

Foundation Investigation Report

*Noise Barrier Walls, Highway 427 at the BAPS Shri Swaminarayan Mandir
Etobicoke, Ontario*

MTO Agreement No. 2017-E-0016-040, G.W.P. 2135-20-00

Submitted to:

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GEOCRES No. 30M12-512

Latitude: 43.738247
Longitude: -79.627726



Distribution List

1 E-Copy - MTO Central Region

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the design of two noise barrier walls, approximately 168 m and 234 m in length, which are proposed along the east side of Highway 427 near the BAPS Shri Swaminarayan Mandir (BAPS property), located approximately 500 m north of Finch Avenue West, within the MTO Right-of-Way (ROW).

This report summarizes the results of the soil and groundwater conditions encountered during a 2020 foundation investigation carried out for the proposed noise barrier walls.

The foundation engineering services have been carried out in accordance with MTO's Terms of Reference for this project (Agreement No. 2017-E-0016, Assignment #39 and Assignment #40), dated August 2020 and November 2020, respectively.

2.0 SITE DESCRIPTION

Based on the General Arrangement drawings for the noise barrier walls provided by MH on April 16, 2021, two walls (designated Noise Barriers 'A' and 'B') are proposed to be constructed along the east side of the existing Highway 427 embankment as shown on Drawing 1. The BAPS property (fence and parking area) is located directly east of the proposed noise wall locations and a stormwater management pond is located to the east of the south limit of the proposed walls. Highway 427 is located directly west of the proposed walls, with the Claireville Reservoir, the West Humber River, and the West Humber Trail located further west of Highway 427 and south of the proposed noise walls. Industrial lands containing warehouses and retail buildings generally exist to the north of the proposed noise walls.

Noise Barrier Wall 'A' is about 168 m long and is located near the shoulder / crest of the Highway 427 northbound lane (NBL) embankment along the southern portion of the BAPS property and north of the West Humber River bridge. Noise Barrier Wall "B" is about 234 m long and is located east of the Highway 427 NBL embankment toe / ditch near the existing MTO ROW limit and adjacent to the northern portion of the BAPS property / fence line.

The site of the two walls is within the recently widened portion of the Highway 427 NBL embankment. The overall site grade generally slopes downward from north to south towards the West Humber River which is located about 50 m south of the southern wall limit. The Highway 427 NBL grade ranges from about Elevation 167 m to Elevation 174 m and the adjacent ditchline near the toe of the embankment ranges from about Elevation 164 m to 170 m near the noise wall alignments.

3.0 INVESTIGATION PROCEDURES

The foundation investigation was carried out by Golder between November 2 and 4, 2020, during which time seven boreholes (designated as Boreholes NW-1 to NW-7) were advanced along the proposed noise wall locations based on the conceptual design at that time.

The borehole investigation was carried out using a CME-55 track-mounted drill rig supplied and operated by Geo-Environmental Drilling Inc. of Acton, Ontario. The boreholes were advanced using 150 mm outer-diameter continuous flight hollow stem augers.

Soil samples were generally obtained at 0.75 m and 1.5 m intervals of depth using a 50 mm outer-diameter split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-18)¹.

The groundwater conditions in the open boreholes were observed during and immediately following the drilling operations. The boreholes were backfilled with bentonite upon completion in general accordance with Ontario Regulation 903 (Wells, as amended).

The field work was observed on a full-time basis by members of Golder's engineering and technical staff, who located the boreholes in the field, arranged for the clearance of underground services, observed and directed the drilling, sampling, and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's geotechnical laboratory in Mississauga where the samples underwent further visual examination and testing. Index and classification testing, consisting of natural moisture contents, Atterberg limits and grain size distributions, was conducted on selected soil samples in accordance with MTO and / or ASTM standards, as applicable. Two soil samples were submitted to a specialist accredited analytical laboratory (Bureau Veritas Laboratories) under chain of custody procedures for analysis of parameters used to assess the corrosivity and deterioration potential of the site soil to steel and concrete.

The borehole locations were surveyed in the field by Golder personnel relative to existing road features and pre-selected coordinates using a hand-held global positioning system (GPS) unit with an accuracy of 2 cm in the horizontal and vertical directions. The locations given on the borehole records and shown on Drawing 1 are positioned relative to MTM NAD 83 (Zone 10) CSRS CBNv6-2010.0 northing and easting coordinates and the ground surface elevations are referenced to Geodetic (CGVD-1928) datum. The borehole locations, including both MTM NAD 83 and geographic coordinates, ground surface elevation, and drilled depth are summarized below.

