Appendix N

Geotechnical Investigation Report

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REPORT

GEOTECHNICAL INVESTIGATION

Schedule C Class EA Study for Improvements to Warden Avenue, From Major Mackenzie Drive to North of Elgin Mills Road, Markham, Ontario

Submitted to:

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1.0 INTRODUCTION

1.1 General

Golder Associates Ltd. (Golder) was retained by the Regional Municipality of York (Region) to provide a combined pavement and geotechnical investigation with environmental quality testing in support of the Environmental Assessment of Warden Avenue improvements from Major Mackenzie Drive to about 400 m north of Elgin Mills Road, in the City of Markham, Ontario, as shown on the Key Plan on Figures 1 to 7.

The purpose of the field investigation was to obtain information on the existing pavement structure and subsurface soil and groundwater conditions at the site by means of a limited number of boreholes and based on our interpretation of the borehole data, provide pavement engineering and geotechnical recommendations for the proposed road improvements, and watermain and storm sewer servicing along Warden Avenue.

The factual data, interpretations and recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location or elevation, or if the project is not initiated within eighteen months of the date of the field investigation, Golder should be given an opportunity to confirm that the recommendations are still valid. In addition, this report should be read in conjunction with the attached *"Important Information and Limitations of This Report",* included in Appendix A. The reader's attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report.

1.2 Project and Site Description

The site consists of a two-lane rural, asphalt paved road with partially paved shoulders and ditches along both sides of the road. Two water bodies were observed within the project road section running along the east and west direction. In addition, the road is bounded to the east and west by agricultural lands and residential structures.

The proposed urbanization and widening works will extend along Warden Avenue from Major Mackenzie Drive to about 400 m north of Elgin Mills Road, in the City of Markham, Ontario, as shown on Figures 1 to 7. It is understood that the proposed works may include:

- Widening from the current two lanes to four lanes, generally equally on both sides of the centerline of the road; no specific details of the widening have been provided, except that to improve drainage, significant grade raises (~ 1m) will be required throughout the project limits.
- Addition of two turning lanes, in the northbound and southbound directions, at each of the intersections as proposed on the "Community Structure Plan" provided by Webb+Co Limited in an email dated June 3, 2020.
- Road urbanization and addition of new off-road active transportation (AT) facilities on each side of the proposed right-of-way; no specific details of the AT facilities have been provided.
- A new watermain and storm sewer within the proposed road right-of-way and outside of the existing edge of pavement. The inverts of the new watermain and storm sewer are anticipated to extend to a maximum depth of 6 m below the existing centerline of the roads.
- Replacement of two existing culverts.

2.0 INVESTIGATION PROCEDURES

2.1 Pavement Condition Survey

A visual pavement condition survey was carried out by Golder staff on March 9, 2021. Pavements were evaluated in accordance with Ministry's "*Flexible Pavement Condition Rating – Guidelines for Municipalities, 1989*", SP-022. The purpose of the visual pavement condition survey was to record the severity and density of the distresses observed on the existing pavement surface and use the information to develop appropriate rehabilitation or reconstruction strategies. A summary of the pavement condition survey is as follows:

- Warden Avenue within the project limits is an asphalt paved, two-lane rural regional road with turning lanes at the intersection with Major Mackenzie Drive and Elgin Mills Road. The road has partially paved shoulders and ditches along both sides of the road. The pavement is generally in fair to good condition (Pavement Condition Rating (PCR) of 70). Details of the pavement condition survey are presented in Appendix B.

2.2 Borehole Investigation

The borehole investigation was carried out by Golder between January 6 and 26, 2021. A total of twenty-eight boreholes (designated as Boreholes P1 to P13, S1 to S11, and C1 to C4,) were advanced along the paved lanes and shoulders of Warden Avenue at the approximate locations shown on Figures 1 to 7. Borehole P1 to P13 were advanced to depths of 2.0 m below ground surface; Boreholes S1 to S11 were advanced to depths ranging from 7.8 m to 9.6 m below ground surface, and Boreholes C1 to C4 (located in the vicinity of the existing culverts) were advanced to depths ranging from 7.8 m to 9.2 m below ground surface.

A road occupancy permit was obtained from the Region, and the borehole locations were marked in the field and cleared of underground utility services prior to drilling. Traffic protection was provided in accordance with MTO's Book 7 Manual of Temporary Conditions.

The field investigation was directed by members of Golder engineering staff who also determined the borehole locations in the field, logged the boreholes, and took custody of the recovered soil samples. The boreholes were advanced using truck-mounted drill rigs, operated by Landshark Drilling, using either 150 mm or 200 mm outside diameter hollow stem continuous flight augers.

Samples of the granular base and subbase materials, and subgrade soils were obtained from the augers in all boreholes. The soil samples were obtained at regular intervals of depth using 50 mm outer diameter split-spoon samplers and full weight automatic hammers, in accordance with Standard Penetration Testing (SPT) methods (ASTM D1586). The split-spoon samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 35 mm. Therefore, particles or objects that may exist within the soils that are larger than this dimension are not sampled or represented in the grain size distributions. The measured in-situ field results (i.e., SPT 'N'-values) presented in this report are uncorrected.

The groundwater conditions were noted in the open boreholes during drilling and upon completion of drilling. Groundwater monitoring wells, consisting of 50 mm diameter PVC pipe, were installed in eight boreholes (Boreholes S1, S3, S4, S5, S8, S9, S11, and C4) to allow for monitoring of groundwater levels over time. The deep boreholes were backfilled with a mixture of bentonite and soil cuttings and the 2 m deep pavement boreholes were backfilled with soil cuttings in accordance with current environmental regulations. Where applicable, the boreholes were sealed with asphaltic cold patch material at road surface.

The borehole locations and ground surface elevations were obtained using a GPS (Trimble Geo7), having accuracy of about 0.1 m in the vertical and horizontal directions. The locations provided on the borehole records are relative to UTM NAD 83 (Zone 17) northing and easting coordinates and the ground surface elevations are referenced to a geodetic datum.

The collected soil samples were identified in the field, placed in appropriate containers and transported to Golder laboratory in Whitby for detailed examination and geotechnical laboratory testing (moisture content, grain size analysis, and Atterberg Limit testing) on selected samples.

The collected soil samples were reviewed in the field and the presence (if any) of contamination through visual and/or olfactory cues (staining or odours) for each recovered sample was documented. Based on these observations, select samples were submitted for analytical testing to AGAT Laboratories (AGAT) in Mississauga, Ontario, under chain-of-custody documentation. Three soil samples were submitted for testing of corrosion potential (pH, electrical conductivity, resistivity, chloride, and sulphate). Additionally, select samples were submitted for environmental quality testing including six soil samples for metals and inorganics, two soil samples for petroleum hydrocarbon fractions F1 to F4 (PHC F1 to F4) and benzene, toluene, ethylbenzene and xylene (BTEX), and one sample was submitted for testing for select parameters using the toxicity characteristic leaching procedure (TCLP). All analytical samples were placed into laboratory supplied sampling containers and stored on ice until delivered to the analytical laboratory, under chain-of-custody documentation.

3.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

3.1 Regional Geology

The site is located within the Peel Plain physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984). The Peel Plain physiographic region covers portions of the Regional Municipalities of York, Peel, and Halton. A surficial till sheet, which is mapped as the Halton Till, is present throughout much of the Peel Plain and generally follows the surface topography. As outlined in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984), the Halton Till typically consists of cohesive clayey silt to silty clay, with non-cohesive sand to silt zones and is known to contain cobbles and boulders throughout. Shallow, localized deposits of sand and silt and/or clay can overlie this uppermost till sheet, and these represent relatively recent deposits, formed in small glacial melt water ponds scattered throughout the Peel Plain and concentrated near river valleys. The recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand, silt and clay.

3.2 Subsurface Conditions

The subsurface soil and groundwater conditions encountered in the boreholes are shown in detail on the Records of Borehole sheets (i.e. borehole records) in Appendix C. *"Method of Soil Classification, Abbreviations and Terms Used on Records of Boreholes and Test Pits"* and *"List of Symbols"* sheets are also provided in Appendix C to assist in the interpretation of the borehole records. The geotechnical laboratory results are presented in Appendix D and the analytical laboratory results are presented in Appendix E.

The boundaries between the strata on the borehole records have been inferred from drilling observations and non-continuous sampling. Therefore, these boundaries typically represent transitions between soil types rather than exact planes of geological change. Furthermore, the subsurface conditions will vary between and beyond the borehole locations and across the site and caution should be used when extrapolating subsurface conditions between the boreholes.

3.2.1 Existing Pavement Structure

Based on the results of the field investigation, the typical existing pavement structure and the predominant subgrade soil types are summarized in Table 1.

Table 1: Summary of Pavement Thicknesses and Subgrade Soil Types

Location	HMA (mm)	Granular Base (mm)	Granular Subbase (mm)	Total Thickness (mm)	Predominant Subgrade Soil Type
NB Lane	220-340 [1)] (260)	160-440 [2)] (190)	190-550 [3)] (280)	440-1,220 (730)	Sandy Silty Clay
SB Lane	120-300 [4)] (280)	250-280 [2)] (130)	140-630 (410)	720-900 (780)	Sandy Silty Clay
Paved Section of the Shoulders	30-310 (190) [5)]	170-550 [2)] (340)	170-810 [3)] (430)	200-2,130 (820)	Sandy Silty Clay
Gravel section of the shoulder [6)]	-	370-760 (590)	470 [7)]	650-840 (750)	Sandy Silty Clay

Notes:

1) 200-340 (260) represents min-max (average) thickness
2) Granular base material was not encountered in 4 of the boreholes in the mainlanes (boreholes S2, P3. S6 and P13) and in 4 of the paved shoulder boreholes (boreholes S3, C1, C4 and S8).
3) Granular subbase material was not encountered in 1 of the boreholes in the mainlanes (borehole P8) and in 4 of the paved shoulder boreholes (boreholes P4, C2, C3 and S8)
4) Hot Mix Asphalt (HMA) thickness of 120 mm was considered to be an outlier and was excluded from the average
5) Two boreholes with HMA thickness of 30 mm and 60 mm were excluded when calculating the average HMA thickness
6) Two shoulder boreholes encountered total granular thickness >1.3 m. They were not considered to be representative values and were excluded from the averages.
7) Granular subbase material was not encountered in two out of three boreholes (in boreholes P9 and P10) of gravel shoulder.

Gradation testing was carried out on two of the granular base samples, and two of the granular subbase samples. The results indicate that both granular base samples tested did not satisfy the current Ontario Provincial Standards Specification OPSS.PROV 1010 gradation requirements for Granular A, generally due to excessive material passing some of the sieve sizes, as shown on Figure D1. Both samples of the granular subbase material tested did not satisfy the current OPSS.PROV 1010 gradation requirements for Granular B, Type I, due to excessive material passing the 75 µm sieve, as shown on Figure D2 in Appendix D. The water content of the granular base samples ranged from 4 to 5 percent, while the water content of the granular subbase samples was 6 percent.

3.2.2 Pavement Subgrade

The results of the borehole investigation indicate that the predominant subgrade encountered immediately under the granular materials is sandy silty clay, silty clay and sand, silty clay / clayey silt to silt and sand. Based on laboratory test results (Figure D3), the subgrade soils tested have a low susceptibility to frost heaving, as described further in Section 3.2.2.1.

3.2.2.1 Frost Susceptibility

The frost susceptibility of the subgrade soils within the frost depth of 1.4 m has been assessed in accordance with the Ministry of Transportation Ontario’s (MTO) guidelines. Soils are classified as having low, moderate or high susceptibility to frost heaving based on the percent of silt sized particles between 5 µm to 75 µm as summarized in Table 2.

Table 2: MTO Frost Susceptibility Guidelines

Grain Size (5 – 75 µm)	Susceptibility to Frost Heaving
0 – 40 %	Low
40 – 55 %	Moderate
55 – 100 %	High

The laboratory test results indicate that the subgrade materials tested generally had low susceptibility to frost heaving. Moderate to highly frost susceptible soils were not encountered within the frost depth of 1.4 m.

3.2.2.2 Organic Inclusions

Organic inclusions were recorded in Boreholes P4 to P7, P12, S2 to S4, and S7 to S9, underlying the granular materials, as detailed on the borehole records in Appendix C.

3.2.3 Subsurface Soils

3.2.3.1 Cohesive Fill

A cohesive fill layer was encountered beneath the non-cohesive fill layer or crushed granular material in Boreholes C1 to C4, P3 to P7 to P13, S2, and S4 to S11, extending to depths ranging between 1.4 m and 2.9 mbgs. However, in Boreholes P3, P5, P6 and P11 to P13, the thickness of the cohesive fill could not be determined as the boreholes were terminated in the cohesive fill. The cohesive fill ranges in composition and comprised of black to grey to brown gravelly silty clay, sandy silty clay, and sandy silty clay and sand with trace to some gravel. Organic inclusions were observed in Boreholes P4 to P7, P12, S2 to S4, and S7 to S9.

The SPT “N”-values measured within the cohesive fill range from 3 blows to 18 blows per 0.3 m of penetration, indicating a soft to very stiff consistency.

Grain size distribution tests were carried out on three samples of the cohesive fill and the results are shown on Figure D3. Atterberg limit testing was carried out on three samples of the cohesive fill and the results indicate the liquid limit ranging between 27 and 38 percent, plastic limit ranging between 14 and 17 percent, and plasticity indices ranging between 13 and 20 percent. These test results, which are plotted on a plasticity chart on Figure D4, indicate the cohesive fill ranges from a low to intermediate plasticity. The in-situ water contents measured on samples of the cohesive fill range from about 13 percent and 42 percent.

3.2.3.2 Non-Cohesive Fill

A non-cohesive fill layer was encountered beneath the granular base and subbase in Boreholes C1, C4, P1 to P3, P5 to P7, P9, P11 to P13, S1 to S7, and S9 to S11, extending to depths ranging from 0.5 m to 2.1 m below ground surface (mbgs). The fill varies in composition and consists of sand and gravel, gravelly silty sand, sand, and silty sand, some gravel.

The SPT “N”-values measured within the non-cohesive fill range from 11 blows to 39 blows per 0.3 m of penetration, indicating a compact to dense compactness condition. The in-situ water contents measured on six samples of the non-cohesive fill range from about 7 percent to 19 percent.

3.2.3.3 Silty Clay

A silty clay to sandy silty clay with some gravel, was encountered beneath the cohesive fill layer in Boreholes C1, C2, P8, and P10, extending to a depth of 4.0 mbgs. However, in Boreholes P8 and P10, the thickness of the cohesive deposit could not be determined as the boreholes were terminated in this deposit.

The SPT “N”-values measured within the cohesive fill range from 8 blows to 16 blows per 0.3 m of penetration, indicating a stiff to very stiff consistency. The natural water contents measured on two samples of the cohesive deposit are about 22 percent.

3.2.3.4 Sandy Gravel, Sand, Silty Sand to Silt and Sand

Non-cohesive deposits consisting of sandy gravel, sand, silty sand, and silt and sand were encountered in Boreholes C3, C4, S1, S2, S6, S11, P2 and P4, underlying the fill or glacial till deposits.

The SPT “N”-values measured within these non-cohesive deposits range from 18 blows per 0.3 m of penetration to 50 blows for 0.1 m of penetration, indicating a compact to very dense compactness condition.

Grain size distribution tests were carried out on two samples of the silty sand deposit and two samples of the silt and sand deposit, and the results are shown on Figures D5 and D6. Natural water contents measured on samples of the non-cohesive deposit range from about 7 percent to 20 percent.

3.2.3.5 Glacial Till

Glacial till was encountered in Boreholes C1 to C4, S1, S3 to S11, P1 and P7. The glacial till consists of non-cohesive silty sand to gravelly silty sand, sandy silt, cohesive silty clay-clayey silt, and sand to silty clay and sand. The deposit generally extends to the borehole termination depths with the exception of Boreholes S10 and S11. Although cobbles and boulders were not noted during drilling through the till deposit at this site, cobbles and boulders are commonly encountered in glacially derived materials and should be expected within this deposit. Further, the presence of cobbles and/or boulders in the glacial till deposit can be inferred from the multiple instances of auger grinding during drilling as well as the split-spoon sampler not advancing the full sample depth.

3.2.3.6 Silty Clay-Clayey Silt and Sand Till to Silty Clay and Sand Till

The cohesive till was encountered in Boreholes C1 to C4, P1, S1, S3 to S6, S8 and S11 underlying the fill, silty clay, silty sand, or non-cohesive till deposits.

The SPT “N”-values measured within the cohesive till deposit range from 13 blows per 0.3 m of penetration to 50 blows per 0.05 m of penetration, indicating a stiff to hard consistency. In general, the SPT “N”-values are greater than 50 blows and generally hard, with a few lower “N”-values in the till in the upper portion of selected boreholes, where encountered surficially.

Grain size distribution tests were carried out on three samples of the cohesive till deposit and the results are shown on Figure D7. Atterberg limit testing was carried out on two samples of the cohesive till deposit and the results indicate the liquid limit to be ranging between 17 and 18 percent, a plastic limit of about 10 percent, and plasticity indices ranging between 7 and 8 percent. These test results, which are plotted on a plasticity chart on Figure D8, indicate that the tested sample from the deposit is classified as a silty clay-clayey silt to a silty clay of low plasticity. Natural water contents measured on samples of the cohesive till deposit range from about 5 percent to 15 percent, but generally less than 10 percent.

3.2.3.7 *Silty Sand to Sandy Silt Till*

The non-cohesive till was encountered in Boreholes S1, S3, S4, S7, S9, S10 and P7 underlying the fill, sand and cohesive till deposits.

The SPT “N”-values measured within the non-cohesive till range from 15 blows per 0.3 m of penetration to 50 blows per 0.05 m of penetration, indicating a compact to very dense compactness condition, becoming dense to very dense with depth.

Grain size distribution tests were carried out on two samples of the non-cohesive till and the results are shown on Figure D9. Natural water contents measured on samples of non-cohesive till range from about 5 percent to 11 percent

3.2.4 Groundwater

Groundwater observations upon completion of drilling ranged approximately between 2.4 mbgs and 7.6 mbgs, and dry in fourteen boreholes. The groundwater level measurements in the monitoring wells ranged between approximately 0.7 mbgs and 6.8 mbgs (Elevations 208.9 m and 227.0 m) and are summarized in the table below.

Table 3: Summary of Groundwater Levels

Monitoring Well	Ground Surface Elevation (m)	January 29, 2021	
		Depth (m)	Elevation (m)
C4	221.3	3.5	217.8
S1	215.1	3.7	211.4
S3	218.9	3.5	215.4
S4	213.8	2.4	211.4
S5	215.7	6.8	208.9
S8	225.4	0.7	224.7
S9	227.2	1.1	226.1
S11	230.0	3.0	227.0

It should be noted that these observations and measurements reflect the shallow groundwater conditions encountered in the boreholes during the time of the field investigation and that water level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt.

3.2.5 Analytical Results

3.2.5.1 *Environmental Quality*

Analytical laboratory testing was carried out by AGAT Laboratories on select soil samples obtained from the current borehole investigation to assess environmental quality. The samples were submitted for analysis of metals, inorganics, PHCs and BTEX. For the purpose of this report, the analytical results for this testing were compared to the following (different standards may apply depending on the reuse location):

- Ontario Ministry of Environment, Conservations, and Park (MECP) (formerly Ministry of the Environment, MOE) *“Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act”*, April 15, 2011
  - Table 1 full depth background standards for residential / parkland / institutional / community / commercial / industrial land use, fine to medium soil texture; and
  - Table 2 full depth standards for a potable groundwater situation and residential / parkland / institutional land use, fine to medium grained soil texture.
- MECP *“Rules for Soil Management and Excess Soil Quality Standards*”, 2020
  - Table 2.1 full depth volume independent standard for a potable groundwater situation and residential / parkland / institutional land use.

The laboratory certificate of analysis is provided in Appendix E and details of the sample submitted and parameters exceedances are summarized in Table 4.

Table 4: Summary of Analytical Results Exceeding MECP Table 1, Table 2 and Table 2.1 Standards

Borehole	Sample Depth (m)	Parameter Exceeding Table 1 Standards	Parameter Exceeding Table 2 Standards	Parameter Exceeding Table 2.1 Standards
S1 Sa2	0.8 – 1.2	Electrical Conductivity (EC), Sodium Adsorption Ration (SAR)	None	None
S4 Sa3	1.5 – 2.0	EC, SAR	EC, SAR	EC, SAR
S4 Sa4	2.3 – 2.7	EC, SAR	None	None
S7 Sa3	1.5 – 2.0	EC, SAR	EC	EC
S9 Sa3	1.5 – 2.0	EC, SAR	None	None
S11 Sa3	1.5 – 2.0	EC, SAR	EC	EC

In addition to the above, one soil sample was submitted for TCLP analysis of metals, inorganics, benzo(a)pyrene and benzene to assist with classification of the soil for disposal purposes. The results of this testing were compared to the Schedule 4 criteria set out in O.Reg. 347. No exceedances were detected indicating the tested soil would be classified as non-hazardous waste should disposal be required.

3.2.5.2 Corrosivity

A total of three selected soil samples from Boreholes S1, S11 and C4 were submitted to AGAT Laboratories for basic chemical analyses related to potential sulphate attack on buried concrete elements and potential corrosion of buried ferrous elements. The results of corrosivity testing are presented in Table 5 and *Appendix E*. Guidance on the impact of corrosion potential on substructures is contained in Section 4.10 of this report.

Table 5: Summary of Corrosivity Results

Borehole Number	Depth (m)	Chloride (µg/g)	Sulphate (µg/g)	pH	Resistivity (Ohm-cm)
S1	0.8 – 1.2	378	69	8.32	1,230
S11	1.5 – 2.0	858	13	7.62	599
C4	1.5 – 2.0	2,640	<20	7.97	233

4.0 DISCUSSION AND RECOMMENDATIONS

This section of the report provides engineering information for the geotechnical design aspects of the project, based on our interpretation of the data obtained from Golder's field investigation and our understanding of the project requirements. The information in this portion of the report is provided for the guidance of the design engineers. Where comments are made on construction, they are provided only in order to highlight aspects of construction which could affect the design of the project. Contractors bidding on or undertaking any work at the site should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, equipment capabilities, costs, sequencing and the like.

In performing our pavement design analysis, we have referred to the AASHTO 1993 (MTO's MI-183 "*Adaptation and Verification of AASHTO Pavement Design Guide for Ontario conditions*", March 19, 2008) pavement design guidelines as well as the *York Region Road Design Guidelines*.

4.1 Pavement Design Analysis and Recommendations

4.1.1 Traffic Volumes

The traffic data provided by the Region in an email dated February 19, 2021 were used to carry out the analysis and develop pavement design strategies for the rehabilitation and widening of Warden Avenue. A summary of the relevant traffic information is presented in Table 6.

Table 6: Traffic Volumes

Location	AADT (2018)	AADT (2041)	% COMM
Warden Avenue	11,500 1)	40,000 2)	6

Notes:
1) Existing AADT (2 lanes)
2) Projected AADT (4 lanes)

4.1.2 ESAL Calculations

Pavement design for widening of Warden Avenue (new pavement) has been carried out for a 20-year design life, while the design life for the three rehabilitation options considered for the existing lanes ranged from approximately 11 to 14 years. Based on our discussions with staff from York Region, we understand that to improve drainage, significant grade revisions (~ up to 1m) will be required throughout the project limits. As such, reconstruction of the existing lanes may be required for the majority of the pavements within the project limits.

The estimated Equivalent Single Axle Loads (ESALs) over the selected design period are shown in Table 7.

Table 7: Summary of Estimated ESALs

	Design/ Service Life	Estimated ESALs
Widening design	20 years	7.7×10^6
Rehabilitation Option 1	12 years	3.6×10^6
Rehabilitation Option 2	14 years	4.4×10^6
Rehabilitation Option 3	11 years	3.2×10^6

4.1.3 Widening of Warden Avenue

It is understood that Warden Avenue will be widened from the existing two lanes (one lane in each direction) to four lanes and that the rural road cross section will be replaced with an urban cross section. The new off-road active transportation facilities are also proposed on each side of the road.

The results of the field investigation indicate that the predominant subgrade soils within the project limits are sandy silty clay, silty clay and sand, silty clay/clayey silt to silt and sand. Based on the condition of the subgrade soils and the MI-183 guidelines, we have assigned a subgrade resilient modulus of 25,000 kPa for the rehabilitation of the existing section of the road and 20,000 kPa for the widening design.

The minimum pavement structure for a Regional Road as listed in York Region Road Design Guidelines (YRRDG) is as follows:

50 mm	SP 12.5	Surface Course
100 mm	SP 19.0 or SP 25.0	Base Course
150 mm	Granular A	Base Material
450 to 525 mm	Granular B, Type I	Subbase Material

Based on the AASHTO pavement design analysis as well as the need to provide lateral drainage for the existing pavement, following pavement structure is recommended for the widening of Warden Avenue (in both, southbound and northbound direction):

New HMA	-200 mm
New Granular A Base	-150 mm
New Granular B, Type I Subbase	-750 mm
Total thickness	-1,100 mm

It should be noted that 500 mm of new granular B material is structurally sufficient, however, in order to ensure that the bottom of the new Granular B, Type I material matches the bottom of the granular subbase on at least 95 percent of the pavements (to provide lateral drainage), the subbase thickness has been increased to 750 mm.

The structural capacity of the recommended widening design is more than the minimum listed in YRRDG and it also satisfies 20-year AASHTO design.

The following widening strategy is recommended for Warden Avenue:

- Remove the existing shoulder by saw cutting at the pavement edge to remove the HMA and excavating the underlying granular materials and subgrade soils to a depth of approximately 1,100 mm below existing pavement surface. Beyond the existing shoulder, strip the topsoil, organic material and any other deleterious material within the proposed widening area, and excavate or fill as required to a depth of 1,100 mm below the finished pavement surface;
- All organic material and any other deleterious materials present within the limits of proposed widening should be removed regardless of depth;
- Heavily proof roll and inspect the existing subgrade prior to placing any new materials. If soft areas are encountered, remove and replace with new Granular B Type I material as directed by the geotechnical representative on-site;
- Place 750 mm of new OPSS Granular B Type I in lifts not exceeding 300 mm, and compact to 100 percent of the material's Standard Proctor Maximum Dry Density (SPMDD);
- Place 150 mm (compacted thickness) of new OPSS Granular A and compact to 100 percent of the material's SPMDD;
- Place and compact 100 mm of SP 25.0 asphalt (with PG 64-28 asphalt cement);
- Place and compact 50 mm of SP 19.0 asphalt (with PG 64-28 asphalt cement); and
- Place and compact 50 mm lift of SP 12.5 FC2 surface course asphalt (with PG 64-28 asphalt cement).

As the total pavement structure for the widening should match or exceed the depth of the existing adjacent pavement structure to provide lateral drainage, the 95 percentile value for the total pavement thickness was used in the design analysis.

It should be noted that the three rehabilitation options for the mainlanes will result in grade raises ranging from 0 to 50 mm. If an option with a grade raise is selected, the Granular B Type I thickness should be increased by the same amount as the grade raise.

As the SP 25.0 mix can result in a coarse and/or open surface, it should not be used to support traffic. Two 50 mm lifts of SP 19.0 can be placed instead of one 100 mm lift of SP 25.0. It is recommended that the 50 mm surface course lift on the widened portion be placed at the same time as the 50 mm surface course lift (refer to section 4.1.3) for the rehabilitation of the existing lanes.

If the existing pavement on Warden Avenue has to be removed to accommodate the construction of the proposed watermain or storm sewer, the pavement should be reconstructed using the recommended pavement structure for the widening of Warden Avenue, as detailed in this section.

It should be noted that at the time of preparing this report, final information regarding the location of the proposed watermain and storm sewer, the plans showing details of the proposed road widening (symmetrical/asymmetrical) and information regarding the proposed type of construction (open cut or trenchless) were not available to provide more detailed recommendations for the widening or reconstruction of Warden Avenue.

4.1.4 Rehabilitation of Warden Avenue

Three flexible pavement options were considered for the rehabilitation of the existing flexible pavement within the project limits:

- Option 1: Mill 100 mm of HMA and overlay with 100 mm of new HMA (mill 2 lifts and pave two lifts). This option will provide approximately 12 year of service life;
- Option 2: Mill 50 mm of HMA and overlay with 100 mm of new HMA (mill 1 lift and pave two lifts). This option will provide approximately 14 years of service life; and
- Option 3: Scratch-mill 10 mm of HMA and overlay with 50 mm of new HMA (overlay 1 lift). This option will provide approximately 10 years of service life.

4.1.4.1 Life Cycle Cost Analysis

A 50-year Life Cycle Cost Analysis (LCCA) was carried out for the three proposed pavement rehabilitation options and the results are summarized in Table 8. The details of the LCCA are provided in Appendix G, Tables G-1 to G-4. The LCCA is based on the "Life Cycle Cost 2006 Update, Final Report" dated August 2007, prepared by ARA and submitted to MTO, CAC and OHMPA.

Table 8: Summary of LCCA for Alternative Pavement Designs for Rehabilitation

	Option 1 Mill 100 mm / Pave 100 mm	Option 2 Mill 50 mm / Pave 100 mm	Option 3 Mill 10 mm / Pave 50 mm
Design Life	12 years	14 years	10 years
Initial Construction	$ 162 k	$ 139 k	$ 86 k
50-year Life Cycle Cost	$ 314 k	$ 284 k	$ 284 k
Ranking	3	1	1

The LCCA indicates that costs for Option 2 (Mill 50 mm and Pave 100 mm of new HMA) and Option 3 (Mill 10 mm and Pave 50 mm) are the same. However, milling 50 mm as recommended in Option 2 will remove more of the surficial cracks and reduce maintenance costs, especially in the first 10 years after rehabilitation. In addition, Option 2 will provide the longest design life (approximately 14 years). As such, Option 2 is recommended as the preferred option for the rehabilitation of Warden Avenue. The 100 mm of HMA should consist of the following:

- 50 mm of SP 19.0 asphalt (with PG 64-28 asphalt cement); and
- 50 mm lift of SP 12.5 FC2 surface course asphalt (with PG 64-28 asphalt cement).

The milled pavement on the existing lanes can support traffic for a maximum of 3 months before placement of the SP 19.0 binder course asphalt. The asphalt lifts have been selected such that the two lifts of asphalt on the rehabilitated section of Warden Avenue match the top two lifts of HMA on the widened section. This will allow the Contractor more options when paving, as well as when staging the construction. The SP 19.0 lift (upper binder lift) on the rehabilitated as well as the widened sections can support traffic for a maximum of 15 months.

4.1.5 Reconstruction Option

It is understood that the extensive grade raises will be required to improve drainage along Warden Avenue, and this may require the complete reconstruction of the existing lanes. If required, the existing lanes should be reconstructed as follows:

For Grade Raise Greater Than 600 mm

- Remove the existing HMA full depth (an average of 270 mm) and place new structure on top of the existing granular materials as follows:
  - 200 mm New HMA
  - 150 mm New Granular A base material
  - Min 500 mm New Granular B subbase material or as needed to meet the required profile grade
- For New Pavement Widening:
  - Place earth fill as needed to raise grade to 1.2 m below the final grade, than place new pavement structure:
  - 200 mm New HMA
  - 150 mm New Granular A base material
  - 850 mm New Granular B subbase material

For Grade Raise Less Than 600 mm

- Remove the existing HMA full depth and granular material as required to place new pavement structure:
  - 200 mm New HMA
  - 150 mm New Granular A base material
  - Min. 500 mm New Granular B subbase material
- For Pavement Widening:
  - Place earth fill as needed to raise grade to 1.2* m below the final grade, than place new pavement structure:
  - 200 mm New HMA
  - 150 mm New Granular A base material
  - 850 mm New Granular B subbase material

Note: The granular material in widening areas should be placed up to a depth of 1,2 m below the final grade to ensure lateral drainage. The depth of 1.2 m corresponds to 85% of frost depth (1.4 m).

4.1.6 Off-road Active Transportation Facilities

It is understood that as a part of the road urbanization, off-road AT facilities will be added on both sides of the road. It should be noted that at the time of preparing this report, plans showing the locations of the proposed off-road AT facilities were not available for us to provide detail pavement design recommendations for the off-road AT facilities.

It is assumed that the MUPs will primarily serve bicycle traffic with occasional use by snow removal/ maintenance vehicles. The recommended preliminary pavement design for the AT facilities is as follows:

- 40 mm SP 12.5
- 50 mm SP 19.0
- 300 mm Granular A Base material

Over competent subgrade material.

To facilitate positive lateral drainage, it is recommended that subgrade under the proposed AT facilities be sloped towards the subdrains along the adjacent roads.

The preliminary pavement design provided in this report for the AT facilities should be confirmed once the location and elevation of the AT facilities are finalized.

4.1.7 Reuse of Existing Granular Material

The existing granular base and subbase material removed from the widening sections can be re-used on site as acceptable earth fill under the granular subbase layer. It should be noted that any on-site material that is to be re-used, should be kept free of contamination from topsoil and organic material. Care should be taken during excavation to ensure that the existing and new granular materials are not contaminated by subgrade soils or by construction traffic tracking mud, etc.

4.1.8 Drainage

It is understood that the road profile will be urbanized and new off-road AT facilities will be added on each side of the road's right-of-way. Therefore, a proper drainage system should be installed along the edges of the new pavement, immediately below the proposed subgrade elevation. The drainage system should consist of a 150 mm diameter perforated pipes, placed inside a 300 mm by 300 mm trench and surrounded by concrete sand. The trench should be lined with a suitable geotextile prior to placing the concrete sand. At the top of the trench, the geotextile should overlap a minimum of 300 mm. The geotextile should conform to OPSS 1860, Class II and be non-woven with a F.O.S. in the range of 75 to 150 micron. The subdrain inverts should be approximately 250 mm below the bottom of the finished granular subbase elevation.

4.1.9 Hot Mix Asphalt Types and Construction

The SP 19.0 and SP 25.0 asphalt mixes should be compacted to a minimum of 91 percent, and the SP 12.5 FC2 should be compacted to a minimum of 92 percent of their respective Maximum Relative Densities (MRD). HMA material and placement requirements should be in accordance with OPSS 310 and OPSS 1150, as amended by the applicable Regional standards.

4.1.10 Transitions

Transverse and longitudinal joints should be cleaned, and tack coated prior to placing new HMA. Where the new pavement abuts the existing pavement (e.g., at tie-ins to existing pavement), proper lap joints should be constructed to key the new HMA surface course into the existing pavement in accordance with OPSS 310. The existing HMA should be sawcut to provide a vertical face prior to keying-in the new HMA surface course. Any undermined or broken edges resulting from the construction activities should be removed by the sawcut.

4.1.11 Tack Coat

It is recommended that tack coat be applied between all new and existing lifts of HMA. Tack coat should conform to the requirements of Ontario Provincial Standard Specification OPSS.PROV 308 (April 2012) and SSP 308F02 (February 2017).

4.1.12 Performance Graded Asphalt Cement (PGAC)

It is recommended that PG 64-28 asphalt cement be used for all the HMA mixes in accordance with OPSS.MUNI 1101.

4.2 Watermain and Storm Sewer Recommendations

4.2.1 Excavations

It is understood that the watermain and storm sewers will be located along Warden Avenue with a north to south alignment. In addition, three watermain crossings are being proposed to be located around Street A, Street B and Street E. Based on the assumed storm sewer and watermain inverts of up to a maximum depth of 6 m below existing road grade, the anticipated founding native soils will generally consist of stiff to very stiff silty clay, compact to very dense silty sand, compact to dense sand, and very dense/hard glacial till. These soils are generally considered suitable for support of the pipe. The suitability of the founding soils to support the pipe should be confirmed by Golder at the time of excavation.

