Childrens Hospital of Eastern Ontario, Ottawa, ON	Project No.:	11205379

Borehole No.:	MW5-19	Sample No.:	SS2 + SS3
Depth:	0.9m-1.2m / 1.5m-1.7m	Enclosure:	



Silty Clay	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty Sand, Trace Gravel, Trace Clay	8	62	30

Remarks: Silt-size particles (0.074 to 0.002 mm): 20%, Clay-size particles (<0.002 mm): 10%

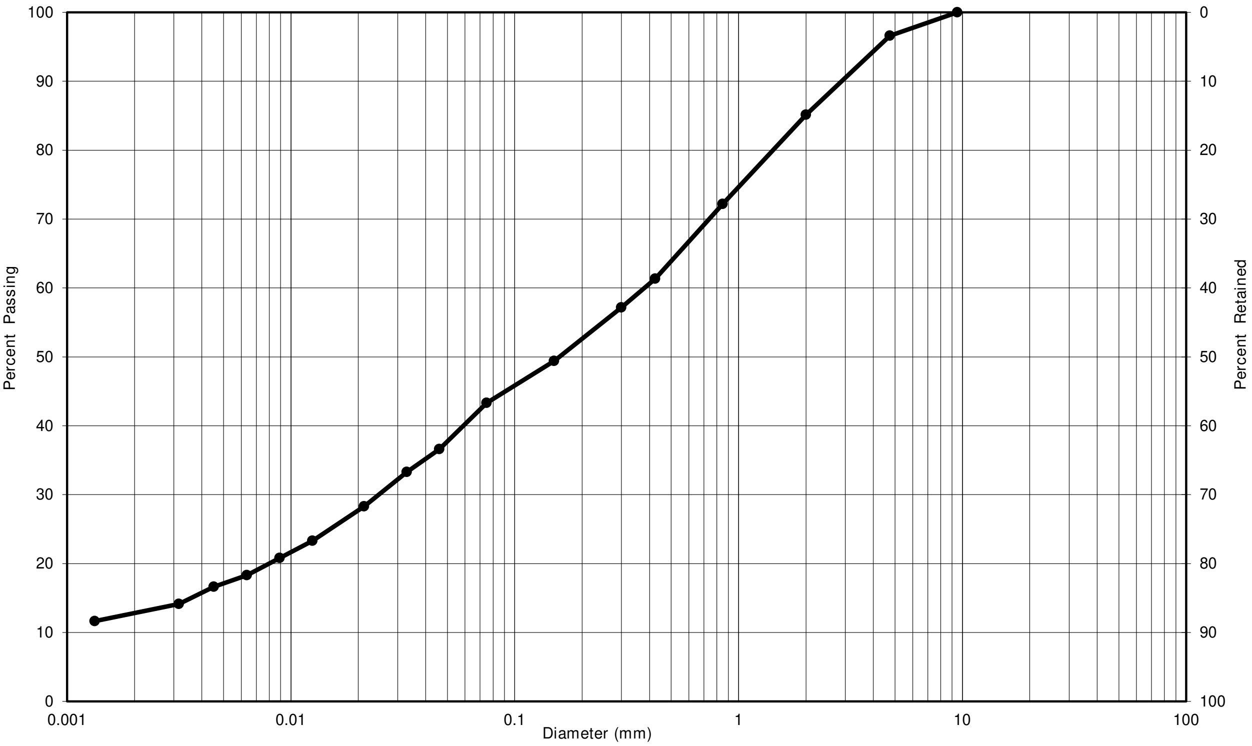
Gravel 8%, Sand 62%, Silt 20%, Clay 10%

Performed by:	Riddhee Panchal	Date:	December 16, 2019
Verified by:	Raj Kadia, C.E.T.	Date:	December 27, 2019

Particle-Size Analysis of Soils
ASTM D422 (Geotechnical)

Client: Infrastructure Ontario (IO)
Lab No.: G2256
Project, Site: Geotechnical Investigation - Childrens Hospital of Eastern Ontario, Ottawa, ON
Project No.: 11205379

Borehole No.: MW7
Sample No.: SS2
Depth: 0.8m - 1.4m
Enclosure:



Silty Clay	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty Sand, Some Clay , Trace Gravel	3	54	43

Remarks: Silt-size particles (0.074 to 0.002 mm): 30%, Clay-size particles (<0.002 mm): 13%

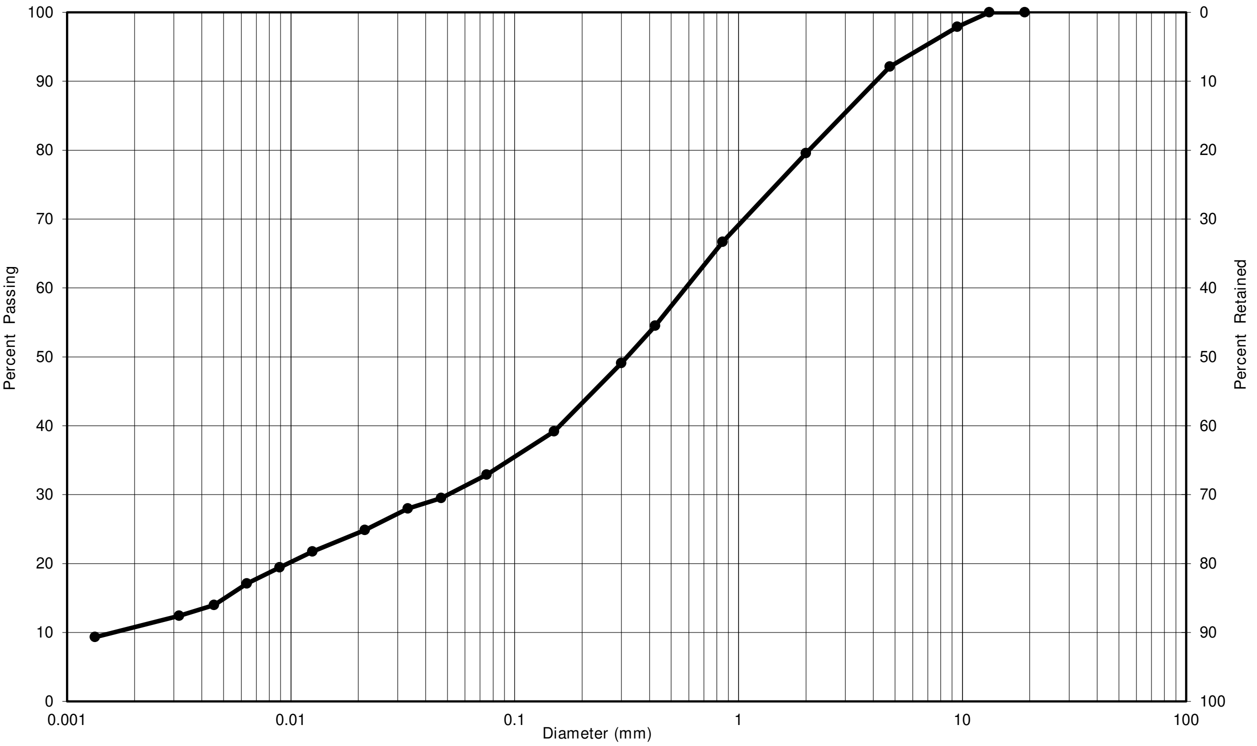
Gravel 3%, Sand 54%, Silt 30%, Clay 13%

Performed by: Riddhee Panchal
Date: December 16, 2019
Verified by: Raj Kadia, C.E.T.
Date: December 27, 2019

Particle-Size Analysis of Soils
ASTM D422 (Geotechnical)

Client:	Infrastructure Ontario (IO)	Lab No.:	G2256
Project, Site:	Geotechnical Investigation - Childrens Hospital of Eastern Ontario, Ottawa, ON	Project No.:	11205379

Borehole No.:	BH8	Sample No.:	SS2
Depth:	0.8m - 1.4m	Enclosure:	



<table>
<tr><td rowspan="2">Silty Clay</td><td colspan="3">Sand</td><td colspan="2">Gravel</td></tr>
<tr><td>Fine</td><td>Medium</td><td>Coarse</td><td>Fine</td><td>Coarse</td></tr>
<tr><td colspan="6">Particle-Size Limits as per USCS (ASTM D-2487)</td></tr>
</table>

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty Sand, Some Clay , Trace Gravel	8	59	33

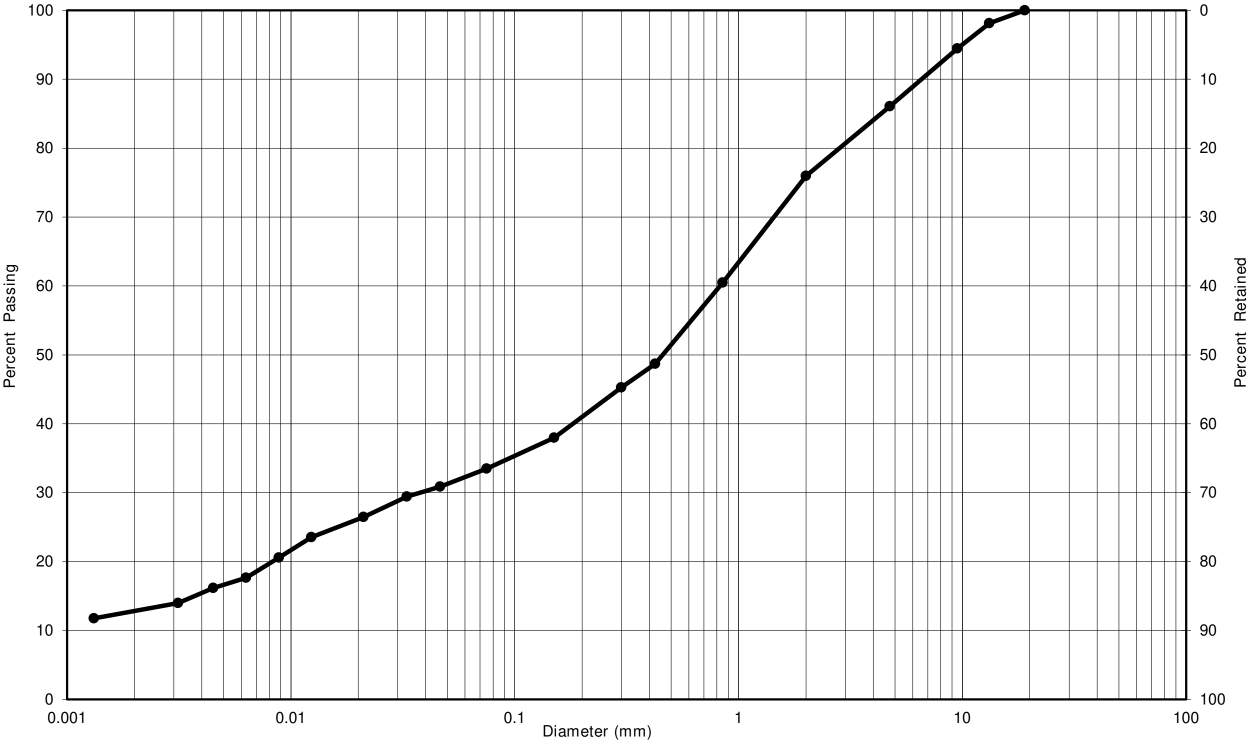
Remarks: Silt-size particles (0.074 to 0.002 mm): 22%, Clay-size particles (<0.002 mm): 11%

Gravel 8%, Sand 59%, Silt 22%, Clay 11%

Performed by:	Riddhee Panchal	Date:	December 16, 2019
Verified by:	Raj Kadia, C.E.T.	Date:	December 27, 2019

Particle-Size Analysis of Soils
ASTM D422 (Geotechnical)

Client:	Infrastructure Ontario (IO)	Lab No.:	G2256
Project, Site:	Geotechnical Investigation - Childrens Hospital of Eastern Ontario, Ottawa, ON	Project No.:	11205379
Borehole No.:	MW9	Sample No.:	SS2 + SS3
Depth:	0.8m-1.4m / 1.5m-2.0m	Enclosure:	



Silty Clay	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty Sand, Some Gravel, Some Clay	14	53	33

Remarks: Silt-size particles (0.074 to 0.002 mm): 20%, Clay-size particles (<0.002 mm): 13%

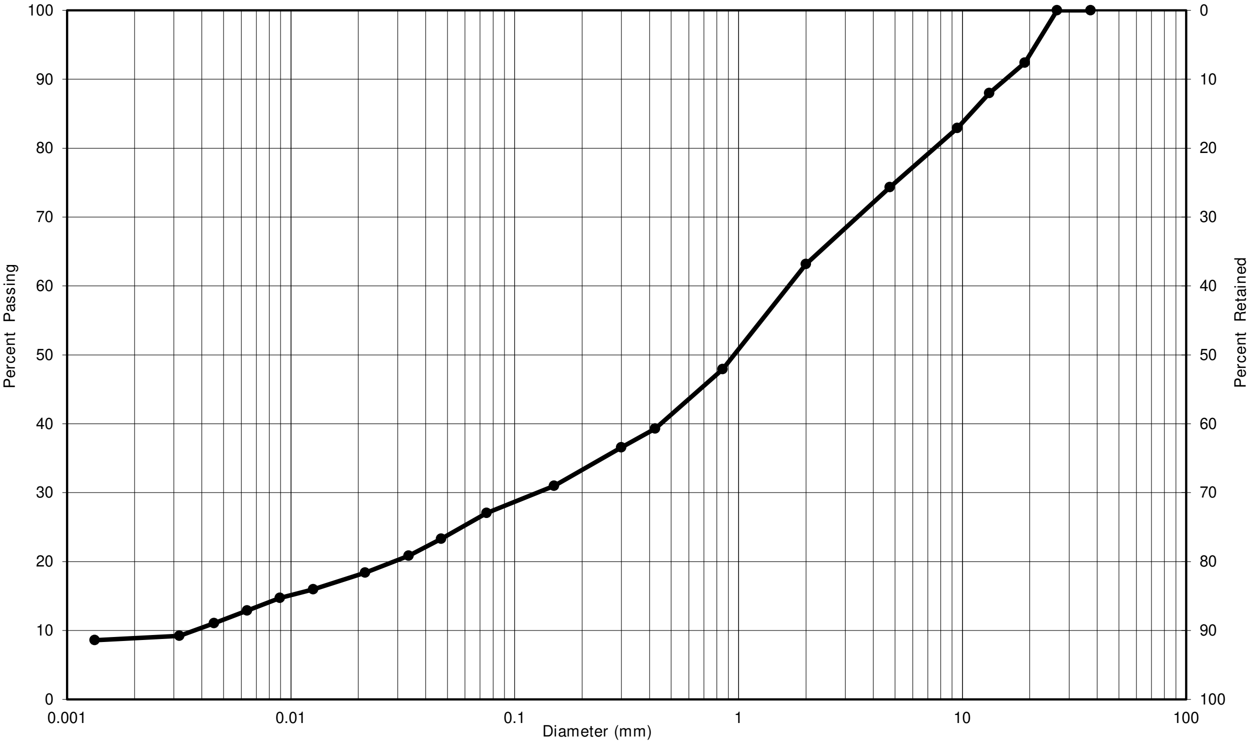
Gravel 14%, Sand 53%, Silt 20%, Clay 13%

Performed by:	Riddhee Panchal	Date:	December 16, 2019
Verified by:	Raj Kadia, C.E.T.	Date:	December 27, 2019

Particle-Size Analysis of Soils
ASTM D422 (Geotechnical)

Client:	Infrastructure Ontario (IO)	Lab No.:	G2253
Project, Site:	Geotechnical Investigation - Childrens Hospital of Eastern Ontario, Ottawa, ON	Project No.:	11205379

Borehole No.:	MW10	Sample No.:	SS2
Depth:	0.8m-1.4m	Enclosure:	



Silty Clay	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty Sand with Gravel, Trace Clay	26	47	27

Remarks: Silt-size particles (0.074 to 0.002 mm): 18%, Clay-size particles (<0.002 mm): 9%

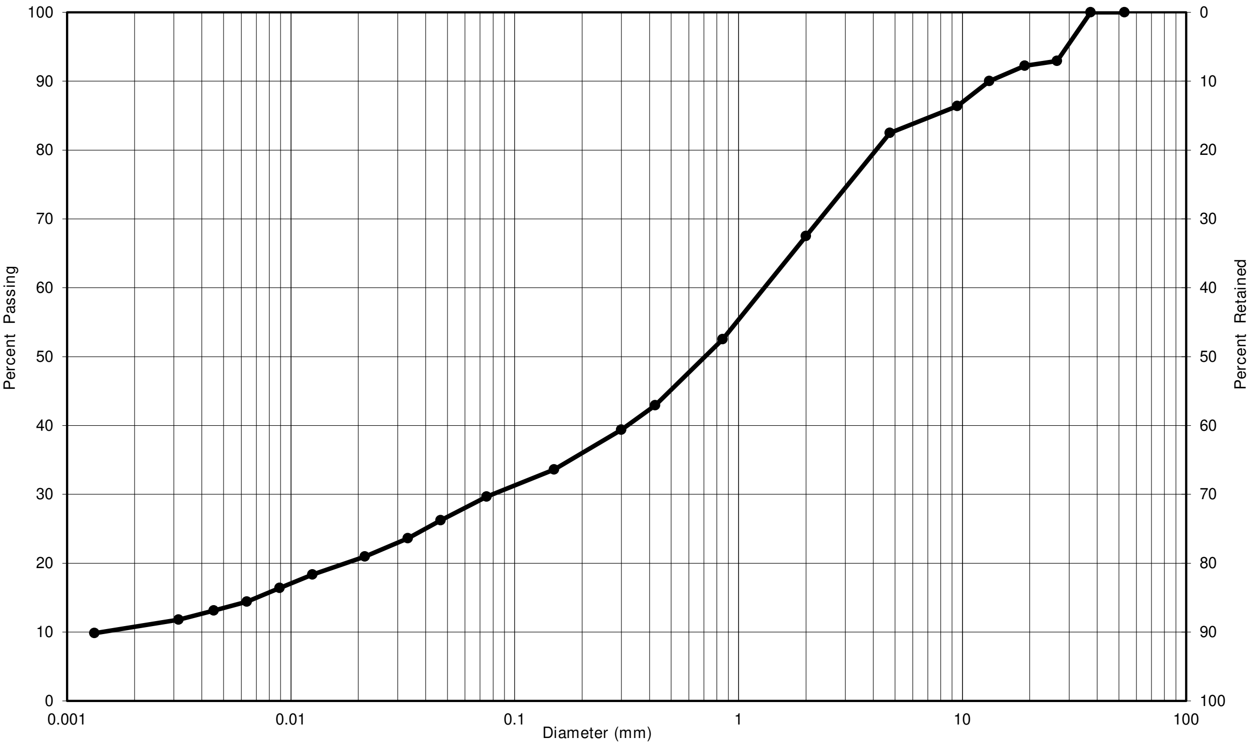
Gravel 26%, Sand 47%, Silt 18%, Clay 9%

Performed by:	Riddhee Panchal	Date:	December 16, 2019
Verified by:	Raj Kadia, C.E.T.	Date:	December 27, 2019

Particle-Size Analysis of Soils
ASTM D422 (Geotechnical)

Client: Infrastructure Ontario (IO)
Lab No.: G2253
Project, Site: Geotechnical Investigation - Childrens Hospital of Eastern Ontario, Ottawa, ON
Project No.: 11205379

Borehole No.: BH12
Sample No.: SS2 + SS3
Depth: 0.8m-1.4m / 1.5m-2.1m
Enclosure:



Silty Clay	Sand			Gravel	
	Fine	Medium	Coarse	Fine	Coarse
Particle-Size Limits as per USCS (ASTM D-2487)					

Soil Description	Gravel (%)	Sand (%)	Clay & Silt (%)
Silty Sand with Gravel, Some Clay	18	52	30

Remarks: Silt-size particles (0.074 to 0.002 mm): 19%, Clay-size particles (<0.002 mm): 11%

Gravel 18%, Sand 52%, Silt 19%, Clay 11%

Performed by: Riddhee Panchal
Date: December 16, 2019
Verified by: Raj Kadia, C.E.T.
Date: December 27, 2019

Appendix B2

Atterberg Limits Results

Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D4318)

Client:	Infrastructure Ontario (IO)	Lab no.:	G2256
Project/Site:	Preliminary Geotechnical Investigation – Childrens Hospital of Eastern Ontario, Ottawa, Ontario	Project no.:	11205379

Borehole no.:	MW3	Sample no.:	SS4	Depth:	2.3m- 2.9 m
Soil description:	Low Plasticity Inorganic Clay (CL)			Date sampled:	28-Nov-19

Apparatus:	Hand Crank	Balance no.:	1	Porcelain bowl no.:	3
Liquid limit device no.:	2	Oven no.:	2	Spatula no.:	1
Sieve no.:	40	Glass plate no.:	1		

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows	35	25	16
Water Content:			
Tare no.	A27	A13	A11
Wet soil+tare, g	19.30	22.77	20.44
Dry soil+tare, g	17.99	20.60	18.71
Mass of water, g	1.31	2.17	1.73
Tare, g	13.54	13.55	13.33
Mass of soil, g	4.45	7.05	5.38
Water content %	29.4%	30.8%	32.2%

Plastic Limit (PL) - Water Content:

Tare no.	A26	A52
Wet soil+tare, g	19.60	19.51
Dry soil+tare, g	18.52	18.47
Mass of water, g	1.08	1.04
Tare, g	13.49	13.47
Mass of soil, g	5.03	5.00
Water content %	21.5%	20.8%
Average water content %	21.1%	

Natural Water Content (W^n):

Tare no.	W21	
Wet soil+tare, g	25.7	
Dry soil+tare, g	23.3	
Mass of water, g	2.40	
Tare, g	1.30	
Mass of soil, g	22.00	
Water content %	10.9%	

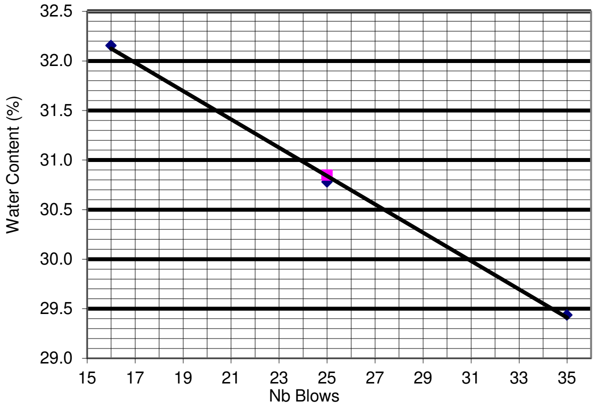
Soil Preparation:

☑ Cohesive <425 µm ☑ Dry preparation

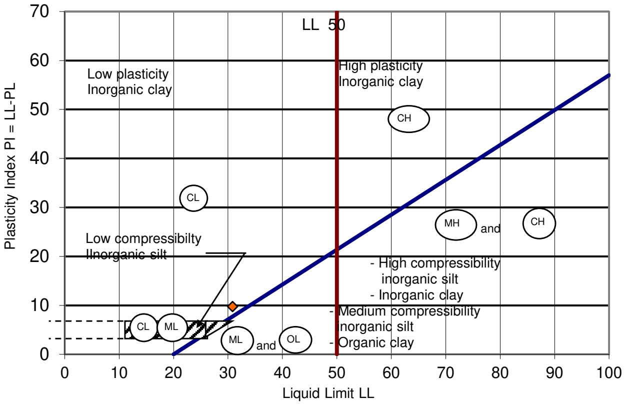
☐ Cohesive >425 µm ☐ Wet preparation

☐ Non-cohesive

Results



Soil Plasticity Chart



Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
31	21	10	11

Remarks:

Performed by:	Sharif Hossain	Date:	12/27/2019
Verified by:	Raj Kadia, C.E.T.	Date:	12/31/2019

Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D4318)

Client: Infrastructure Ontario (IO)

Lab no.: G2256

Project/Site: Preliminary Geotechnical Investigation – Childrens Hospital of Eastern Ontario, Ottawa, Ontario

Project no.: 11205379

Borehole no.: MW4
Sample no.: SS2
Depth: 0.8m- 1.4m
Soil description: Low Plasticity Inorganic Clay (CL)
Date sampled: 28-Nov-19

Apparatus: Hand Crank
Balance no.: 1
Porcelain bowl no.: 1
Liquid limit device no.: 2
Oven no.: 2
Spatula no.: 1
Sieve no.: 40
Glass plate no.: 1

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows	30	29	16
Water Content:			
Tare no.	A23	A52	A13
Wet soil+tare, g	23.42	25.76	25.88
Dry soil+tare, g	21.39	23.04	23.00
Mass of water, g	2.03	2.72	2.88
Tare, g	13.86	13.47	13.54
Mass of soil, g	7.53	9.57	9.46
Water content %	27.0%	28.4%	30.4%

Plastic Limit (PL) - Water Content:

Tare no.	A71	A22
Wet soil+tare, g	19.51	19.57
Dry soil+tare, g	18.49	18.54
Mass of water, g	1.02	1.03
Tare, g	13.34	13.44
Mass of soil, g	5.15	5.10
Water content %	19.8%	20.2%
Average water content %	20.0%	

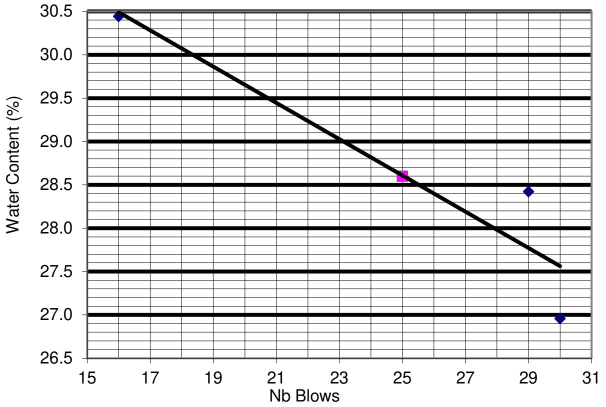
Natural Water Content (W^n):

Tare no.	A18	
Wet soil+tare, g	51.9	
Dry soil+tare, g	45.2	
Mass of water, g	6.70	
Tare, g	1.30	
Mass of soil, g	43.90	
Water content %	15.3%	

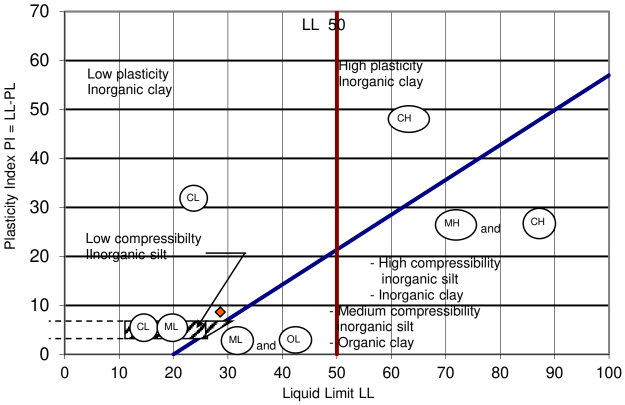
Soil Preparation:

☑ Cohesive <425 μm
☐ Cohesive >425 μm
☐ Non-cohesive
☑ Dry preparation
☐ Wet preparation

Results



Soil Plasticity Chart



Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
29	20	9	15

Remarks:

Performed by: Sharif Hossain
Date: 12/27/2019

Verified by: Raj Kadia, C.E.T.
Date: 12/31/2019

Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D4318)

Client: Infrastructure Ontario (IO)
Lab no.: G2253
Project/Site: Preliminary Geotechnical Investigation – Childrens Hospital of Eastern Ontario, Ottawa, Ontario
Project no.: 11205379

Borehole no.: MW5
Sample no.: SS2+SS3
Depth: 0.9m- 1.7m
Soil description: Low Plasticity Inorganic Clay (CL)
Date sampled: 28-Nov-19

Apparatus: Hand Crank
Balance no.: 1
Porcelain bowl no.: 2
Liquid limit device no.: 2
Oven no.: 2
Spatula no.: 1
Sieve no.: 40
Glass plate no.: 1

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows	35	30	25
Water Content:			
Tare no.	A2	A20	A10
Wet soil+tare, g	23.83	23.44	25.84
Dry soil+tare, g	21.66	21.24	23.07
Mass of water, g	2.17	2.20	2.77
Tare, g	13.40	13.23	13.61
Mass of soil, g	8.26	8.01	9.46
Water content %	26.3%	27.5%	29.3%

Plastic Limit (PL) - Water Content:

Tare no.	A23	A24
Wet soil+tare, g	19.62	20.27
Dry soil+tare, g	18.75	19.26
Mass of water, g	0.87	1.01
Tare, g	13.59	13.33
Mass of soil, g	5.16	5.93
Water content %	16.9%	17.0%
Average water content %	16.9%	

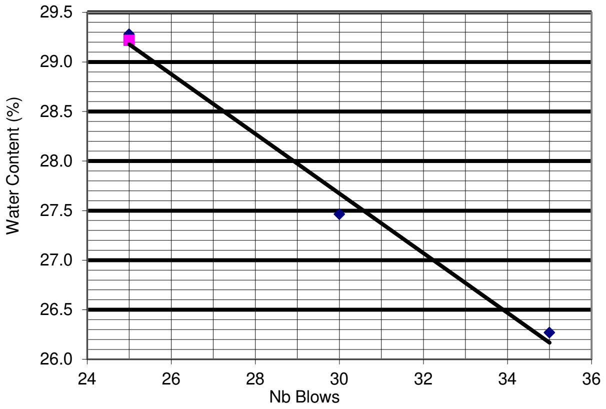
Natural Water Content (W^n):

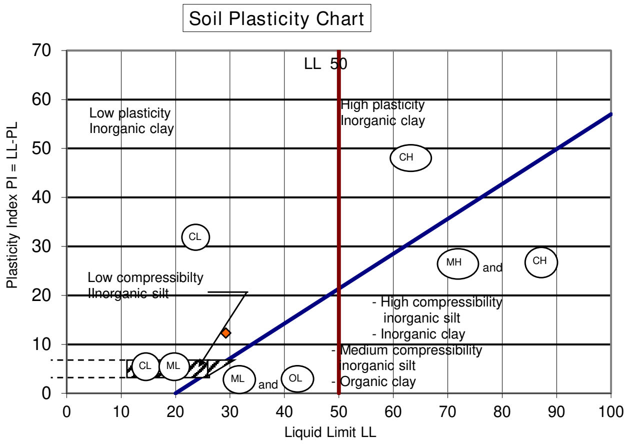
Tare no.	W1	
Wet soil+tare, g	24.2	
Dry soil+tare, g	22.4	
Mass of water, g	1.80	
Tare, g	1.30	
Mass of soil, g	21.10	
Water content %	8.5%	

Soil Preparation:

☑ Cohesive <425 µm
☐ Cohesive >425 µm
☐ Non-cohesive
☑ Dry preparation
☐ Wet preparation

Results





Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
29	17	12	9

Remarks:

Performed by: Riddhee Panchal
Date: 12/24/2019

Verified by: Raj Kadia, C.E.T.
Date: 12/31/2019

Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D4318)

Client: Infrastructure Ontario (IO)
Lab no.: G2256
Project/Site: Preliminary Geotechnical Investigation – Childrens Hospital of Eastern Ontario, Ottawa, Ontario
Project no.: 11205379

Borehole no.: BH7
Sample no.: SS2
Depth: 0.8m- 1.4m
Soil description: Low Plasticity Inorganic Clay (CL)
Date sampled: 28-Nov-19

Apparatus: Hand Crank
Balance no.: 1
Porcelain bowl no.: 1
Liquid limit device no.: 2
Oven no.: 2
Spatula no.: 1
Sieve no.: 40
Glass plate no.: 1

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows	35	20	19
Water Content:			
Tare no.	A9	A16	A23
Wet soil+tare, g	19.65	20.31	25.45
Dry soil+tare, g	18.23	18.73	22.73
Mass of water, g	1.42	1.58	2.72
Tare, g	13.33	13.42	13.83
Mass of soil, g	4.90	5.31	8.90
Water content %	29.0%	29.8%	30.6%

Plastic Limit (PL) - Water Content:

Tare no.	A71	A4
Wet soil+tare, g	17.55	17.65
Dry soil+tare, g	16.75	16.94
Mass of water, g	0.80	0.71
Tare, g	13.34	13.62
Mass of soil, g	3.41	3.32
Water content %	23.5%	21.4%
Average water content %	22.4%	

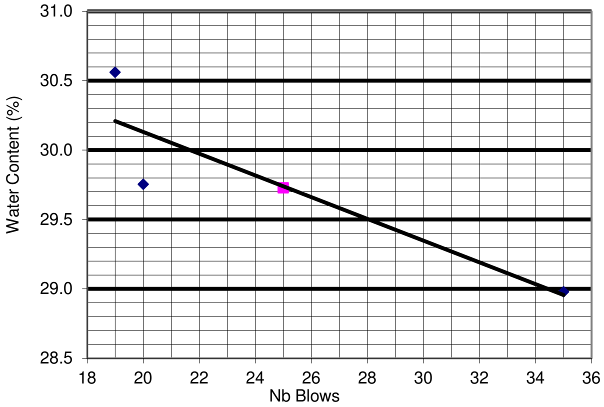
Natural Water Content (W^n):

Tare no.	W89	
Wet soil+tare, g	30.5	
Dry soil+tare, g	28.6	
Mass of water, g	1.90	
Tare, g	1.30	
Mass of soil, g	27.30	
Water content %	7.0%	

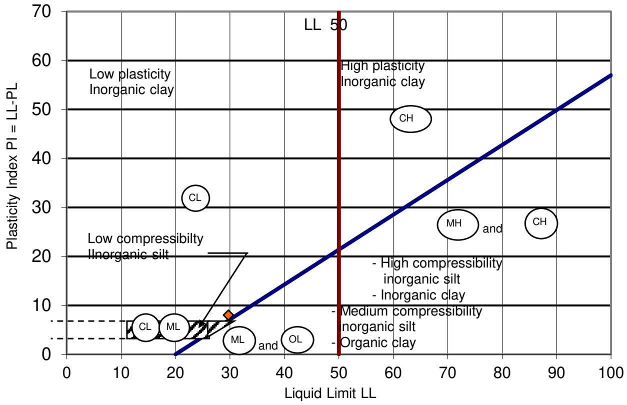
Soil Preparation:

☑ Cohesive <425 µm
☐ Cohesive >425 µm
☐ Non-cohesive
☑ Dry preparation
☐ Wet preparation

Results



Soil Plasticity Chart



Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
30	22	8	7

Remarks:

Performed by: Sharif Hossain
Date: 12/27/2019

Verified by: Raj Kadia, C.E.T.
Date: 12/31/2019

Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D4318)

Client: Infrastructure Ontario (IO)
Lab no.: G2256
Project/Site: Preliminary Geotechnical Investigation – Childrens Hospital of Eastern Ontario, Ottawa, Ontario
Project no.: 11205379

Borehole no.: BH8
Sample no.: SS2
Depth: 0.8m- 1.4m
Soil description: Low Compressibiity Inorganic Silt (CL-ML)
Date sampled: 28-Nov-19

Apparatus: Hand Crank
Balance no.: 1
Porcelain bowl no.: 1
Liquid limit device no.: 2
Oven no.: 2
Spatula no.: 1
Sieve no.: 40
Glass plate no.: 1

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows	28	27	18
Water Content:			
Tare no.	A11	A9	A16
Wet soil+tare, g	25.69	27.66	29.73
Dry soil+tare, g	23.34	24.96	26.50
Mass of water, g	2.35	2.70	3.23
Tare, g	13.35	13.34	13.43
Mass of soil, g	9.99	11.62	13.07
Water content %	23.5%	23.2%	24.7%

Plastic Limit (PL) - Water Content:

Tare no.	A20	A10
Wet soil+tare, g	21.21	20.11
Dry soil+tare, g	19.94	19.07
Mass of water, g	1.27	1.04
Tare, g	13.23	13.63
Mass of soil, g	6.71	5.44
Water content %	18.9%	19.1%
Average water content %	19.0%	

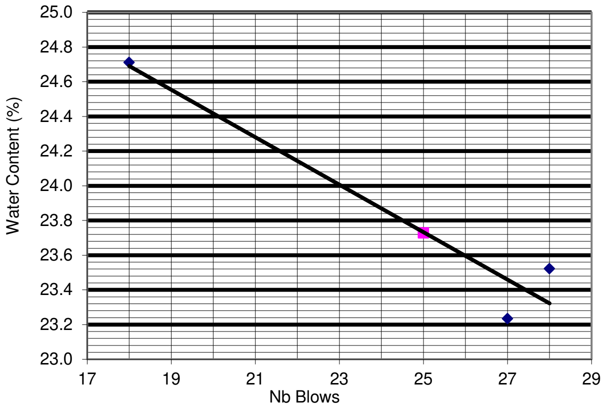
Natural Water Content (W^n):

Tare no.	C97	
Wet soil+tare, g	31.8	
Dry soil+tare, g	29.1	
Mass of water, g	2.70	
Tare, g	1.30	
Mass of soil, g	27.80	
Water content %	9.7%	

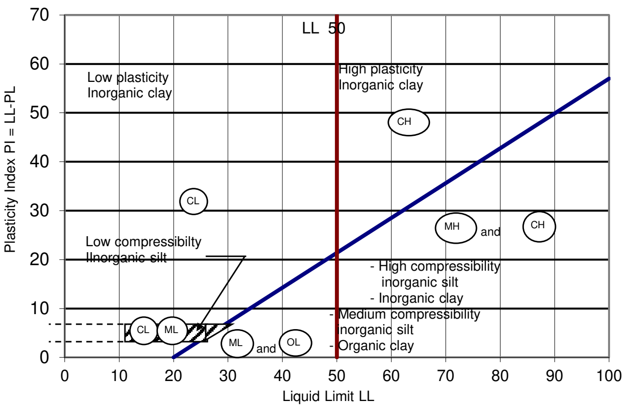
Soil Preparation:

