FINAL REPORT

Foundation Investigation
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

Submitted to:

WSP Canada Group Limited
2611 Queensview Drive, Suite 300
Ottawa, Ontario
K2B 8K2

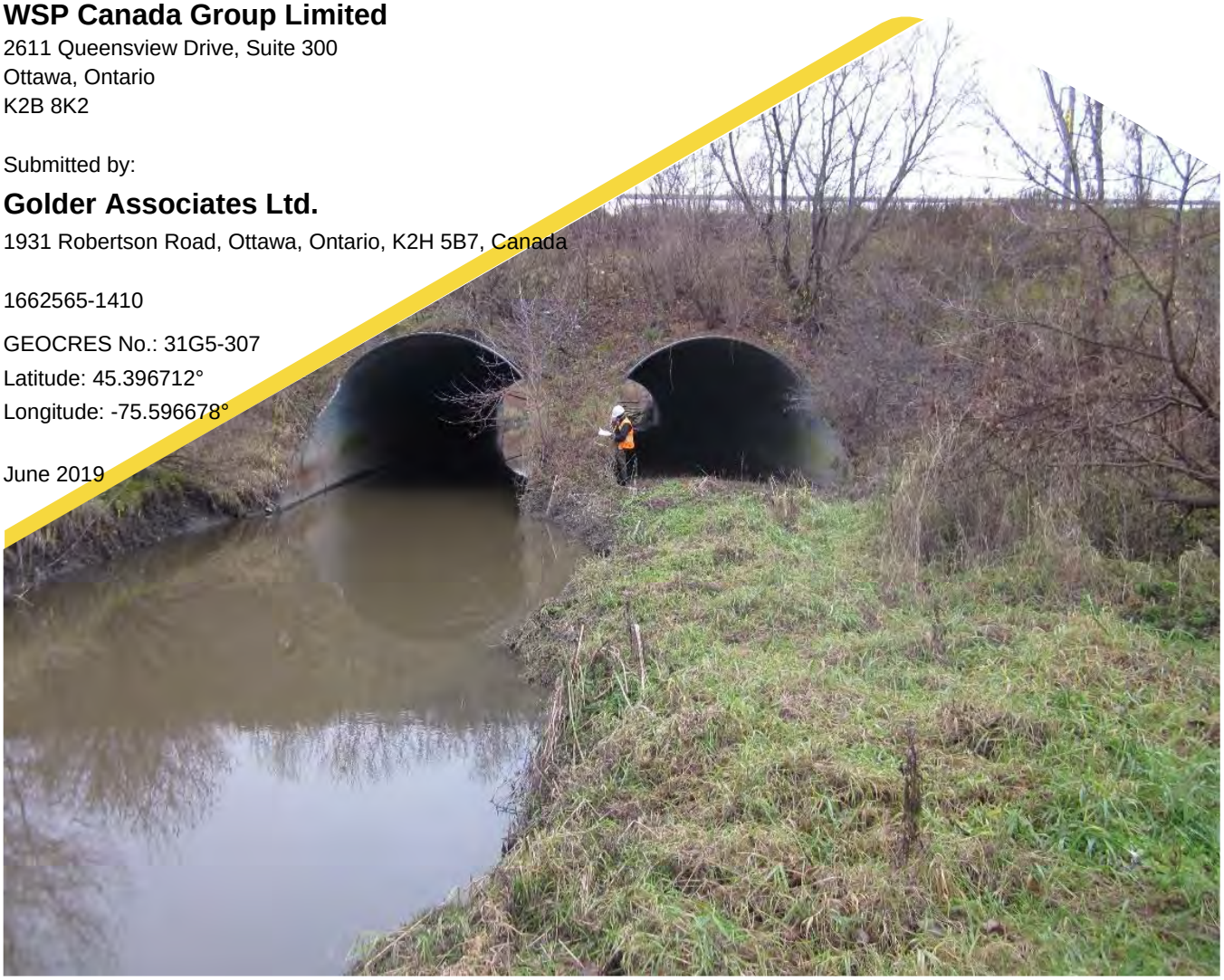
Submitted by:

Golder Associates Ltd.
1931 Robertson Road, Ottawa, Ontario, K2H 5B7, Canada

1662565-1410

GEOCRES No.: 31G5-307
Latitude: 45.396712°
Longitude: -75.596678°

June 2019



Distribution List

4 copies - Ministry of Transportation Ontario

1 e-copy - Golder

Table of Contents

PART A – FOUNDATION INVESTIGATION

TABLES

DRAWINGS

APPENDICES

PART A

Foundation Investigation
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

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.

[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

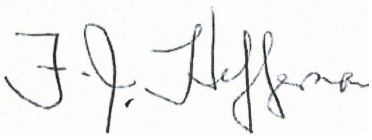
5.0 CLOSURE

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.

Golder Associates Ltd.

