FINAL REPORT

Foundation Investigation and Design
Green’s Creek Twin Culverts Rehabilitation
Temporary Water Diversion Systems
Site No. 3-312/C
Walkley Road
Ottawa, Ontario

GWP No. 4099-11-00

W.P. 4320-13-01

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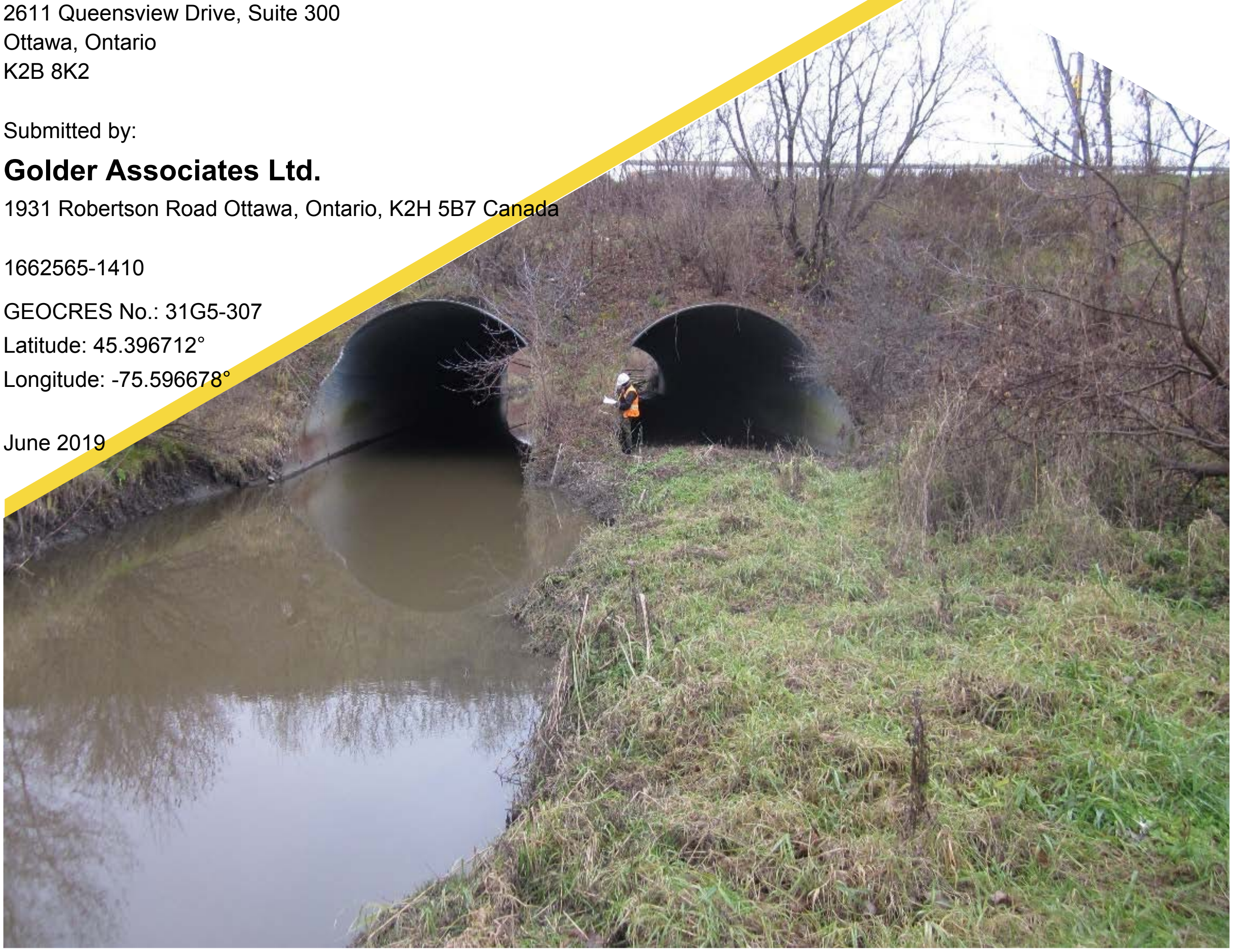

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PART A

Foundation Investigation
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Temporary Water Diversion Systems

Site No. 3-312/C
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W.P. 4320-13-01

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by WSP Canada Group Limited (WSP) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations associated with numerous bridge and structural culvert rehabilitations and/or replacements on Highway 417 between the Aviation Parkway and Ramsayville Road as well as the widening of Highway 417 from Ottawa Regional Road 174 (OR 174) to Hunt Club Road in Ottawa, Ontario (Assignment number 4016-E-0008).

This report presents the results of the foundation investigation carried out for the temporary water diversion systems associated with the rehabilitation of the Green's Creek twin culverts (Site No. 3-312/C) located beneath Walkley Road in Ottawa, Ontario, (W.P. 4320-13-01).

The terms of reference and scope of work for the foundation investigation are outlined in the MTO's Request for Proposal (RFP), dated May 2016, and subsequent addenda. Golder's scope of work for foundation engineering services associated with this culvert site is contained in Table 17.8.3 of WSP's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Quality Control Plan for foundation engineering services for this project dated May 13, 2017.

2.0 SITE DESCRIPTION AND GEOLOGY

2.1 General

The twin culverts (Site 3-312/C) are located at approximate Station 10+375 on Walkley Road, approximately 350 m southwest of the Highway 417 / Walkley Road interchange in the City of Ottawa, Ontario. The location of the twin culverts is shown on the Key Plan on Drawing 1.

Walkley Road at this location has two through lanes in each direction separated by a concrete median. The roadway was constructed with an urban cross section with concrete curbs and paved sidewalks. The Walkley Road northbound N-E on-ramp to Highway 417 eastbound, and the Highway 417 eastbound E-S off-ramp also extend over the existing twin culverts. There are steel beam guide rail systems present along both sides of Walkley Road in the vicinity of the twin culverts crossing.

Archival construction drawings indicate that the existing twin culverts are 66.5 m long, steel plate culverts that have an internal diameter of 5.5 m and were constructed with beveled inlet and outlet sections. Information provided in the RFP indicates that the twin culverts were constructed in 1973. Based on the noted culvert invert elevation of Elevation 60.0 m, the existing twin culverts are likely founded in the silty clay stratum. The flow through the twin culverts is from south to north. It was noted in WSP's culvert inspection report that creek flow was only through the east culvert as upwards of 2.0 m of sediment and other debris has block creek flow from entering the west culvert.

It is understood that the existing culverts are to remain and that the proposed rehabilitation plan will include invert concrete paving of both culverts. It is anticipated that the existing creek flow will be diverted through the first culvert while work is being carried out in the second. Once rehabilitation works are completed in the second culvert, flow will be diverted through it and rehabilitation works would be completed in the first.

The existing pavement grade of Walkley Road at the location is at approximate Elevation 70.0 m as such upwards of 4.5 m of fill has been placed over the top of the existing twin culverts beneath the travel lanes. Mature trees are located on the north side of Walkley Road while the south side is brush and grass covered. The existing embankment slopes appear to be performing well with no signs of slope instability/distresses observed during

Golder's field investigation program. Some erosion of the creek banks was noted in WSP's culvert inspection report.

2.2 Regional Geology

As delineated in *The Physiography of Southern Ontario*[1], this section of Walkley Road lies within the minor physiographic regions known as the Ottawa Valley Clay Plain, which lies within the major physiographic region of the Ottawa-St. Lawrence Lowland.

The Ottawa Valley Clay Plain region is characterized by relatively thick deposits of sensitive marine clay, silt and silty clay that were deposited within the Champlain Sea basin. These deposits, known as the Champlain Sea clay or Leda clay, overlie relatively thin, commonly reworked glacial till and glaciofluvial deposits, that in turn overlie bedrock[1].

This region is underlain by a series of sedimentary rocks, consisting of sandstones, dolostones, limestones and shales that are, in turn, underlain at depth by igneous and metamorphic bedrock of the Precambrian Shield. Regional bedrock mapping indicates that the bedrock at this site is primarily shale of the Carlsbad Formation[2] The shales were described as thinly bedded and fine grained.

The site falls within the Western Québec (WQ) seismic zone according to the Geological Survey of Canada. The WQ zone constitutes a large area which encompasses the urban areas of Montreal, Ottawa-Hull and Cornwall. Within the WQ zone recent seismic activity has been concentrated in two subzones; one along the Ottawa River and another more active subzone along the Montreal-Maniwaki axis. The two major earthquakes in the WQ zone includes the 1935 Témiscaming event which had a magnitude (i.e., a measure of the intensity of the earthquake) of 6.2, and the 1944 Cornwall-Massena event which had a magnitude of 5.6.

3.0 INVESTIGATION PROCEDURES

3.1 Current Investigation (2018)

The subsurface investigation for the rehabilitation of the twin culverts was carried out between August 16 and 22, 2018 and September 3 to 6, 2018, and included advancing a total of four boreholes designated 18-4101 to 18-4104, inclusive. The NAD83 CSRS CBNV6-2010.0 MTM Zone 9 locations and ground surface elevations of the boreholes are shown on Drawing 1. As this investigation was for temporary water diversion systems associated with the rehabilitation of the Green's Creek twin culverts boreholes were located at the inlet and outlet of the twin culverts.

The boreholes were advanced using portable rotary drilling equipment operated by Ohlmann Geotechnical Services Inc. of Almonte, Ontario. Traffic control required to close the driving lanes of the Walkley Road while carrying out field operations was provided Beacon Lite Ltd. of Ottawa Ontario.

The boreholes were advanced to refusal at depths ranging from approximately 7.3 to 10.4 m below the existing ground surface. The boreholes were sampled in continuous increments of about 0.6 m with a 50 mm outer diameter split-spoon sampler in accordance with ASTM D1586. In-situ vane testing was carried out within the cohesive deposits, where possible, specifically in Borehole 18-4103, using the MTO B-size vane.

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[1] Chapman, L. J. and Putnam, D. F., 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey. Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000. Ontario Ministry of Natural Resources.

[2] Belanger, J.R. "Urban Geology of Canada's National Capital Area", in Urban Geology of Canadian Cities, Geological Association of Canada Special Paper 42, Ed. P.F. Karrow and O.L. White, 1998.

A monitoring well was installed in Borehole 18-4102 to monitor the groundwater level at the site. The monitoring well consisted of 30 mm inside diameter PVC tubing with a 3.5 m long screen. The final groundwater levels were measured in the well on October 12, 2018 and then the well was decommissioned according to O.Reg 903.

The remainder of the boreholes were backfilled with bentonite mixed with soil cuttings. The site conditions were restored following completion of the field work.

The field work was supervised on a full-time basis by members of Golder's staff who located the boreholes in the field, directed the drilling, sampling and in-situ testing operations, logged the boreholes, and examined and cared for the soil samples. The soil samples were identified in the field, placed in appropriate containers, and transported to Golder's laboratory in Ottawa for further examination and testing. Index and classification tests consisting of water content determinations, Atterberg Limits testing, and grain size distribution analyses were carried out on selected soil samples. The laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate.

One soil sample from Borehole 18-4103 was submitted to Eurofins Environment Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack).

The borehole locations and elevations were surveyed by Golder using a Trimble R8 GPS unit referenced to the NAD83 CSRS CBNV6-2010.0 MTM Zone 9 geodetic datum. The borehole locations, including drilled depths, northing and easting coordinates, and ground surface elevations are summarized in Table 1.

Table 1: Borehole Summary 2018 Investigation

Borehole	Location	NAD83 CSRS CBNV6-2010.0 MTM Zone 9		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (m)	Easting (m)		
18-4101	North End of Culvert (east side of outlet)	5028959.4	375525.2	65.8	9.5
18-4102	North End of Culvert (west side of outlet)	5028949.0	375497.0	65.8	7.3
18-4103	South End of Culvert (east side of inlet)	5028902.9	375551.1	65.8	9.1
18-4104	South End of Culvert (west side of inlet)	5028891.1	375520.3	66.7	10.4

3.2 Previous Investigation (1972)

A previous investigation was carried out in 1972 by the Ministry of Transportation and Communications, Ontario for the design and construction of the existing twin culverts. The results of that investigation are contained in the report titled *"Foundation Investigation Report for Proposed Structure at the Crossing of the Walkley Road Extension and the Green Creek Diversion, Township of Gloucester, Regional Municipality of Ottawa-Carleton. District No. 9 (Ottawa)* W.P. 10-69-13" dated December 28, 1972, (GEOCRES 31G05-87).

As part of the current assignment, previously collected subsurface information pertinent to the site was reviewed and compiled.

A total of two boreholes and one dynamic cone penetration test were advanced at the site as part of the 1972 investigation, with the Boreholes 1, 1A and 2 located along the then proposed Green's Creek realignment and culvert alignment. The Record of Borehole sheets and laboratory testing results from the previous investigation are provided for reference in Appendix C. The approximate borehole locations and ground surface elevations are included on the Record of Borehole and are also shown on Drawing 1. The locations and ground surface elevations of the previous test hole locations should be considered approximate since the locations were referenced to an imperial borehole location plan and elevation datum rather than metric MTM coordinates.

4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 General

The subsurface soil, bedrock and groundwater conditions encountered in the boreholes and the results of in-situ and laboratory testing from the current investigation are given on the Record of Borehole sheets presented in Appendix A. The results of geotechnical laboratory testing from the current investigation are presented on Figures B1 to B5 in Appendix B. The results of basic chemical analysis carried out on a single soil sample from Borehole 18-4103 are included in Appendix D. The borehole locations and the interpreted stratigraphic profile in the areas of the proposed temporary water diversion systems (existing inlet/outlet of the twin culverts) are shown on Drawing 1. Site Photographs showing the general conditions of the site are provided in Appendix E.