☑ Cohesive <425 µm
☑ Dry preparation
☐ Cohesive >425 µm
☐ Wet preparation
☐ Non-cohesive

Results



Soil Plasticity Chart



Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
24	19	5	10

Remarks:

Performed by: Sharif Hossain
Date: 12/27/2019

Verified by: Raj Kadia, C.E.T.
Date: 12/31/2019

Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D4318)

Client:	Infrastructure Ontario (IO)	Lab no.:	G2256
Project/Site:	Preliminary Geotechnical Investigation – Childrens Hospital of Eastern Ontario, Ottawa, Ontario	Project no.:	11205379

Borehole no.:	MW9	Sample no.:	SS2+SS3	Depth:	0.8m- 2.0m
Soil description:	Low Compressibiity Inorganic Silt (CL-ML)			Date sampled:	28-Nov-19

Apparatus:	Hand Crank	Balance no.:	1	Porcelain bowl no.:	1
Liquid limit device no.:	2	Oven no.:	2	Spatula no.:	1
Sieve no.:	40	Glass plate no.:	1		

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows	25	22	16
Water Content:			
Tare no.	A14	A12	A28
Wet soil+tare, g	23.85	26.05	31.69
Dry soil+tare, g	21.68	23.42	27.71
Mass of water, g	2.17	2.63	3.98
Tare, g	13.47	13.77	13.53
Mass of soil, g	8.21	9.65	14.18
Water content %	26.4%	27.3%	28.1%

Plastic Limit (PL) - Water Content:

Tare no.	A71	A22
Wet soil+tare, g	19.51	19.57
Dry soil+tare, g	18.49	18.54
Mass of water, g	1.02	1.03
Tare, g	13.34	13.44
Mass of soil, g	5.15	5.10
Water content %	19.8%	20.2%
Average water content %	20.0%	

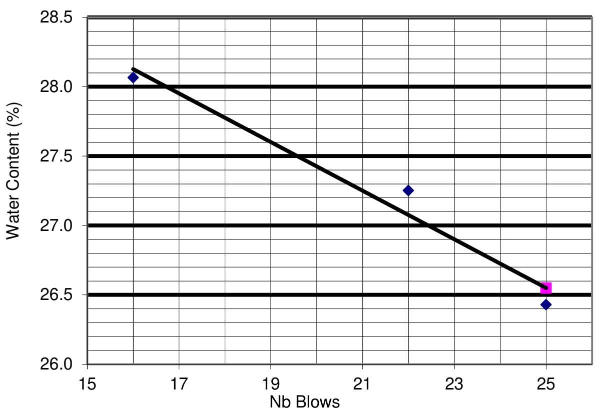
Natural Water Content (W^n):

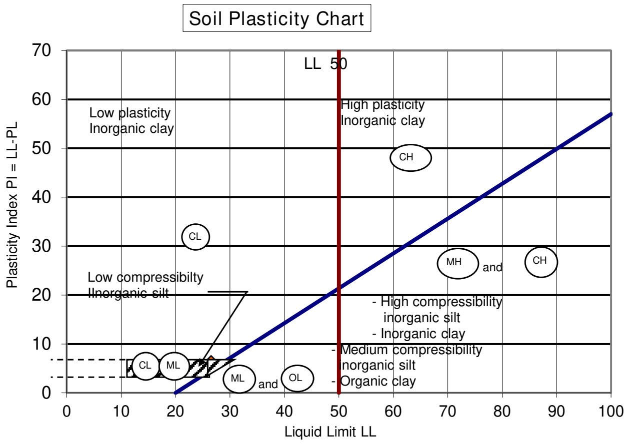
Tare no.	W29	
Wet soil+tare, g	23.6	
Dry soil+tare, g	21.7	
Mass of water, g	1.90	
Tare, g	1.30	
Mass of soil, g	20.40	
Water content %	9.3%	

Soil Preparation:

☑ Cohesive <425 µm
☐ Cohesive >425 µm
☐ Non-cohesive
☑ Dry preparation
☐ Wet preparation

Results





Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
27	20	7	9

Remarks:

Performed by:	Sharif Hossain	Date:	12/27/2019
Verified by:	Raj Kadia, C.E.T.	Date:	12/31/2019

Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D4318)

Client: Infrastructure Ontario (IO)
Lab no.: G2253
Project/Site: Preliminary Geotechnical Investigation – Childrens Hospital of Eastern Ontario, Ottawa, Ontario
Project no.: 11205379

Borehole no.: MW10
Sample no.: SS2
Depth: 0.8m- 1.4m
Soil description: Inorganic Silt (ML)
Date sampled: 28-Nov-19

Apparatus: Hand Crank
Balance no.: 1
Porcelain bowl no.: 3
Liquid limit device no.: 2
Oven no.: 2
Spatula no.: 1
Sieve no.: 40
Glass plate no.: 1

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows	28	21	16
Water Content:			
Tare no.	A4	A26	A24
Wet soil+tare, g	19.22	33.10	27.75
Dry soil+tare, g	18.24	28.82	24.41
Mass of water, g	0.98	4.28	3.34
Tare, g	13.56	13.50	13.34
Mass of soil, g	4.68	15.32	11.07
Water content %	20.9%	27.9%	30.2%

Soil Preparation:

☑ Cohesive <425 µm
☐ Cohesive >425 µm
☐ Non-cohesive
☑ Dry preparation
☑ Wet preparation

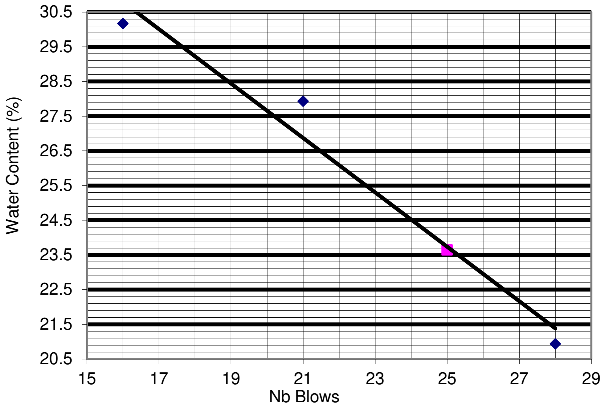
Plastic Limit (PL) - Water Content:

Tare no.	A27	A23
Wet soil+tare, g	19.22	22.51
Dry soil+tare, g	18.24	20.90
Mass of water, g	0.98	1.61
Tare, g	13.56	13.57
Mass of soil, g	4.68	7.33
Water content %	20.9%	22.0%
Average water content %	21.5%	

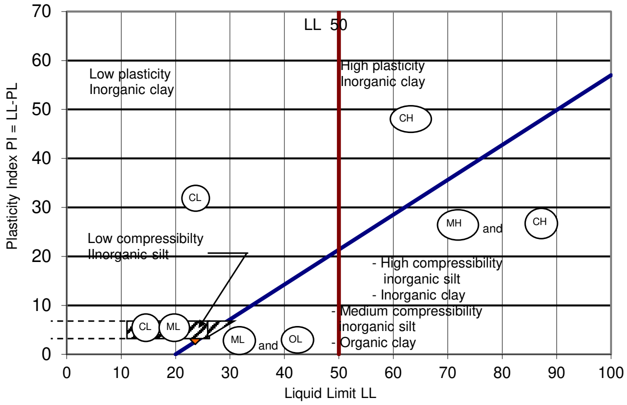
Natural Water Content (W^n):

Tare no.	E10	
Wet soil+tare, g	21.7	
Dry soil+tare, g	20.1	
Mass of water, g	1.60	
Tare, g	1.30	
Mass of soil, g	18.80	
Water content %	8.5%	

Results



Soil Plasticity Chart



Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
24	21	3	9

Remarks:

Performed by: Sharif Hossain
Date: 12/27/2019

Verified by: Raj Kadia, C.E.T.
Date: 12/31/2019

Liquid Limit, Plastic Limit and Plasticity Index of Soils
(ASTM D4318)

Client: Infrastructure Ontario (IO)
Lab no.: G2253
Project/Site: Preliminary Geotechnical Investigation – Childrens Hospital of Eastern Ontario, Ottawa, Ontario
Project no.: 11205379

Borehole no.: BH12
Sample no.: SS2+SS3
Depth: 0.8m- 2.1m
Soil description: Low Compressibility Inorganic Silt (CL-ML)
Date sampled: 28-Nov-19

Apparatus: Hand Crank
Balance no.: 1
Porcelain bowl no.: 3
Liquid limit device no.: 2
Oven no.: 2
Spatula no.: 1
Sieve no.: 40
Glass plate no.: 1

Liquid Limit (LL):

	Test No. 1	Test No. 2	Test No. 3
Number of blows	34	25	17
Water Content:			
Tare no.	A7	A17	A21
Wet soil+tare, g	26.98	27.17	25.65
Dry soil+tare, g	24.30	24.30	23.10
Mass of water, g	2.68	2.87	2.55
Tare, g	13.32	13.35	13.50
Mass of soil, g	10.98	10.95	9.60
Water content %	24.4%	26.2%	26.6%

Plastic Limit (PL) - Water Content:

Tare no.	A18	A25
Wet soil+tare, g	21.35	20.11
Dry soil+tare, g	20.07	18.99
Mass of water, g	1.28	1.12
Tare, g	13.64	13.42
Mass of soil, g	6.43	5.57
Water content %	19.9%	20.1%
Average water content %	20.0%	

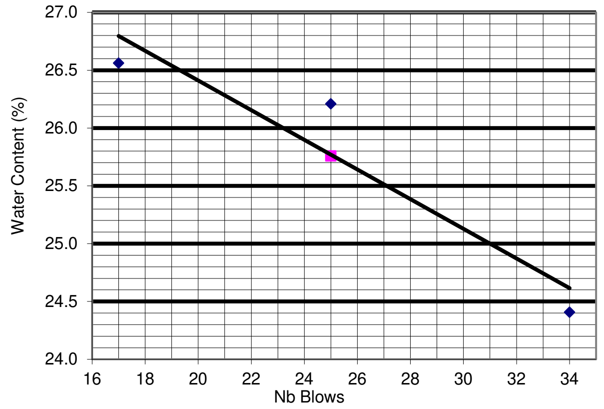
Natural Water Content (W^n):

Tare no.	E6	
Wet soil+tare, g	32.5	
Dry soil+tare, g	31.2	
Mass of water, g	1.30	
Tare, g	1.30	
Mass of soil, g	29.90	
Water content %	4.3%	

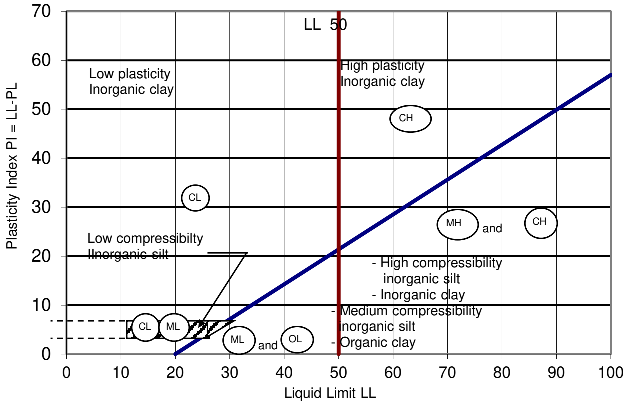
Soil Preparation:

☑ Cohesive <425 µm
☐ Cohesive >425 µm
☐ Non-cohesive
☑ Dry preparation
☐ Wet preparation

Results



Soil Plasticity Chart



Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Natural Water Content W^n
26	20	6	4

Remarks:

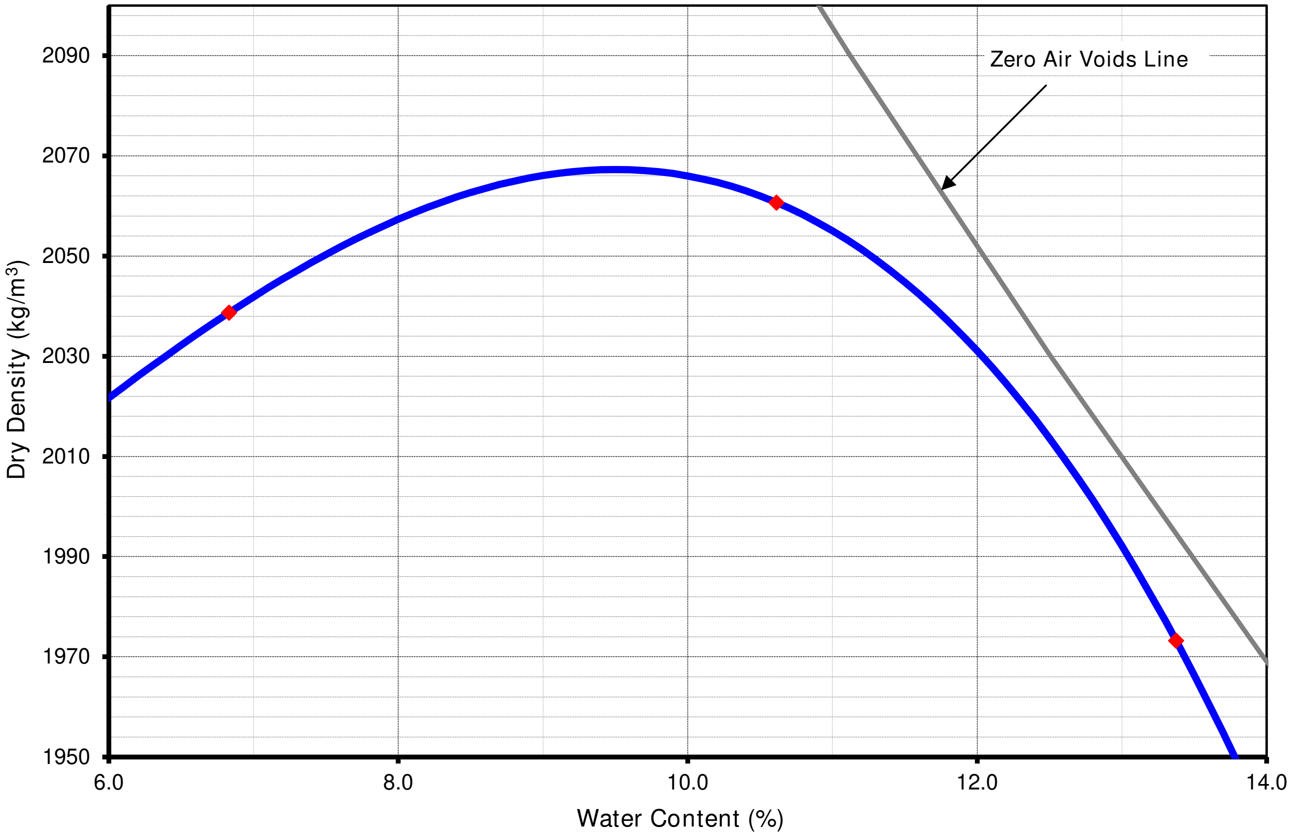
Performed by: Sharif Hossain
Date: 12/27/2019

Verified by: Raj Kadia, C.E.T.
Date: 12/31/2019

Appendix B3
Proctor Test Results

Standard Proctor Test
(ASTM D698)

Client :	Infrastructure Ontario (IO)	Lab No :	S1912
Project/Site :	Preliminary Geotechnical Investigation – Children's Hospital of Eastern Ontario Campus	Project No :	11205379



Prepared Sample:	Dry	X	Moist	--			Assumed G_s:	2.80
ASTM D698 Test Method:	A	X	B	--	C	-	Type of Hammer:	Manual

Soil Type:	Fill
Material:	Augured Material
Proposed Use:	N/A
Sample Identification:	MW1
Sample Location:	N/A
Aggregate Supplier / Pit Name:	N/A
Sample Date:	December 9, 2019
Sampled By:	S.H

Max. Dry Density:	2067	kg/m³
Optimum Moisture:	9.5	%
% Retained on 19.0 mm:	0.0	%
Corrected Dry Density:	2067	kg/m³
Corrected Opt. Moist.:	9.5	%

Remarks :

Performed by :	Sharif Hossain	Date :	December 19, 2019
Verified by :	Raj Kadia, C.E.T.	Date :	December 31, 2019

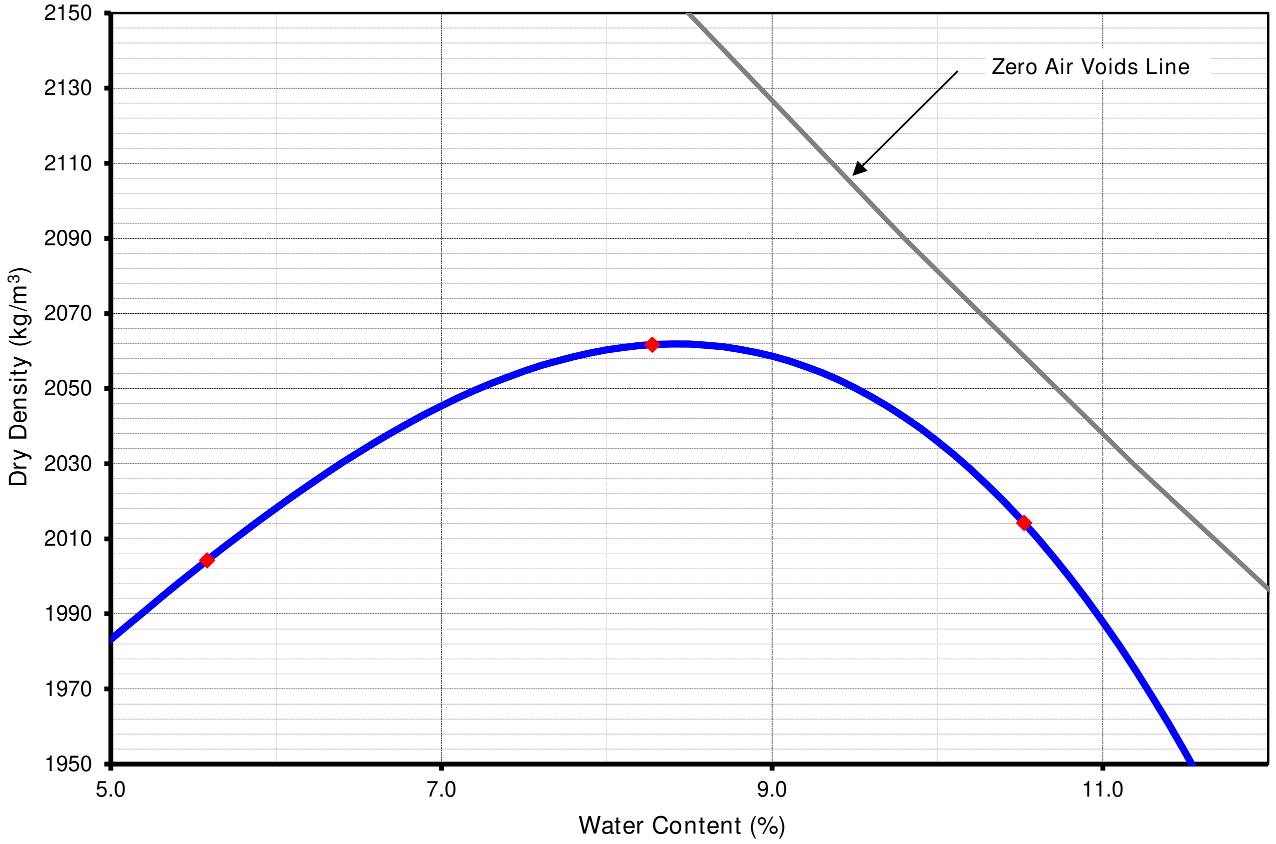
Standard Proctor Test
(ASTM D698)

Client : Infrastructure Ontario (IO)

Lab No : S1916

Project/Site : Preliminary Geotechnical Investigation – Children's Hospital of Eastern Ontario Campus

Project No : 11205379



Prepared Sample: Dry X Moist --

ASTM D698 Test Method: A X B -- C -

Assumed G_s: 2.70

Type of Hammer: Manual

Soil Type: Sandy Silt, Trace Gravel

Material: Augured Material

Proposed Use: N/A

Sample Identification: MW3-19

Sample Location: N/A

Aggregate Supplier / Pit Name: N/A

Sample Date: December 9, 2019

Sampled By: S.H

Max. Dry Density:	2062	kg/m^3
Optimum Moisture:	8.4	%
% Retained on 19.0 mm:	0.0	%
Corrected Dry Density:	2062	kg/m^3
Corrected Opt. Moist.:	8.4	%

Remarks :

Performed by : Sharif Hossain

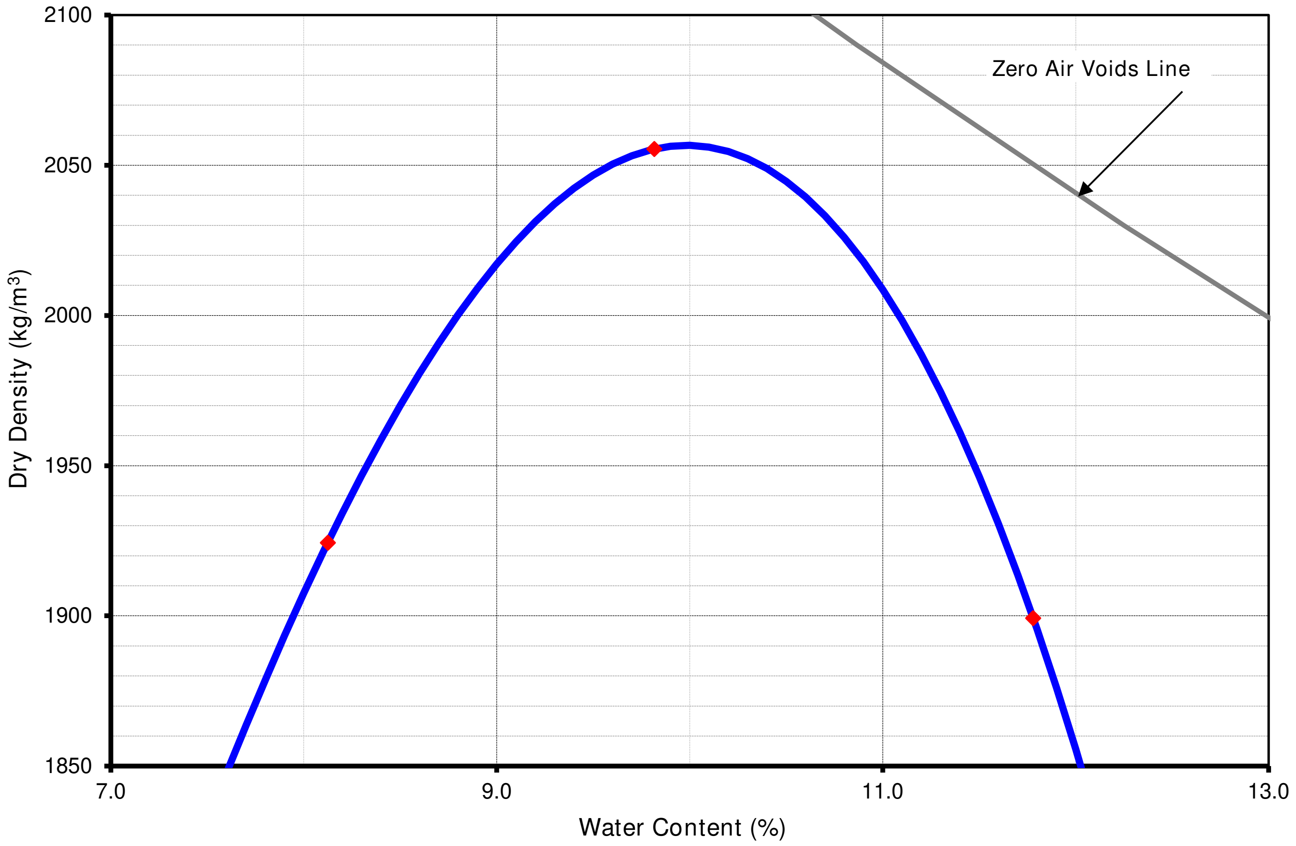
Date : December 19, 2019

Verified by : Raj Kadia, C.E.T.

Date : December 31, 2019

Standard Proctor Test
(ASTM D698)

Client :	Infrastructure Ontario (IO)	Lab No :	S1914
Project/Site :	Preliminary Geotechnical Investigation – Children's Hospital of Eastern Ontario Campus	Project No :	11205379



Prepared Sample:	Dry	X	Moist	--			Assumed G_s:	2.80
ASTM D698 Test Method:	A	X	B	--	C	-	Type of Hammer:	Manual

Soil Type:	Fill
Material:	Augured Sample
Proposed Use:	N/A
Sample Identification:	MW5
Sample Location:	N/A
Aggregate Supplier / Pit Name:	N/A
Sample Date:	December 9, 2019
Sampled By:	S.H

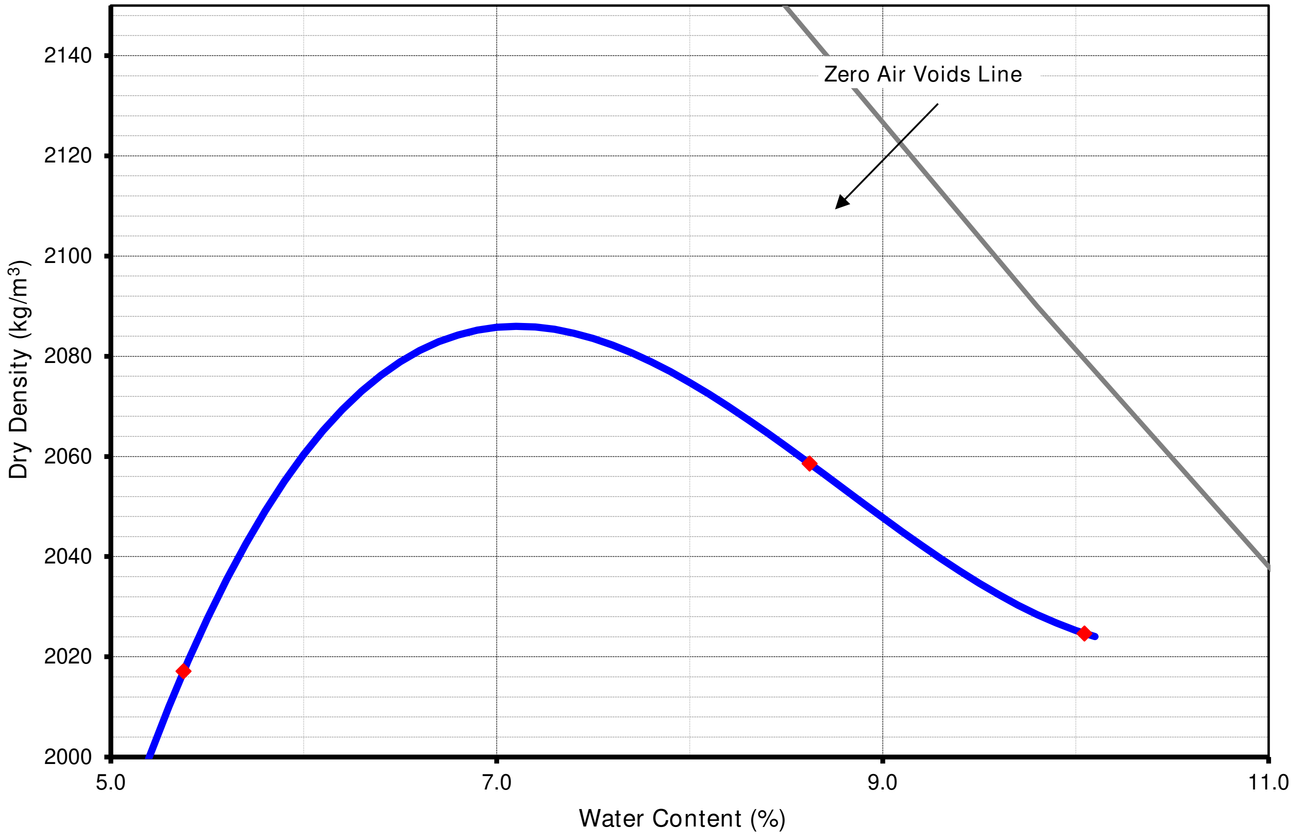
Max. Dry Density:	2057	kg/m^3
Optimum Moisture:	10.0	%
% Retained on 19.0 mm:	0.0	%
Corrected Dry Density:	2057	kg/m^3
Corrected Opt. Moist.:	10.0	%

Remarks :

Performed by :	Basharat Ali	Date :	December 17, 2019
Verified by :	Raj Kadia, C.E.T.	Date :	December 20, 2019

Standard Proctor Test
(ASTM D698)

Client :	Infrastructure Ontario (IO)	Lab No :	S1913
Project/Site :	Preliminary Geotechnical Investigation – Children's Hospital of Eastern Ontario Campus	Project No :	11205379



Prepared Sample:	Dry	X	Moist	--		Assumed G_s:	2.80
ASTM D698 Test Method:	A	X	B	--	C -	Type of Hammer:	Manual

Soil Type:	Fill
Material:	Augured Material
Proposed Use:	N/A
Sample Identification:	BH6
Sample Location:	
Aggregate Supplier / Pit Name:	N/A
Sample Date:	December 9, 2019
Sampled By:	S.H

Max. Dry Density:	2086	kg/m^3
Optimum Moisture:	7.1	%
% Retained on 19.0 mm:	0.0	%
Corrected Dry Density:	2086	kg/m^3
Corrected Opt. Moist.:	7.1	%

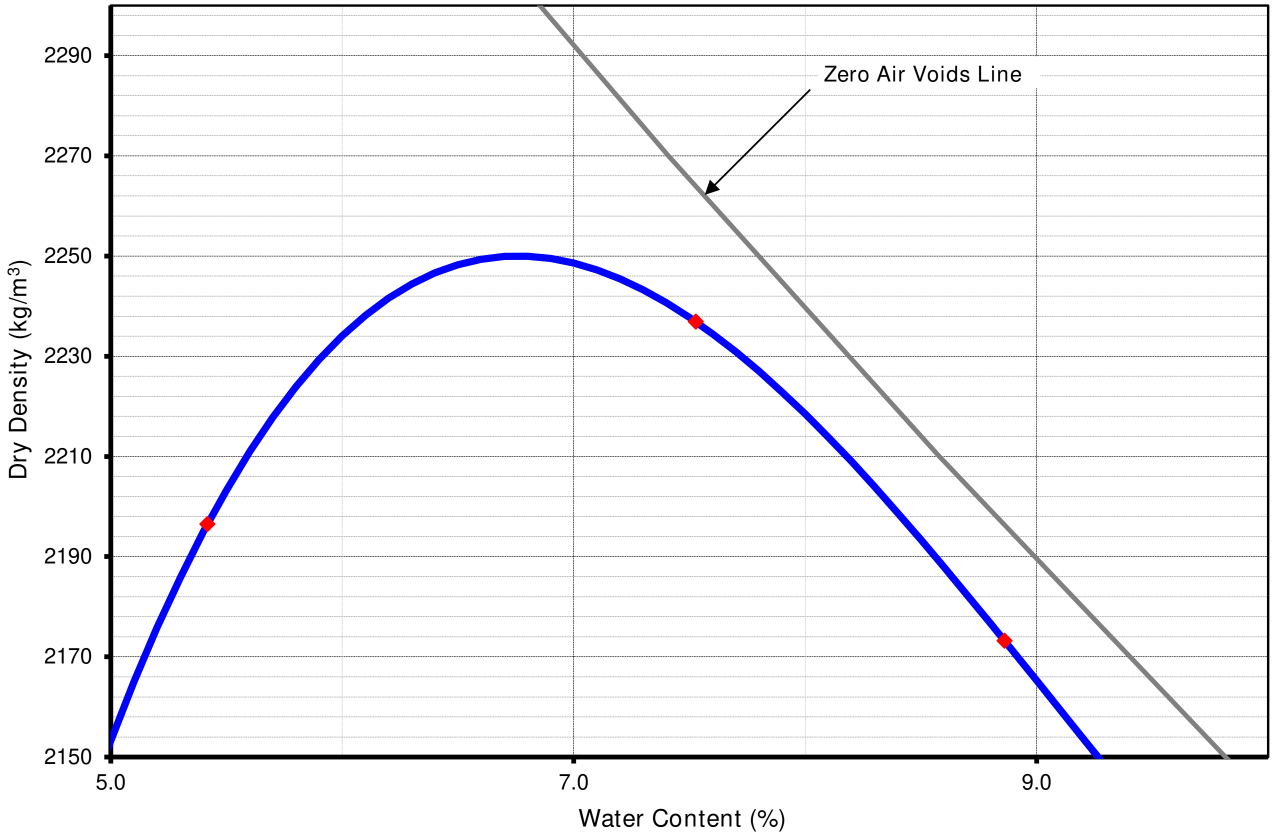
Remarks :

Performed by :	Sharif Hossain	Date :	December 17, 2019
Verified by :	Raj Kadia, C.E.T.	Date :	December 31, 2019

Standard Proctor Test
(ASTM D698)

Client : Infrastructure Ontario (IO)
Lab No : S1917

Project/Site : Preliminary Geotechnical Investigation – Children's Hospital of Eastern Ontario Campus
Project No : 11205379



Prepared Sample: Dry ☒ Moist --
Assumed G_s: 2.80

ASTM D698 Test Method: A ☒ B -- C -
Type of Hammer: Manual

Soil Type: Fill
Material: Augured Material
Proposed Use: N/A
Sample Identification: BH12
Sample Location:
Aggregate Supplier / Pit Name: N/A
Sample Date: December 9, 2019
Sampled By: S.H

Max. Dry Density:	2250	kg/m^3
Optimum Moisture:	6.8	%
% Retained on 19.0 mm:	0.7	%
Corrected Dry Density:	2250	kg/m^3
Corrected Opt. Moist.:	6.8	%

Remarks :

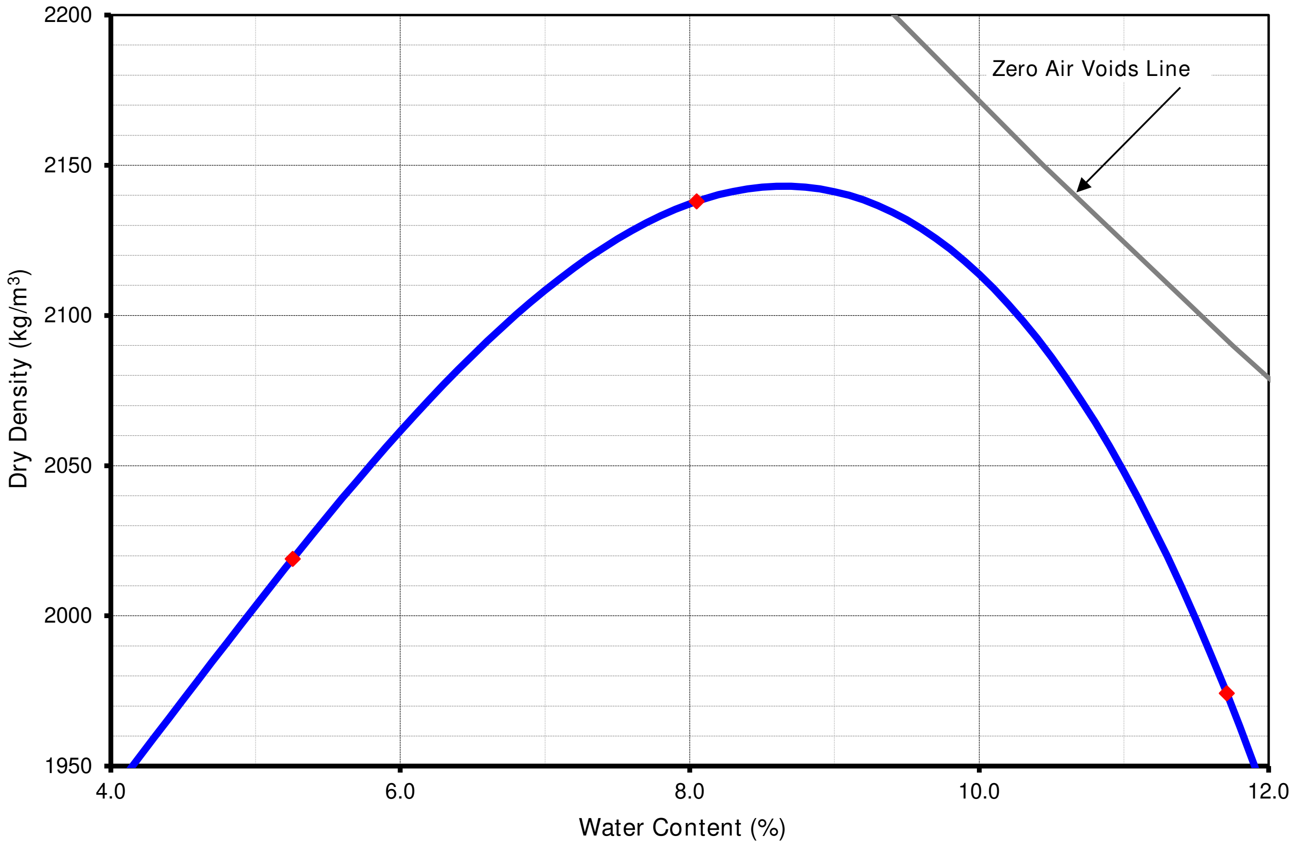
Performed by : B.Ali
Date : December 14, 2019