Borehole No.	MTM NAD83 (Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude °)	Easting (m) (Longitude °)		
NW-1	4,844,188.5 (43.737589)	294,518.9 (-79.627638)	168.2	8.2
NW-2	4,844,269.2 (43.738316)	294,507.3 (-79.627784)	169.4	8.2
NW-3	4,844,333.0 (43.738890)	294,498.7 (-79.627892)	170.3	8.2
NW-4	4,844,418.4 (43.739659)	294,493.6 (-79.627956)	169.2	8.2
NW-5	4,844,487.4 (43.740279)	294,482.3 (-79.628099)	169.9	8.2
NW-6	4,844,575.0 (43.741068)	294,470.2 (-79.628251)	170.9	8.2

¹ ASTM D1586-18 – Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.

Borehole No.	MTM NAD83 (Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude °)	Easting (m) (Longitude °)		
NW-7	4,844,625.5 (43.741522)	294,463.5 (-79.628334)	171.5	8.2

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 427 is located within the physiographic region known as the Peel Plain, according to *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)².

The Peel Plain region is characterized by an extensive, level-to-undulating deposit of clayey silt to silty clay till covering about 775 square kilometers and including the Regions of York, Peel and Halton. Shallow surficial deposits (the “Peel ponds deposits”) are scattered on top of this till sheet throughout the region, consisting of firm to very stiff clayey silt to silty clay and loose to compact sands and silts. The surface topography slopes gradually and uniformly southwards towards Lake Ontario and contains deep cut valleys of numerous rivers including the Credit, Humber and Rouge Rivers.

4.2 General Overview of Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during the 2020 investigation, including water level readings and the results of the geotechnical laboratory tests carried out on selected soil samples, are presented on the borehole records provided in Appendix A. The results of the in-situ field tests (i.e., SPT “N”-values) as presented on the borehole records and in Section 4.2 are uncorrected. Plots of the grain size distribution and Atterberg limits test results are shown on Figures B1 to B7, inclusive, presented in Appendix B.

The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole locations.

In general, the encountered subsurface soils consist of a surficial layer of topsoil, underlain by fill that typically consists of non-cohesive over cohesive soils within the highway embankment. The fill is generally underlain by a deposit of clayey silt till to silt till which is in turn underlain by a deposit of sandy silt to silty sand to sand. More detailed descriptions of the subsurface conditions encountered in the boreholes are provided in the following sections.

4.2.1 Topsoil

An approximately 70 mm to 150 mm thick layer of topsoil was encountered at surface in all boreholes.

² Chapman, L.J. and Putman, D.F., 1984, *The Physiography of Southern Ontario*, Ontario Geological Society, Special Volume 2, Third Edition. Accompanied by Map p. 2715, Scale 1:600,000.)

The soil was classified solely based on visual and textural evidence. Testing of organic content or for other nutrients was not carried out. Therefore, the use of materials classified as topsoil cannot be relied upon for support and growth of landscaping vegetation.

4.2.2 Gravelly SAND (SW-SM) to SAND (SW) and Gravel (FILL)

A 0.4 m thick layer of non-cohesive fill was encountered below the topsoil in Boreholes NW-1 to NW-3, which were drilled through the outside shoulder of the highway embankment. The non-cohesive fill ranges in composition from gravelly sand to sand and gravel. The top of the non-cohesive fill was encountered at a depth of 0.2 m below ground surface (between Elevations 170.1 m and 168.0 m) and it extends to a depth of 0.6 m below ground surface (between Elevations 169.7 m and 167.6 m).

The SPT “N” values measured within the non-cohesive fill range from about 17 blows to 44 blows per 0.3 m of penetration, indicating a compact to dense state of compactness.

Grain size distribution testing was carried out on a sample of the non-cohesive fill and the results are presented in Figure B1 in Appendix B. The water content measured on a selected sample of the granular fill layer was about 10%.

4.2.3 SILTY CLAY (CI) to CLAYEY SILT (CL) - FILL

A 0.5 m to 3.1 m thick layer of cohesive fill was encountered below the non-cohesive fill in Boreholes NW-1 to NW-3 and below the topsoil in Boreholes NW-4 to NW-7. The cohesive fill ranges in composition from silty clay to clayey silt with some layers described as sandy to gravelly. The top of the cohesive fill was encountered at depths ranging from 0.1 m to 0.6 m below ground surface (between Elevations 171.4 m and 167.6 m) and it extends to depths ranging from 0.6 m to 3.7 m below ground surface (between Elevations 170.9 m and 164.5 m).