The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic section are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

4.2 Site Stratigraphy Overview

In general, the subsurface conditions at the borehole locations consist of a thin layer of surficial topsoil materials extending down to depths of 0.1 and 0.2 m (Elevations 65.6 to 66.5 m). Below the surficial topsoil materials, the embankment fill materials, where encountered, extends down to depths of 1.8 to 2.4 m (Elevations 64.0 to 64.3 m), overlying a silty clay deposit extending down to depths of 7.0 to 7.9 m (Elevations 57.9 m to 58.9 m). A sand and silt layer was encountered below the silty clay layer that extends down to depths of between 8.5 to 9.2 m (Elevations 56.7 to 57.6 m). The sand and silt layer is underlain by a silt and sand glacial till extending down to depths between 9.5 to 14.6 m (Elevation 51.9 to 56.3). The depth to the bedrock surface was proved by coring in a single borehole from the 1972 investigation at a depth of 14 m corresponding to Elevation 52.1 m.

The groundwater level was measured at a depth of 2.6 m (Elevation 63.2 m) in Borehole 18-4102.

4.3 Surficial Materials

A layer of topsoil was encountered at the ground surface in all boreholes advanced during the current investigation. The thickness of this layer ranged from 100 to 200 mm at the borehole locations.

4.4 Fill

Silty Sand

A fill layer consisting predominantly of sand with varying amounts of silt and gravel was encountered below the surficial topsoil in Boreholes 18-4101 and 18-4104. The top of this layer was encountered at elevations 65.7 and 66.5 m. The thickness of the layer was 1.7 and 2.2 m. The SPT N values ranged from 17 to 77, but more typically 17 to 28 indicating a compact condition.

The moisture content of the samples tested were 5 and 6 percent.

4.5 Silty Clay to Clay

A grey-brown weathered clay/silty clay crust deposit was encountered beneath the fill materials in Boreholes 18-4101 and 18-4104 and below the surficial topsoil in Boreholes 18-4102 and 18-4103. The top of this layer ranges from Elevation 64.0 to 65.6 m. The thickness of this layer ranged from 2.0 to 4.4 m. The SPT N values ranged from 4 to 35, indicating a stiff to very stiff consistency but typically very stiff.

The moisture content of the samples tested ranged from 27 to 60 percent. The results of a grain size analysis test conducted on a single sample of this material are illustrated on Figure B2 in Appendix B. The results of six Atterberg Limits tests completed on this material indicated liquid limits ranging from 46 to 57, plastic limits ranging from 19 to 24, and plasticity indices ranging from 26 to 33. Atterberg Limits analysis results are illustrated on Figure B1 in Appendix B and indicate a clay/silty clay with intermediate to high plasticity (CI to CH), but typically high plasticity (CH).

A grey silty clay with silt seams was encountered beneath the clay crust in the boreholes. The top of this layer ranges from Elevation 61.2 to 62.0 m. The thickness of this layer ranged from 2.3 to 4.0 m. The SPT N values ranged from 2 to 12. In-situ shear vane test results indicated undrained shear strengths ranging from 29 to 80 kPa, indicating a firm to stiff consistency, but more typically stiff.

The moisture content of the samples tested ranged from 34 to 60 percent. The results of grain size analysis testing conducted on three samples of this material are illustrated on Figure B3 in Appendix B. The results of four Atterberg Limits tests completed on this material indicated liquid limits ranging from 29 to 38, plastic limits ranging from 14 to 17, and plasticity indices ranging from 13 to 19. Atterberg Limits analysis results are illustrated on Figure B1 in Appendix B and indicate a silty clay with a low to intermediate plasticity (CL to CI), but typically low plasticity (CL).

4.6 Sand and Silt

A sand and silt layer with varying amounts of clay and gravel was encountered below the silty clay layer in Boreholes 18-4101, 18-1403 and 18-4104. In Borehole 18-4104 this layer also becomes a clayey sandy silt. The top of this layer ranges from Elevation 57.9 to 58.9 m. The thickness of this layer ranged from 1.2 to 1.5 m. The SPT N values ranged from 5 to 12, indicating a loose to compact condition.

The moisture content of the samples tested ranged from 8 to 9 percent. The results of grain size analysis testing conducted on two samples of this material are illustrated on Figure B4 in Appendix B. The results of an Atterberg Limits test completed on a single sample of the clayey sandy silt material from Borehole 18-4104 indicated a liquid limit of 17, a plastic limit of 12, and a plasticity index of 5, indicating a clayey silt (CL-ML). Atterberg Limits analysis results are illustrated on Figure B5 in Appendix B

4.7 Gravelly Sand and Silt - Glacial Till

A non-cohesive glacial till deposit consisting of a heterogeneous mixture of sand, gravel and silt was encountered beneath the sand and silt layer in Boreholes 18-4101 and 18-4104. The top of this layer ranges from Elevation 57.3 to 57.6 m. The thickness of this layer ranged from 1.0 to 1.2 m as inferred from casing refusal. The SPT N values ranged from 20 to greater than 100, indicating a compact to very dense condition. Cobbles were noted in this layer in Borehole 18-4101 and may have affected the SPT N values.

The moisture content of the samples tested ranged from 8 to 15 percent.

4.8 Auger Refusal and Bedrock

The overburden materials were underlain by a grey shale. Bedrock geology mapping indicates the shale bedrock is of the Carlsbad Formation. The depth to and elevation of the bedrock surface was inferred by refusal to auger advancement in Borehole 1 and proved by coring with BX-size coring equipment in Borehole 2, during the 1972 investigation. Refusal to auger advancement was encountered in/on the glacial till layer in two of the boreholes advanced during the current investigation.

Table 2 summarizes the depth to, and the elevation of the auger refusal as encountered at the borehole locations from the current investigation.

Table 2: Summary of Refusal Depths and Elevations Current Investigation

Borehole	Existing Ground Surface Elevation (m)	Depth to Refusal (m)	Refusal Elevation (m)
18-4101	65.8	9.5	56.3
18-4103	65.8	9.1	56.7

Table 3 summarizes the depth to, and the elevation of the auger refusal and the bedrock surface proved by coring as encountered at the borehole locations during the 1972 investigation. The bedrock encountered in these boreholes consist of slightly weathered to fresh, medium bedded, grey, fine grained, porous shale with limestone partings.

Table 3: Summary of Bedrock Surface Depths and Elevation (1972 Investigation)

Borehole	Existing Ground Surface Elevation (m)	Depth to Refusal (1) / Bedrock Surface (2) (m)	Refusal / Bedrock Surface Elevation (m)	Cored Length (m)
BH 1 (1972)	66.5	14.6(1)	51.9	-
BH 2 (1972)	66.1	14.0(2)	52.1	1.7

Note (1) Depth and elevation to sound bedrock inferred from refusal to auger advancement.
(2) Depth and elevation to the bedrock surface proved by coring.

4.9 Groundwater Conditions

A groundwater monitoring well was installed in Borehole 18-4102 to monitor the groundwater level at the site. Table 4 summarizes the depth to, and the elevations of the groundwater level measured in the monitoring well on October 12, 2018.

Table 4: Summary of Groundwater Conditions

Borehole	Ground Surface Elevation (m)	Screened Interval Material	Water Level	
			Depth (m)	Elevation (m)
18-4102	65.8	Bedrock	2.6	63.2

It should be noted that these groundwater observations are considered short-term readings and that groundwater levels in the area are subject to fluctuations both seasonally and with precipitation events.

4.10 Steel Corrosion and Sulphate Attack, Chemical Analysis

One soil sample from Borehole 18-4103 was submitted to Eurofins Environment Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack). The test results are provided in Appendix D and are summarized in Table 5.

Table 5: Steel Corrosion and Sulphate Attack, Chemical Analysis

Borehole	Sample Depth (m)	Sample Type	Chloride (%)	pH	Electrical Conductivity (mS/cm)	Resistivity (ohm-cm)	Sulphate (µg/g)
18-4103	5.3 – 5.9	Silty Clay	0.006	8.6	0.26	3,850	110

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Kenton Power, P.Eng. and was reviewed by Mr. Michael Snow, P.Eng., a Principal and senior geotechnical engineer with Golder. Mr. Fin Heffernan, P.Eng., Golder's Designated MTO Foundations Contact for this project, conducted an independent quality review of the report.

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PART B

Foundation Design
Green's Creek Twin Culverts Rehabilitation
Temporary Water Diversion Systems
Site No. 3-312/C
Walkley Road
Ottawa, Ontario
GWP No. 4099-11-00
W.P. 4320-13-01

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

The following sections of the report provide foundation design recommendations for the construction of temporary water diversion systems for the rehabilitation of the Green's Creek twin culverts (Site 3-312/C), located beneath Walkley Road approximately 350 m southwest of the Highway 417 / Walkley Road interchange in Ottawa, Ontario. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current subsurface investigation as well as the available GEOCRES information for the site.

The foundation design report, discussion, and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO) and shall not be used or relied upon for any other purpose or by any other parties, including the construction contractor. The contractor must make their own interpretation based on the factual data in Part A (Foundation Investigation) of the report. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project. Those requiring information on the aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Overview

Archival construction drawings indicated that the existing twin structures are 66.5 m long, steel plate culverts that have an internal diameter of 5.5 m and were constructed with beveled inlet and outlet sections. Concrete cutoff walls were also to be constructed below the end of the beveled sections at both the culvert inlet and outlet. Information provided in the RFP indicates that the twin culverts were constructed in 1973. Based on the noted invert elevation of 60.0 m from the General Layout (GL) Drawing (3-312-1), the existing twin culverts are likely founded in the silty clay strata. The cover material surrounding the culverts was to be select subgrade material (SSM) as indicated on the GL drawing. Sampling of the bedding material was not part of the scope of this foundation investigation however the gradation of SSM ranges from sand to silty sand and gravel.

The flow through the twin culverts is from south to north. However, as noted in WSP's culvert inspection report creek flow was only though the east culvert as upwards of 2.0 m of sediment and other debris blocks the creek flow from entering the west culvert.

The existing pavement grade of Walkley Road at the location of the twin culverts is at approximate Elevation 70.0 m. Upwards of 4.5 m of fill has been placed over the top of the existing twin culverts beneath the travel lanes. Walkley Road at this location has two through lanes in each direction separated by a concrete median. The roadway was constructed with an urban cross section with concrete curbs and paved sidewalks. The Walkley Road northbound N-E on-ramp to Highway 417 eastbound, and the Highway 417 E-S off-ramp also extend over the existing twin culverts. There are steel beam guide rail systems present along both sides of Walkley Road in the vicinity of the twin culverts.

It is understood that the rehabilitation of the Green's Creek twin culverts will include invert concrete paving of both culverts. Temporary water course diversion will be required to carry out the rehabilitation of the twin culverts in the dry, as such temporary cofferdams are being consider. It is assumed that the existing creek flow will be diverted through the first culvert while work is being carried out in the second. Once rehabilitation works are completed in the second culvert, flow will be diverted through it and rehabilitation works would be completed in the first.

6.3 Seismic Considerations

The site is located in an area where there exists a history of earthquake activity. A seismic Site Class needs to be assigned to this site, for use by the structural designer.

The CHBDC states that the seismic hazard values associated with the design earthquakes should be those established for the National Building Code of Canada (NBCC) by the Geological Survey of Canada (GSC). The current seismic hazard maps (referred to as the 5th generation seismic hazard maps) were developed by the GSC and were made available for public use in December 2015.

The seismic design provisions of the NBCC depend, in part, on the shear wave velocity of the upper 30 metres of soil and/or rock below the founding level. The NBCC permits the Site Class to be specified based solely on the stratigraphy and in-situ testing data (i.e., standard penetration test and in-situ shear strength test results), rather than from direct measurements of the shear wave velocity. Based on the anticipated foundation level within the silty clay and the relatively shallow depth to bedrock, the site may be classified as Site Class D in accordance with Table 4.1 of the CHBDC, in the absence of any geophysical testing. If required geophysical measurement of the shear wave velocity profile for the upper 30 metres of soil and/or bedrock may be carried out subsequently to obtain a more accurate/favourable specification of the Seismic Site Classification.

6.4 Design and Construction Considerations

6.4.1 Temporary Water Diversion Systems

Control of the creek flow, surface water and groundwater will be necessary for the rehabilitation of the twin culverts to be carried out in dry conditions.

Depending on the creek flow, surface water flow conditions and the groundwater levels at the time of construction, water flow could be bypassed using alternating temporary water diversions to an existing culvert while rehabilitation works are being carried out in the other. Temporary water diversion systems would consist of either diverting the flow toward or pumping from behind a temporary water diversion system. Temporary water diversion systems for these works could consist of either steel sheet pile cut-off walls or sand bags or glacial till / weathered crust cofferdams, both advanced to an appropriate depth to control the surface water and groundwater inflow from the creek. Alternatively, an inflatable water diversion system could be used.

Based on the measured groundwater levels, and the shallow excavations depths anticipated to line the culvert inverts, it is anticipated that the groundwater table will not be encountered to the depths of the proposed works. Groundwater control requirements will largely be dictated by the method of excavation support. If groundwater flow/seepage is encountered, pumping from sumps in the excavations would probably be adequate to handle the inflow to the excavations. Also, minimal seepage is anticipated from the clay layer due to the low permeability of the material. However, given that the excavation will be adjacent to, and extend about 1 m below the creek, appropriate measures will need to be implemented to avoid inflow of creek water into the temporary excavations.

The selection and design of temporary unwatering/dewatering system is the responsibility of the contractor and shall be carried out in accordance with Ontario Provincial Standard Specification (OPSS) PROV 517 *(Dewatering)* with amendments as per Special Provision (SP) 517F01 *(Dewatering System)*. Given the groundwater and soil conditions at this site, dewatering is expected to be of low complexity, and it is therefore not a requirement to carry out a preconstruction survey or to require a dewatering design engineer for the dewatering system as per Table A of SP517F01.

The water level will fluctuate and the minimum water elevation at the time of the proposed work should be taken as the creek water level of the 5-year design storm return period.

A Permit-To-Take-Water (PTTW) is required from the Ministry of the Environment, Conservation and Parks (MECP) if a volume of water (groundwater water and surface water) greater than 400,000 litres per day is pumped from the excavations. If the volume of water to be pumped will be less than 400,000 litres per day, but more than 50,000 litres per day, the water taking will not require a PTTW, but will need to be registered in the Environmental

Activity and Sector Registry (EASR) as a prescribed activity. Depending on the size of the excavations, the number of excavations that are open at one time, and the time of year that the excavating takes place, pumping of volumes greater than 50,000 litres per day (but less than 400,000 litres per day) may occur, and EASR registration may be required.