Verified by : Raj Kadia, C.E.T.
Date : December 31, 2019

Standard Proctor Test
(ASTM D698)

Client : Infrastructure Ontario (IO)
Lab No : S1910

Project/Site : Preliminary Geotechnical Investigation – Children's Hospital of Eastern Ontario Campus
Project No : 11205379



Prepared Sample: Dry ☒ X Moist ☐ --
Assumed G_s: 2.80

ASTM D698 Test Method: A ☒ X B ☐ -- C ☐ -
Type of Hammer: Manual

Soil Type: Fill
Material: Augured Material
Proposed Use: N/A
Sample Identification: BH13
Sample Location:
Aggregate Supplier / Pit Name: N/A
Sample Date: December 12, 2019
Sampled By: Simon

Max. Dry Density:	2143	kg/m^3
Optimum Moisture:	8.7	%
% Retained on 19.0 mm:	0.0	%
Corrected Dry Density:	2143	kg/m^3
Corrected Opt. Moist.:	8.7	%

Remarks :

Performed by : Sharif Hossain
Date : December 17, 2019

Verified by : Raj Kadia, C.E.T.
Date : December 31, 2019

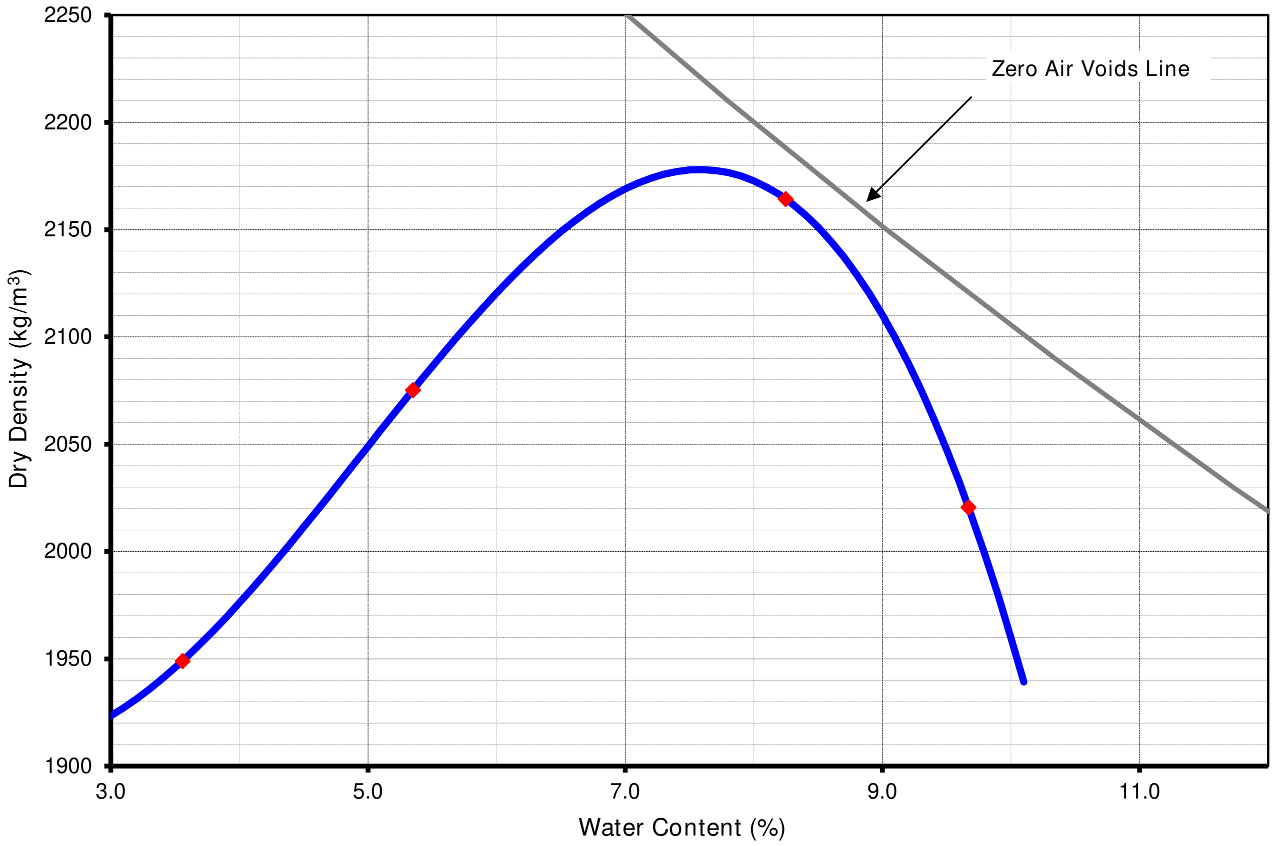
Standard Proctor Test
(ASTM D698)

Client : Infrastructure Ontario (IO)

Lab No : S1919

Project/Site : Preliminary Geotechnical Investigation – Children's Hospital of Eastern Ontario Campus

Project No : 11205379



Prepared Sample: Dry ☒ Moist --

Assumed G_s: 2.80

ASTM D698 Test Method: A ☒ B -- C -

Type of Hammer: Manual

Soil Type: Fill

Material: Augured Material

Proposed Use: N/A

Sample Identification: BH14

Sample Location: Depth 0' to 2'

Aggregate Supplier / Pit Name: N/A

Sample Date: December 9, 2019

Sampled By: S.H

Max. Dry Density:	2178	kg/m^3
Optimum Moisture:	7.6	%
% Retained on 19.0 mm:	0.0	%
Corrected Dry Density:	2178	kg/m^3
Corrected Opt. Moist.:	7.6	%

Remarks :

Performed by : Sharif Hossain

Date : December 12, 2019

Verified by : Raj Kadia, C.E.T.

Date : December 31, 2019

Appendix B4

Uniaxial Compression Strength Test Results of Rock

Uniaxial Compressive Strength of Intact Rock Core Specimens
(ASTM D7012 - Method C)

CLIENT: Infrastructure Ontario

LAB No.: WLT 293-1

PROJECT/ SITE: Preliminary Geotechnical Investigation: 401 Smyth Road, Ottawa, ON

PROJECT No.: 11205379

Borehole No.: MW2

Sampled ID: n/a

Depth: 5.13 m

Date Sampled: n/a

Lithologic Description: Shale

Initial Specimen Parameters	
Diameter, cm	6.3
Height, cm	12.8
Height-to-Diameter Ratio	2.0
Volume, cm^3	391.7
Mass, g	1042.0
Bulk Density, kg/m^3	2661
Moisture Condition	As Received
Moisture Content, %	2.0

Maximum Applied Load, kN	110.3
Compressive Strength, MPa	35.9

REMARKS:

PERFORMED BY: M. Mitchell

DATE: December 3, 2019

VERIFIED BY: Michael Braverman

DATE: December 16, 2019

Uniaxial Compressive Strength of Intact Rock Core Specimens
(ASTM D7012 - Method C)

CLIENT: Infrastructure Ontario

LAB No.: WLT 293-2

PROJECT/ SITE: Preliminary Geotechnical Investigation: 401 Smyth Road, Ottawa, ON

PROJECT No.: 11205379

Borehole No.: MW2

Sampled ID: -

Depth: 7.67 m

Date Sampled: n/a

Lithologic Description: Shale

Initial Specimen Parameters	
Diameter, cm	6.2
Height, cm	13.1
Height-to-Diameter Ratio	2.1
Volume, cm^3	402.4
Mass, g	1067.1
Bulk Density, kg/m^3	2652
Moisture Condition	As Received
Moisture Content, %	2.3

Maximum Applied Load, kN	96.2
Compressive Strength, MPa	31.4

REMARKS:

PERFORMED BY: M. Mitchell

DATE: December 3, 2019

VERIFIED BY: Michael Braverman

DATE: December 16, 2019

Uniaxial Compressive Strength of Intact Rock Core Specimens
(ASTM D7012 - Method C)

CLIENT:	Infrastructure Ontario	**LAB No.:**	WLT 293-3
PROJECT/ SITE:	Preliminary Geotechnical Investigation: 401 Smyth Road, Ottawa	**PROJECT No.:**	11205379

Borehole No.:	MW2	**Sampled ID:**	-
Depth:	9.70 m	**Date Sampled:**	n/a
Lithologic Description:	Shale		

Initial Specimen Parameters	
Diameter, cm	6.2
Height, cm	12.8
Height-to-Diameter Ratio	2.1
Volume, cm^3	393.6
Mass, g	1052.9
Bulk Density, kg/m^3	2675
Moisture Condition	As Received
Moisture Content, %	2.0

Maximum Applied Load, kN	75.0
Compressive Strength, MPa	24.4

REMARKS:

PERFORMED BY:	M. Mitchell	**DATE:**	December 3, 2019
VERIFIED BY:	Michael Braverman	**DATE:**	December 16, 2019

Uniaxial Compressive Strength of Intact Rock Core Specimens
(ASTM D7012 - Method C)

CLIENT: Infrastructure Ontario

LAB No.: WLT 293-4

PROJECT/ SITE: Preliminary Geotechnical Investigation: 401 Smyth Road, Ottawa, ON

PROJECT No.: 11205379

Borehole No.: MW3

Sampled ID: -

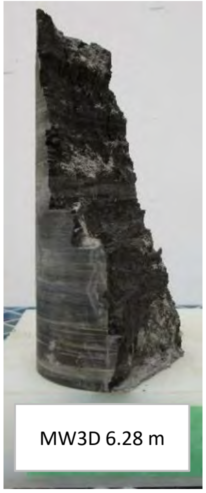
Depth: 6.28 m

Date Sampled: n/a

Lithologic Description: Shale

Initial Specimen Parameters	
Diameter, cm	6.3
Height, cm	13.1
Height-to-Diameter Ratio	2.1
Volume, cm^3	401.6
Mass, g	1067.4
Bulk Density, kg/m^3	2658
Moisture Condition	As Received
Moisture Content, %	2.1

Maximum Applied Load, kN	87.2
Compressive Strength, MPa	28.4



REMARKS:

PERFORMED BY: M. Mitchell

DATE: December 3, 2019

VERIFIED BY: Michael Braverman

DATE: December 16, 2019

Uniaxial Compressive Strength of Intact Rock Core Specimens
(ASTM D7012 - Method C)

CLIENT:	Infrastructure Ontario	**LAB No.:**	WLT 293-5
PROJECT/ SITE:	Preliminary Geotechnical Investigation: 401 Smyth Road, Ottawa. ON	**PROJECT No.:**	11205379

Borehole No.:	MW3	**Sampled ID:**	-
Depth:	7.83 m	**Date Sampled:**	n/a

Lithologic Description: Shale

Initial Specimen Parameters	
Diameter, cm	6.3
Height, cm	12.8
Height-to-Diameter Ratio	2.0
Volume, cm^3	394.0
Mass, g	1041.1
Bulk Density, kg/m^3	2642
Moisture Condition	As Received
Moisture Content, %	2.2

Maximum Applied Load, kN	103.2
Compressive Strength, MPa	33.5

REMARKS:

PERFORMED BY:	M. Mitchell	**DATE:**	December 3, 2017
VERIFIED BY:	Michael Braverman	**DATE:**	December 16, 2019

Uniaxial Compressive Strength of Intact Rock Core Specimens
(ASTM D7012 - Method C)

CLIENT:	Infrastructure Ontario	**LAB No.:**	WLT 293-6
PROJECT/ SITE:	Preliminary Geotechnical Investigation: 401 Smyth Road, Ottawa	**PROJECT No.:**	11205379

Borehole No.:	MW3	**Sampled ID:**	-
Depth:	10.27 m	**Date Sampled:**	n/a

Lithologic Description: Shale

Initial Specimen Parameters	
Diameter, cm	6.3
Height, cm	12.4
Height-to-Diameter Ratio	2.0
Volume, cm^3	383.6
Mass, g	1036.8
Bulk Density, kg/m^3	2703
Moisture Condition	As Received
Moisture Content, %	1.8

Maximum Applied Load, kN	109.0
Compressive Strength, MPa	35.4

REMARKS:

PERFORMED BY:	M. Mitchell	**DATE:**	December 3, 2019
VERIFIED BY:	Michael Braverman	**DATE:**	December 16, 2019

Uniaxial Compressive Strength of Intact Rock Core Specimens
(ASTM D7012 - Method C)

CLIENT: Infrastructure Ontario

LAB No.: WLT 293-7

PROJECT/ SITE: Preliminary Geotechnical Investigation: 401 Smyth Road, Ottawa

PROJECT No.: 11205379

Borehole No.: MW4

Sampled ID: -

Depth: 3.26 m

Date Sampled: n/a

Lithologic Description: Shale

Initial Specimen Parameters	
Diameter, cm	6.2
Height, cm	12.5
Height-to-Diameter Ratio	2.0
Volume, cm^3	383.9
Mass, g	1023.1
Bulk Density, kg/m^3	2665
Moisture Condition	As Received
Moisture Content, %	2.2

Maximum Applied Load, kN	128.0
Compressive Strength, MPa	41.8

REMARKS:

PERFORMED BY: M. Mitchell

DATE: December 3, 2019

VERIFIED BY: Michael Braverman

DATE: December 16, 2019

Uniaxial Compressive Strength of Intact Rock Core Specimens
(ASTM D7012 - Method C)

CLIENT: Infrastructure Ontario **LAB No.:** WLT 293-8

PROJECT/ SITE: Preliminary Geotechnical Investigation: 401 Smyth Road, Ottawa **PROJECT No.:** 11205379

Borehole No.: MW4 **Sampled ID:** -

Depth: 6.38 m **Date Sampled:** n/a

Lithologic Description: Shale

Initial Specimen Parameters	
Diameter, cm	6.3
Height, cm	12.5
Height-to-Diameter Ratio	2.0
Volume, cm^3	384.0
Mass, g	1020.3
Bulk Density, kg/m^3	2657
Moisture Condition	As Received
Moisture Content, %	1.8

Maximum Applied Load, kN	87.5
Compressive Strength, MPa	28.5

REMARKS:

PERFORMED BY: M. Mitchell **DATE:** December 3, 2019

VERIFIED BY: Michael Braverman **DATE:** December 16, 2019

Uniaxial Compressive Strength of Intact Rock Core Specimens
(ASTM D7012 - Method C)

CLIENT:	Infrastructure Ontario	**LAB No.:**	WLT 293-9
PROJECT/ SITE:	Preliminary Geotechnical Investigation: 401 Smyth Road, Ottawa	**PROJECT No.:**	11205379

Borehole No.:	MW4	**Sampled ID:**	-
Depth:	7.58 m	**Date Sampled:**	n/a

Lithologic Description: Shale

Initial Specimen Parameters	
Diameter, cm	6.2
Height, cm	12.7
Height-to-Diameter Ratio	2.0
Volume, cm^3	390.5
Mass, g	1036.8
Bulk Density, kg/m^3	2655
Moisture Condition	As Received
Moisture Content, %	2.3

Maximum Applied Load, kN	93.5
Compressive Strength, MPa	30.5

REMARKS:

PERFORMED BY:	M. Mitchell	**DATE:**	December 3, 2019
VERIFIED BY:	Michael Braverman	**DATE:**	December 16, 2019

Appendix B5

Free Swell Test Results of Rock

FINAL REPORT

Results of Free Swell Tests on Shale of Georgian Bay Formation and Blue Mountain/Billings Formations

Children's Hospital of Eastern Ontario Campus – Preliminary Geotechnical Investigation
Ottawa, ON

Project No. 11205379

Prepared for:

GHD
111 Brunel Road Suite 200
Mississauga, ON

K. Y. Lo Inc.

April 21, 2020

TABLE OF CONTENT

Appendix

1. Introduction

K.Y. Lo Inc. was retained by GHD to test the swelling characteristics of shale cores of the Georgian Bay Formation and Blue Mountain/Billings Formations for the Children's Hospital of Eastern Ontario Campus – Preliminary Geotechnical Investigation project in Ottawa. Rock cores from boreholes MW2D, MW3D and MW4D were provided for testing. Four (4) free swell tests were requested by GHD to be performed on these rock cores; one from MW2D, one from MW3D and two from MW4D.

This report presents factual laboratory results of four (4) free swell tests completed on the received rock samples. The results of calcite content test, pore water salinity tests and water content tests done on the same rock samples are also included.

2. Methodology of Testing

2.1 Free Swell Test

Free swell test (FST) was performed using the method developed by Lo et al. (1978). In free swell tests, freshly trimmed rock specimen is permitted to deform unrestrictedly in all directions. A typical specimen for a free swell test is shown on Figure 1. The diameter-ratio of the cylindrical sample should be approximately one to one. However, sometimes it is controlled by availability of the rock core.

Three orthogonal dimensional changes of the specimen preserved under constant temperature and 100% relative humidity with direct access to fresh (tap) water, are measured with time. The "UWO deformation gauge" shown on Figure 1 is used to measure the dimensions of the two horizontal (X and Y) and vertical (axial/Z) directions for 100 days. Test data were plotted as strain vs. the logarithm (to the base of 10) of elapsed time.

2.2 Water Content, Salinity and Calcite Content Tests

The gravimetric method was used to measure water content of the rock sample. In this method the measurement of water content is direct, being simply the mass of water lost on drying in a convection oven at a temperature of 105°C until the mass remains constant.

It was experimentally established that shales need 4 days of drying to reach constant dry mass.

The salinity of rock pore fluid was determined by adding distilled water to the powdered rock sample and then centrifuging the mixture. The electrical conductivity of the supernatant of the centrifuged solution was measured using a conductivity meter (WTW TetraCon 325), and then converted to the salinity (salt concentration) expressed in grams per litre of pore water, NaCl equivalent.

Water content and salinity of each swell test specimen were measured before and after the test (after 100 days of swelling). Before a swell test, water content and salinity were measured on rock pieces adjacent to the swell test specimen. After swell test, water content and salinity tests were performed on the actual swell test specimen. The gasometric method using the Chittick apparatus (Dreimanis, 1962) was used to estimate the amount of calcite in the rock samples after swell test.

3. Results of Laboratory Testing

The results of free swell tests are presented on the attached graphs. The results of calcite content, water content and salinity tests performed before and after free swell tests are presented on the insert in each graph.

K.Y. Lo Inc.

Prepared by	Reviewed by
Silvana Micic, Ph.D., P.Eng.	Kwan Yee Lo, Ph.D., P.Eng., FEIC

4. References

Dreimans, A. 1962. Quantitative Gasometric Determination of Calcite and Dolomite Using Chittick Apparatus. Journal of Sedimentary Petrology, Vol. 32, pp. 520-529.

Lo, K.Y., Wai, R.S.C., Palmer, J.H.L. and Quigley, R.M. 1978. Time-dependent Deformation of Shaly Rocks in Southern Ontario. Canadian Geotechnical Journal, Vol. 15, pp. 537-547.

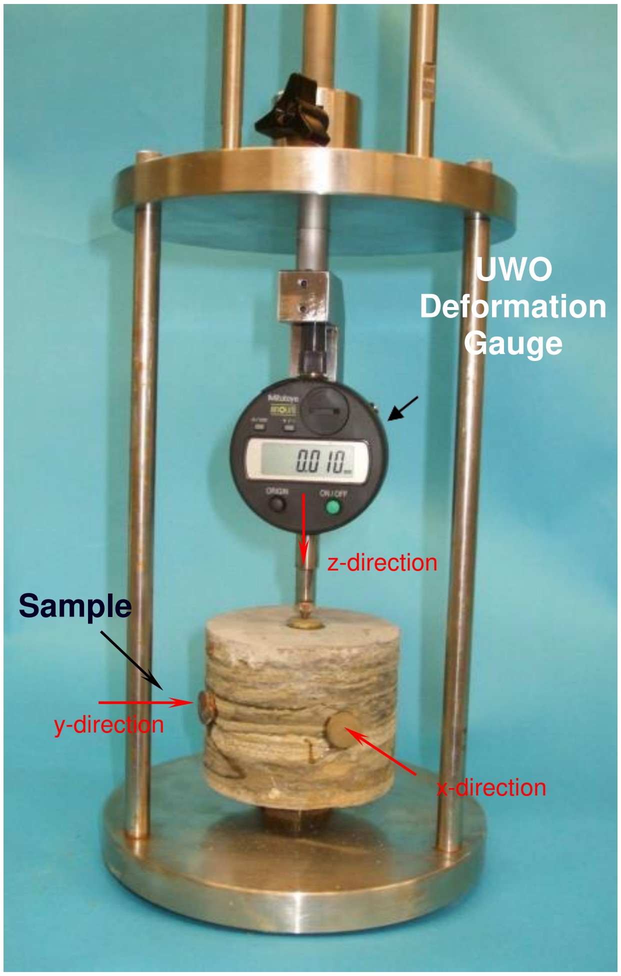


Figure 1. Typical set-up for free swell tests

.

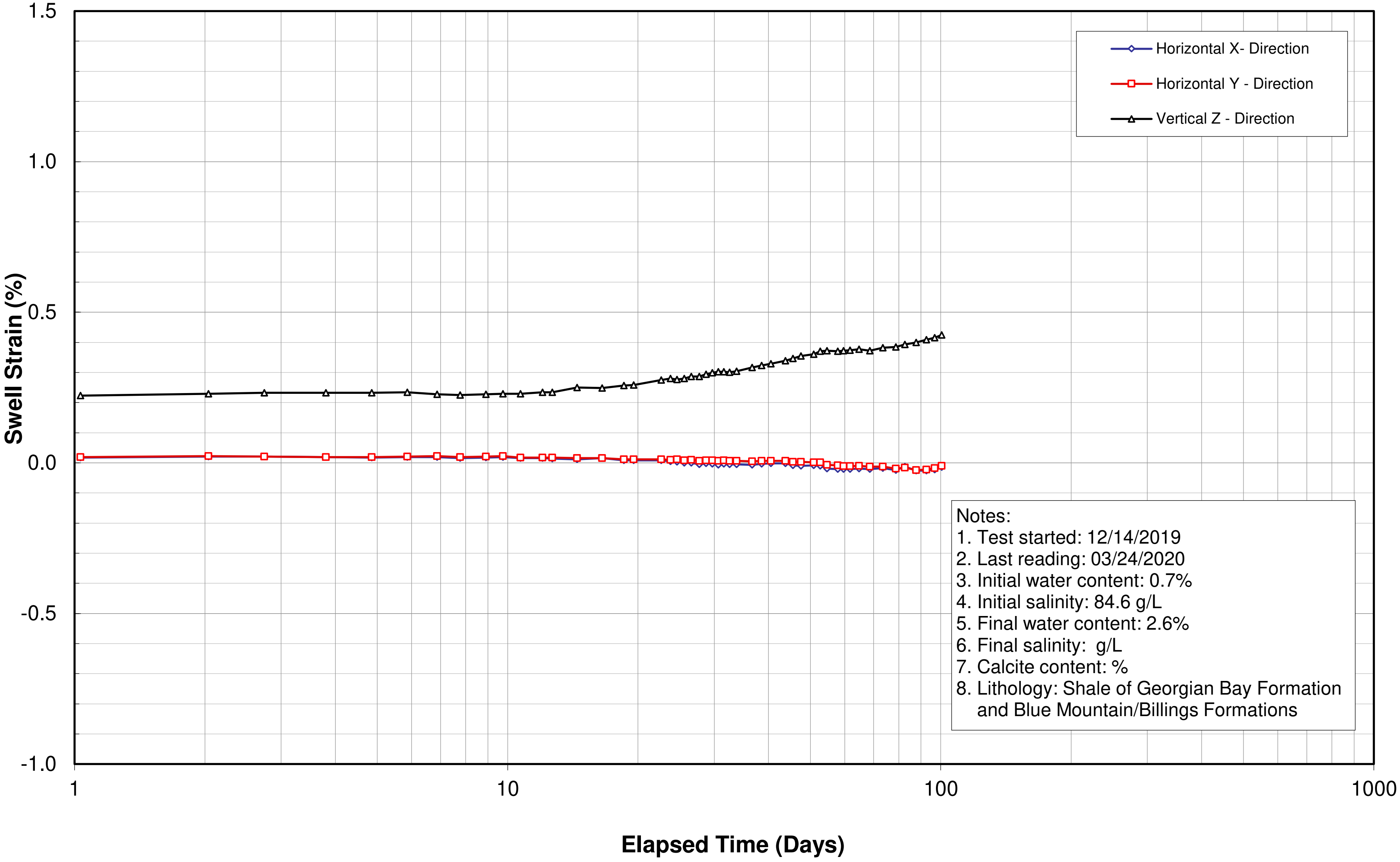
Appendix A – Results of Free Swell Tests

K.Y. Lo Inc.

Free Swell Test
Children's Hospital of Eastern Ontario Campus -
Preliminary Geotechnical Investigation, Ottawa

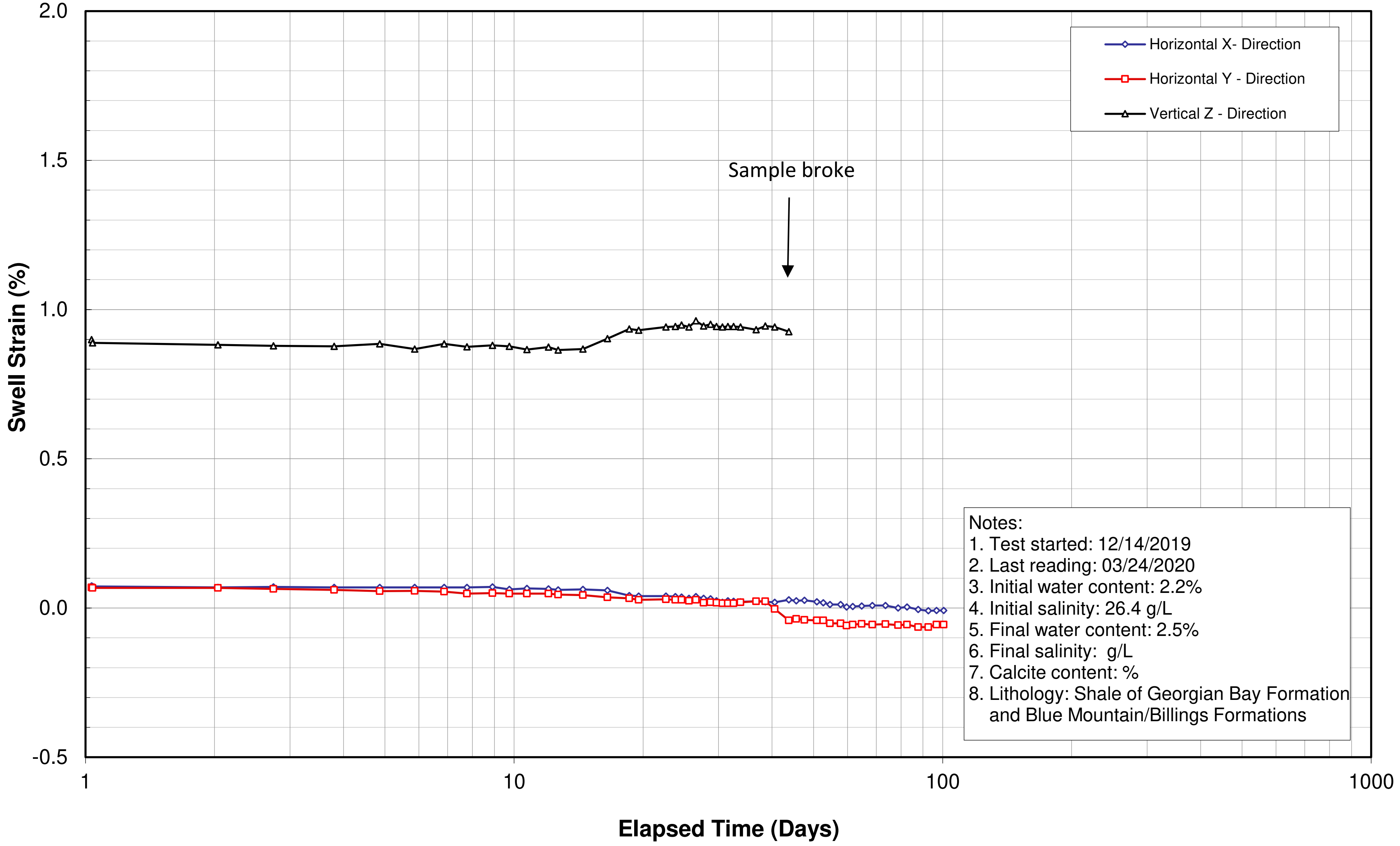
FST-MW2D-1

BH: MW2D; **Depth**: 4.38m - 4.44m



Notes:
1. Test started: 12/14/2019
2. Last reading: 03/24/2020
3. Initial water content: 0.7%
4. Initial salinity: 84.6 g/L
5. Final water content: 2.6%
6. Final salinity: g/L
7. Calcite content: %
8. Lithology: Shale of Georgian Bay Formation
   and Blue Mountain/Billings Formations

Free Swell Test
Children's Hospital of Eastern Ontario Campus - Preliminary Geotechnical Investigation, Ottawa
FST-MW3D-1
BH: MW3D; **Depth**: 4.85m - 4.91m

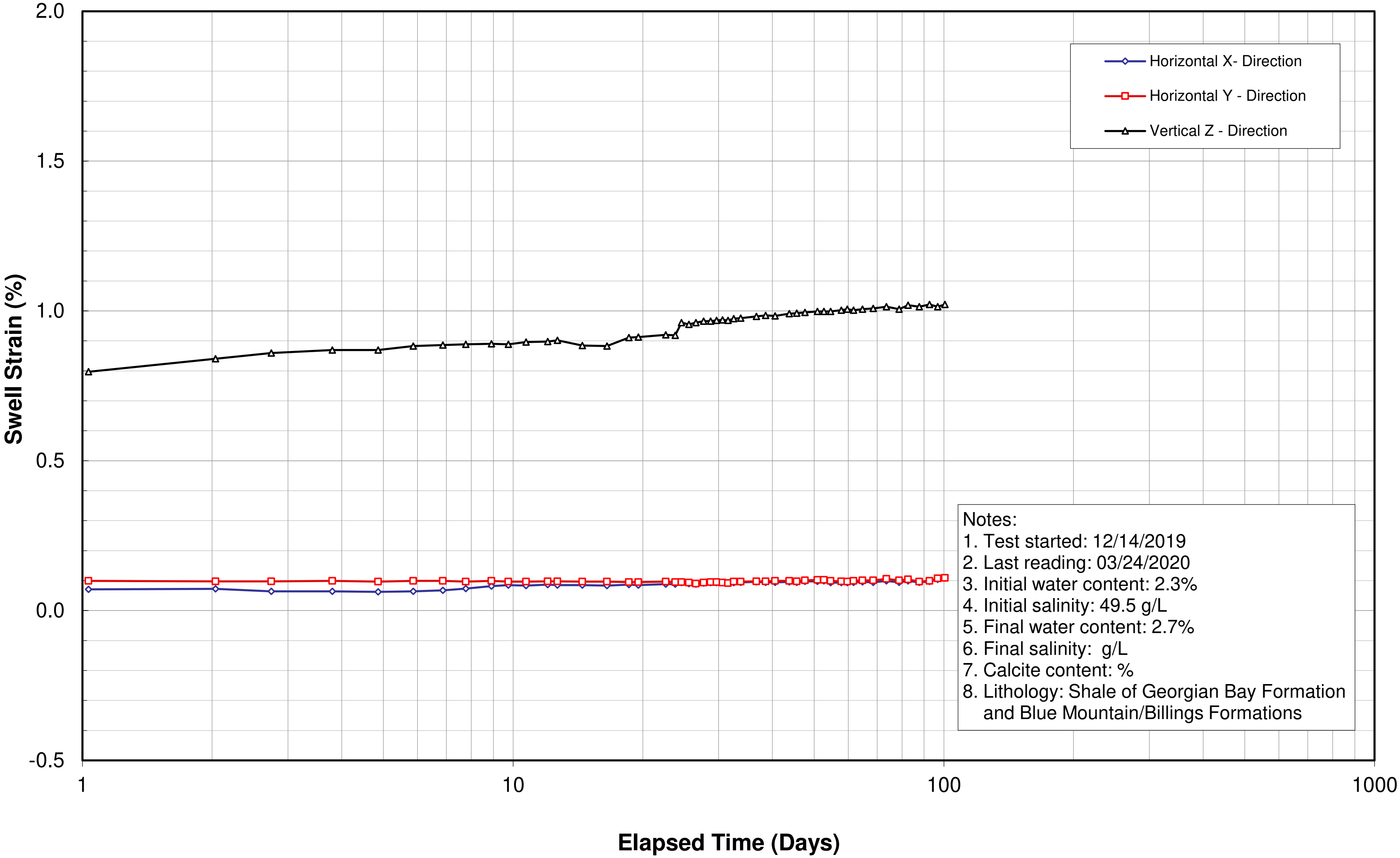


Sample broke

Notes:
1. Test started: 12/14/2019
2. Last reading: 03/24/2020
3. Initial water content: 2.2%
4. Initial salinity: 26.4 g/L
5. Final water content: 2.5%
6. Final salinity: g/L
7. Calcite content: %
8. Lithology: Shale of Georgian Bay Formation
   and Blue Mountain/Billings Formations

K.Y. Lo Inc.

Free Swell Test
Children's Hospital of Eastern Ontario Campus - Preliminary Geotechnical Investigation, Ottawa
FST-MW4D-1
BH: MW4D; **Depth**: 4.51m - 4.60m



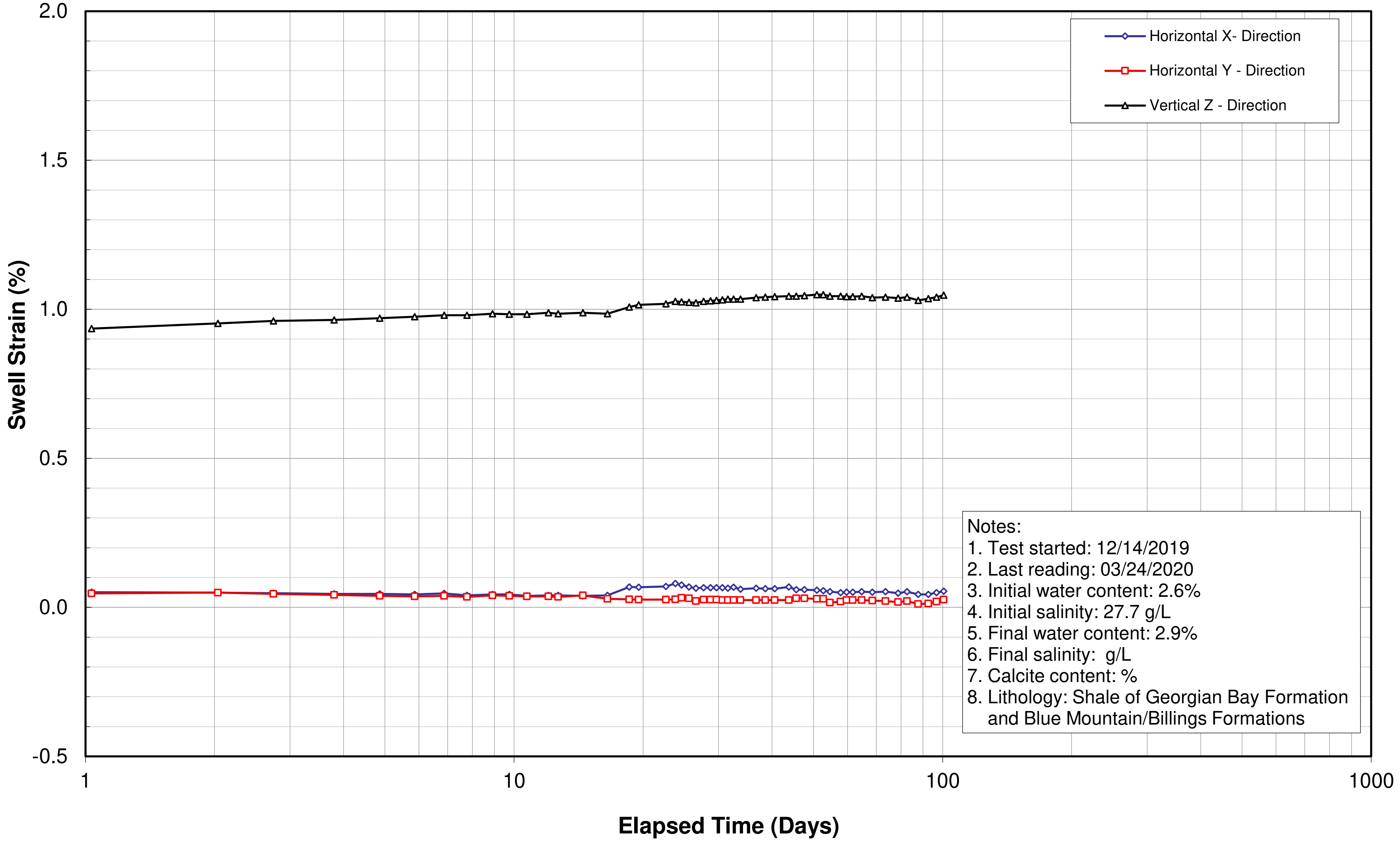
Notes:
1. Test started: 12/14/2019
2. Last reading: 03/24/2020
3. Initial water content: 2.3%
4. Initial salinity: 49.5 g/L
5. Final water content: 2.7%
6. Final salinity: g/L
7. Calcite content: %
8. Lithology: Shale of Georgian Bay Formation
   and Blue Mountain/Billings Formations

K.Y. Lo Inc.