The SPT “N” values measured within the cohesive fill range from about 5 blows to 18 blows per 0.3 m of penetration, suggesting a firm to very stiff consistency.

Grain size distribution testing was carried out on a sample of the cohesive fill and the result is shown on Figure B2 in Appendix B. Atterberg limits testing was carried out on selected samples of the cohesive fill and the results are presented on Figure B3 in Appendix B. The Atterberg limit tests measured liquid limits of about 34% and 37%, plastic limits of about 17% and 18%, and plasticity indices of about 17% and 18%, indicating that the cohesive fill is comprised of a clayey silt of low plasticity to silty clay of medium plasticity. The water content measured on samples of the deposit ranges from about 11% to 22%.

4.2.4 SILTY CLAY (CI) to CLAYEY SILT-SILT (CL-ML) - TILL Containing SILT (ML) to Gravelly SAND (SP) (TILL) Zones or Interlayers

A 1.3 m to 7.6 m thick deposit of cohesive till with non-cohesive interlayers was encountered below the fill in all boreholes. The glacial till generally ranges in composition from silty clay to clayey silt with interlayers of gravelly sand to sandy silt to silt. The top of the glacial till was encountered at depths ranging from 0.6 m to 3.7 m below ground surface (between Elevations 170.9 m and 164.5 m) and it extends to depths ranging from 5.0 m to greater than 8.2 m below ground surface (between Elevation 163.8 m and lower than 162.7 m). Boreholes NW-6 and NW-7 were terminated within the glacial till deposit at a depth of 8.2 m (Elevation 162.7 m and 163.3 m, respectively).

Zones or interlayers of non-cohesive gravelly sand to sandy silt to silt (till) were encountered in Boreholes NW-2, NW-5, NW-6 and NW-7 at depths of 0.6 m to 2.2 m (Elevation 170.3 m to 167.2 m) and were each about 0.8 m thick. Such zones should be expected at any depth within the cohesive till deposit.

Auger grinding was encountered at various depths within the till deposit in Boreholes NW-1, NW-4, NW-5 and NW-7. Given the auger grinding and known presence of cobbles / boulders within the glacially derived soils in this area of Southern Ontario, cobbles/boulders are inferred to be present within this deposit and/or near the interface of this deposit with adjacent soil layers.

The SPT “N” values measured within the cohesive glacial till range from about 9 blows to 52 blows per 0.3 m of penetration, suggesting a stiff to hard consistency. The SPT “N” values measured within the non-cohesive glacial till interlayers ranged from 24 blows to 43 blows per 0.3 m of penetration, indicating a compact to dense level of compactness. Grain size distribution testing was carried out on selected samples of the cohesive till deposit and the results are shown on Figures B4A and B4B in Appendix B. Atterberg limits testing was carried out on selected samples of cohesive till and the results are presented on Figures B5A in Appendix B. The Atterberg limit tests measured liquid limits ranging from about 20% to 39%, plastic limits ranging from about 13% to 20%, and plasticity indices ranging from about 6% to 21%, indicating that the cohesive till is comprised of clayey silt-silt of low plasticity and silty clay of medium plasticity. The water content measured on samples of the cohesive deposit range from about 8% to 22%.

Grain size distribution testing was carried out on three samples of the non-cohesive gravelly sand to silt till interlayers and the results are shown on Figure B6 in Appendix B. Atterberg limits testing carried out on three samples of the silt till interlayers measured liquid limits of about 16% to 20%, plastic limits of about 12% to 18%, and corresponding plasticity indices of about 2% to 4% as shown on Figure B5B. The results of the testing indicate the silt interlayers are slightly plastic. The water content measured on samples of the non-cohesive till interlayers range from about 8% to 16%.

4.2.5 Sandy SILT (ML) to SILTY SAND (SM) to Sandy GRAVEL (GP)

A non-cohesive deposit consisting of sandy silt to silty sand, sand, and sandy gravel was encountered below the cohesive till in Boreholes NW-1 to NW-5. The top of the non-cohesive deposit was encountered at depths ranging from 5.0 m to 7.2 m below ground surface (between Elevations 163.8 m and 162.7 m). Boreholes NW-1 to NW-5 were terminated within the cohesionless deposit at a depth of 8.2 m (Elevations 162.1 m to 160.0 m) after penetrating the deposit for thicknesses ranging from 1.0 m to 3.2 m.