It is anticipated that the excavations will likely consist of conventional temporary open cuts. All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects. Based on the OHSA, the dense sand and very dense silty sand deposits are generally classified as a Type 3 soil and all excavations in excess of 1.2 m in depth through these soils should be sloped no steeper than 1 horizontal to 1 vertical for excavation above the groundwater level. For excavations below the groundwater level within the dense sand and very dense silty sand deposits, these are classified as a Type 4 soil and these soils should be sloped no steeper than 3 horizontal to 1 vertical. The dense to very dense/hard glacial till is generally classified as Type 2 soils with a 1 horizontal to 1 vertical to 1.2 m or less from its bottom above the groundwater level, and Type 3 soils if excavating below the groundwater level. Depending upon the construction procedures adopted by the contractor, the success of the contractor's groundwater control methods and weather conditions at the time of construction, some flattening and/or blanketing of the slopes may be required.

To maintain temporary excavation stability, excavated materials must be placed away from the edge of the excavation a distance equal to the depth of the excavation or greater. In addition, stockpiling of the material should be prohibited adjacent to the excavation to minimize surcharge loading near the excavation crest. Where sufficient space is not available to stockpile the excavated material at the site, off-site disposal of the excavated material intended for reuse would need to be arranged.

We understand that trench boxes are frequently used for this type of construction to protect the construction personnel and minimize the size of the excavation. It must be emphasized that a trench liner box provides protection for construction personnel but does not restrict movement of the excavation walls or prevent granular soils from flowing under the influence of groundwater, which may be the case at this site. Any voids between the excavation wall and the trench liner box should be filled immediately to minimize the potential for loss of ground and support of adjacent utilities, roadway pavements and the like. Further, it is recommended that the trench excavation be carried out in short sections with the support system installed immediately upon completion of excavation and, as a minimum, backfilled at the end of each working day. It is imperative that any underground services adjacent to the excavations be accurately located prior to construction and adequate support be provided where required.

If a shored excavation is required to support adjacent utilities or structures, the shoring should be designed and constructed in accordance with OPSS 539 (Temporary Protection Systems), including an evaluation of base stability, soil squeezing stability and the hydraulic uplift stability as defined in the Canadian Foundation Engineering Manual (2006). Design of temporary works, including dewatering, will be entirely the responsibility of the contractor.

4.2.2 Groundwater Control

Groundwater levels were measured at depths ranging between about 0.7 mbgs and 6.8 mbgs (Elevations 208.9 m and 227.0 m). It has been assumed that excavations for site servicing (including approximately 0.2 m of bedding material) are anticipated to extend to a maximum depth of 6 m below final road grade. As such, depending on the proposed storm sewer and watermain profile, the excavations will extend up to about 6 m below the groundwater level.

Due to the low hydraulic conductivity of the glacial till, it is anticipated that groundwater seepage into the trenches will not be significant and that any localized seepage can most likely be controlled by pumping from filtered sumps installed within the trenches. However, we recommend that trench excavations should be left open for as short a duration as possible to reduce the potential for water accumulation both from potential seepage and from precipitation. In addition, groundwater within the wet silty sand deposit underlying the glacial till may be pressurized and a significant amount of groundwater may be generated where excavation extends into this deposit. It is therefore anticipated that proactive dewatering of the silty sand and sand deposits will likely be required.

The actual rate of groundwater inflow to the excavations will depend on many factors including the contractor's schedule and rate of excavation, the size of the excavation, the number of working areas being excavated at one time, and the time of year at which the excavation is made. Also, there may be instances where significant volumes of precipitation, surface runoff and / or groundwater may collect in an open excavation and must be pumped out. Care should be taken at all times to ensure trenching operations adhere to OHSA requirements at a minimum. Surface water runoff should be directed away from open excavations. In case of the need for active dewatering, the groundwater level should be drawn down to at least 1 m below the bottom of the trench.

It is recommended to carry out a "public digging" (i.e. test pitting) during the tender stages, to allow prospective bidders to assess the subsurface conditions and determine the type of groundwater control required, consistent with their equipment capabilities and the actual groundwater conditions at that time. The locations of the test pits should be determined in consultation with the geotechnical engineer.

Groundwater control measures that extract more than 50,000 L/day of water are subject to regulation by the Ontario Ministry of the Environment, Conservation and Parks (MECP). Certain takings of groundwater and stormwater for construction dewatering purposes with a combined total less than 400,000 L/day qualify for self-registration on the MECP's Environmental Activity and Sector Registry (EASR). Registry on the EASR replaces the need to obtain a Permit to take Water (PTTW) for water taking and a Section 53 approval for discharge of water to the environment. A "Water Taking Plan" and a "Discharge Plan" are required by the MECP if water is taken in accordance with an EASR. In all cases, discharge under the EASR must be in accordance with a Discharge Plan (to be developed by a qualified professional). A Category 3 PTTW would be required for water takings in excess of 400,000 L/day.

An accurate prediction of the groundwater pumping volumes cannot be made at this time, as the flow rate would be dependent on construction methods adopted by the contractor and the final inverts. A hydrogeological study may be warranted in support of an EASR or PTTW depending on construction methods and equipment used. Pumping discharges should also conform to any requirements from the local municipalities and conservation agencies. It is anticipated that an EASR will likely be required at this site for the trench excavations. Golder can be retained to carry out a detailed hydrogeological assessment once the details of the proposed storm sewer and watermain profile are made available.

4.2.3 Pipe Bedding and Cover

The bedding for watermains and sewers should be compatible with the size, type, and class of pipe, surrounding soil and loading conditions and should be designed in accordance with the Provincial, York Region and City of Markham standards. Where granular bedding is deemed to be acceptable, it should consist of at least 150 mm of OPSS Granular ‘A’ or 19 mm crusher run limestone material. Clear stone should not be used as bedding material nor to stabilize the base at this site. Sand cover may be used from the spring line to 300 mm above the obvert of the pipes. All bedding material and cover should be placed in maximum 150 mm loose lifts and uniformly compacted to a minimum of 100 percent of the material's SPMDD.

4.2.4 Trench Backfill

The excavated materials will generally consist of fill material, silty clay, sand, sandy gravel, silty sand to silt and sand, and glacial till. The excavated materials at suitable water contents may be reused as trench backfill provided, they are free of significant amounts of organics, or other deleterious material and are placed and compacted as outlined below. However, the cohesive fill and silty clay encountered within the site should not be used as backfill material due to their high compressibility and high water contents. These soils should be separated and disposed off-site.

All oversized cobbles and boulders (i.e. greater than 150 mm in size), if encountered, should be removed from the backfill. The excavated soils are expected to be near and above their estimated optimum water contents for compaction, and therefore some drying prior to reuse as trench backfill may be required. All trench backfill from the top of the cover material to 1.0 m below subgrade elevation should be uniformly compacted to at least 95 percent of the materials SPMDD. From 1.0 m below subgrade to the subgrade elevation, the materials should be placed in maximum 300 mm loose lifts and uniformly compacted to at least 98 percent of material’s SPMDD. Effort will be required to break down the cohesive till materials to reduce clod size, the presence of voids, and the associated potential for future settlements. Backfilling operations during cold weather should avoid inclusions of frozen lumps of material, snow, and ice. All pipes should be protected with a minimum of 1.4 m of earth cover, or equivalent insulation, for frost protection.

Alternatively, if soil water contents at the time of construction are too high, or if there is a shortage of suitable in-situ material, then an approved imported granular material which meets the requirements for OPSS.PROV 1010 Select Subgrade Material (SSM) could be used, placed, and compacted as described above. If strict control of backfill settlement is required, the trenches may be backfilled with unshrinkable fill. Backfilling operations during cold weather should avoid inclusions of frozen lumps of material, snow and ice.

Normal post-construction settlement of the compacted trench backfill should be anticipated, with the majority of such settlement taking place within about six months following the completion of trench backfilling operations. This settlement will be reflected at the surface of any new pavement placed over trenched sections. If the asphalt binder course is placed shortly following the completion of trench backfilling operations, any settlement that may be reflected by subsidence of the surface of the binder asphalt should be compensated for by placing an additional thickness of binder asphalt or by padding. Post-construction settlement of the restored ground surface in the off-road trench areas is also expected and should be topped-up and re-landscaped, as required.

It should be noted that in some cases, even though the compaction requirements have been met, the subgrade strength in the trench backfill areas may not be adequate to support heavy construction loading, especially during wet weather or where backfill materials wet of optimum have been placed. In any event, the subgrade should be proof-rolled and inspected by Golder prior to placing granular material for road reconstruction, as required, consistent with the prevailing weather conditions and anticipated use by construction traffic.

It is recommended that, where the utility trench encounters high permeability non-cohesive soils (if any), trench plugs should be constructed to prevent preferential water flow through the granular bedding and trench backfill. These low permeability plugs could be constructed using excavated cohesive material or concrete. The need for and frequency of trench plugs must be evaluated in the field during construction and/or once the servicing details are known. As such, it should be included in the contract as a provisional item.

4.3 Open Footing Culvert Recommendations

Two existing Corrugated Steel Pipe (CSP) culverts are located along Warden Avenue. The existing culverts are located within the vicinity of Boreholes C1 to C4. Based on the culvert inspection report provided by the Region, the CSP culvert range in diameter from 0.6 m to 0.8 m, with a soil cover ranging from 0.5 m to 1.0 m. The approximate invert is at a maximum depth of 1.6 m. For the purpose of this assessment, the existing CSP culverts are assumed to be removed and replaced with open footing concrete culverts with a proposed dimension of 1.5 m by 1.5 m. At the time of this report, the invert elevations, hydraulic capacity and other details of the proposed culvert have not been determined.

4.3.1 Foundation Design

The shallow strip footings for the culvert must be founded at a minimum depth of 2.2 mbgs after removal of fill and any disturbed soils, based on the borehole logs. In addition, all footings should have a minimum of 1.4 m of cover for frost protection.

The strip footings founded on the compact native sand and silty sand, or stiff silty clay and may be designed using a factored resistance at Ultimate Limit States (ULS) of 225 kPa and a geotechnical reaction at Serviceability Limit States (SLS) of 150 kPa for 25 mm of settlement.

The factored ultimate and factored serviceability geotechnical resistances are based on a footing size ranging from 0.3 m to 0.9 m, the geotechnical resistances should be reviewed if the footing width is greater than or less than that specified above or if the founding elevation differs from that given above.

The founding materials are susceptible to disturbance by construction activity especially during wet weather and care should be taken to preserve the integrity of the bearing strata. Prior to pouring concrete for the footings, the foundation excavations must be inspected by Golder to confirm that the footings are located in a competent bearing stratum, which has been cleaned of ponded water and loosened or softened material. If the concrete for the footings on the soil cannot be poured immediately after excavation and inspection, it is recommended that a working mat of lean concrete be placed in the excavation to protect the integrity of the bearing strata. The bearing soil and fresh concrete must be protected from freezing during cold weather construction.

4.3.2 Culvert Backfill and Erosion Protection

Open footings are founded directly on the subgrade, so bedding is not required. Backfill and cover for the culverts should be completed in accordance with OPSD 803.010 *(Backfill and Cover for Concrete Culverts).* Backfill to culvert walls should consist of Granular ‘A’ or Granular ‘B’ Type II fill.

The backfill material should be placed and compacted in accordance with OPSS.MUNI 501 *(Compacting).* The fill depth during placement should be maintained equal on both sides of the culvert walls, with one side not exceeding the other by more than 400 mm. The culvert replacements or extensions should be designed for the full overburden and hydrostatic pressures and live load, assuming that the fill above and/or surrounding the culverts has a unit weight of 22 kN/m^3 for Granular ‘A’, and 21 kN/m^3 for Granular ‘B’ Type II or select earth fill.

To prevent surface water from flowing either beneath the culverts (potentially causing undermining and scouring) or around the culverts (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), a clay seal should be provided at the upstream end of open footing culverts within the vicinity of Boreholes C3 and C4. Clay seals should also be placed adjacent to the culvert inlet opening. The clay material should meet the requirements of OPSS.MUNI 1205 *(Material Specification for Clay Seal)*. The clay seal should have a thickness of 1 m, and the seal should extend from a depth of 1 m below the scour level to a minimum horizontal distance of 2 m on either side of the culvert inlet opening, and a minimum vertical height equivalent to the high-water level including treatment of the adjacent side slopes. Alternatively, a clay blanket may be constructed, extending upstream to a distance equal to three times the culvert height, and extending along the adjacent side slopes to a height of two times the culvert height or the high-water level, whichever is higher.

If the water flow velocities are sufficiently high under the base or design storm condition(s), a provision should be made for scour and erosion protection (suitable non-woven geotextiles and/or rip-rap) at the culvert inlets and outlets, including in front of any retaining walls adjacent to the water channel. The requirements for and design of erosion protection measures for the culvert inlets should be assessed by the hydraulic design engineer. As a minimum, rip-rap treatment for the culvert outlets should be consistent with the standard Treatment Type A presented in OPSD 810.010 *(Rip-Rap Treatment for Sewer and Culvert Outlets),* with rip-rap placed up to the toe of slope level, in combination with the cut-off measures noted above. Similarly, rip-rap should be provided over the full extent of the clay blanket if adopted, including the side slopes and embankment fill slope adjacent to the culverts.

4.3.3 Lateral Earth Pressure for Open Footing Culvert

The lateral earth pressures acting on the culvert walls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls.

The following recommendations are made concerning the design of the walls.

- Free-draining granular fill meeting the specifications of OPSS.MUNI 1010 (*Aggregates*) Granular ‘A’ or Granular ‘B’ Type II should be used as backfill behind the walls. Longitudinal drains or weep holes should be installed to provide positive drainage of the granular backfill, as applicable.
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls. Care must be taken during the compaction operation not to overstress the wall, with limitations on heavy construction equipment and requirements for the use of hand-operated

compaction equipment per OPSS.MUNI 501 (*Compacting*). Other surcharge loadings should be accounted for in the design, as required.

- For restrained walls, granular fill should be placed in a zone with the width equal to at least 1.4 m behind the back of the wall. For unrestrained walls, fill should be placed within the wedge-shaped zone defined by a line drawn at flatter than 1 horizontal to 1 vertical extending up and back from the rear face of the wall or footing, as applicable.
- A unit weight of 21 kN/m^3, a coefficient of lateral earth pressure at rest of 0.47, and a coefficient of active lateral earth pressure of 0.31 should be used for the granular fill.

If the wall does not allow lateral yielding (i.e., restrained structure where the rotational or horizontal movement is not sufficient to mobilize an active earth pressure condition), at-rest earth pressures (plus any compaction surcharge) should be assumed for geotechnical design.

4.3.4 Excavations and Groundwater Control

Temporary open cut excavations for the culvert extensions/replacement will be made through the existing fill and into the sand, silty sand, and silty clay deposits. Excavation works must be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects. The existing fill would be classified as Type 4 soil with side slopes formed at no steeper than 3 horizontal to 1 vertical.

Groundwater level is anticipated to be below the base of excavation and proactive dewatering is not required. However, considering that the upper non-cohesive fill has a high permeability, surface water seepage into the excavation should be expected and this can likely be controlled by pumping from properly filtered sumps installed inside the excavation. The water channel should also be diverted prior to construction.

4.4 Recommendations for CSP Extension

As an alternative to removing and replacing the existing CSP culvert with an open footing culvert, the existing CSP culverts may be extended. As discussed above, the CSP culverts range in diameter from 0.6 m to 0.8 m, with a soil cover ranging from about 0.5 m to 1.0 m. The approximate invert is at a maximum depth of 1.6 m.

The construction of extensions to the culverts may potentially result in differential settlement between the newly placed CSP culvert extension and the existing CSP culvert which is expected to have undergone some degree of settlement over its service life. Based on the existing founding depth of 1.6 m, the culvert extension will likely be founded within the soft to firm silty clay fill.

In order to reduce the impact of differential settlement due to the effective stresses generated by the soil cover, the exposed base should be subexcavated to about 2.2 mbgs into the native soils consisting of stiff to very stiff silty clay and/or compact silty sand and sand deposits. The excavated soils should then be replaced with Granular B, Type II material up to the pipe invert elevation and compacted to at least 98 percent SPMDD.

The engineered granular fill may be designed using a factored resistance at Ultimate Limit States (ULS) of 225 kPa and a geotechnical reaction at Serviceability Limit States (SLS) of 150 kPa for 25 mm of total settlement and 20 mm of differential settlement.

Culverts backfill and erosion control should be in accordance with Section 4.3.2. Excavation and groundwater control for the CSP extension should be carried out based on recommendations in Section 4.3.4.

4.5 Trenchless Crossing

Based on the provided plan and preliminary external servicing alignment drawing entitled "*Map SP1 Detailed Land Use, Berczy Glen Secondary Plan"*, dated November 27, 2018 and "*Figure 1 – Preliminary External Servicing Alignment*" dated April 2021, it is understood that the proposed 600 mm and 750 mm diameter watermain will be spanning along Warden Avenue between Berczy Glen Street and Major Mackenzie Drive East.

Three watermain crossings are being proposed to be located around Street A, Street B and Street E within the vicinity of Boreholes S2, S3 and S5. The 400 mm diameter PVC watermain will be installed within a 600 mm diameter steel casing using trenchless techniques. The obvert of the tunnel casing is anticipated to be at about 2.1 m below the existing centerline of Warden Avenue.

Successful completion of any trenchless technology or tunnelling project largely depends on the skills and experience of the Contractor. The final selection of the trenchless undercrossing technique should be made by the Contractor based on his experience and equipment capabilities and his assessment of the subsurface conditions, although in the event of alternative methods, the Contractor must make his own interpretation of the anticipated ground behaviour, based on the information provided herein. Reference to Ontario Provincial Standard Specification, OPSS 415, OPSS 416 and OPSS 450 should be made in the contract depending on the final installation method chosen.

Prior to commencement of the trenchless crossings, the contractor will have to carefully expose any other utilities that may cross the pipeline alignment and confirm their locations and elevations. The contractor's work plan should include a method of supporting the face of the tunnel in the case of an emergency, as well as a provision for compensation grouting under the road, should the need arise. The Contractor's proposed methodology should be reviewed by the geotechnical engineer prior to construction.

Given that other utilities maybe present in the vicinity of the crossing of Warden Avenue, we recommend that a minimum separation distance of 3.0 m be maintained over the length of the trenchless crossings between any existing utilities and the watermain casing. If this distance cannot be maintained, the utility owners should be contacted regarding their settlement and vibration tolerance.

Based on the proposed inverts, the tunnels will encounter the dense to very dense silty sand, dense silty sand till, stiff to hard silty clay to clayey silt till below the groundwater level, within and above the tunnel horizon. Firm to very stiff silty clay fill containing organics was also encountered above the proposed obverts. Correlating the soil classification with a modified version of Terzaghi's Tunnelman's Classification System. (Heuer, 1974, modified from Terzaghi, 1950), the silty sand and silty sand till can be described as running to slow raveling, while the cohesive till can be described as slow raveling to firm. The surface soil and groundwater conditions near the watermain crossings are based on Boreholes S2, S3, S4 and S5. Typically, a minimum of two boreholes should be advanced for each crossing, one at either end of the crossing and at 25 m to 50 m spacing along the crossings and should be advanced to confirm the subsurface conditions and our recommendations. It is also recommended that monitoring wells be installed and screened at the pipe invert level as part of the detailed geotechnical investigation to monitor groundwater levels.

Installation of a trenchless crossing within the till deposits may present challenges with the potential for encountering cobbles and boulders, as evidenced by the SPT spoon not advancing its full depth between 2.1 m and the terminated depth of 7.9 m in Borehole S5. Further, cobbles and boulders are inherently encountered in glacially derived materials.

Trenchless technology covers a wide range of methods, such as “pipe ramming”, “jack and bore”, “horizontal directional drilling (HDD)” and “micro-tunnelling” techniques. Some or most of the methods would be considered feasible provided specific mitigation measures are in place, depending on the selected approach. This discussion is considered preliminary until additional borehole information is obtained and the horizontal and vertical alignments are confirmed.

4.5.1 Pipe Ramming

Pipe ramming involves the use of a percussive hammer to advance a steel casing with a cutting shoe attached at the front end of the casing, much like horizontal pile driving. The casing is generally advanced open-ended and the soil within the casing is typically removed after the casing has been driven the entire length of the installation, thereby reducing the potential for ground loss into the casing during driving and avoiding the need for dewatering along the full alignment.

Pipe ramming is considered feasible for this crossing. Pipe ramming methods are better suited for penetrating through potential obstructions such as cobbles and boulders; however, deflection and/or refusal to penetration of the casing can still occur if large obstructions are encountered. Lubrication (i.e. bentonite) at the face may be required to aid in reducing side friction and advancing the steel pipe. Furthermore, a “plug” of soil may form at the head of the casing inducing surficial ground heave as the pipe is advanced. This can be controlled by periodically stopping the operation and removing some limited spoils from within the pipe before advancing further. However, since this method is predicated on the casing pipe remaining full of soil to prevent ground loss, if for whatever reason augering of the soils is required before the crossing is complete, ground loss may occur.

A disadvantage of pipe ramming is the inability to adjust the alignment as it is advanced, particularly if it deflects offline due to obstructions. Oversizing the casing could be considered to accommodate for any required alignment adjustments. Another disadvantage is the high level of vibrations that are created during the ramming process could affect nearby structures or utilities. The advantage of pipe ramming over jack and bore is that there is less chance for ground loss to occur as the soil is removed from the pipe after completion of jacking.

4.5.2 Jack and Bore

Auger “jack and bore” is a method of forming a near horizontal bore from a jacking (i.e., entry) pit where boring is undertaken with a rotating cutter head and a continuous welded casing is jacked through reaction against a thrust block located within the jacking pit. Spoil from the tunnel excavation is transported to the jacking pit along helical auger flights and the new pipe is then installed within the casing. This is considered an open face method with an unsupported face, subject to the anticipated ground behaviour and stand-up time of the encountered soils.

The steering ability and grade control is somewhat limited with this method although some jack and bore systems use a pilot tube with a spider head adapter where a small 75 mm to 100 mm pilot tube is first pushed through and then the auger jack and bore follows behind as the pilot tube is pushed out the exit pit. It should be noted that the spider head adapters do not provide a fully closed face and ground loss can still occur in some soil conditions.

Auger jack and bore is considered feasible at this site, however, dewatering (if required, depending on detailed investigation and installation of monitoring wells) along the full alignment would be required for this method, particularly in the non-cohesive silty sand deposit Based on the groundwater levels measured in nearby relevant boreholes during the investigation, the groundwater table was encountered below the pipe invert, although this should be confirmed at each crossing location. Further, in denser/stiffer soils, the spider adapter may create a plug and thus ground heave, which should be carefully monitored.

In order to mitigate encountering cobbles and boulders, the auger can be adapted to use rock-cutting teeth or a small boring unit (SBU) could be attached to the casing, although the SBU is still considered an uncontrolled open face method, subject to potential ground loss. Sufficient rig power, as well as suitable tools including cutting heads appropriate for the installation of the pipe in the anticipated ground conditions should be used with this method. The casing may be lubricated to reduce the frictional forces between casing and the surrounding soils. The characteristics of the surrounding soil should be considered in selecting the appropriate lubricant.

To reduce (but not eliminate) loss of ground and associated disturbance, consideration should be given to jacking the liner as far as practical, prior to augering. However, the presence of the dense to very dense soils could make this difficult and deflection and/or refusal to penetration of the casing may occur, especially if obstructions are encountered. Therefore, we recommend that a soil plug of at least one casing diameter be maintained between the leading edge of the casing and the auger as a mitigation measure to prevent ingress of soils. The contractors work plan should discuss these measures, including the potential for a longer plug, if required. Further, continuous operations should be considered if a suitable bulkhead cannot be provided during work stoppages and the leading edge of the casing should not be stopped within the travelled roadway, if possible. The volume of mucked soil versus the theoretical volume should be closely monitored to provide an indication of potential ground loss.

The advantage of this method is that it is a relatively straightforward trenchless method and there are many experienced contractors available. Further, the soil conditions are suitable for this method to be used. The disadvantage of this method is the potential to encounter cobbles and boulders and also that there is the potential for high ground loss if saturated soils are encountered which are not fully dewatered along the entire length, or if the contractor is not experienced with this method.

4.5.3 Horizontal Directional Drilling (HDD)

The HDD method involves forward thrusting a small rotating and steerable bit launched from the ground surface or shallow pit which is used to drill a pilot hole supported by properly designed and engineered drilling fluid. Once the pilot bore is complete, a back reamer is used to enlarge the bore so the permanent pipe can be pulled into place.

HDD is technically feasible at this site; however, the alignment must be selected such that the radius of curvature of the alignment is sufficiently large such that the HDD drill rods can readily accommodate the proposed alignment, and that the watermain can be installed/pulled along the proposed alignment without being overstressed. With such a large pipe and shallow cover at these crossing locations, and considering that this method does not typically utilize a liner for installation, there is a large potential for inadvertent returns to surface (i.e. “frac-out”).

Once design details are known and additional boreholes are advanced at the crossing locations, a detailed frac-out analysis should be carried out and the pipe depth adjusted accordingly, if necessary. In addition, any contractor bidding on the work would need to ensure that adequate mitigation measures are put in place to eliminate frac-out under the roadway, should this method be considered.

4.5.4 Micro-tunnelling

Micro-tunnel boring machines (MTBM) typically use pressurized bentonite slurry to counterbalance the earth and water pressures acting at the tunnel face and to transport the cuttings to the surface. A remotely controlled rotating cutterhead is used to excavate soil in a controlled manner at the face and together with the pressurized slurry that act to minimize loss of ground during tunnel advance. Although a slurry based MTBM is technically feasible and ideally suited for this site in terms of minimizing the risk of loss of ground and ground surface settlement, for such a short tunneling segments, it is relatively expensive to mobilize this type of equipment and the availability of machines with the suitable diameter bore and the mobilization costs for such equipment may constrain their use on this project.

4.5.5 Summary of Trenchless Methods

It is our opinion that pipe ramming, jack and bore, or HDD could be utilized at this site with appropriate mitigation and contingency measures in place, along with settlement monitoring. Ultimately the contractor should determine the method which best suits the soil and groundwater conditions at this site.

4.5.6 Grouting/Sealing

Depending on the trenchless method of installation selected and overcut (diameter of tunnel/bore excavation relative to the outside diameter of the casing), grouting of the annulus during and/or after installation of the casing may be required to reduce the risk and/or limit settlements to tolerable levels.

For installations where the settlement monitoring or excavation volume monitoring indicates that pavement settlement or ground loss might have occurred, or where signs of ground loss have been noted or inferred, a provision should also be made for a program of compensation grouting above the casing pipe and/or to maintain the pavement structure.

4.6 Settlement Monitoring

Settlements associated with trenchless installation methods are typically of two types:

- Large settlements: These settlements are the result of loss of ground due to over-excavation caused by the inability to control adverse ground conditions or due to the operator errors. Large settlements can lead to the creation of voids and/or sinkholes above the installed pipe.
- Systematic settlements: These settlements are primarily caused by the collapse of the annular space between the pipe and the bore annulus or by deformation of the soils ahead of the advanced bore.

Contractors should be utilizing trenchless installation best practices to avoid/minimize settlements. The anticipated systematic settlement/deformation above the alignment where it crosses Warden Avenue (for 2.1 m of cover or greater) is estimated to be less than 10 mm in these deposits, provided that suitable boring methods are implemented along with good workmanship. The magnitude of such settlement is highly dependent on the construction procedures utilized.

A settlement monitoring program must be carried out to:

- Document the effects of the trenchless installations on the overlying road;
- Obtain prior warning of ground movements that could occur due to the construction methods and equipment or unforeseen ground conditions;
- Verify the contractor’s compliance with the ground movement limits imposed in the Contract; and,
- Allow adjustments to be made to the tunnelling/boring methods such that the ground movement limits established are not exceeded.

4.7 Instrumentation

A series of surface monitoring and in-ground monitoring points should be installed along the centreline of the watermain alignment at each crossing. The exact locations of the monitoring points will depend on the actual site conditions and final alignment of the crossings and sending/receiving shaft locations.

The monitoring points should be installed as follows:

- Surface monitoring points (i.e., reflectors and/or identifiable markings) directly over the alignment along the centreline of the proposed watermain where these services cross Warden Avenue, on the paved surface of road. The surface monitoring points should be spaced at 5 m (maximum). Alternatively, precision reflectorless survey monitoring may be used provided repeatable accuracy and precision as specified in the Contract is achieved.
- In-ground monitoring points consisting of a sleeved iron bar set in a concrete anchor to a minimum depth of 1.2 m below ground/pavement surface and extending to no deeper than 1.0 m above the tunnel/bore obvert elevation. The elevation of the top of the bars may be read remotely using reflectors at the top of the iron bars. Alternatively, precision reflectorless survey monitoring may be used at the top of the bars. The in-ground monitoring points provide the best measure of the ground settlement effects of trenchless methods, as they are unaffected by frost or the bridging action of the pavement structure. Where space permits, one in-ground point should be installed in the each of the east and west boulevard of Warden Avenue, along the alignment, and about 5 m from the pits.

4.8 Monitoring

A qualified surveying firm should be retained to confirm the locations and to carry out the settlement monitoring during construction; their equipment and procedures must be capable of surveying the settlement point elevation to within ± 2 mm of the actual elevation with repeatable accuracy and precision. It is noted that at this site, traffic control will likely be required to carry out monitoring of the instrumentation unless adequate reflector locations and/or reflectorless technology are used at all locations.

Prior to the start of construction, all monitoring points should be read a minimum of two times, on three separate days, to provide a baseline against which all subsequent monitoring results will be compared. The monitoring points should be surveyed a minimum of two times (sets) per day during trenchless installation of the casing pipe, including during shut-down periods and weekends. An allowance should be made for more frequent monitoring (up to every four hours) should observations dictate. Once installation of the casing pipe is complete, monitoring should continue daily for a minimum of two weeks, and provided further settlement has stopped, after which monitoring may be reduced to monthly for 3 months.

Based on the monitoring results, the following represents trigger levels that define magnitude of movement and corresponding actions:

- If the Review Level (maximum of 10 mm of displacement relative to baseline readings) is reached, the Contractor will need to review or modify the trenchless method, rate of sequence of construction or ground stabilization measures to mitigate further ground displacement. The Contractor should provide a formal plan that states actions that will be implemented to ensure that the Alert Level is not reached.
- If the Alert Level (maximum of 15 mm of displacement relative to the baseline readings) is reached, the Contractor will need to stop all work/construction and execute pre-planned methods to secure the site and

mitigate further movements to assure safety of public and to maintain vehicular traffic. No construction is to take place until the conditions specified in the Contractors mitigation plan are satisfied.

In addition to settlement monitoring, line and grade should be carefully monitored during construction. To the extent that is practical, measurement of the volumes and/or weights of cuttings on a regular basis (e.g., every 3 m length of casing or pipe installed) could provide a secondary means of monitoring ground control during tunnelling.

The installation of the monitoring points in the field should be carried out by the contractor under the supervision of Golder and the subsequent survey monitoring would be carried out by the contractor with the results being promptly reviewed by Golder on an ongoing basis.

4.9 Sending and Receiving Pits

4.9.1 Temporary Excavations

The invert elevations of the sending and receiving pits are anticipated to be about 3.2 m below the existing road centerline along Warden Avenue. As such, the base of the excavations for the sending and receiving pits will likely be within very dense silty sand till, stiff to hard cohesive till deposits and likely close to or above the measured groundwater table.

Excavations for the entry and exit pits are anticipated to be located near the boreholes and extend through the surficial cohesive fill, and native dense to very dense silty sand, dense silty sand, and hard silty clay to clayey silt till deposits.

All excavations must be carried out in accordance with Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects. Based on OHSA, the existing fill can be classified as Type 3 soils and all excavations more than 1.2 m in depth through these soils should be sloped no steeper than 1 horizontal to 1 vertical (1H:1V) above the groundwater level. However, the dense to very dense/hard native soils can be classified as Type 2 soils above the groundwater table which require side slopes no steeper than 1H:1V to 1.2 m or less from the bottom of excavation. Where excavations extend below the groundwater level, these soils are considered to be Type 3 soils. Depending upon the construction procedures adopted by the contractor, the success of the contractor’s groundwater control methods and weather conditions at the time of construction, some flattening and/or blanketing of the slopes may be required.

To maintain temporary excavation stability, excavated materials should be placed away from the edge of the excavation at a distance equal to the depth of the excavation or greater. In addition, stockpiling of the excavated soil, construction material, and construction equipment should be prohibited adjacent to the excavations to minimize surcharge loading near the crest of the excavations.

Proper pit construction is essential for the success of any trenchless operation. For this reason, it is preferable that construction of pits be carried out by (or in close collaboration with) the specialist trenchless subcontractor. If the pits are to be constructed by the general contractor on behalf of the trenchless contractor, the pit design and construction must be compatible with the trenchless equipment and methods.

4.9.2 Temporary Protection Systems

Due to the proximity of Warden Avenue to the proposed pits at the eastern and western limits of the proposed crossings and as well as the presence of underground utilities along Warden Avenue, temporary protection systems will likely be required.

It is anticipated that a driven interlocking steel sheet pile system or a slide rail system is suitable at this site. Alternatively, the contractor may use a soldier pile and lagging system. The sheet piles or posts/sheeting forming the slide rail system or soldier piles will need to extend to a sufficient depth to provide the necessary passive resistance for the retained soil height, plus any surcharge loads behind the protection system. Difficulties and/or inability of driven piles to penetrate through the glacial till deposit may be encountered due to the potential presence of cobbles/boulders in the till, reducing the potential for a cantilever design. Lateral support of the sheet pile wall or slide rail system wall or soldier pile wall could be provided in the form of struts, rakers, or temporary anchors, if and as required.

Drilling through/into the cobbles/boulders may also be necessary to permit construction of the pits, depending on the detailed design of the pits. The temporary protection systems should be designed/engineered and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems*). The lateral movement of the protection systems should meet Performance Level 2 as a minimum and as specified in OPSS.PROV 539, provided that any utilities, if present within the zone of influence, can tolerate this magnitude of deformation. If not, a more stringent Performance Level may be required by the affected utility owners.

The selection, design, construction, maintenance, and monitoring of the temporary protection system(s) is the responsibility of the Contractor.

The temporary protection systems may be designed using the following soil parameters:

Table 9: Soil Parameters for Temporary Protection Systems

Fill / Soil Type	**Bulk Unit Weight, ɣ [1]**	**Internal Angle of Friction, ϕ′**	**Undrained Shear Strength, S_u**	**Lateral Earth Pressure Coefficients [2]**		
				K_a (Active)	**K_o (At-Rest)**	**K_p (Passive [3])**
Existing Fill	18 kN/m^3	25°	-	0.41	0.58	2.44
Dense to Very dense Silty Sand	20 kN/m^3	32°	-	0.31	0.47	3.23
Dense to Very dense Silty Sand Till	21 kN/m^3	33°	-	0.29	0.46	3.45
Stiff to Hard Cohesive Till	20 kN/m^3	30°	100 to 200 kPa	0.33	0.50	3.03

Notes:

1) The design groundwater level may be assumed to be at 3.5 m at the entry/exit pit. The effective unit weight (i.e., unit weight of water subtracted from the bulk unit weight) should be used for soils/fills below the groundwater table.
2) The lateral earth pressure coefficients presented above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are expected, the coefficients should be corrected accordingly.
3) The total passive resistance below the base of the excavation (i.e., within the temporary protection system enclosure) may be calculated based on the values of Kp indicated above but reduced by an appropriate factor that considers the allowable wall movement.