As per Ontario Provincial Standard Drawing (OPSD) 3090.101 *(Foundation Frost Penetration Depths for Southern Ontario)*, the frost penetration depth at the site is 1.8 m below the existing ground surface.

6.4.1.1 Sheet Pile Cut-off Wall

Temporary water diversion systems consisting of steel sheet pile cut-off walls driven to found within the native silty clay or glacial till deposits would be feasible at all of the culvert inlet and outlet locations. These systems should be designed and constructed in accordance with OPSS.PROV 539. The lateral movement of the temporary sheet pile cut-off walls should meet Performance Level 3 as specified in OPSS.PROV 539. The design of a temporary water diversion system consisting of braced sheet piles shall be based on the anticipated unbalanced hydraulic loads and the earth pressure distribution for soft to firm cohesive soils provided in the Canadian Foundations Engineering Manual (CFEM 2006) using the design parameters given in Table 6 below.

For cantilever walls or where the support to the wall is provided by anchors, the wall design should be based on a triangular earth pressure distribution using the design parameters given below. The supports must be designed to accommodate the loads applied from earth pressures and surcharge pressures from area, line or point loads as may be imposed by construction equipment and materials, as well as the impact of sloping ground behind the system.

The temporary cut-off wall design should be assessed for both the drained and undrained cases, based on the more conservative earth pressure conditions. The earth pressure coefficients noted in Table 6 are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficient of earth pressure should be adjusted accordingly.

6.4.1.2 Sand Bags or Glacial Till / Weather Crust Cofferdam

Alternatively, the water diversion system could consist of a sand bag embankment or temporary earth embankment with a clay core.

For both options, the base of the temporary water diversion system should be excavated to a depth of about 0.5 m into the native silty clay subgrade to create a continuous cut off between the native clayey soil and the temporary embankments. Further comments with regards to temporary excavations are provided in Section 6.4.2.

Where a clay core is used, it should be covered with an approximately 0.5 m thick layer of OPSS.PROV 1010 (Aggregates) Granular B Type II to reduce the potential for erosion of the embankment side slopes.

6.4.1.3 Inflatable Water Diversion System

Consideration could also be given to the use of an inflatable water diversion system. These systems typically consist of vinyl coated polyester water-inflated bladders with internal baffle systems. Various barrier heights are available, with a standard maximum height of about 2.5 m. However, the height of barrier should typically maintain a minimum of at least 25 percent of freeboard above the static water level. Inflatable systems also rely on surface friction in order to stabilize when exposed to uneven water pressure. An anchoring system at the creek bank may also be required depending on the water flow in the creek at the time of construction. The design parameters provided in Table 6 can be used for the design of an inflatable water diversion system; however, it should be noted that these types of systems are proprietary to individual suppliers and may require additional investigation and/or input for design.

Table 6: Design Parameter – Inflatable Water Diversion System

Soil Type	Internal Angle of Friction (ϕ)	Unit Weight (γ, kN/m^3)	Coefficients of Earth Pressure		
			Active, Ka	At-Rest, Ko	Passive, Kp
Silt and sand	30°	20	0.33	0.50	3.00
Silty Clay	28°	19	0.36	0.47	2.77
Till	35°	22	0.43	0.27	3.70

6.4.2 Temporary Excavations, and Shoring

Should excavations be required for the installation of the temporary water diversion systems it is anticipated that the overburden soils can be excavated using conventional excavating equipment.

Excavation works must be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act and Regulations for Construction Projects (OHSA). The soils at this site would be generally classified as Type 3 soils (compact to loose fill material above groundwater level and stiff to very stiff clay below the groundwater) in accordance with the OHSA. Accordingly, temporary excavations may be made with side slopes at 1 horizontal to 1 vertical, or flatter from the base of the excavation.

However, due to the proximity of the existing roadway, the excavations, if required, may need to be carried out within supported (i.e. shored) excavations for worker safety and road embankment support. A conventional shoring system for these conditions could consist of soldier piling and lagging or driven sheet piles. This support system should be designed and constructed by the contractor in accordance with the OPSS.PROV 539. The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS.PROV 539.

Bedrock is not anticipated within the depth of excavation. The elevation of the bedrock surface encountered at the site is at about Elevation 52.0 m, which is at approximately 8.0 m below the existing invert of the twin culverts.

6.4.3 Obstructions in Glacial Till

Cobbles and boulders were encountered or inferred within the glacial till deposit. Appropriate equipment and methods will need to penetrate through such obstructions, if encountered. Although excavations in the glacial till are not anticipated, it is recommended that an NSSP be included in the Contract Documents to warn the Contractor of this condition. Suggested wording for an NSSP alerting the Contractor to the presence of these obstructions in the overburden materials is provided in Appendix F.

6.4.4 Cement Type and Steel Corrosion Potential

A single soil sample from Borehole 18-4103 was submitted for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack).

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. The sulphate results in Table 5 were compared with Table 3 of Canadian Standards Association Standards A23.1-14 (CSA A23.1) and generally indicate a low degree of sulphate attack potential on concrete structures at this site. Accordingly, GU cement could be specified for concrete in below grade applications.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The test results provided in Table 5 indicate a moderate potential for corrosion of exposed ferrous metal at the site which should be considered in the design of below grade structures.

6.4.5 Erosion Protection

The need for (and design of) erosion protection at the inlet and outlet of the twin culverts (including the slopes and sides of the channel) will depend on the anticipated hydrologic/hydraulic conditions. Typically, rip-rap protection should be provided over these areas. The rip-rap layer should cover all surfaces on the embankment slopes against which creek water is likely to be in contact. If needed, rip-rap treatment should be consistent with the OPSD 810.010.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Kenton Power, P.Eng. and was reviewed by Mr. Michael Snow, P.Eng., a Principal and senior geotechnical engineer with Golder. Mr. Fin Heffernan, P.Eng., Golder's Designated MTO Foundations Contact for this project, conducted an independent quality review of the report.

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KCP/MSS/FJH/mvrd
https://golderassociates.sharepoint.com/sites/11263g/shared documents/01_foundations/6 - reports/1410 green's creek walkley/final/1662565-1410-r-rev0-greens creek culvert-06-2019_fidr.docx

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METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

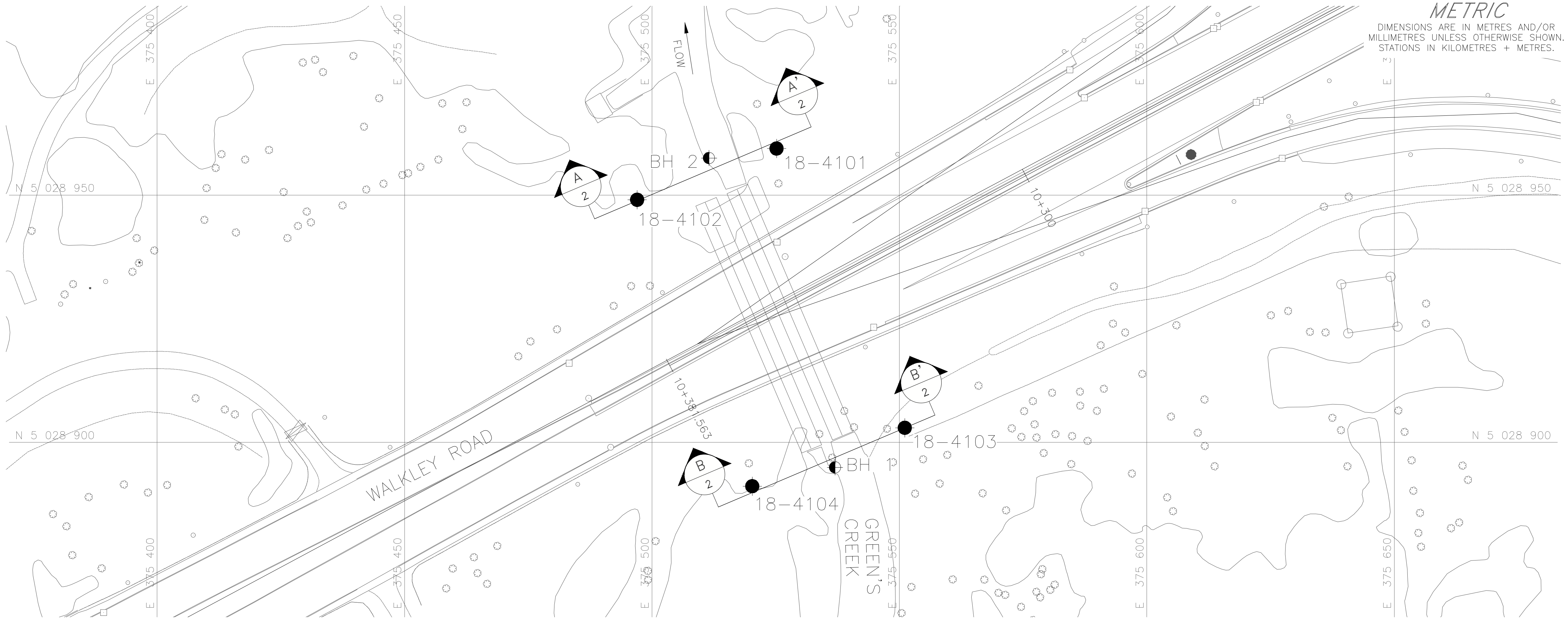
CONT No.
GWP No. 4099-11-00

SHEET

GREEN'S CREEK CULVERTS

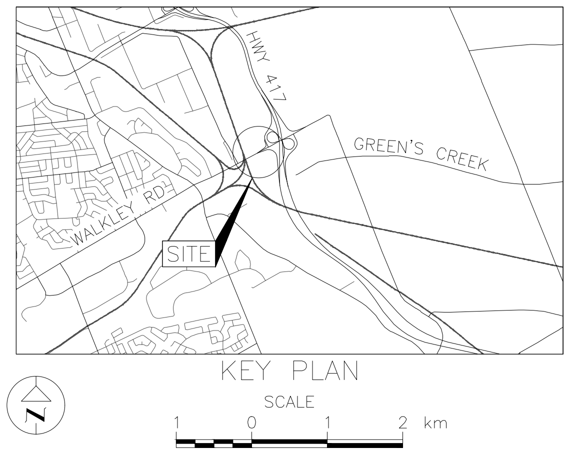
HIGHWAY 417 AT WALKLEY ROAD
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.396712 LONG. -75.596678