Free Swell Test
Children's Hospital of Eastern Ontario Campus -
- Preliminary Geotechnical Investigation, Ottawa

FST-MW4D-2

BH: MW4D; **Depth**: 4.84m - 4.90m

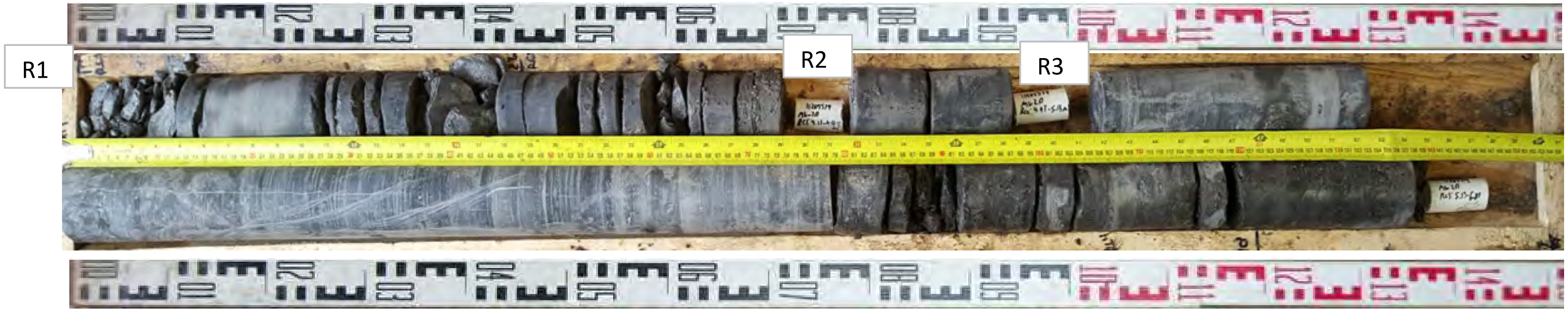


Notes:
1. Test started: 12/14/2019
2. Last reading: 03/24/2020
3. Initial water content: 2.6%
4. Initial salinity: 27.7 g/L
5. Final water content: 2.9%
6. Final salinity: g/L
7. Calcite content: %
8. Lithology: Shale of Georgian Bay Formation and Blue Mountain/Billings Formations

Appendix C

Rock Core Photographs

Rock Core Photo Log MW2



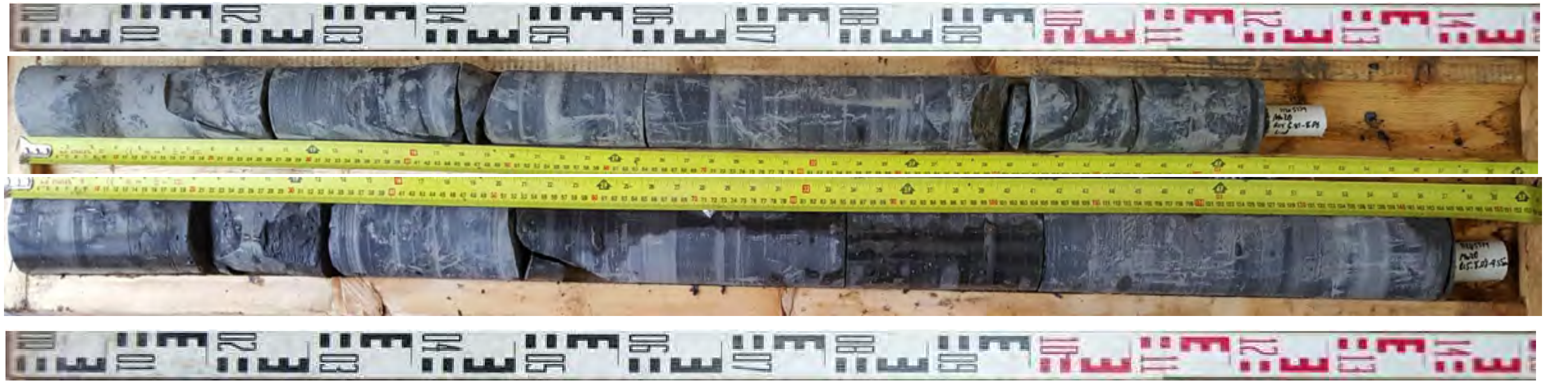
R1 (RUN 1): 4.12 m - 4.93 m
R2 (RUN 2): 4.93 m - 5.13 m
R3 (RUN 3): 5.13 m - 6.81 m

ROCK CORE PHOTO LOG MW2
Geotechnical Investigation - Infrastructure Ontario (I.O.)
Childrens Hospital of Eastern Ontario - 401 Smyth Road, Ottawa, Ontario

Prepared by: Omar Badaoui
Checked by: A.Sorour

Scale: As Shown
DATE: 09/01/2020
Reference No.: 11205379

Rock Core Photo Log MW2

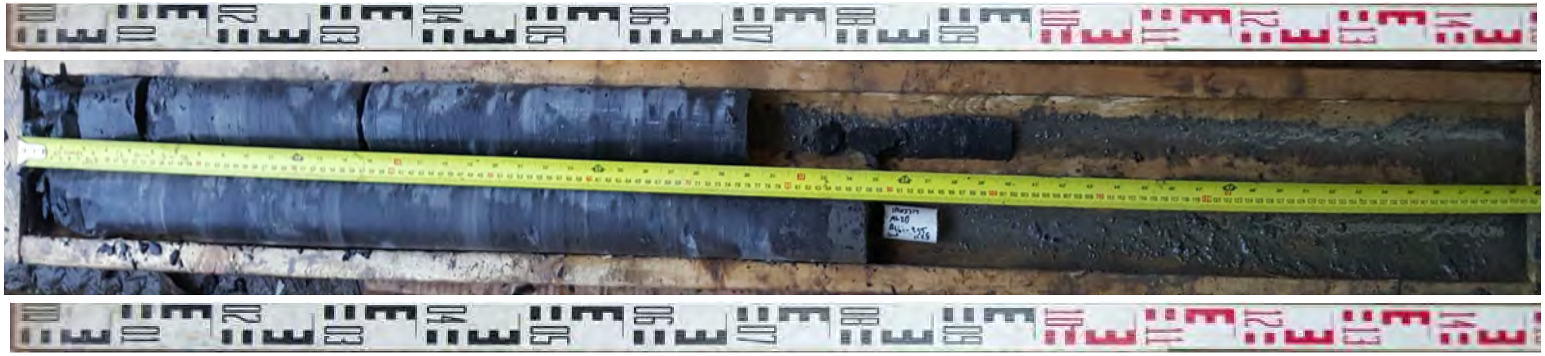


R4 (RUN 4): 6.81 m - 8.08 m
R5 (RUN 5): 8.08 m - 9.55 m

ROCK CORE PHOTO LOG MW2
Geotechnical Investigation - Infrastructure Ontario (I.O.)
Childrens Hospital of Eastern Ontario - 401 Smyth Road, Ottawa, Ontario

Prepared by: Omar Badaoui
Checked by: A.Sorour
Scale: As Shown
DATE: 09/01/2020
Reference No.: 11205379

Rock Core Photo Log MW2



R6 (RUN 6): 9.55 m - 11.28 m

ROCK CORE PHOTO LOG MW2
Geotechnical Investigation - Infrastructure Ontario (I.O.)
Childrens Hospital of Eastern Ontario - 401 Smyth Road, Ottawa, Ontario

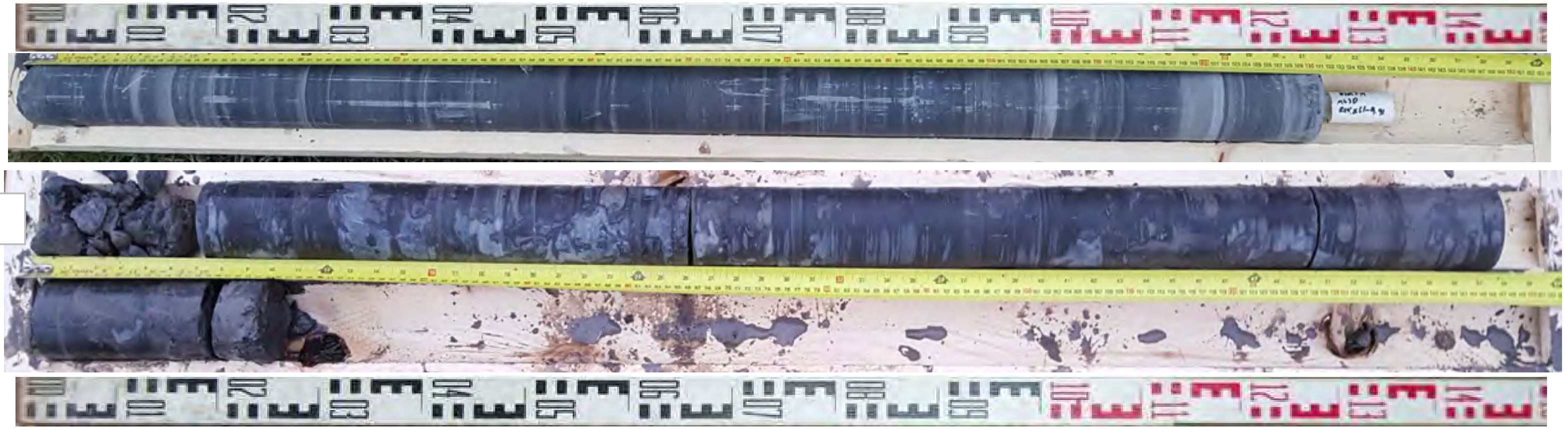
Prepared by: Omar Badaoui
Checked by: A.Sorour
Scale: As Shown
DATE: 09/01/2020
Reference No.: 11205379

Rock Core Photo Log MW3

R1 (RUN 1): 4.11 m - 5.64 m
R2 (RUN 2): 5.64 m - 7.13 m
R3 (RUN 3): 7.13 m - 8.62 m

ROCK CORE PHOTO LOG MW3 Geotechnical Investigation - Infrastructure Ontario (I.O.) Childrens Hospital of Eastern Ontario - 401 Smyth Road, Ottawa, Ontario	Prepared by: Omar Badaoui	Scale: As Shown DATE: 09/01/2020	GHD
	Checked by: A.Sorour	Reference No.: 11205379	

Rock Core Photo Log MW3



R5

R4 (RUN 4): 8.62 m - 9.91 m
R5 (RUN 5): 9.91 m - 11.43 m

ROCK CORE PHOTO LOG MW3
Geotechnical Investigation - Infrastructure Ontario (I.O.)
Childrens Hospital of Eastern Ontario - 401 Smyth Road, Ottawa, Ontario

Prepared by: Omar Badaoui	Scale: As Shown
	DATE: 09/01/2020
Checked by: A.Sorour	Reference No.: 11205379

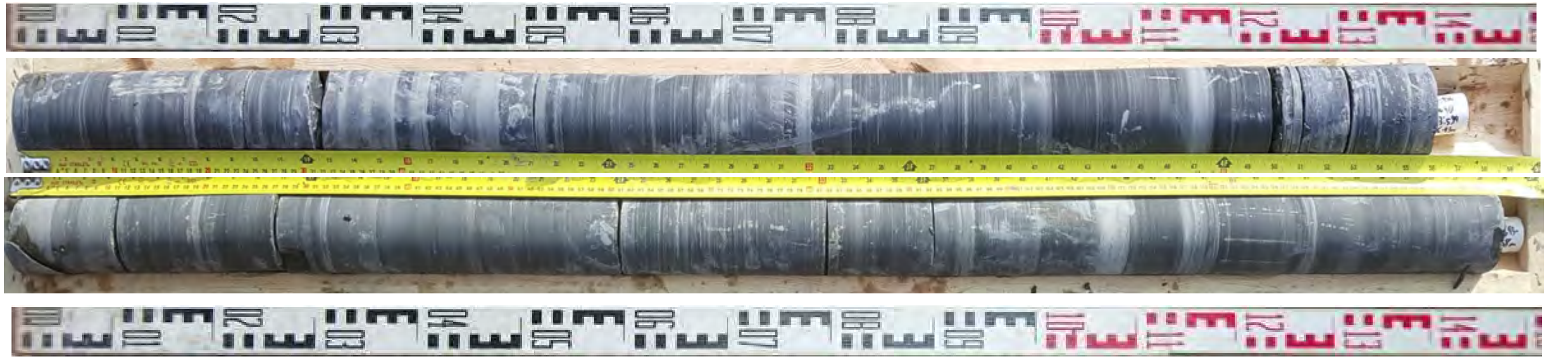
Rock Core Photo Log MW4

R1 (RUN 1): 2.69 m - 3.86 m
R2 (RUN 2): 3.86 m - 5.49 m

ROCK CORE PHOTO LOG MW4
Geotechnical Investigation - Infrastructure Ontario (I.O.)
Childrens Hospital of Eastern Ontario - 401 Smyth Road, Ottawa, Ontario

Prepared by: Omar Badaoui	Scale: As Shown
	DATE: 09/01/2020
Checked by: A.Sorour	Reference No.: 11205379

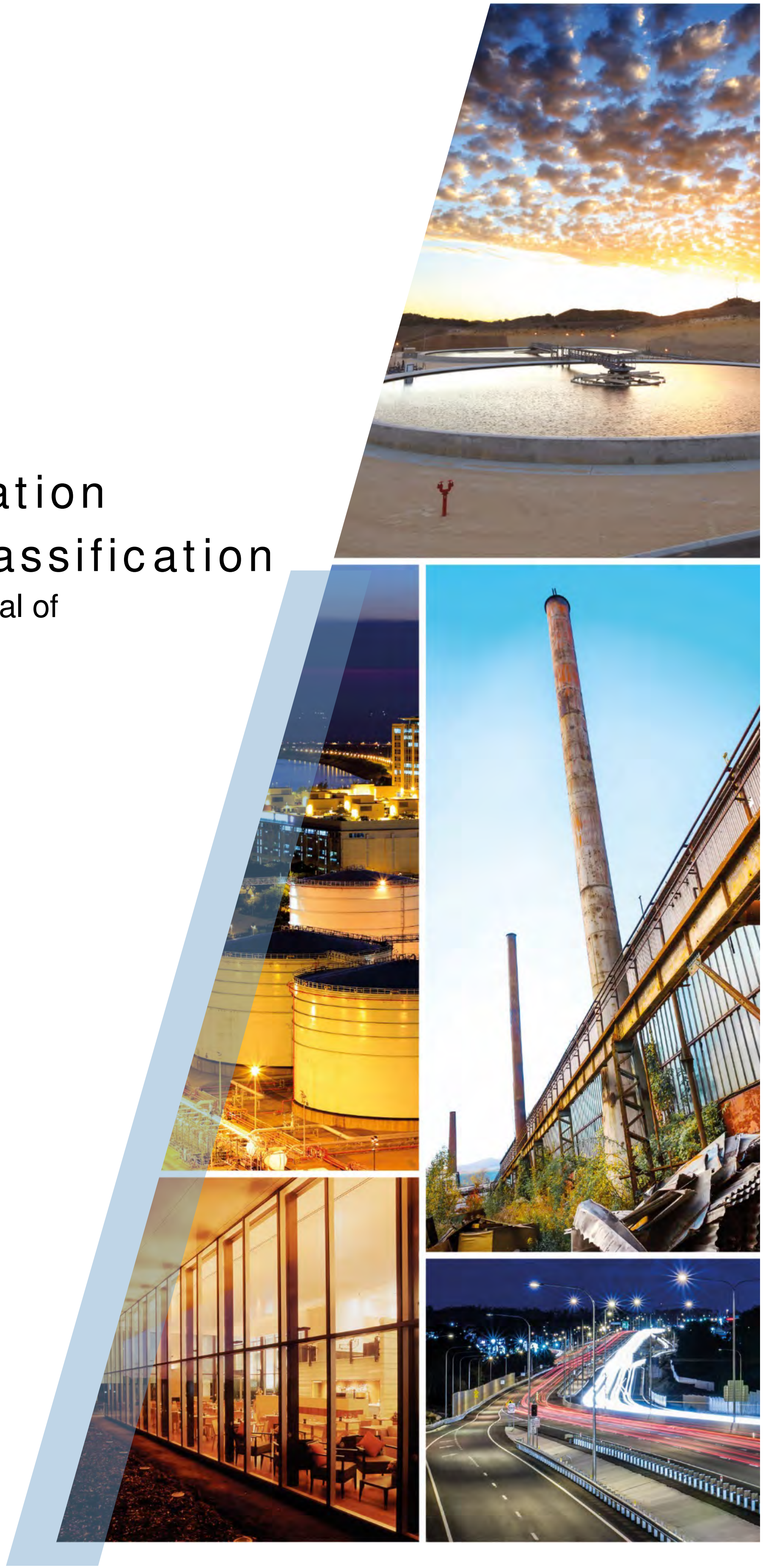
Rock Core Photo Log MW4



R3 (RUN 3): 5.49 m - 6.93 m
R4 (RUN 4): 6.93 m - 8.38 m

ROCK CORE PHOTO LOG MW4 Geotechnical Investigation - Infrastructure Ontario (I.O.) Childrens Hospital of Eastern Ontario - 401 Smyth Road, Ottawa, Ontario	Prepared by: Omar Badaoui	Scale: As Shown DATE: 09/01/2020	
	Checked by: A.Sorour	Reference No.: 11205379	

Appendix D
Multi-Channel Analysis of Surface Waves (MASW)



MASW Investigation
Seismic Site Classification

Portion of Children's Hospital of Eastern Ontario
401 and 407 Smyth Road
Ottawa, Ontario

Infrastructure Ontario

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Appendix Index

1. Introduction

GHD was retained by Ontario Infrastructure and Lands Corporation (Client) to conduct a Multichannel Analysis of Surface Waves (MASW) investigation for the proposed 1Door4Care building which will be part of the Children's Hospital of Eastern Ontario (CHEO) Campus in Ottawa, Ontario (Site). The proposed development would be located at the southwestern portion of the CHEO's Campus, which is currently developed with parking lot and landscape areas. A site location map is provided on Figure 1.

The purpose of the MASW survey was to assist with the seismic site class determination by measuring the average shear wave velocity approximately within the upper 30 m of the soil/rock profile below the founding elevation of the proposed building at the site. The shear wave velocity measurements were carried out along two MASW survey lines assumed to be representative of the Site. The investigation line locations are shown in the attached Figure 2.

Based on the available geotechnical information (GHD Report 3 – Preliminary Geotechnical Investigation, Jan 2020), the Site in general consists of fill materials consisting of sitly sand to sand. The fill is underlain by sandy silty clay deposit which is underlain by bedrock. The thickness of the overburden (fill and native) layer range from 1.0 to 3.81 m. The boreholes were terminated in the bedrock.

The SPT 'N' values within the native layer ranged from 6 to over 50 blows per 0.3 m of penetration. The low 'N' values (less than 15) in some boreholes were obtained at the interface of fill and native layer. The SPT 'N' values (above 15) indicate the stiff to hard consistency of the native deposit.

2. MASW Procedure

To carry out the MASW test, 24 transducers (geophones) are deployed along a line at certain distances from a seismic source. The length of the geophone array determines the deepest investigation depth that can be obtained from the measurements. The source should produce enough seismic energy over the desired test frequency range to allow for detection of Rayleigh waves above background noise (Park et al 1999[1]). A common seismic source is either a sledgehammer or a drop weight hitting a metallic or rubber base plate set at ground surface. The existing traffic noise or the noise generated by heavy machinery travelling close to the survey line can also be utilized as a source for investigating deep soil layers. For this site, only active seismic source is used. Figure 2.1 shows a typical MASW setup.

---

[1] Park, C.B., Miller, R.D., and Xia, J., 1999, Multichannel analysis of surface waves: Geophysics, v. 64, n. 3, pp. 800-808.

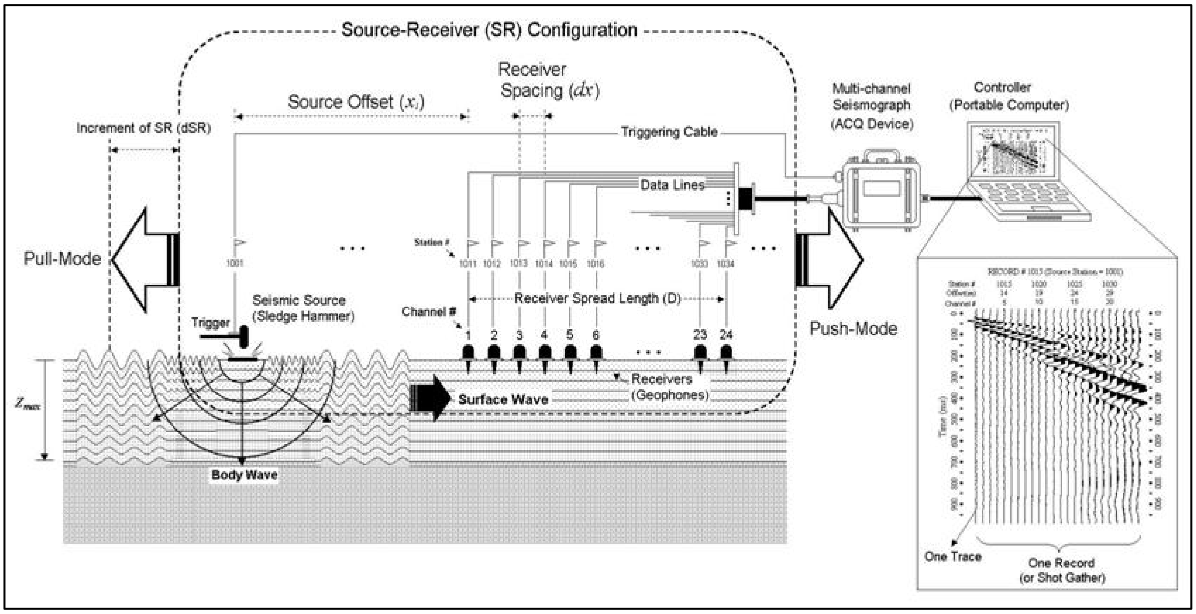


Figure 2.1: Schematic Layout of MASW Test Setup (Park et al 1999 and Xia et al 1999[2])

3. Fieldwork

The fieldwork for this MASW investigation program was carried out on December 17, 2019 by GHD professionals. The field data was collected using a 24 channel seismograph (Geometrics Geode 24 consol #3389), twenty-four 4.5 Hz geophones, and one 24 take-out cable with 5 m spacing. A Panasonic Toughbook© laptop was used in the field to record and collect the seismic data utilizing Geometrics single geode OS controller version 9.14.0.0.

The survey was carried out along two survey lines along the north-south and east-west directions in the vicinity of boreholes and monitoring wells MW-9, BH-6, BH-7, BH-8, MW-4S, and MW-2S as shown on Figure 2. For all line locations, the geophones were installed 75 mm into the ground by manually pushing them into position.

A multi geometry approach was utilized for data collection along both lines. The active data sets were collected using a 4.5 kg sledge hammer hitting the ground surface at three different offset distances (distance between the source and first geophone) along each survey line. The following table summarizes the geometry for each investigation line.

MASW Line Geometry

Line No.	Designation	Geophone Spacing (m)	Array Length (m)	Offset Distances (m)
Line 1 and Line 2	Long	2.0	46.0	24.0, 16.0, 8.0
	Short	1.0	23.0	12.0, 8.0, 4.0

---

[2] Xia, J., Miller, R.D., and Park, C.B., 1999, Estimation of near-surface shear-wave velocity by inversion of Rayleigh waves: Geophysics, v. 64, n. 3, p. 691-700.

Three sets of data files (active) were collected for each array location/set up. For the active survey measurements, the ground vibrations were recorded for four seconds with one sample per 0.25 ms.

4. Data Interpretation

Data analysis including generation of dispersion curves, inversion of the obtained dispersion curves and development of the 1D shear wave velocity profiles at the Site were carried out using SurfSeis© version 6.0. The dispersion curves were calculated at the middle stations along each line. At each investigation line, the dispersion images obtained from active data at different offsets were stacked to obtain a combined dispersion curve. The data inversion was carried out using a 10-layer soil velocity numerical model to obtain 1D shear wave velocity profiles at the location of each mid station. The calculated 1D velocity profile along the investigation lines are shown on the attached Shear Wave Velocity Profile. Figure 3 shows the obtained results at the proposed location for the construction of the building.

In accordance with the requirements of Ontario Building Code (OBC 2012) and National Building Code of Canada 2015 (NBC 2015), the variation of the measured shear wave velocity versus depth up to 30 m below the proposed founding level of the building (assumed to be 1.5 m bgs) was obtained along each line and is shown on Tables 1-A and 1-B. The average shear wave velocity within the upper 30 m of the soil/rock profile (Vs_{30}) immediately below the founding level of the building (at 3.0 m bgs) were obtained utilizing the averaging scheme introduced in Sentence 4.1.8.4 (2) of Commentary J of NBC (2010) User's Guide.

Based on the calculations presented in the attached Tables, the lowest average shear wave velocity (from 3.0 m bgs to 33.0 m bgs) along the investigation line is 1302 m/s (along Line 1). Therefore, in accordance Table 4.1.8.4.A of OBC 2012 (Table 2) and based on the measured average shear wave velocity, for seismic load calculations the Site can be classified as Class 'B'.

As per the Geotechnical report (GHD, 2019), the foundation of the structure will be supported on native sandy silt, the Site can be classified as Class ‘C’. As per OBC 2012, Site Class A and B are only applicable if footings are founded on bedrock.

The seismic site classification provided in this report is based solely on the shear wave velocity values derived from the MASW method and that it can be superseded by other geotechnical information as per requirement from NBC (2010).

The seismic hazards for the site as obtained from Natural Resources Canada (NRC) website are provided as Appendix A to this correspondence.

5. Closure

It is important to emphasize that the results and conclusions of the MASW analysis are based on the available geotechnical information and the survey conducted along two investigation lines. Should any conditions at the Site be encountered which differ from those found at the test locations, we request that we be notified immediately in order to permit a reassessment of our recommendations.

All of Which is Respectfully Submitted,

GHD

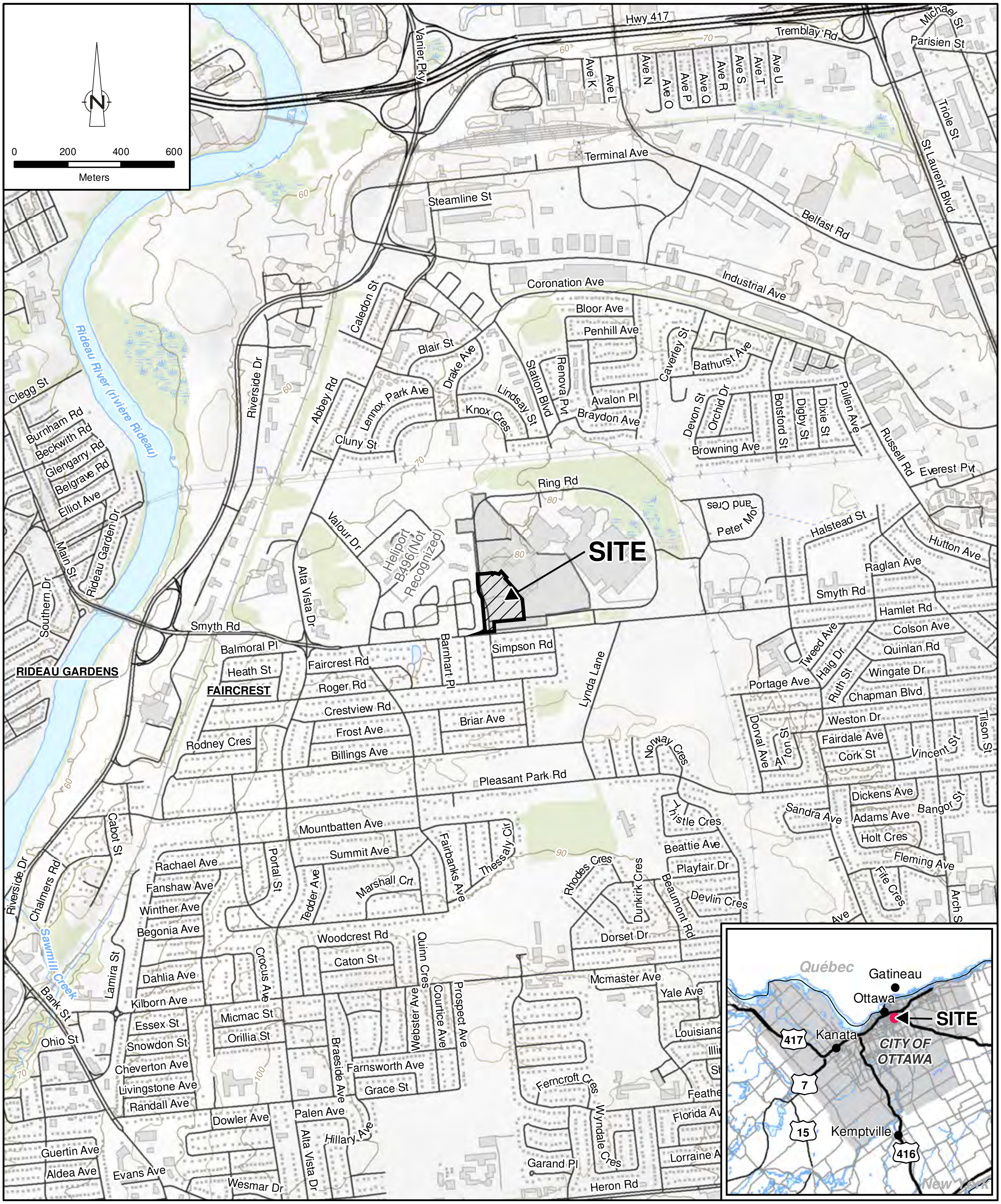
LICENSED PROFESSIONAL ENGINEER
H. ALI
100517806
1-15-2020
PROVINCE OF ONTARIO

Hassan Ali, Ph.D. P. Eng.

Ali Ghassemi, Ph.D.

Farsheed Bagheri, P. Eng.

Figures



Source: MNRF NRVIS, 2018. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2020

GHD

PARKING LOT AND ACCESS ROADS
PORTION OF CHILDREN'S HOSPITAL OF EASTERN ONTARIO
401 AND 407 SMYTH ROAD, OTTAWA, ONTARIO

11205379
Jan 14, 2020

SITE LOCATION MAP

FIGURE 1

GIS File: Q:\GIS\PROJECTS\11205000s\11205379\Layouts\202001_MASW\11205379_202001_MASW_GIS001.mxd

0 10 20 30m

Coordinate System:
UTM ZONE 18 NAD83
METRES

N

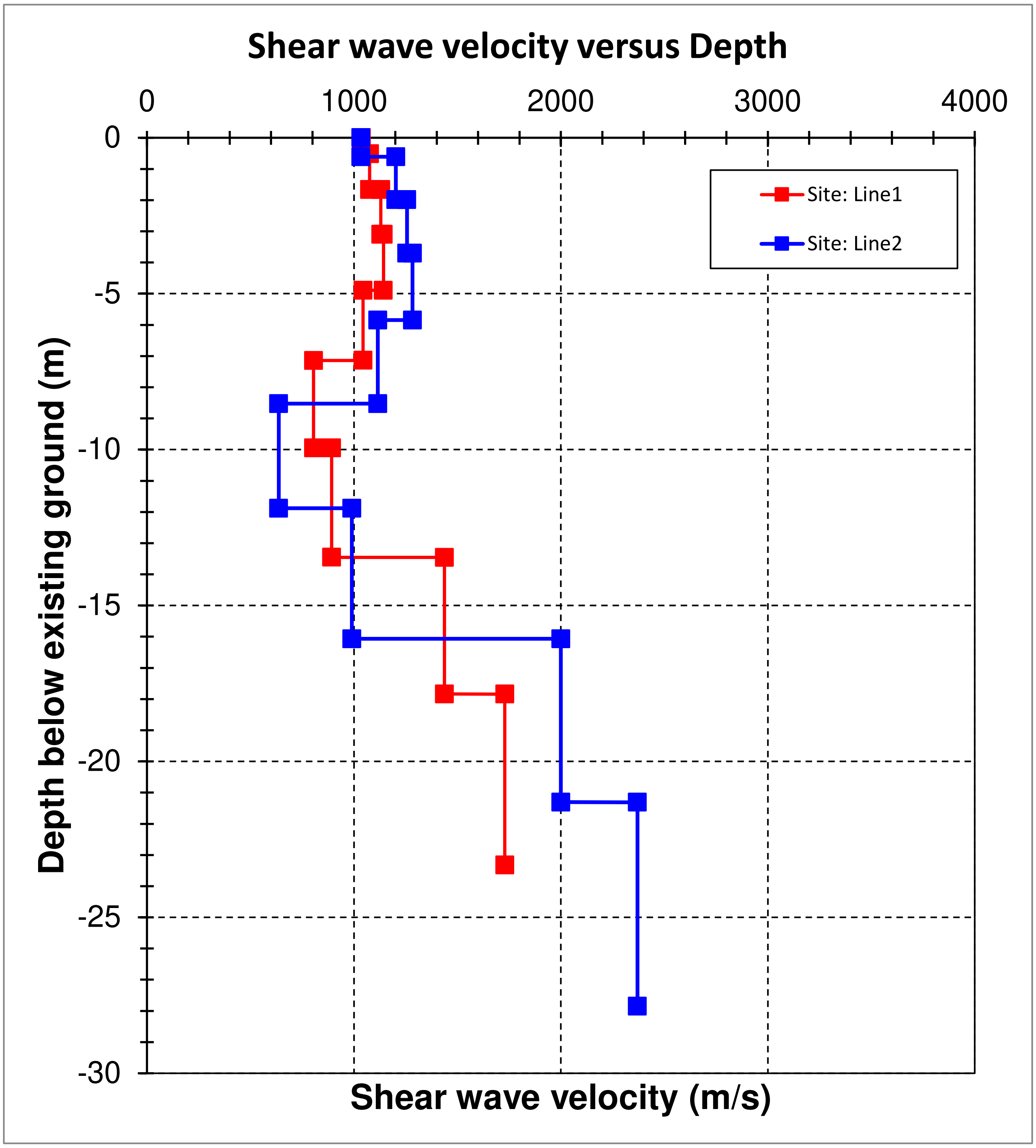
PROPOSED 1DOOR4CARE BULIDING
CHILDREN'S HOSPITAL OF
EASTERN ONTARIO CAMPUS
401 SMYTH ROAD, OTTAWA, ONTARIO

SITE PLAN AND
INVESTIGATIVE LOCATIONS

Project No. **11205379**
Date **January 15,2020**

FIGURE 2

Source: Microsoft Product Screen Shot(s) Reprinted with permission from Microsoft Corporation, Accessed: 2019



Infrastructure Ontario
Proposed 1Door4Care Development
Part of Childrens Hospital of Eastern Ontario Campus
401 and 407 Smyth Road, Ottawa Ontario

SHEAR WAVE VELOCITY VS DEPTH

PROJECT NO.
11205379
DATE
13-Jan-19

FIGURE NO. 3

Tables

Table 1
Summary of Shear Wave Velocity Measurements
Seismic Site Class Determination
Proposed 1Door4Care Development
Part of Childrens Hospital of Eastern Ontario Campus
401 and 407 Smyth Road, Ottawa Ontario

Table 1-A: Average Shear Wave Velocity (VS_{30})
(Assumed foundaiton at 3.0 m below existing ground surface)

Line 1					
Layer No.	Depth (m bgs)		Thickness	V_s	d_i/V_{si}
	From	To	m	m/s	
1	3.0	3.1	0.1	1130	0.0001
2	3.1	4.9	1.8	1143	0.0016
3	4.9	7.1	2.2	1045	0.0021
4	7.1	9.9	2.8	805	0.0035
5	9.9	13.5	3.5	893	0.0039
6	13.5	17.8	4.4	1438	0.0030
7	17.8	33.0	15.2	1729	0.0088
Total			30.0		0.0230
Average Shear Wave Velocity Along the Line (m/s)					***1302***

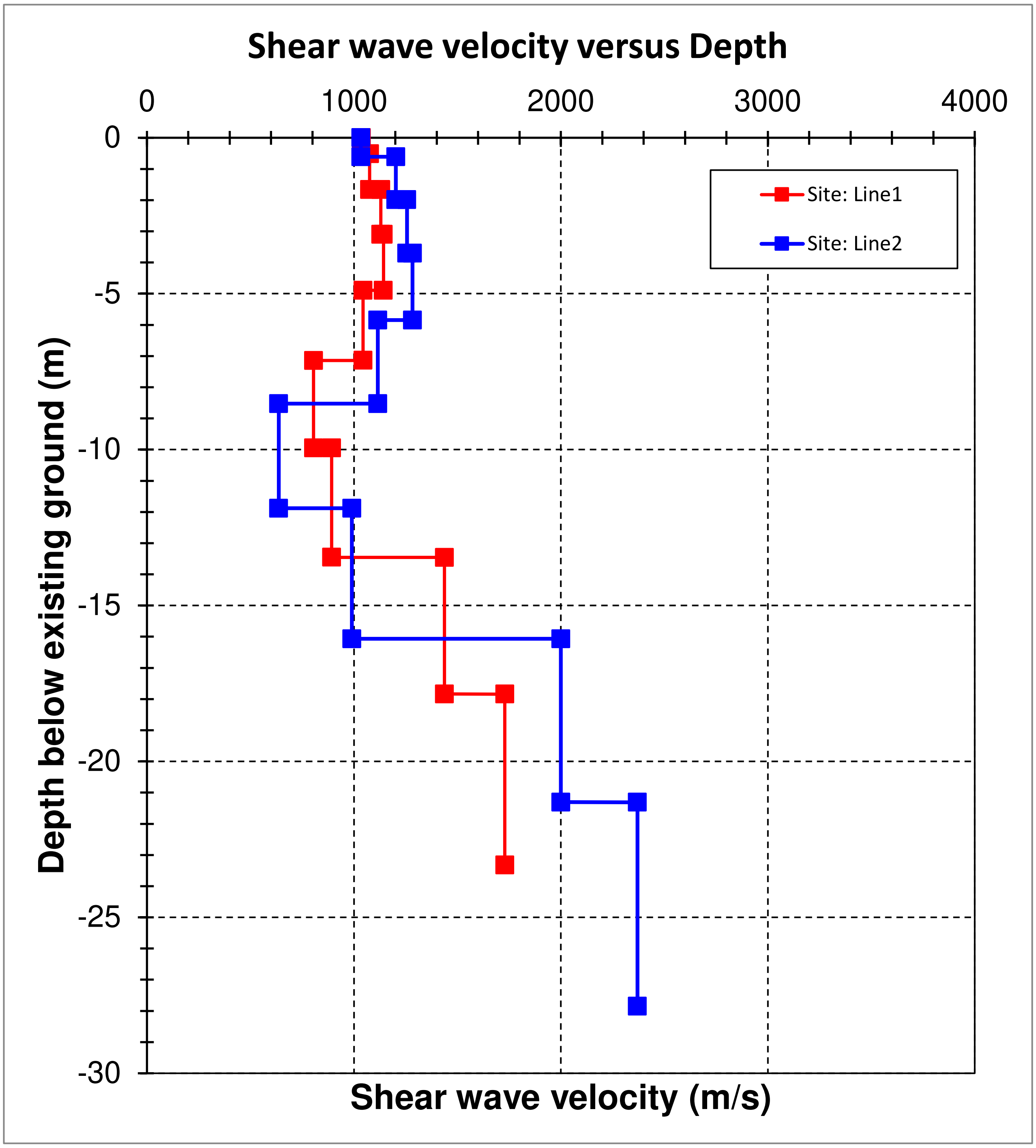
Table 1-B: Average Shear Wave Velocity (VS_{30})
(Assumed foundaiton at 3.0 m below existing ground surface)

Line 2					
Layer No.	Depth (m bgs)		Thickness	V_s	d_i/V_{si}
	From	To	m	m/s	
1	3.0	3.7	0.7	1256	0.0006
2	3.7	5.8	2.1	1284	0.0017
3	5.8	8.5	2.7	1115	0.0024
4	8.5	11.9	3.4	637	0.0053
5	11.9	16.1	4.2	990	0.0042
6	16.1	21.3	5.2	2000	0.0026
7	21.3	33.0	11.7	2370	0.0049
Total			30.0		0.0217
Average Shear Wave Velocity Along the Line (m/s)					***1384***

Average VS_{30} = **1343** **m/s**

Recommended Site Class: **B** Subjected to Code requirements

Notes:
1 - The Seismic Site class is recommended in accordance to Table 4.1.8.4.A of the National Building code of Canada 2010 and based on the lowest measured average shear wave velocity measured along the investigated lines.
2 - VS30 is calculated based on the average shear wave velocity below the proposed founding elevation.
3 - Site Classes A and B are only applicable if footings are founded on bedrock or there is no more than 3.0 m of soil between founding elevation and bedrock.
4 - The recommended site class is only applicable if site conditions for Site Class F (liquefiable soil/soft soil layers more than 3.0 m thick) are not applicable.