The loading from construction equipment as well as any material stockpiles within a distance defined by a 1 horizontal to 1 vertical (1H:1V) line drawn from the bottom of the excavation to the existing ground surface should be included as a surcharge load in the design of the temporary protection system.

4.9.3 Surface Water and Groundwater Control for Trenchless Method

Based on the available groundwater levels in the vicinity of the proposed watermain crossing (Boreholes S2, S3, S4 and S5), it is anticipated that excavations for the proposed pits/shafts will be above or near the groundwater level. This should be confirmed with additional monitoring wells as discussed previously.

For pits extending below the invert of the proposed watermain and below a depth of about 3.5 m, groundwater lowering/dewatering will be required to facilitate excavation of the pits, installation of maintenance holes within the pits, where required, and operation of the trenchless activities in dry.

In any case, the groundwater level should be lowered to at least 1 m below the base of the proposed excavation level to maintain basal stability and allow for construction in dry conditions at the pits.

The Contractor is responsible for the design, operation, monitoring and impacts of dewatering, which depends on their chosen method of excavation or temporary protection system to construct the pits and trenchless installation. The Contractor is also responsible for confirming that the radius of groundwater drawdown does not impact the existing road and any surrounding settlement-sensitive utilities, infrastructure, or water wells. Given the relatively compact to dense nature of the native soils and the groundwater level, it is not anticipated that dewatering activities will have a major impact on the road.

Water taking activities for construction projects must meet the latest legislative requirements of the Ministry of the Environment, Conservation and Parks (MECP). Therefore, if groundwater taking limits are less than 50 m^3/day, no requirements are needed by the Contractor. If groundwater taking limits range between 50 m^3/day and 400 m^3/day, an Environmental Activity and Sector Registry (EASR) will be required to be prepared and submitted by the Contractor. If groundwater takings are greater than 400 m^3/day, a Permit to Take Water (PTTW) will need to be prepared and submitted by the Contractor for review and approval.

Surface water should be directed away from open excavation areas to prevent ponding of water that could result in disturbance and weakening of the subgrade and/or affect construction or open cut/temporary support system operations, as applicable.

4.10 Corrosivity

The corrosivity results were compared to Table 2 values obtained from a guideline entitled, "*Performance Guideline for Buried Steel Structures, Durability of Structural Plate Corrugated Steel Pipe and Deep Corrugated Structural Plate Structures*", dated February 2012.

The soil aggressiveness to concrete was evaluated by analytical testing for soluble sulphate concentrations in selected soil samples to the Canadian Standards Association (CSA) A23.1 (Table 1 and 3) Standard, "*Concrete materials and methods of concrete construction*". Based on the analytical results, the sulphate concentration in the soils is non-aggressive to concrete.

The electrical resistivity ranged between 233 and 1230 ohm-cm which indicates that the soil corrosiveness is high (<5000 ohm-cm) as per Table A1.1 of CSA A23.2:19. The chloride concentration measured in the native soils ranged between 378 and 2640 µg/g (or mg/L), which is high indicating that the soil is very aggressive (i.e. >200 mg/L).

The results indicate that concrete made with Type GU Portland cement should be acceptable for substructures. The results also indicate a high potential for corrosion of exposed ferrous metal, which should be considered during the design of the substructure.

These recommendations are provided as guidance only; the structural designer should take the results of the laboratory testing, the potential for corrosion and the ultimate selection of materials into consideration.

4.11 Soil Reuse / Excess Soil Disposal

Based on the results of the environmental testing and comparison to selected criteria (see above), the following comments are provided regarding the management of excess soil:

On-site Reuse of Excess Soil

Based on the above limited testing, most of the tested soil has been impacted by the application of de-icing salt. Excavated soil resulting from the construction work can be reused on-site subject to the following:

- Soil screening, consisting of visual inspection for consistency of soil type, presence of debris, odours or staining, should be carried out during excavation and prior to reuse. Should any unexpected soil conditions be encountered, or any potential environmental issues be detected either during excavation or placement of the soil, reuse of the material should cease, and the soil be reassessed.
- Reuse of soil should be limited to the locations and depths for which testing was conducted. Additional testing would be required if material from different locations or depths is proposed for reuse.
- Reuse is subject to the geotechnical suitability of the material.
- The reuse of EC and SAR impacted soil is subject to acceptance and approval from the receiver/property owner. Its reuse should generally be limited to the project area associated with the proposed construction work and where there will be continued application of de-icing salt. EC and SAR impacted soil should not be reused within 30 m of a water body or 100 m of a potable water well.

Off-site Reuse of Excess Soil

As of January 1, 2021, the new Excess Soil Quality Standards, under O.Reg. 406/19, came into effect. A preliminary review of the data collected as part of this investigation suggests that the soil would be suitable for off-site reuse (based on the comparison standard and associated land use noted above) subject to the requirements relating to salt-impacted excess soil. Specifically, in addition to the requirements relating to on-site reuse (see above), the following would also be required:

- The reuse of EC and SAR impacted soil is subject to acceptance and approval from the receiver/property owner. Its reuse should generally be limited to a road allowance (where there will be continued application of de-icing salt) or within a commercial/industrial property to which the non-potable standards apply or at a depth of at least 1.5 m below ground surface. The material should not be reused within 30 m of a water body, within 100 m of a potable water well or on land that will be used for growing crops or pasturing livestock unless the excess soil is placed 1.5 m or greater below the soil surface.

It is noted that this assessment was conducted for preliminary planning only and is not intended to meet the requirements of O.Reg. 406/19. This regulation should be reviewed in conjunction with the proposed construction work including construction schedule, locations from which excess soil will be generated, soil volumes, proposed soil management options and reuse location. There are additional requirements of the regulation that take effect in 2022 for which pre-planning will be required and which should be considered in conjunction with the work including the preparation of an assessment of past uses report, sampling and analysis plan, excess soil characterization report, soil destination report and a soil tracking program. There are also several timing extensions and exemptions provided in the regulation for infrastructure projects which should be reviewed in light of the proposed work. The reuse/receiving site may have specific acceptance criteria which should be determined as part of the construction planning process. Furthermore, movement of soil to a site that has a Record of Site

Condition on file with the MECP may require that specific testing protocols are followed and that the materials must satisfy site specific standards.

Off-site Soil Disposal

In the event that excess soil cannot be reused on- or off-site, the excess soil will require disposal at a MECP approved receiving or waste management facility. The receiving facility will have specific acceptance criteria which would need to be addressed in conjunction with the project planning.

4.12 Monitoring Well Decommissioning

Eight groundwater monitoring wells (Boreholes C4, S1, S3, S4, S5, S8, S9 and S11) were installed to permit monitoring of the groundwater level at the site. Ontario Regulation (O.Reg.) 903 amended by O.Reg. 128/03 of the Ontario Water Resources Act requires that monitoring wells are properly abandoned/decommissioned by qualified personnel. We recommend that the decommissioning of the monitoring wells be carried out as part of the construction activities at the site so that water level measurements can be taken immediately prior to construction. If requested, Golder could provide assistance in arranging for the decommissioning of the monitoring wells by a licensed water well drilling contractor.

4.13 Additional Work

As discussed in Sections 4.5 to 4.9, we recommend that once the final horizontal and vertical alignments of the trenchless crossing are known, that additional boreholes and monitoring wells be installed to confirm the soil and groundwater conditions specific to each crossing location. We should be given the opportunity to review the trenchless recommendations (including pit construction) provided in this report.

4.14 Construction Monitoring and Inspections

The geotechnical aspects of the final design drawings and specifications should be reviewed by Golder prior to tendering and construction to confirm that the intent of this report has been met. Specifically, we should review the trenchless drawings and specifications, as well as the contractor work plan submissions, from a geotechnical perspective.

During construction, full time inspections should be carried out by Golder to confirm that the conditions exposed are consistent with those encountered in the boreholes and in-situ materials testing should be carried out to monitor conformance to the pertinent project specifications. HMA and granular materials testing should be carried out in CCIL and CSA certified laboratories. Full time on-site inspection of the trenchless crossings should be carried out by Golder personnel so that we can be proactive in assisting the owner in dealing with on site issues related to ground disturbance.

5.0 CLOSURE

We trust that this report provides sufficient information for you to proceed with the detailed design of the project. If you have any questions regarding the contents of this report, please contact our office.

Signature Page

Golder Associates Ltd.

ORIGINAL SIGNED BY

ORIGINAL SIGNED BY

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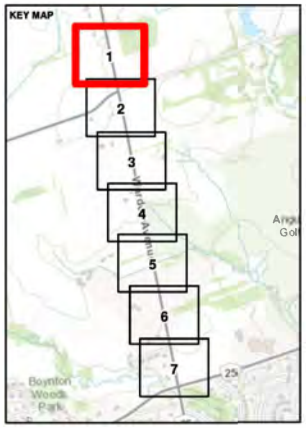
LEGEND

◆ APPROXIMATE BOREHOLE LOCATION – ROAD LANE

◆ APPROXIMATE BOREHOLE LOCATION – ROAD SHOULDER

◆ APPROXIMATE BOREHOLE WITH MONITORING WELL LOCATION



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CLIENT

THE REGIONAL MUNICIPALITY OF YORK

PROJECT

PROPOSED ROAD IMPROVEMENTS OF WARDEN AVENUE, MARKHAM

TITLE

BOREHOLE LOCATION PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2021-03-01
DESIGNED	CGE
PREPARED	CGE
REVIEWED	AP
APPROVED	-

PROJECT NO.	CONTROL	REV.	FIGURE
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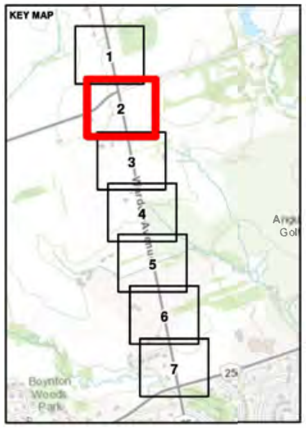
- ◆ APPROXIMATE BOREHOLE LOCATION – ROAD LANE
- ◆ APPROXIMATE BOREHOLE LOCATION – ROAD SHOULDER
- ◆ APPROXIMATE BOREHOLE WITH MONITORING WELL LOCATION



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PROPOSED ROAD IMPROVEMENTS OF WARDEN AVENUE, MARKHAM

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CONSULTANT
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YYYY-MM-DD	2021-03-01
DESIGNED	CGE
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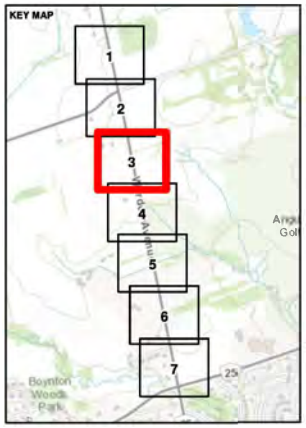
◆	APPROXIMATE BOREHOLE LOCATION – ROAD LANE
◆	APPROXIMATE BOREHOLE LOCATION – ROAD SHOULDER
◆	APPROXIMATE BOREHOLE WITH MONITORING WELL LOCATION



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PROPOSED ROAD IMPROVEMENTS OF WARDEN AVENUE, MARKHAM

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BOREHOLE LOCATION PLAN

CONSULTANT

GOLDER

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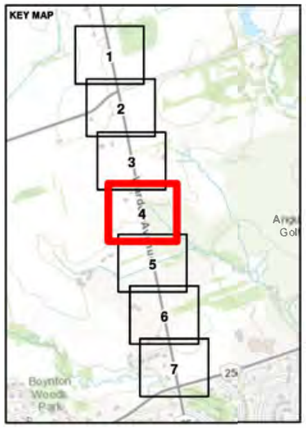
⯁ APPROXIMATE BOREHOLE LOCATION – ROAD LANE

🟧 APPROXIMATE BOREHOLE LOCATION – ROAD SHOULDER

🟦 APPROXIMATE BOREHOLE WITH MONITORING WELL LOCATION



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THE REGIONAL MUNICIPALITY OF YORK

PROJECT

PROPOSED ROAD IMPROVEMENTS OF WARDEN AVENUE, MARKHAM

TITLE

BOREHOLE LOCATION PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2021-03-01
DESIGNED	CGE
PREPARED	CGE
REVIEWED	AP
APPROVED	-

PROJECT NO.	CONTROL	REV.	FIGURE
20146456	0001	-	4

PATH: S:\Clients\Region_of_York\Major_MacKenzie_Drive\99_PROJ\20146456\40_PROD\0001_Geotech\20146456-0001-BG-0001.mxd PRINTED ON: 2021-03-01 AT: 9:53:12 PM

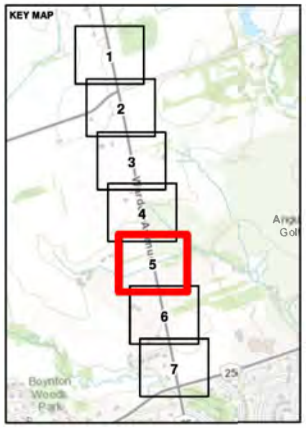
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

25mm

0

LEGEND

◆	APPROXIMATE BOREHOLE LOCATION – ROAD LANE
◆	APPROXIMATE BOREHOLE LOCATION – ROAD SHOULDER
◆	APPROXIMATE BOREHOLE WITH MONITORING WELL LOCATION



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REFERENCE(S)
1. BASE DATA - MNRF 2020
2. BASE IMAGERY - SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS,

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PROJECT NO.	CONTROL	REV.	FIGURE
20146456	0001	-	5

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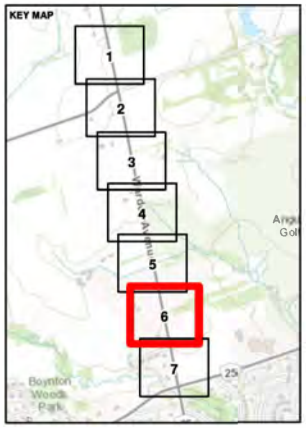
LEGEND

- ◆ APPROXIMATE BOREHOLE LOCATION – ROAD LANE
- ◆ APPROXIMATE BOREHOLE LOCATION – ROAD SHOULDER
- ◆ APPROXIMATE BOREHOLE WITH MONITORING WELL LOCATION



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PROJECT NO.	CONTROL	REV.	FIGURE
20146456	0001	-	6

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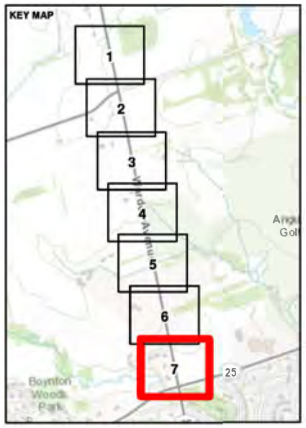
25mm

LEGEND

- ⯐ APPROXIMATE BOREHOLE LOCATION – ROAD LANE
- ⯐ APPROXIMATE BOREHOLE LOCATION – ROAD SHOULDER
- ⯐ APPROXIMATE BOREHOLE WITH MONITORING WELL LOCATION

KEY MAP



0 50 100

1:1,500 METRES

REFERENCE(S)

1. BASE DATA - MNRF 2020
2. BASE IMAGERY - SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS,

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PROJECT NO.	CONTROL	REV.	FIGURE
20146456	0001	-	7

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

Warden Avenue NB

Warden Avenue SB

CLIENT

The Regional Municipality of York

PROJECT

Geotechnical Investigation

Proposed Road Improvements of Warden Avenue, Markham, Ontario

CONSULTANT

GOLDER

YYYY-MM-DD 22021-03-09

TAKEN BY IM

CHECKED BY ACB

TITLE

Site Photographs

PROJECT No. 20146456

FIGURE **8**

Warden Avenue SB lane, south of intersection with Elgin Mills Road

Warden Avenue SB lane

CLIENT

The Regional Municipality of York

PROJECT

Geotechnical Investigation

Proposed Road Improvements of Warden Avenue, Markham, Ontario

CONSULTANT

GOLDER

YYYY-MM-DD 22021-03-09

TAKEN BY IM

CHECKED BY ACB

TITLE

Site Photographs

PROJECT No. 20146456

FIGURE **9**

APPENDIX A

Important Information and Limitations of This Report

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client can not rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Ground Water Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client’s expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder’s report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder’s report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder’s report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder’s report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder’s responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

APPENDIX B

Pavement Condition Survey Sheets

FLEXIBLE PAVEMENT CONDITION EVALUATION FORM (MUNICIPALITIES)

Road No. (Street) Warden Avenue **Location From** Major Mackenzie Drive **To** 400 m north of Elgin Mills Road

Section Length 2.4 (KM) **Survey Date** March 9, 2021 **Traffic Direction** B

B: Both Directions, N: North Bound
S: South Bound, E: East Bound, W: West Bound

Contract No. **Work Project No.** 20146456 **Class** M

F: Freeway, C: Connecting Link, A: Major Artierial
M: Minor Artierial, R: Residential

Pavement Condition Rating (PCR) 70 **Riding Condition Rating (RCR)** 7 **Evaluated by** IM

Riding Condition Rating (At Posted Speed)

10 – 8	8 – 6	6 – 4	4 – 2	2 – 0
Excellent	Good	Fair	Poor	Very Poor
Smooth and Pleasant	Comfort-able	Uncomfort-able	Very Rough and Bumpy	Dangerous at Posted Speed

Pavement Distress Manifestation			Severity of Distress			Density of Distress % Extent of Occurrence		
			Slight	Moderate	Severe	Intermittent	Frequent	Extensive
			1	2	3	< 20 1	20-50 2	> 50 3
Surface Defects	Ravelling	1	X				X	
	Flushing	2						
	Potholes	3						
	Pavement Edge Breaks	4	X			X		
	Manholes and Catchbasins	5						
Surface Deformation	Rippling and Shoving	6						
	Wheel Track Rutting	7	X				X	
	Distortion	8						
	Utility Trenches	9						
Cracking	Longitudinal	10	X	X			X	
	Transverse	11	X	X		X		
	Pavement Edge	12		X		X		
	Map	13	X			X		
	Alligator	14						

Distress Comments (Items not covered above)

Ditches generaly well maintained. Localized sections with shallow ditches with standing water were observed. Cracks are more dense north of Elgin Mills Road. Cracks north of Elgin Mills Road are mostly sealed (except the shoulder edge cracks which are not sealed).

Recommendation by Evaluator

Shoulder Distress Manifestation			Severity of Distress						Density of Distress % Extent of Occurrence					
			Right			Left			Right			Left		
Dominant Type	one	Distress	Sli 1	Mod 2	Sev 3	Sli 1	Mod 2	Sev 3	<20 1	20-50 2	>50 3	<20 1	20-50 2	>50 3
Paved Full		Pavement Edge Paved Shoulder Separation												
Paved Partial	X	Edge Cracking		X			X			X			X	
Surface Treated		Breakup and Potholes												
		Distortion												
Primed		Pavement Edge Curb Sepatation												

Maitenance Treatment

Pavement	Extent of Occurrence %			**Shoulder**	Extent of Occurrence %		
	<20 1	20-50 2	>50 3		<20 1	20-50 2	>50 3
Manual Patching				Manual patching			
Machine Patching				Manual Spray Patching			
Manual Spray patching				Manual Chip Seal			
Manual Chip Seal				Crack Rout and Seal			
Machine Chip Seal							
Fog Seal							
Surface Treatment							
Manual Burn & Seal							
Crack Rout and Seal							

APPENDIX C

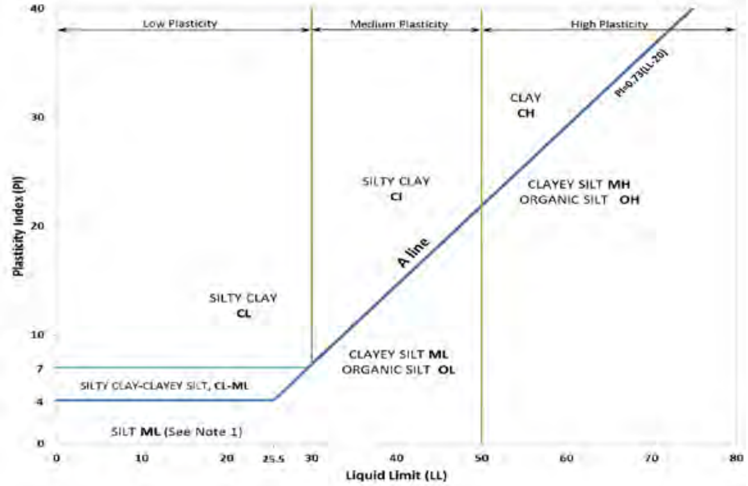
Borehole Records

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10}xD_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name
				Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)			
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
				Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
				Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
				None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% **(see Note 2)**	CL	SILTY CLAY
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
			Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures							30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat							75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.
Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.
For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.
For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.
A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)
An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.
2. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\ \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma$ - u)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
NP	non-plastic
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength (ϕ = 0 analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

PROJECT: 20146456

LOCATION: N 4862071.08; E 632899.94

RECORD OF BOREHOLE: C1

BORING DATE: January 13, 2021

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

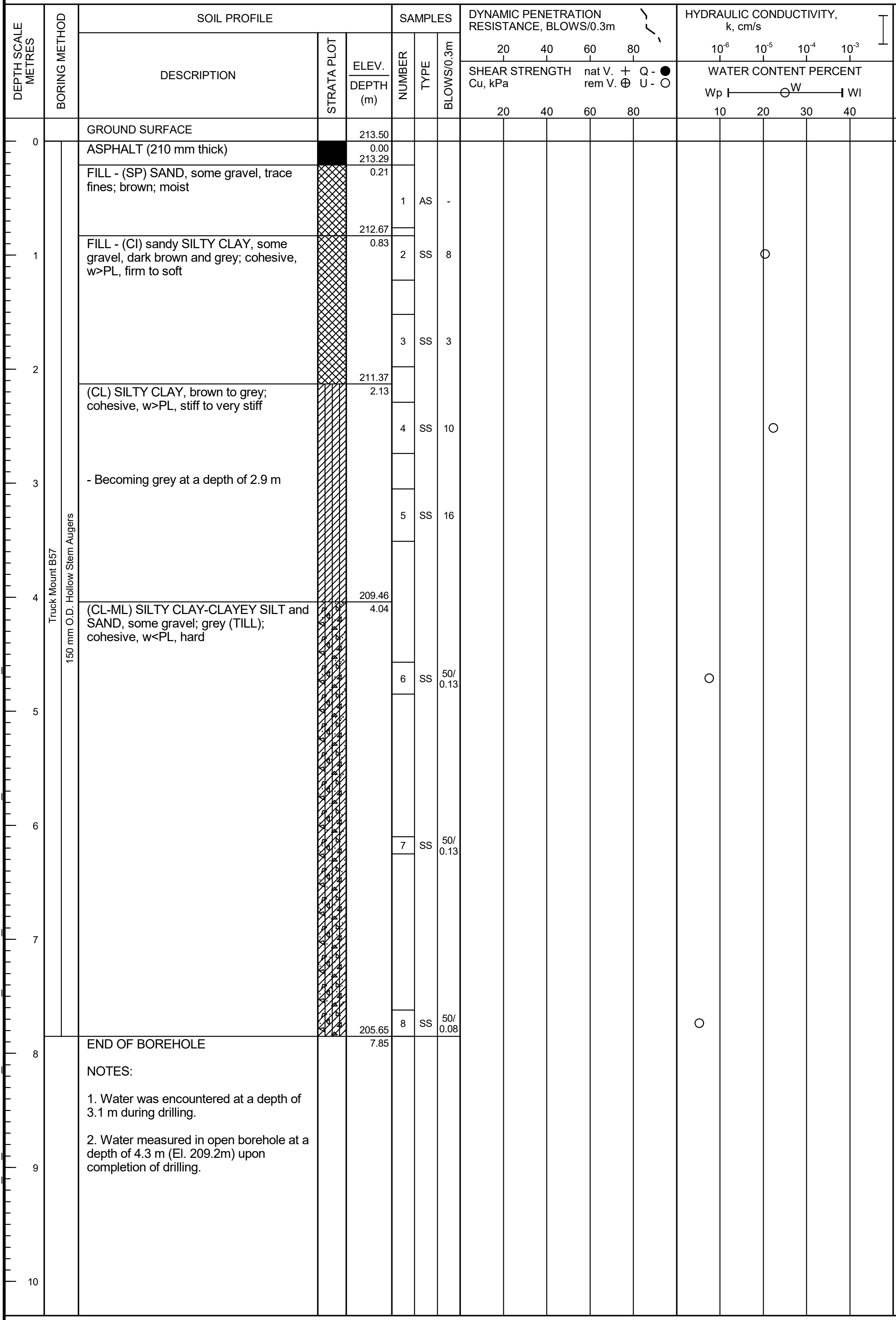
BORING METHOD: Truck Mount B57
150 mm O.D. Hollow Stem Augers

SOIL PROFILE			SAMPLES		
DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE		213.50			
ASPHALT (210 mm thick)	■	0.00			
FILL - (SP) SAND, some gravel, trace fines; brown; moist	▨	213.29 0.21	1	AS	-
FILL - (CI) sandy SILTY CLAY, some gravel, dark brown and grey; cohesive, w>PL, firm to soft	▨	212.67 0.83	2 3	SS SS	8 3
(CL) SILTY CLAY, brown to grey; cohesive, w>PL, stiff to very stiff - Becoming grey at a depth of 2.9 m	▨	211.37 2.13	4 5	SS SS	10 16
(CL-ML) SILTY CLAY-CLAYEY SILT and SAND, some gravel; grey (TILL); cohesive, w<PL, hard	▨	209.46 4.04	6 7 8	SS SS SS	50/ 0.13 50/ 0.13 50/ 0.08
END OF BOREHOLE		205.65 7.85			

NOTES:

1. Water was encountered at a depth of 3.1 m during drilling.

2. Water measured in open borehole at a depth of 4.3 m (El. 209.2m) upon completion of drilling.



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456
LOCATION: N 4862076.92; E 632892.20

RECORD OF BOREHOLE: C2

BORING DATE: January 12, 2021

SHEET 1 OF 1
DATUM: Geodetic

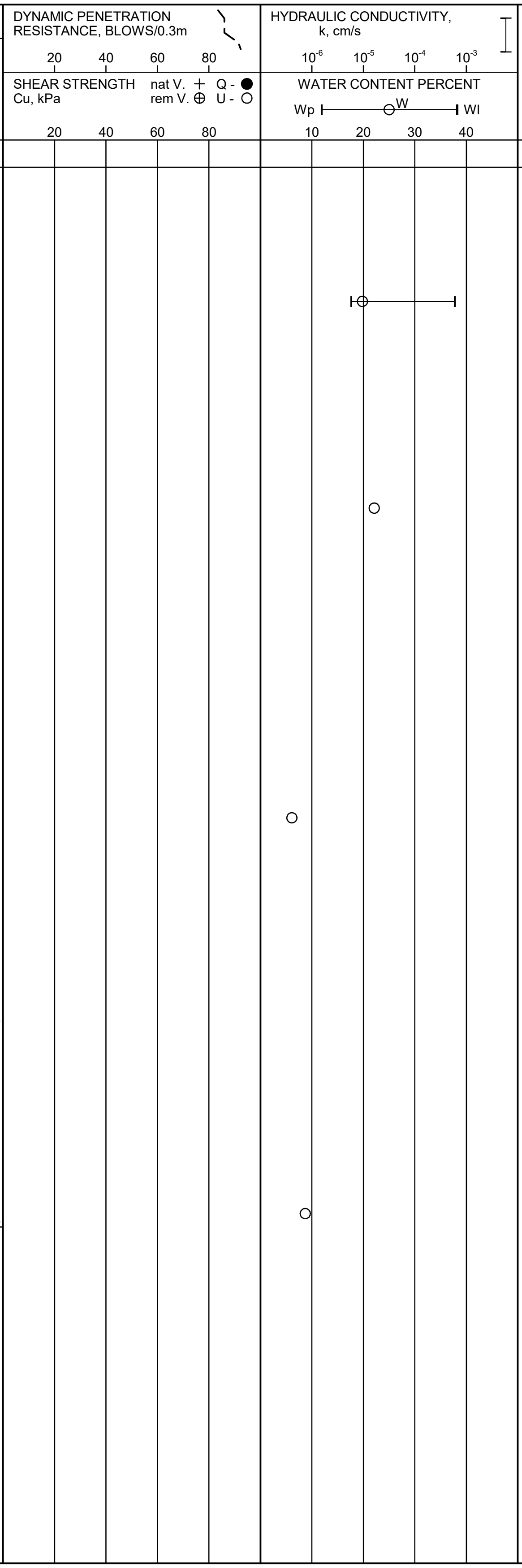
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

BORING METHOD: Truck Mount B57, 150 mm O.D. Hollow Stem Augers

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
	GROUND SURFACE	213.50
0	ASPHALT (315 mm thick)	0.00
	Crushed granular; brown	213.18 0.32
	FILL - (CI) sandy SILTY CLAY, some gravel, dark brown and grey; cohesive, w>PL, stiff to firm	212.76 0.74
	(CL) SILTY CLAY, brown; cohesive, w>PL, very stiff to stiff	211.37 2.13
	(CL-ML) SILTY CLAY-CLAYEY SILT and SAND, some gravel; grey (TILL); cohesive, w<PL, hard	209.46 4.04
	END OF BOREHOLE	205.68 7.82

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	AS	-	
2	SS	13	MH
3	SS	4	
4	SS	16	
5	SS	14	
6	SS	70	
7	SS	50/ 0.13	
8	SS	50/ 0.05	



PIEZOMETER OR STANDPIPE INSTALLATION

NOTES:

1. Water was encountered at a depth of 6.1 m during drilling.

2. Water measured in open borehole at a depth of 4.3 m (El. 209.2m) upon completion of drilling.

GTA-BHS 001 S:\CLIENTS\REGION_OF_YORK\MAJOR_MACKENZIE_DRIVE\02_DATA\GINT\MARKHAM_WARDEN&KENNEDY_RD.GPJ GAL-MIS.GDT 3/23/21

DEPTH SCALE
1 : 50

GOLDER

LOGGED: YS
CHECKED: TO

PROJECT: 20146456
LOCATION: N 4862531.20; E 632797.89

RECORD OF BOREHOLE: C3

BORING DATE: January 11, 2021

SHEET 1 OF 1
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC

BORING METHOD: Truck Mount B57; 150 mm O.D. Hollow Stem Augers

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20, 40, 60, 80
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○: 20, 40, 60, 80
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}
WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl: 10, 20, 30, 40

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	221.20					
ASPHALT (200 mm thick)	0.00					
Crushed granular; brown	221.00 0.20	1	AS	-		
FILL - (CI) sandy SILTY CLAY, some gravel; dark grey; cohesive, w>PL, firm to soft	220.52 0.68	2 3	SS SS	6 3		
(SM) SILTY SAND, trace gravel; brown; non-cohesive, wet, compact to dense	219.07 2.13	4 5	SS SS	18 47	 MH	
(CL-ML) SILTY CLAY-CLAYEY SILT and SAND, some gravel; grey (TILL); cohesive, w<PL, hard	217.16 4.04	6 7 8	SS SS SS	50/0.1 50/0.08 50/0.08		
END OF BOREHOLE	213.35 7.85					

NOTE:

1. Water measured in open borehole at a depth of 2.4 m (El. 218.8m) upon completion of drilling.

DEPTH SCALE
1 : 50

GOLDER

LOGGED: YS
CHECKED: TO

PROJECT: 20146456
LOCATION: N 4862538.53; E 632805.31

RECORD OF BOREHOLE: C4

BORING DATE: January 11, 2021

SHEET 1 OF 2
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		221.30					
0	Truck Mount B57 200 mm O.D. Hollow Stem Augers	ASPHALT (30 mm thick)		0.00 0.03					
		FILL - (SP) SAND, some gravel, trace fines; brown; moist	▨		1	AS	-		50 mm Dia. PVC Monitoring Well
1		FILL - (CI) sandy SILTY CLAY, some gravel, dark grey and brown; cohesive, w>PL, stiff to soft	▨	220.46 0.84	2	SS	10		
					3	SS	3		
2		(SP) SAND, brown; non-cohesive, wet, compact		219.17 2.13	4	SS	19		
3		(SM) SILTY SAND, brown; non-cohesive, wet, dense		218.40 2.90	5	SS	33		▽ January 29, 2021
4		(CL-ML) SILTY CLAY-CLAYEY SILT and SAND, some gravel; grey (TILL); cohesive, w<PL to w>PL, hard		217.26 4.04	6	SS	50/ 0.13		
5									Bentonite
6					7	SS	90	MH	
7									Sand
					8	SS	50/ 0.13	MH	
8									Sand and Screen
9				212.08	9	SS	50/ 0.08		
		END OF BOREHOLE		9.22					
		NOTES:							
		1. Water was encountered at a depth of 2.3 m during drilling.							
10									

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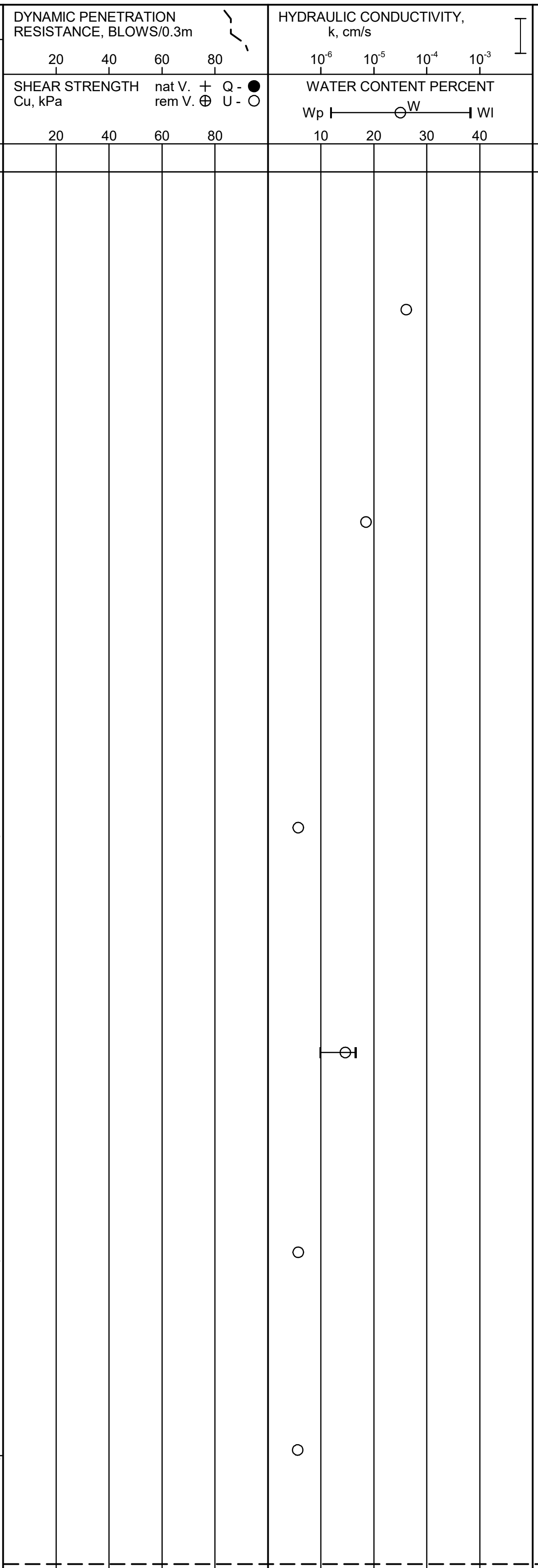