GOLDER



PLAN

SCALE 10 0 10 20 m



KEY PLAN

SCALE 1 0 1 2 km

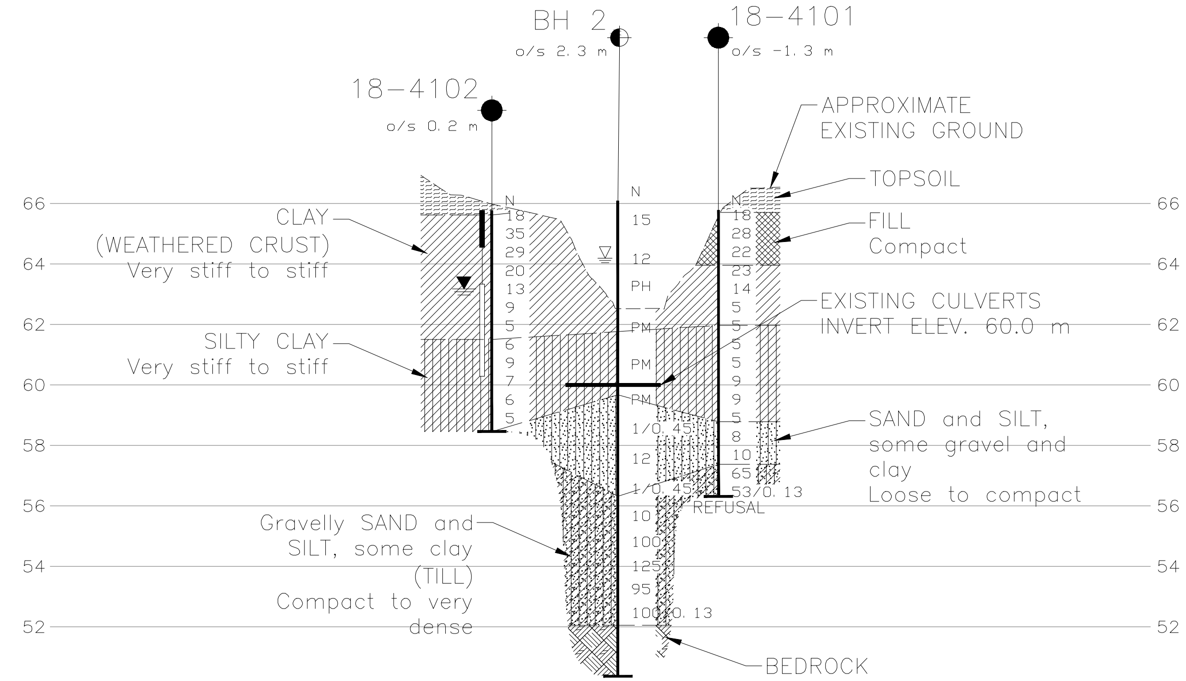
F. J. HEFFERNAN
2019/06/04

K. T. C. POWER
100130652
2019/06/04

LEGEND

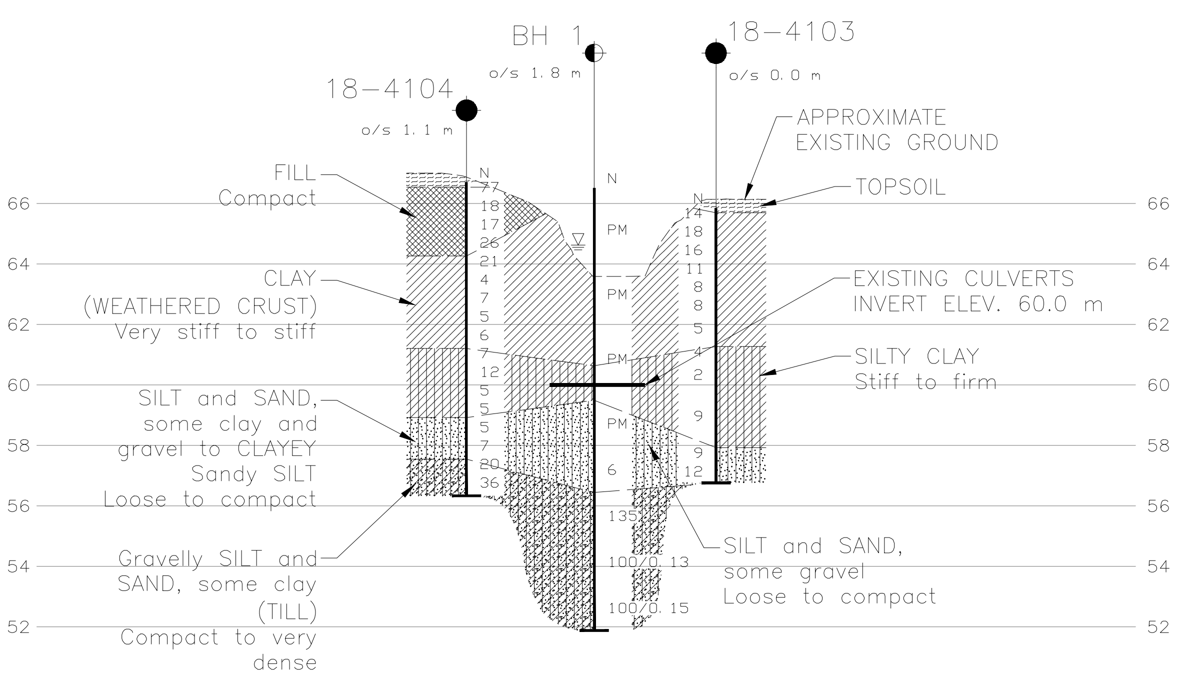
●	Borehole – Current Investigation
◐	Borehole – Previous Investigation (Geocres No. 31G5-87)
▮	Seal
▯	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
▼	WL in piezometer, measured on Oct. 12, 2018
▽	WL in open borehole, measured at time of 1972 investigation

BOREHOLE CO-ORDINATES (MTM ZONE 9)			
No.	ELEVATION	NORTHING	EASTING
18-4101	65.8	5028959.4	375525.2
18-4102	65.8	5028949.0	375497.0
18-4103	65.8	5028902.9	375551.1
18-4104	66.7	5028891.1	375520.3
BH 1	66.5	5028894.9	375537.0
BH 2	66.1	5028957.5	375511.5



CROSS-SECTION A-A'

SCALE 10 0 10 20 m / 2.5 0 2.5 5



CROSS-SECTION B-B'

SCALE 10 0 10 20 m / 2.5 0 2.5 5

REFERENCE

Base plans provided in digital format by WSP Canada Limited, drawing file nos. XA1-NAD 83.dwg and XB1-NAD 83 (CSRS).dwg, received APR. 19, 2017.

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

NO.	DATE	BY	REVISION

Geocres No. 31G5-307

HWY. 417		PROJECT NO. 1662565-1410	DIST. EASTERN
SUBM'D. KP	CHKD. KP	DATE: 6/4/2019	SITE: 3-312/C
DRAWN: JM	CHKD. FJH	APPD. FJH	DWG. 1

PLOT DATE: June 5, 2019
FILENAME: N:\Active\Spatial_IM\MTO\Hwy417Rehab&Widening\99_PROJ\1662565_MTO_Hwy417Replacements\40_PROD\0020_GreenCreekCulvert\1662565-0020-BG-0001.dwg

APPENDIX A

Record of Boreholes and Drillholes - Current Investigation

Lists of Abbreviations and Symbols

Lithological and Geotechnical Rock Description Terminology

Records of Boreholes 18-4101 to 18-4104

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
FoS	factor of safety

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
	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, 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 = $(w_l - w_p)$
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	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 $= \sigma'_p / \sigma'_{vo}$

(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 = $\tan \delta$
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ 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

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. 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.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; 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, 60º 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

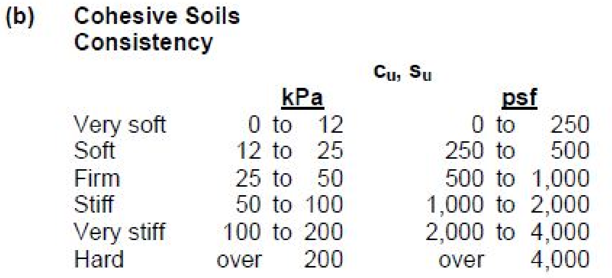
Piezo-Cone Penetration Test (CPT)

A 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 (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Compactness Condition	**N** **Blows/300 mm or Blows/ft**
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50



(b) Cohesive Soils

Consistency	c_u, s_u **kPa**	**psf**
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
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, G_s)
DS	direct shear test
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	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	**Modifier**	**Example**
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid segments.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN	Joint	PL	Planar
FLT	Fault	CU	Curved
SH	Shear	UN	Undulating
VN	Vein	IR	Irregular
FR	Fracture	K	Slickensided
SY	Stylolite	PO	Polished
BD	Bedding	SM	Smooth
FO	Foliation	SR	Slightly Rough
CO	Contact	RO	Rough
AXJ	Axial Joint	VR	Very Rough
KV	Karstic Void		
MB	Mechanical Break		

RECORD OF BOREHOLE No 18-4101

SHEET 1 OF 1

METRIC

PROJECT 1662565-1410

G.W.P. 4099-11-00

DIST Eastern HWY 417

DATUM Geodetic

LOCATION N 5028959.4; E 375525.2 NAD 83 MTM ZONE 9 (LAT. 45.397010; LONG. -75.596658)

BOREHOLE TYPE Portable Drill, BW Casing

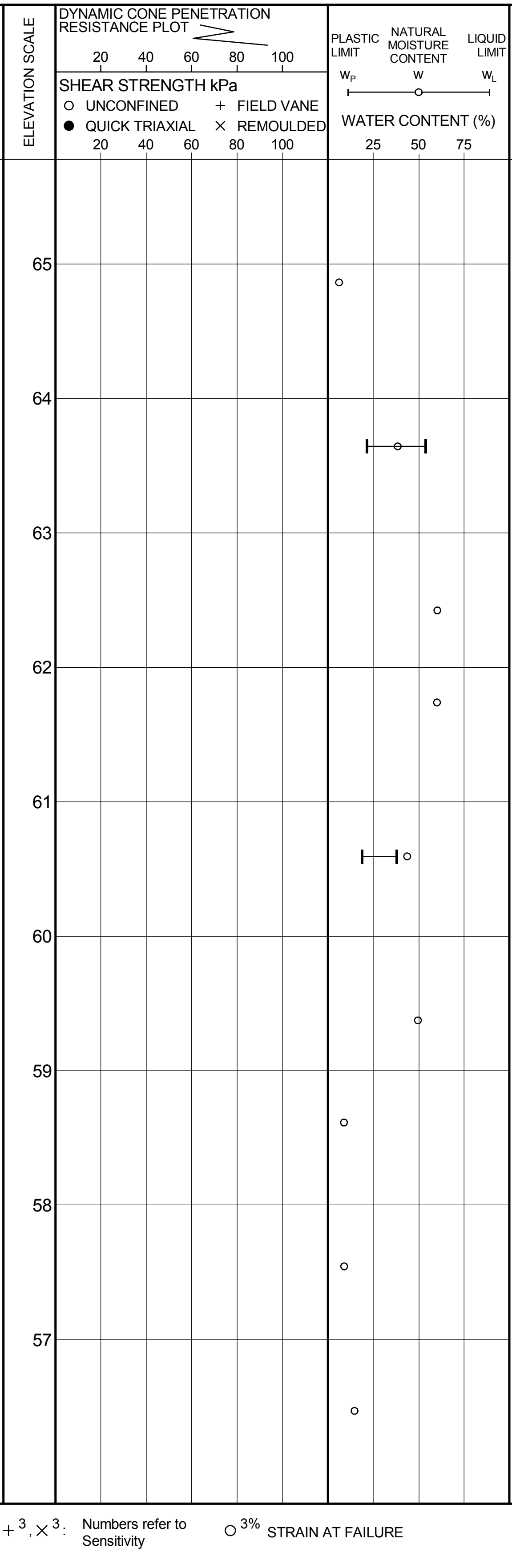
DATE September 3-4, 2018

ORIGINATED BY DJG

COMPILED BY ZS

CHECKED BY KP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
65.8	GROUND SURFACE							
0.0	(SM) Silty sand (TOPSOIL) Brown							
0.1	(SM/CI) Silty sand and silty clay, trace gravel (FILL) Compact Brown Dry	1	SS	18				
		2	SS	28				
		3	SS	22				
64.0 1.8	(CH) CLAY (WEATHERED CRUST) Very stiff to stiff Grey-brown Stiff	4	SS	23				
		5	SS	14				
		6	SS	5				
62.0 3.8	(CI) SILTY CLAY, contains silt layers Stiff Grey Wet	7	SS	5				
		8	SS	5				
		9	SS	5	0	1	51	48
		10	SS	9				
		11	SS	9				
58.8 7.0	(ML-SM) SILT and SAND, trace clay and gravel Loose to compact Brown Wet	12	SS	5				
		13	SS	8				
		14	SS	10	8	48	34	10
57.3 8.5	(SM/ML) Gravelly SAND and SILT, some clay, contains cobbles and boulders (TILL) Very dense Grey	15	SS	65				
		16	SS	53/0.13				
56.3 9.5	END OF BOREHOLE							



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-4102

SHEET 1 OF 1

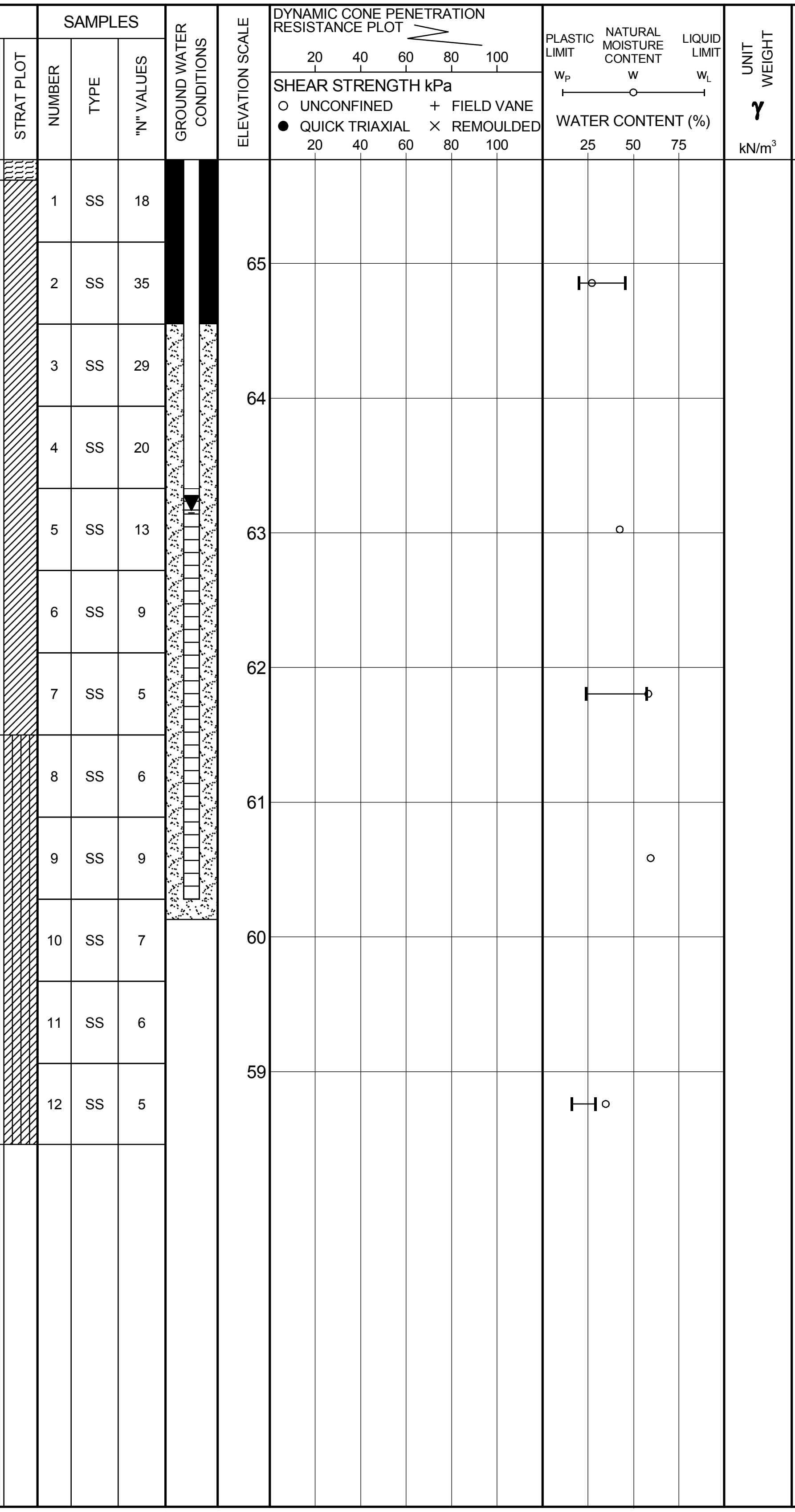
METRIC

PROJECT 1662565-1410
G.W.P. 4099-11-00
DIST Eastern HWY 417
DATUM Geodetic
LOCATION N 5028949.0; E 375497.0 NAD 83 MTM ZONE 9 (LAT. 45.396920; LONG. -75.597019)
BOREHOLE TYPE Portable Drill, BW Casing
DATE September 6, 2018
ORIGINATED BY DJG
COMPILED BY ZS
CHECKED BY KP