Infrastructure Ontario
Proposed 1Door4Care Development
Part of Childrens Hospital of Eastern Ontario Campus
401 and 407 Smyth Road, Ottawa Ontario

PROJECT NO.
11205379
DATE
13-Jan-19

SHEAR WAVE VELOCITY VS DEPTH

FIGURE NO. 3

Table 2

Site Classification for Seismic Site Response Forming Part of Sentences 4.1.8.4. (1) to (3)

	Ground Profile Name	Average Properties in Top 30 m		
		Average Shear Wave Velocity, $\bar{V}_s$ (m/s)	Average Standard Penetration Resistance, $\bar{N}_{60}$	Soil Undrained Shear Strength, s_u
A	Hard rock	$\bar{V}_s > 1500$	N/A	N/A
B	Rock	$760 < \bar{V}_s \leq 1500$	N/A	N/A
C	Very dense soil and soft rock	$360 < \bar{V}_s < 760$	$\bar{N}_{60} > 50$	$s_u > 100$ kPa
D	Stiff soil	$180 < \bar{V}_s < 360$	$15 \leq \bar{N}_{60} \leq 50$	50 kPa $< s_u \leq$ 100 kPa
E	Soft soil	$\bar{V}_s < 180$	$\bar{N}_{60} \leq 15$	$s_u < 50$ kPa
		Any profile with more than 3m of soil with the following characteristics: plasticity index: PI > 20 moisture content w ≥ 40%, and undrained shear strength: $s_u < 25$ kPa		
F	Other soils	Site-specific evaluation required		
Reference: *2012 Ontario Building Code Compendium, Division B – Part 4, Section 4.1.8.4.*				

Appendices

Appendix A
Seismic Hazard Values

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 45.400N 75.653W **User File Reference:** Children's Hospital of Eastern Ontario Campus 2020-01-06 20:17 UT

Requested by: GHD

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.453	0.251	0.150	0.044
Sa (0.1)	0.530	0.304	0.189	0.061
Sa (0.2)	0.444	0.258	0.162	0.055
Sa (0.3)	0.337	0.197	0.125	0.044
Sa (0.5)	0.239	0.140	0.089	0.031
Sa (1.0)	0.119	0.070	0.045	0.015
Sa (2.0)	0.056	0.033	0.021	0.006
Sa (5.0)	0.015	0.008	0.005	0.001
Sa (10.0)	0.005	0.003	0.002	0.001
PGA (g)	0.284	0.165	0.103	0.033
PGV (m/s)	0.198	0.112	0.068	0.021

Notes: Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

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

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

Natural Resources Canada Ressources naturelles Canada

Canada

Appendix E
Geophysical Survey Report

GEOPHYSICAL INTERPRETATION REPORT

REGARDING FREQUENCY DOMAIN ELECTROMAGNETICS FOR DETECTION OF UNDERGROUND STORAGE TANKS

401 SMYTH ROAD, OTTAWA, ON, CANADA

Prepared For:
Aditya Khandekar
PE, Project Manager
GHD
184 Front Street East, Suite 302, Toronto ,Ontario, Canada, M5A 4N3

Submitted By:
Joel Halverson
Geophysical Technologist
MULTIVIEW LOCATES INC.
325 Matheson Blvd East, Mississauga ON, L4Z 1X8

April 16, 2020

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

DIGITAL ARCHIVE CONTENT

Table 1: Digital Archive Content

Folder	Content
...//Deliverables/	Digital copy of the survey results, final documents and maps
...//Maps/	Grid and interpretation maps
...//Reports/	Geophysical survey report

PROJECT SPECIFICATION LIST

Table 2: Project Specification List

Contract	
MLI Reference Number	45561
Report Date	April 16, 2020
Client	
Legal Name	GHD
Address	184 Front Street East, Suite 302, Toronto ,Ontario, Canada, M5A 4N3
Phone	416-360-1600
Contact	
Client Representative:	Aditya Khandekar
Qualifications:	PE, Project Manager
Email	aditya.khandekar@ghd.com
Survey	
Survey Description	Detection of Underground Storage Tanks
Methodology	Frequency Domain Electromagnetics
Location	401 Smyth Road, Ottawa, ON, Canada
Execution Date	21/11/2019
Contractor	
Survey by:	multiVIEW Locates Inc.
Responsible	Joel Halverson
Qualifications	Geophysical Technologist
Phone	800-363-3116
Email	jhalverson@multiview.ca

CONTRACT RELEASE LETTER: 45561

April 16, 2020

GHD

184 Front Street East, Suite 302, Toronto ,Ontario, Canada, M5A 4N3
Phone: 416-360-1600

Attention to: Mr. Aditya Khandekar, PE, Project Manager

Re: Geophysical Interpretation Report regarding Detection of Underground Storage Tanks at 401 Smyth Road, Ottawa, ON, Canada.

Dear Mr. Aditya Khandekar:

GHD retained multiVIEW Locates Inc. to carry out Frequency Domain Electromagnetics for Detection of Underground Storage Tanks for the site located at 401 Smyth Road, Ottawa, ON, Canada. The geophysical survey was undertaken on 19/11/2019 and was completed on 21/11/2019.

Included, you will find a geophysical survey report describing the data acquisition, methodology, data quality, processing, interpretation results, conclusion and recommendations relevant to survey objectives, including appendices, tables and figures. A digital archive containing the acquired raw data and final processed results, digital maps, presentations and documents is also provided.

This represents the end of our contractual agreement regarding the aforementioned geophysical survey. Contact us if you need any additional material or information.

Thank you,

Signed by: ___________________

Joel Halverson, Geophysical Technologist
multiVIEW Locates Inc.

1 INTRODUCTION

GHD retained multiVIEW Locates Inc. (multiVIEW) to carry out a Frequency Domain Electromagnetics for Detection of Underground Storage Tanks for the site located at the Children's Hospital of Eastern Ontario (CHEO), 401 Smyth Road, Ottawa, ON, Canada.

This geophysical interpretation report summarizes the data collection logistics and methodology, processing results and data interpretation associated with the geophysical investigation.

The acquisition, processing and analysis of the data were performed according to professionally regulated industry standards. The geophysical data are presented in screen captured figures and plan maps throughout the sections of the report.

The geophysical interpretation contained in this report is based on the analysis of the Frequency Domain Electromagnetics (FDEM) responses recorded during the field acquisition stage. The images and figures presented in the body of the report are scaled to fit the report page size and should be used for illustration purposes only. Detailed maps and images of the data and results are available in the digital archive supplied along with the interpretation report.

The interpretation of the geophysical data obtained during this investigation is intended to provide guidance for any potential intrusive subsurface investigation work. Interpretation of the data used during any subsequent programs is subject to the Law of Physics and Technical limitations of the geophysical techniques used. The criteria and models used for the interpretation of the acquired data are not unique and may not represent the actual objects present on site.

1.1 SURVEY OBJECTIVES

The primary objective of the investigation was to detect and map the presence of potential underground storage tanks in the survey area.

The inferred location of interpreted geophysical signatures was documented and transferred to digital drawings for referencing and assessment.

2 PROJECT OVERVIEW

The geophysical study was completed using Frequency Domain Electromagnetics techniques. The exploration and acquisition phase of the survey was completed on 21/11/2019. The raw data and survey results presented as digital plan maps and sections are:

- Integrated Interpretation Plan Maps depicting the spatial location of interpreted geophysical signatures and subsurface features;
- Frequency Domain Electromagnetics (FDEM) In-Phase and Quadrature Contour Grids;

2.1 SITE LOCATION AND ACCESS

The geophysical project is located at 401 Smyth Road, Ottawa, ON, Canada, depicted in Figure 2-1. The site is occupied by an active parking lot and garden area located south west of CHEO. The survey area spanned from the eastern curb of the road way located at the entrance of the Hospital and extended 80 meters to the south west to the western limit of the parking lot. An accurate outline of the survey area is displayed in Figure 3-1.

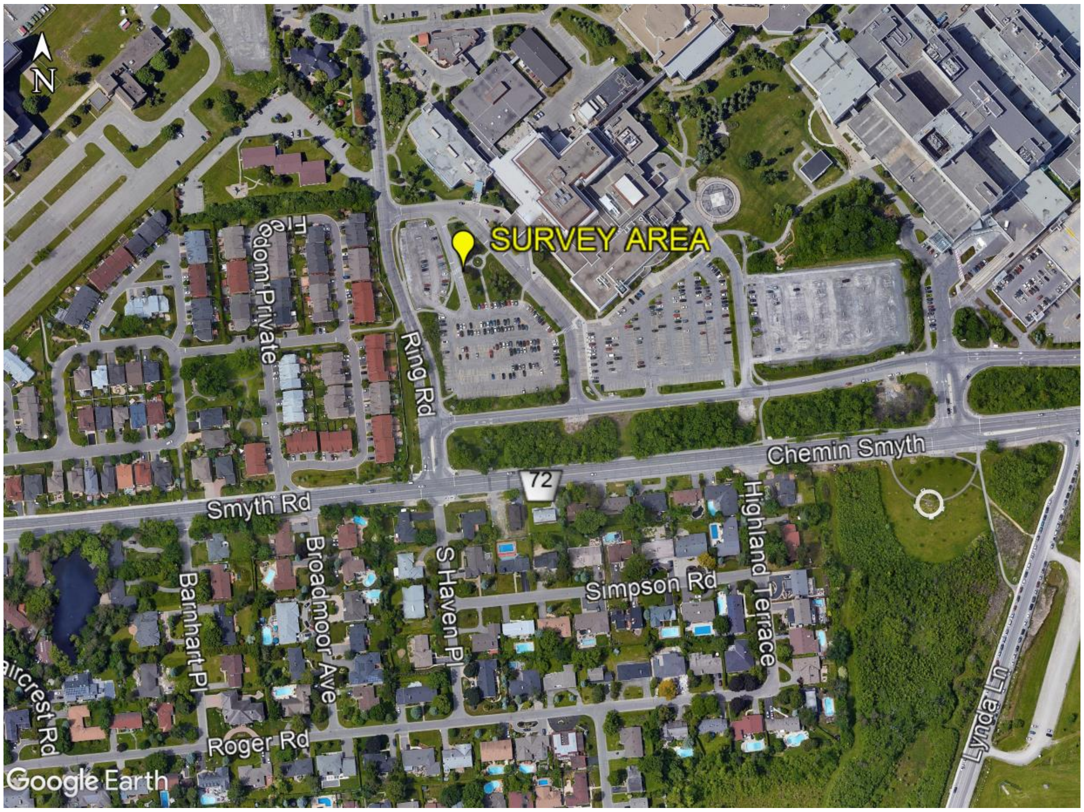


Figure 2-1: Geophysical Survey General Location Map

2.2 WEATHER AND TERRAIN CONDITIONS

The geophysical data acquisition was performed at night to avoid traffic and vehicles in the parking lot. Average temperatures fluctuated from ~-7 degrees Celsius to ~3 degrees Celsius.

The parking lots, roads and pathways were clear and plowed clean of snow, however portions along the perimeter of the parking lots and within the garden and grassed areas contained deep snow.

3 METHODOLOGY

The geophysical study was done using Frequency Domain Electromagnetics techniques. The FDEM data acquisition was performed using a terrain conductivity meter from Geonics Limited. The acquisition phase of the survey was completed on 21/11/2019.

Field labor included the following activities:

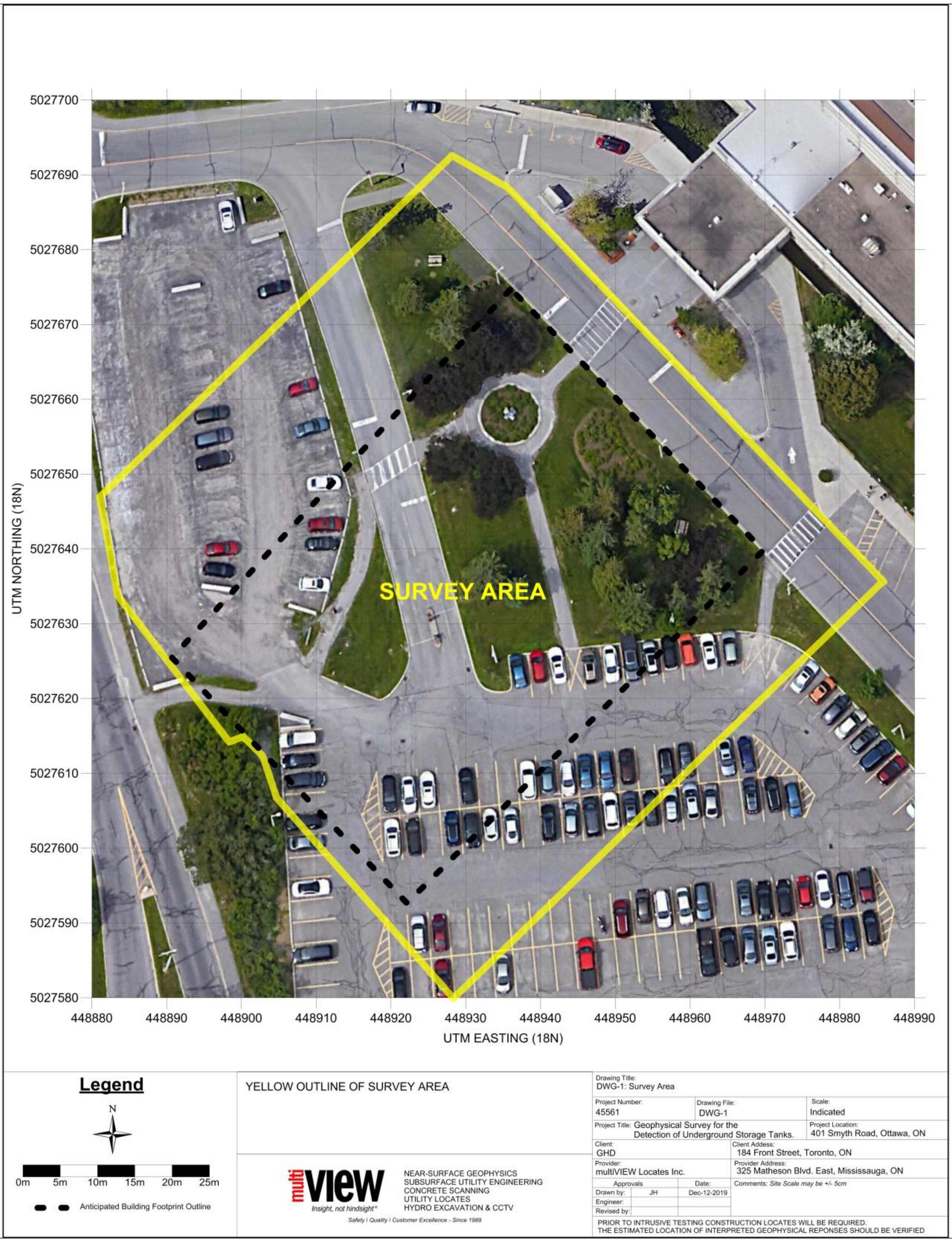
- GRID and GPS survey control;
- FDEM soil conductivity profiling;
- Site documentation;
- Data interpretation and results presentation;

3.1 SURVEY GRID INSTALLMENT

A GPS receiver was utilized for the geophysical data acquisition. UTM WGS84/Zone 18N coordinates were acquired for the purpose of grid establishment and positioning during survey. The grid layout was done using commercial measuring tapes and line-of-site positioning. Data referenced to grid coordinates were acquired for the purpose of grid establishment, geophysical data collection, interpretation and map creation.

FDEM data was acquired at a station spacing of roughly 2 meters along survey lines spaced at 2metres. Survey lines and data collection were partially restricted by large surface objects including trees and bushes.

The project area measured approximately 6000 square metres. The extent of the total survey coverage is displayed by the yellow line in Figure 3-1. This map is presented digitally in “DWG-1 Survey Area”.



YELLOW OUTLINE OF SURVEY AREA

Drawing Title: DWG-1: Survey Area

Project Number: 45561

Drawing File: DWG-1

Scale: Indicated

Project Title: Geophysical Survey for the Detection of Underground Storage Tanks.

Project Location: 401 Smyth Road, Ottawa, ON

Client: GHD

Client Addess: 184 Front Street, Toronto, ON

Provider: multiVIEW Locates Inc.

Provider Address: 325 Matheson Blvd. East, Mississauga, ON

Approvals		Date:
Drawn by:	JH	Dec-12-2019
Engineer:		
Revised by:		

Comments: *Site Scale may be +/- 5cm*

PRIOR TO INTRUSIVE TESTING CONSTRUCTION LOCATES WILL BE REQUIRED.
THE ESTIMATED LOCATION OF INTERPRETED GEOPHYSICAL REPONSES SHOULD BE VERIFIED

Figure 3-1: Geophysical Survey Location Map

3.2 FREQUENCY DOMAIN EM DATA ACQUISITION (EM31)

FDEM data acquisition was conducted across the proposed site using an EM31 system manufactured by Geonics Limited Ltd. The EM31 instrumentation provides data for indirect detection of buried metal objects and soil conductivity mapping to 3 to 6 metres depth using a horizontal coplanar coil configuration. A general system configuration is shown in Figure 3-2.

The measurement units of the system are “milli-Siemens per metre” (mS/m) for the Quadrature component and “parts per thousand” (ppt) for the In-phase component of the measured electromagnetic field. The electromagnetic data were acquired at approximate station spacing of 2 metres along lines spaced at 2 metres apart, excluding obstructed areas. GPS data were collected synchronously with the FDEM data using a receiver externally mounted on the EM31 logging system. Following the field survey, the GPS data were integrated with the FDEM data.

Figure 3-2: Typical FDEM Acquisition System Setup

3.3 GEOPHYSICAL DATA INTERPRETATION AND PRESENTATION

FDEM interpretation was completed by comparing the characteristics of the acquired profiles and maps to examples and results available at multiVIEW from in-house tests and historic field surveys. The inferred location of all identified features and interpreted anomalous zones was documented and transferred to digital drawings.

Unusual soil conditions and natural subsurface disturbances are expressed as quadrature or conductivity anomalous zones. Generally the soil and materials over these zones have higher porosity and higher water content (including clay and TDS content) than *surrounding* consolidated soil or materials, therefore higher conductivity is reflected in the acquired electromagnetic data. In Arctic locations the permafrost negates the higher conductivity readings as an increase in ice in the soil decreases the soils conductivity. In locations adjacent to bodies of salt water, increased soil conductivity can be observed in the subsurface as salt may infiltrate into the ground water along the shore line of the body of water. The rate of change in conductivity measurements or quadrature is generally greater in the vicinity of non-native materials and slowly varying in areas of native materials. Metallic minerals in the subsoil produce high conductivity responses.

By mapping high conductivity or quadrature electromagnetic anomalies it is possible to infer the location of different fill materials, clay and contamination. The amount and composition of colloids may also contribute to measured conductivity. Bedrock typically has a lower conductivity because of high density and the generally lower porosity present within the rock matrix. The irregular nature of landfilled material and the frequent presence of ferrous metals and high chloride concentration provide for an electromagnetic response that typically contrasts the more homogeneous natural materials in an area.

In-phase responses will have a well-defined positive peak over buried metal objects, greatly facilitating quick and accurate location of a target in the field. In general, positive In-phase anomalies are representative of metallic masses. In-phase responses with high positive values indicate metal objects parallel to the orientation of the instrument coils. Positive anomalous values are commonly associated with buried metal objects. Large positive In-phase responses, in parts per thousand (ppt) of the total field strength are interpreted as metallic objects. Alternatively, strong negative In-phase values are observed when high conductive objects such as iron or steel are oriented perpendicular and near to instrument coils.

By integrating Quadrature in conjunction with the In-phase data, it is possible to discriminate buried metal objects from different types of soils, fill materials, contamination, buried foundation and construction remains. Local areas with high conductivity responses may be interpreted to represent more conductive non-homogeneous fill materials and contamination.

4 RESULTS

4.1 FDEM QUADRATURE CONTOUR GRID MAP

For the Apparent Conductivity (Quadrature) colour contoured map, the background electromagnetic responses (from ~20 mS/m to ~40 mS/m) are represented by green colours; and the anomalous responses (>60 mS/m) are denoted by yellow-orange-red colour contours. Off-scale negative measurements are indicative of near or above surface metallic objects. A Quadrature contour grid map is presented in Figure 4-2.

Scaled Quadrature contour grid map is presented digitally in “DWG-2 Apparent Conductivity”.

4.2 FDEM IN-PHASE CONTOUR GRID MAP

For the In-phase colour contoured map, the background electromagnetic responses (from ~-1 ppt to ~3 ppt) are represented by green colours. The anomalous responses (>3 ppt or <-3 ppt) are denoted by yellow orange-red or blue colour contours.

Positive In-phase anomalies (from >3 ppt to 30 ppt) and (from <-3 ppt to -30 ppt) are indicative of metallic buried objects and masses. The In-phase contour grid map for the survey area is presented in Figure 4-3.

Scaled In-phase contour grid map is presented digitally in “DWG-3 In-phase Data”.

4.3 FDEM INTERPRETATION

All elevated readings were evaluated based on the proximity to know surface objects that could have produced the elevated readings. The readings deemed likely to be caused by surface features were discounted as subsurface responses and were not included in the interpretation figures and not listed as potential targets for further investigation.

A compilation of the interpreted FDEM anomalous responses is presented in Figure 4-3. The plan map illustrates the position and extent of the anomalous responses interpreted as:

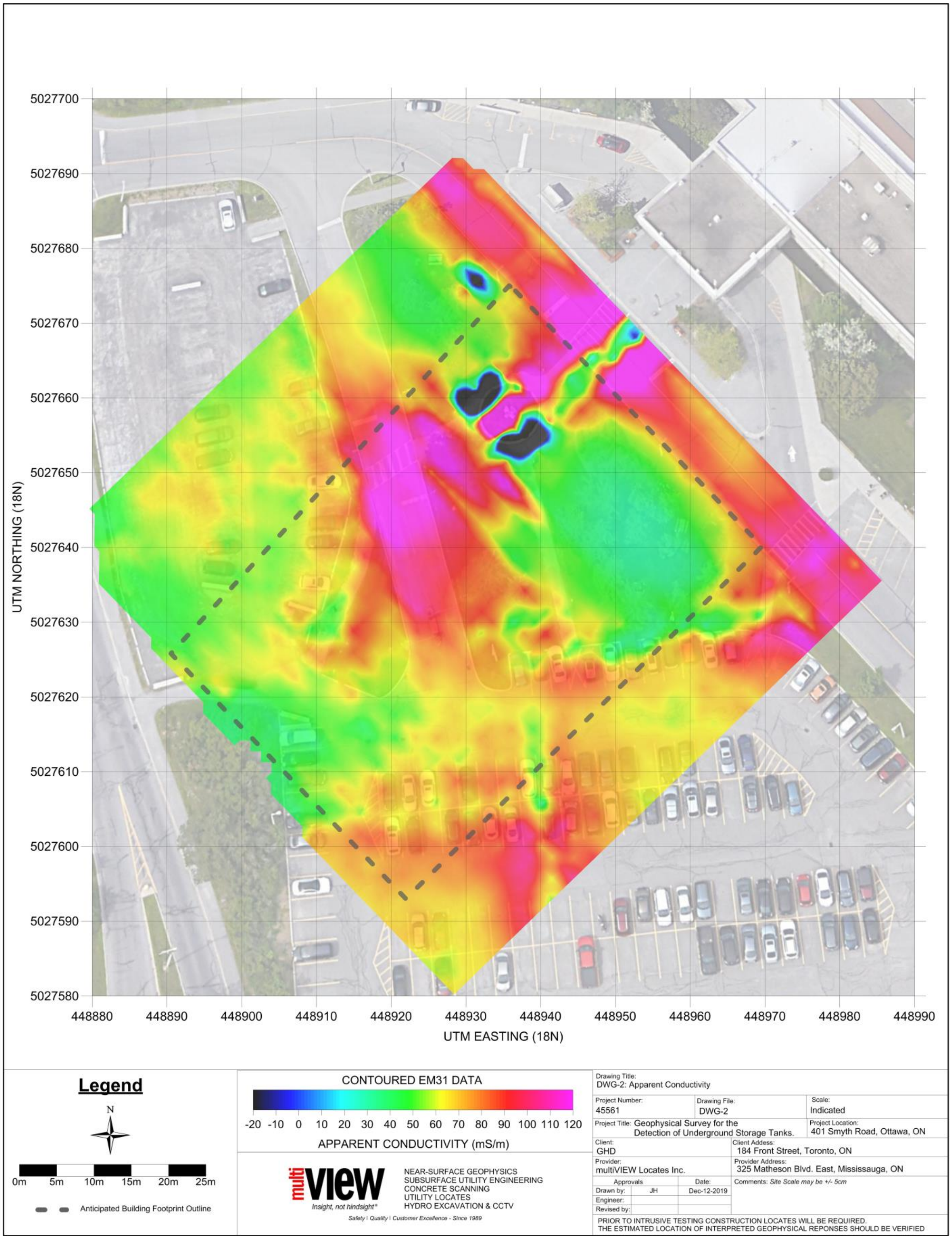
- Potential unusual soil conditions exist in Anomaly AC-1 as seen the Apparent Conductivity data.
- Potential buried metal objects exist in anomaly IP-1 as seen in the In-Phase data. Much of this area was snow covered and metal surface objects and buried electrical lines servicing the light posts may exist
- Linear anomalies were detected in the FDEM data. In a previous utility survey by multiVIEW Locates Inc, most of these linear anomalies were identified utilities. These notes are outlined in the interpretation summary table.

Scaled Interpretation map is presented digitally in “DWG-4 Interpretation Map”.

All Anomalies displayed in the interpretation figure are outlined in the Geophysical Interpretation Summary Table, which includes the coordinates and Interpretation Note.

Anomaly	EM Data Observed	UTM Easting (18N)	UTM Northing (18N)	Interpretation
AC-1	Perimeter of Conductivity Anomaly	448912.6189	5027655.15	Zone of elevated apparent conductivity. Unusual soil conditions may exist
AC-1	Perimeter of Conductivity Anomaly	448922.8783	5027630.002	
AC-1	Perimeter of Conductivity Anomaly	448931.6364	5027640.262	
AC-1	Perimeter of Conductivity Anomaly	448929.7597	5027646.642	
AC-1	Perimeter of Conductivity Anomaly	448938.6428	5027644.766	
AC-1	Perimeter of Conductivity Anomaly	448936.3907	5027648.519	
AC-1	Perimeter of Conductivity Anomaly	448924.8802	5027659.529	
IP-1	Perimeter of In-Phase Anomaly	448933.1378	5027644.14	Zone of elevated In-phase data. Buried metal objects may exist. Buried electrical servicing the light posts and metal mesh in the concrete may exist surrounding the statue.
IP-1	Perimeter of In-Phase Anomaly	448939.0182	5027644.14	
IP-1	Perimeter of In-Phase Anomaly	448937.767	5027650.271	
IP-1	Perimeter of In-Phase Anomaly	448946.6502	5027658.653	
IP-1	Perimeter of In-Phase Anomaly	448937.6419	5027669.163	
IP-1	Perimeter of In-Phase Anomaly	448927.6327	5027663.158	
IP-1	Perimeter of In-Phase Anomaly	448924.8802	5027658.278	
IP-1	Perimeter of In-Phase Anomaly	448926.3816	5027651.272	
LA-1	Linear In-Phase Anomaly	448906.7385	5027603.728	Linear Anomaly, Possible Utility
LA-1	Linear In-Phase Anomaly	448939.0182	5027606.856	
LA-2	Linear In-Phase Anomaly	448941.1451	5027592.968	Linear Anomaly, Likely Electrical to Lights
LA-2	Linear In-Phase Anomaly	448937.5168	5027630.378	
LA-3	Linear In-Phase Anomaly	448928.0081	5027626.999	Linear Anomaly, Likely Electrical to Lights
LA-3	Linear In-Phase Anomaly	448931.3862	5027624.122	
LA-3	Linear In-Phase Anomaly	448963.916	5027629.877	
LA-3	Linear In-Phase Anomaly	448974.5508	5027633.255	
LA-3	Linear In-Phase Anomaly	448981.9325	5027638.635	
LA-4	Linear In-Phase Anomaly	448930.135	5027627.75	Linear Anomaly, Likely Electrical to Lights
LA-4	Linear In-Phase Anomaly	448937.0163	5027631.003	
LA-4	Linear In-Phase Anomaly	448944.1479	5027631.378	
LA-5	Linear In-Phase Anomaly	448924.8802	5027650.146	Linear Anomaly, Likely Electrical to Lights
LA-5	Linear In-Phase Anomaly	448922.6281	5027658.779	
LA-5	Linear In-Phase Anomaly	448944.1479	5027631.378	
LA-6	Linear In-Phase Anomaly	448977.9289	5027629.502	Linear Anomaly, Likely Electrical to Lights
LA-6	Linear In-Phase Anomaly	448924.1295	5027686.554	
LA-7	Linear In-Phase Anomaly	448980.8065	5027631.754	Linear Anomaly, Likely Sewer Pipes
LA-7	Linear In-Phase Anomaly	448926.3816	5027689.682	
LA-8	Linear In-Phase Anomaly	448984.1846	5027635.257	Linear Anomaly, Likely Water Pipe
LA-8	Linear In-Phase Anomaly	448930.6355	5027689.932	
LA-9	Linear In-Phase Anomaly	448939.7379	5027656.851	Linear Anomaly, Possible Utility
LA-9	Linear In-Phase Anomaly	448952.6453	5027669.759	

Table 3: Geophysical Interpretation Summary Table



Drawing Title: DWG-2: Apparent Conductivity

Project Number: 45561

Drawing File: DWG-2

Scale: Indicated

Project Title: Geophysical Survey for the Detection of Underground Storage Tanks.

Project Location: 401 Smyth Road, Ottawa, ON

Client: GHD

Client Addess: 184 Front Street, Toronto, ON

Provider: multiVIEW Locates Inc.

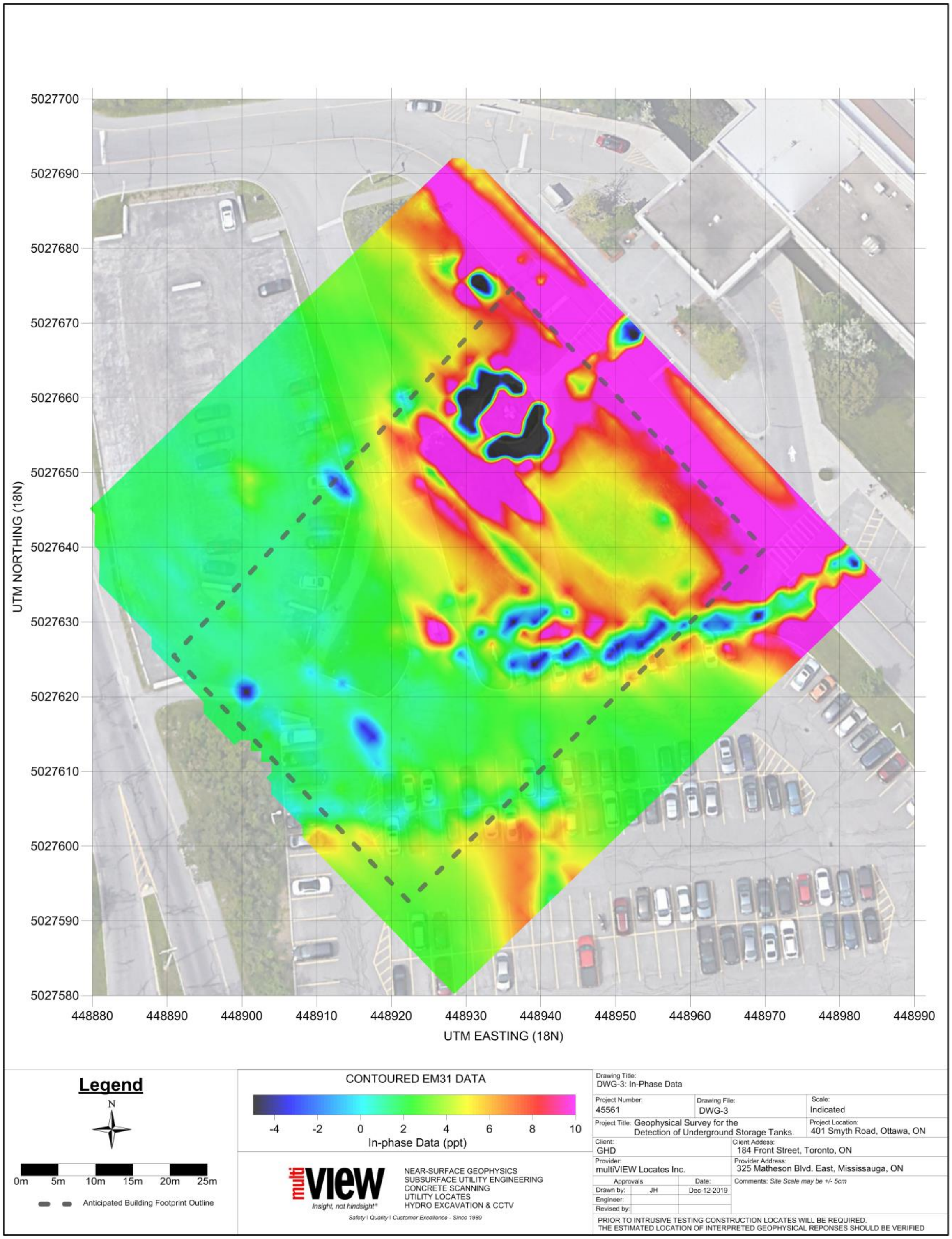
Provider Address: 325 Matheson Blvd. East, Mississauga, ON

Approvals		Date:
Drawn by:	JH	Dec-12-2019
Engineer:		
Revised by:		

Comments: *Site Scale may be +/- 5cm*

PRIOR TO INTRUSIVE TESTING CONSTRUCTION LOCATES WILL BE REQUIRED.
THE ESTIMATED LOCATION OF INTERPRETED GEOPHYSICAL REPONSES SHOULD BE VERIFIED

Figure 4-1: FDEM Apparent Conductivity



Drawing Title: DWG-3: In-Phase Data

Project Number: 45561

Drawing File: DWG-3

Scale: Indicated

Project Title: Geophysical Survey for the Detection of Underground Storage Tanks.