DEPTH SCALE
1 : 50

GOLDER

LOGGED: YS
CHECKED: TO

PROJECT: 20146456

RECORD OF BOREHOLE: C4

SHEET 2 OF 2

LOCATION: N 4862538.53; E 632805.31

BORING DATE: January 11, 2021

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		2. Groundwater level was measured in monitoring well at a depth of 5.9 mbgs (El. 215.4m) upon completion of drilling. 3. Groundwater level was measured in monitoring well at 3.5 mbgs (El. 217.8m) on January 29, 2021.									
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456

LOCATION: N 4861296.93; E 633061.47

RECORD OF BOREHOLE: P1

BORING DATE: January 20, 2021

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}; WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	213.50							
0	Truck Mount B57 150 mm O.D. Hollow Stem Augers	ASPHALT (340 mm thick)	0.00							
		Crushed granular; brown	213.16 0.34	1A	AS	-				
		FILL - (SP) SAND, some gravel; trace fines; brown; moist	0.51	1B						
1		(CL) SILTY CLAY and SAND, some gravel; brown (TILL); cohesive, w<PL, very stiff to hard	212.79 0.71	2	SS	22				
				3	SS	97		○ ⊢—⊣	MH	
2		END OF BOREHOLE	211.52 1.98							

NOTE:

1. Borehole open and dry upon completion of drilling.

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456
LOCATION: N 4861450.81; E 633030.53

RECORD OF BOREHOLE: P2

BORING DATE: January 6, 2021

SHEET 1 OF 1
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

BORING METHOD: Truck Mount B57 200 mm O.D. Hollow Stem Augers

DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
GROUND SURFACE	217.60				
ASPHALT (200 mm thick)	0.00 217.40				
Crushed granular; brown	0.20	1	AS	-	
FILL - (SP) SAND, trace fines; brown; non-cohesive, moist, compact	216.85 0.75	2	SS	17	
(ML) SILT and SAND, trace gravel; brown; non-cohesive, moist, compact	216.23 1.37	3	SS	15	MH NP
END OF BOREHOLE	215.62 1.98				

NOTES:

1. Borehole was open and dry upon completion of drilling.

2. NP= Non-plastic

DEPTH SCALE
1 : 50

GOLDER

LOGGED: YS
CHECKED: TO

PROJECT: 20146456

LOCATION: N 4861664.23; E 632982.24

RECORD OF BOREHOLE: P3

BORING DATE: January 6, 2021

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m				
		GROUND SURFACE		219.80							
0	Truck Mount B57 200 mm O.D. Hollow Stem Augers	ASPHALT (230 mm thick)	■	0.00 219.57							
		FILL - (SP) SAND, some gravel, trace fines; brown; moist	▨	0.23 219.30	1	AS	-				
1		FILL - (CI) sandy SILTY CLAY, some gravel; brown and dark grey; cohesive, w>PL, stiff	▨	0.50	2	SS	11				
			▨	217.82	3	SS	10		○		
2		END OF BOREHOLE NOTE: 1. Borehole was open and dry upon completion of drilling.		1.98							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456

LOCATION: N 4861851.29; E 632945.93

RECORD OF BOREHOLE: P4

BORING DATE: January 6, 2021

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		216.50							
0	Truck Mount B57 150 mm O.D. Hollow Stem Augers	ASPHALT (60 mm thick)		0.00							
		Crushed ganular; brown		0.06	1	AS	-				
1		FILL - (CI) sandy SILTY CLAY, some sand, some gravel; dark grey, organic inclusions; cohesive, w>PL, stiff		215.98 0.52	2	SS	8		○		
		(SM) SILTY SAND, some gravel; brown; non-cohesive, moist, compact		215.13 1.37	3	SS	19		○	MH	
2		END OF BOREHOLE NOTE: 1. Borehole was open and dry upon completion of drilling.		214.52 1.98							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456

LOCATION: N 4862041.54; E 632903.86

RECORD OF BOREHOLE: P5

BORING DATE: January 6, 2021

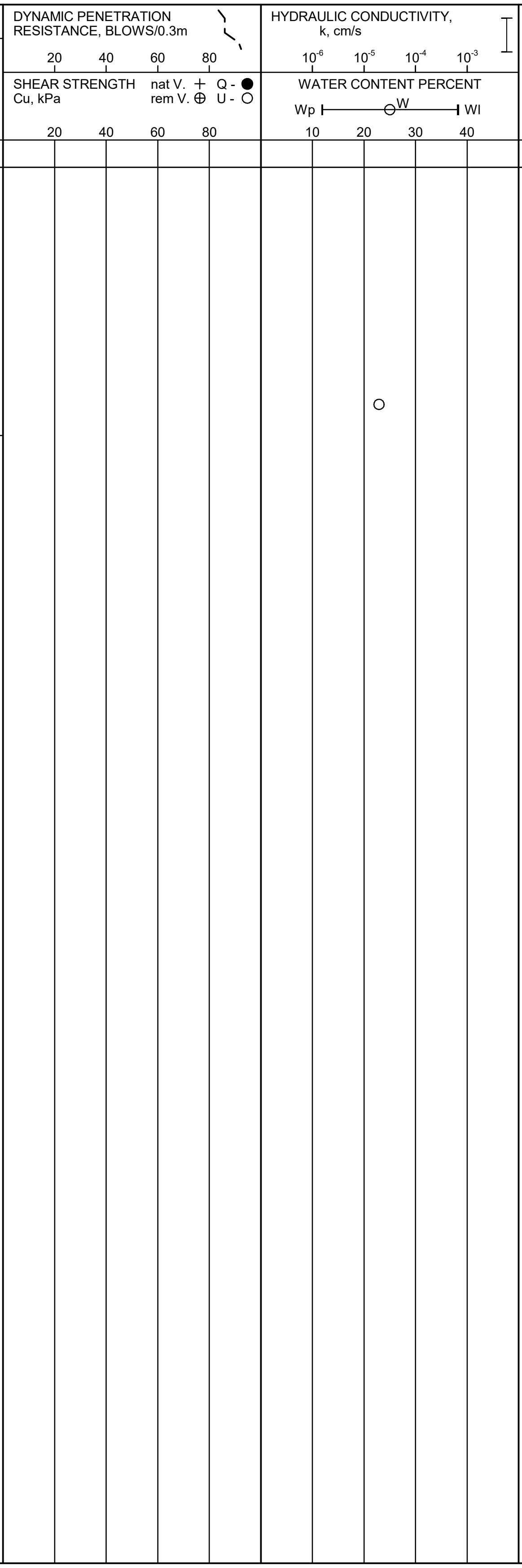
SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		213.50					
0	Truck Mount B57 150 mm O.D. Hollow Stem Augers	ASPHALT (220 mm thick)	■	0.00 213.28					
		Crushed granular; brown	▨	0.22 212.84	1	AS	-		
		FILL - (SP) SAND, some gravel, trace fines; brown; moist	▨	0.66 212.65	2A	SS	12		
1		FILL - (CI) sandy SILTY CLAY, some gravel; black and grey, organic inclusions; cohesive, w>PL, stiff to firm	▨	0.85	2B				
				211.52	3	SS	4		
2		END OF BOREHOLE NOTE: 1. Borehole was open and dry upon completion of drilling		1.98					
3									
4									
5									
6									
7									
8									
9									
10									



DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456

LOCATION: N 4862147.36; E 632884.51

RECORD OF BOREHOLE: P6

BORING DATE: January 6, 2021

SHEET 1 OF 1

DATUM: Geodetic

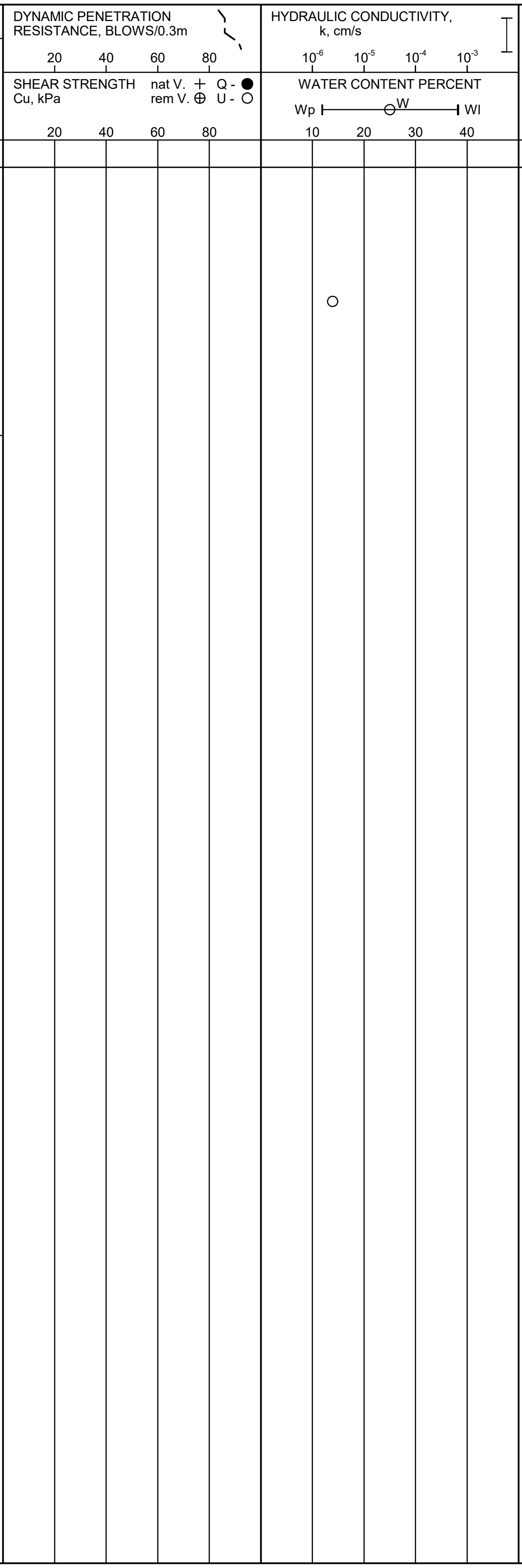
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE		214.10			
0	Truck Mount B57 150 mm O.D. Hollow Stem Augers	ASPHALT (150 mm thick)	■	0.00			
		Crushed granular; brown	▨	0.15	1A	AS	-
		FILL - (SP) SAND, some gravel; trace fines; brown; moist	▨	213.62 0.48	1B		
1		FILL - (CI) SILTY CLAY, some sand, some gravel; dark brown, organic inclusions; cohesive, w~PL to w>PL, stiff	▨	213.44 0.66	2	SS	9
					3	SS	9
2		END OF BOREHOLE		212.12 1.98			

NOTE:

1. Borehole was open and dry upon completion of drilling



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

Depth scale: 0 1 2 3 4 5 6 7 8 9 10

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DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456

LOCATION: N 4862351.03; E 632840.88

RECORD OF BOREHOLE: P7

BORING DATE: January 6, 2021

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m
		GROUND SURFACE	219.20			
0	Truck Mount B57 150 mm O.D. Hollow Stem Augers	ASPHALT (230 mm thick)	0.00 218.97			
		Crushed granular; brown	0.23	1A	AS	-
		FILL - (SP) SAND, some gravel; trace fines; brown; moist	0.39 218.54	1B		
1		FILL - (CI) sandy SILTY CLAY, some gravel; brown and dark grey, organic inclusions; cohesive, w>PL, very stiff	0.66 217.83	2	SS	19
		(ML) sandy SILT, some gravel; brown (TILL); non-cohesive, moist, compact	1.37 217.22	3	SS	22
2		END OF BOREHOLE	1.98			

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl 10 20 30 40

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

NOTE:

1. Borehole was open and dry upon completion of drilling

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456
LOCATION: N 4862629.70; E 632783.93

RECORD OF BOREHOLE: P8

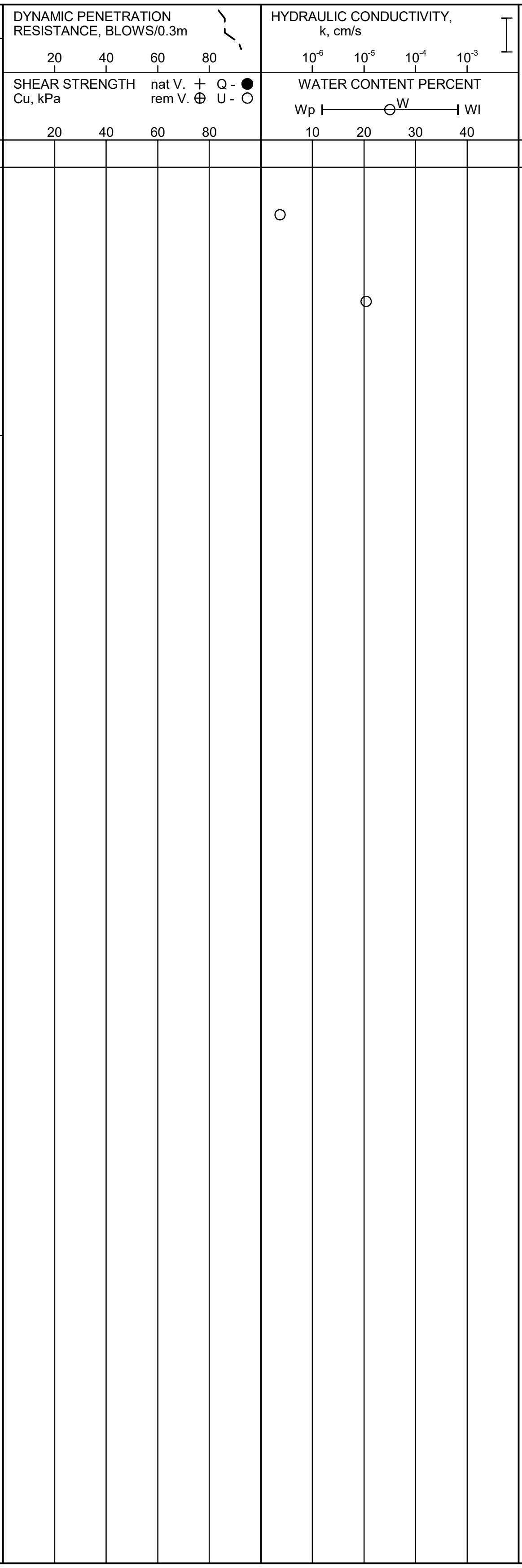
BORING DATE: January 6, 2021

SHEET 1 OF 1
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		224.00					
0	Truck Mount B57 150 mm O.D. Hollow Stem Augers	ASPHALT (260 mm thick)	■	0.00					
		Crushed granular; brown	▩	223.74 0.26	1	AS	-	M	
1		FILL - (CI) SILTY CLAY, some sand, some gravel; brown; cohesive, w>PL, stiff	▩	223.56 0.44	2	SS	12		
		(CL) sandy SILTY CLAY, some gravel; brown; cohesive, w~PL, stiff	▨	222.63 1.37	3	SS	8		
2		END OF BOREHOLE NOTE: 1. Borehole was open and dry upon completion of drilling		222.02 1.98					
3									
4									
5									
6									
7									
8									
9									
10									



DEPTH SCALE
1 : 50

GOLDER

LOGGED: YS
CHECKED: TO

PROJECT: 20146456
LOCATION: N 4862822.87; E 632747.49

RECORD OF BOREHOLE: P9

BORING DATE: January 6, 2021

SHEET 1 OF 1
DATUM: Geodetic

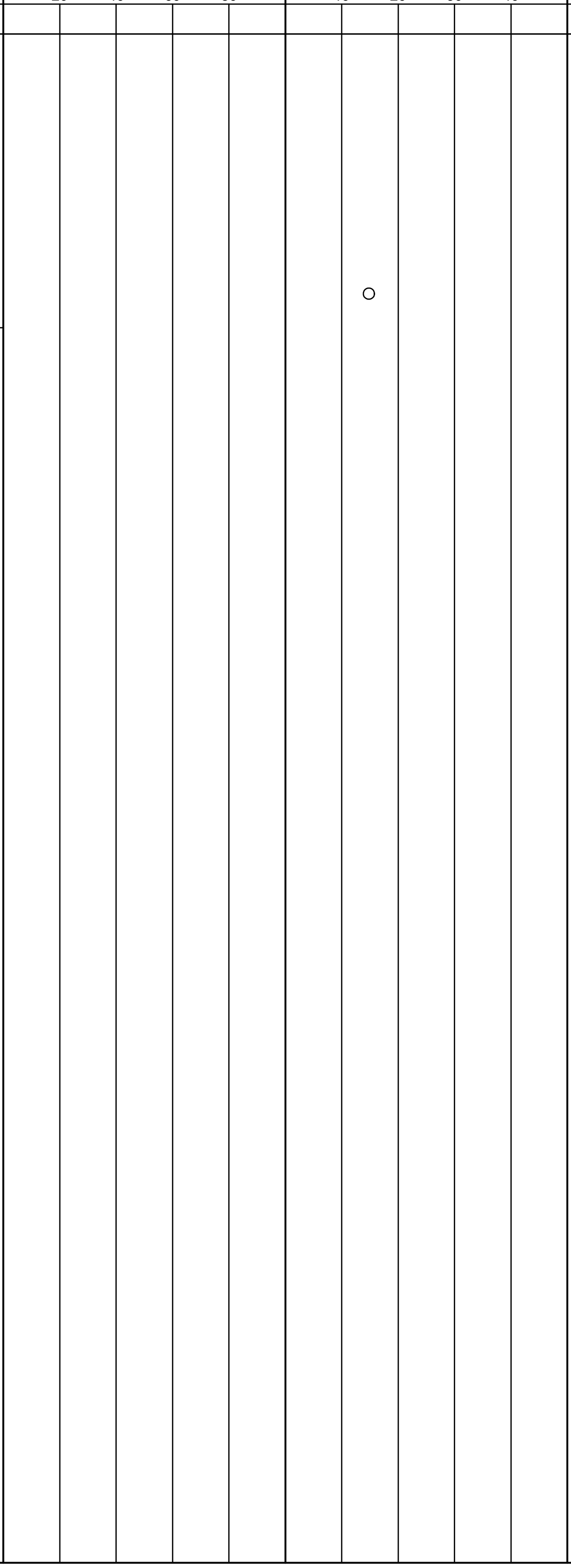
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m
		GROUND SURFACE		225.10			
0	Truck Mount B57 150 mm O.D. Hollow Stem Augers	Crushed granular; brown	▨	0.00	1	AS	-
		FILL - (CI) SILTY CLAY, some sand, some gravel; brown and grey; cohesive, w>PL, soft	▨	224.45 0.65	2	SS	3
		FILL - (SM) SILTY SAND, some gravel; brown; non-cohesive, moist, compact	▨	223.73 1.37	3	SS	18
2		END OF BOREHOLE NOTE: 1. Borehole was open and dry upon completion of drilling.		223.12 1.98			

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ ; 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}
WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl ; 10 20 30 40



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

GOLDER

LOGGED: YS
CHECKED: TO

PROJECT: 20146456
LOCATION: N 4863026.74; E 632707.15

RECORD OF BOREHOLE: P10

BORING DATE: January 6, 2021

SHEET 1 OF 1
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		226.40							
0	Truck Mount B57 150 mm O.D. Hollow Stem Augers	Crushed granular; brown	▩	0.00	1	AS	-				
		FILL - (CI) sandy SILTY CLAY, dark brown; cohesive, w>PL, firm	▩	225.64 0.76	2	SS	4		○		
1		(CL) SILTY CLAY, brown; cohesive, w~PL, stiff	▥	225.03 1.37	3	SS	12				
2		END OF BOREHOLE NOTE: 1. Borehole was open and dry upon completion of drilling.		224.42 1.98							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

GOLDER

LOGGED: YS
CHECKED: TO

PROJECT: 20146456

LOCATION: N 4863200.29; E 632674.25

RECORD OF BOREHOLE: P11

BORING DATE: January 26, 2021

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		228.20							
0	Truck Mount B57 150 mm O.D. Hollow Stem Augers	ASPHALT (300 mm thick)	■	0.00							
		Crushed granular; brown	▨	227.90 0.30	1	AS	-				
1		FILL - (SP) SAND, some gravel; trace fines; brown; non-cohesive, moist, compact	▨	227.53 0.67	2	SS	11				
		FILL - (CL) sandy SILTY CLAY, brown; cohesive, w~PL, stiff	▨	226.98 1.22	3	SS	11		○ 10		
2		END OF BOREHOLE		226.22 1.98							

NOTE:

1. Borehole was open and dry upon completion of drilling.

GTA-BHS 001 S:\CLIENTS\REGION_OF_YORK\MAJOR_MACKENZIE_DRIVE\02_DATA\GINT\MARKHAM_WARDEN&KENNEDY_RD.GPJ GAL-MIS.GDT 3/23/21

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456
LOCATION: N 4863438.25; E 632621.67

RECORD OF BOREHOLE: P12

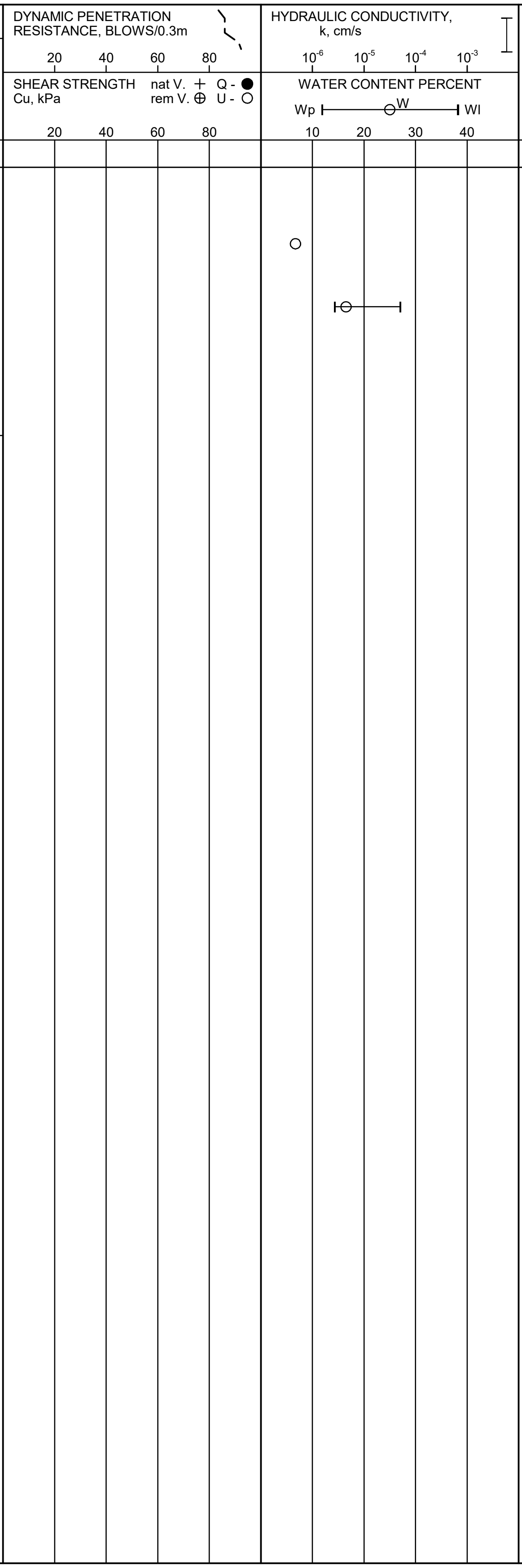
BORING DATE: January 7, 2021

SHEET 1 OF 1
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		229.50					
0	Truck Mount B57 150 mm O.D. Hollow Stem Augers	Crushed granular; brown	▨	0.00	1A	AS	-		
		FILL - (SP) SAND and GRAVEL, some fines; brown; moist	▨	229.13 0.37	1B			M	
1		FILL - (CL) gravelly SILTY CLAY and SAND; dark grey, organic inclusions; containing organics; cohesive, w>PL, stiff to very stiff	▨	228.66 0.84	2A 2B	SS	10	MH	
					3	SS	24		
2		END OF BOREHOLE NOTE: 1. Borehole was open and dry upon completion of drilling.		227.52 1.98					



DEPTH SCALE
1 : 50

LOGGED: YS
CHECKED: TO

PROJECT: 20146456

LOCATION: N 4863639.64; E 632575.62

RECORD OF BOREHOLE: P13

BORING DATE: January 6, 2021

SHEET 1 OF 1

DATUM: Geodetic

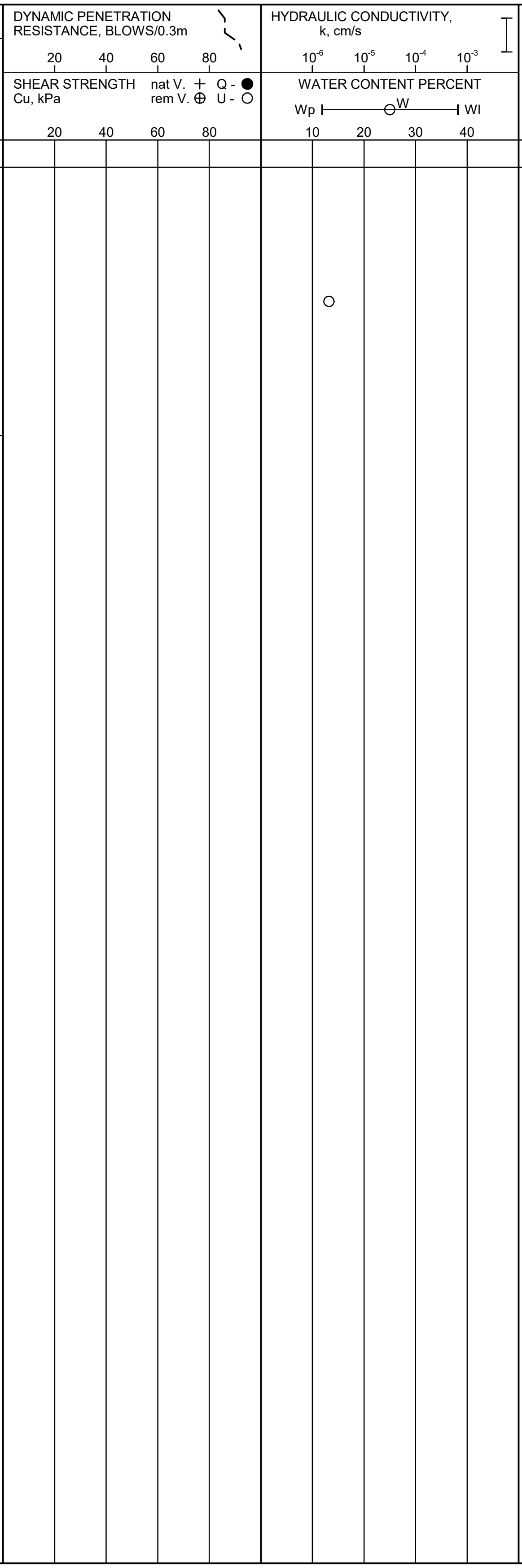
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m
		GROUND SURFACE		230.80			
0	Truck Mount B57 150 mm O.D. Hollow Stem Augers	ASPHALT (240 mm thick)	■	0.00 230.56			
		FILL - (SP) SAND, some gravel, trace fines; brown; moist	▨	0.24	1	AS	-
1		FILL - (CL) sandy SILTY CLAY, some gravel; brown; cohesive, w~PL, very stiff	▨	230.07 0.73	2	SS	15
					3	SS	16
2		END OF BOREHOLE		228.82 1.98			

NOTE:

1. Borehole was open and dry upon completion of drilling.



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

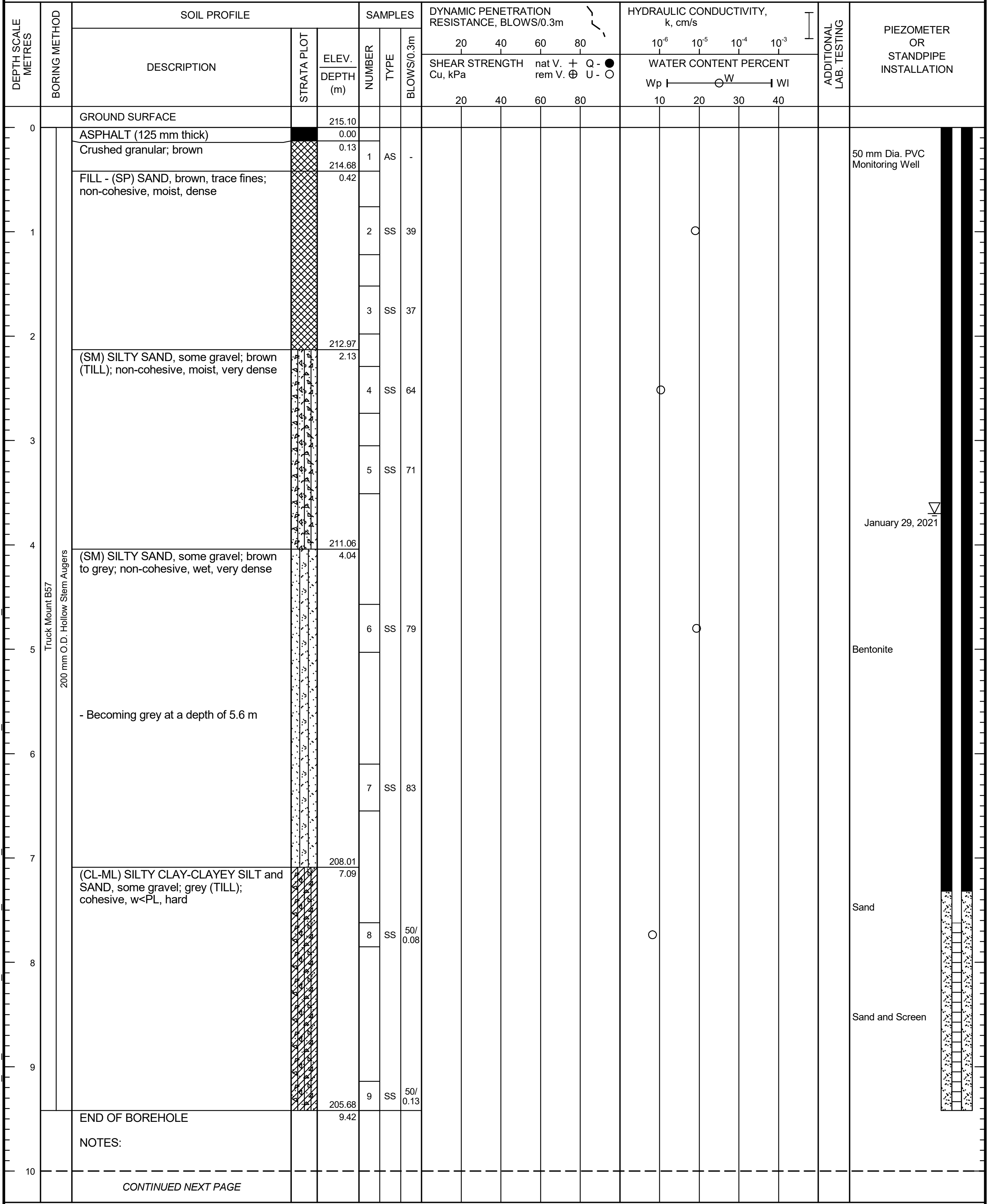
PROJECT: 20146456
LOCATION: N 4861359.73; E 633031.43

RECORD OF BOREHOLE: S1

BORING DATE: January 15, 2021

SHEET 1 OF 2
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC



DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	215.10			
ASPHALT (125 mm thick)	0.00			
Crushed granular; brown	0.13	1	AS	-
FILL - (SP) SAND, brown, trace fines; non-cohesive, moist, dense	214.68 0.42	2	SS	39
		3	SS	37
(SM) SILTY SAND, some gravel; brown (TILL); non-cohesive, moist, very dense	212.97 2.13	4	SS	64
		5	SS	71
(SM) SILTY SAND, some gravel; brown to grey; non-cohesive, wet, very dense	211.06 4.04	6	SS	79
- Becoming grey at a depth of 5.6 m		7	SS	83
(CL-ML) SILTY CLAY-CLAYEY SILT and SAND, some gravel; grey (TILL); cohesive, w<PL, hard	208.01 7.09	8	SS	50/ 0.08
		9	SS	50/ 0.13
END OF BOREHOLE	205.68 9.42			

NOTES:

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

GOLDER

LOGGED: YS
CHECKED: TO

PROJECT: 20146456

LOCATION: N 4861359.73; E 633031.43

RECORD OF BOREHOLE: S1

BORING DATE: January 15, 2021

SHEET 2 OF 2

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		1. Water was encountered at a depth of 4.6 m during drilling. 2. Groundwater level was measured at a depth of 4.4 mbgs (El. 210.7m) after well installation. 3. Groundwater level was measured in monitoring well at a depth of 3.7 mbgs (El. 211.4m) on January 29, 2021.									
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456
LOCATION: N 4861546.26; E 633002.39

RECORD OF BOREHOLE: S2

BORING DATE: January 15, 2021

SHEET 1 OF 1
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC

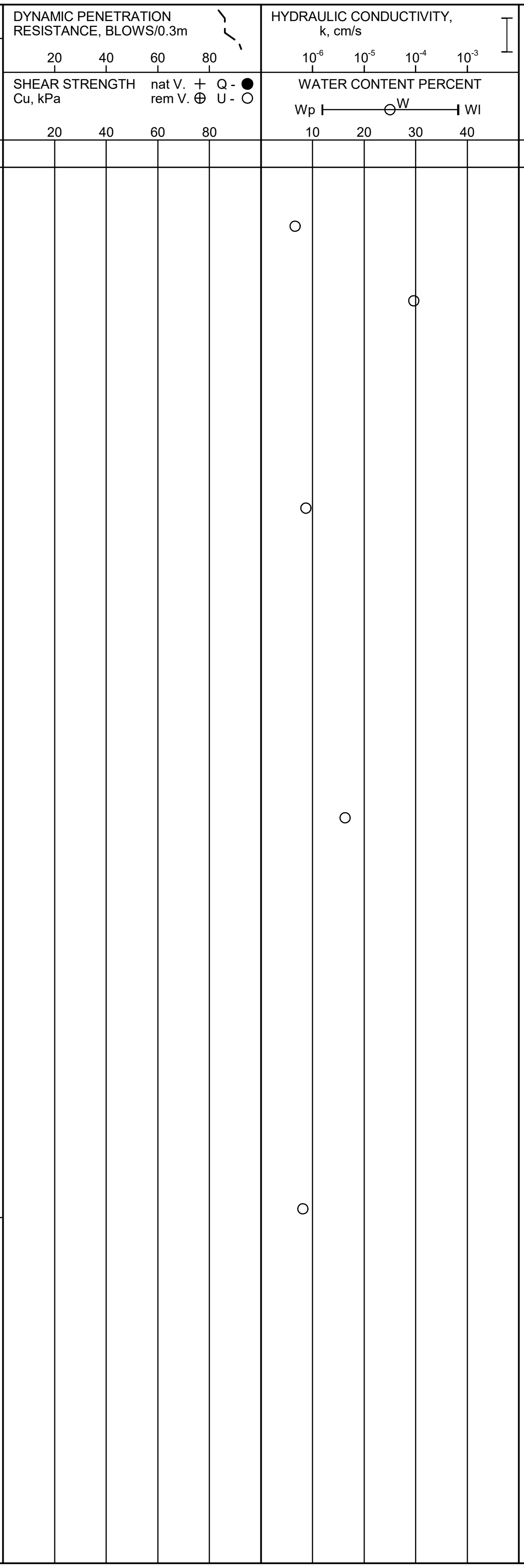
BORING METHOD: Truck Mount B57 — 150 mm O.D. Hollow Stem Augers