The SPT “N” values measured within the non-cohesive deposit generally range from about 32 blows to 87 blows per 0.3 m of penetration indicating a dense to very dense level of compactness.

Grain size distribution testing was carried out on two selected samples of the cohesionless deposit and the results are shown on Figure B7 in Appendix B. Atterberg limits testing was carried out on two selected samples of the non-cohesive deposit and the results classified the deposit as non-plastic. The water content was measured on samples of the deposit and range from about 11% to 15%.

4.2.6 Groundwater Conditions

The soil samples obtained from the geotechnical investigation were generally described as moist. The groundwater level in the open boreholes was measured from ground surface upon completion of drilling operations. These water level readings are shown on the borehole records and are summarized below.

Borehole No.	Depth to Groundwater (m)	Groundwater Elevation (m)	Date
NW-1	5.2	163.0	November 2, 2020
NW-2	6.1	163.3	November 2, 2020
NW-3	Dry	--	November 2, 2020
NW-4	Dry	--	November 3, 2020
NW-5	6.7	163.2	November 3, 2020
NW-6	7.1	163.8	November 3, 2020
NW-7	6.7	164.8	November 4, 2020

The water levels measured inside the boreholes immediately after completion of drilling may not represent the stabilized groundwater level at the site. The groundwater level will be subject to seasonal fluctuations and should be expected to be higher during the spring season or during and following periods of heavy precipitation. It is noted that Boreholes NW-5 to NW-7 are located near the existing drainage ditch adjacent to the highway embankment and perched water levels near ground surface may be expected in this area during wet conditions.

4.3 Analytical Testing Results

Two soil samples were submitted for analysis of parameters used to assess the potential corrosivity of the site soil to steel and concrete. The details of the analytical tests are included in Appendix C and the results are summarized below:

Borehole No. / Sample No.	pH	Resistivity (ohm-cm)	Electrical Conductivity (µmho/cm)	Soluble Chlorides (µg/g)	Soluble Sulphates (µg/g)
NW-1 / SA 3	7.87	560	1,780	890	280
NW-3 / SA 4	7.74	500	1,990	1,300	210

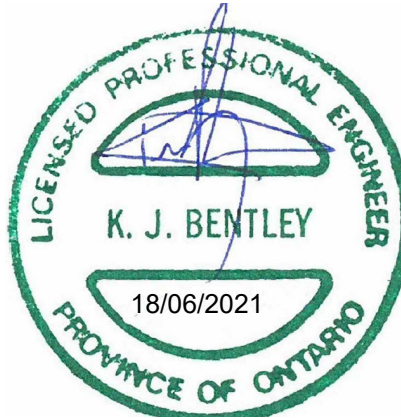
5.0 CLOSURE

This Foundation Investigation Report was prepared Mr. Carter Comish, E.I.T. and reviewed by Mr. Kevin Bentley, P.Eng., an MTO Foundations Designated Contact and Geotechnical Engineer. Ms. Lisa Coyne, P.Eng., Principal and MTO Foundations Designated Contact, performed an independent quality control review of the report.

Golder Associates Ltd.



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Geotechnical Engineer-In-Training