Kenton C. Power, P.Eng.
Geotechnical Engineer

Michael Snow, P.Eng.
Principal, Senior Geotechnical Engineer



Fintan J. Heffernan, P.Eng.
Designated MTO Foundations Contact

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_fir.docx

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

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

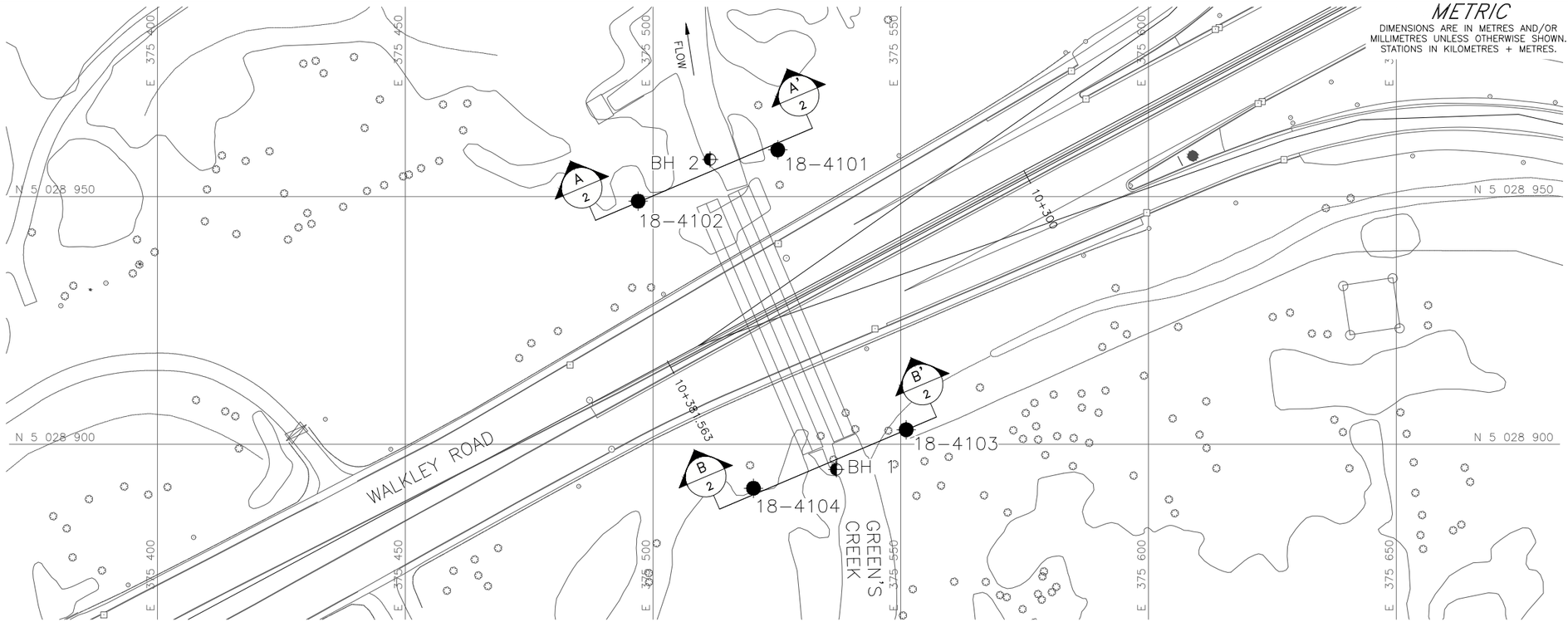
CONT No.
GWP No. 4099-11-00

SHEET

GREEN'S CREEK CULVERTS

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

GOLDER



PLAN

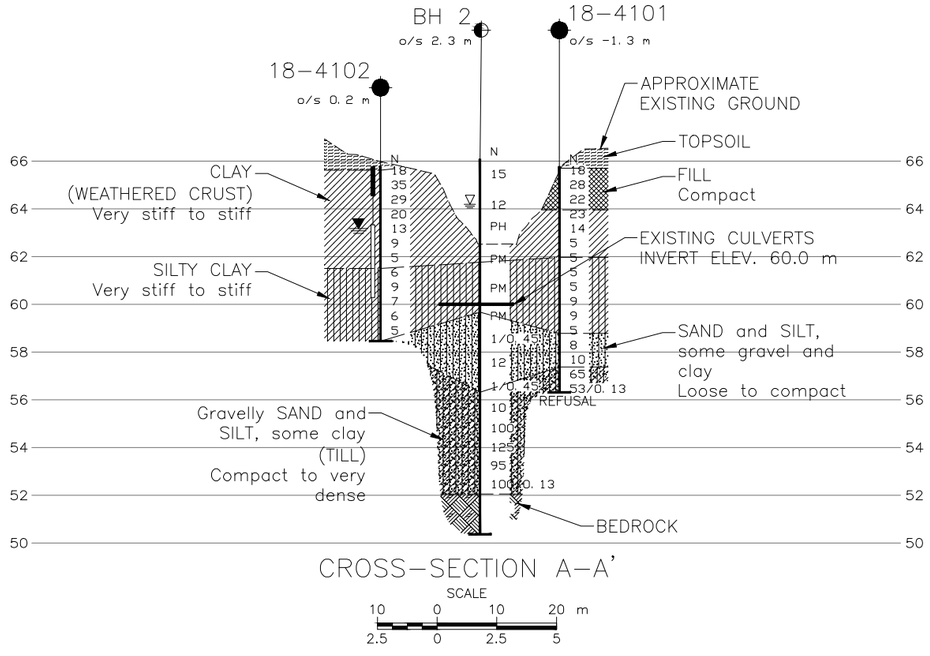
SCALE
10 0 10 20 m

KEY PLAN

SCALE
1 0 1 2 km

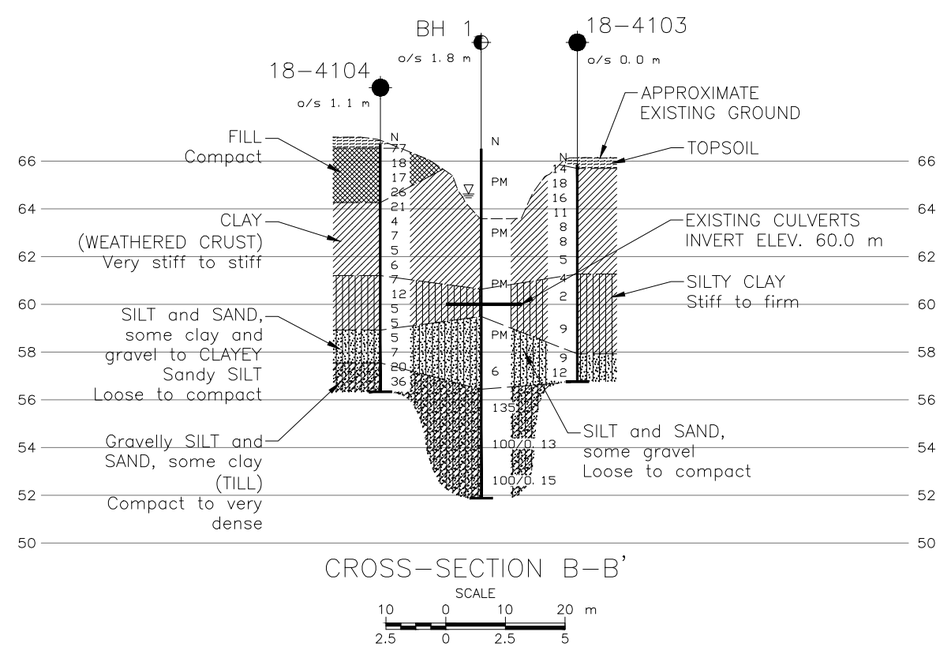
LEGEND

- 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



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

F. J. HEFFERNAN
REGISTERED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

K. T. C. POWER
100130652
LICENSED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

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

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: K:\Active\Spatial_MV\MTO\Hwy417Retrofit&Widening\99_PROJ\1662565_MTO_Hwy417Replacements\40_PROD\02D0_CreenCreekCulvert\1662565-0020-BS-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
σ	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 = 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 ($\phi = 0$ 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	c_u, s_u 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	Sand and Gravel
	With (cohesive)	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
FLT Fault
SH Shear
VN Vein
FR Fracture
SY Stylolite
BD Bedding
FO Foliation
CO Contact
AXJ Axial Joint
KV Karstic Void
MB Mechanical Break