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	219.80
ASPHALT (120 mm thick)	0.00
FILL - (SM) gravelly SILTY SAND, brown; non-cohesive, moist	0.12
FILL - (CI) sandy SILTY CLAY, some gravel; brown and black, organic inclusions; cohesive, w>PL, stiff	219.05 0.75
(SM) SILTY SAND, trace to some gravel; brown; non-cohesive, moist to wet, dense to very dense - Becoming wet at a depth of 4.6 m	217.67 2.13
(GP) sandy GRAVEL, trace fines; grey; non-cohesive, wet, very dense	212.71 7.09
END OF BOREHOLE	212.05 7.75

NOTE:

1. Water was encountered at a depth of 4.6 m during drilling.

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	AS	-	M
2	SS	11	
3	SS	9	
4	SS	35	
5	SS	54	
6	SS	48	
7	SS	50/ 0.1	
8	SS	50/ 0.13	



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

GOLDER

LOGGED: YS
CHECKED: TO

PROJECT: 20146456
LOCATION: N 4861732.90; E 632961.79

RECORD OF BOREHOLE: S3

BORING DATE: January 13, 2021

SHEET 1 OF 2
DATUM: Geodetic

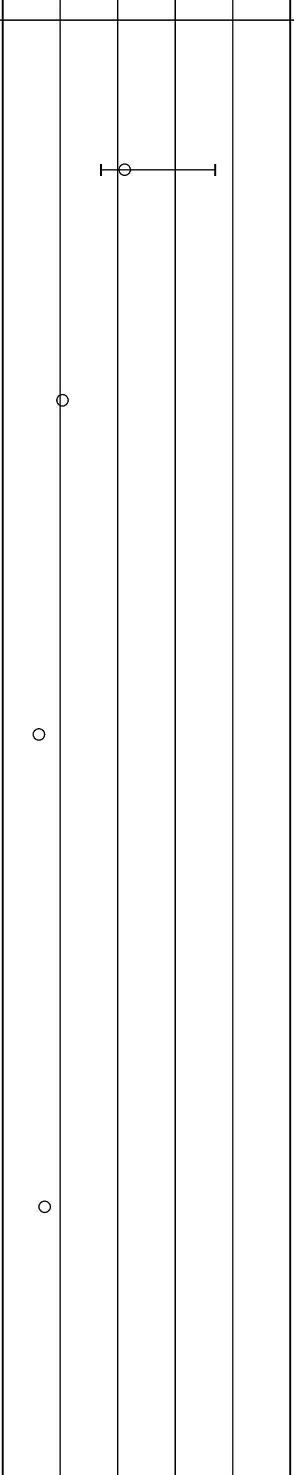
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
HAMMER TYPE: AUTOMATIC

BORING METHOD: Truck Mount B57; 200 mm O.D. Hollow Stem Augers

DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	218.90					
ASPHALT (200 mm thick)	0.00 218.70					50 mm Dia. PVC Monitoring Well
FILL - (SP) SAND, some gravel, trace fines; brown; moist	0.20 218.20	1	AS	-		
FILL - (CI) sandy SILTY CLAY, trace gravel, brown and black; organic inclusions; cohesive, w>PL, firm to stiff	0.70	2	SS	7	MH	
		3	SS	13		
	216.77					
(CL) SILTY CLAY and SAND, some gravel; brown (TILL); cohesive, w~PL, stiff	2.13	4	SS	13		
	216.00					
(SM) SILTY SAND, some gravel; brown (TILL); non-cohesive, moist, dense	2.90	5	SS	44		January 29, 2021
	214.86					
(CL-ML) SILTY CLAY-CLAYEY SILT and SAND, some gravel; grey (TILL); cohesive, w<PL, hard	4.04	6	SS	50/ 0.15		Bentonite
		7	SS	77		Sand
		8	SS	65		Sand and Screen
		9	SS	90/ 0.13		
	209.32					
END OF BOREHOLE	9.58					

NOTES:

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}
WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl 10 20 30 40



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DEPTH SCALE
1 : 50

LOGGED: YS
CHECKED: TO

PROJECT: 20146456

LOCATION: N 4861732.90; E 632961.79

RECORD OF BOREHOLE: S3

BORING DATE: January 13, 2021

SHEET 2 OF 2

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m				
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		1. Borehole was open and dry upon completion of drilling. 2. Groundwater level was measured in monitoring well at a depth of 3.5 mbgs (El. 215.4m) on January 29, 2021									
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456
LOCATION: N 4861956.56; E 632915.36

RECORD OF BOREHOLE: S4

BORING DATE: January 13, 2021

SHEET 1 OF 1
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

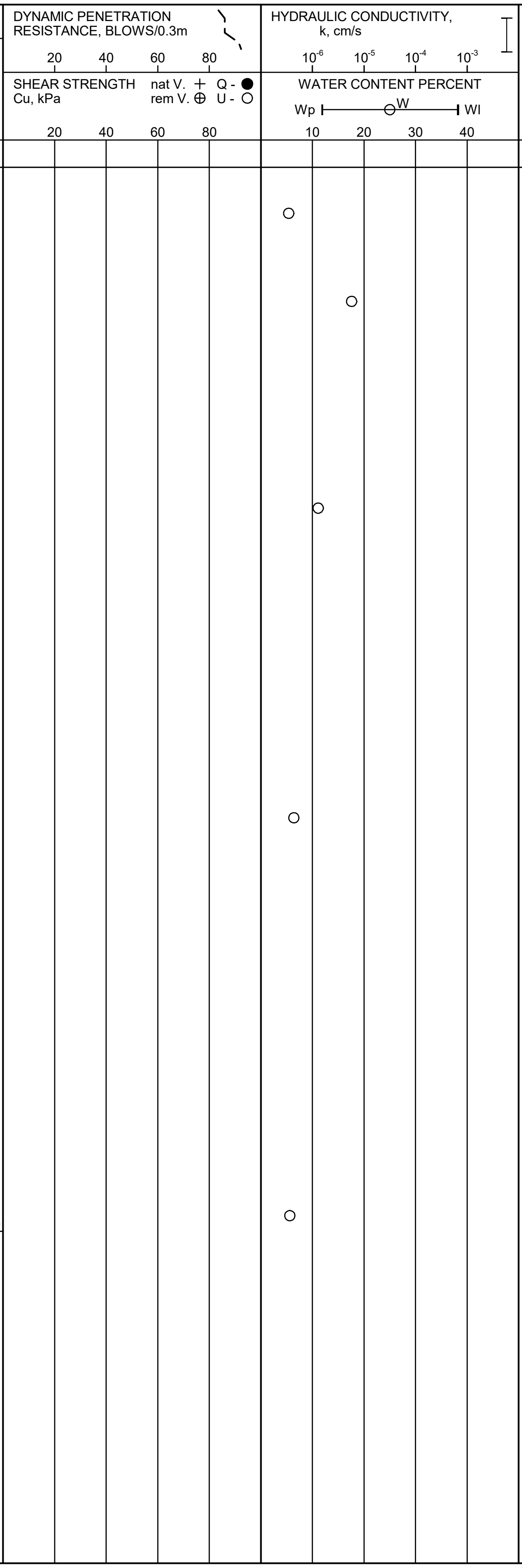
BORING METHOD: Truck Mount B57, 150 mm O.D. Hollow Stem Augers

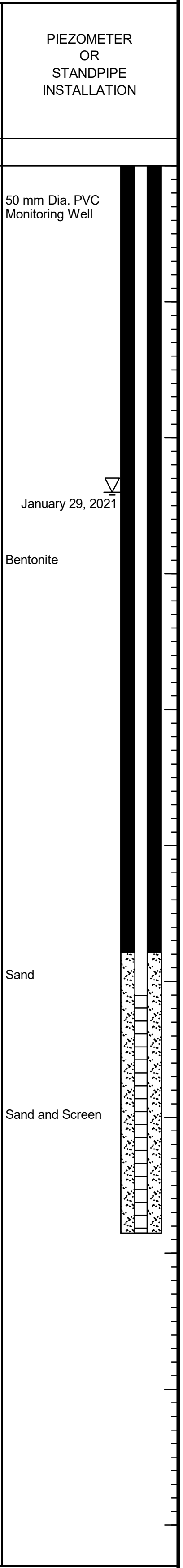
SOIL PROFILE

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	213.80
ASPHALT (215 mm thick)	0.00
Curshed granular; brown	213.58 0.22
FILL - (SP) SAND, some gravel, trace fines; brown, moist	213.34 0.46
FILL - (CI) sandy SILTY CLAY, some gravel; brown and black, organic inclusions; cohesive, w>PL, stiff	0.63
(SM) gravelly SILTY SAND, brown (TILL); non-cohesive, moist, compact	211.67 2.13
(SM) SILTY SAND, some gravel; grey; non-cohesive, moist, loose	211.29 2.51
(CL-ML) SILTY CLAY-CLAYEY SILT and SAND, some gravel; grey (TILL); cohesive, w<PL, hard	209.76 4.04
END OF BOREHOLE	205.95 7.85

SAMPLES

NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1A	AS	-	M
1B			
2	SS	11	
3	SS	9	
4	SS	15	MH
5	SS	8	
6	SS	89	
7	SS	80	
8	SS	50/ 0.08	





NOTES:

1. Water was encountered at a depth of 2.3 m during drilling.

2. Groundwater level was measured at a depth of 5.3 mbgs (El. 208.5m) after well installation.

3. Groundwater level was measured in monitoring well at 2.4 mbgs (El. 211.5m) on January 29, 2021.

DEPTH SCALE
1 : 50

GOLDER

LOGGED: YS
CHECKED: TO

PROJECT: 20146456

LOCATION: N 4862226.60; E 632859.96

RECORD OF BOREHOLE: S5

BORING DATE: January 12, 2021

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

BORING METHOD: Truck Mount B57 — 200 mm O.D. Hollow Stem Augers

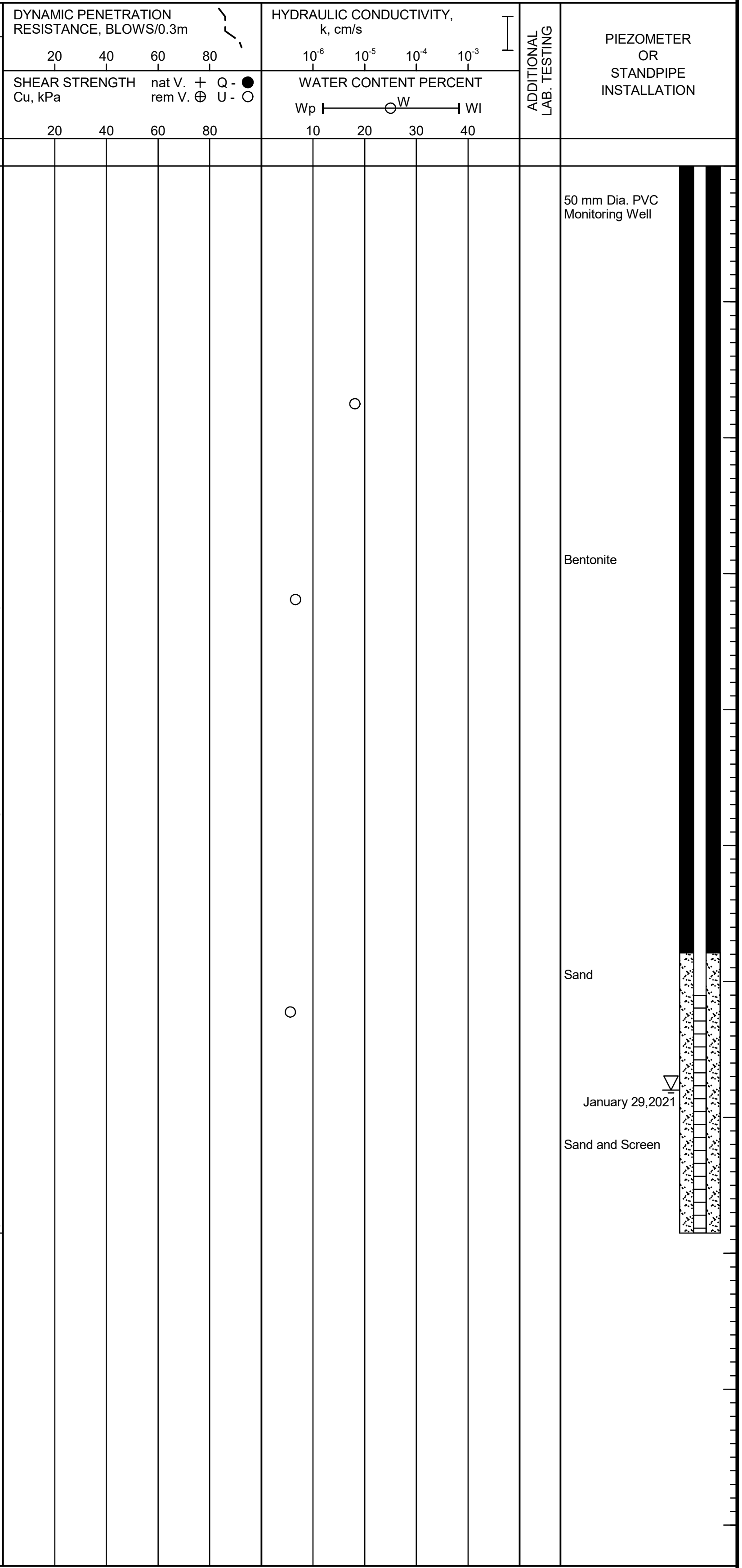
DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	215.70
ASPHALT (200 mm thick)	0.00 215.50
Crushed granular; brown	0.20 215.23
FILL - (SP) SAND, some gravel, trace fines; brown; moist	0.47 215.02
FILL - (CI) sandy SILTY CLAY, some gravel; brown; cohesive, w>PL, stiff to very stiff	0.68 213.57
(CL-ML) SILTY CLAY-CLAYEY SILT and SAND, some gravel; brown to grey (TILL); cohesive, w<PL, hard - Becoming grey at a depth of 5.5 m	2.13 207.85
END OF BOREHOLE	7.85

NUMBER	TYPE	BLOWS/0.3m
1A	AS	-
1B		
2	SS	14
3	SS	16
4	SS	86/ 0.23
5	SS	50/ 0.13
6	SS	50/ 0.15
7	SS	50/ 0.1
8	SS	50/ 0.08

NOTES:

1. Borehole was open and dry upon completion of drilling.

2. Groundwater level was measured in monitoring well at a depth of 6.8 mbgs (El.208.9m) on January 29, 2021.



DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456
LOCATION: N 4862442.27; E 632817.44

RECORD OF BOREHOLE: S6

BORING DATE: January 12, 2021

SHEET 1 OF 1
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

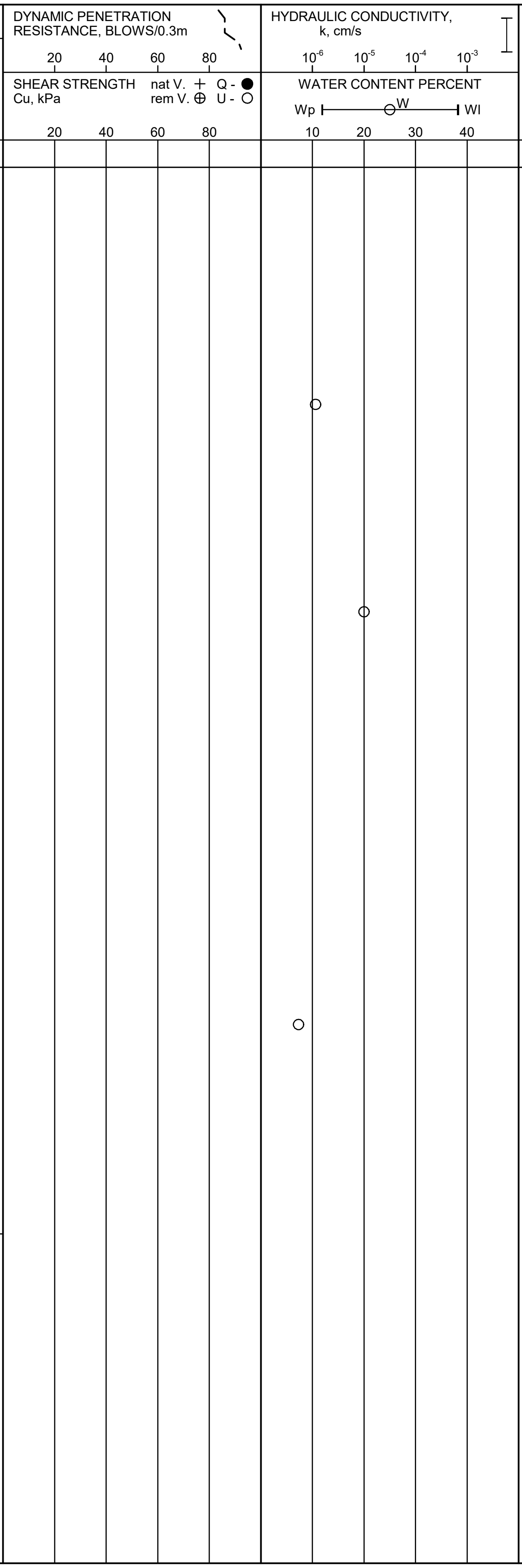
HAMMER TYPE: AUTOMATIC

BORING METHOD: Truck Mount B57; 150 mm O.D. Hollow Stem Augers

DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
GROUND SURFACE	221.40				
ASPHALT (255 mm thick)	0.00				
FILL - (SP) SAND, some gravel, trace fines; brown; moist	221.14 0.26	1	AS	-	
FILL - (CI) sandy SILTY CLAY, some gravel; dark brown; cohesive, w~PL, stiff	220.65 0.75	2	SS	10	
(ML) SILT and SAND, brown; non-cohesive, moist to wet, compact to dense	220.03 1.37	3	SS	18	MH
		4	SS	32	
		5	SS	49	
(CL-ML) SILTY CLAY-CLAYEY SILT and SAND, some gravel; grey (TILL); cohesive, w<PL, hard	217.36 4.04	6	SS	57	
- Auger grinding between depths of 5.5 m and 5.8 m		7	SS	96	
		8	SS	50/ 0.1	
END OF BOREHOLE	213.53 7.87				

NOTES:

1. Water measured in open borehole at a depth of 2.7 m upon completion of drilling.



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

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DEPTH SCALE
1 : 50

GOLDER

LOGGED: YS
CHECKED: TO

PROJECT: 20146456

LOCATION: N 4862728.76; E 632759.43

RECORD OF BOREHOLE: S7

BORING DATE: January 11, 2021

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

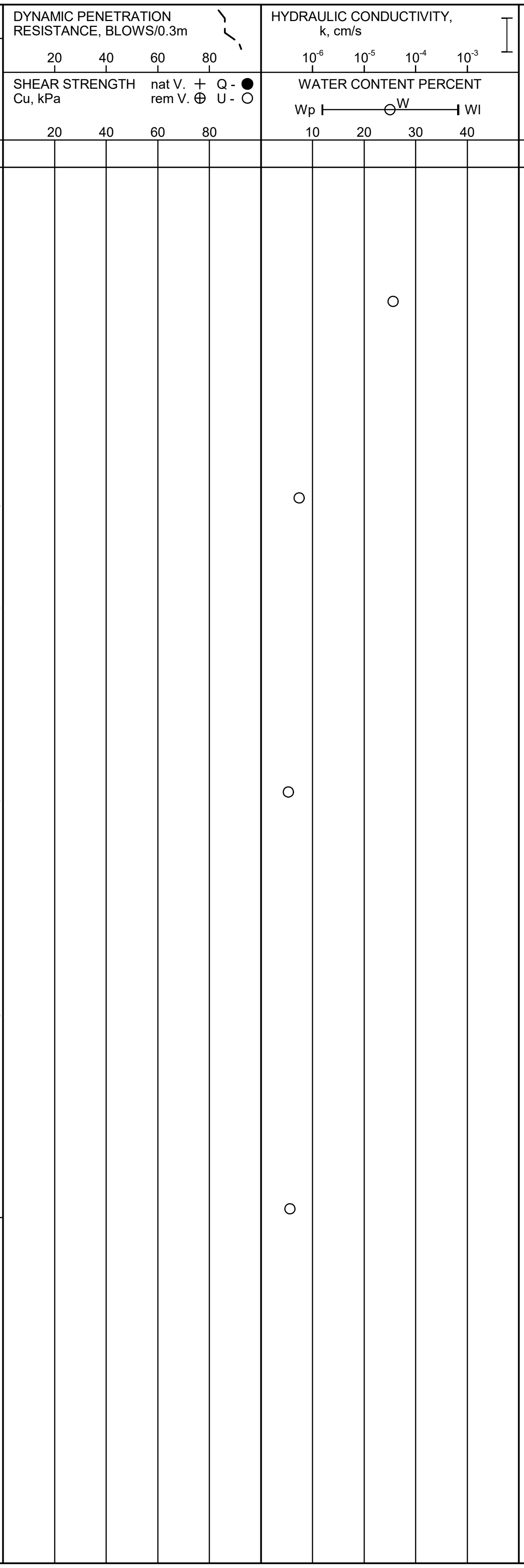
BORING METHOD: Truck Mount B57 — 150 mm O.D. Hollow Stem Augers

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	225.10
ASPHALT (305 mm thick)	0.00
Crushed granular; brown	224.79 0.31
FILL - (SP) SAND, some gravel, trace fines; brown; moist	224.51 0.59
FILL - (CI) sandy SILTY CLAY, some gravel; brown and black, organic inclusions; cohesive, w>PL, stiff to very stiff	0.73
(ML) sandy SILT, some gravel; brown to grey (TILL); non-cohesive, moist, very dense - Auger grinding between depths of 4.3 m and 4.6 m - Becoming grey at a depth of 5.4 m	222.97 2.13
END OF BOREHOLE	217.35 7.75

NOTE:

1. Borehole open and dry upon completion of drilling.

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1A	AS	-
1B		
2	SS	10
3	SS	18
4	SS	50/ 0.15
5	SS	50/ 0.13
6	SS	50/ 0.08
7	SS	50/ 0.05
8	SS	50/ 0.13



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456

LOCATION: N 4862908.93; E 632721.43

RECORD OF BOREHOLE: S8

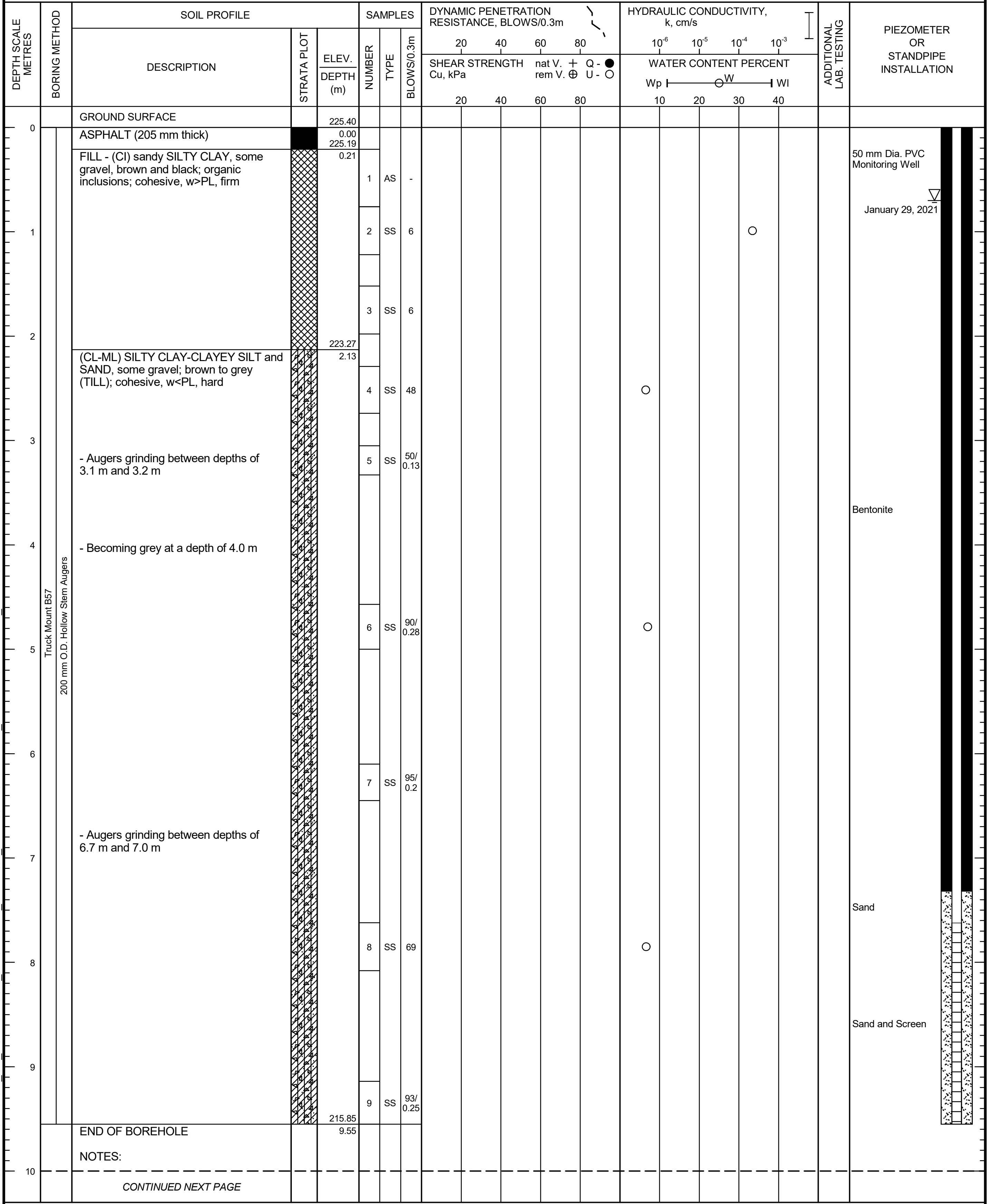
BORING DATE: January 8, 2021

SHEET 1 OF 2

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC



BORING METHOD: Truck Mount B57; 200 mm O.D. Hollow Stem Augers

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	225.40			
ASPHALT (205 mm thick)	0.00 225.19			
FILL - (CI) sandy SILTY CLAY, some gravel, brown and black; organic inclusions; cohesive, w>PL, firm	0.21	1	AS	-
		2	SS	6
		3	SS	6
	223.27			
(CL-ML) SILTY CLAY-CLAYEY SILT and SAND, some gravel; brown to grey (TILL); cohesive, w<PL, hard	2.13	4	SS	48
- Augers grinding between depths of 3.1 m and 3.2 m		5	SS	50/ 0.13
- Becoming grey at a depth of 4.0 m				
		6	SS	90/ 0.28
		7	SS	95/ 0.2
- Augers grinding between depths of 6.7 m and 7.0 m				
		8	SS	69
		9	SS	93/ 0.25
	215.85			
END OF BOREHOLE	9.55			

NOTES:

PIEZOMETER OR STANDPIPE INSTALLATION:

50 mm Dia. PVC Monitoring Well

∇ January 29, 2021

Bentonite

Sand

Sand and Screen

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456

LOCATION: N 4862908.93; E 632721.43

RECORD OF BOREHOLE: S8

BORING DATE: January 8, 2021

SHEET 2 OF 2

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10		1. Borehole open and dry upon completion of drilling 2. Groundwater level was measured at a depth of 6.2 mbgs (El. 219.2m) after well installation. 3. Groundwater level was measured in monitoring well at 0.7 mbgs (El. 224.7m) on January 29, 2021									
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

GTA-BHS 001 S:\CLIENTS\REGION_OF_YORK\MAJOR_MACKENZIE_DRIVE\02_DATA\GINT\MARKHAM_WARDEN&KENNEDY_RD.GPJ GAL-MIS.GDT 3/23/21

PROJECT: 20146456
LOCATION: N 4863112.93; E 632678.98

RECORD OF BOREHOLE: S9

BORING DATE: January 8, 2021

SHEET 1 OF 1
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

BORING METHOD: Truck Mount B57 / 200 mm O.D. Hollow Stem Augers

SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
GROUND SURFACE	227.20				
ASPHALT (155 mm thick)	0.00				
Crushed granular; brown	0.16	1A	AS	-	
FILL - (SP) SAND, some gravel, trace fines; brown; moist	0.33	1B			
FILL - (CI) sandy SILTY CLAY, some gravel, brown, organic inclusions; cohesive, w>PL, firm to stiff	226.59 0.61	2	SS	6	
		3	SS	10	
(SM) SILTY SAND, some gravel; brown to grey(TILL); non-cohesive, moist, dense to very dense	225.07 2.13	4	SS	46	MH NP
		5	SS	50/ 0.13	
- Auger grinding between depths of 3.4 m and 3.7 m					
- Becoming grey at a depth of 4.0 m					
		6	SS	75	
		7	SS	50/ 0.13	
	219.45	8	SS	50/ 0.13	
END OF BOREHOLE	7.75				

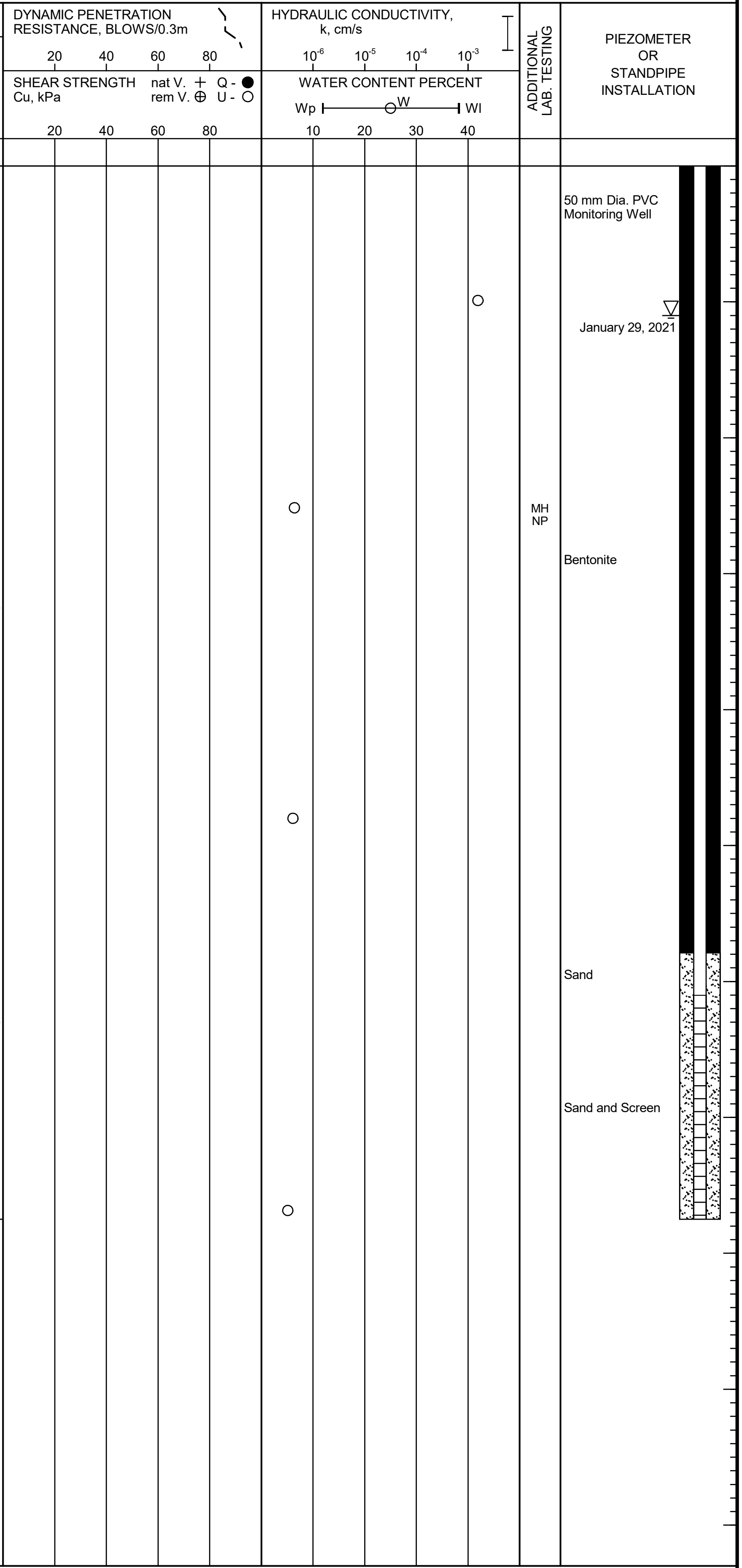
NOTES:

1. Borehole open and dry upon completion of drilling.

2. Groundwater level was measured at a depth of 7.5 mbgs (El. 219.7m) after well installation.

3. Groundwater level was measured in monitoring well at 1.1 mbgs (El. 226.1m) on January 29, 2021.

4. NP = Non-plastic



DEPTH SCALE
1 : 50

GOLDER

LOGGED: YS
CHECKED: TO

PROJECT: 20146456

LOCATION: N 4863316.72; E 632638.19

RECORD OF BOREHOLE: S10

BORING DATE: January 7, 2021

SHEET 1 OF 1

DATUM: Geodetic

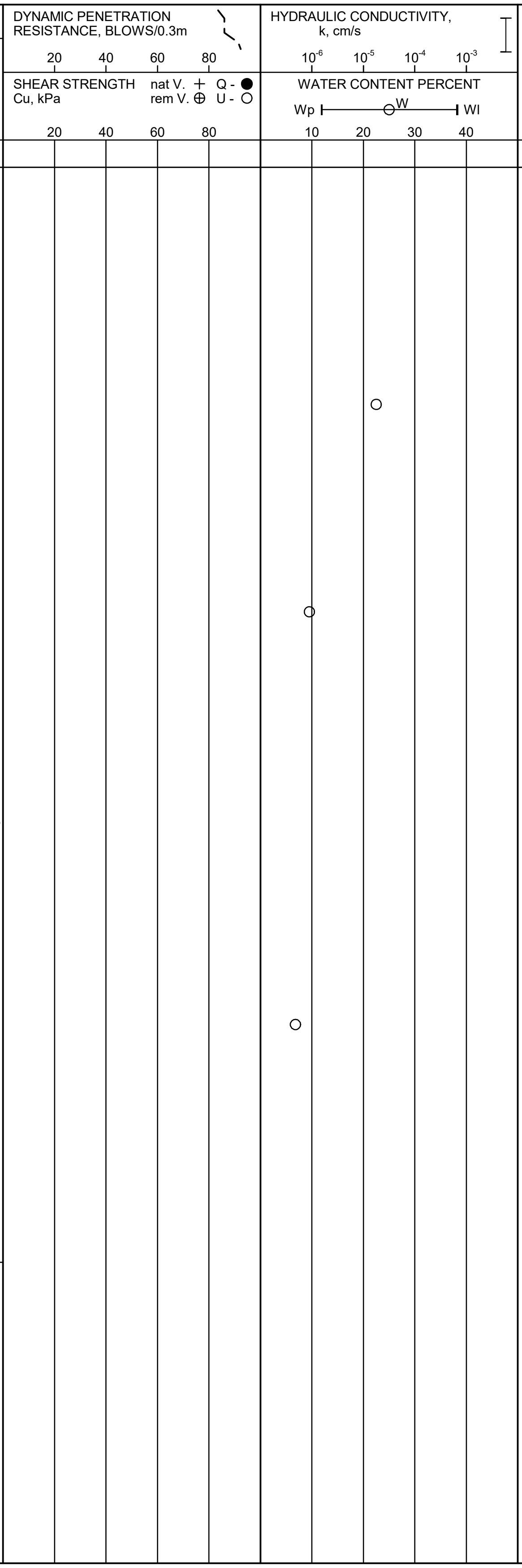
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