Project Location: 401 Smyth Road, Ottawa, ON

Client: GHD

Client Addess: 184 Front Street, Toronto, ON

Provider: multiVIEW Locates Inc.

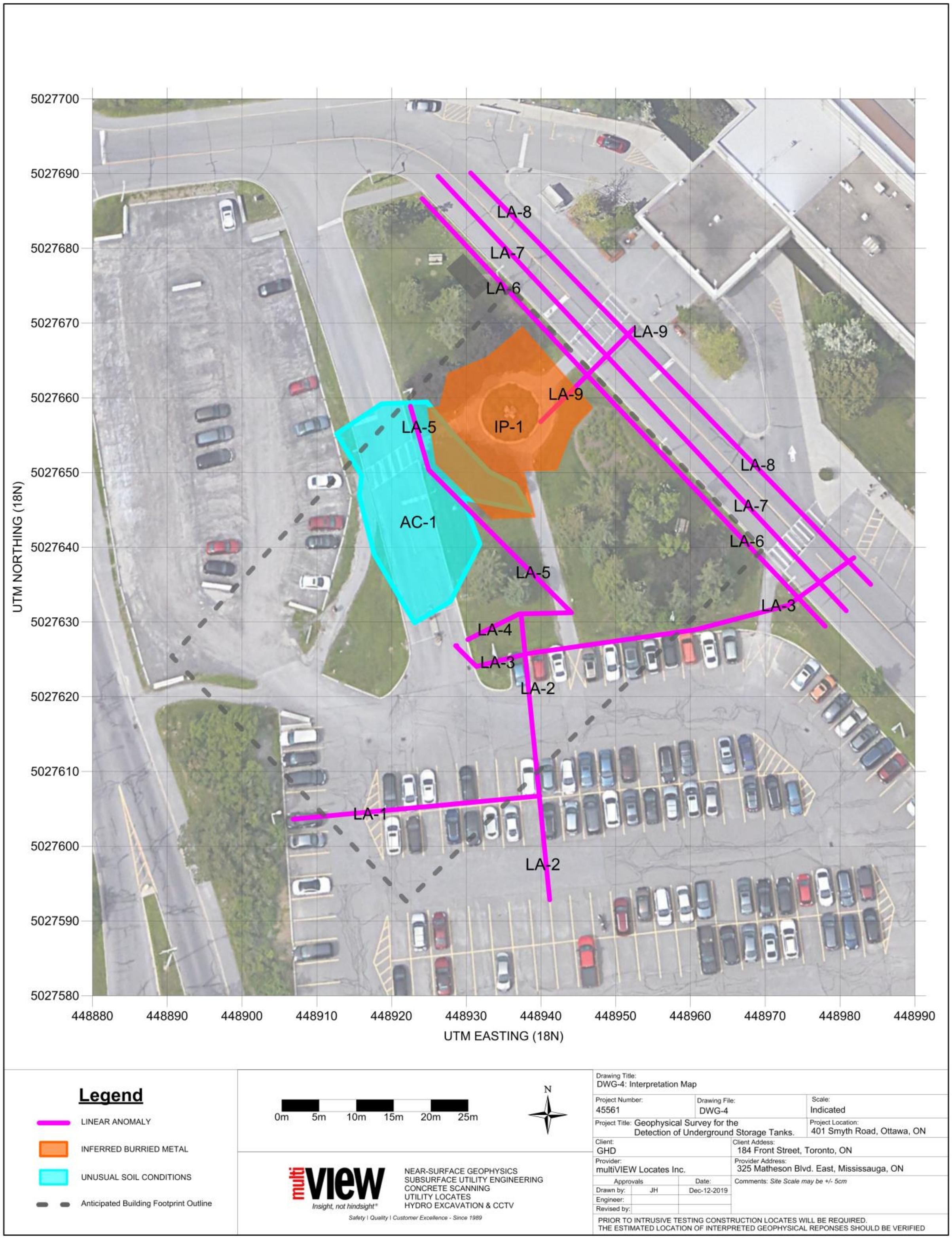
Provider Address: 325 Matheson Blvd. East, Mississauga, ON

Approvals		Date:
Drawn by:	JH	Dec-12-2019
Engineer:		
Revised by:		

Comments: *Site Scale may be +/- 5cm*

PRIOR TO INTRUSIVE TESTING CONSTRUCTION LOCATES WILL BE REQUIRED.
THE ESTIMATED LOCATION OF INTERPRETED GEOPHYSICAL REPONSES SHOULD BE VERIFIED

Figure 4-2: FDEM In-Phase Data



Drawing Title: DWG-4: Interpretation Map

Project Number: 45561

Drawing File: DWG-4

Scale: Indicated

Project Title: Geophysical Survey for the Detection of Underground Storage Tanks.

Project Location: 401 Smyth Road, Ottawa, ON

Client: GHD

Client Addess: 184 Front Street, Toronto, ON

Provider: multiVIEW Locates Inc.

Provider Address: 325 Matheson Blvd. East, Mississauga, ON

Approvals		Date:
Drawn by:	JH	Dec-12-2019
Engineer:		
Revised by:		

Comments: *Site Scale may be +/- 5cm*

PRIOR TO INTRUSIVE TESTING CONSTRUCTION LOCATES WILL BE REQUIRED.
THE ESTIMATED LOCATION OF INTERPRETED GEOPHYSICAL REPONSES SHOULD BE VERIFIED

Figure 4-3: FDEM Interpretation Map

5 CONCLUSION

Frequency Domain Electromagnetics were carried out in the property located at 401 Smyth Road, Ottawa, ON, Canada. The primary objective of the investigation was to map the presence of potential underground storage tanks.

The results of the geophysical survey served to delineate various anomalous zones in the Frequency Domain Electromagnetics data and outlined potential subsurface variance within project area. Localized small area FDEM responses with high positive/negative amplitude observed in the property may represent buried metallic objects. A summary depicting the interpretation of the geophysical responses is provided in the following list:

- Identified 1 zone of elevated apparent conductivity (AC-1), was identified along the staff parking lot access road, which may indicate that unusual soil conditions may exist.
- Identified 1 zone of elevated In-phase data (IP-1) was identified surrounding the statue in the parking area. Buried metal objects may exist. Buried electrical servicing the light posts and metal mesh in the concrete may exist surrounding the statue.
- The electromagnetic responses in immediate vicinity of above ground structures, metal objects produce a fairly broad halo of elevated values around these features. These can include signs, lights, curbs, concrete, manholes, catch basins, picnic tables and any other surface feature on site during the survey.
- Snow covered parts of the site during the survey and ground level surface objects may have been not recorded.
- Elevated apparent conductivity readings were observed in pedestrian pathways, parking areas and roadways and are likely caused by the annual application of high volumes of ice salt.

The geophysical data obtained during this investigation is intended for the guidance of the geotechnical engineering and excavation activities only. Interpretation of the data used during any subsequent programs is subject to the Law of Physics and Technical limitations. Additional information regarding advantages and limitations of this geophysical data is provided in the report appendices.

MultiVIEW services and geophysical technical limitations can be found at http://www.multiview.ca/Services/Terms-and-Conditions.

When physically locating the interpreted geophysical responses over the terrain for intrusive testing, excavation or site rehabilitation, it is recommended to properly correlate the reference grid stations with the stations presented on the digital maps.

Respectfully Submitted,

February 20, 2020

[signature and date]
Joel Halverson
Geophysical Technologist
multiVIEW Locates Inc.

Revised by:

PROFESSIONAL GEOSCIENTIST ONTARIO
4/16/20
EVELIO MARTINEZ DEL PINO
PRACTISING MEMBER
1058
EMdP

April 16, 2020

[signature and date]
Evelio Martinez del Pino, P.Geo., M.Sc., CESA
Senior Geophysicist
multiVIEW Locates Inc.

6 REFERENCES

- Geonics Limited. 2002. Geophysical instrumentation for exploration & the environment. Geonics Limited.
- Misac N. Nabighian. 2008. Electromagnetic Methods in Applied Geophysics: Volume 2, Application, Parts A and B. (Society of Exploration Geophysicists). Newmont Exploration Limited, Denver, Colorado, US.
- Lisa Dojack. 2012. Ground Penetrating Radar Theory, Data Collection, Processing, and Interpretation: A Guide for Archaeologists.
- Reynolds, J.M. 2011. An Introduction to Applied and Environmental Geophysics. John Wiley & Sons Ltd, Chichester, 712 pp.

APPENDICES

APPENDIX A

Terms and Conditions for Electromagnetic Investigations

Data Presentation

1. The electromagnetic point data were acquired at the station spacing and on the date as defined in the survey objectives.
2. Colour-contoured maps were created from the collected electromagnetic data and referenced to the survey grid coordinates
3. The images of the colour contoured maps presented in the body of the report are for display and review purposes only. The images are scaled to fit page sizes. Data acquired for QC/QA purposes (base station, background or auxiliary data) are available in the digital archive. The raw data and maps in the digital archive are properly referenced to the survey area, using either grid or UTM coordinates. The maps are presented at a scale to facilitate the accompanying interpretation.

Data Interpretation

Interpretation of the electromagnetic data is intended for guidance on environmental engineering and excavation purposes only. The user must be aware of the following interpretive restrictions:

4. Features shown on the interpretation map are related to the expression of subsurface man-made objects and other geological features and structures underground. The projection and location of these features on the surface is referenced to the grid coordinate system established at the time of the survey. All detected features are not necessarily shown due to the weak and non-relevance of the observed responses.
5. Interpretation of buried features or change in soil conditions cannot be made in areas where data were not collected.
6. The electromagnetic data were reviewed with respect to the position of the cultural features (i.e. man-made metallic objects) identified on site. The electromagnetic response observed in proximity to a known cultural feature is attributed to that feature.
7. Where known surface or subsurface metallic objects exist within 2 metres of the electromagnetic data observation station, it is possible that other metallic objects or a change in soil conditions may be present but not identified in the interpretation because the electromagnetic response is attributed to, or masked by, the known feature.
8. The spatial position of all interpreted electromagnetic anomalies (zones where electromagnetic fields are different than background) inferred to represent buried metallic objects are indicated in red on this figure.
9. If red anomalies are not present on this figure, no electromagnetic signatures were identified which could not reasonably be ascribed to known metallic objects and/or no isolated electromagnetic anomalies could be identified.
10. The spatial position of all interpreted electromagnetic anomalies inferred to represent unusual soil conditions is indicated in blue on this figure. These anomalies may represent local changes in soil type or geology, changes in soil moisture conditions; fill versus natural soils or contaminated areas.
11. If blue anomalies are not present on this figure, no electromagnetic signatures were identified which could not reasonably be ascribed to known changes in soil type or geology, changes in soil moisture conditions, fill versus natural soils or contaminated areas.

Comments for Subsequent Investigations

12. The electromagnetic anomalies identified within the survey area and as potential buried objects relevant to the survey objectives should be excavated to confirm the source of the electromagnetic response. The excavation point and/or area must be referenced to the site survey grid and located in the center of the anomaly.
13. The survey grid coordinates were established using survey tapes. The stations and lines were picketed and marked over the ground and left in-place upon completion of the survey. After survey completion, if markings are unclear, the survey grid should be reconstructed prior to excavation activities, using all the information provided in this report and in the digital archive (e.g. GPS locations, photographs and additional location maps).
14. In all cases, excavation should be extended to a minimum depth of 2 metres to allow confident identification of the anomaly source.
15. It is recommended that this document be retained on site during any excavation activities. Excavation may reveal features not identified in the interpretation process due to the limitations of the technique.

APPENDIX B

FDEM (EM-31) Instrumentation

GROUND CONDUCTIVITY METERS

EM31-MK2

Using a patented electromagnetic inductive technique that allows measurement without any requirement for either electrodes or ground contact, the EM31-MK2 Ground Conductivity Meter maps soil materials, groundwater contaminants or any subsurface feature associated with changes in conductivity. With this inductive method, surveys can be conducted over any surface conditions, including those with high resistivity materials such as sand, gravel and asphalt.

Ground conductivity (quad-phase) and magnetic susceptibility (in-phase) measurements are recorded directly onto an integrated Archer field computer. The field computer provides many features for enhanced data collection including Bluetooth wireless communication, GPS compatibility, real-time data graphics, and compatibility with Windows Mobile applications.

The effective depth of exploration is about six metres from the instrument, making it ideal for environmental and engineering site characterization. Important advantages of the EM31-MK2 over conventional resistivity methods include: speed of operation; high-volume, continuous data collection; high spatial resolution of data; and the precision with which small changes in conductivity can be measured. Additionally, the in-phase component is particularly useful for the detection of buried metallic structure and waste material.

EM31-SH

The EM31-SH is a "short" version of the standard EM31-MK2 providing an effective depth of exploration of about four metres. With a smaller coil separation (2 m) and lighter weight, the EM31-SH offers improvements in sensitivity to smaller near-surface targets, lateral resolution and portability, while maintaining the high levels of accuracy and stability provided by the standard EM31-MK2. Where field conditions allow, a supporting wheel assembly is an option.

Specifications

MEASURED QUANTITIES	1: Apparent conductivity in millisiemens per metre (mS/m) 2: In-phase ratio of the secondary to primary magnetic field in parts per thousand (ppt)
INTERCOIL SPACING	3.66 metres
OPERATING FREQUENCY	9.8 kHz
MEASURING RANGES	Conductivity: 10, 100, 1000 mS/m; In-phase: ± 20 ppt
MEASUREMENT RESOLUTION	± 0.1 % of full scale
MEASUREMENT ACCURACY	± 5 % at 20 mS/m
NOISE LEVELS	Conductivity: 0.1 mS/m; In-phase: 0.03 ppt
DATA STORAGE	512 MB internal disk; SD and CF slots, user accessible
POWER SOURCE	8 disposable "C" cells (approx. 20 h continuous)
OPERATING TEMPERATURE	Instrument: -40° C to +50° C Field Computer: -30° C to +55° C
DIMENSIONS	Boom: 4.0 m extended, 1.4 m stored Shipping Case: 145 x 38 x 23 cm
WEIGHTS	Instrument: 12.4 kg; Shipping: 28 kg

APPENDIX C

Electromagnetic Theory and Application

The EM method is based on the induction of electrical currents in subsurface conductors by electromagnetic waves which are generated on the surface. The EM source is commonly a closed loop (transmitter) in which a controlled alternating current produces a time-varying magnetic field. The time-variant magnetic field induces alternating currents (often called eddy currents) in subsurface conductors which produce a secondary time-variant magnetic field that is measured at the surface with another closed loop of wire (receiver).

The secondary field is often not in phase with the primary (transmitted) field. The secondary field is divided into the portion of the field that is in phase and the portion that is out of phase with the primary field. These quantities may be referred to using a variety of names; in-phase and quadrature components, or real and imaginary components. The quadrature component is linearly related to terrain conductivity under normal subsurface conditions.

Electromagnetic measurements facilitate rapid determination of the average terrain conductivity because they do not require direct electrical contact with the ground. A disadvantage is that unless measurements are taken at different coil spacing, little vertical information is gained. However, EM profiling can be effective in investigations for locating lateral discontinuities such as landfill boundaries, changes in soil composition, or in the search for buried objects.

Terrain conductivity is defined as the conductivity that the instrument would report if located over a homogenous half-space with exactly that conductivity. As the earth is seldom well characterized as a homogenous half-space, the instrument simply integrates the effects of all the subsurface variations and indicates an "apparent conductivity" as terrain conductivity. The units are millisiemens/metre or inverse ohm-metres times 1000.

The conductivity measurement is dependent upon the density, porosity, moisture content, and presence or absence of electrolytes or colloids of the subsurface materials. Typically, clay soils have a high conductivity due to substantial cation exchange capacity. These cations contribute to the electrolyte concentration.

To a lesser extent, the amount and composition of colloids may also contribute to measured conductivity. Bedrock typically has a lower conductivity because of high density and the generally lower porosity present within the rock matrix. The irregular nature of landfilled material and the frequent presence of ferrous metals provide for an electromagnetic response that typically contrasts the more homogeneous natural materials in an area.

Electromagnetic methods (EM) are frequently used in the search for minerals and in shallow geophysical applications related to engineering, groundwater and environmental investigations.

Electrical Properties of Subsurface Materials

Conduction of electricity in materials takes place through electronic or ionic processes. Solid conductive materials can be divided into three classes: metals, electron semiconductors, and solid electrolytes. In the shallow groundwater environment, it is expected that the only metallic conductors are related to man-made objects such as pipes, tanks, and metallic landfill material rather than natural metallic bodies. Nearly all materials which are not true metal are electron semiconductors to some extent. The silicate rock-forming minerals in sedimentary formations are in the class of solid electrolytes.

Porosity, saturation, and pore fluid chemistry are much more important to the bulk electrical properties of a soil or rock than the electrical properties of the solid matrix. Most pore fluids contain some salts in solution and electrolytic conduction is the dominant conduction mechanism. The relative ability of a material to conduct electricity when a voltage is applied is expressed as conductivity in units of Siemens/metre (S/m).

Frequency Domain Electromagnetic Data (Geonics EM31 Terrain Conductivity Meter)

The EM31 equipment is a simple "Slingram" consisting of a magnetic dipole (a current loop) transmitter (Tx) and a coplanar magnetic dipole receiver (Rx) operating at a fixed frequency of 9.8 kHz and with a fixed distance between Tx and Rx of 3.66 m.

When a current is injected into the Tx coil a primary magnetic field is generated. Assume that the system is oriented with the dipole moments pointing in the vertical z-direction, i.e. the current loops lie in a horizontal plane, then the primary (or vacuum) field at the position of the receiver located with a distance r from the Tx, can be expressed in complex form as:

$$H_z^P = -\frac{m}{4\pi r^3}\exp(i\omega t) = -\frac{m}{4\pi r^3}[\cos(\omega t) + i\sin(\omega t)]$$

where m is the magnetic dipole moment of the transmitter, ω is the cyclic frequency and t is time. By convention the real primary field as measured as a function of time in the receiver is obtained as the real part of the above expression. Notice that the primary field varies strongly with distance. For example if the distance changes by 1 cm from 366 cm to 365 cm (ca 3 per mille) the primary field changes by 9 per mille. Therefore the distance must be kept fixed and well defined in order to avoid that artificial anomalies are introduced.

When the primary magnetic field interacts with the electrical conductors in the earth secondary currents are induced in them. These secondary currents in turn generate a secondary magnetic field that adds to the primary field at the position of the receiver. However, due to the delay in the induction process the secondary field is delayed with respect to the primary field. Thus we can write

$$H_z^S = \exp(-i\varphi)RH_z^P$$

where R is the ratio between the amplitudes of the secondary and primary fields and φ is the phase angle.

For normal earth materials which are only moderately conductive it turns out that the phase angle is close to 90 degrees. This means that the secondary field is out of phase with the primary field so that the ratio between the secondary field and the primary field can be written as

$$\frac{H_z^S}{H_z^P} = \exp(-i\varphi)R \cong -iR$$

This ratio, which is measured in the instrument, in turn is related to the electrical conductivity of a hypothetical half-space, the so-called apparent conductivity as follows:

$$\sigma_a = \frac{4}{\omega\mu_0 r^2}\left|\frac{H_z^S}{H_z^P}\right|$$

The electrical conductivity is measured in units of Siemens/m=[S/m]= 1000 millimmho/m= 1000 [mmho/m].

Earth materials may typically have the following electrical conductivities:

	Dry crystalline rock	Wet crystalline rock	Dry sand	Wet sand	Till	Clay	Sulphides
Electrical conductivity [mmho/m]	0.05	0.2	2	6	20	60	1000

Metals have much higher conductivities than rocks and loose sediments (for example the electrical conductivity of iron is $10^{10}\ mmho/m$). In this case the phase of the secondary field may deviate considerably from -90 degrees. Then both the real and imaginary parts of the secondary field changes. It turns out that the real part is more reliable than the imaginary part for identifying metals.

The electromagnetic data acquisition can be done using horizontal (normal) or vertical coil configurations. With the horizontal configuration, the depth of penetration of the electromagnetic signal can reach up to 6m. With the vertical configuration, the depth of penetration can reach 3m. For both configurations, the quadrature (imaginary) part is used for conductivity mapping and the In-phase part (real) is used for metal detection.

Each measurement of the electromagnetic field taken with the EM31 system represents some average conductivity over a volume with a scale of ca 4 meters. Independent measurements can then be obtained with spacing between measurements of 4 meters. It is advised to use 2 meters in order to get a reasonable overlap.

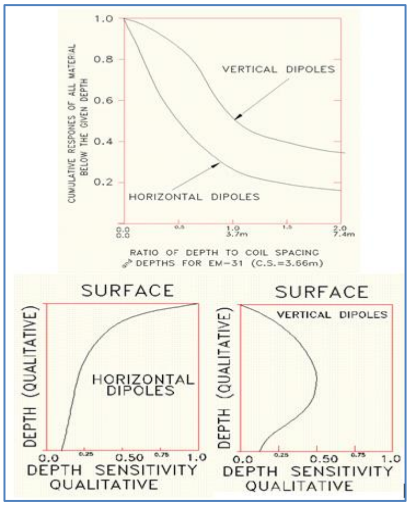
The outputs of an EM-31 survey are the conductivity (quadrature) and In-phase components of the secondary magnetic field. The secondary magnetic field is a complicated function of the intercoil spacing, the operating frequency, and the ground conductivity. The relationship is simplified when certain constraints, technically defined as "operation at low induction number", are met. When the low induction number constraints are not satisfied the measured quadrature and In-phase responses deviate from expected values.

In order to find out if there are strong lateral variations at a given measurement point you can rotate the instrument around a vertical axis by 90 degrees. If conductivities deviate much it means that over a 4 meter scale there are significant lateral variations.

Apparent conductivity measurements from a given area can be contoured and represented in map form like magnetic anomaly data. The data can be filtered like magnetic data in order to enhance deeper features. The maximum depth of investigation is around 6 meters, therefore shallow features will show up as more concentrated anomalies compared to those from deeper features.

Usually the data from EM31 measurements are only qualitatively interpreted. That means the measurements are used to find bumps or anomalous features. It is of course possible to interpret the data using quantitative models. In very conductive terrain, or in the presence of metal, (>300 mS/m) the quadrature component of the received magnetic field is not linearly proportional to the terrain conductivity, so conductivity readings are not accurate. Also at high conductivity, the In-phase portion of the received magnetic field increases in magnitude and, due to the limited dynamic range of the EM-31, the In-phase signal saturates the instrument's amplifiers causing the recorded data to be clipped.

To understand the depth of investigation of the EM-31 it is useful to consider a homogeneous halfspace with the addition of a thin layer at some depth. It is possible to calculate the secondary magnetic field that results from this thin layer as a function of depth. Material located at a depth of 0.4 times the coil spacing gives the most contribution to the response; however deeper layers still contribute a significant amount to the response (figures).

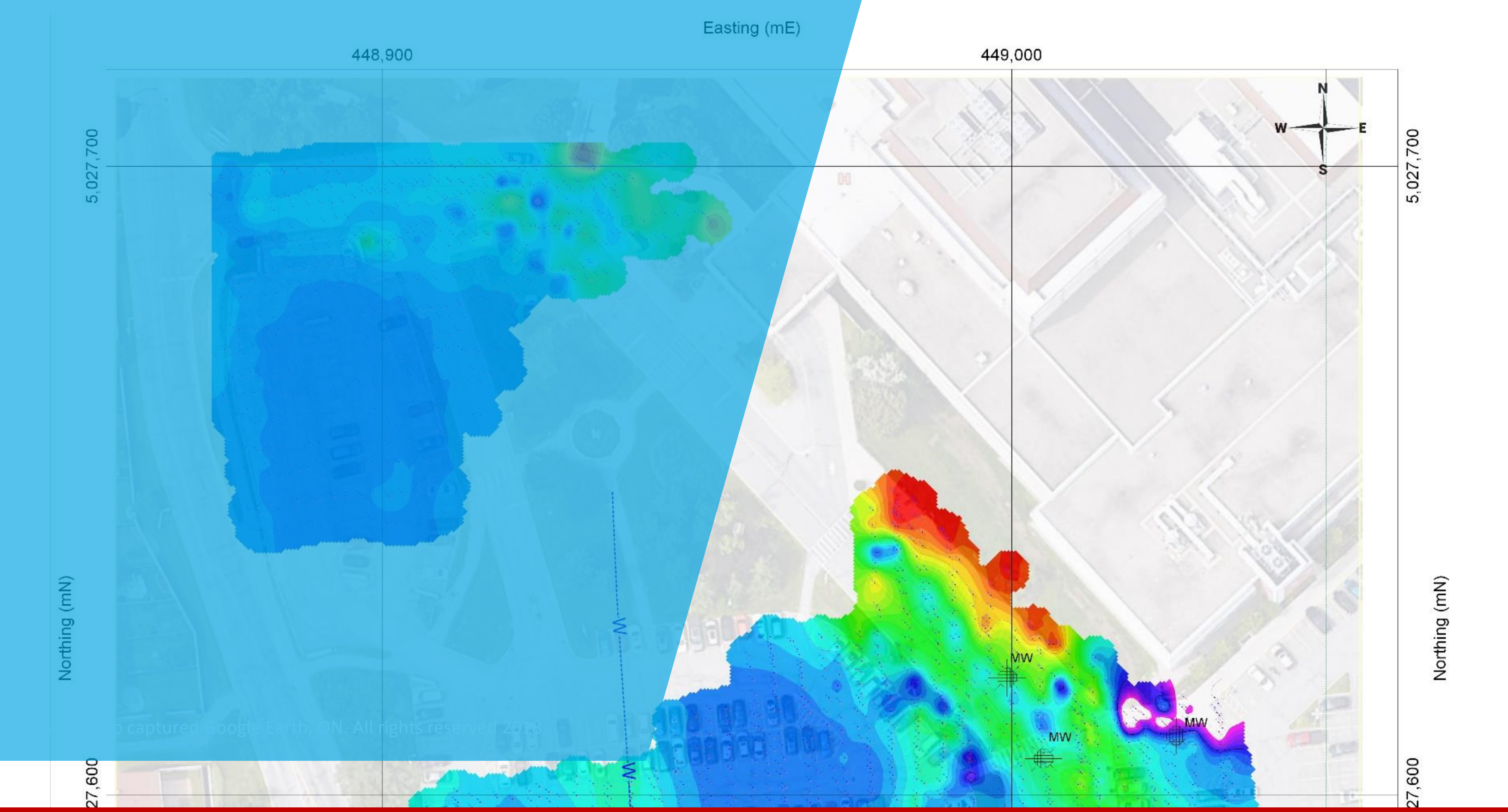


The geometry of an anomalous conductor can be inferred from the size and lateral extent of a feature. A strong In-phase response is expected over highly conductive bodies, such as buried metal. Anisotropic subsurface conductors can often be detected by comparing EM measurements from orthogonal instrument orientations. For example, a conductivity value output by an EM-31 instrument with the boom parallel to a north-south azimuth will be different from the conductivity value obtained with the boom parallel to an east-west azimuth, if the subsurface consists of an anisotropic conductor.

Taking the difference of the north-south measurement from the east-west measurement yields a non-zero number which is a relative indication of the amount of anisotropy. Difference plots also help to enhance lateral conductor boundaries when the boundaries are sharp transitions (landfill boundaries, for example).

It is necessary to integrate any possible external information into the EM interpretation, whether it is in the form of historical information or an interpretation from a different geophysical method. It is important to separate anomalies caused by cultural features such as debris piles, pipes, and buildings from subsurface related anomalies.

Field maps of cultural features enable the identification of cultural EM anomalies and distinguish known features from subsurface targets. One additional rule of thumb that is important in mapping objects is that the station spacing should be less (preferably 50% or so) than the coil spacing.



GEOPHYSICAL SUMMARY INTERPRETATION REPORT

REGARDING GROUND PENETRATING RADAR AND FREQUENCY DOMAIN ELECTROMAGNETIC FOR UNDERGROUND STORAGE TANK AND UTILITY MAPPING

CHILDREN'S HOSPITAL OF EASTERN ONTARIO
401 SMYTH ROAD, OTTAWA, ONTARIO

Prepared For:
Aditya Khandekar, PE., Project Manager
GHD
184 Front Street, Suite 302, Toronto, ON, M5A 4N3, Canada

Submitted By:
Evelio Martinez del Pino, P.Geo., M.Sc., CESA, Senior Geophysicist
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February 19, 2020

February 19, 2020

GHD
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Tel: 416-360-1600
Email: aditya.khandekar@ghd.com

Attention to Mr.: Aditya Khandekar, PE., Project Manager

Re: Geophysical Summary Report regarding Ground Penetrating Radar and Frequency Domain Electromagnetic for Underground Storage Tank and Utility Mapping at Children's Hospital of Eastern Ontario 401 Smyth Road, Ottawa, Ontario.

Dear Mr. Aditya Khandekar, PE.

Included, you will find a field report describing the data acquisition and interpretation results relevant to the survey objectives of the aforementioned geophysical survey (GHD Project No. 11205379). A digital archive containing the acquired data, interpretation maps and supporting documents relevant to the current survey is also provided.

This represents the end of our contractual agreement regarding the geophysical survey. Contact us if you need any additional material or information.

Respectfully Submitted,

Evelio Martinez del Pino, P.Geo., M.Sc., CESA
Senior Geophysicist
multiVIEW Locates Inc..

1 INTRODUCTION

GHD retained multiVIEW Locates Inc. (multiVIEW) to carry out a Ground Penetrating Radar and Frequency Domain Electromagnetic for Underground Storage Tank and Utility Mapping at Children's Hospital of Eastern Ontario 401 Smyth Road, Ottawa, Ontario.

This geophysical interpretation report summarizes the data collection logistics and methodology, processing results and data interpretation associated with the geophysical investigation.

The geophysical interpretation contained in this report is based on the analysis of the Ground Penetrating Radar and Frequency Domain Electromagnetic responses recorded during the field acquisition stage. The images and figures presented in the body of the report are scaled to fit the report page size and should be used for illustration purposes only. Detailed maps and images of the data and results are available in the digital archive supplied along with the interpretation report.

1.1 SURVEY OBJECTIVES

The primary objective of the investigation was to determine the location and extent of potential underground storage tanks on the property project area.

Additionally, the survey should assist on determine presence of general-purpose utilities and piping, buried metallic and non-metallic objects and structures.

2.1 SITE LOCATION AND ACCESS

The geophysical project is located at Children's Hospital of Eastern Ontario 401 Smyth Road, Ottawa, Ontario. The general location of the geophysical project is depicted in Figure 1.

Figure 1: Geophysical Project General Location Map

2 METHODOLOGY

The geophysical study was completed using Ground Penetrating Radar and Frequency Domain Electromagnetic techniques. The data acquisition was performed using a Noggin Smart Cart GPR System - 250MHz manufactured by Sensors & Software Inc and EM31 system manufactured by Geonics Limited Ltd. The geophysical data acquisition phase of the survey was completed by Joel Halverson (DPT, Geophysical Technologist), on December 16, 2019; December 17, 2019 and on January 24, 2020.

Field labor included the following activities:

- Geophysical survey grid installment;
- GPR profile imaging;
- FDEM profiling;
- Site Documentation;
- Data Interpretation and Results Presentation;

Nine (9) GPR and two (2) FDEM survey grids were established for the project at Children's Hospital of Eastern Ontario 401 Smyth Road, Ottawa, Ontario. Figure 2 shows the general position and reference stations of the survey areas and scanned lines. Starting from the reference position, the grids were installed with parallel and cross lines at 1.0 metre intervals. The grid layout was done using commercial measuring tapes and line-of-site positioning. Additional figures showing the survey area extent, surface features and line location (at the time of the survey) are included in the digital archive.

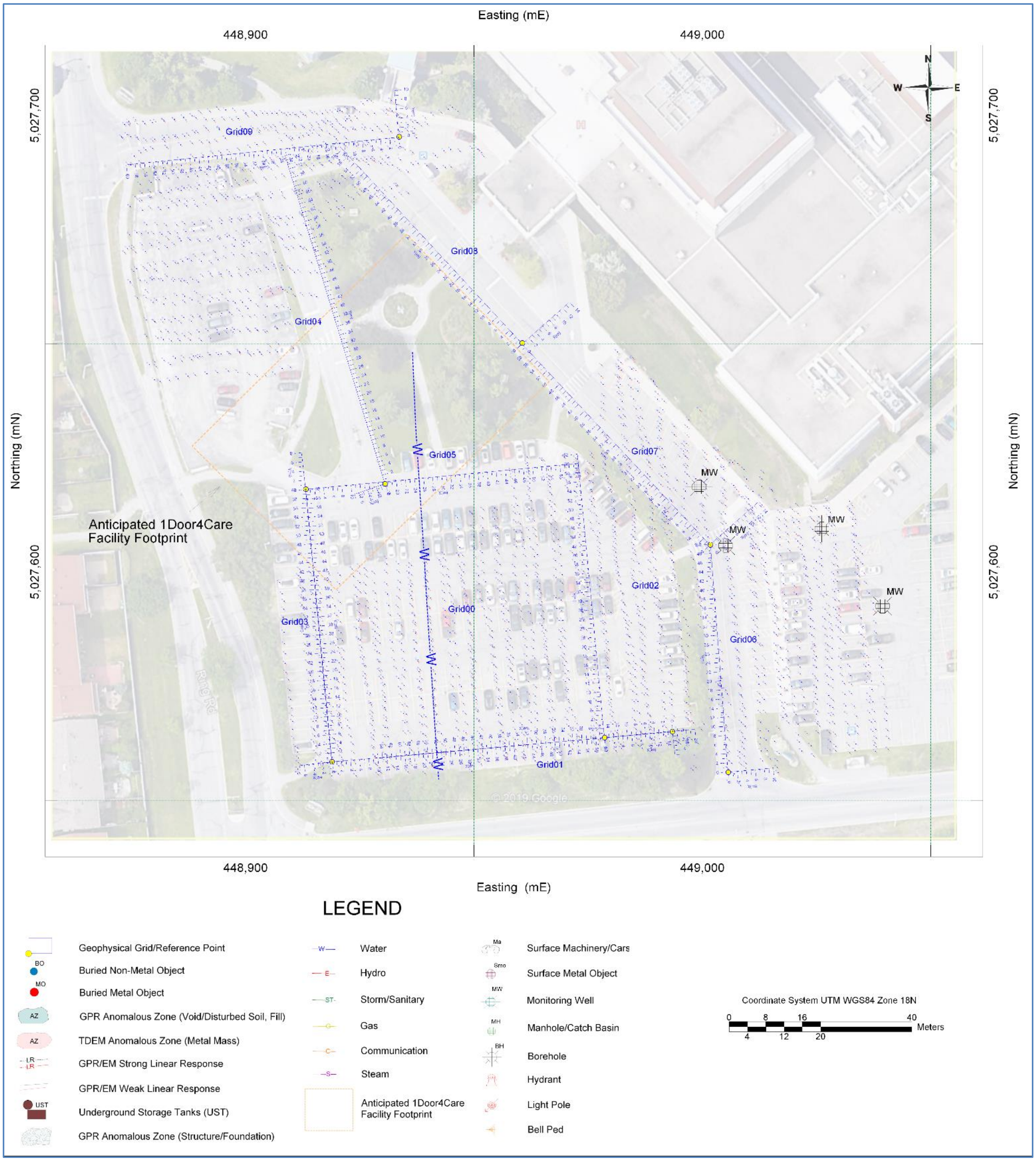


Figure 2: Geophysical Grid Location Map

2.1 GROUND PENETRATING RADAR DATA ACQUISITION

The GPR survey was completed using a Noggin 250MHz GPR system manufactured by Sensors & Software Inc. A general system configuration is shown in Figure 3. The GPR data were acquired with station spacing of 0.05m along the grid profiles established for the entire survey grid. Over the scanned area, the GPR profiling was run with parallel lines spaced at approximately 1 meter interval as shown in the geophysical line location map.

The ground penetrating radar electromagnetic signal transmitted into the subsurface and reflected by the structures, geological features and buried objects are recorded by Ground Penetrating Radar (GPR) instrumentation permitting real-time interpretation of subsurface features to a depth.

Figure 3: Typical GPR Acquisition System Setup

2.2 FREQUENCY DOMAIN EM DATA ACQUISITION

FDEM data acquisition was conducted across the entire project area using an EM31 system manufactured by Geonics Limited Ltd. The EM31 instrumentation provides data for indirect detection of buried metal objects and soil conductivity mapping to 3 to 6 meters depth using a horizontal coplanar coil configuration. A general system system configuration is shown in Figure 4.

Two components of the electromagnetic field (Quadrature and Inphase) were measured over the survey profiles. The measurement units of the system are "milli-Siemens per meter" (mS/m) for the Quadrature component and "parts per thousand" (ppt) for the Inphase component of the measured electromagnetic field.

The electromagnetic data were acquired at approximate station spacing of 0.2 meters along lines spaced at 1-3 meters apart, excluding obstructed areas.

Figure 4: Photo Illustrating a Typical Frequency Domain EM31 Acquisition System Setup

2.3 DATA INTERPRETATION AND PRESENTATION

GPR uses the physical principles of electromagnetic wave propagation throughout media. The GPR transmitted signal will be reflected, refracted and diffracted from the boundaries between objects with different dielectric properties. Buried object detection and mapping using GPR is possible due to the dielectric contrast between scanned objects the soil matrix.