Kevin Bentley, P.Eng
Associate, MTO Foundations Designated Contact

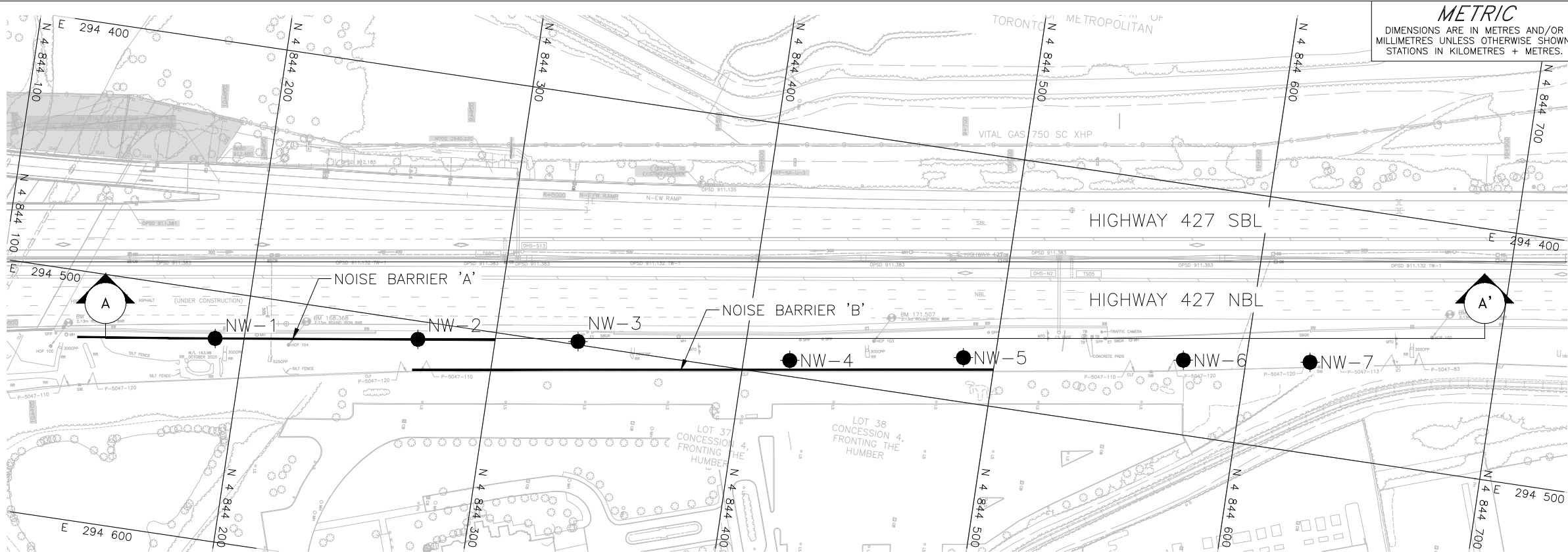


Lisa Coyne, P.Eng.
Principal, MTO Foundations Designated Contact

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PLAN



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

CONT No.
GWP No. 2135-20-00



HIGHWAY 427
NOISE WALL
BOREHOLE LOCATIONS AND SOIL
STRATA

SHEET



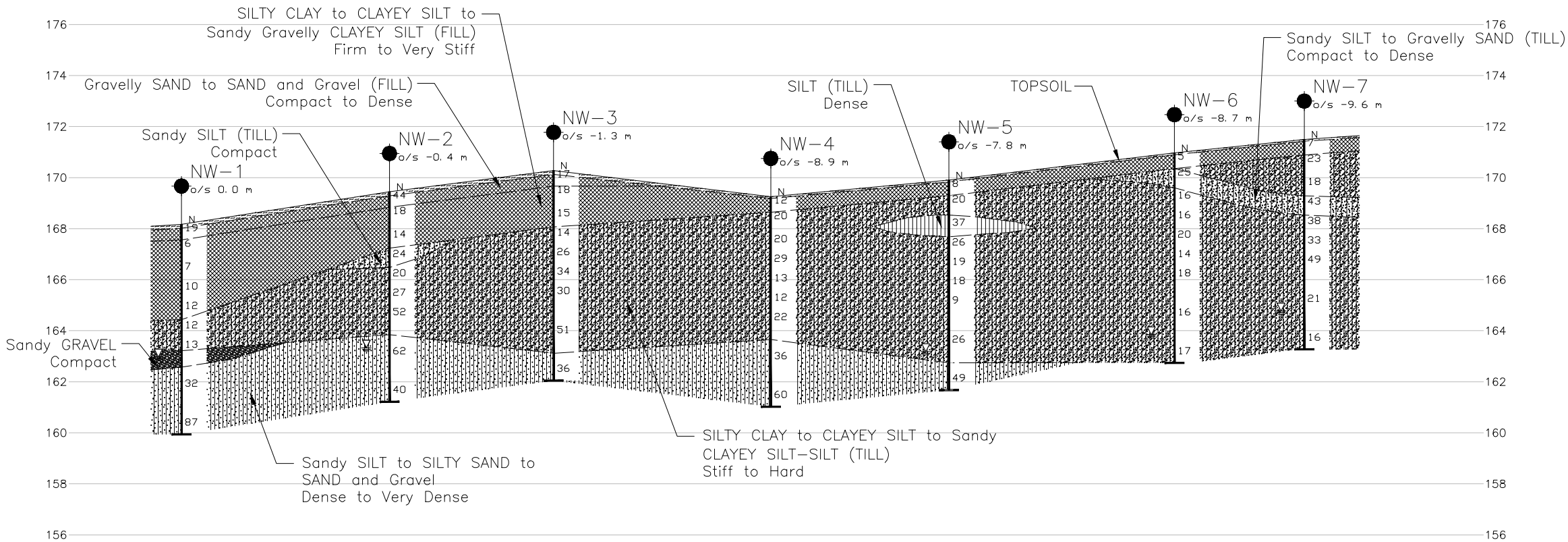
KEY PLAN
SCALE
1 0 1 2 km

LEGEND

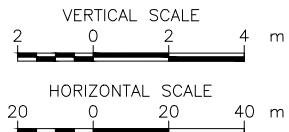
- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow)
- ≡ WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
NW-1	168.2	4844188.5	294518.9
NW-2	169.4	4844269.2	294507.3
NW-3	170.3	4844333.0	294498.7
NW-4	169.2	4844418.4	294493.6
NW-5	169.9	4844487.4	294482.3
NW-6	170.9	4844575.0	294470.2
NW-7	171.5	4844625.5	294463.5

Site coordinates: Latitude: 43.738247 Longitude: -79.627726



PROFILE A-A'



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.

REFERENCE

Base plans provided in digital format by MORRISON HERSHFELD, drawing file No. x1171166_Baseplan with link 427 parts.dwg, received December 10, 2020 and X1171166.40_NC.dwg, received April 16, 2021.

NO.	DATE	BY	REVISION
Geocres No. 30M12-512			
HWY. 427	PROJECT NO. 1786658		DIST. .
SUBM'D. CC	CHKD. CC	DATE: 06/14/2021	SITE: .
DRAWN: SA/DD	CHKD. KJB	APPD. LCC	DWG. 1



APPENDIX A

Borehole Records

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

MINISTRY OF TRANSPORTATION, ONTARIO

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>200	>8
COBBLES	Not Applicable	75 to 200	3 to 8
GRAVEL	Coarse	19 to 75	0.75 to 3
	Fine	4.75 to 19	(4) to 0.75
	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
FINES	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY COMPONENTS^{1,2}

Percentage by Mass	Modifier
> 35	Use 'and' to combine primary and secondary component (<i>i.e.</i> , SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (<i>i.e.</i> , some sand)
≤ 10	trace (<i>i.e.</i> , trace fines)

1. Only applicable to components not described by Primary Group Name.

2. Classification of Primary Group Name based on Unified Soil Classification System (ASTM D2487) for coarse-grained soils; fine-grained soils described per current MTO Soil Classification System.

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve friction (f_s) are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d :

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

SAMPLES

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

SOIL TESTS

w	water content
PL, w_p	plastic limit
LL, w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_r	relative density (specific gravity, G_s)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
Y	unit weight

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

COARSE-GRAINED SOILS