BORING METHOD: Truck Mount B57 — 200 mm O.D. Hollow Stem Augers

SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)
GROUND SURFACE		229.10
ASPHALT (270 mm thick)	■	0.00
Crushed granular; brown	▨	228.83 0.27
FILL - (SP) SAND, some gravel, trace fines; brown; moist	▨	228.58 0.52
FILL - (CI) sandy SILTY CLAY, some gravel, grey and dark brown; cohesive, w>PL, stiff	▨	228.20 0.90
FILL - (SM) SILTY SAND, brown; non-cohesive, moist, compact	▨	226.97 2.13
(ML) SILT and SAND, some gravel; brown (TILL); non-cohesive, moist, compact to very dense		226.20 2.90
(SM) SILTY SAND, brown; non-cohesive, wet, very dense		222.01 7.09
END OF BOREHOLE		221.02 8.08

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1A	AS	-
1B		
2A	SS	10
2B		
3	SS	11
4	SS	19
5	SS	26
6	SS	90/ 0.25
7	SS	74
8	SS	55



DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

NOTES:

1. Water was encountered at a depth of 7.6 m during drilling.

2. Water measured in open borehole at a depth of 4.6 m upon completion of drilling.

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

PROJECT: 20146456

LOCATION: N 4863518.07; E 632594.40

RECORD OF BOREHOLE: S11

BORING DATE: January 7, 2021

SHEET 1 OF 1

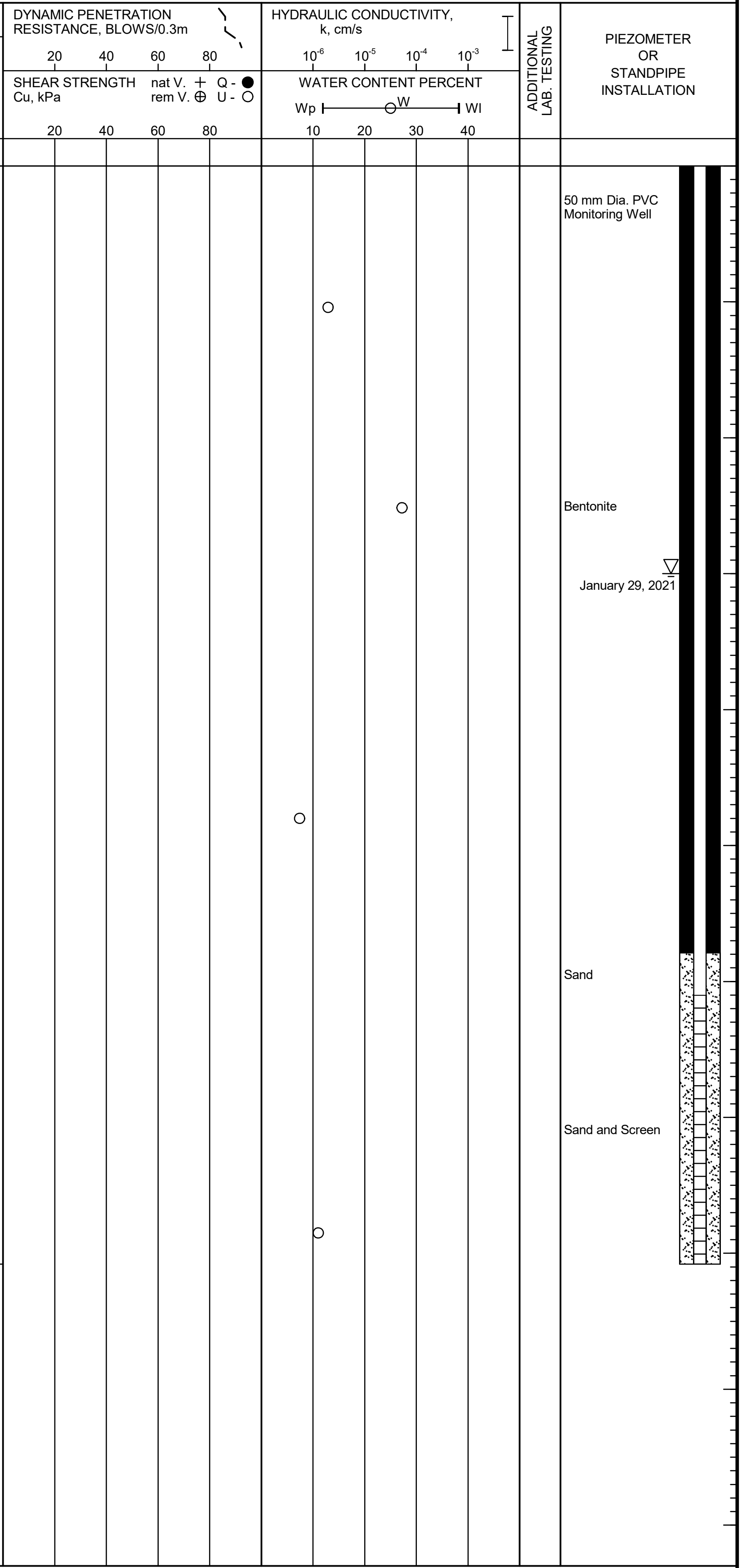
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

HAMMER TYPE: AUTOMATIC

BORING METHOD: Truck Mount B57; 200 mm O.D. Hollow Stem Augers

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
	GROUND SURFACE	230.00			
0	ASPHALT (160 mm thick)	0.00			
	Crushed granular; brown	0.16	1A	AS	-
	FILL - (SP) SAND, some gravel, trace fines; brown; moist	229.65 0.35	1B		
	FILL - (CL) sandy SILTY CLAY, some gravel, brown; cohesive, w~PL to w>PL, stiff	229.14 0.86	2A 2B	SS	9
			3	SS	12
			4	SS	8
3	(CL-ML) SILTY CLAY-CLAYEY SILT and SAND, some gravel; brown (TILL); cohesive, w<PL, very stiff to hard	227.10 2.90	5	SS	20
			6	SS	62
	(SP) SAND, brown; non-cohesive, wet, dense to compact	224.44 5.56	7	SS	32
			8	SS	25
8	END OF BOREHOLE	221.92 8.08			



NPOTES:

1. Water was encountered at a depth of 6.1 m during drilling.

2. Groundwater level was measured at a depth of 3.7 mbgs (El. 226.3m) after well installation.

3. Groundwater level was measured in monitoring well at 3.0 mbgs (El. 227.0m) on January 29, 2021.

DEPTH SCALE

1 : 50

GOLDER

LOGGED: YS

CHECKED: TO

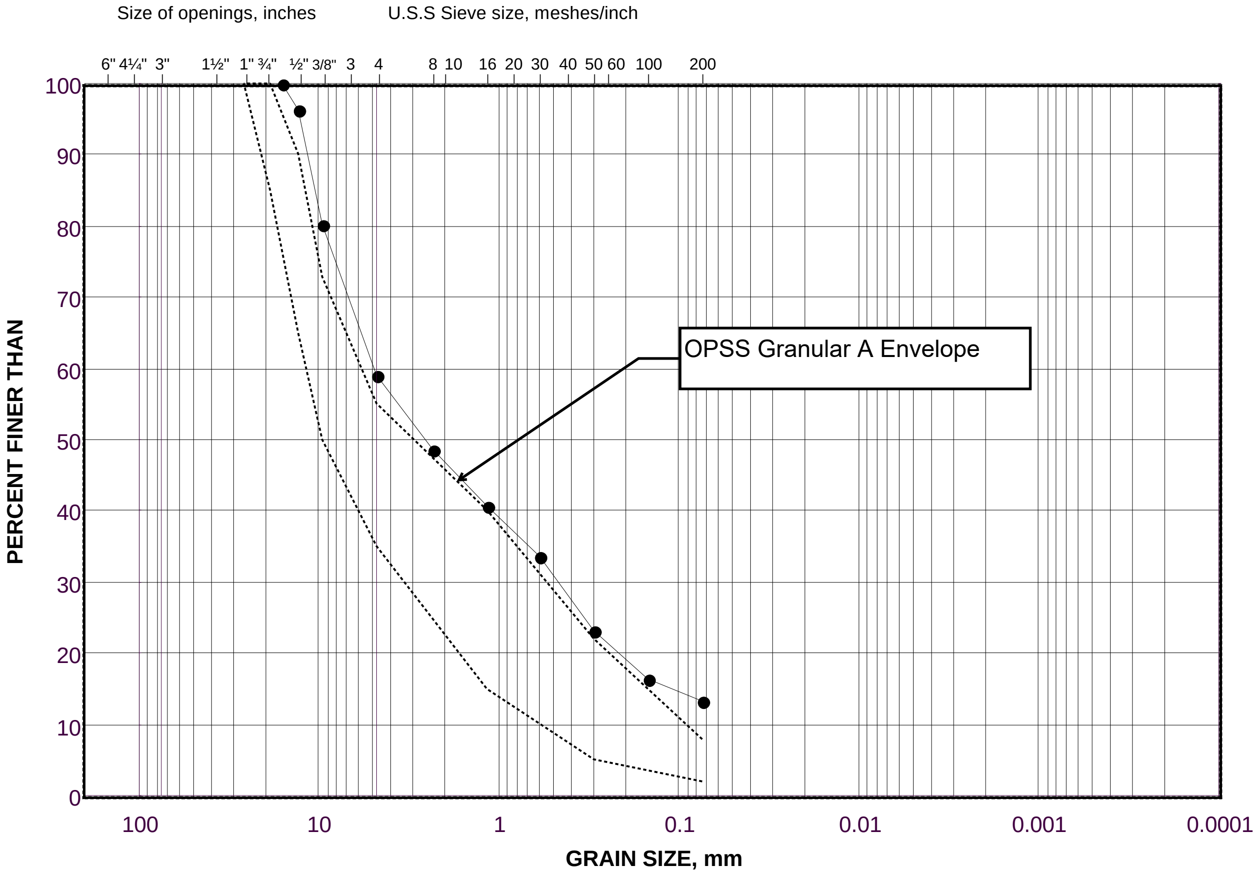
APPENDIX D

Geotechnical Laboratory Results

GRAIN SIZE DISTRIBUTION

Typical Base Material

FIGURE D1



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	**GRAVEL SIZE**		**SAND SIZE**			**FINE GRAINED**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	P8	1	0.3 - 0.4

Project Number: 20146456 (2000)(3)

Checked By: TO

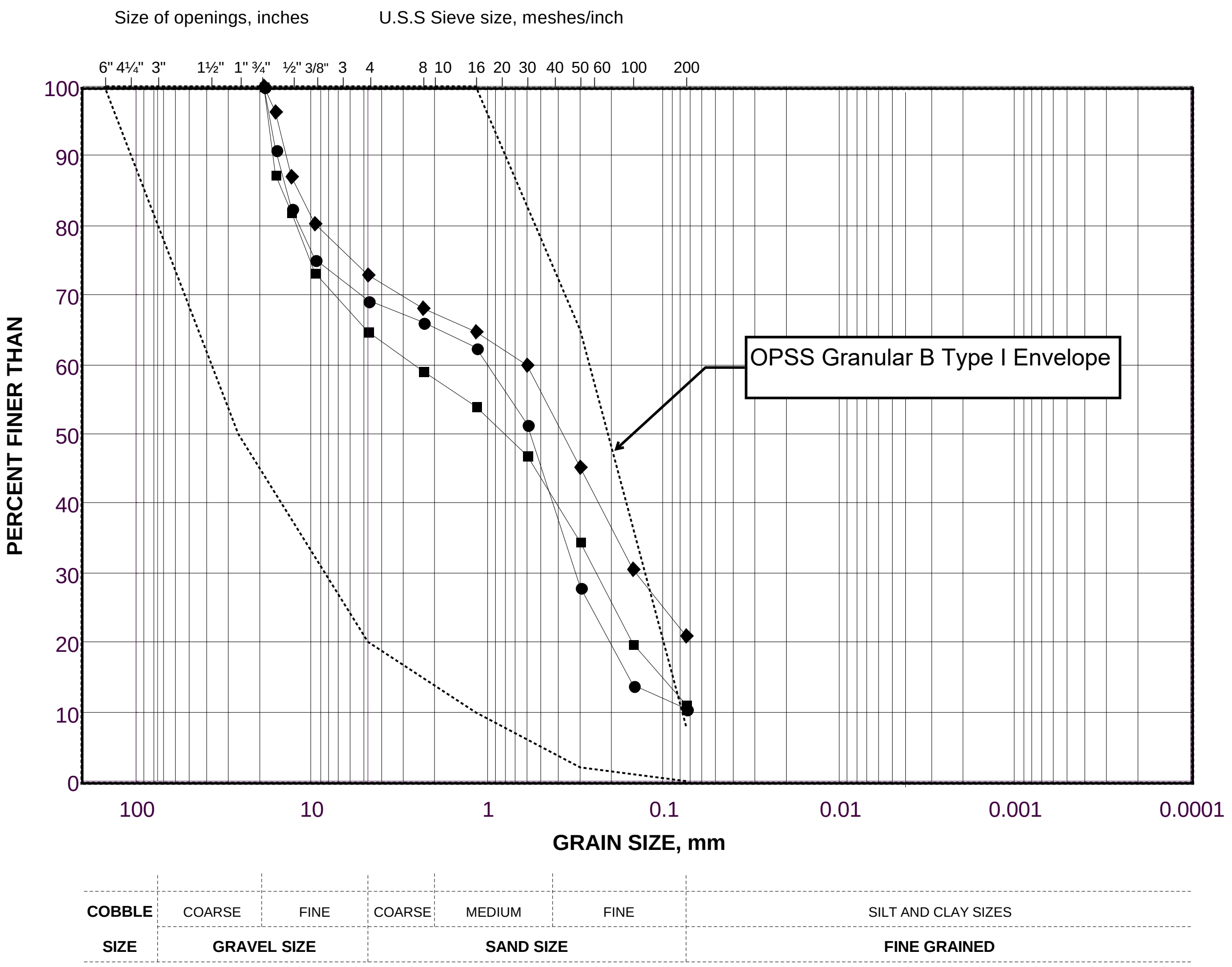
Golder Associates

Date: 23-Feb-21

GRAIN SIZE DISTRIBUTION

Typical Subbase Material

FIGURE D2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	S4	1	0.2 - 0.6
■	P12	1B	0.4 - 0.8
◆	S2	1B	0.1 - 0.8

Project Number: 20146456 (2000)(3)

Checked By: TO

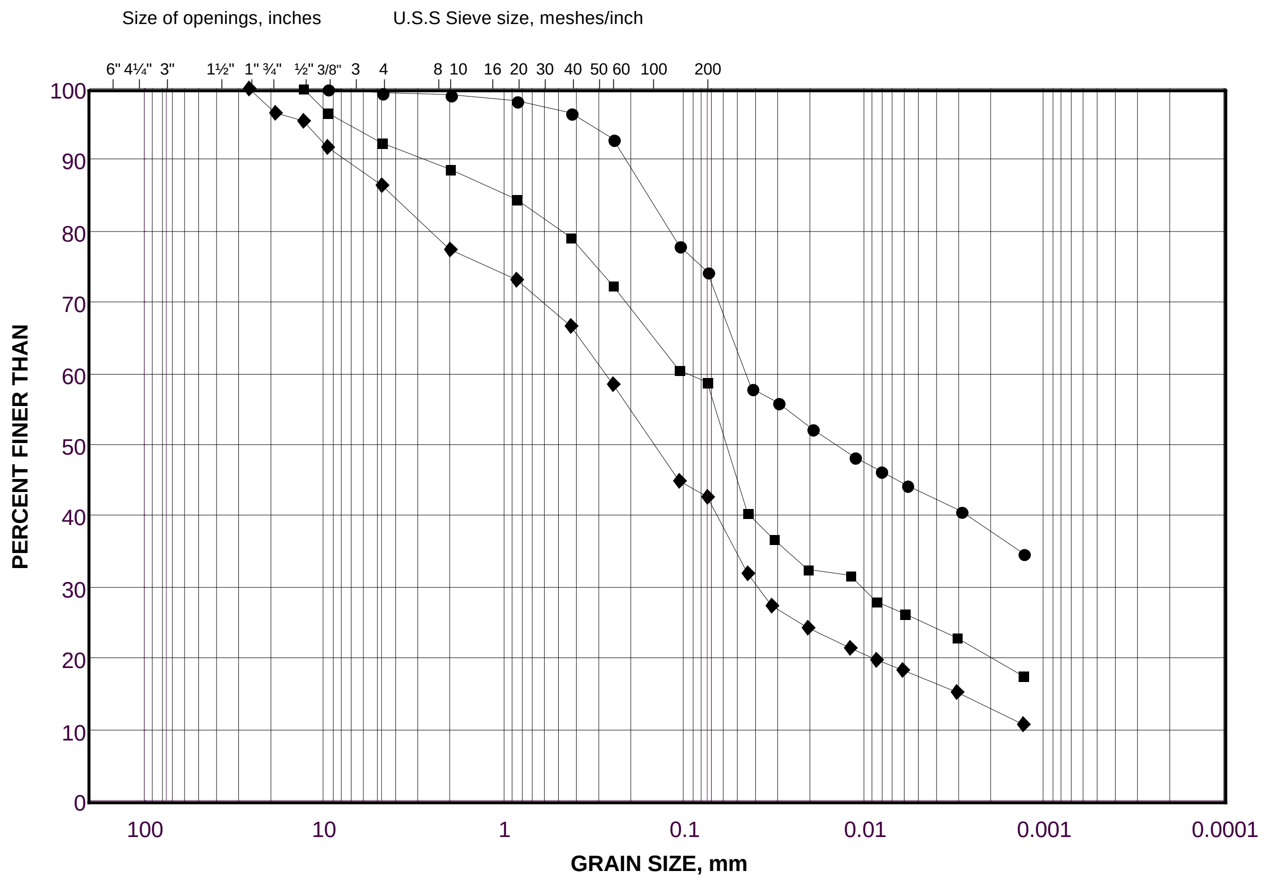
Golder Associates

Date: 23-Feb-21

GRAIN SIZE DISTRIBUTION

FILL - (CL) gravelly SILTY CLAY and SAND
to (CI) sandy SILTY CLAY

FIGURE D3



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	**GRAVEL SIZE**		**SAND SIZE**			**FINE GRAINED**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	S3	2	0.80 - 1.20
■	C2	2	0.80 - 1.20
◆	P12	2	0.80 - 1.20

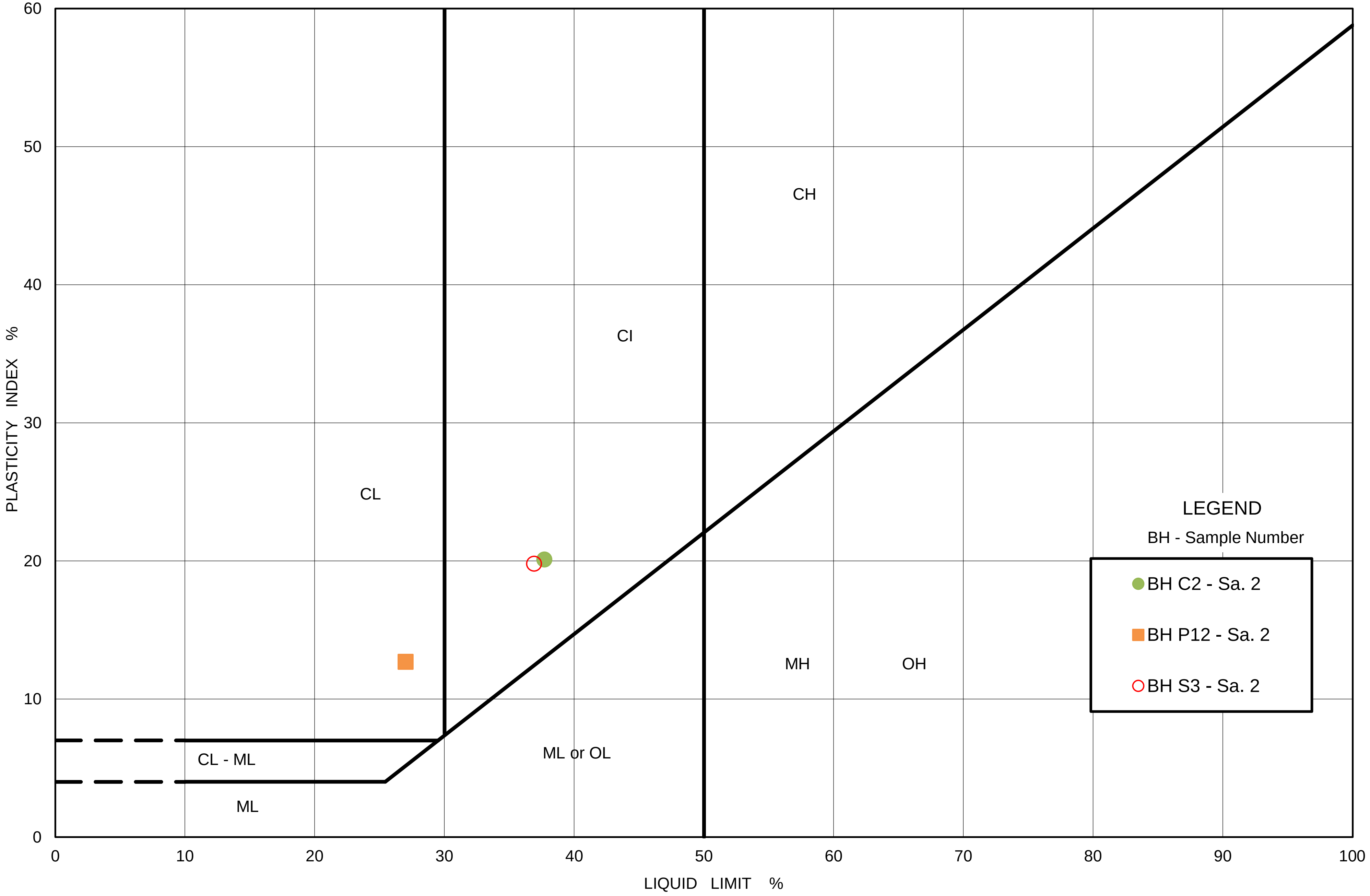
Project Number: 20146456 (2000)(3)

Checked By: ____________________

Golder Associates

Date: 27-Feb-21

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS (ASTM D4318)



GOLDER

PLASTICITY CHART

FILL-(CL) gravelly SILTY CLAY and SAND
to (CI) sandy SILTY CLAY

Figure No.: D4

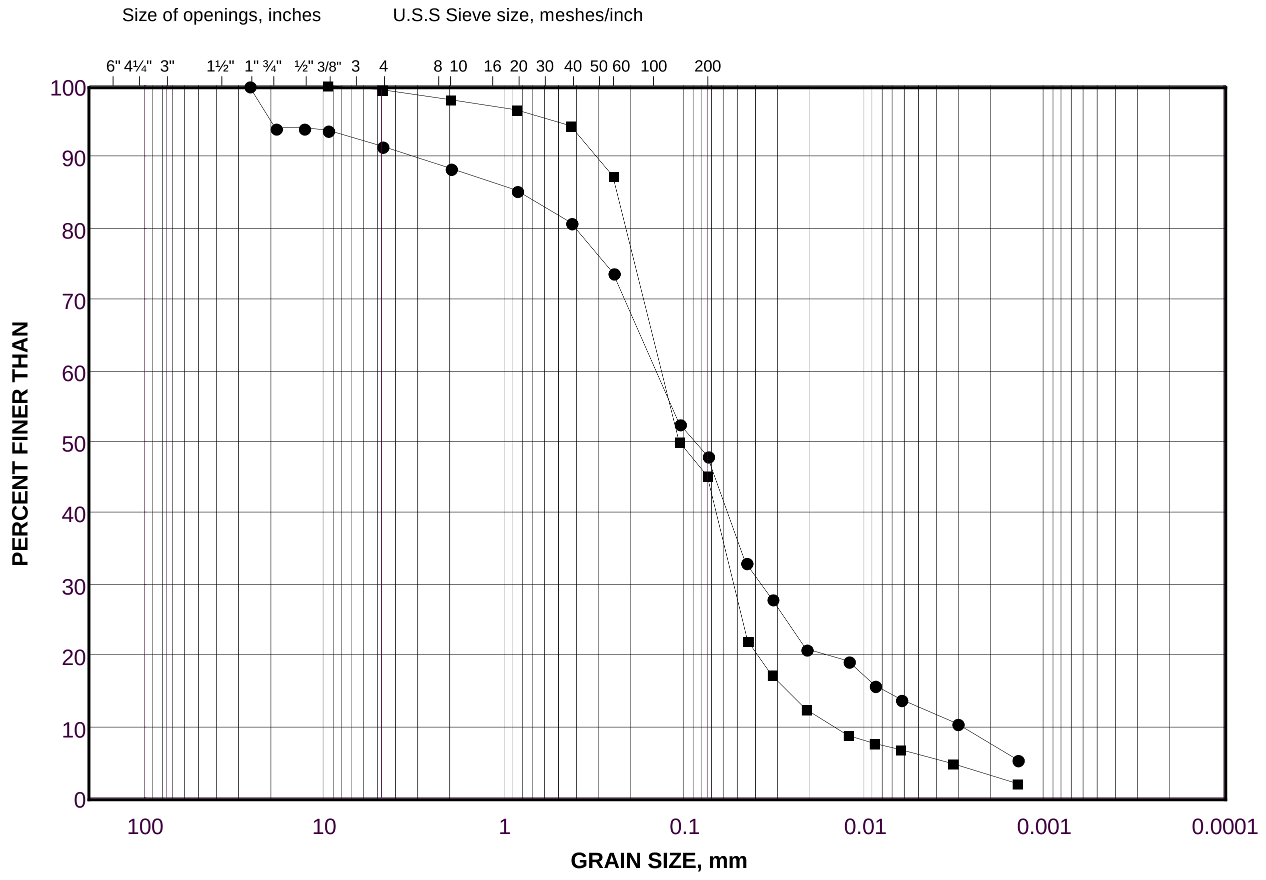
Project No.: 20146456

Checked By: TO

GRAIN SIZE DISTRIBUTION

(SM) SILTY AND

FIGURE D5



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	**GRAVEL SIZE**		**SAND SIZE**			**FINE GRAINED**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	P4	3	1.5 - 2.0
■	C3	5	3.0 - 3.5

Project Number: 20146456 (2000)(3)

Checked By: TO

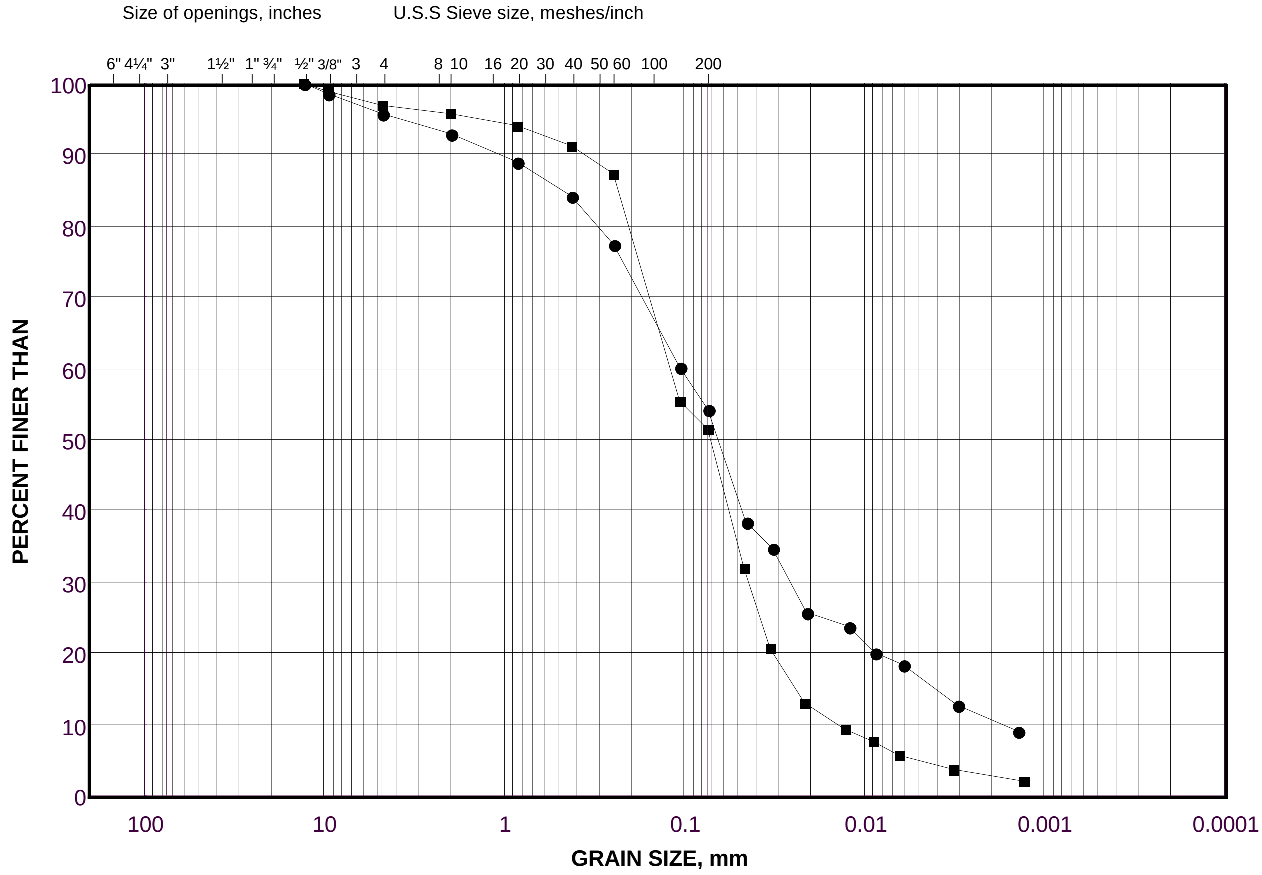
Golder Associates

Date: 27-Feb-21

GRAIN SIZE DISTRIBUTION

(ML) SILT and SAND

FIGURE D6



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	**GRAVEL SIZE**		**SAND SIZE**			**FINE GRAINED**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	P2	3	1.5 - 2.0
■	S6	3	1.5 - 2.0

Project Number: 20146456 (2000)(3)

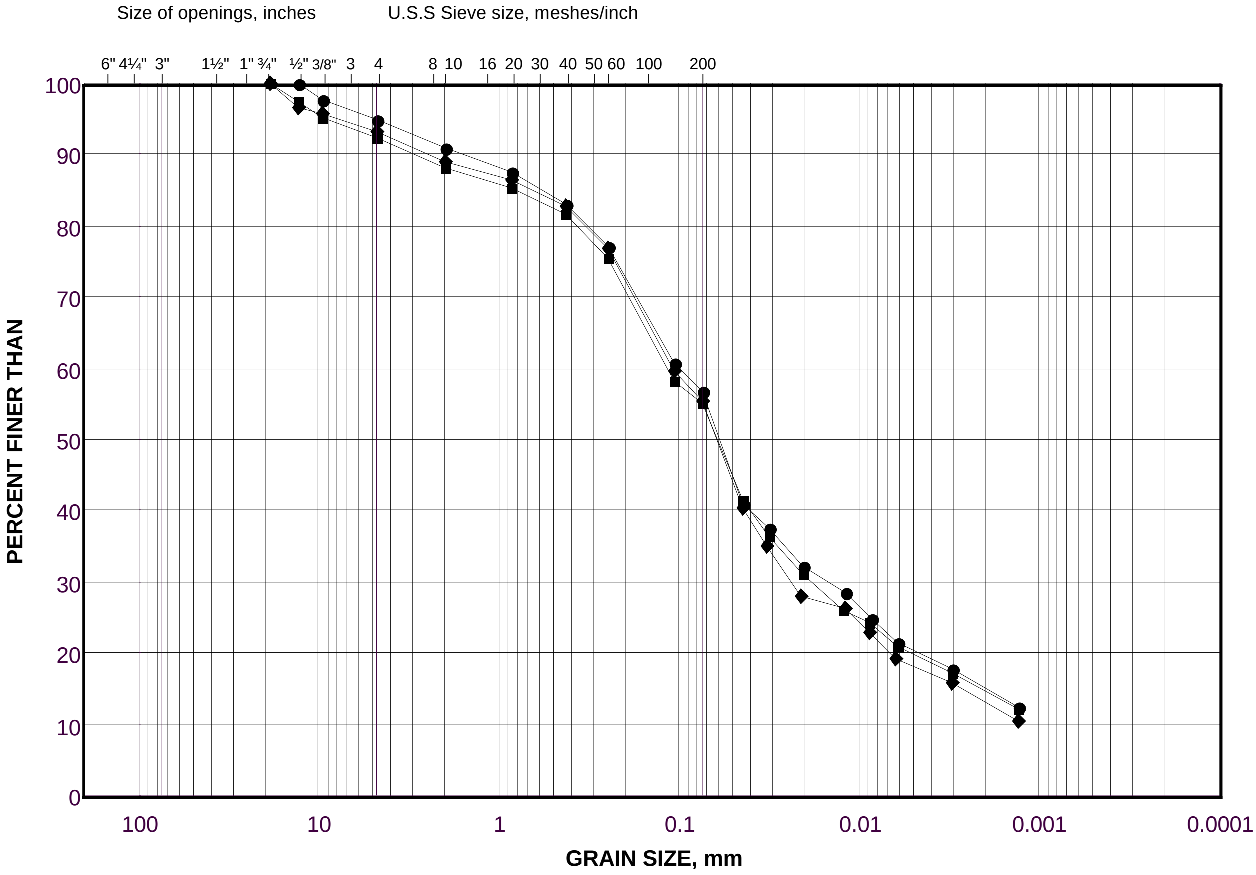
Checked By: TO

Golder Associates

Date: 27-Feb-21

GRAIN SIZE DISTRIBUTION
(CL-ML) SILTY CLAY-CLAYEY SILT and SAND (TILL)
to (CL) SILTY CLAY and SAND (TILL)

FIGURE D7



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	P1	3	1.5 - 2.0
■	C4	7	6.0 - 6.5
◆	C4	8	7.5 - 7.8