PL Planar
CU Curved
UN Undulating
IR Irregular
K Slickensided
PO Polished
SM Smooth
SR Slightly Rough
RO Rough
VR Very Rough

GOLDER

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	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
65.8	GROUND SURFACE										
0.0 / 0.1	(SM) Silty sand (TOPSOIL) Brown										
	(SM/CI) Silty sand and silty clay, trace gravel (FILL) Compact Brown Dry		1	SS	18						
			2	SS	28		65		○		
			3	SS	22						
64.0							64				
1.8	(CH) CLAY (WEATHERED CRUST) Very stiff to stiff Grey-brown Stiff		4	SS	23				⊢○⊣		
			5	SS	14		63				
			6	SS	5				○		
62.0							62				
3.8	(CI) SILTY CLAY, contains silt layers Stiff Grey Wet		7	SS	5				○		
			8	SS	5						
			9	SS	5		61		⊢○		0 1 51 48
			10	SS	9						
			11	SS	9		60		○		
58.8											
7.0	(ML-SM) SILT and SAND, trace clay and gravel Loose to compact Brown Wet		12	SS	5		59		○		
			13	SS	8						
			14	SS	10		58		○		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		57				
			16	SS	53/0.13				○		
56.3											
9.5	END OF BOREHOLE										

+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

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

GOLDER

RECORD OF BOREHOLE No 18-4102

SHEET 1 OF 1

METRIC

PROJECT 1662565-1410

G.W.P. 4099-11-00

LOCATION N 5028949.0; E 375497.0 NAD 83 MTM ZONE 9 (LAT. 45.396920; LONG. -75.597019)

ORIGINATED BY DJG

DIST Eastern HWY 417

BOREHOLE TYPE Portable Drill, BW Casing

COMPILED BY ZS

DATUM Geodetic

DATE September 6, 2018

CHECKED BY KP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	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
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		65				
			3	SS	29						
			4	SS	20		64				
			5	SS	13		63				
			6	SS	9						
61.5			7	SS	5		62				
4.3	(CL) SILTY CLAY, contains silt seams Stiff Grey Wet		8	SS	6						
			9	SS	9		61				
			10	SS	7						
			11	SS	6		60				
	- some sand, trace gravel		12	SS	5		59				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.

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

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

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

GOLDER

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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
65.8	GROUND SURFACE					
0.0	(SM) Silty sand (TOPSOIL) Dark brown Moist		1	SS	14	
0.2	(CH) CLAY (WEATHERED CRUST) Very stiff to stiff Grey-brown Moist		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	
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					

ELEVATION SCALE: 65, 64, 63, 62, 61, 60, 59, 58, 57

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
0	2	54	44

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

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

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

GOLDER

RECORD OF BOREHOLE No 18-4104

SHEET 1 OF 2

METRIC

PROJECT 1662565-1410

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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
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		66				
			3	SS	17		65				
64.3			4	SS	26						
2.4	(CH) CLAY (WEATHERED CRUST) Very stiff to stiff Grey-brown		5	SS	21		64				
			6	SS	4						
			7	SS	7		63				
			8	SS	5		62				0 1 40 59
61.2			9	SS	6						
5.5	(CI) SILTY CLAY, contains silt seams Stiff Grey		10	SS	7		61				
			11	SS	12						
			12	SS	5		60				
58.9			13	SS	5						
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		59				
			15	SS	7		58				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		57				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No 18-4104

SHEET 2 OF 2

METRIC

PROJECT 1662565-1410

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

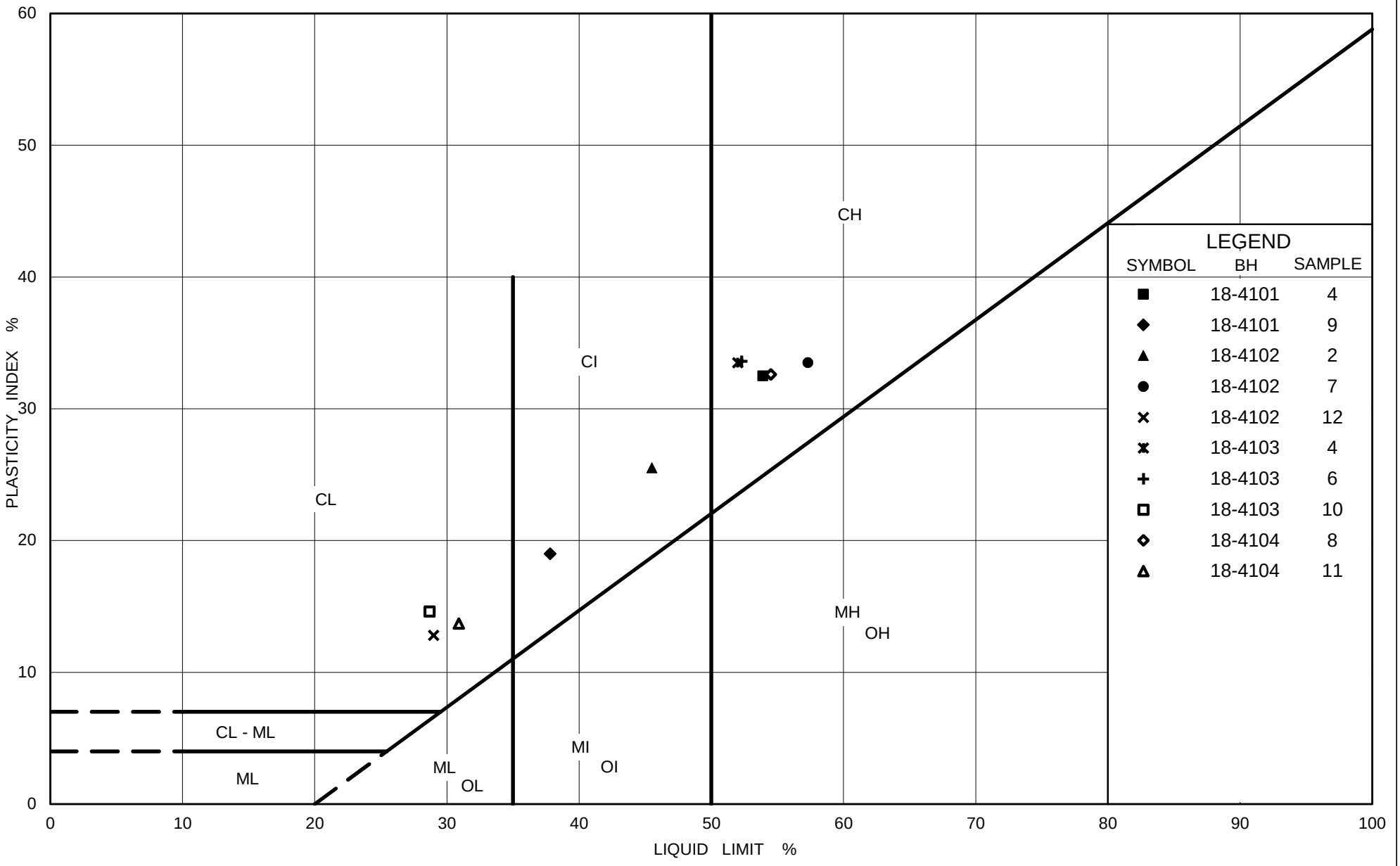
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 25 50 75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