Compactness¹

Term	SPT 'N' (blows/0.3m) ²
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

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

FINE-GRAINED SOILS

Consistency

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

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

Field Moisture Condition

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

LIST OF SYMBOLS

MINISTRY OF TRANSPORTATION, ONTARIO

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
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)

σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
$C_{a(e)}$	secondary compression index
C_a	rate of secondary compression
$C_{a(e)}$	modified 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
c'	effective cohesion
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
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 or q'	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

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

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
shear strength = (compressive strength)/2

PROJECT 1786658		RECORD OF BOREHOLE No NW-1		SHEET 1 OF 1		METRIC									
G.W.P. 2135-20-00		LOCATION N 4844188.5; E 294518.9 MTM NAD 83 ZONE 10 (LAT. 43.737589; LONG. -79.627638)		ORIGINATED BY BL											
DIST Central HWY 427		BOREHOLE TYPE Power Auger, 70 mm I.D., 150 mm O.D. Hollow Stem Augers		COMPILED BY CC											
DATUM Geodetic (CGVD-1928)		DATE November 2, 2020		CHECKED BY KJB											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa		WATER CONTENT (%)		γ		GR SA SI CL	
168.2	GROUND SURFACE							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED		W _p — W — W _L 10 20 30		kN/m ³			
0.0	TOPSOIL (150 mm)		1A	SS	19		168								
0.2	SAND (SW) and Gravel (FILL)		1B	SS	19										
167.6	Compact Brown Moist		2	SS	6										
0.6	Sandy Gravelly CLAYEY SILT (CL) (FILL)						167								
166.8	Firm Brown Moist		3	SS	7										
1.4	CLAYEY SILT (CL), trace to some sand, trace gravel (FILL)						166								
	Firm to stiff Brown Moist		4	SS	10										
			5	SS	12		165								
164.5	Sandy CLAYEY SILT (CL), trace gravel (TILL)		6	SS	12		164								
3.7	Stiff Brown/grey Moist		7A	SS	13										
163.3			7B	SS	13		163								
5.0	Sandy GRAVEL (GP), some silt, augers grinding														
162.6	Compact Brown Moist						162								
5.6	SILTY SAND (SM) and Gravel to SAND (SP) and Gravel		8	SS	32										
	Dense to very dense Brown Wet						161								
			9	SS	87		160								
160.0	END OF BOREHOLE														
8.2	NOTES:														
	1. Borehole caved to a depth of 5.7 m below ground surface (Elevation 165.5 m) upon removal of augers.														
	2. Groundwater measured at 5.2 m below ground surface (Elevation 163.0 m) in open borehole on completion of drilling.														