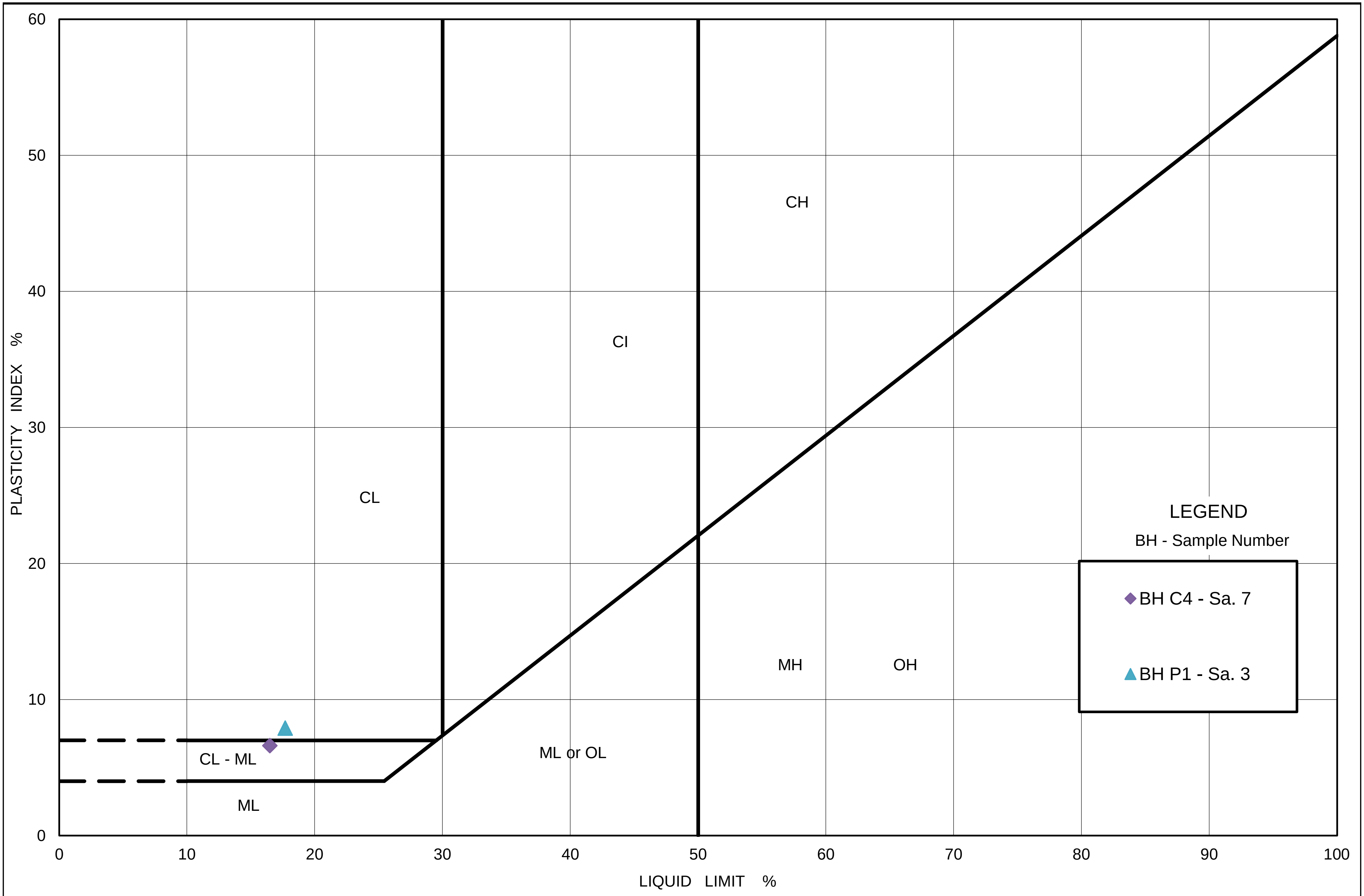
Project Number: 20146456 (2000)(3)

Checked By: TO

Golder Associates

Date: 27-Feb-21

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS (ASTM D4318)



GOLDER

PLASTICITY CHART

(CL-ML) SILTY CLAY-CLAYEY SILT and SAND (TILL)
to (CL) SILTY CLAY and SAND (TILL)

Figure No.: D8

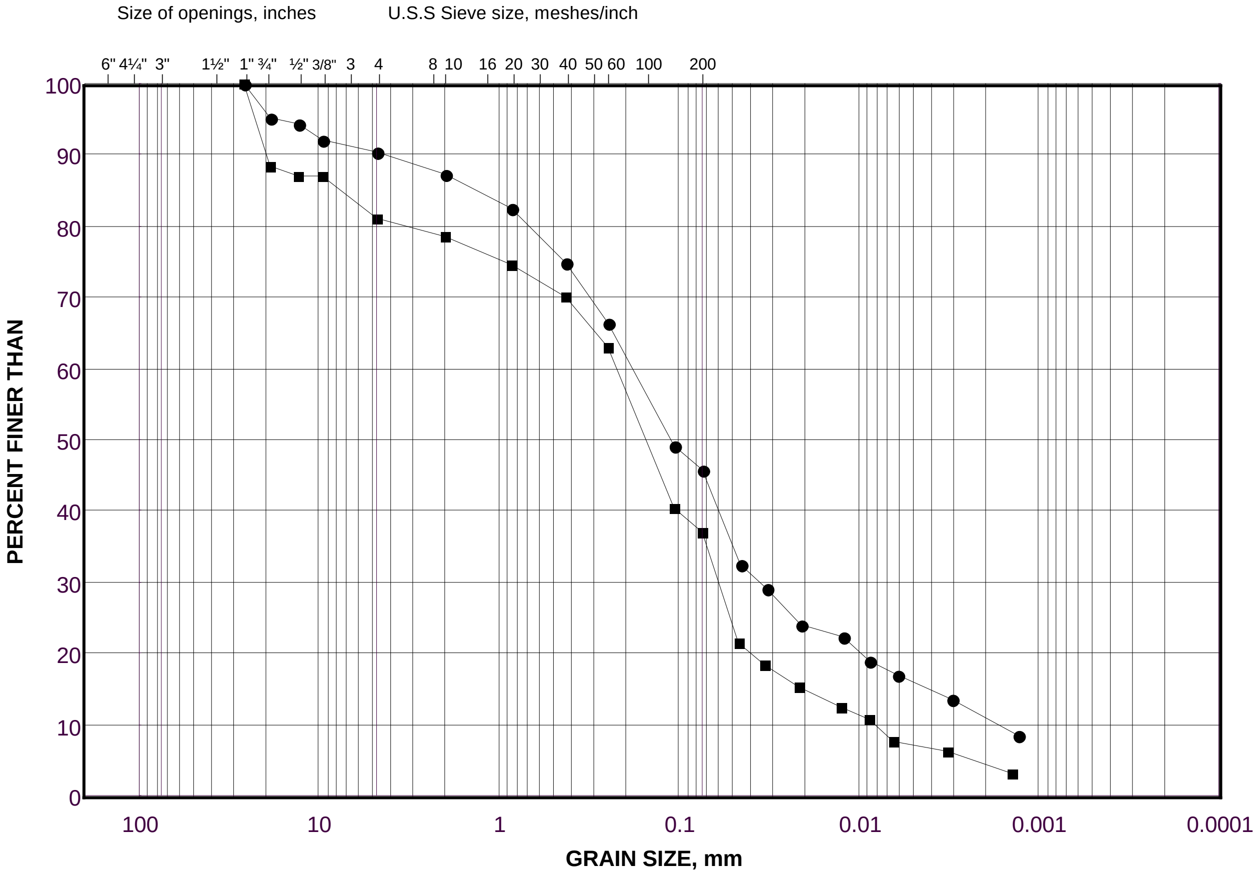
Project No.: 20146456

Checked By: TO

GRAIN SIZE DISTRIBUTION

(SM) SILTY SAND (TILL)

FIGURE D9



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	**GRAVEL SIZE**		**SAND SIZE**			**FINE GRAINED**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	S9	4	2.3 - 2.7
■	S4	4	2.3 - 2.7

Project Number: 20146456 (2000)(3)

Checked By: TO

Golder Associates

Date: 27-Feb-21

APPENDIX E

Analytical Laboratory Results

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

CLIENT NAME: GOLDER ASSOCIATES LTD.
100 SCOTIA COURT
WHITBY, ON L1N8Y6
(905) 723-2727
ATTENTION TO: Yusuf Soliman
PROJECT: 20146456
AGAT WORK ORDER: 21T701373
SOIL ANALYSIS REVIEWED BY: Jacky Zhu, Spectroscopy Technician
TRACE ORGANICS REVIEWED BY: Neli Popnikolova, Senior Chemist
DATE REPORTED: Feb 26, 2021
PAGES (INCLUDING COVER): 16
VERSION*: 1

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

*Notes

VERSION 1:Revised report with one sample ID corrected. 2021/02/26

Disclaimer:

- All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may incorporate modifications from the specified reference methods to improve performance.
- All samples will be disposed of within 30 days following analysis, unless expressly agreed otherwise in writing. Please contact your Client Project Manager if you require additional sample storage time.
- AGAT's liability in connection with any delay, performance or non-performance of these services is only to the Client and does not extend to any other third party. Unless expressly agreed otherwise in writing, AGAT's liability is limited to the actual cost of the specific analysis or analyses included in the services.
- This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
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Environmental Services Association of Alberta (ESAA)

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Certificate of Analysis

AGAT WORK ORDER: 21T701373
PROJECT: 20146456

CLIENT NAME: GOLDER ASSOCIATES LTD.
SAMPLING SITE:

ATTENTION TO: Yusuf Soliman
SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2021-01-19

DATE REPORTED: 2021-02-26

			SAMPLE DESCRIPTION:	S1 Sa2		S11 Sa3		C4 Sa3
			SAMPLE TYPE:	Soil		Soil		Soil
			DATE SAMPLED:	2021-01-15 11:00		2021-01-07 11:00		2021-01-11 14:00
Parameter	Unit	G / S	RDL	1977097	RDL	1977099	RDL	1977104
Chloride (2:1)	µg/g	NA	2	378	4	858	20	2640
Sulphate (2:1)	µg/g		2	69	4	13	20	<20
pH (2:1)	pH Units		NA	8.32	NA	7.62	NA	7.97
Electrical Conductivity (2:1)	mS/cm	0.57	0.005	0.814	0.005	1.67	0.005	4.29
Resistivity (2:1) (Calculated)	ohm.cm		1	1230	1	599	1	233
Redox Potential 1	mV		NA	218	NA	105	NA	124
Redox Potential 2	mV		NA	223	NA	104	NA	119
Redox Potential 3	mV		NA	228	NA	113	NA	139

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to Table 1: Full Depth Background Site Condition Standards - Soil - Residential/Parkland/Institutional/Industrial/Commercial/Community Property Use
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

1977097 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.
Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

1977099-1977104 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.
Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

Dilution required, RDL has been increased accordingly.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

NIANDONG ZHU

Certificate of Analysis

AGAT WORK ORDER: 21T701373
PROJECT: 20146456

CLIENT NAME: GOLDER ASSOCIATES LTD.
SAMPLING SITE:

ATTENTION TO: Yusuf Soliman
SAMPLED BY:

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2021-01-19

DATE REPORTED: 2021-02-26

			SAMPLE DESCRIPTION:	S1 Sa2	S11 Sa3	S7 Sa3	S9 Sa3	S4 Sa4	C4 Sa3
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2021-01-15 11:00	2021-01-07 11:00	2021-01-11 09:00	2021-01-13 09:00	2021-01-13 11:00	2021-01-11 14:00
Parameter	Unit	G / S	RDL	1977097	1977099	1977100	1977101	1977102	1977104
Antimony	µg/g	1.3	0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
Arsenic	µg/g	18	1	1	3	2	3	2	3
Barium	µg/g	220	2	9	92	42	122	28	95
Beryllium	µg/g	2.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron	µg/g	36	5	<5	5	<5	7	<5	<5
Boron (Hot Water Soluble)	µg/g	NA	0.10	<0.10	0.47	<0.10	0.46	<0.10	0.25
Cadmium	µg/g	1.2	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	µg/g	70	5	<5	18	9	20	7	18
Cobalt	µg/g	21	0.5	1.4	7.2	3.8	7.3	3.1	6.6
Copper	µg/g	92	1	3	13	7	14	6	12
Lead	µg/g	120	1	1	18	4	13	3	9
Molybdenum	µg/g	2	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Nickel	µg/g	82	1	2	15	7	16	5	13
Selenium	µg/g	1.5	0.4	<0.4	0.6	<0.4	0.5	<0.4	0.6
Silver	µg/g	0.5	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/g	1	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Uranium	µg/g	2.5	0.5	<0.5	0.6	<0.5	0.5	<0.5	<0.5
Vanadium	µg/g	86	1	11	29	17	31	14	29
Zinc	µg/g	290	5	8	55	20	73	17	120
Chromium, Hexavalent	µg/g	0.66	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cyanide, Free	µg/g	0.051	0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
Mercury	µg/g	0.27	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Electrical Conductivity (2:1)	mS/cm	0.57	0.005	0.814	1.67	1.45	0.848	0.868	4.29
Sodium Adsorption Ratio (2:1) (Calc.)	N/A	2.4	N/A	9.79	4.32	5.63	9.80	5.84	38.7
pH, 2:1 CaCl2 Extraction	pH Units		NA	7.95	7.44	7.77	7.65	7.82	7.60

Certified By: Xiandong Zhu

XIANDONG ZHU

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2021-01-19

DATE REPORTED: 2021-02-26

Comments:	RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to Table 1: Full Depth Background Site Condition Standards - Soil - Residential/Parkland/Institutional/Industrial/Commercial/Community Property Use Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.
1977097-1977104	EC was determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio. SAR is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

NIANDONG ZHU

Certificate of Analysis

AGAT WORK ORDER: 21T701373
PROJECT: 20146456

CLIENT NAME: GOLDER ASSOCIATES LTD.
SAMPLING SITE:

ATTENTION TO: Yusuf Soliman
SAMPLED BY:

O. Reg. 558 Metals and Inorganics

DATE RECEIVED: 2021-01-19

DATE REPORTED: 2021-02-26

			SAMPLE DESCRIPTION:	S5 TCLP
			SAMPLE TYPE:	Soil
			DATE SAMPLED:	2021-01-12 14:00
Parameter	Unit	G / S	RDL	1977105
Arsenic Leachate	mg/L	2.5	0.010	<0.010
Barium Leachate	mg/L	100	0.100	0.652
Boron Leachate	mg/L	500	0.050	<0.050
Cadmium Leachate	mg/L	0.5	0.010	<0.010
Chromium Leachate	mg/L	5	0.010	<0.010
Lead Leachate	mg/L	5	0.010	<0.010
Mercury Leachate	mg/L	0.1	0.01	<0.01
Selenium Leachate	mg/L	1	0.010	<0.010
Silver Leachate	mg/L	5	0.010	<0.010
Uranium Leachate	mg/L	10	0.050	<0.050
Fluoride Leachate	mg/L	150	0.05	0.20
Cyanide Leachate	mg/L	20	0.05	<0.05
(Nitrate + Nitrite) as N Leachate	mg/L	1000	0.70	<0.70

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to O. Reg. 558 - Schedule IV Leachate Quality Criteria
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

NIANDONG ZHU

O. Reg. 153(511) - PHCs F1 - F4 (Soil)

DATE RECEIVED: 2021-01-19

DATE REPORTED: 2021-02-26

			SAMPLE DESCRIPTION:	S1 Sa2	S11 Sa3
			SAMPLE TYPE:	Soil	Soil
			DATE SAMPLED:	2021-01-15 11:00	2021-01-07 11:00
Parameter	Unit	G / S	RDL	1977097	1977099
Benzene	µg/g	0.02	0.02	<0.02	<0.02
Toluene	µg/g	0.2	0.05	<0.05	<0.05
Ethylbenzene	µg/g	0.05	0.05	<0.05	<0.05
m & p-Xylene	µg/g		0.05	<0.05	<0.05
o-Xylene	µg/g		0.05	<0.05	<0.05
Xylenes (Total)	µg/g	0.05	0.05	<0.05	<0.05
F1 (C6 to C10)	µg/g	25	5	<5	<5
F1 (C6 to C10) minus BTEX	µg/g	25	5	<5	<5
F2 (C10 to C16)	µg/g	10	10	<10	<10
F3 (C16 to C34)	µg/g	240	50	69	<50
F4 (C34 to C50)	µg/g	120	50	78	<50
Gravimetric Heavy Hydrocarbons	µg/g	120	50	NA	NA
Moisture Content	%		0.1	11.5	13.2
Surrogate	Unit	Acceptable Limits			
Toluene-d8	% Recovery	50-140		84	89
Terphenyl	%	60-140		90	106

Certified By: NPopukolof

O. Reg. 153(511) - PHCs F1 - F4 (Soil)

DATE RECEIVED: 2021-01-19

DATE REPORTED: 2021-02-26

Comments:	RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to Table 1: Full Depth Background Site Condition Standards - Soil - Residential/Parkland/Institutional/Industrial/Commercial/Community Property Use Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.
1977097-1977099	Results are based on sample dry weight. The C6-C10 fraction is calculated using Toluene response factor. Xylenes is a calculated parameter. The calculated value is the sum of m&p-Xylene and o-Xylene. C6–C10 (F1 minus BTEX) is a calculated parameter. The calculated value is F1 minus BTEX. The calculated parameters are non-accredited. The parameters that are components of the calculation are accredited. The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and n-C34. Gravimetric Heavy Hydrocarbons are not included in the Total C16-C50 and are only determined if the chromatogram of the C34 - C50 hydrocarbons indicates that hydrocarbons >C50 are present. The chromatogram has returned to baseline by the retention time of nC50. Total C6 - C50 results are corrected for BTEX contribution. This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory. nC6 and nC10 response factors are within 30% of Toluene response factor. nC10, nC16 and nC34 response factors are within 10% of their average. C50 response factor is within 70% of nC10 + nC16 + nC34 average. Linearity is within 15%. Extraction and holding times were met for this sample. Fractions 1-4 are quantified with the contribution of PAHs. Under Ontario Regulation 153, results are considered valid without determining the PAH contribution if not requested by the client. Quality Control Data is available upon request.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By: NPopukolof

Certificate of Analysis

AGAT WORK ORDER: 21T701373

PROJECT: 20146456

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
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CLIENT NAME: GOLDER ASSOCIATES LTD.

ATTENTION TO: Yusuf Soliman

SAMPLING SITE:

SAMPLED BY:

O. Reg. 558 - Benzene

DATE RECEIVED: 2021-01-19

DATE REPORTED: 2021-02-26

			SAMPLE DESCRIPTION:	S5 TCLP
			SAMPLE TYPE:	Soil
			DATE SAMPLED:	2021-01-12 14:00
Parameter	Unit	G / S	RDL	1977105
Benzene	mg/L	0.5	0.020	<0.020

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to O. Reg. 558 - Schedule IV Leachate Quality Criteria
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

1977105 Surrogate Recovery for Toluene-d8: %
Surrogate recovery for 4-Bromofluorobenzene: %
Sample was prepared using Regulation 558 protocol and a zero headspace extractor.
Results relate only to the items tested.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By: NPopukolof

O. Reg. 558 - Benzo(a) pyrene

DATE RECEIVED: 2021-01-19

DATE REPORTED: 2021-02-26

			SAMPLE DESCRIPTION:	S5 TCLP
			SAMPLE TYPE:	Soil
			DATE SAMPLED:	2021-01-12 14:00
Parameter	Unit	G / S	RDL	1977105
Benzo(a)pyrene	mg/L	0.001	0.001	<0.001
Surrogate	Unit	Acceptable Limits		
Naphthalene-d8	%	50-140		71
Acenaphthene-d10	%	50-140		71
Chrysene-d12	%	50-140		109

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to O. Reg. 558 - Schedule IV Leachate Quality Criteria
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

1977105 The sample was leached according to Regulation 558 protocol. Analysis was performed on the leachate.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

SAMPLEID	SAMPLE TITLE	GUIDELINE	ANALYSIS PACKAGE	PARAMETER	UNIT	GUIDEVALUE	RESULT
1977097	S1 Sa2	ON T1 S RPI/ICC	Corrosivity Package	Electrical Conductivity (2:1)	mS/cm	0.57	0.814
1977097	S1 Sa2	ON T1 S RPI/ICC	O. Reg. 153(511) - Metals & Inorganics (Soil)	Electrical Conductivity (2:1)	mS/cm	0.57	0.814
1977097	S1 Sa2	ON T1 S RPI/ICC	O. Reg. 153(511) - Metals & Inorganics (Soil)	Sodium Adsorption Ratio (2:1) (Calc.	N/A	2.4	9.79
1977099	S11 Sa3	ON T1 S RPI/ICC	Corrosivity Package	Electrical Conductivity (2:1)	mS/cm	0.57	1.67
1977099	S11 Sa3	ON T1 S RPI/ICC	O. Reg. 153(511) - Metals & Inorganics (Soil)	Electrical Conductivity (2:1)	mS/cm	0.57	1.67
1977099	S11 Sa3	ON T1 S RPI/ICC	O. Reg. 153(511) - Metals & Inorganics (Soil)	Sodium Adsorption Ratio (2:1) (Calc.)	N/A	2.4	4.32
1977100	S7 Sa3	ON T1 S RPI/ICC	O. Reg. 153(511) - Metals & Inorganics (Soil)	Electrical Conductivity (2:1)	mS/cm	0.57	1.45
1977100	S7 Sa3	ON T1 S RPI/ICC	O. Reg. 153(511) - Metals & Inorganics (Soil)	Sodium Adsorption Ratio (2:1) (Calc.)	N/A	2.4	5.63
1977101	S9 Sa3	ON T1 S RPI/ICC	O. Reg. 153(511) - Metals & Inorganics (Soil)	Electrical Conductivity (2:1)	mS/cm	0.57	0.848
1977101	S9 Sa3	ON T1 S RPI/ICC	O. Reg. 153(511) - Metals & Inorganics (Soil)	Sodium Adsorption Ratio (2:1) (Calc.)	N/A	2.4	9.80
1977102	S4 Sa4	ON T1 S RPI/ICC	O. Reg. 153(511) - Metals & Inorganics (Soil)	Electrical Conductivity (2:1)	mS/cm	0.57	0.868
1977102	S4 Sa4	ON T1 S RPI/ICC	O. Reg. 153(511) - Metals & Inorganics (Soil)	Sodium Adsorption Ratio (2:1) (Calc.)	N/A	2.4	5.84
1977104	C4 Sa3	ON T1 S RPI/ICC	Corrosivity Package	Electrical Conductivity (2:1)	mS/cm	0.57	4.29
1977104	C4 Sa3	ON T1 S RPI/ICC	O. Reg. 153(511) - Metals & Inorganics (Soil)	Electrical Conductivity (2:1)	mS/cm	0.57	4.29
1977104	C4 Sa3	ON T1 S RPI/ICC	O. Reg. 153(511) - Metals & Inorganics (Soil)	Sodium Adsorption Ratio (2:1) (Calc.	N/A	2.4	38.7

Quality Assurance

CLIENT NAME: GOLDER ASSOCIATES LTD.
PROJECT: 20146456
SAMPLING SITE:

AGAT WORK ORDER: 21T701373
ATTENTION TO: Yusuf Soliman
SAMPLED BY:

Soil Analysis

RPT Date: Feb 26, 2021			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
O. Reg. 153(511) - Metals & Inorganics (Soil)															
Antimony	1985928		< 0.8	< 0.8	NA	< 0.8	100%	70%	130%	100%	80%	120%	107%	70%	130%
Arsenic	1985928		< 1	< 1	NA	< 1	94%	70%	130%	113%	80%	120%	116%	70%	130%
Barium	1985928		13	13	0.0%	< 2	95%	70%	130%	97%	80%	120%	110%	70%	130%
Beryllium	1985928		< 0.5	< 0.5	NA	< 0.5	116%	70%	130%	100%	80%	120%	96%	70%	130%
Boron	1985928		< 5	< 5	NA	< 5	101%	70%	130%	84%	80%	120%	79%	70%	130%
Boron (Hot Water Soluble)	1986659		<0.10	<0.10	NA	< 0.10	105%	60%	140%	102%	70%	130%	104%	60%	140%
Cadmium	1985928		< 0.5	< 0.5	NA	< 0.5	98%	70%	130%	98%	80%	120%	104%	70%	130%
Chromium	1985928		<5	5	NA	< 5	99%	70%	130%	103%	80%	120%	97%	70%	130%
Cobalt	1985928		1.9	1.9	NA	< 0.5	103%	70%	130%	99%	80%	120%	98%	70%	130%
Copper	1985928		3	3	NA	< 1	97%	70%	130%	99%	80%	120%	94%	70%	130%
Lead	1985928		2	2	NA	< 1	98%	70%	130%	102%	80%	120%	96%	70%	130%
Molybdenum	1985928		< 0.5	< 0.5	NA	< 0.5	99%	70%	130%	98%	80%	120%	106%	70%	130%
Nickel	1985928		2	2	NA	< 1	99%	70%	130%	101%	80%	120%	95%	70%	130%
Selenium	1985928		< 0.4	< 0.4	NA	< 0.4	101%	70%	130%	103%	80%	120%	121%	70%	130%
Silver	1985928		< 0.2	< 0.2	NA	< 0.2	101%	70%	130%	105%	80%	120%	96%	70%	130%
Thallium	1985928		< 0.4	< 0.4	NA	< 0.4	99%	70%	130%	109%	80%	120%	106%	70%	130%
Uranium	1985928		< 0.5	< 0.5	NA	< 0.5	106%	70%	130%	110%	80%	120%	113%	70%	130%
Vanadium	1985928		14	17	19.4%	< 1	103%	70%	130%	90%	80%	120%	115%	70%	130%
Zinc	1985928		8	8	NA	< 5	96%	70%	130%	100%	80%	120%	104%	70%	130%
Chromium, Hexavalent	1977101	1977101	<0.2	<0.2	NA	< 0.2	101%	70%	130%	105%	80%	120%	98%	70%	130%
Cyanide, Free	1983112		<0.040	<0.040	NA	< 0.040	101%	70%	130%	111%	80%	120%	88%	70%	130%
Mercury	1985928		0.21	0.23	NA	< 0.10	104%	70%	130%	109%	80%	120%	108%	70%	130%
Electrical Conductivity (2:1)	1983173		0.861	0.897	4.1%	< 0.005	112%	80%	120%						
Sodium Adsorption Ratio (2:1) (Calc.)	1986659		0.183	0.184	0.5%	NA									
pH, 2:1 CaCl2 Extraction	1977102	1977102	7.82	7.84	0.3%	NA	100%	80%	120%						
Corrosivity Package															
Chloride (2:1)	1979229		430	430	0.0%	< 2	95%	70%	130%	104%	80%	120%	99%	70%	130%
Sulphate (2:1)	1979229		387	387	0.0%	< 2	93%	70%	130%	101%	80%	120%	96%	70%	130%
pH (2:1)	1977097	1977097	8.32	8.41	1.1%	NA	100%	90%	110%						
Electrical Conductivity (2:1)	1983173		0.861	0.897	4.1%	< 0.005	112%	80%	120%						
Redox Potential 1	1						100%	90%	110%						
O. Reg. 558 Metals and Inorganics															
Arsenic Leachate	1977105	1977105	<0.010	<0.010	NA	< 0.010	95%	70%	130%	109%	80%	120%	110%	70%	130%
Barium Leachate	1977105	1977105	0.652	0.723	10.3%	< 0.100	101%	70%	130%	107%	80%	120%	119%	70%	130%
Boron Leachate	1977105	1977105	<0.050	<0.050	NA	< 0.050	99%	70%	130%	98%	80%	120%	98%	70%	130%
Cadmium Leachate	1977105	1977105	<0.010	<0.010	NA	< 0.010	100%	70%	130%	95%	80%	120%	94%	70%	130%
Chromium Leachate	1977105	1977105	<0.010	<0.010	NA	< 0.010	101%	70%	130%	107%	80%	120%	97%	70%	130%
Lead Leachate	1977105	1977105	<0.010	<0.010	NA	< 0.010	100%	70%	130%	91%	80%	120%	89%	70%	130%

Quality Assurance

CLIENT NAME: GOLDER ASSOCIATES LTD.
PROJECT: 20146456
SAMPLING SITE:

AGAT WORK ORDER: 21T701373
ATTENTION TO: Yusuf Soliman
SAMPLED BY:

Soil Analysis (Continued)

RPT Date: Feb 26, 2021			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
Mercury Leachate	1977105	1977105	<0.01	<0.01	NA	< 0.01	100%	70%	130%	91%	80%	120%	92%	70%	130%
Selenium Leachate	1977105	1977105	<0.010	<0.010	NA	< 0.010	101%	70%	130%	113%	80%	120%	114%	70%	130%
Silver Leachate	1977105	1977105	<0.010	<0.010	NA	< 0.010	99%	70%	130%	87%	80%	120%	87%	70%	130%
Uranium Leachate	1977105	1977105	<0.050	<0.050	NA	< 0.050	97%	70%	130%	99%	80%	120%	97%	70%	130%
Fluoride Leachate	1977105	1977105	0.20	0.20	NA	< 0.05	101%	90%	110%	100%	90%	110%	96%	70%	130%
Cyanide Leachate	1977105	1977105	<0.05	<0.05	NA	< 0.05	109%	70%	130%	110%	80%	120%	104%	70%	130%
(Nitrate + Nitrite) as N Leachate	1960580		<0.70	<0.70	NA	< 0.70	98%	80%	120%	101%	80%	120%	94%	70%	130%

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.
Duplicate NA: results are under 5X the RDL and will not be calculated.

Certified By: Xiaodong Zhu

NIANDONG ZHU

Quality Assurance

CLIENT NAME: GOLDER ASSOCIATES LTD.
PROJECT: 20146456
SAMPLING SITE:

AGAT WORK ORDER: 21T701373
ATTENTION TO: Yusuf Soliman
SAMPLED BY:

Trace Organics Analysis

RPT Date: Feb 26, 2021			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
O. Reg. 153(511) - PHCs F1 - F4 (Soil)															
Benzene	1977663		< 0.02	< 0.02	NA	< 0.02	98%	50%	140%	98%	60%	130%	93%	50%	140%
Toluene	1977663		< 0.05	< 0.05	NA	< 0.05	94%	50%	140%	99%	60%	130%	90%	50%	140%
Ethylbenzene	1977663		< 0.05	< 0.05	NA	< 0.05	96%	50%	140%	106%	60%	130%	97%	50%	140%
m & p-Xylene	1977663		< 0.05	< 0.05	NA	< 0.05	95%	50%	140%	94%	60%	130%	105%	50%	140%
o-Xylene	1977663		< 0.05	< 0.05	NA	< 0.05	92%	50%	140%	100%	60%	130%	85%	50%	140%
Xylenes (Total)	1977663		< 0.05	< 0.05	NA	< 0.05	93%	50%	140%	97%	60%	130%	95%	50%	140%
F1 (C6 to C10)	1977663		< 5	< 5	NA	< 5	96%	60%	140%	99%	60%	140%	83%	60%	140%
F2 (C10 to C16)	1977415		< 10	< 10	NA	< 10	108%	60%	140%	97%	60%	140%	88%	60%	140%
F3 (C16 to C34)	1977415		< 50	< 50	NA	< 50	108%	60%	140%	84%	60%	140%	80%	60%	140%
F4 (C34 to C50)	1977415		< 50	< 50	NA	< 50	102%	60%	140%	84%	60%	140%	105%	60%	140%
O. Reg. 558 - Benzo(a) pyrene															
Benzo(a)pyrene	1977105	1977105	< 0.001	< 0.001	NA	< 0.001	101%	50%	140%	85%	50%	140%	72%	50%	140%
O. Reg. 558 - Benzene															
Benzene	1960571		<0.020	<0.020	NA	< 0.020	92%	50%	140%	90%	50%	140%	74%	60%	130%

Comments: When the average of the sample and duplicate results is less than 5x the RDL, the Relative Percent Difference (RPD) will be indicated as Not Applicable (NA).

Certified By:

Method Summary

CLIENT NAME: GOLDER ASSOCIATES LTD.
PROJECT: 20146456
SAMPLING SITE:

AGAT WORK ORDER: 21T701373
ATTENTION TO: Yusuf Soliman
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from 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	modified from MSA PART 3, CH 14 and 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	modified G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	modified G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	modified G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Antimony	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Arsenic	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Barium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Beryllium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Boron	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Boron (Hot Water Soluble)	MET-93-6104	modified from EPA 6010D and MSA PART 3, CH 21	ICP/OES
Cadmium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Chromium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Cobalt	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Copper	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Lead	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Molybdenum	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Nickel	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Selenium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Silver	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Thallium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Uranium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Vanadium	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Zinc	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS
Chromium, Hexavalent	INOR-93-6068	modified from EPA 3060 and EPA 7196	SPECTROPHOTOMETER
Cyanide, Free	INOR-93-6052	modified from ON MOECC E3015, SM 4500-CN- I, G-387	TECHNICON AUTO ANALYZER
Mercury	MET-93-6103	modified from EPA 3050B and EPA 6020B and ON MOECC	ICP-MS

Method Summary

CLIENT NAME: GOLDER ASSOCIATES LTD.
PROJECT: 20146456
SAMPLING SITE:

AGAT WORK ORDER: 21T701373
ATTENTION TO: Yusuf Soliman
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Sodium Adsorption Ratio (2:1) (Calc.)	INOR-93-6007	modified from EPA 6010D & Analytical Protocol	ICP/OES
pH, 2:1 CaCl2 Extraction	INOR-93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Arsenic Leachate	MET-93-6103	EPA 1311 & modified from EPA 6020B	ICP-MS
Barium Leachate	MET-93-6103	EPA 1311 & modified from EPA 6020B	ICP-MS
Boron Leachate	MET-93-6103	EPA 1311 & modified from EPA 6020B	ICP-MS
Cadmium Leachate	MET-93-6103	EPA 1311 & modified from EPA 6020B	ICP-MS
Chromium Leachate	MET-93-6103	EPA 1311 & modified from EPA 6020B	ICP-MS
Lead Leachate	MET-93-6103	EPA 1311 & modified from EPA 6020B	ICP-MS
Mercury Leachate	MET-93-6103	EPA 1311 & modified from EPA 6020B	ICP-MS
Selenium Leachate	MET-93-6103	EPA 1311 & modified from EPA 6020B	ICP-MS
Silver Leachate	MET-93-6103	EPA 1311 & modified from EPA 6020B	ICP-MS
Uranium Leachate	MET-93-6103	EPA 1311 & modified from EPA 6020B	ICP-MS
Fluoride Leachate	INOR-93-6018	EPA 1311 & modified from SM4500-F-C	ION SELECTIVE ELECTRODE
Cyanide Leachate	INOR-93-6052	EPA 1311 modified from MOE 3015 SM 4500 CN-I,G387	TECHNICON AUTO ANALYZER
(Nitrate + Nitrite) as N Leachate	INOR-93-6053	EPA SW 846-1311 & modified from SM 4500 - NO3- I	LACHAT FIA
Trace Organics Analysis			
Benzene	VOL-91-5009	modified from CCME Tier 1 Method	(P&T)GC/MS
Toluene	VOL-91-5009	modified from CCME Tier 1 Method	(P&T)GC/MS
Ethylbenzene	VOL-91-5009	modified from CCME Tier 1 Method	(P&T)GC/MS
m & p-Xylene	VOL-91-5009	modified from CCME Tier 1 Method	(P&T)GC/MS
o-Xylene	VOL-91-5009	modified from CCME Tier 1 Method	(P&T)GC/MS
Xylenes (Total)	VOL-91-5009	modified from CCME Tier 1 Method	(P&T)GC/MS
F1 (C6 to C10)	VOL-91-5009	modified from CCME Tier 1 Method	P&T GC/FID
F1 (C6 to C10) minus BTEX	VOL-91-5009	modified from CCME Tier 1 Method	P&T GC/FID
Toluene-d8	VOL-91-5009	modified from EPA SW-846 5030C & 8260D	(P&T)GC/MS
F2 (C10 to C16)	VOL-91-5009	modified from CCME Tier 1 Method	GC/FID
F3 (C16 to C34)	VOL-91-5009	modified from CCME Tier 1 Method	GC/FID
F4 (C34 to C50)	VOL-91-5009	modified from CCME Tier 1 Method	GC/FID
Gravimetric Heavy Hydrocarbons	VOL-91-5009	modified from CCME Tier 1 Method	BALANCE
Moisture Content	VOL-91-5009	Tier 1 Method	BALANCE
Terphenyl	VOL-91-5009	modified from CCME Tier 1 Method	GC/FID
Benzene	VOL-91-5001	EPA 1311, EPA 8260D	(P&T)GC/MS
Benzo(a)pyrene	ORG-91-5105	modified from EPA 3510C and EPA 8270E	GC/MS
Naphthalene-d8	ORG-91-5105	modified from EPA 3510C and EPA 8270E	GC/MS
Acenaphthene-d10	ORG-91-5105	modified from EPA 3510C and EPA 8270E	GC/MS
Chrysene-d12	ORG-91-5105	modified from EPA 3541 and EPA 8270E	GC/MS

AGAT Laboratories / Sul

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 #: 21T701373

Cooler Quantity:

Arrival Temperatures: 4.8 | 4.9 | 4.9 / 4.5 | 4.8 | 4.8

Custody Seal Intact: ☐Yes ☐No ☐N/A

Notes: Free Ice

Report Information:

Company: Golder Associates Ltd.
Contact: Yusuf Soliman
Address: 100 Scotia Court
Whitby ON L1N 8Y6
Phone: 289 356 6235 Fax:
Reports to be sent to:
1. Email: ysoliman@golder.com
2. Email: Anastasia_Poliacik@golder.com

Regulatory Requirements:

(Please check all applicable boxes)

☑ Regulation 153/04
Table 1 (Indicate One)
☑ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture (Check One)
☐ Coarse
☐ Fine

☐ Excess Soils R406
Table ____ (Indicate One)
☐ Regulation 558
☐ CCME

☐ Sewer Use
☐ Sanitary ☐ Storm
____ Region
☐ 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: 20146456
Site Location: Warden Ave, Markham
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:
Contact:
Address:
Email:

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, DOC Y / N	O. Reg 153 Metals & Inorganics	O. Reg 153 Metals - ☐ CrVI, ☐ Hg, ☐ HWSB	O. Reg 153 BTEX, F1-F4 PHCs	O. Reg 153 Analyze F4G if required ☐ Yes ☐ No	PAHs	PCBs	VOC	O. Reg 558 Landfill Disposal Characterization TCLP: TCLP: ☒M&I ☐VOCs ☐ABNs ☐B(a)P ☐PCBs	O. Reg 406 Excess Soils SPLP Rainwater Leach SPLP: ☐ Metals ☐ VOCs ☐ SVOCs	O. Reg 406 Excess Soils Characterization Package pH, ICPMS Metals, BTEX, F1-F4	Salt - EC/SAR	Corrosivity	TCLP-Benzene	TCLP-Benzo(a)pyrene					Potentially Hazardous or High Concentration (Y/N)
S1 Sa2	Jan 15/21	11 [✓ AM] PM	3	Soil			X		X									X							
S11 Sa3	Jan 7/21	11 [✓ AM] PM	3	↓			X		X									X							
S7 Sa3	Jan 11/21	9 [✓ AM] PM	1	↓			X																		
S9 Sa3	Jan 13/21	9 [✓ AM] PM	1	↓			X																		
S4 Sa4	Jan 13/21	11 [✓ AM] PM	1	↓			X																		
C4 Sa3	Jan 11/21	2 AM [✓ PM]	1	↓			X											X							
S5 TCLP	Jan 12/21	2 AM [✓ PM]	3	↓										X					X	X					
		AM PM																							
		AM PM																							
		AM PM																							
		AM PM																							

Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
Yusuf Soliman	Jan 18/21	6AM	2021/01/19		10:40
Samples Relinquished By (Print Name and Sign): 2021/01/19	Date	Time 3:50	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 113628

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

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
http://www.agatlabs.com

CLIENT NAME: GOLDER ASSOCIATES LTD.
100 SCOTIA COURT
WHITBY, ON L1N8Y6
(905) 723-2727

ATTENTION TO: Yusuf Soliman

PROJECT: 21T701373

AGAT WORK ORDER: 21T703309

SOLID ANALYSIS REVIEWED BY: Sherin Moussa, Senior Technician

DATE REPORTED: Jan 27, 2021

PAGES (INCLUDING COVER): 5

Should you require any information regarding this analysis please contact your client services representative at (905) 501-9998

*NOTES

All samples are stored at no charge for 90 days. Please contact the lab if you require additional sample storage time.