The GPR anomaly identification was accomplished by examining the subsurface electromagnetic reflection characteristics such as continuous anomalous trending and high amplitude hyperbolic reflection identification. Results of the ground penetrating radar survey (GPR) are presented plan maps and in sectional views (distance versus depth profiles) extracted from the line raw data as required for the interpretation.

The inferred location of all GPR features and interpreted anomalous zones was documented and transferred to digital drawings. Detailed plan maps illustrating the interpreted GPR anomalies associated with underground features are presented in the report. All distance units used throughout this report are in meters unless otherwise noted. GPR interpretation and compilation was completed by comparing the characteristics of the acquired profiles to examples and results available at multiVIEW from in-house tests and historic field surveys.

Unusual soil conditions and natural subsurface disturbances are expressed as Frequency Domain Electromagnetic quadrature or conductivity anomalous zones. Generally, the soil and materials over these zones have higher porosity and higher water content (including clay content) than surrounding consolidated soil or materials, therefore higher conductivity is reflected in the acquired electromagnetic data. The rate of change in conductivity measurements or quadrature is generally greater in the vicinity of non-native materials and slowly varying in areas of native materials. Metallic minerals in the subsoil produce high conductivity responses. By mapping high conductivity or quadrature electromagnetic anomalies it is possible to infer the location of different fill materials and lithology.

Frequency Domain Electromagnetic Inphase responses will show positive responses over buried metal objects. In general, positive Inphase anomalies are representative of metallic objects. Inphase responses with high positive values indicate metal objects parallel to the orientation of the instrument coils. Positive anomalous values are commonly associated with buried metal objects. High amplitude Inphase responses (usually greater than twenty parts per thousand of the total field strength) are interpreted as large metallic objects. Alternatively, strong negative Inphase values are observed when high conductive objects such as iron or steel are oriented perpendicular and near to instrument coils.

By integrating Quadrature in conjunction with the Inphase data, it is possible to discriminate buried metal objects from different types of soils, fill materials and lithology. Local areas with high conductivity responses may be interpreted to represent more conductive non-homogeneous fill materials.

3 RESULTS

GPR and FDEM data for the survey grids were of good quality for providing a comprehensive interpretation of electromagnetic reflective responses and anomalous zones within the scanned areas. The main source of the GPR electromagnetic reflections, diffractions and edge-type responses observed in the acquired raw data are possibly related to buried objects, potential utilities, structures and disturbed soil. The source of the high amplitude FDEM responses are interpreted as buried metallic objects and linear features.

GPR and FDEM anomalous zones suggesting the presence of UST were not observed in the raw data. Alternatively, the interpreted buried features are illustrated in the interpretation compilation map in Figure 5. The following signatures were identified in the project survey area:

- Thirty-two (32) GPR linear responses (LRgpr-1 to LRgpr-32) potentially related to buried utilities and piping;
- Twelve (12) FDEM linear responses (LRem-1 to LRem-12) potentially related to metallic buried utilities and piping;
- Four (4) FDEM responses (MO-1 to MO-4) are potentially related to small buried metallic objects;
- Four (4) GPR responses (BO-1 to BO-4) are potentially related to small buried objects.

GPR depth slice maps at 50cm, 100cm and 150cm depths are provided in Figure 6, Figure 7 and Figure 8 in order to illustrate the size and extent of the interpreted GPR features. Example of sections depicting the GPR responses along the survey profiles are provided in Figure 12 to Figure 23. FDEM Quadrature and Inphase amplitude contour grid maps are presented in Figure 9 and Figure 10.

The following Table 1 summarises the interpreted underground buried features of relevance to the exploration program. The inferred location of the geophysical signatures was documented and transferred to digital drawings for referencing and assessment. For details on location of the responses refer to the geophysical interpretation maps, profiles and tables provided digitally.

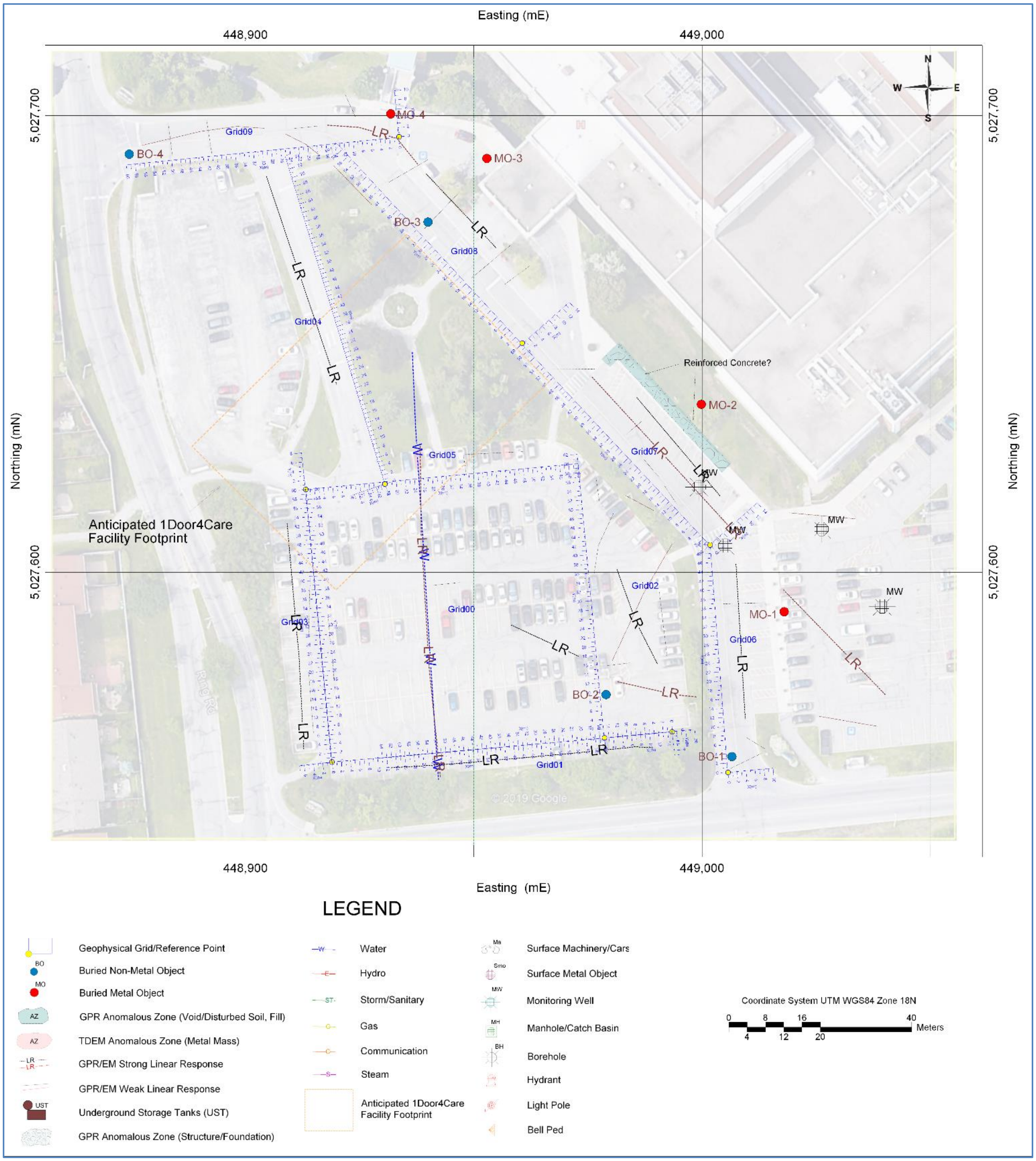


Figure 5: Geophysical Interpretation Plan Map

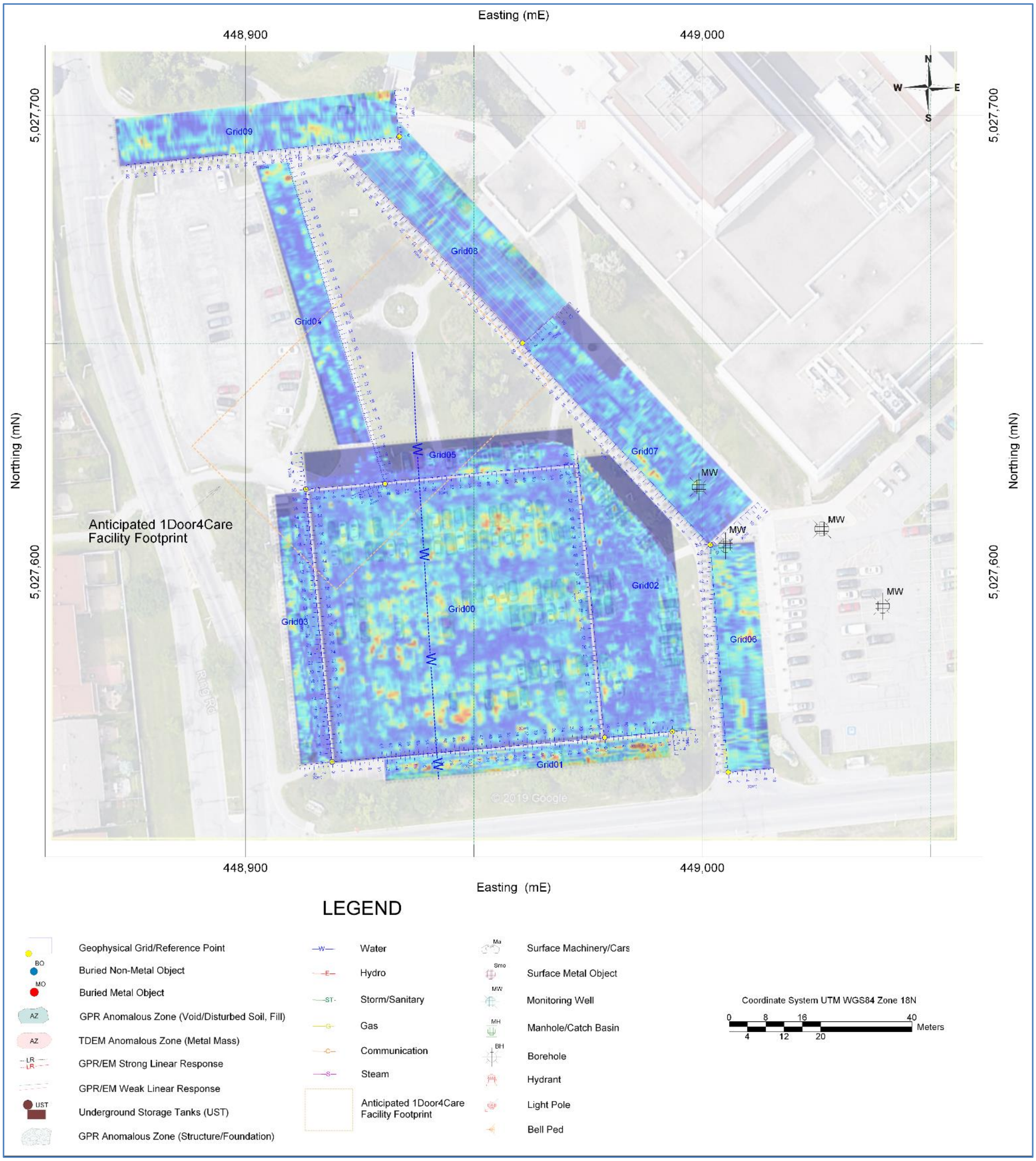


Figure 6: GPR Signal Amplitude at 50cm Depth

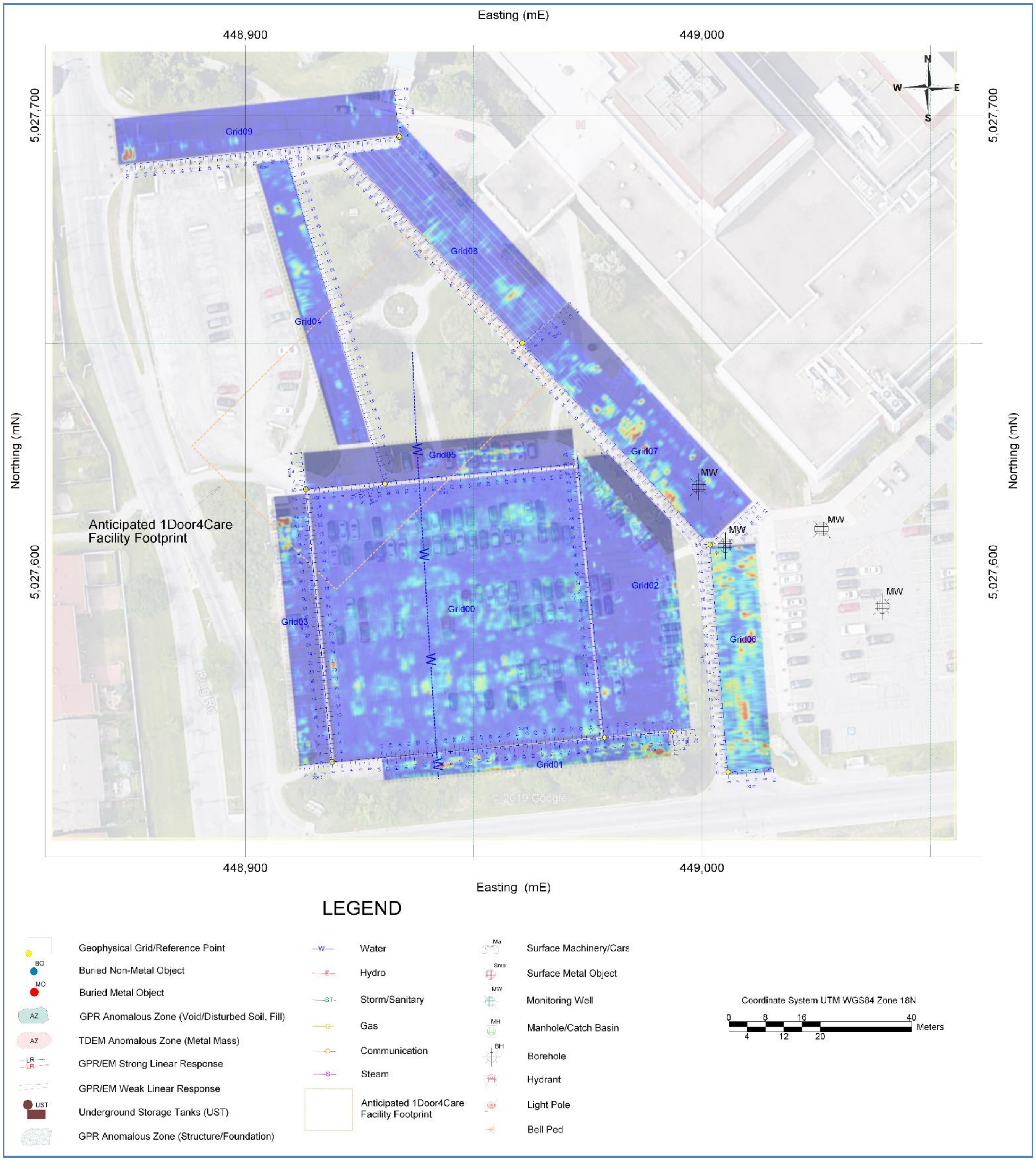


Figure 7: GPR Signal Amplitude at 100cm Depth

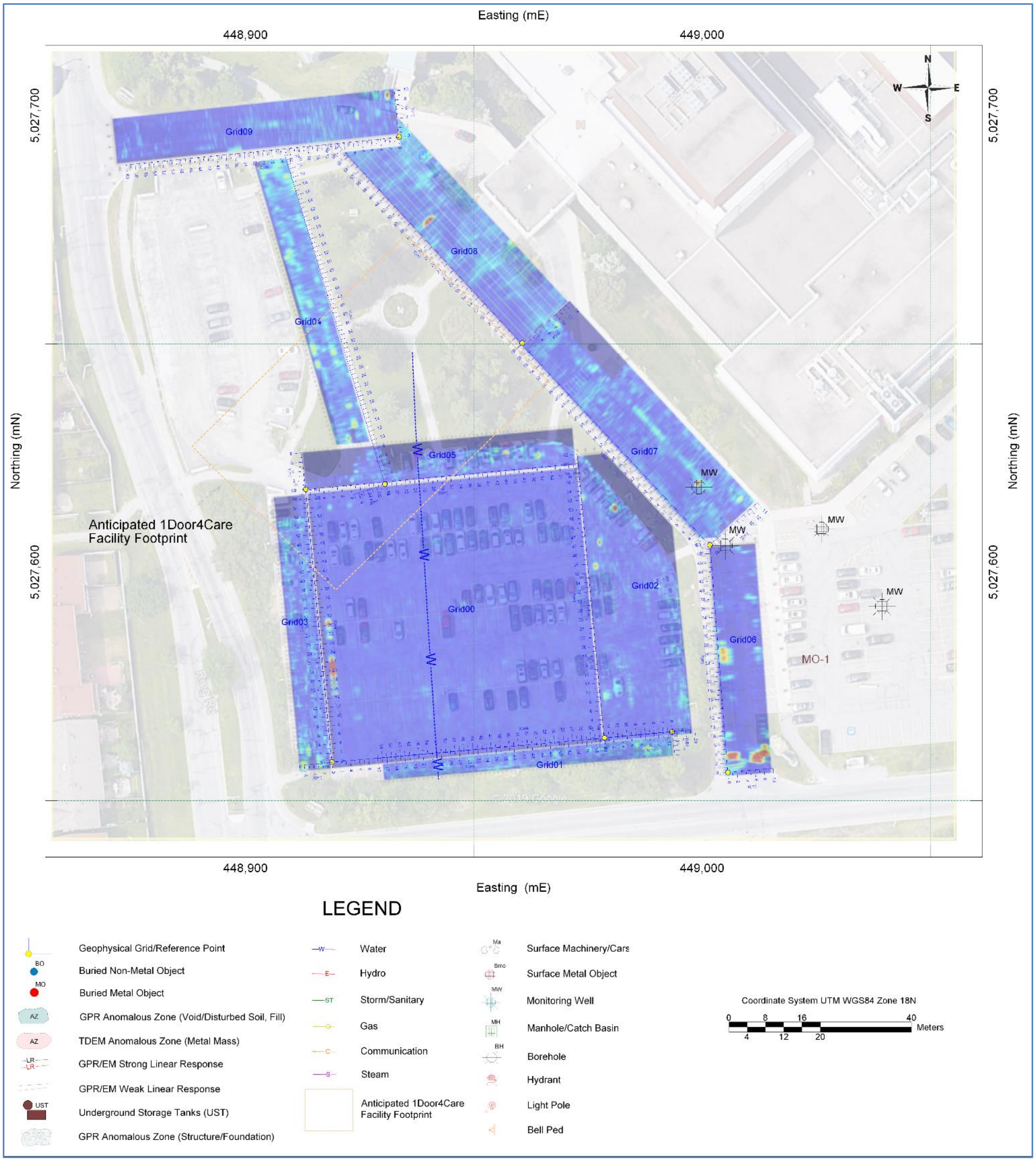


Figure 8: GPR Signal Amplitude at 150cm Depth

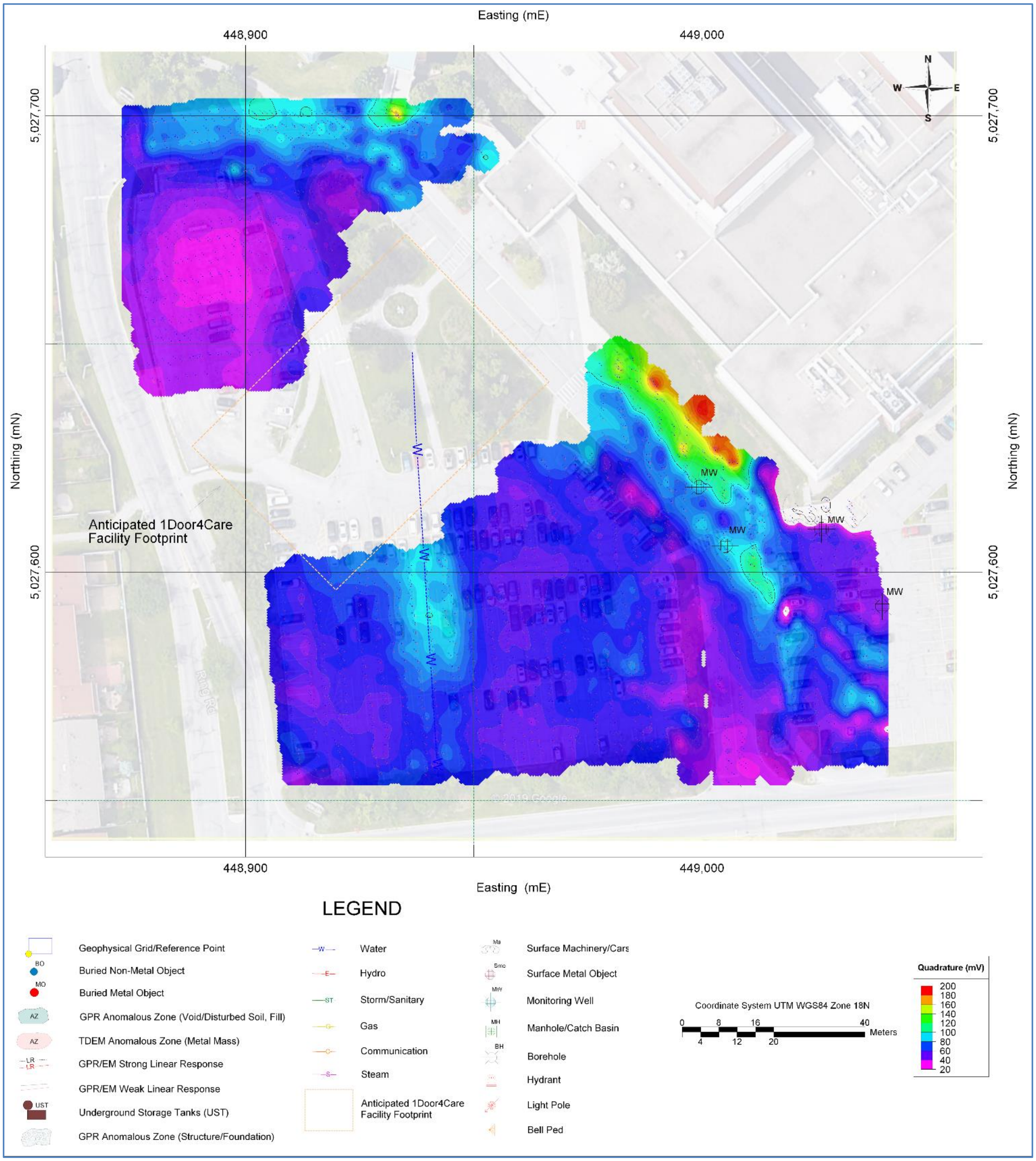


Figure 9: FDEM Quadrature Contour Grid Map

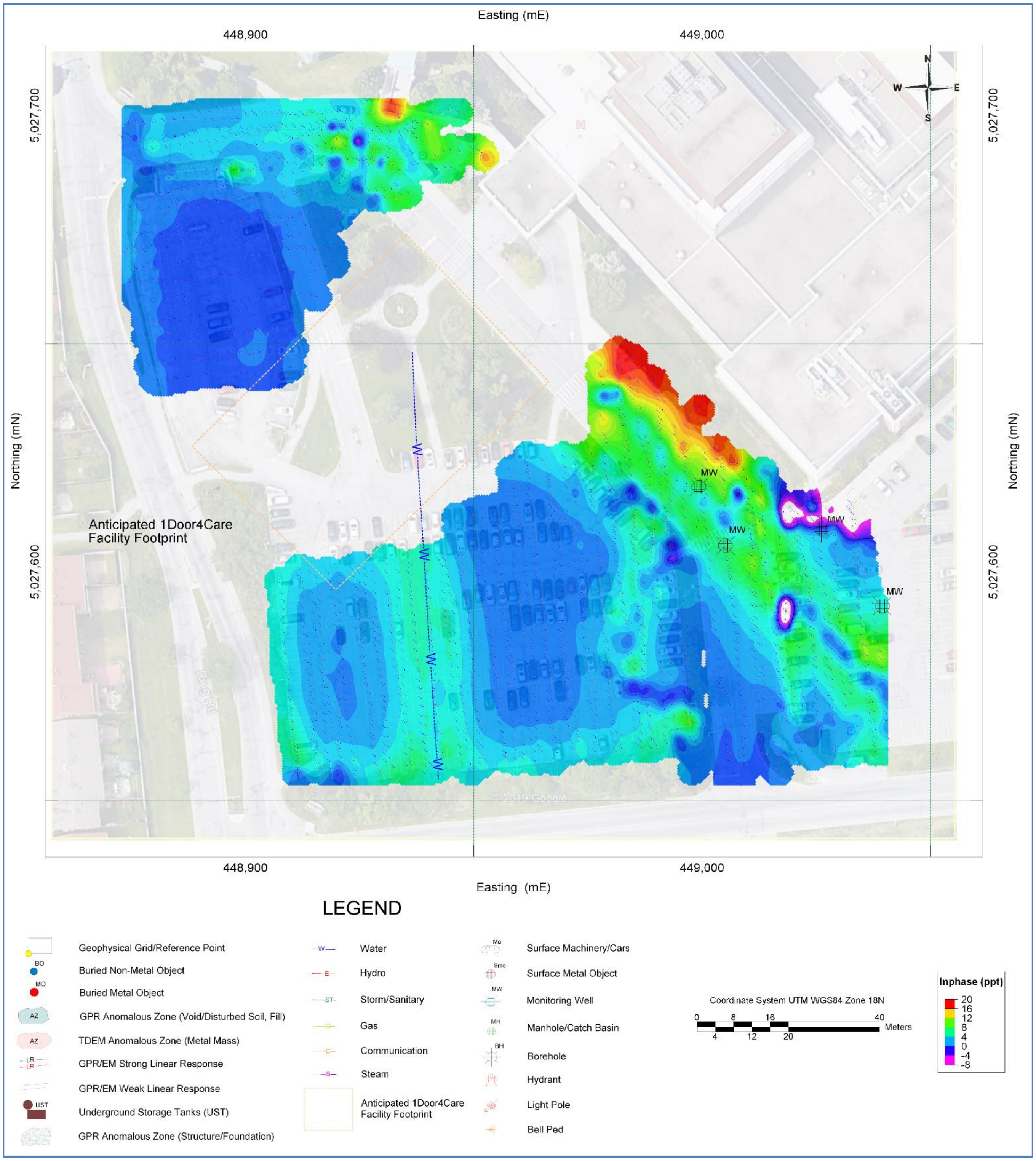


Figure 10: FDEM Inphase Contour Grid Map

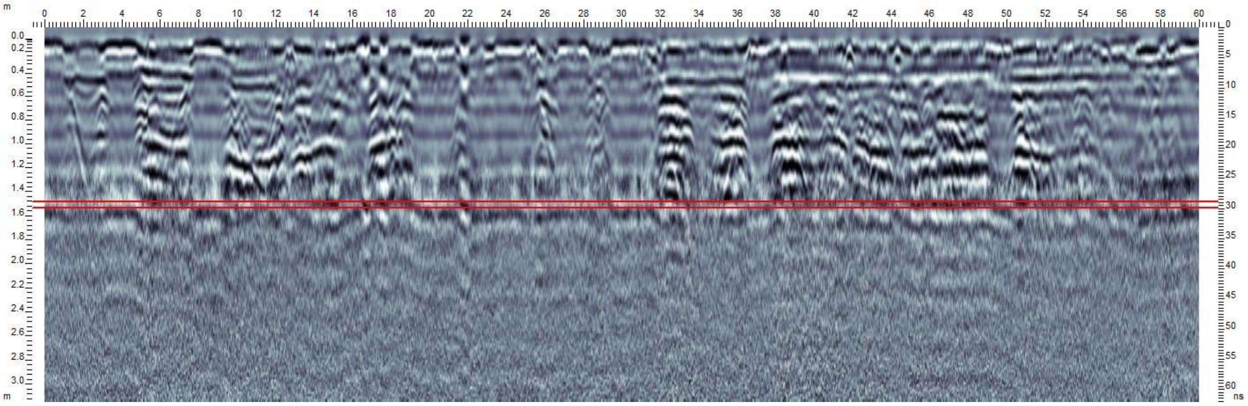
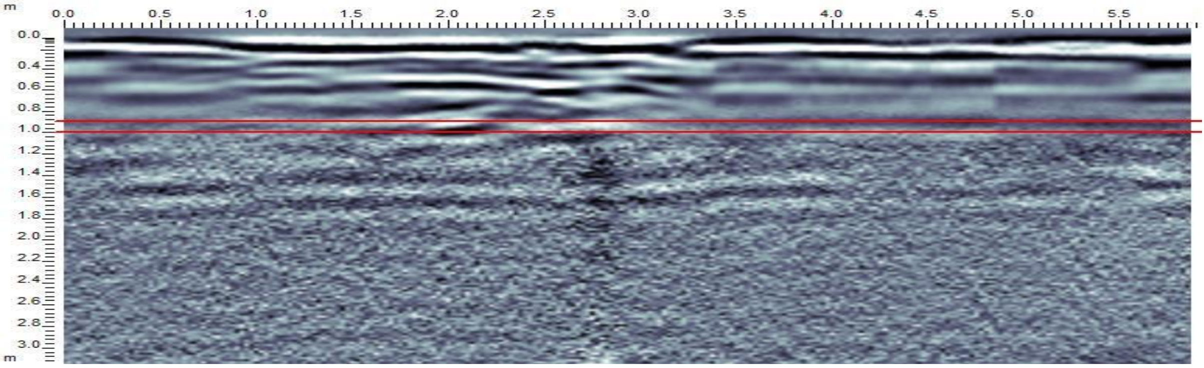


Figure 11: Example of GPR Profiles - Grid0 Xline



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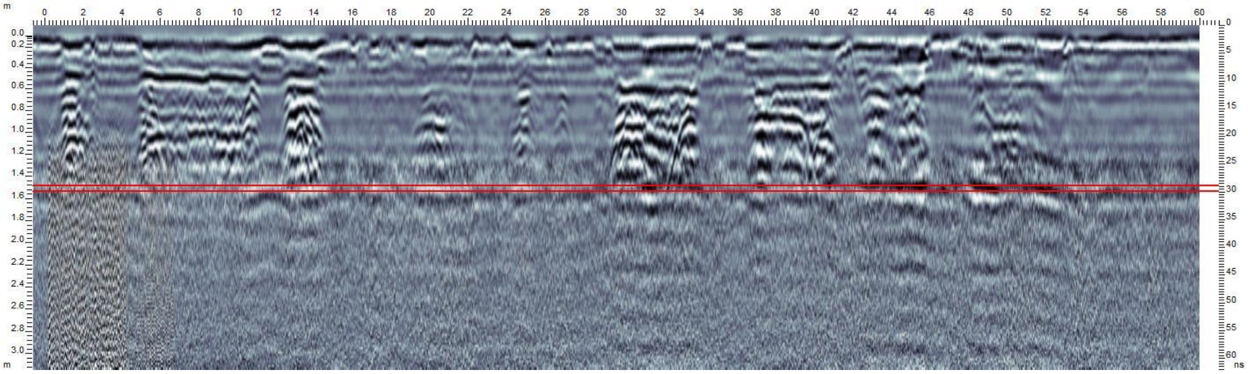