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

APPENDIX B

Laboratory Test Results - Current Investigation

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
CLAY / SILTY CLAY

FIG No. B1

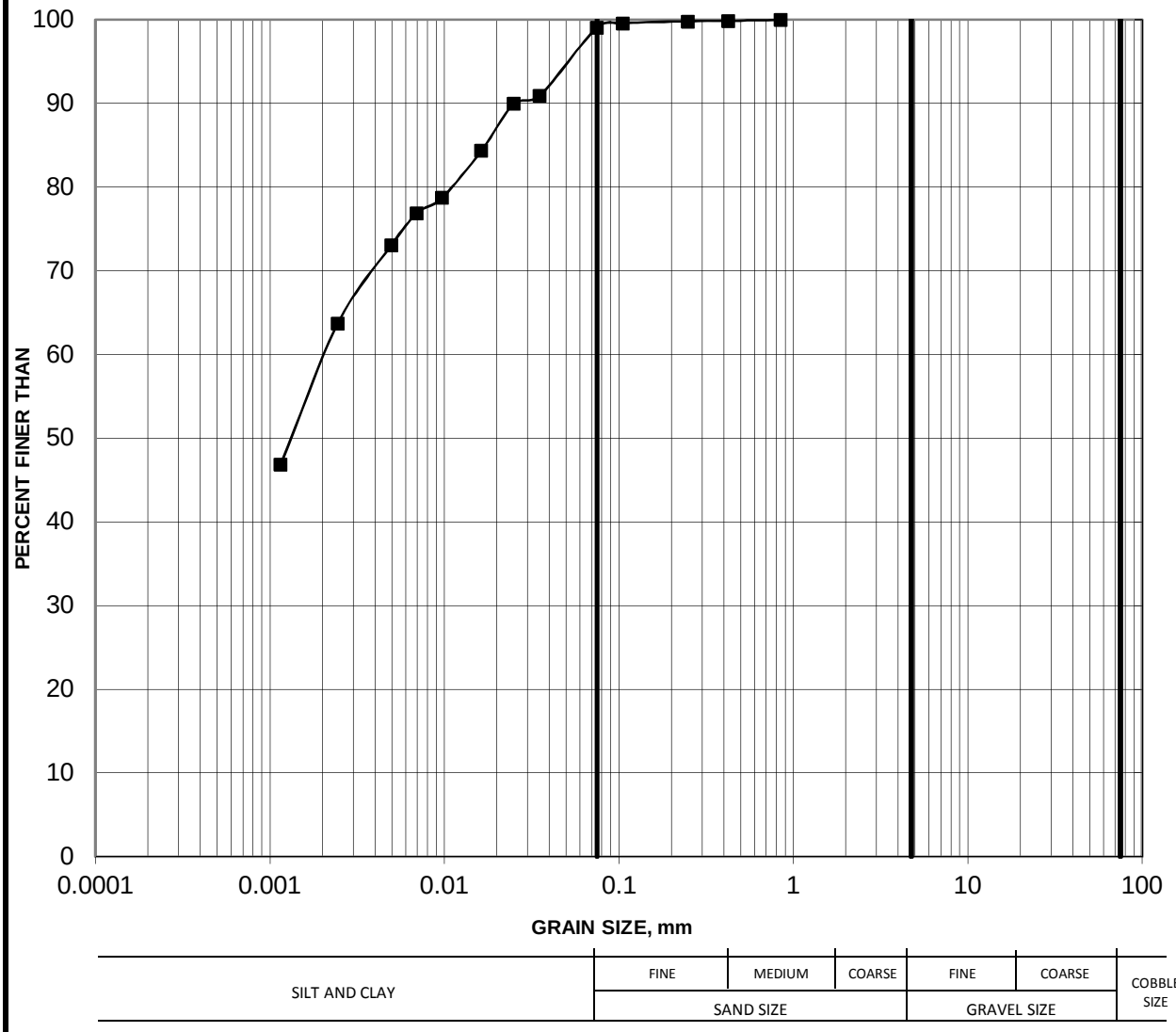
Project No. 1662565/1410

Compiled By : MI Checked By : CW

GRAIN SIZE DISTRIBUTION

FIGURE B2

WEATHERED CRUST



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

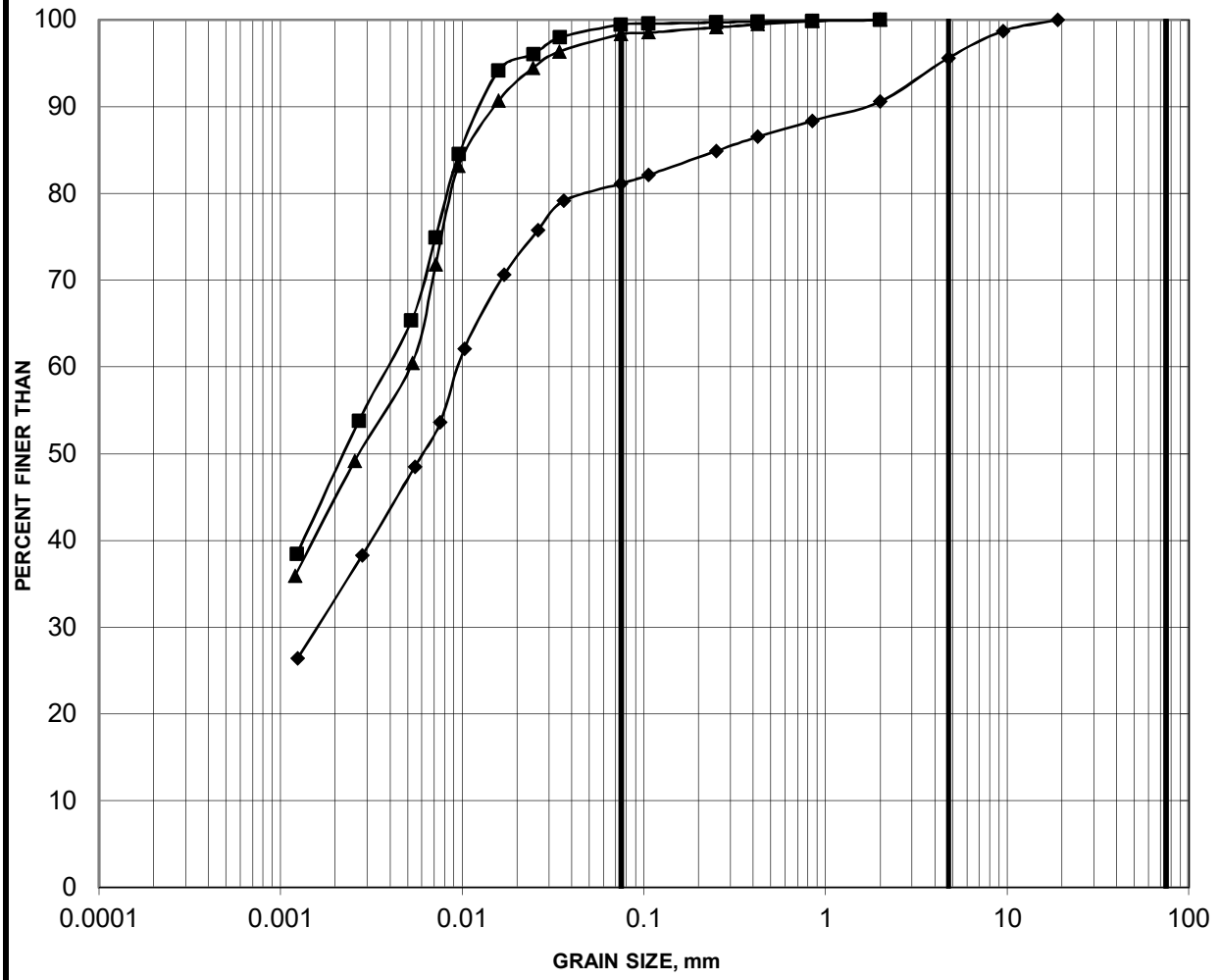
Project: 1662565/1410

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

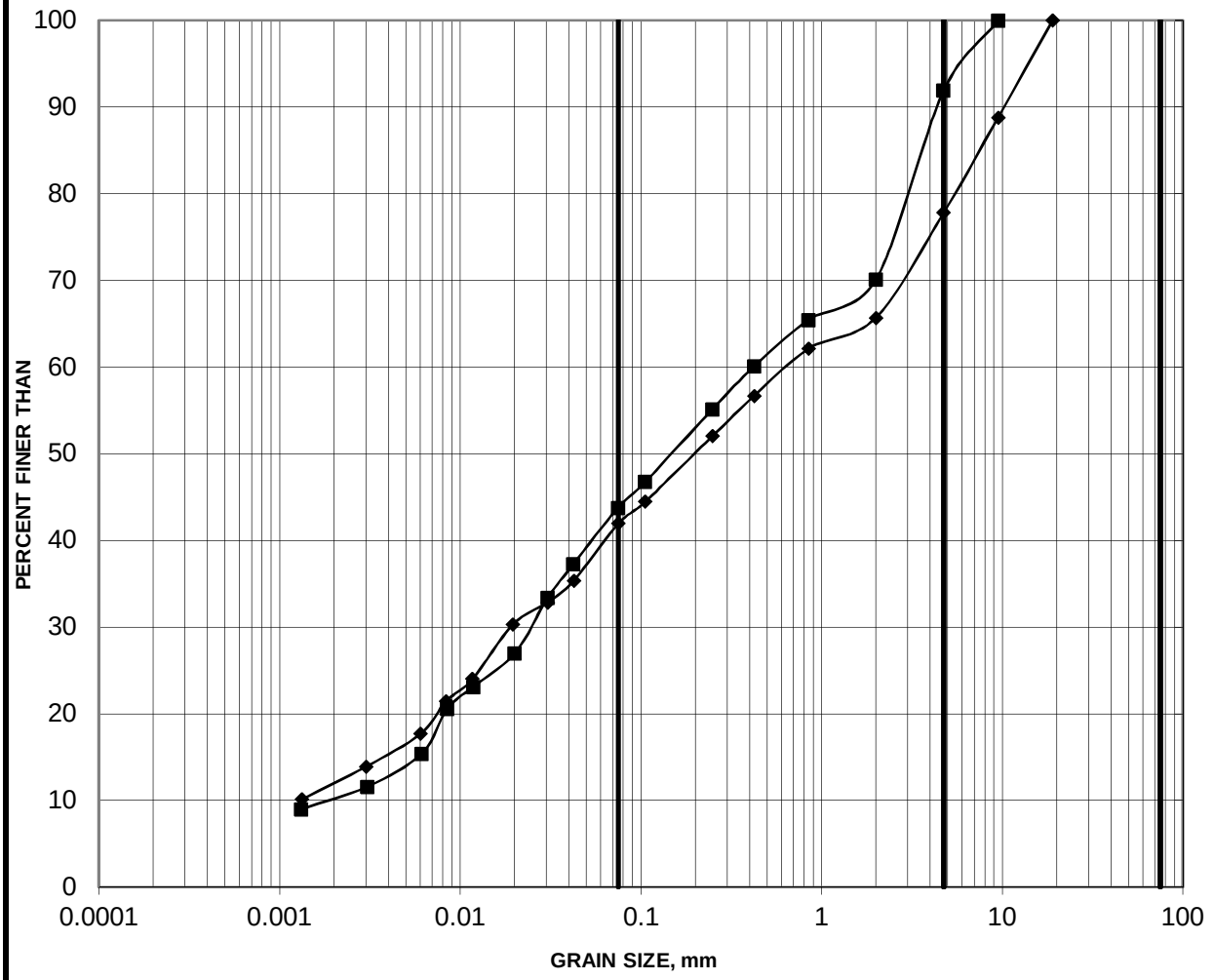
Created by: MI

Checked by: CW

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILT AND SAND



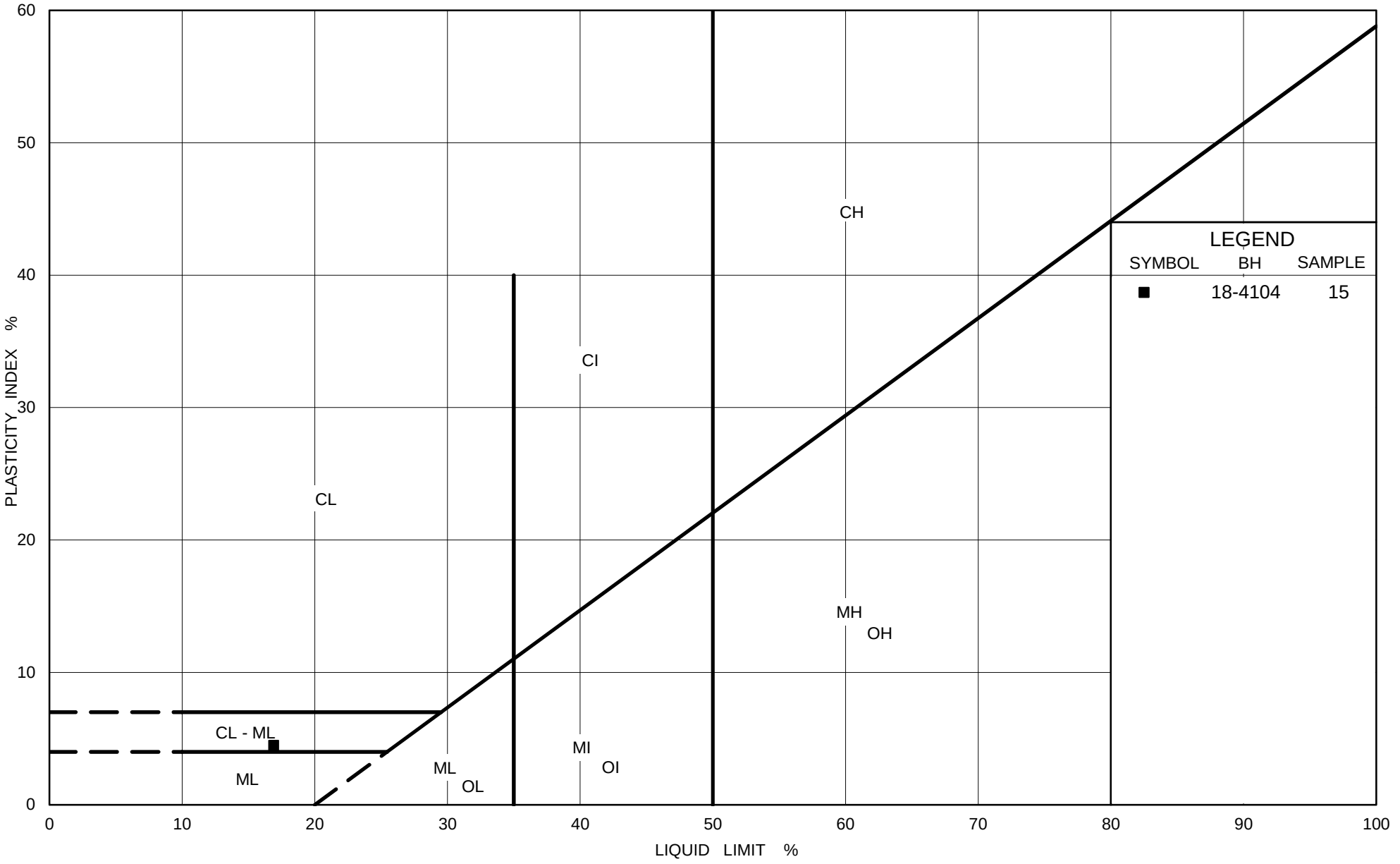
Borehole	Sample	Depth (m)
18-4101	14	7.92-8.53
18-4104	15	8.53-9.14

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 — LOCATION Co-ords. 498,275 N; 231,995 E. — ORIGINATED BY JC

W.P. 10-69-13 — BORING DATE Oct. 20/72 — COMPILED BY JC

DATUM Geodetic — BOREHOLE TYPE Flight Auger and Cone Test — CHECKED BY

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