PROJECT 1786658		RECORD OF BOREHOLE No NW-2				SHEET 1 OF 1				METRIC			
G.W.P. 2135-20-00		LOCATION N 4844269.2; E 294507.3 MTM NAD 83 ZONE 10 (LAT. 43.738316; LONG. -79.627784)				ORIGINATED BY BL							
DIST Central HWY 427		BOREHOLE TYPE Power Auger, 70 mm I.D., 150 mm O.D. Hollow Stem Augers				COMPILED BY CC							
DATUM Geodetic (CGVD-1928)		DATE November 2, 2020				CHECKED BY KJB							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		
								○ UNCONFINED + FIELD VANE			w _p w w _L		
								● QUICK TRIAXIAL × REMOULDED			WATER CONTENT (%)		
								20 40 60 80 100			10 20 30		
169.4	GROUND SURFACE												
0.0	TOPSOIL (150 mm)												
0.2	Gravelly SAND (SW-SM), trace silt, trace clay (FILL)		1A	SS	44		169					33 58 8 1	
168.8	Very dense Brown Moist		2	SS	18								
0.6	CLAYEY SILT (CL), some sand to sandy, trace silt (FILL)						168						
	Stiff to very stiff Brown Moist		3	SS	14								
167.2	Sandy SILT (ML), trace gravel, trace plastic fines (TILL)						167						
2.2	Compact Brown Moist		4	SS	24								
166.4	CLAYEY SILT (CL), trace gravel, trace sand, oxidation staining (TILL)						166						
3.0	Stiff Brown Moist		5	SS	20								
165.7	Sandy CLAYEY SILT (CL), trace gravel (TILL)						165						
3.7	Very stiff Brown Moist		6	SS	27								
164.9	Sandy CLAYEY SILT-SILT (CL-ML), trace gravel (TILL)						164						
4.5	Hard Brown Moist		7	SS	52								
163.8	SILTY SAND (SM), trace gravel						163					5 80 12 3	
5.6	Dense to very dense Brown Moist		8	SS	62								
							162						
161.2	END OF BOREHOLE		9	SS	40								
8.2	NOTES: 1. Borehole caved to a depth of 7.0 m below ground surface (Elevation 162.4 m) upon removal of augers. 2. Groundwater measured at 6.1 m below ground surface (Elevation 163.3 m) in open borehole on completion of drilling.												

PROJECT		1786658		RECORD OF BOREHOLE No NW-3		SHEET 1 OF 1		METRIC									
G.W.P.		2135-20-00		LOCATION		N 4844333.0; E 294498.7 MTM NAD 83 ZONE 10 (LAT. 43.738890; LONG. -79.627892)		ORIGINATED BY									
DIST		Central HWY 427		BOREHOLE TYPE		Power Auger, 70 mm I.D., 150 mm O.D. Hollow Stem Augers		COMPILED BY									
DATUM		Geodetic (CGVD-1928)		DATE		November 2, 2020		CHECKED BY									
								KJB									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
170.3	GROUND SURFACE																
0.0	TOPSOIL (150 mm)		1A	SS	17												
0.2	SAND (SW) and Gravel (FILL)		1B	SS	17												
169.7	Compact Brown Moist		2	SS	18												
0.6	CLAYEY SILT (CL), trace sand, contains rootlets (FILL) Stiff to very stiff Brown Moist		3	SS	15												
168.1	CLAYEY SILT (CL), some sand to sandy, trace gravel (TILL) Stiff to hard Brown Moist		4	SS	14												
2.2			5	SS	26												
	- oxidation staining between a depth of 3.8 m and 5.2 m (Elev. 166.5 m and 165.1 m)		6	SS	34												
			7	SS	30												
164.7	Sandy CLAYEY SILT-SILT (CL-ML), trace gravel (TILL) Hard Grey Moist		8	SS	51												
5.6																	
163.1	SILTY SAND (SM), some gravel Dense Grey Moist		9	SS	36												
7.2																	
162.1	END OF BOREHOLE																
8.2	NOTES: 1. Borehole caved to a depth of 6.7 m below ground surface (Elevation 163.6 m) upon removal of augers. 2. Open borehole dry on completion of drilling.																