CLIENT NAME: GOLDER ASSOCIATES LTD.

ATTENTION TO: Yusuf Soliman

(201-042) Sulfide

DATE SAMPLED: Jan 24, 2021 DATE RECEIVED: Jan 25, 2021 DATE REPORTED: Jan 27, 2021 SAMPLE TYPE: Other

	Analyte:	Sulfide
	Unit:	%
Sample ID (AGAT ID)	RDL:	0.05
S1 Sa2-1977097 (1998977)		<0.05
S11 Sa3-1977199 (1998978)		<0.05
S4 Sa3-1977104 (1998979)		<0.05

Comments: RDL - Reported Detection Limit

Analysis performed at AGAT 5623 McAdam Rd., Mississauga, ON (unless marked by *)

Certified By: Sherin Moussa

(201-042) Sulfide

	REPLICATE #1				REPLICATE #2				REPLICATE #3							
Parameter	Sample ID	Original	Replicate	RPD	Sample ID	Original	Replicate	RPD	Sample ID	Original	Replicate	RPD				
S	1998977	0.012	0.014	15.4%	1998978	0.035	0.035	0.0%	1998979	0.034	0.035	2.9%				
Sulfate	1998977	< 0.01	< 0.01	0.0%	1998978	< 0.01	< 0.01	0.0%	1998979	< 0.01	< 0.01	0.0%				
Sulfide	1998977	< 0.05	< 0.05	0.0%	1998978	< 0.05	< 0.05	0.0%	1998979	< 0.05	< 0.05	0.0%				

Quality Assurance - Certified Reference materials

AGAT WORK ORDER: 21T703309
PROJECT: 21T701373

CLIENT NAME: GOLDER ASSOCIATES LTD.
ATTENTION TO: Yusuf Soliman

(201-042) Sulfide

	CRM #1				CRM #2				CRM #3							
Parameter	Expect	Actual	Recovery	Limits	Expect	Actual	Recovery	Limits	Expect	Actual	Recovery	Limits				
S	0.80	0.81	101%	90% - 110%	0.80	0.80	100%	90% - 110%	0.80	0.80	100%	90% - 110%				
Sulfate	0.01	0.01	100%	90% - 110%	0.01	0.01	100%	90% - 110%	0.01	0.01	100%	90% - 110%				
Sulfide	0.80	0.80	100%	90% - 110%	0.80	0.79	98%	90% - 110%	0.80	0.79	98%	90% - 110%				

Method Summary

CLIENT NAME: GOLDER ASSOCIATES LTD.
PROJECT: 21T701373
SAMPLING SITE:

AGAT WORK ORDER: 21T703309
ATTENTION TO: Yusuf Soliman
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Solid Analysis			
Sulfide	MIN-200-12037		LECO

APPENDIX F

AASHTO Design Sheets

Table F-1
EQUIVALENT SINGLE AXLE LOAD CALCULATION

Warden Avenue - Widening design 20 years

1) Traffic Analysis

Traffic Data Year	2018		2041		2050
Design Year	**2023**				
Traffic Analysis Period		23		9	
Average Annual Daily Traffic (AADT)	11,500		40,000		65,153
Average Rate of Increase in Traffic (%)		5.57		5.57	
Truck Fraction of Total Traffic (%)	6		6		6
Average Rate of Increase in Truck Fraction (%)		0.00		0.00	
Number of Lanes in One Direction	1		2		2
Directional Factor	0.5		0.5		0.5
Lane Distribution Factor	1		0.8		0.8
Daily Truck Volume	**452**		**960**		**1,564**

2) Daily ESALs Analysis

Road Classification		***Urban Minor Arterial***		
Traffic Analysis Base Year		2023	2041	2050
Breakdown of Truck Proportions (%)	Class 1	65		
	Class 2	5		
	Class 3	20		
	Class 4	10		
Daily Truck Volumes for 4 Classes	Class 1	294	624	1,016
	Class 2	23	48	78
	Class 3	90	192	313
	Class 4	45	96	156
Truck Factors for 4 Classes of Truck	Class 1	0.5		
	Class 2	2.3		
	Class 3	1.6		
	Class 4	5.5		
Weighted Average Truck Factor			**1.310**	
Daily ESALs per Truck Class	Class 1	147	312	508
	Class 2	52	110	180
	Class 3	145	307	500
	Class 4	249	528	860
Total Daily ESALs in Design Lane		**593**	**1,258**	**2,048**

3) Total ESALs for Base Year

Base Year	2023	2041	2050
Number of Days of Truck Traffic	365	365	365
Total ESALs for Base Year	**216,307**	**459,024**	**747,665**

4) Cumulative ESALs for the Design Period

Design Period (Years)	**20**	
Span of Design Periods	2023 to 2041	2041 to 2043
Average Rate of Increase in Truck Volume (%)	4.27	5.57
Years of Design Periods	18	2
Growth Factor	29.67	2.06
ESALs for the Design Periods	6,419,000	944,000
Cumulative ESALs for the Design Period	7,362,294	

Note: The ESAL calculations are baesd on the guidelines "Procedures for Estimating Traffic Loads for Pavement Design" by Jerry Hajek, 1995, and on MTO's "Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions", March 19, 2008.

Designed by: IM
Checked by: ACB

Golder Associates Ltd.

Table F-2
PAVEMENT DESIGN AND ANALYSIS - FLEXIBLE STRUCTURAL DESIGN MODULE

Warden Avenue - Reconstruction and Widening design 20 years

Flexible Structural Design

80-kN ESALs Over Initial Performance Period	7,400,000
Initial Serviceability	4.4
Terminal Serviceability	2.2
Reliability Level (%)	90
Overall Standard Deviation	0.47
Roadbed Soil Resilient Modulus	20,000 kPa
Stage Construction	1.0
Calculated Design Structural Number	152

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di) (mm)	Required Thickness (mm)	Calculated SN (mm)
1	New Hot Mix Asphalt	0.42	1.00	200	200	84
2	New Granular A Base	0.14	1.00	150	150	21
3	New Granular B,Type I	0.09	1.00	500	500	45
Total	-	-	-	850	850	150

Layered Thickness Design

Thickness precision

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Actual Spec Thickness (Di) (mm)	Min Thickness (Di) (mm)	Elastic Modulus (kPa)	Calculated Thickness (mm)	Calculated SN (mm)
1	New Hot Mix Asphalt	0.42	1.00	-	-	2,750,000	160	67
2	New Granular A Base	0.14	1.00	-	-	240,000	151	21
3	New Granular B,Type I	0.09	1.00	-	-	110,000	711	64
Total	-	-	-	-	-	-	1022	152
-								

Designed by: IM
Checked by: ACB

Table F-3
EQUIVALENT SINGLE AXLE LOAD CALCULATION

Warden Avenue - Rehabilitation design
12 year ESALs

1) Traffic Analysis

Traffic Data Year	2018		2041		2050
Design Year	**2023**				
Traffic Analysis Period		23		9	
Average Annual Daily Traffic (AADT)	11,500		40,000		65,153
Average Rate of Increase in Traffic (%)		5.57		5.57	
Truck Fraction of Total Traffic (%)	6		6		6
Average Rate of Increase in Truck Fraction (%)		0.00		0.00	
Number of Lanes in One Direction	1		2		2
Directional Factor	0.5		0.5		0.5
Lane Distribution Factor	1		0.8		0.8
Daily Truck Volume	**452**		**960**		**1,564**

2) Daily ESALs Analysis

Road Classification		***Urban Minor Arterial***		
Traffic Analysis Base Year		2023	2041	2050
Breakdown of Truck Proportions (%)	Class 1	65		
	Class 2	5		
	Class 3	20		
	Class 4	10		
Daily Truck Volumes for 4 Classes	Class 1	294	624	1,016
	Class 2	23	48	78
	Class 3	90	192	313
	Class 4	45	96	156
Truck Factors for 4 Classes of Truck	Class 1	0.5		
	Class 2	2.3		
	Class 3	1.6		
	Class 4	5.5		
Weighted Average Truck Factor			**1.310**	
Daily ESALs per Truck Class	Class 1	147	312	508
	Class 2	52	110	180
	Class 3	145	307	500
	Class 4	249	528	860
Total Daily ESALs in Design Lane		**593**	**1,258**	**2,048**

3) Total ESALs for Base Year

Base Year	2023	2041	2050
Number of Days of Truck Traffic	365	365	365
Total ESALs for Base Year	**216,307**	**459,024**	**747,665**

4) Cumulative ESALs for the Design Period

Design Period (Years)	**12**
Span of Design Periods	2023 to 2035
Average Rate of Increase in Truck Volume (%)	4.27
Years of Design Periods	12
Growth Factor	16.45
ESALs for the Design Periods	3,559,000
Cumulative ESALs for the Design Period	**3,558,624**

Note: The ESAL calculations are baesd on the guidelines "Procedures for Estimating Traffic Loads for Pavement Design" by Jerry Hajek, 1995, and on MTO's "Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions", March 19, 2008.

Designed by: IM
Checked by: ACB

Golder Associates Ltd.

Table F-4
EQUIVALENT SINGLE AXLE LOAD CALCULATION

Warden Avenue - Rehabilitation design
14 year ESALs

---

1) Traffic Analysis

Traffic Data Year	2018		2041		2050
Design Year	**2023**				
Traffic Analysis Period		23		9	
Average Annual Daily Traffic (AADT)	11,500		40,000		65,153
Average Rate of Increase in Traffic (%)		5.57		5.57	
Truck Fraction of Total Traffic (%)	6		6		6
Average Rate of Increase in Truck Fraction (%)		0.00		0.00	
Number of Lanes in One Direction	1		2		2
Directional Factor	0.5		0.5		0.5
Lane Distribution Factor	1		0.8		0.8
Daily Truck Volume	**452**		**960**		**1,564**

2) Daily ESALs Analysis

Road Classification		***Urban Minor Arterial***		
Traffic Analysis Base Year		2023	2041	2050
Breakdown of Truck Proportions (%)	Class 1	65		
	Class 2	5		
	Class 3	20		
	Class 4	10		
Daily Truck Volumes for 4 Classes	Class 1	294	624	1,016
	Class 2	23	48	78
	Class 3	90	192	313
	Class 4	45	96	156
Truck Factors for 4 Classes of Truck	Class 1	0.5		
	Class 2	2.3		
	Class 3	1.6		
	Class 4	5.5		
Weighted Average Truck Factor			**1.310**	
Daily ESALs per Truck Class	Class 1	147	312	508
	Class 2	52	110	180
	Class 3	145	307	500
	Class 4	249	528	860
Total Daily ESALs in Design Lane		**593**	**1,258**	**2,048**

3) Total ESALs for Base Year

Base Year	2023	2041	2050
Number of Days of Truck Traffic	365	365	365
Total ESALs for Base Year	**216,307**	**459,024**	**747,665**

4) Cumulative ESALs for the Design Period

Design Period (Years)		**14**
Span of Design Periods	2023 to 2037	
Average Rate of Increase in Truck Volume (%)	4.27	
Years of Design Periods	14	
Growth Factor	20.39	
ESALs for the Design Periods	4,411,000	
Cumulative ESALs for the Design Period		**4,410,701**

Note: The ESAL calculations are baesd on the guidelines "Procedures for Estimating Traffic Loads for Pavement Design" by Jerry Hajek, 1995, and on MTO's "Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions", March 19, 2008.

Designed by: IM
Checked by: ACB

Table F-5
EQUIVALENT SINGLE AXLE LOAD CALCULATION

Warden Avenue - Rehabilitation design
11 year ESALs

---

1) Traffic Analysis

Traffic Data Year	2018		2041		2050
Design Year	<u>**2023**</u>				
Traffic Analysis Period		23		9	
Average Annual Daily Traffic (AADT)	11,500		40,000		65,153
Average Rate of Increase in Traffic (%)		5.57		5.57	
Truck Fraction of Total Traffic (%)	6		6		6
Average Rate of Increase in Truck Fraction (%)		0.00		0.00	
Number of Lanes in One Direction	1		2		2
Directional Factor	0.5		0.5		0.5
Lane Distribution Factor	1		0.8		0.8
Daily Truck Volume	**452**		**960**		**1,564**

2) Daily ESALs Analysis

Road Classification			***Urban Minor Arterial***	
Traffic Analysis Base Year		2023	2041	2050
Breakdown of Truck Proportions (%)	Class 1	65		
	Class 2	5		
	Class 3	20		
	Class 4	10		
Daily Truck Volumes for 4 Classes	Class 1	294	624	1,016
	Class 2	23	48	78
	Class 3	90	192	313
	Class 4	45	96	156
Truck Factors for 4 Classes of Truck	Class 1	0.5		
	Class 2	2.3		
	Class 3	1.6		
	Class 4	5.5		
Weighted Average Truck Factor			**1.310**	
Daily ESALs per Truck Class	Class 1	147	312	508
	Class 2	52	110	180
	Class 3	145	307	500
	Class 4	249	528	860
Total Daily ESALs in Design Lane		**593**	**1,258**	**2,048**

3) Total ESALs for Base Year

Base Year	2023	2041	2050
Number of Days of Truck Traffic	365	365	365
Total ESALs for Base Year	**216,307**	**459,024**	**747,665**

4) Cumulative ESALs for the Design Period

Design Period (Years)	<u>**11**</u>
Span of Design Periods	<u>2023 to 2034</u>
Average Rate of Increase in Truck Volume (%)	4.27
Years of Design Periods	11
Growth Factor	14.64
ESALs for the Design Periods	3,166,000
Cumulative ESALs for the Design Period	<u>**3,165,995**</u>

Note: The ESAL calculations are baesd on the guidelines "Procedures for Estimating Traffic Loads for Pavement Design" by Jerry Hajek, 1995, and on MTO's "Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions", March 19, 2008.

Designed by: IM
Checked by: ACB

Table F-6
PAVEMENT DESIGN AND ANALYSIS - FLEXIBLE STRUCTURAL DESIGN MODULE

Warden Avenue - Rehabilitation design
Mill 100 mm / Pave 100 mm
(no grade raise)

Flexible Structural Design

80-kN ESALs Over Initial Performance Period	3,600,000
Initial Serviceability	4.4
Terminal Serviceability	2.2
Reliability Level (%)	90
Overall Standard Deviation	0.47
Roadbed Soil Resilient Modulus	25,000 kPa
Stage Construction	1.0
Calculated Design Structural Number	129

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di) (mm)	Required Thickness (mm)	Calculated SN (mm)
1	New Hot Mix Asphalt	0.42	1.00	100	100	42
2	Existing Hot Mix Asphalt	0.28	1.00	160	160	45
3	Existing Granular Base	0.10	0.90	190	190	17
4	Existing Granuar Subbase	0.07	0.90	280	280	18
Total	-	-	-	730	730	122

Layered Thickness Design

Thickness precision

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Actual Spec Thickness (Di) (mm)	Min Thickness (Di) (mm)	Elastic Modulus (kPa)	Calculated Thickness (mm)	Calculated SN (mm)
1	New Hot Mix Asphalt	0.42	1.00	-	-	2,750,000	52	22
2	Existing Hot Mix Asphalt	0.28	1.00	-	-	2,500,000	143	40
3	Existing Granular Base	0.10	0.90	-	-	220,000	193	17
4	Existing Granuar Subbase	0.07	0.90	-	-	110,000	798	50
Total	-	-	-	-	-	-	1186	129

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Designed by: IM
Checked by:ACB

Table F-7
PAVEMENT DESIGN AND ANALYSIS - FLEXIBLE STRUCTURAL DESIGN MODULE

Warden Avenue - Rehabilitation design
Mill 50 mm / Pave 100 mm
(grade raise 50 mm)

Flexible Structural Design

80-kN ESALs Over Initial Performance Period	4,400,000
Initial Serviceability	4.4
Terminal Serviceability	2.2
Reliability Level (%)	90
Overall Standard Deviation	0.47
Roadbed Soil Resilient Modulus	25,000 kPa
Stage Construction	1.0
Calculated Design Structural Number	133

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di) (mm)	Required Thickness (mm)	Calculated SN (mm)
1	New Hot Mix Asphalt	0.42	1.00	100	100	42
2	Existing Hot Mix Asphalt	0.28	1.00	210	210	59
3	Existing Granular Base	0.10	0.90	190	190	17
4	Existing Granuar Subbase	0.07	0.90	280	280	18
Total	-	-	-	780	780	136

Layered Thickness Design

Thickness precision

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Actual Spec Thickness (Di) (mm)	Min Thickness (Di) (mm)	Elastic Modulus (kPa)	Calculated Thickness (mm)	Calculated SN (mm)
1	New Hot Mix Asphalt	0.42	1.00	-	-	2,750,000	55	23
2	Existing Hot Mix Asphalt	0.28	1.00	-	-	2,500,000	146	41
3	Existing Granular Base	0.10	0.90	-	-	220,000	198	18
4	Existing Granuar Subbase	0.07	0.90	-	-	110,000	815	51
Total	-	-	-	-	-	-	1214	133

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Designed by: IM
Checked by: ACB

Table F-8

PAVEMENT DESIGN AND ANALYSIS - FLEXIBLE STRUCTURAL DESIGN MODULE

Warden Avenue - Rehabilitation design
Mill 10 mm / Pave 50 mm
(grade raise 40 mm)

Flexible Structural Design

80-kN ESALs Over Initial Performance Period	3,200,000
Initial Serviceability	4.4
Terminal Serviceability	2.2
Reliability Level (%)	90
Overall Standard Deviation	0.47
Roadbed Soil Resilient Modulus	25,000 kPa
Stage Construction	1.0
Calculated Design Structural Number	127

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di) (mm)	Required Thickness (mm)	Calculated SN (mm)
1	New Hot Mix Asphalt	0.42	1.00	50	50	21
2	Existing Hot Mix Asphalt	0.28	1.00	250	250	70
3	Existing Granular Base	0.10	0.90	190	190	17
4	Existing Granuar Subbase	0.07	0.90	280	280	18
Total	-	-	-	770	770	126

Layered Thickness Design

Thickness precision

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Actual Spec Thickness (Di) (mm)	Min Thickness (Di) (mm)	Elastic Modulus (kPa)	Calculated Thickness (mm)	Calculated SN (mm)
1	New Hot Mix Asphalt	0.42	1.00	-	-	2,750,000	51	21
2	Existing Hot Mix Asphalt	0.28	1.00	-	-	2,500,000	141	39
3	Existing Granular Base	0.10	0.90	-	-	220,000	190	17
4	Existing Granuar Subbase	0.07	0.90	-	-	110,000	788	50
Total	-	-	-	-	-	-	1170	127

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Designed by: IM
Checked by: ACB

APPENDIX G

Life Cycle Cost Analysis

Table G-1

REHABILITATION COST ANALYSIS (Per Lane, Per Kilometre)

Warden Avenue Rehabilitation Options

SUMMARY OF LIFE COST ANALYSIS

OPTIONS	STRATEGY DESCRIPTION	INITIAL COST	MAIN'T COST	50 YEAR LCC	RANKING
Option 1	**Mill 100 mm /Place 100 mm (12-year)**	$162,469	$152,379	$314,848	**3**
Option 2	**Mill 50 mm / Place 100 mm (14-year)**	$139,219	$145,088	$284,307	**1**
Option 3	**Mill 10 mm / Place 50 mm (10-year)**	$86,438	$197,775	$284,213	**1**

Length	**1,000**	m
Width	**3.75**	m
Area	**3750**	sq.m

Option 1 Mill 100 mm /Place 100 mm (12-year)

	%	Thickness (mm)	Unit Weight	Quantity	Unit	Unit Price	Cost
Milling	200%	100	-	7,500	sq.m	6.20	46,500
SP 12.5 FC2	100%	50	2.50	469	t	130.00	60,938
SP 19.0	100%	50	2.45	459	t	110.00	50,531
Tack Coat	200%	-	-	7,500	sq.m	0.60	4,500
						TOTAL	**162,469**

Option 2 Mill 50 mm / Place 100 mm (14-year)

	%	Thickness (mm)	Unit Weight	Quantity	Unit	Unit Price	Cost
Milling	100%	50	-	3,750	sq.m	6.20	23,250
SP 12.5 FC2	100%	50	2.50	469	t	130.00	60,938
SP 19.0	100%	50	2.45	459	t	110.00	50,531
Tack Coat	200%	-	-	7,500	sq.m	0.60	4,500
						TOTAL	**139,219**

Option 3 Mill 10 mm / Place 50 mm (10-year)

	%	Thickness (mm)	Unit Weight	Quantity	Unit	Unit Price	Cost
Milling	100%	10	-	3,750	sq.m	6.20	23,250
SP 12.5 FC2	100%	50	2.50	469	t	130.00	60,938
Tack Coat	100%	-	-	3,750	sq.m	0.60	2,250
						TOTAL	**86,438**

Table G-2
50 YEAR LIFE CYCLE COST ANALYSIS
(Per Lane, Per Kilometer, 5.0 % Discount Rate)
Warden Avenue Rehabilitation Options
Mill 100 mm /Place 100 mm (12-year)
OPTION 1

Scheduled Maint/Rehab Year	**Maintenance/Rehabilitation Treatment**	**Work %**	**Quantities** (Per C/L km)	**Pay Item Price** ($)	**Cost** (Per C/L km)	**Maint/Rehab Cost** (Per C/L km)	**Net Present Worth $**
0	**Initial Construction Cost**						**$162,469**
3	Rout and Seal Cracks		120 m	$12.00	$1,440	$1,440	$1,244
8	Rout and Seal Cracks		240 m	$12.00	$2,880	$2,880	$1,949
8	Mill 50 mm and Patch 50 mm		150 sq.m	$17.50	$2,625	$2,625	$1,777
12	**Mill 50 mm asphalt pavement**	100%	3,750 sq.m	$6.20	$23,250	**$86,438**	**$48,132**
	Resurface SP 12.5 FC2 - 50 mm	100%	469 t	$130.00	$60,938		
	Tack Coat - 1 layer	100%	3,750 sq.m	$0.60	$2,250		
15	Rout and Seal Cracks		150 m	$12.00	$1,800	$1,800	$866
18	Rout and Seal Cracks		280 m	$12.00	$3,360	$6,860	$2,850
	Mill 50 mm and Patch 50 mm		200 sq.m	$17.50	$3,500		
21	**Mill 100 mm asphalt pavement**	200%	7,500 sq.m	$6.20	$46,500	**$162,469**	**$58,317**
	Resurface SP 12.5 FC2 - 50 mm	100%	469 t	$130.00	$60,938		
	SP 19.0 - 50 mm	100%	459 t	$110.00	$50,531		
	Tack Coat - 2 layers	200%	7,500 sq.m	$0.60	$4,500		
24	Rout and Seal Cracks		120 m	$12.00	$1,440	$1,440	$446
29	Rout and Seal Cracks		240 m	$12.00	$2,880	$2,880	$700
29	Mill 50 mm and Patch 50 mm		150 sq.m	$17.50	$2,625	$2,625	$638
33	**Mill 50 mm asphalt pavement**	100%	3,750 sq.m	$6.20	$23,250	**$86,438**	**$17,276**
	Resurface SP 12.5 FC2 - 50 mm	100%	469 t	$130.00	$60,938		
	Tack Coat - 1 layer	100%	3,750 sq.m	$0.60	$2,250		
36	Rout and Seal Cracks		150 m	$12.00	$1,800	$1,800	$311
39	Rout and Seal Cracks		280 m	$12.00	$3,360	$3,360	$501
39	Mill 50 mm and Patch 50 mm		200 sq.m	$17.50	$3,500	$3,500	$522
42	**Mill 100 mm asphalt pavement**	200%	7,500 sq.m	$6.20	$46,500	**$162,469**	**$20,932**
	Resurface SP 12.5 FC2 - 50 mm	100%	469 t	$130.00	$60,938		
	SP 19.0 - 50 mm	100%	459 t	$110.00	$50,531		
	Tack Coat - 2 layers	200%	7,500 sq.m	$0.60	$4,500		
45	Rout and Seal Cracks		120 m	$12.00	$1,440	$1,440	$160
50	Rout and Seal Cracks		240 m	$12.00	$2,880	$2,880	$251
50	Mill 50 mm and Patch 50 mm		150 sq.m	$17.50	$2,625	$2,625	$229
50	**Salvage Value**				-$54,156	**-$54,156**	**-$4,723**
						Subtotal	$152,379
						Initial Cost	$162,469
						TOTAL	**$314,848**

Table G-3
50 YEAR LIFE CYCLE COST ANALYSIS

(Per Lane, Per Kilometer, 5.0 % Discount Rate)
Warden Avenue Rehabilitation Options

Mill 50 mm / Place 100 mm (14-year)

OPTION 2

Scheduled Maint/Rehab Year	**Maintenance/Rehabilitation Treatment**	**Work %**	**Quantities** (Per C/L km)	**Pay Item Price** ($)	**Cost** (Per C/L km)	**Maint/Rehab Cost** (Per C/L km)	**Net Present Worth $**
0	**Initial Construction Cost**						**$139,219**
3	Rout and Seal Cracks		120 m	$12.00	$1,440	$1,440	$1,244
8	Rout and Seal Cracks		240 m	$12.00	$2,880	$2,880	$1,949
8	Mill 50 mm and Patch 50 mm		150 sq.m	$17.50	$2,625	$2,625	$1,777
11	Rout and Seal Cracks		240 m	$12.00	$2,880	$2,880	$1,684
11	Mill 50 mm and Patch 50 mm		150 sq.m	$17.50	$2,625	$2,625	$1,535
14	**Mill 50 mm asphalt pavement**	100%	3,750 sq.m	$6.20	$23,250	**$86,438**	**$43,657**
	Resurface SP 12.5 FC2 - 50 mm	100%	469 t	$130.00	$60,938		
	Tack Coat - 1 layer	100%	3,750 sq.m	$0.60	$2,250		
17	Rout and Seal Cracks		150 m	$12.00	$1,800	$1,800	$785
20	Rout and Seal Cracks		280 m	$12.00	$3,360	$6,860	$2,585
	Mill 50 mm and Patch 50 mm		200 sq.m	$17.50	$3,500		
23	**Mill 100 mm asphalt pavement**	200%	7,500 sq.m	$6.20	$46,500	**$162,469**	**$52,895**
	Resurface SP 12.5 FC2 - 50 mm	100%	469 t	$130.00	$60,938		
	SP 19.0 - 50 mm	100%	459 t	$110.00	$50,531		
	Tack Coat - 2 layers	200%	7,500 sq.m	$0.60	$4,500		
26	Rout and Seal Cracks		120 m	$12.00	$1,440	$1,440	$405
31	Rout and Seal Cracks		240 m	$12.00	$2,880	$2,880	$635
31	Mill 50 mm and Patch 50 mm		150 sq.m	$17.50	$2,625	$2,625	$578
35	**Mill 50 mm asphalt pavement**	100%	3,750 sq.m	$6.20	$23,250	**$86,438**	**$15,670**
	Resurface SP 12.5 FC2 - 50 mm	100%	469 t	$130.00	$60,938		
	Tack Coat - 1 layer	100%	3,750 sq.m	$0.60	$2,250		
38	Rout and Seal Cracks		150 m	$12.00	$1,800	$1,800	$282
41	Rout and Seal Cracks		280 m	$12.00	$3,360	$6,860	$928
	Mill 50 mm and Patch 50 mm		200 sq.m	$17.50	$3,500		
44	**Mill 100 mm asphalt pavement**	200%	7,500 sq.m	$6.20	$46,500	**$162,469**	**$18,986**
	Resurface SP 12.5 FC2 - 50 mm	100%	469 t	$130.00	$60,938		
	SP 19.0 - 50 mm	100%	459 t	$110.00	$50,531		
	Tack Coat - 2 layers	200%	7,500 sq.m	$0.60	$4,500		
47	Rout and Seal Cracks		120 m	$12.00	$1,440	$1,440	$145
49	Rout and Seal Cracks		240 m	$12.00	$2,880	$2,880	$264
	Mill 50 mm and Patch 50 mm		150 sq.m	$17.50	$2,625	$2,625	$2,625
50	**Salvage Value**				-$40,617	**-$40,617**	**-$3,542**
						Subtotal	$145,088
						Initial Cost	$139,219
						TOTAL	**$284,307**

Table G-4

50 YEAR LIFE CYCLE COST ANALYSIS

(Per Lane, Per Kilometer, 5.0 % Discount Rate)

Warden Avenue Rehabilitation Options

Mill 10 mm / Place 50 mm (10-year)

OPTION 3

Scheduled Maint/Rehab Year	**Maintenance/Rehabilitation Treatment**	**Work %**	**Quantities** (Per C/L km)	**Pay Item Price** ($)	**Cost** (Per C/L km)	**Maint/Rehab Cost** (Per C/L km)	**Net Present Worth $**
0	**Initial Construction Cost**						**$86,438**
3	Rout and Seal Cracks		400 m	$12.00	$4,800	$4,800	$4,146
7	Rout and Seal Cracks		500 m	$12.00	$6,000	$6,000	$4,264
7	Mill 50 mm and Patch 50 mm		400 sq.m	$17.50	$7,000	$7,000	$4,975
10	**Mill 100 mm asphalt pavement**	200%	7,500 sq.m	$6.20	$46,500	**$162,469**	**$99,742**
	Resurface SP 12.5 FC2 - 50 mm	100%	469 t	$130.00	$60,938		
	SP 19.0 - 50 mm	100%	459 t	$110.00	$50,531		
	Tack Coat - 2 layers	200%	7,500 sq.m	$0.60	$4,500		
13	Rout and Seal Cracks		150 m	$12.00	$1,800	$1,800	$955
18	Rout and Seal Cracks		280 m	$12.00	$3,360	$6,860	$2,850
	Mill 50 mm and Patch 50 mm		200 sq.m	$17.50	$3,500		
22	**Mill 50 mm asphalt pavement**	100%	3,750 sq.m	$6.20	$23,250	**$86,438**	**$29,549**
	Resurface SP 12.5 FC2 - 50 mm	100%	469 t	$130.00	$60,938		
	Tack Coat - 1 layer	100%	3,750 sq.m	$0.60	$2,250		
25	Rout and Seal Cracks		200 m	$12.00	$2,400	$2,400	$709
28	Rout and Seal Cracks		300 m	$12.00	$3,600	$3,600	$918
28	Mill 50 mm and Patch 50 mm		250 sq.m	$17.50	$4,375	$4,375	$1,116
31	**Mill 100 mm asphalt pavement**	200%	7,500 sq.m	$6.20	$46,500	**$162,469**	**$35,802**
	Resurface SP 12.5 FC2 - 50 mm	100%	469 t	$130.00	$60,938		
	SP 19.0 - 50 mm	100%	459 t	$110.00	$50,531		
	Tack Coat - 2 layers	200%	7,500 sq.m	$0.60	$4,500		
34	Rout and Seal Cracks		150 m	$12.00	$1,800	$1,800	$343
38	Rout and Seal Cracks		280 m	$12.00	$3,360	$6,860	$1,074
	Mill 50 mm and Patch 50 mm		200 sq.m	$17.50	$3,500		
42	**Mill 50 mm asphalt pavement**	100%	3,750 sq.m	$6.20	$23,250	**$86,438**	**$11,137**
	Resurface SP 12.5 FC2 - 50 mm	100%	469 t	$130.00	$60,938		
	Tack Coat - 1 layer	100%	3,750 sq.m	$0.60	$2,250		
45	Rout and Seal Cracks		200 m	$12.00	$2,400	$2,400	$267
48	Rout and Seal Cracks		300 m	$12.00	$3,600	$3,600	$346
48	Mill 50 mm and Patch 50 mm		250 sq.m	$17.50	$4,375	$4,375	$421
50	**Salvage Value**				-$9,604	**-$9,604**	**-$838**
						Subtotal	$197,775
						Initial Cost	$86,438
						TOTAL	**$284,213**

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