ELEV. SCALE: 215, 210, 205, 200, 195, 190, 185, 180, 175, 170

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT — 25 50 75 100 125

SHEAR STRENGTH P.S.F. — ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE — 400 800 1200 1600 2000

LIQUID LIMIT —— w_L — PLASTIC LIMIT —— w_P — WATER CONTENT —— w

w_P w w_L

WATER CONTENT % — 15 30 45

BULK DENSITY γ P.C.F.

REMARKS	GR SA SI CL
117.5	
e_o=0.8 C_c=0.3	212.0
110.5	
	0 53 40 7
	28 35 28 9
	0 41 48 11

OFFICE REPORT OF SOIL EXPLORATION

20 15 5 10 % STRAIN AT FAILURE

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 1A

JOB 72-11088 LOCATION Co-ords. 498,080 N; 232,010 E. ORIGINATED BY JC

W.P. 10-69-13 BORING DATE Oct. 20, 1972 COMPILED BY JC

DATUM Geodetic BOREHOLE TYPE Dynamic Cone Test CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 25 50 75 100 125	LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w	BULK DENSITY	REMARKS
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	w_P w w_L WATER CONTENT %	γ P.C.F.	GR. SA. SI. CL.
218.8	Ground Level					215				
						210				
						205				
						200				
						195				
						190				
181.8						185				