Figure 12: Example of GPR Profiles - Grid0 Yline29

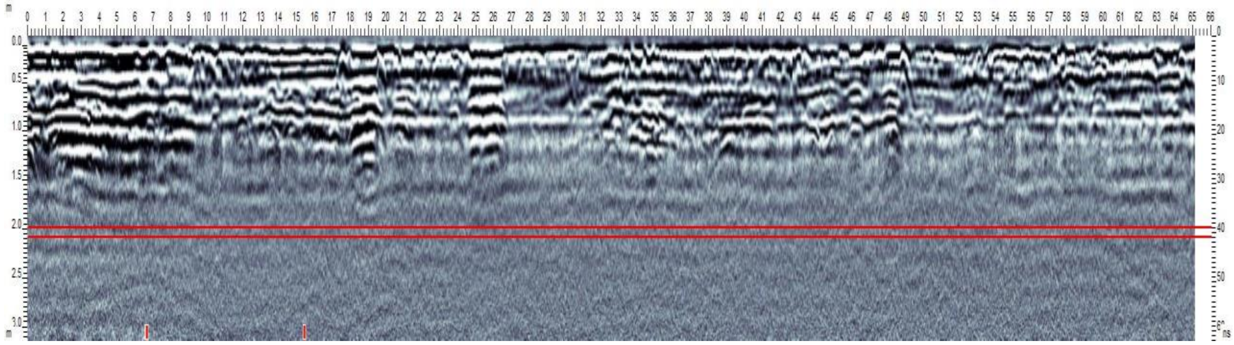

Figure 13: Example of GPR Profiles - Grid1 Xline4

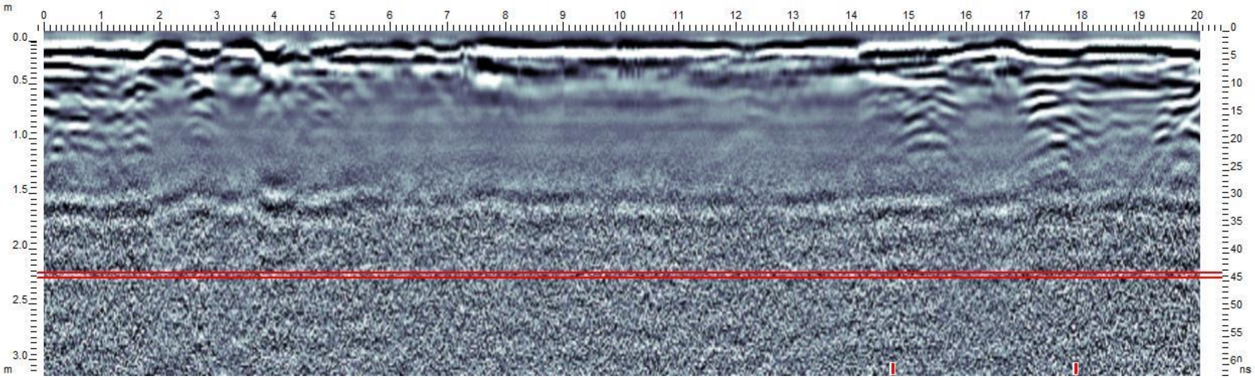

Figure 14: Example of GPR Profiles - Grid2 XLine34

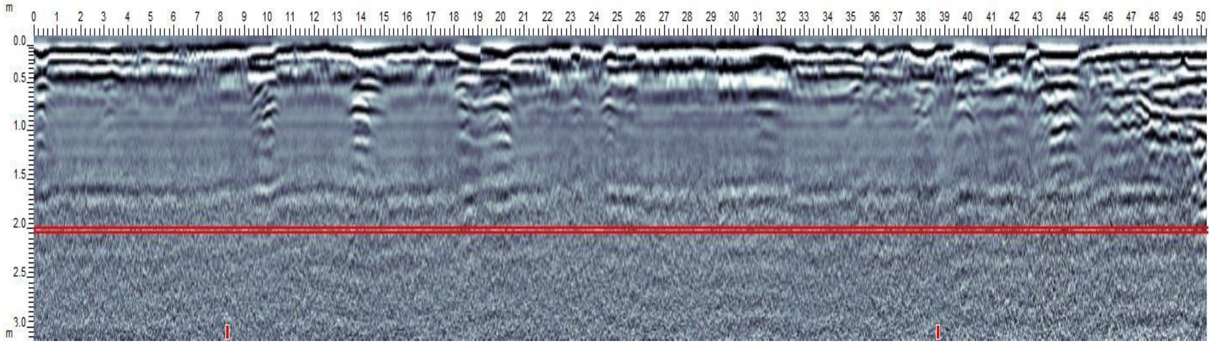

Figure 15: Example of GPR Profiles - Grid2 YLine10

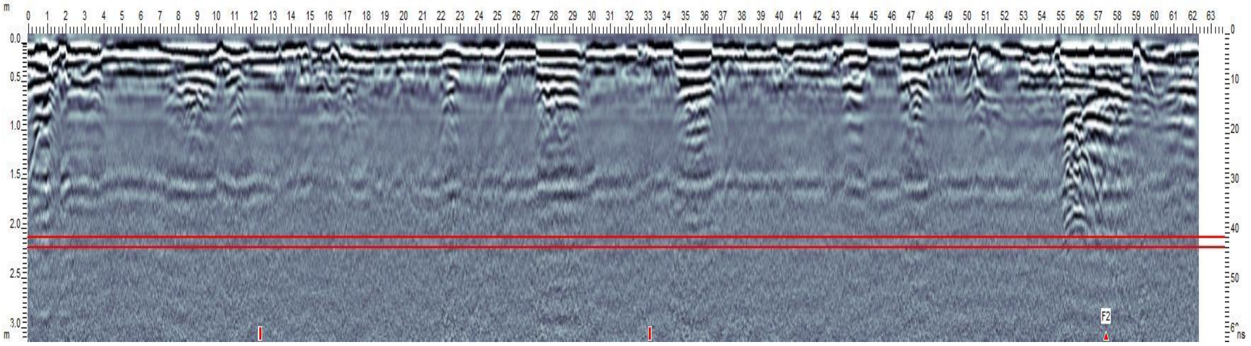

Figure 16: Example of GPR Profiles - Grid3 XLine2

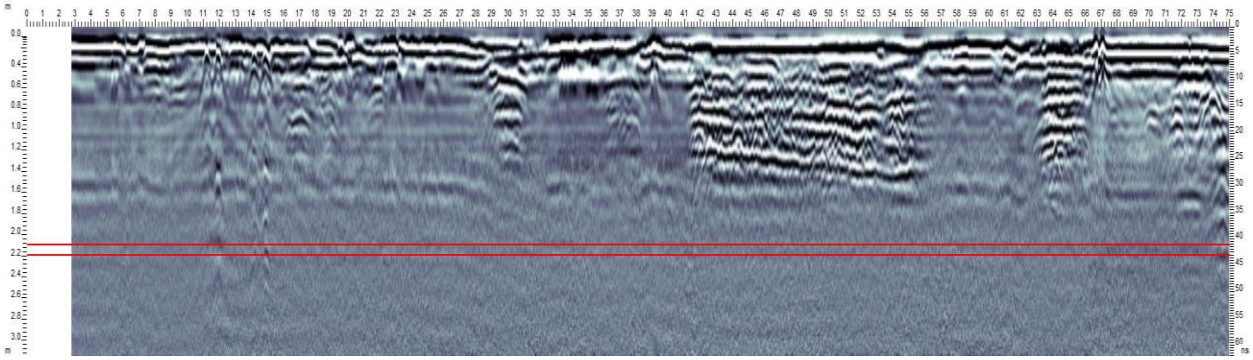

Figure 17: Example of GPR Profiles - Grid4 XLine5

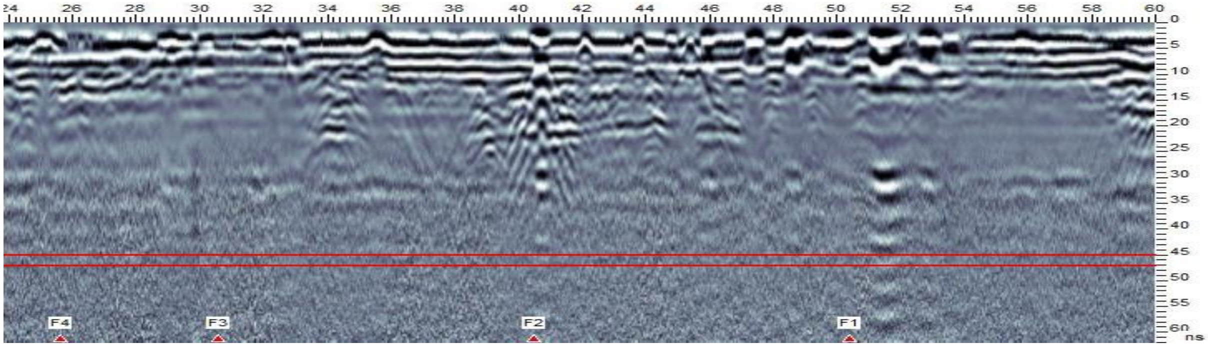

Figure 18: Example of GPR Profiles - Grid5 XLine3

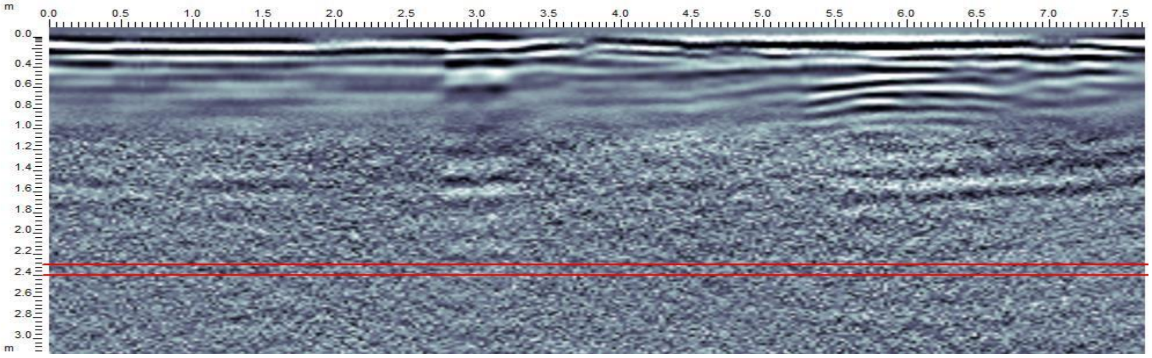

Figure 19: Example of GPR Profiles - Grid5 YLine13

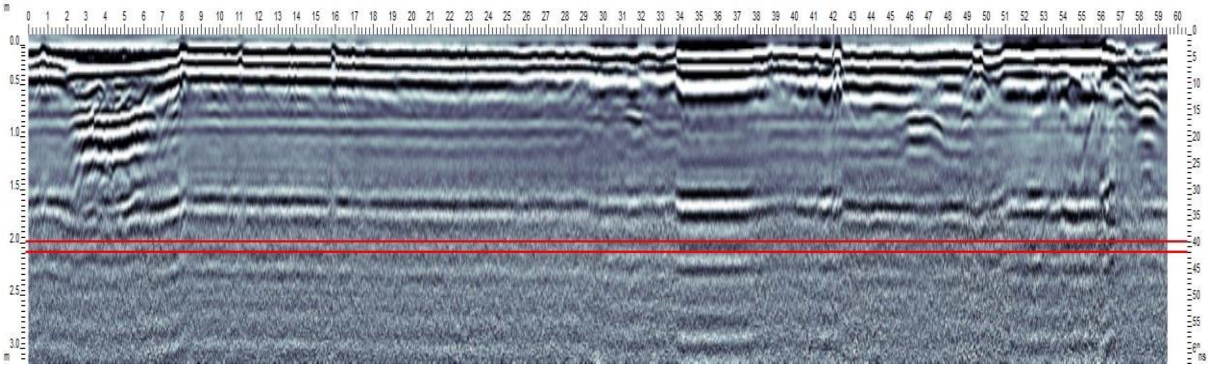

Figure 20: Example of GPR Profiles - Grid6 YLine6

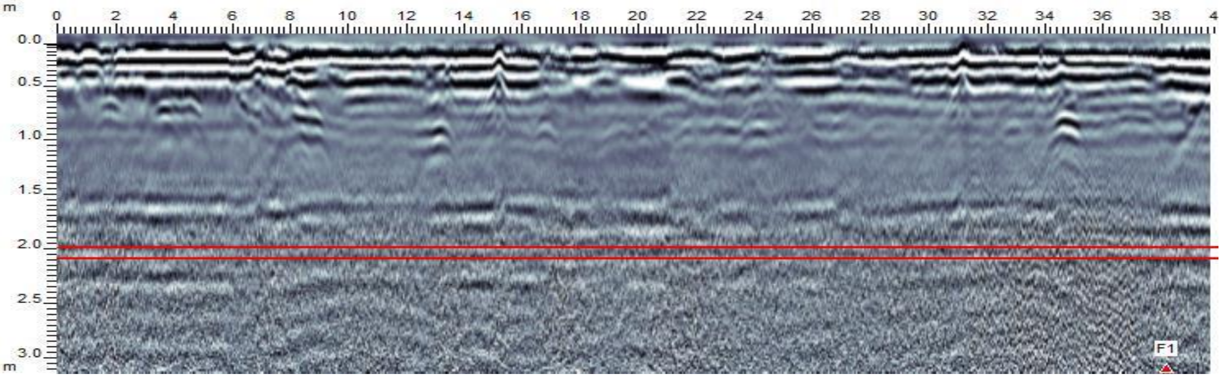

Figure 21: Example of GPR Profiles - Grid7 YLine13

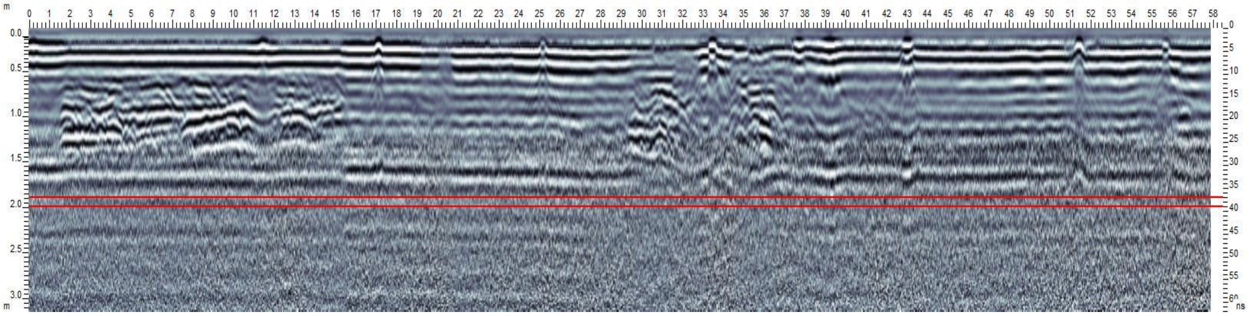

Figure 22: Example of GPR Profiles - Grid8 YLine5

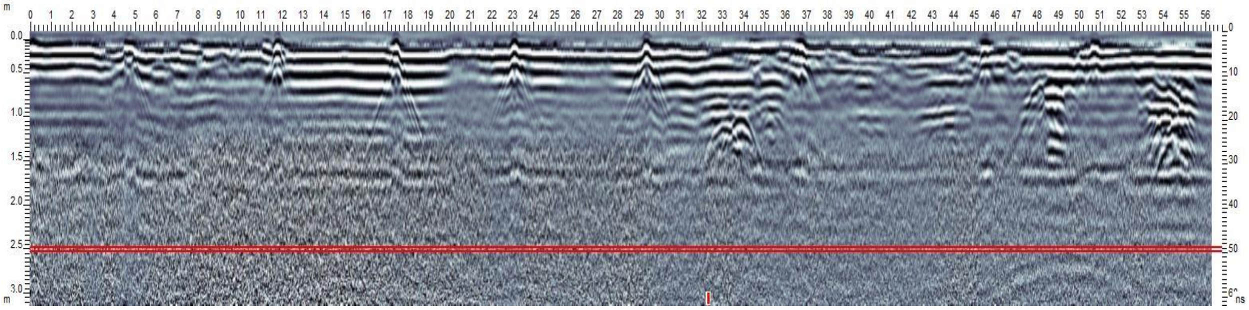

Figure 23: Example of GPR Profiles - Grid9 YLine3

Table 1: Geophysical Interpretation Summary Table

Interpretation	Easting	Northing	Feature ID
GPR Linear Response	448883	5027698	LRgpr-1
GPR Linear Response	448884.1	5027692	LRgpr-1
GPR Linear Response	448891.4	5027698	LRgpr-2
GPR Linear Response	448892.2	5027692	LRgpr-2
GPR Linear Response	448905.4	5027685	LRgpr-3
GPR Linear Response	448919.7	5027643	LRgpr-3
GPR Linear Response	448910.4	5027697	LRgpr-4
GPR Linear Response	448916	5027697	LRgpr-4
GPR Linear Response	448922.2	5027704	LRgpr-5
GPR Linear Response	448924.2	5027699	LRgpr-5
GPR Linear Response	448912.7	5027562	LRgpr-6
GPR Linear Response	448909.3	5027610	LRgpr-6
GPR Linear Response	448914.9	5027565	LRgpr-7
GPR Linear Response	448914.1	5027579	LRgpr-7
GPR Linear Response	448913.8	5027587	LRgpr-8
GPR Linear Response	448913.8	5027598	LRgpr-8
GPR Linear Response	448918.8	5027577	LRgpr-9
GPR Linear Response	448918.3	5027590	LRgpr-9
GPR Linear Response	448931.1	5027686	LRgpr-10
GPR Linear Response	448939.5	5027689	LRgpr-10
GPR Linear Response	448939.8	5027676	LRgpr-11
GPR Linear Response	448946	5027684	LRgpr-11
GPR Linear Response	448949.6	5027665	LRgpr-12
GPR Linear Response	448955.8	5027671	LRgpr-12
GPR Linear Response	448956.9	5027664	LRgpr-13
GPR Linear Response	448962.2	5027666	LRgpr-13
GPR Linear Response	448939.5	5027687	LRgpr-14
GPR Linear Response	448953.8	5027672	LRgpr-14
GPR Linear Response	448967.8	5027645	LRgpr-15
GPR Linear Response	448975.9	5027645	LRgpr-15
GPR Linear Response	448947.7	5027626	LRgpr-16
GPR Linear Response	448961.4	5027626	LRgpr-16
GPR Linear Response	448947.7	5027621	LRgpr-17
GPR Linear Response	448947.7	5027625	LRgpr-17
GPR Linear Response	448940.4	5027597	LRgpr-18
GPR Linear Response	448945.7	5027597	LRgpr-18
GPR Linear Response	448958.9	5027588	LRgpr-19
GPR Linear Response	448972.3	5027582	LRgpr-19
GPR Linear Response	448978.7	5027578	LRgpr-20
GPR Linear Response	448984.3	5027580	LRgpr-20
GPR Linear Response	448932.3	5027557	LRgpr-21
GPR Linear Response	448988.5	5027562	LRgpr-21
GPR Linear Response	448976.5	5027601	LRgpr-22
GPR Linear Response	448980.1	5027613	LRgpr-22
GPR Linear Response	448975.9	5027622	LRgpr-23
GPR Linear Response	448977.3	5027616	LRgpr-23
GPR Linear Response	448981.5	5027600	LRgpr-24
GPR Linear Response	448990.2	5027580	LRgpr-24
GPR Linear Response	448990.8	5027596	LRgpr-25
GPR Linear Response	448992.4	5027582	LRgpr-25
GPR Linear Response	448985.4	5027627	LRgpr-26
GPR Linear Response	448993.8	5027615	LRgpr-26
GPR Linear Response	448983.2	5027629	LRgpr-27
GPR Linear Response	448986.8	5027633	LRgpr-27
GPR Linear Response	448985.4	5027638	LRgpr-28
GPR Linear Response	449003.9	5027617	LRgpr-28
GPR Linear Response	449007.8	5027602	LRgpr-29
GPR Linear Response	449009	5027568	LRgpr-29

GPR Linear Response	449004.8	5027594	LRgpr-30
GPR Linear Response	449012.6	5027593	LRgpr-30
GPR Linear Response	449010.1	5027564	LRgpr-31
GPR Linear Response	449014	5027561	LRgpr-31
GPR Linear Response	449006.2	5027557	LRgpr-32
GPR Linear Response	449013.7	5027560	LRgpr-32
FDEM Linear Response	448877.7	5027694	LRem-1
FDEM Linear Response	448903.4	5027697	LRem-1
FDEM Linear Response	448909.3	5027696	LRem-2
FDEM Linear Response	448916.6	5027692	LRem-2
FDEM Linear Response	448919.4	5027689	LRem-3
FDEM Linear Response	448927.5	5027680	LRem-3
FDEM Linear Response	448918.8	5027698	LRem-4
FDEM Linear Response	448936.7	5027691	LRem-4
FDEM Linear Response	448942.9	5027555	LRem-5
FDEM Linear Response	448938.1	5027627	LRem-5
FDEM Linear Response	448981.2	5027576	LRem-6
FDEM Linear Response	448996.9	5027572	LRem-6
FDEM Linear Response	448981	5027582	LRem-7
FDEM Linear Response	448993.8	5027606	LRem-7
FDEM Linear Response	448982.6	5027617	LRem-8
FDEM Linear Response	448988.5	5027613	LRem-8
FDEM Linear Response	448975.9	5027642	LRem-9
FDEM Linear Response	449007.6	5027608	LRem-9
FDEM Linear Response	449025.2	5027568	LRem-10
FDEM Linear Response	449038.6	5027566	LRem-10
FDEM Linear Response	449018.2	5027596	LRem-11
FDEM Linear Response	449040	5027573	LRem-11
FDEM Linear Response	449019.6	5027613	LRem-12
FDEM Linear Response	449033.3	5027611	LRem-12
FDEM Response - Buried Metal Object	449018.2	5027591	MO-1
FDEM Response - Buried Metal Object	448999.4	5027637	MO-2
FDEM Response - Buried Metal Object	448953	5027690	MO-3
FDEM Response - Buried Metal Object	448932	5027700	MO-4
GPR Response - Buried Object	449006.2	5027559	BO-1
GPR Response - Buried Object	448978.7	5027573	BO-2
GPR Response - Buried Object	448939.3	5027677	BO-3
GPR Response - Buried Object	448874.1	5027692	BO-4

4 CONCLUSION AND RECOMMENDATIONS

A ground geophysical investigation was carried out at Children's Hospital of Eastern Ontario 401 Smyth Road, Ottawa, Ontario for Underground Storage Tank and Utility Mapping. The survey was able to delineate distinct anomalous zones and discrete responses in the Ground Penetrating Radar and Frequency Domain Electromagnetic raw data like those responses related to utilities and buried metallic and non-metallic objects.

GPR and FDEM anomalous zones suggesting the presence of UST were not observed in the raw data. Multiple GPR reflections and metallic responses indicating subsurface features were identified throughout the survey area as follow:

- Thirty-two (32) GPR linear responses (LRgpr-1 to LRgpr-32) potentially related to buried utilities and piping;
- Twelve (12) FDEM linear responses (LRem-1 to LRem-12) potentially related to metallic buried utilities and piping;
- Four (4) FDEM responses (MO-1 to MO-4) are potentially related to small buried metallic objects;
- Four (4) GPR responses (BO-1 to BO-4) are potentially related to small buried objects.

Intrusive testing of the interpreted anomalous zone is recommended to verify the source of these responses. The GPR signal penetration averaged at 2.0-3.0 meters throughout the survey area. Geophysical anomalies from subsurface features at greater depths or within 1 meter from any building wall or fix structure would be distorted or not detectable.

Respectfully Submitted,

Evelio Martinez del Pino, P.Geo., M.Sc., CESA
Senior Geophysicist
multiVIEW Locates Inc.

PROFESSIONAL GEOSCIENTIST ONTARIO
EVELIO MARTINEZ DEL PINO
PRACTISING MEMBER
1058
4/16/2020

5 TERMS AND CONDITIONS

Further exploration may be considered in order to determine the true nature of the interpreted geophysical anomalies, particularly those representing potential buried objects and liabilities not locatable by using radio detection techniques. Intrusive testing is recommended to determine the source and corroborate/correct the depth of the interpreted responses, particularly where high amplitude anomalies were identified on site.

Interpretation of the data used during any subsequent programs is subject to the Law of Physics and Technical limitations of the used survey techniques. Additional information regarding advantages and technical limitations of geophysical surveys can be found at http://www.multiview.ca/Services/Terms-and-Conditions.

When physically locating the interpreted responses over the terrain for intrusive testing, excavation or rehabilitation activities, it is recommended to properly correlate the reference grid stations with the stations presented on the digital maps. The raw data should also be reviewed for further interpretation and validation of the interpreted responses.

Appendix F

Laboratory Certificates of Analysis

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: GHD LIMITED
455 Phillip St
WATERLOO, ON N2V1C2
(519) 884-0510

ATTENTION TO: Jennifer Balkwill

PROJECT: 11205379-30 (PO#73518459)

AGAT WORK ORDER: 19T553493

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Supervisor

DATE REPORTED: Jan 08, 2020

PAGES (INCLUDING COVER): 6

VERSION*: 2

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

VERSION 2:Revised report issued January 08, 2020.

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T553493
PROJECT: 11205379-30 (PO#73518459)

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: Jennifer Balkwill
SAMPLED BY:

Loss on Ignition (Soil)

DATE RECEIVED: 2019-12-09

DATE REPORTED: 2020-01-08

					SAMPLE DESCRIPTION:	MW1	BH6	MW5	MW2	MW3	BH12
					SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil
					DATE SAMPLED:	2019-12-07	2019-12-07	2019-12-07	2019-12-07	2019-12-07	2019-12-07
Parameter	Unit	G / S	RDL	Date Prepared	Date Analyzed	783860	783884	783885	783886	783887	783888
Loss on Ignition	%		0.01	2020-01-06	2020-01-07	1.09	2.04	2.52	2.97	1.22	3.30

					SAMPLE DESCRIPTION:	BH13	BH14
					SAMPLE TYPE:	Soil	Soil
					DATE SAMPLED:	2019-12-07	2019-12-07
Parameter	Unit	G / S	RDL	Date Prepared	Date Analyzed	783889	783890
Loss on Ignition	%		0.01	2020-01-06	2020-01-07	2.28	2.46

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
783860-783890 Loss on Ignition is not an accredited analysis. Analysis was performed at 475°C .
Analysis performed at AGAT Toronto (unless marked by *)

Certified By: Amanjot Bhela

CHARTERED
AMANJOT BHELA
CHEMIST

Quality Assurance

CLIENT NAME: GHD LIMITED

PROJECT: 11205379-30 (PO#73518459)

SAMPLING SITE:

AGAT WORK ORDER: 19T553493

ATTENTION TO: Jennifer Balkwill

SAMPLED BY:

Soil Analysis

RPT Date: Jan 08, 2020			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Loss on Igniton															
LOI	783887		11.0	11.0	0.0%	< 0.5									
Loss on Ignition (Soil)															
Loss on Ignition	783860	783860	1.09	1.06	2.8%	< 0.01									

Certified By: Amanjot Bhela

AMANJOT BHELA

Method Summary

CLIENT NAME: GHD LIMITED

PROJECT: 11205379-30 (PO#73518459)

SAMPLING SITE:

AGAT WORK ORDER: 19T553493

ATTENTION TO: Jennifer Balkwill

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Loss on Ignition		MOE E3139	FURNACE
LOI	INOR-181-6030	ASTM D2974-07a	GRAVIMETRIC

AGAT Laboratories

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Laboratory Use Only

Work Order #: 19T553493

Cooler Quantity:

Arrival Temperatures: 2.0 | 1.7 | 2.3

Custody Seal Intact: ☐ Yes ☐ No ☒ N/A

Notes: ICE

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Report Information:

Company: GHD Ltd
Contact: Ahmed Sonnu
Address: 111 Brunel Rd
Mississauga Road
Phone: 647 463 8522 Fax:
Reports to be sent to:
1. Email: Ahmed.Sonnu@ghd.com
2. Email:

Regulatory Requirements:

☐ No Regulatory Requirement

(Please check all applicable boxes)

☐ Regulation 153/04
Table ______ *Indicate One*
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture *(Check One)*
☐ Coarse
☐ Fine

☐ Sewer Use
☐ Sanitary
☐ Storm
Region ______ *Indicate One*
☐ MISA

☐ Regulation 558
☐ CCME
☐ Prov. Water Quality Objectives (PWQO)
☐ Other
______ *Indicate One*

Is this submission for a **Record of Site Condition?** ☐ Yes ☐ No

Report Guideline on *Certificate of Analysis* ☐ Yes ☐ No

Turnaround Time (TAT) Required:

Regular TAT ☑ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CPM

Project Information:

Project: 1165379 - GHD
Site Location:
Sampled By:
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis

Invoice Information:

Bill To Same: Yes ☐ No ☐

Company: GHD Ltd
Contact: Ahmed Sonnu
Address: 111 Brunel Road, Mississauga. ON
Email: Ahmed.Sonnu@ghd.com

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI Y / N	O. Reg 153 Metals and Inorganics	☐ All Metals ☐ 153 Metals (excl. Hydrides)	☐ Hydride Metals ☐ 153 Metals (Incl. Hydrides)	ORPs: ☐ B-HWS ☐ Cl⁻ ☐ CN ☐ Cr⁶⁺ ☐ EC ☐ FOC ☐ Hg ☐ pH ☐ SAR	Full Metals Scan	Regulation/Custom Metals	Nutrients: ☐ TP ☐ NH₃ ☐ TKN ☐ NO₃ ☐ NO₂ ☐ NO₃+NO₂	Volatiles: ☐ VOC ☐ BTEX ☐ THM	PHCs F1 - F4	ABNs	PAHs	PCBs: ☐ Total ☐ Aroclors	Organochlorine Pesticides	TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs	Sewer Use	Organic Content (ASTM Standards)					Potentially Hazardous or High Concentration (Y/N)
MW1	Dec 07	10:00 am	1	SOIL																		✓					
BH6	"	"	1	"																		✓					
MW5	"	"	1	"																		✓					
MW2	"	"	1	"																		✓					
MW3	"	"	1	"																		✓					
BH12	"	"	1	"																		✓					
BH13	"	"	1	"																		✓					
BH14	"	"	1	"																		✓					

Samples Relinquished By (Print Name and Sign)	Date	Time	Samples Received By (Print Name and Sign)	Date	Time
Md-Shams Uddin	Dec 9/19	9:08 am	N. Bary	Dec 9	8:30

Page ______ of ______

Nº: T 098054

Pink Copy - Client | Yellow Copy - AGAT | White Copy- AGAT

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: GHD LIMITED
455 Phillip St
WATERLOO, ON N2V1C2
(519) 884-0510

ATTENTION TO: Jennifer Balkwill

PROJECT: 11205379 (PO#73518459)

AGAT WORK ORDER: 19T555371

MISCELLANEOUS ANALYSIS REVIEWED BY: Yris Verastegui, Report Reviewer

SOIL ANALYSIS REVIEWED BY: Yris Verastegui, Report Reviewer

DATE REPORTED: Dec 31, 2019

PAGES (INCLUDING COVER): 8

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Certificate of Analysis

AGAT WORK ORDER: 19T555371
PROJECT: 11205379 (PO#73518459)

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: Jennifer Balkwill
SAMPLED BY:

Sulphide

DATE RECEIVED: 2019-12-12

DATE REPORTED: 2019-12-31

					SAMPLE DESCRIPTION:	11205379-MW1 (SS2+SS3)	11205379-MW1 (SS6)	11205379-MW2-SS4	11205379-MW3-SS4	11205379-MW4 (SS2+SS3)	11205379-MW5-SS4
					SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil
					DATE SAMPLED:	2019-12-11	2019-12-11	2019-12-11	2019-12-11	2019-12-11	2019-12-11
Parameter	Unit	G / S	RDL	Date Prepared	Date Analyzed	796593	796645	796646	796647	796648	796649
Sulfide (S2-)	%		0.05			0.18	0.94	0.36	0.31	0.14	0.75

					SAMPLE DESCRIPTION:	11205379-BH6 (SS2+SS3)	11205379-BH7 (SS3)	11205379-BH8 (SS3)	11205379-BH9 (SS3+SS4)	11205379-BH12 (SS3+SS4)
					SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil
					DATE SAMPLED:	2019-12-11	2019-12-11	2019-12-11	2019-12-11	2019-12-11
Parameter	Unit	G / S	RDL	Date Prepared	Date Analyzed	796650	796651	796652	796653	796654
Sulfide (S2-)	%		0.05			0.60	0.86	0.30	0.09	0.06

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
796593-796654 Analysis performed at AGAT 5623 McAdam.
Analysis performed at AGAT Toronto (unless marked by *)

Certified By: Iris Verástegui

Certificate of Analysis

AGAT WORK ORDER: 19T555371
PROJECT: 11205379 (PO#73518459)

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: Jennifer Balkwill
SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2019-12-12

DATE REPORTED: 2019-12-31

						11205379-MW1		11205379-MW1		11205379-MW2-
					SAMPLE DESCRIPTION:	(SS2+SS3)		(SS6)		SS4
					SAMPLE TYPE:	Soil		Soil		Soil
					DATE SAMPLED:	2019-12-11		2019-12-11		2019-12-11
Parameter	Unit	G / S	RDL	Date Prepared	Date Analyzed	796593	RDL	796645	RDL	796646
Chloride (2:1)	µg/g		2	2019-12-19	2019-12-19	60	4	185	2	145
Sulphate (2:1)	µg/g		2	2019-12-19	2019-12-19	200	4	1000	2	130
pH (2:1)	pH Units		NA	2019-12-20	2019-12-20	7.87	NA	7.78	NA	7.78
Electrical Conductivity (2:1)	mS/cm		0.005	2019-12-19	2019-12-19	0.447	0.005	1.34	0.005	0.765
Resistivity (2:1) (Calculated)	ohm.cm		1	2019-12-19	2019-12-19	2240	1	746	1	1310
Redox Potential 1	mV		NA	2019-12-19	2019-12-19	269	NA	241	NA	223
Redox Potential 2	mV		NA	2019-12-19	2019-12-19	268	NA	219	NA	214
Redox Potential 3	mV		NA	2019-12-19	2019-12-19	271	NA	230	NA	219

						11205379-MW3-		11205379-MW4		11205379-MW5-	11205379-BH6
					SAMPLE DESCRIPTION:	SS4		(SS2+SS3)		SS4	(SS2+SS3)
					SAMPLE TYPE:	Soil		Soil		Soil	Soil
					DATE SAMPLED:	2019-12-11		2019-12-11		2019-12-11	2019-12-11
Parameter	Unit	G / S	RDL	Date Prepared	Date Analyzed	796647	RDL	796648	RDL	796649	796650
Chloride (2:1)	µg/g		4	2019-12-19	2019-12-19	736	2	44	4	531	403
Sulphate (2:1)	µg/g		4	2019-12-19	2019-12-19	286	2	96	4	337	272
pH (2:1)	pH Units		NA	2019-12-20	2019-12-20	7.88	NA	8.29	NA	9.21	8.54
Electrical Conductivity (2:1)	mS/cm		0.005	2019-12-19	2019-12-19	1.60	0.005	0.460	0.005	1.54	1.17
Resistivity (2:1) (Calculated)	ohm.cm		1	2019-12-19	2019-12-19	625	1	2170	1	649	855
Redox Potential 1	mV		NA	2019-12-19	2019-12-19	234	NA	179	NA	173	180
Redox Potential 2	mV		NA	2019-12-19	2019-12-19	241	NA	186	NA	173	182
Redox Potential 3	mV		NA	2019-12-19	2019-12-19	246	NA	193	NA	179	186

Certified By: Iris Verástegui

Certificate of Analysis

AGAT WORK ORDER: 19T555371
PROJECT: 11205379 (PO#73518459)

CLIENT NAME: GHD LIMITED
ATTENTION TO: Jennifer Balkwill
SAMPLING SITE:
SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2019-12-12
DATE REPORTED: 2019-12-31

						11205379-BH7		11205379-BH8		11205379-BH9
					SAMPLE DESCRIPTION:	(SS3)		(SS3)		(SS3+SS4)
					SAMPLE TYPE:	Soil		Soil		Soil
					DATE SAMPLED:	2019-12-11		2019-12-11		2019-12-11
Parameter	Unit	G / S	RDL	Date Prepared	Date Analyzed	796651	RDL	796652	RDL	796653
Chloride (2:1)	µg/g		2	2019-12-19	2019-12-19	117	4	416	2	167
Sulphate (2:1)	µg/g		2	2019-12-19	2019-12-19	365	4	225	2	124
pH (2:1)	pH Units		NA	2019-12-20	2019-12-20	8.01	NA	8.62	NA	7.95
Electrical Conductivity (2:1)	mS/cm		0.005	2019-12-19	2019-12-19	0.732	0.005	1.12	0.005	0.573
Resistivity (2:1) (Calculated)	ohm.cm		1	2019-12-19	2019-12-19	1370	1	893	1	1750
Redox Potential 1	mV		NA	2019-12-19	2019-12-19	203	NA	206	NA	205
Redox Potential 2	mV		NA	2019-12-19	2019-12-19	206	NA	205	NA	205
Redox Potential 3	mV		NA	2019-12-19	2019-12-19	205	NA	208	NA	208

						11205379-BH12
					SAMPLE DESCRIPTION:	(SS3+SS4)
					SAMPLE TYPE:	Soil
					DATE SAMPLED:	2019-12-11
Parameter	Unit	G / S	RDL	Date Prepared	Date Analyzed	796654
Chloride (2:1)	µg/g		4	2019-12-19	2019-12-19	665
Sulphate (2:1)	µg/g		4	2019-12-19	2019-12-19	130
pH (2:1)	pH Units		NA	2019-12-20	2019-12-20	8.81
Electrical Conductivity (2:1)	mS/cm		0.005	2019-12-19	2019-12-19	1.41
Resistivity (2:1) (Calculated)	ohm.cm		1	2019-12-19	2019-12-19	709
Redox Potential 1	mV		NA	2019-12-19	2019-12-19	212
Redox Potential 2	mV		NA	2019-12-19	2019-12-19	225
Redox Potential 3	mV		NA	2019-12-19	2019-12-19	221

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

796593-796654 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.

Elevated RDLs indicate the degree of sample dilutions prior to the analysis to keep analytes within the calibration range, reduce matrix interference and/or to avoid contaminating the instrument.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By: Iris Verástegui

Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11205379 (PO#73518459)
SAMPLING SITE:

AGAT WORK ORDER: 19T555371
ATTENTION TO: Jennifer Balkwill
SAMPLED BY:

Miscellaneous Analysis

RPT Date: Dec 31, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Sulphide															
Sulfide (S2-)	796593	796593	0.18	0.17	5.7%	< 0.01	97%	80%	120%						

Certified By: Iris Verástegui

Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11205379 (PO#73518459)
SAMPLING SITE:

AGAT WORK ORDER: 19T555371
ATTENTION TO: Jennifer Balkwill
SAMPLED BY:

Soil Analysis

RPT Date: Dec 31, 2019			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Corrosivity Package															
Chloride (2:1)	796593	796593	60	60	0.0%	< 2	98%	80%	120%	106%	80%	120%	98%	70%	130%
Sulphate (2:1)	796593	796593	200	200	0.0%	< 2	104%	80%	120%	106%	80%	120%	101%	70%	130%
pH (2:1)	796593	796593	7.87	7.86	0.1%	NA	101%	90%	110%						
Electrical Conductivity (2:1)	796593	796593	0.447	0.448	0.2%	< 0.005	100%	90%	110%						
Redox Potential 1	1					NA	100%	90%	110%						

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Certified By: Iris Verástegui

Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11205379 (PO#73518459)
SAMPLING SITE:

AGAT WORK ORDER: 19T555371
ATTENTION TO: Jennifer Balkwill
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Miscellaneous Analysis			
Sulfide (S2-)	MIN-200-12025	ASTM E1915-09	GRAVIMETRIC
Soil Analysis			
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE

AGAT Laboratories

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Laboratory Use Only

Work Order #: 19T555371

Cooler Quantity: 1 Med Blue (no ice)

Arrival Temperatures: 7.1 | 6.9 | 6.8

Custody Seal Intact: ☐Yes ☐No ☐N/A

Notes:

Report Information:

Company: GHD Ltd
Contact: Ahmed Sonowa
Address: 111-BRUNEL ROAD
Mississauga Rd, ON
Phone: 647-463-3522 Fax:
Reports to be sent to:
1. Email: Ahmed.Sonowan@ghd.com
2. Email:

Regulatory Requirements:

☐ No Regulatory Requirement

(Please check all applicable boxes)

☐Regulation 153/04
Table ____ Indicate One
☐Ind/Com
☐Res/Park
☐Agriculture
Soil Texture (Check One)
☐Coarse
☐Fine

☐Sewer Use
☐Sanitary
☐Storm
Region ____ Indicate One
☐MISA

☐Regulation 558
☐CCME
☐Prov. Water Quality Objectives (PWQO)
☐Other
____ Indicate One

Is this submission for a **Record of Site Condition?** ☐ Yes ☐ No

Report Guideline on *Certificate of Analysis* ☐ Yes ☐ No

Turnaround Time (TAT) Required:

Regular TAT ☑ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CPM

Project Information:

Project: Infrastructure Ontario
Site Location:
Sampled By: Shanif
AGAT Quote #: PO:

Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☐ No ☐

Company: GHD Ltd
Contact: Ahmed Sonowa
Address: 111-BRUNEL ROAD, Mississauga ON
Email: Ahmed Sonowa@ghd.com

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI Y / N	O. Reg 153 Metals and Inorganics	☐ All Metals ☐ 153 Metals (excl. Hydrides) ☐ Hydride Metals ☐ 153 Metals (Incl. Hydrides)	ORPs: ☐B-HWS ☐Cl⁻ ☐CN ☐Cr⁶⁺ ☐EC ☐FOC ☐Hg ☐pH ☐SAR	Full Metals Scan	Regulation/Custom Metals	Nutrients: ☐TP ☐NH₃ ☐TKN ☐NO₃ ☐NO₂ ☐NO₃+NO₂	Volatiles: ☐VOC ☐BTEX ☐THM	PHCs F1 - F4	ABNs	PAHs	PCBs: ☐Total ☐Aroclors	Organochlorine Pesticides	TCLP: ☐M&I ☐VOCs ☐ABNs ☐B(a)P ☐PCBs	Sewer Use	CORROSIVITY PACKAGE					Potentially Hazardous or High Concentration (Y/N)
11205379-MW1 (SS2+SS3)	~~Dec 11~~	~~Dec~~	1	SOIL																	✓					
11205379-MW1 (SS6)	"	5:00pm	1	"																	✓					
11205379-MW2-SS4	"	"	1	"																	✓					
11205379-MW3-SS4	"	"	1	"																	✓					
11205379-MW4 (SS2+SS3)	"	"	1	"																	✓					
11205379-MW5-SS4	"	"	1	"																	✓					
11205379-BH6 (SS2+SS3)	"	"	1	"																	✓					
11205379-BH7 (SS3)	"	"	1	"																	✓					
11205379-BH8 (SS3)	"	"	1	"																	✓					
11205379-BH9 (SS3+SS4)	"	"	1	"																	✓					
11205379-BH12 (SS3+SS4)	"	"	1	"																	✓					

Samples Relinquished By (Print Name and Sign): Md - Shanif	Date Dec 12/19	Time 3:00pm	Samples Received By (Print Name and Sign): Neil Ramnaraign	Date Dec-12/19	Time 4:03PM
Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time

Page ____ of ____

Nº: T 098350

about
GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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