SOIL PROFILE		SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
65.8	GROUND SURFACE							
0.0	(SM) Silty sand (TOPSOIL) Brown Dry	1	SS	18				
0.2	(CI-CH) CLAY (WEATHERED CRUST) Very stiff to stiff Grey-brown Dry	2	SS	35				
		3	SS	29				
		4	SS	20				
		5	SS	13				
		6	SS	9				
		7	SS	5				
61.5 4.3	(CL) SILTY CLAY, contains silt seams Stiff Grey Wet	8	SS	6				
		9	SS	9				
		10	SS	7				
	- some sand, trace gravel	11	SS	6				
		12	SS	5	4	15	48	33
58.5 7.3	END OF BOREHOLE							

NOTES:

1. Water level in well screen at a depth of 2.6 m below ground surface (Elev. 63.2 m), measured on October 12, 2018.



+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL_IM\MTO\HWY417REHAB&WIDENING\02_DATA\GINT\1662565.GPJ GAL-GTA.GDT 5/31/19 ZS

RECORD OF BOREHOLE No 18-4103

SHEET 1 OF 1

METRIC

PROJECT 1662565-1410

G.W.P. 4099-11-00

LOCATION N 5028902.9; E 375551.1 NAD 83 MTM ZONE 9 (LAT. 45.396499; LONG. -75.596335)

ORIGINATED BY DJG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill, BW Casing

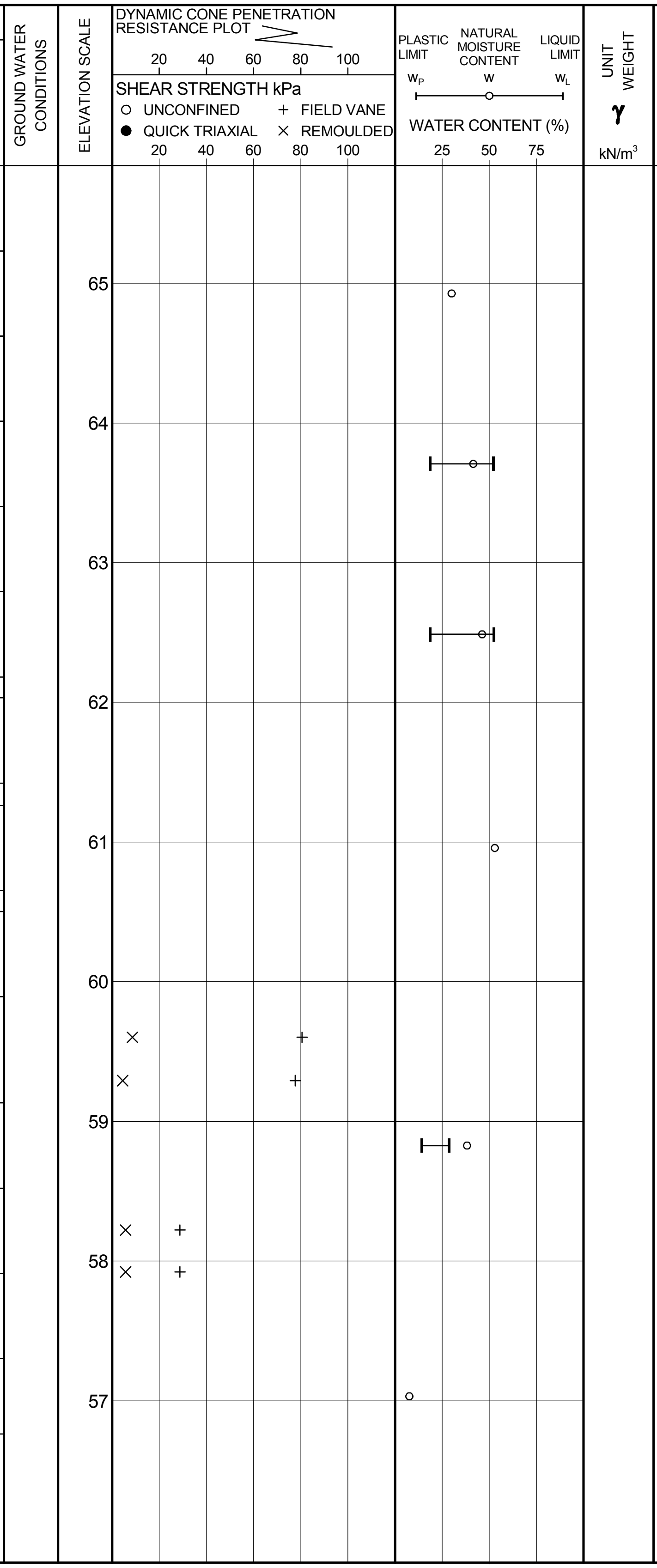
COMPILED BY ZS

DATUM Geodetic

DATE August 16, 2018

CHECKED BY KP

SOIL PROFILE		SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
65.8	GROUND SURFACE							
0.0	(SM) Silty sand (TOPSOIL) Dark brown Moist							
0.2	(CH) CLAY (WEATHERED CRUST) Very stiff to stiff Grey-brown Moist	1	SS	14				
		2	SS	18				
		3	SS	16				
		4	SS	11				
		5	SS	8				
		6	SS	8				
		7	SS	5				
61.2 4.6	(CL) SILTY CLAY, contains silt seams Stiff to firm Grey Wet	8	SS	4				
		9	SS	2				
		10	SS	9	0	2	54	44
57.9 7.9	(ML-SM) SILT and SAND, some clay and gravel Loose to compact Grey Wet	11	SS	9				
		12	SS	12				
56.7 9.1	END OF BOREHOLE							



$+^3, \times^3$: Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-4104

SHEET 1 OF 2

METRIC

PROJECT 1662565-1410

G.W.P. 4099-11-00

DIST Eastern HWY 417

DATUM Geodetic

LOCATION N 5028891.1; E 375520.3 NAD 83 MTM ZONE 9 (LAT. 45.396396; LONG. -75.596730)

BOREHOLE TYPE Portable Drill, BW Casing

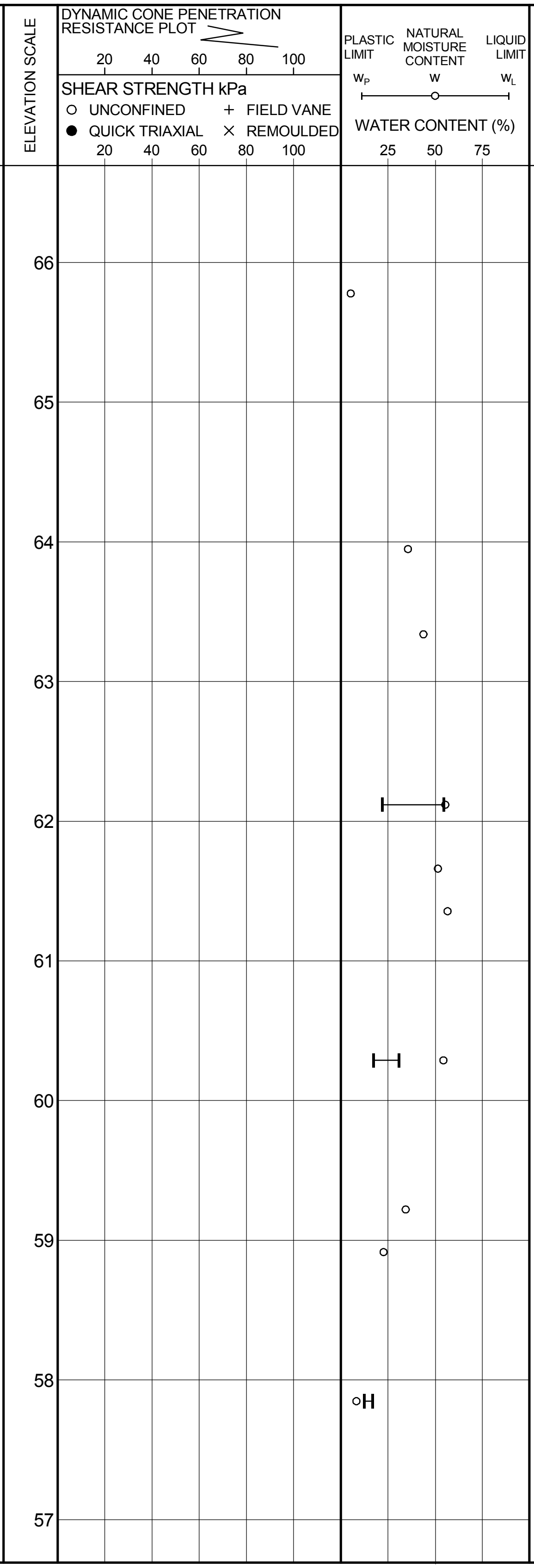
DATE August 20-22, 2018

ORIGINATED BY DJG

COMPILED BY ZS

CHECKED BY KP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
66.7	GROUND SURFACE							
0.0	(SM) Silty sand, some gravel (TOPSOIL) Brown Moist	1	SS	77				
0.2	(SM) Gravelly silty sand, trace gravel (FILL) Compact Brown Dry	2	SS	18				
		3	SS	17				
		4	SS	26				
64.3 2.4	(CH) CLAY (WEATHERED CRUST) Very stiff to stiff Grey-brown	5	SS	21				
		6	SS	4				
		7	SS	7				
		8	SS	5	0	1	40	59
		9	SS	6				
61.2 5.5	(CI) SILTY CLAY, contains silt seams Stiff Grey	10	SS	7				
		11	SS	12				
		12	SS	5				
		13	SS	5				
58.9 7.8	(ML/SM) SILT and SAND, some clay and gravel to (CL-ML/SM) CLAYEY Sandy SILT Loose to compact Grey Wet	14	SS	5				
		15	SS	7	22	36	30	12
57.6 9.2	(SM/ML) Gravelly SILT and SAND, some clay (TILL) Compact to dense Dry Wet	16	SS	20				



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

PROJECT 1662565-1410

RECORD OF BOREHOLE No 18-4104

SHEET 2 OF 2

METRIC

G.W.P. 4099-11-00

LOCATION N 5028891.1; E 375520.3 NAD 83 MTM ZONE 9 (LAT. 45.396396; LONG. -75.596730)

ORIGINATED BY DJG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill, BW Casing

COMPILED BY ZS

DATUM Geodetic

DATE August 20-22, 2018

CHECKED BY KP

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION --- *CONTINUED FROM PREVIOUS PAGE* ---	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		▨	17	SS	36				○		
56.3 10.4	END OF BOREHOLE										

+³, ×³: Numbers refer to Sensitivity

○³% STRAIN AT FAILURE

APPENDIX B

Laboratory Test Results - Current Investigation

Figure B1 – Plasticity Chart – Clay/Silty Clay

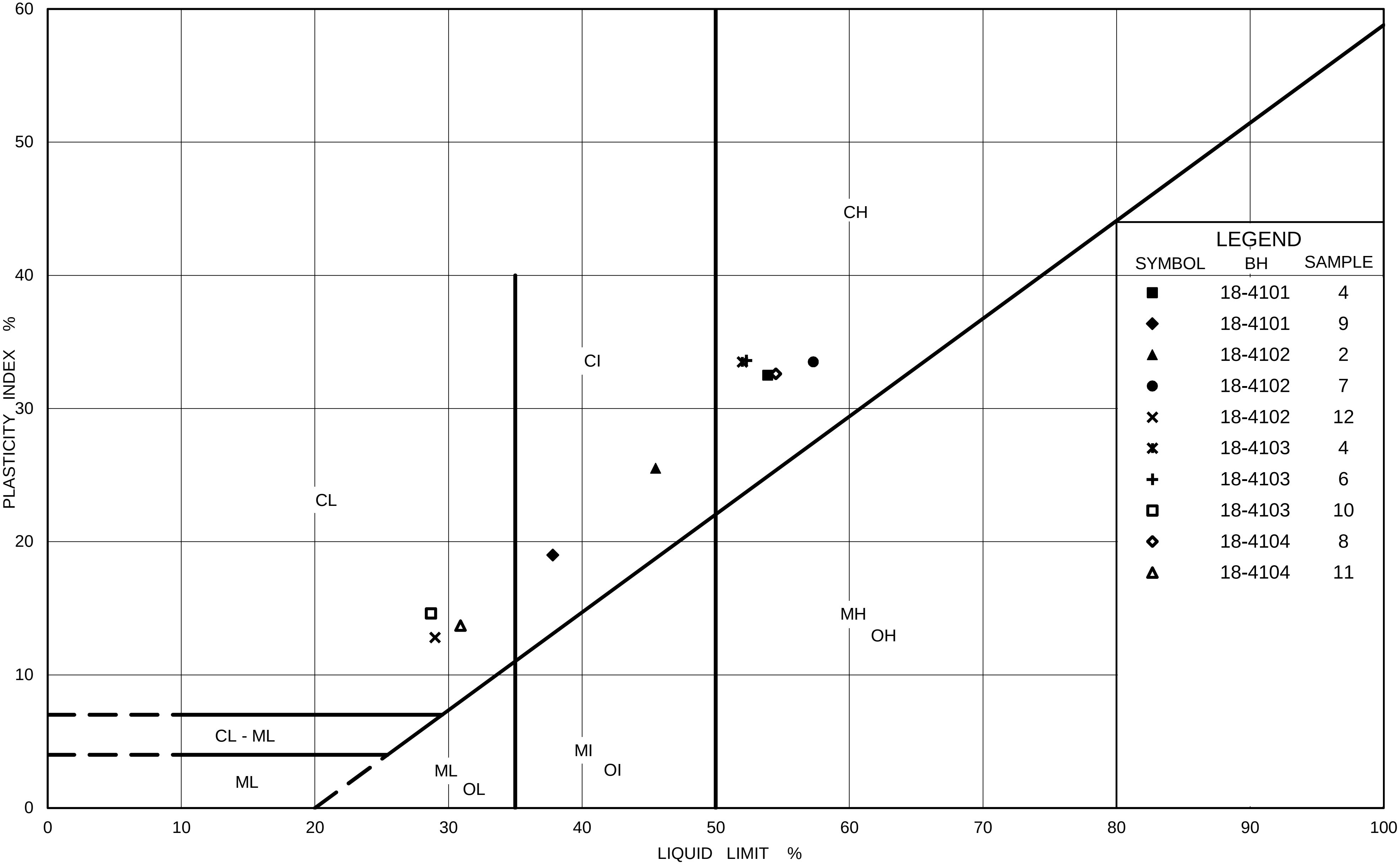
Figure B2 – Grain Size Distribution Test Results – Weathered Crust