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 — LOCATION Co-ord. 498,472 N; 231,916 E. — ORIGINATED BY JC

W.P. 10-69-13 — BORING DATE Oct. 18/72 — COMPILED BY JC

DATUM Geodetic — BOREHOLE TYPE Flight Auger and BXL Rock Core — CHECKED BY

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT
216.8	Ground Level				
0.0	Silty clay to clay		1	SS	15
	with seams of clayey silt up to 2" thick		2	SS	12
	below El. 205.		3	TW	PH
	Very Stiff to Firm		4	TW	PM
	Grey		5	TW	PM
195.8					
21.0	Silt with fine sand (with occ. thin seams of clayey silt)		6	TW	PM
	Very Loose to Compact		7	SS	1/18"
	Dark Grey		8	SS	12
184.8			9	SS	1/18"
32.0	Het. mix. of silt, sand and clay.		10	SS	10
	(Glacial Till)		11	SS	100
	Compact to Very Dense		12	SS	125
	Grey		13	SS	95
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				

ELEV. SCALE: 215, 210, 205, 200, 195, 190, 185, 180, 175, 170, 165

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
400 800 1200 1600 2000

+8.5 +8.4 +9.7 +2.7

LIQUID LIMIT W_L
PLASTIC LIMIT W_P
WATER CONTENT W
W_P W W_L
WATER CONTENT %
15 30 45

BULK DENSITY γ P.C.F.