Figure B3 – Grain Size Distribution Test Results – Clay/Silty Clay

Figure B4 – Grain Size Distribution Test Results – Silt and Sand

Figure B5 – Plasticity Chart – Clayey Silty Sand

Oct 75, FF-S-21



SYMBOL	BH	SAMPLE
■	18-4101	4
◆	18-4101	9
▲	18-4102	2
●	18-4102	7
×	18-4102	12
✖	18-4103	4
+	18-4103	6
□	18-4103	10
◇	18-4104	8
△	18-4104	11

Ministry of Transportation

Ontario

PLASTICITY CHART
CLAY / SILTY CLAY

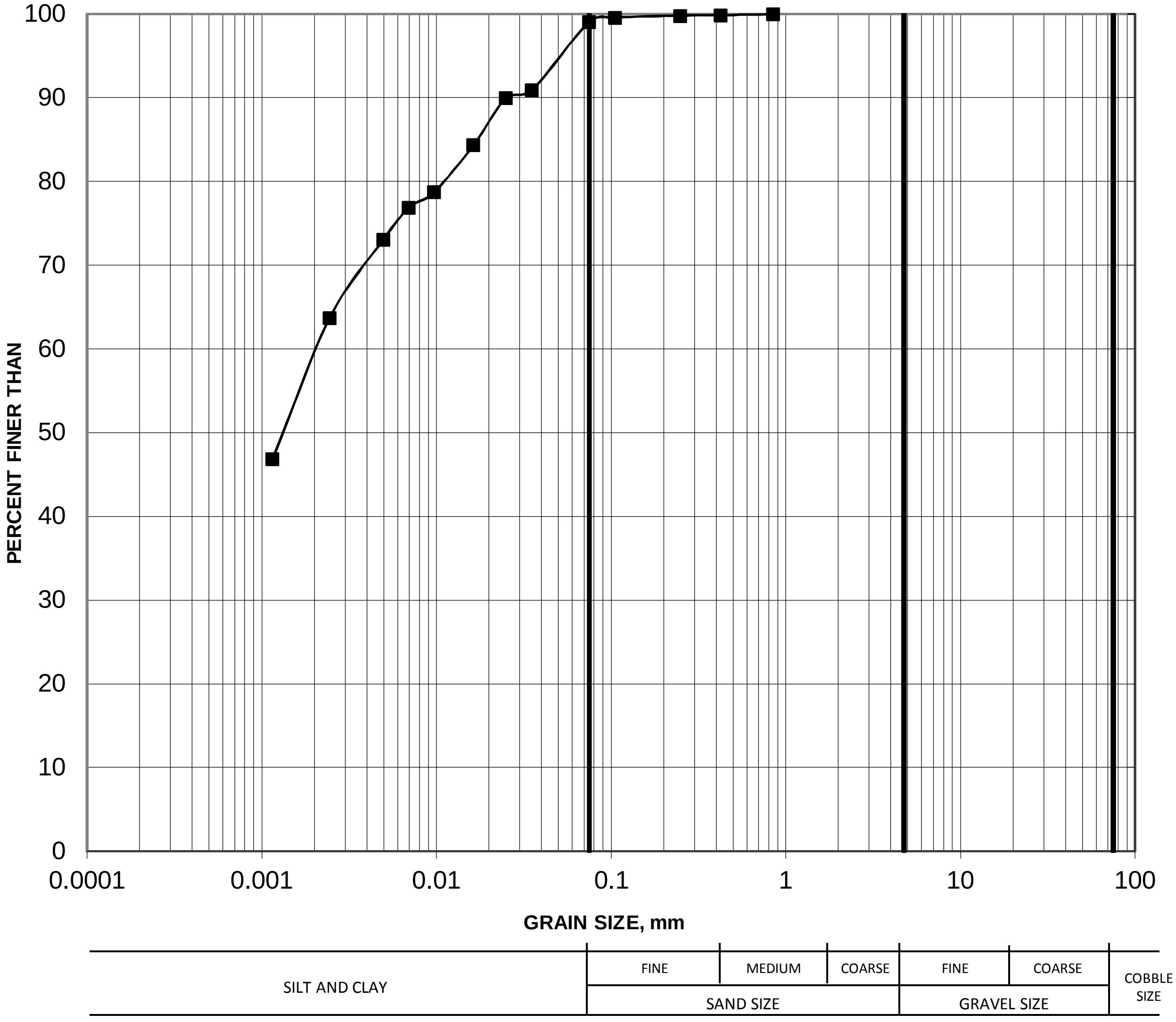
FIG No. B1

Project No. 1662565/1410

Compiled By : MI Checked By : CW

GRAIN SIZE DISTRIBUTION

FIGURE B2



WEATHERED CRUST

Borehole	Sample	Depth (m)
─■─ 18-4104	8	4.27-4.88

Project: 1662565/1410

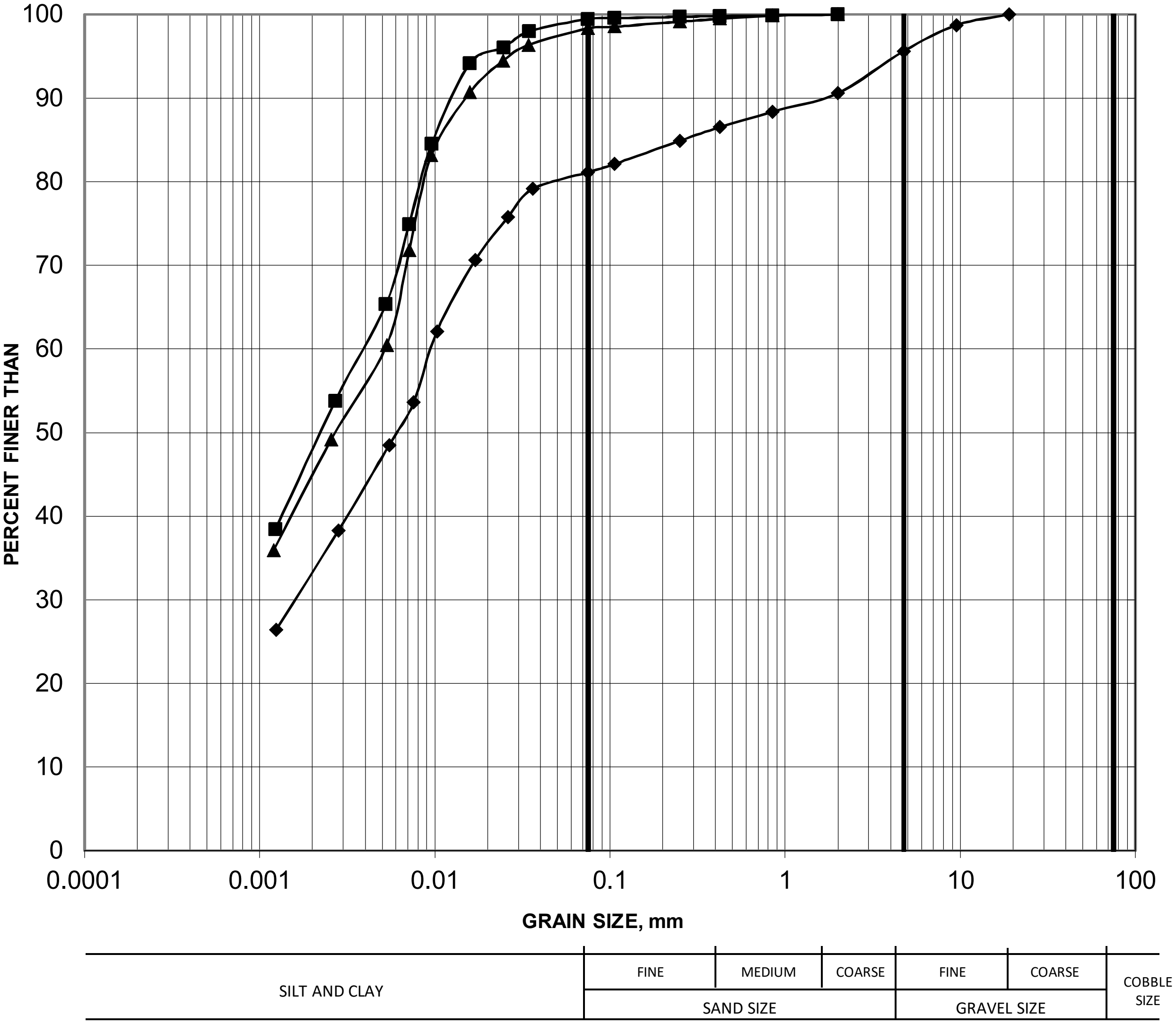
Golder Associates

Created by: CW
Checked by: MI

GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY CLAY / CLAY



Borehole	Sample	Depth (m)
—■— 18-4101	9	4.88-5.49
—◆— 18-4102	12	6.71-7.32
—▲— 18-4103	10	6.71-7.92

Project: 1662565/1410

Golder Associates

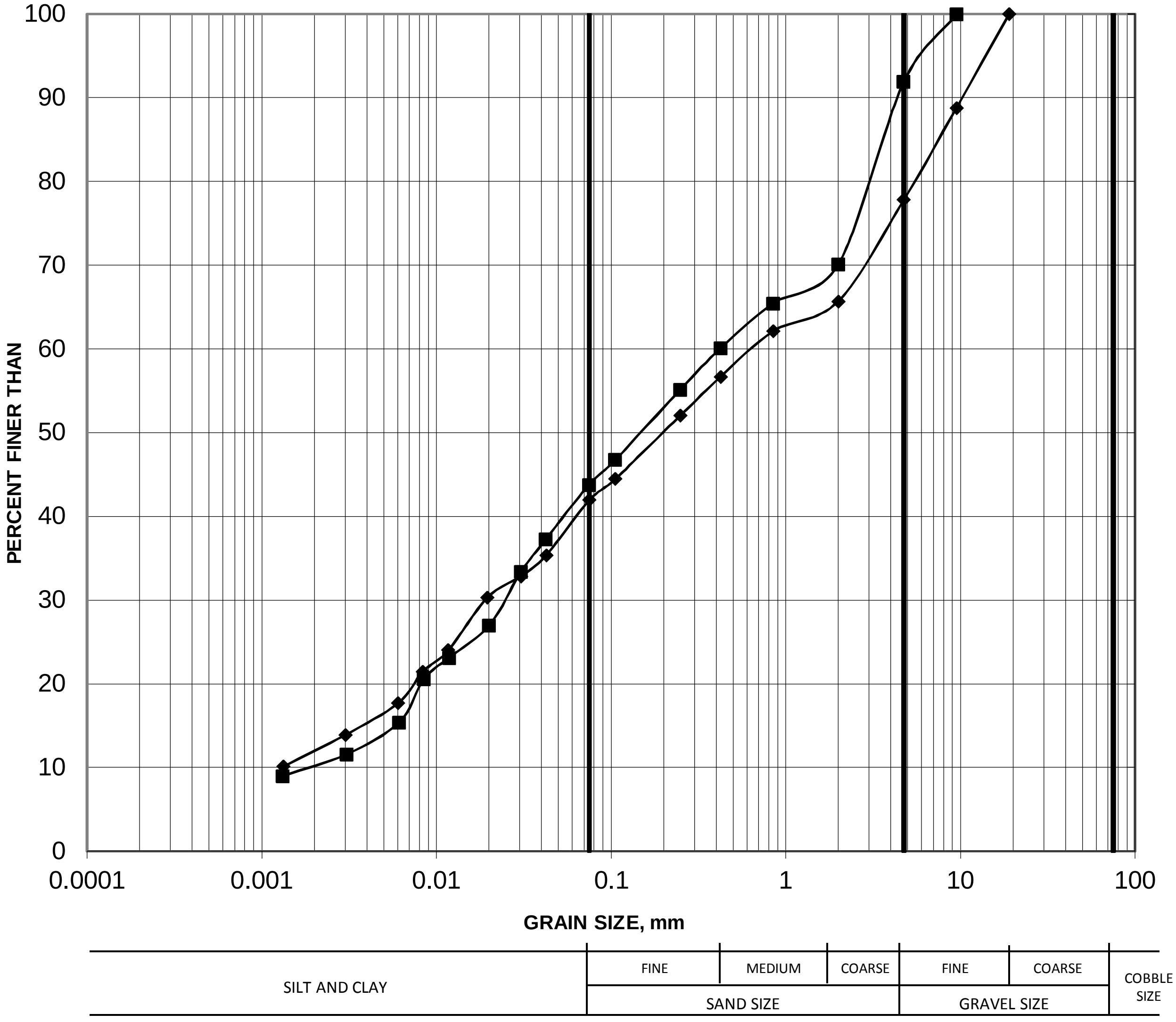
Created by: MI

Checked by: CW

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILT AND SAND



Borehole	Sample	Depth (m)
■ 18-4101	14	7.92-8.53
◆ 18-4104	15	8.53-9.14

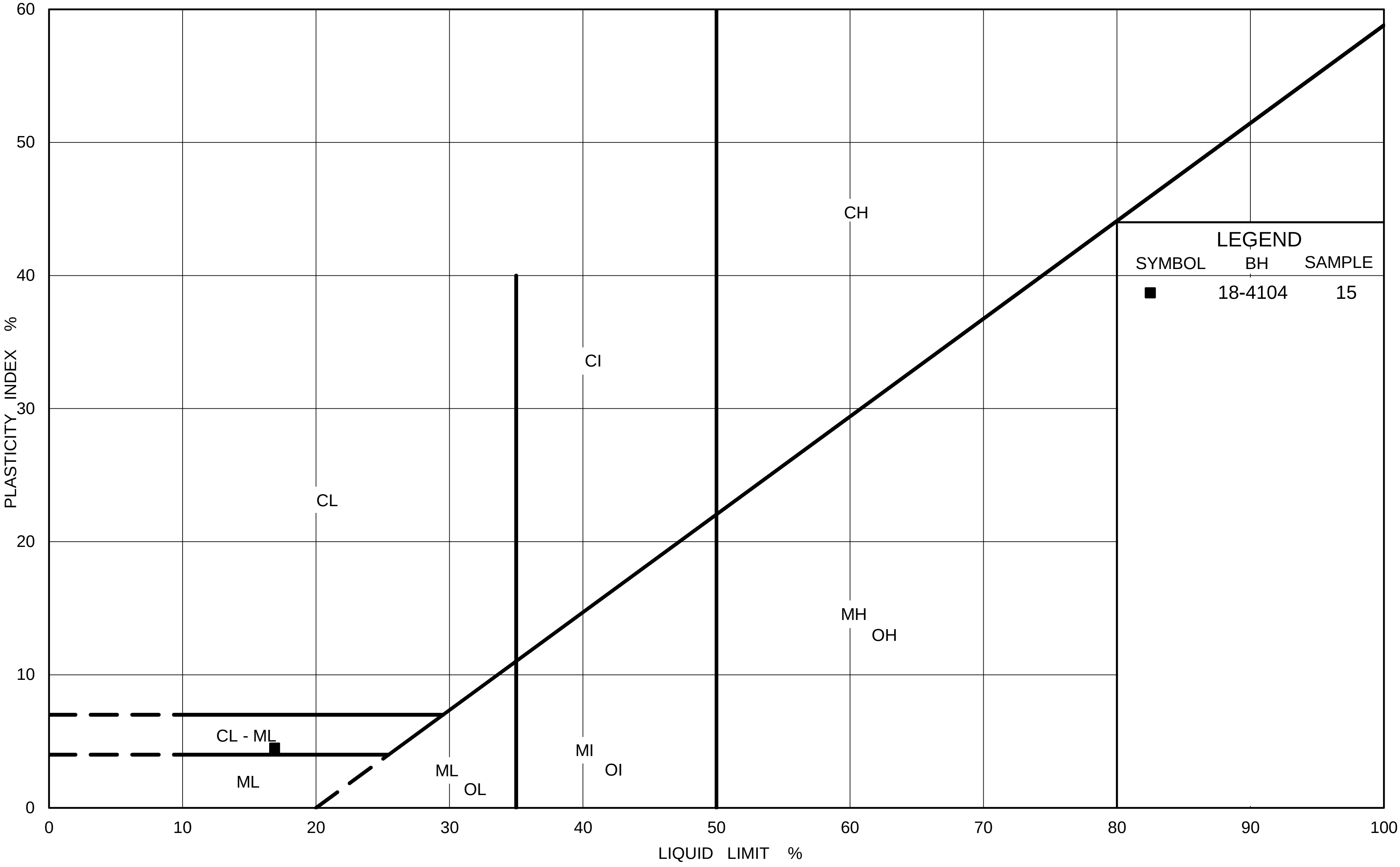
Project: 1662565/1410

Golder Associates

Created by: CW

Checked by: MI

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
CLAYEY SILTY SAND

FIG No. B5

Project No. 1662565/1410

Compiled By : CW Checked By : MI

APPENDIX C

Borehole Record and Laboratory Test Results (Previous Investigation, GEOCRES No. 31G05-087)

Records of Previous Boreholes BHs 1, 1A and 2

Laboratory Test Results

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

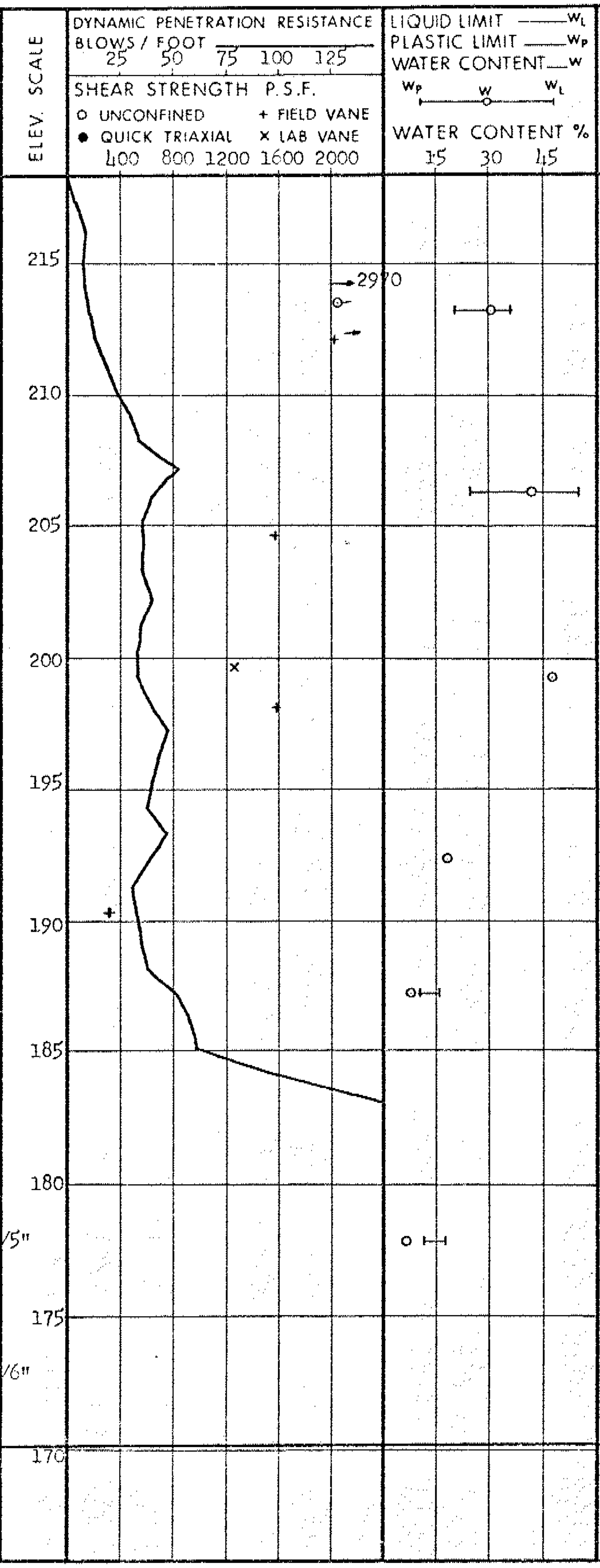
DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 1

JOB 72-11088
W.P. 10-69-13
DATUM Geodetic
LOCATION Co-ords. 498,275 N; 231,995 E.
BORING DATE Oct. 20/72
BOREHOLE TYPE Flight Auger and Cone Test
ORIGINATED BY JC
COMPILED BY JC
CHECKED BY

SOIL PROFILE		SAMPLES		
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FOOT
218.2	Ground Level			
0.0	Silty clay to clay with seams of clayey silt to silt up to 2" thick below El. 205. Very Stiff to Firm Grey	1	TW	PM
		2	TW	PM
		3	TW	PM
195.2 23.0	Silt with fine sand with occ. thin seams of clayey silt. Very Loose to Loose Dark Grey	4	SS	PM
		5	SS	6
185.2 33.0	Het.mix.of silt, sand and clay (Glacial Till) Very Dense Grey	6	SS	135
		7	SS	100/5"
		8	SS	100/6"
170.2 48.0	End of Borehole Probable Bedrock			



BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
117.5 eo=0.[illegible] Cc=0.[illegible]	212.0
110.5	
	0 53 40 7
	28 35 28 9
	0 41 48 11

20
15 ⌖ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 1A

JOB 72-11088

W.P. 10-69-13

DATUM Geodetic

LOCATION Co-ords. 498,080 N; 232,010 E.

BORING DATE Oct. 20, 1972

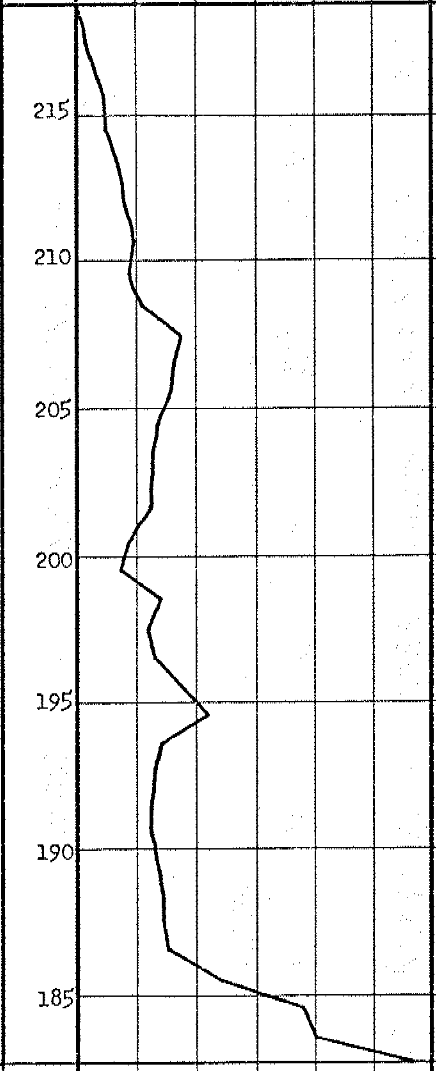
BOREHOLE TYPE Dynamic Cone Test

ORIGINATED BY JC

COMPILED BY JC

CHECKED BY

SOIL PROFILE			SAMPLES				DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 25 50 75 100 125 SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT —— W_L PLASTIC LIMIT —— W_P WATER CONTENT —— W W_P W W_L WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE				
218.8	Ground Level									
181.8 37.0	End of Cone Test									



20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

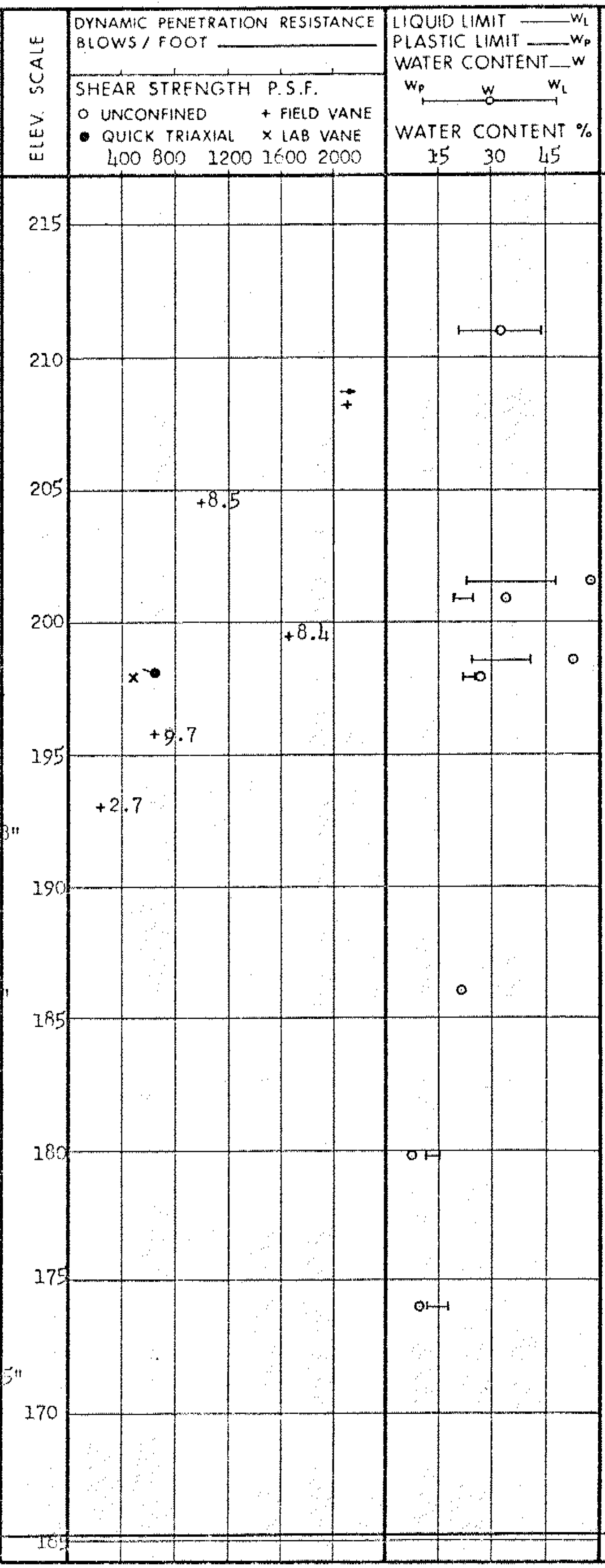
DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 2

JOB 72-11088
W.P. 10-69-13
DATUM Geodetic
LOCATION Co-ord. 498,472 N; 231,916 E.
BORING DATE Oct. 18/72
BOREHOLE TYPE Flight Auger and BXL Rock Core
ORIGINATED BY JC
COMPILED BY JC
CHECKED BY