111
120

REMARKS — GR. SA. SI. CL.

210.6

0 33 52 15

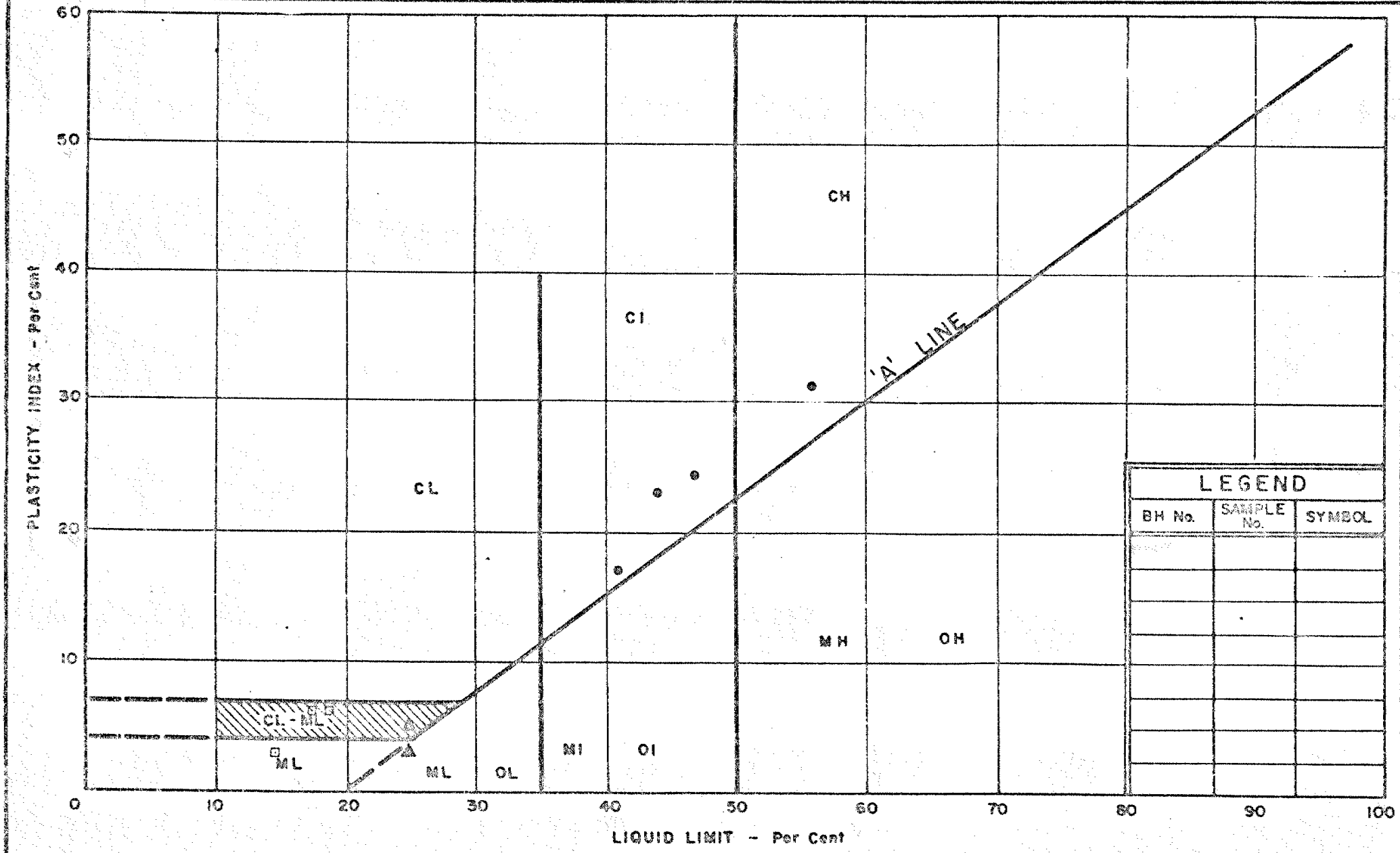
0 43 52 5

0 35 53 12

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

FORM 08-MT 252
REVISED JUL 1966



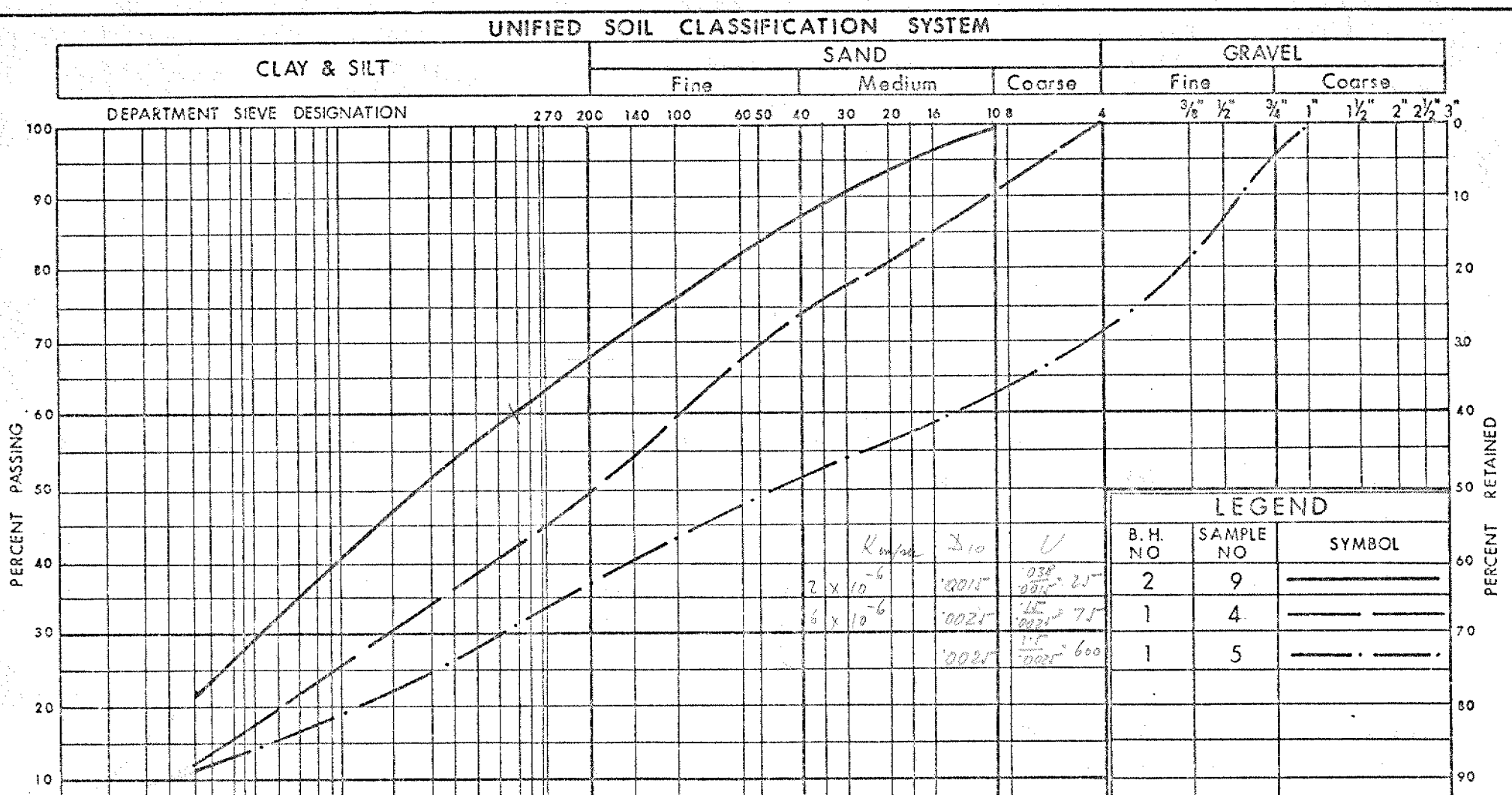
DEPARTMENT OF HIGHWAYS
MATERIALS and TESTING DIVISION

PLASTICITY CHART

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

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