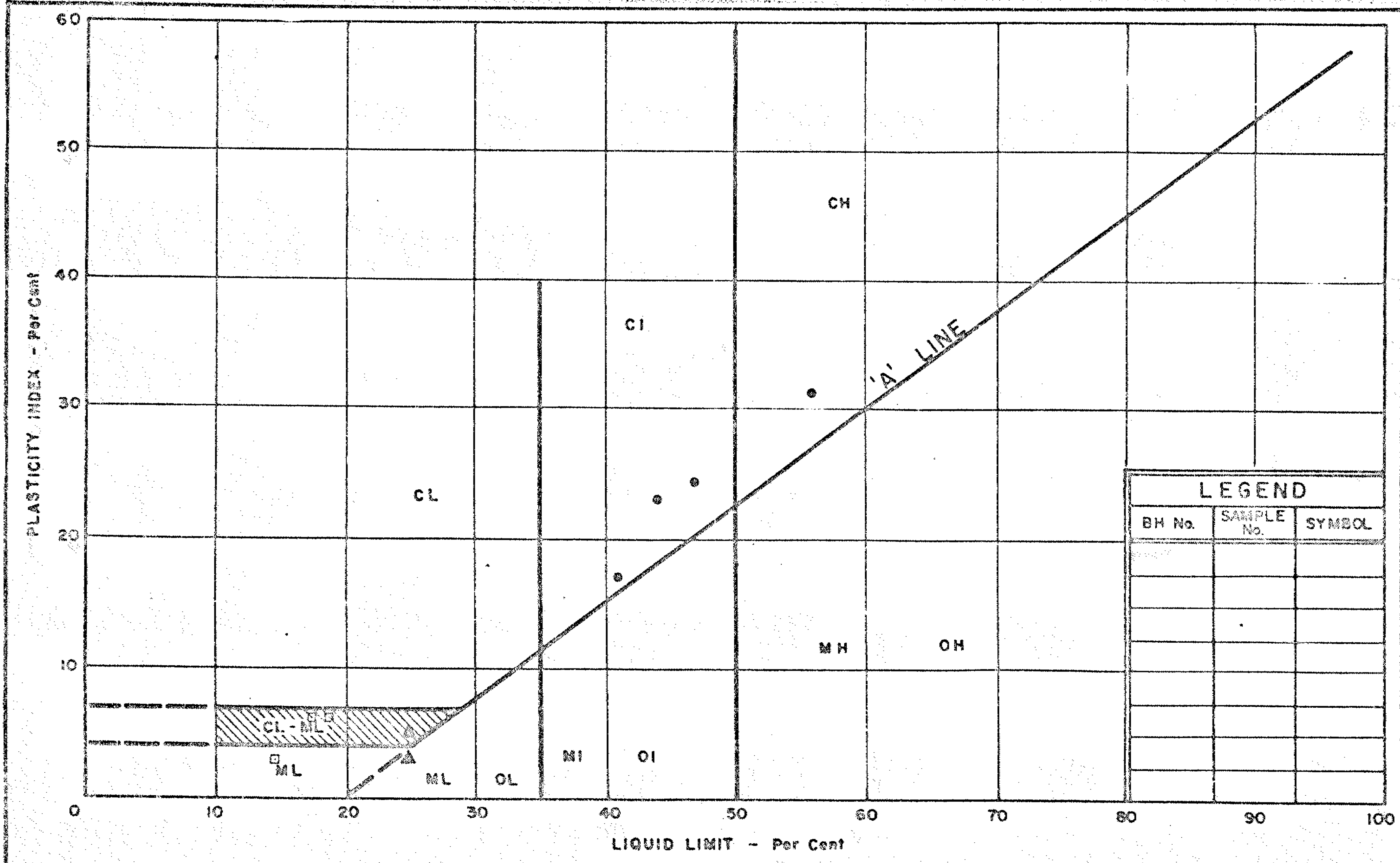
SOIL PROFILE		SAMPLES			BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FOOT		
216.8	Ground Level					
0.0	Silty clay to clay with seams of clayey silt up to 2" thick below El. 205. Very Stiff to Firm Grey	1	SS	15		
		2	SS	12		▼210.6
		3	TW	PH		
		4	TW	PM	111	
195.8		5	TW	PM	120	
21.0	Silt with fine sand (with occ. thin seams of clayey silt) Very Loose to Compact Dark Grey	6	TW	PM		
		7	SS	1/18"		
		8	SS	12		
184.8		9	SS	1/18"		0 33 52 15
32.0	Het.mix.of silt,sand and clay. (Glacial Till) Compact to Very Dense Grey	10	SS	10		
		11	SS	100		0 43 52 5
		12	SS	125		
		13	SS	95		0 35 53 12
170.8		14	SS	100/5"		
46.0	Sound Shale	15	RC BXL	91%		
165.3		16	RC BXL	100%		
51.5	End of Borehole					



20
15 ⌖ 5 % STRAIN AT FAILURE
10

OFFICE REPORT SOIL EXPLORATION

FORM 08-MT-252
REVISED JUL [illegible] 1966



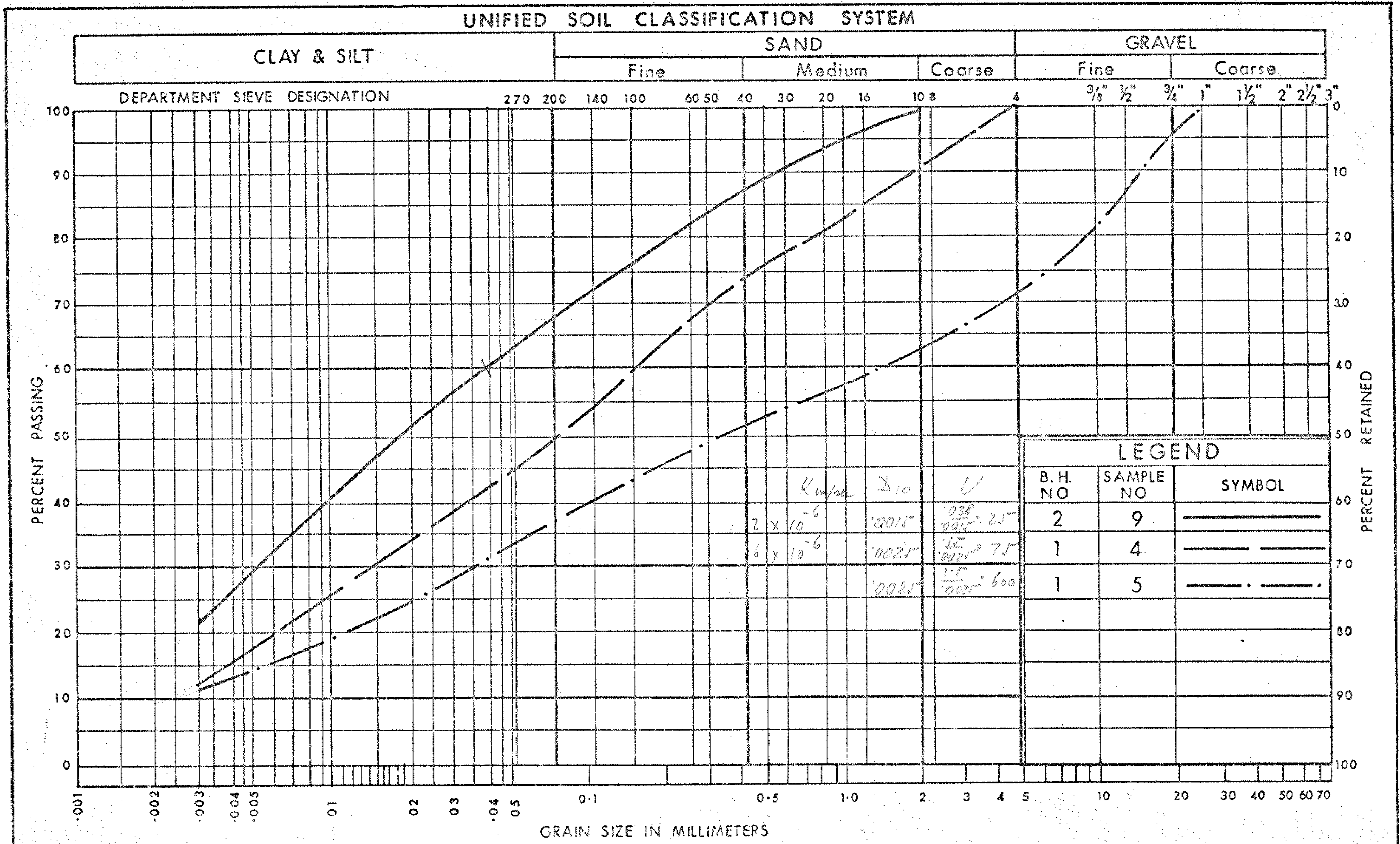
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION

PLASTICITY CHART

● SILTY CLAY
▲ CLAYEY SILT TO SILT SEAMS
□ GLACIAL TILL

W.P. No. 10-69-13
JOB No. 72-11088
FIG. No.1

FORM OD-MT-1?
REV. AUG. 1971



K cm/sec	D10	U
2 x 10^{-6}	.0015	.038/.0015 = 25
6 x 10^{-6}	.0025	.15/.0025 = 75
	.0025	1.5/.0025 = 600

LEGEND

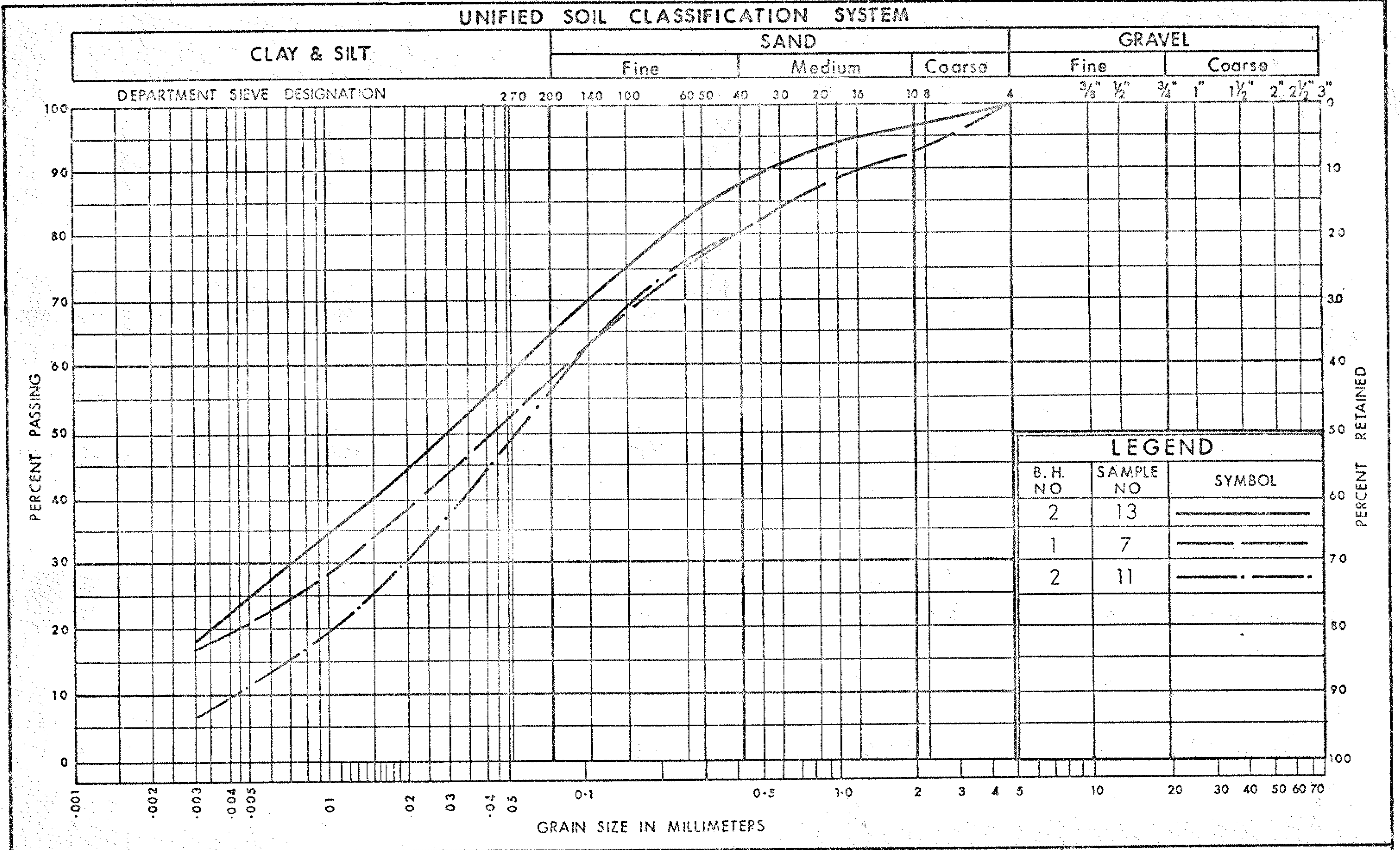
B.H. NO	SAMPLE NO	SYMBOL
2	9	———
1	4	— —
1	5	—·—

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS
ONTARIO
DESIGN SERVICES BRANCH

GRAIN SIZE DISTRIBUTION
SILT
WITH FINE SAND

W.P. No. 10-69-13
JOB No. 72-11088
FIG No. 2

FORM OD-MT-17
REV. AUG. 1971



DEPARTMENT
OF
TRANSPORTATION AND COMMUNICATIONS

DESIGN SERVICES
BRANCH

ONTARIO

GRAIN SIZE DISTRIBUTION
GLACIAL TILL
HET. MIXTURE OF SILT, SAND & CLAY

W.P. No. 10-69-13

JOB No. 72-11088

FIG No. 3

APPENDIX D

Basic Chemical Analysis – Eurofins Report Number 1817148

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Mr. Gabrielle Marcotte
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1817148
Date Submitted: 2018-09-20
Date Reported: 2018-09-29
Project: 1662565/1410
COC #: 835892

				Lab I.D.	1388758
				Sample Matrix	Soil
				Sample Type	
				Sampling Date	2018-09-16
				Sample I.D.	18-4103 SA 9
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Anions	Cl	0.002	%		0.006
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.26
	pH	2.00			8.56
	Resistivity	1	ohm-cm		3850
Subcontract	SO4	20	ug/g		110

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

APPENDIX E

Site Photographs

Photograph 1: Looking south towards culvert outlets

Photograph 2: Looking north towards culvert inlets

Photograph 3: Looking Downstream from culvert outlets

Photograph 4: Looking upstream from culvert inlets

APPENDIX F

Non-Standard Special Provisions

EARTH EXCAVATION FOR STRUCTURE – Item No.

Special Provision

Amendment to OPSS 902, November 2010

Excavating Through Obstructions – Structures

902.07 CONSTRUCTION

Section 902.07 of OPSS 902 shall be amended by the addition of the following:

The Contactor is alerted to the potential presence of cobbles and boulders within the glacial till. Consideration of the presence of these obstructions shall be made in the selection of appropriate equipment and procedures for excavations and temporary protection systems.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

GOLDER

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