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



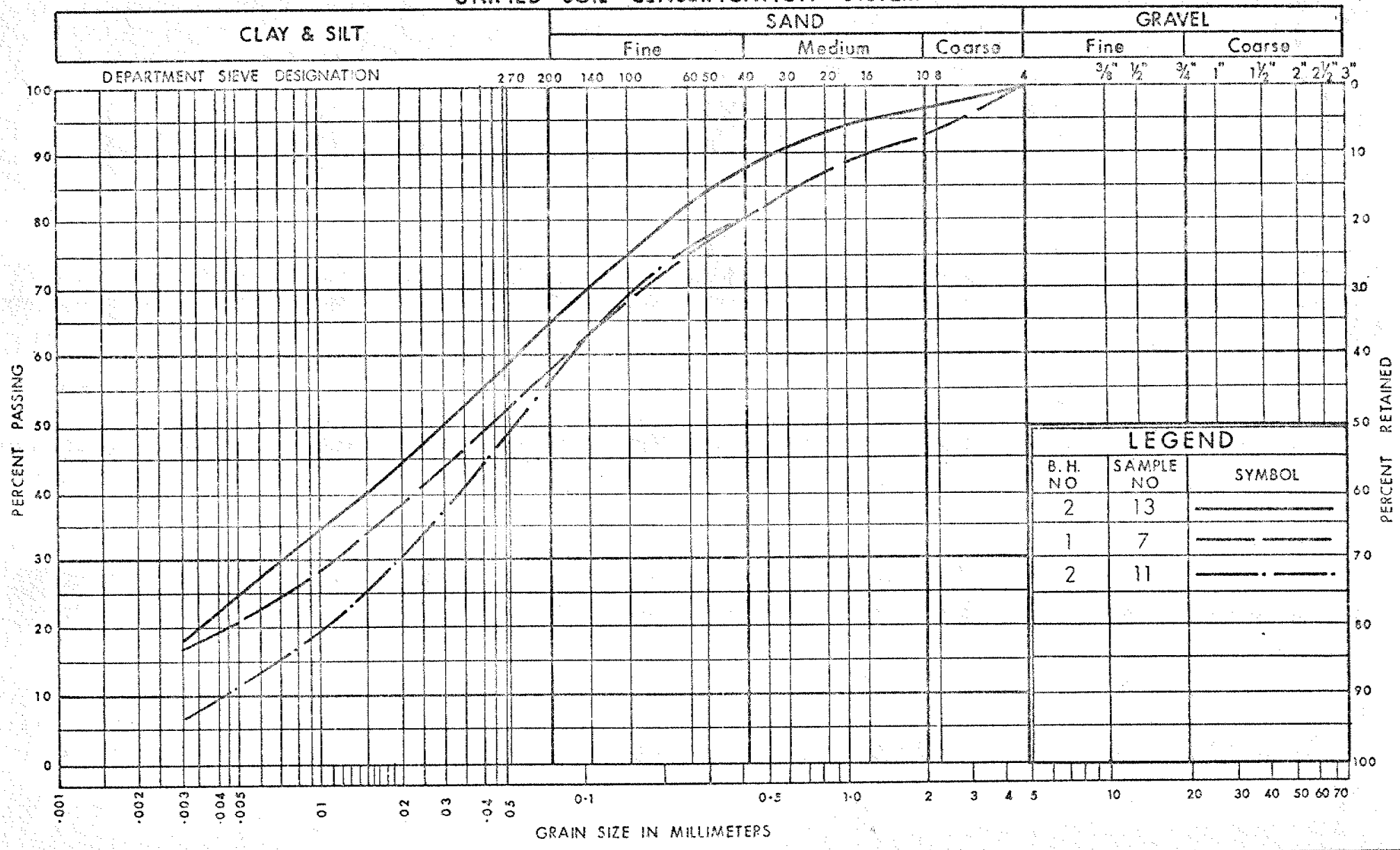
DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS
ONTARIO
DESIGN SERVICES BRANCH

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

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS
ONTARIO
DESIGN SERVICES BRANCH

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

eurofins | Environment Testing

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

golder.com