PROJECT		1786658		RECORD OF BOREHOLE No NW-4		SHEET 1 OF 1		METRIC																
G.W.P.		2135-20-00		LOCATION		N 4844418.4; E 294493.6 MTM NAD 83 ZONE 10 (LAT. 43.739659; LONG. -79.627956)		ORIGINATED BY																
DIST		Central HWY 427		BOREHOLE TYPE		Power Auger, 70 mm I.D., 150 mm O.D. Hollow Stem Augers		COMPILED BY																
DATUM		Geodetic (CGVD-1928)		DATE		November 3, 2020		CHECKED BY																
								KJB																
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			ELEVATION SCALE			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES																		
169.2		GROUND SURFACE																						
168.6	0.6	TOPSOIL (70 mm) CLAYEY SILT (CL), some sand (FILL) Stiff Brown Moist		1	SS	12																		
				2	SS	20																		
		CLAYEY SILT, (CL) some sand to sandy, trace gravel (TILL) Stiff to very stiff Brown to grey Moist		3	SS	20																		
		- augers grinding between a depth of 4.6 m and 5.2 m (Elev. 164.6 m and 164.0 m)		4	SS	29																		
				5	SS	13																		
				6	SS	12																		
				7	SS	22																		
163.6	5.6	SILTY SAND (SM), trace gravel Dense Grey Moist		8	SS	36																		
162.0	7.2	Sandy SILT (ML) Very dense Grey Moist		9	SS	60																		
161.0	8.2	END OF BOREHOLE																						
		NOTES: 1. Borehole caved to a depth of 6.6 m below ground surface (Elevation 162.6 m) upon removal of augers. 2. Open borehole dry on completion of drilling.																						

PROJECT		1786658		RECORD OF BOREHOLE No NW-5		SHEET 1 OF 1		METRIC			
G.W.P.		2135-20-00		LOCATION		N 4844487.4; E 294482.3 MTM NAD 83 ZONE 10 (LAT. 43.740279; LONG. -79.628099)		ORIGINATED BY BL			
DIST		Central HWY 427		BOREHOLE TYPE		Power Auger, 70 mm I.D., 150 mm O.D. Hollow Stem Augers		COMPILED BY CC			
DATUM		Geodetic (CGVD-1928)		DATE		November 3, 2020		CHECKED BY KJB			
SOIL PROFILE											
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
								SHEAR STRENGTH kPa	W _P W W _L	γ	GR SA SI CL
169.9	GROUND SURFACE							○ UNCONFINED + FIELD VANE			
169.3	TOPSOIL (70 mm)		1	SS	8			● QUICK TRIAXIAL × REMOULDED			
169.3	CLAYEY SILT (CL), trace sand, trace rootlets (FILL) Stiff Brown Moist		2	SS	20						
168.5	CLAYEY SILT (CL), some sand (TILL) Very Stiff Brown Moist		3	SS	37						
167.7	SILT (ML), some sand, trace gravel, trace plastic fines (TILL) Dense Brown Moist		4	SS	26						
	CLAYEY SILT (CL), trace to some sand, trace gravel (TILL) Stiff to very stiff Grey Moist		5	SS	19						
	- augers grinding between a depth of 3.1 m and 3.8 m (Elev. 166.8 m and 166.1 m)		6	SS	18						
			7	SS	9						
			8	SS	26						
162.7	SAND (SP), some silt, trace gravel Dense Grey Wet		9	SS	49						
161.7	END OF BOREHOLE										
NOTES:											
1. Borehole caved to a depth of 6.8 m below ground surface (Elevation 163.1 m) upon removal of augers.											
2. Groundwater measured at 6.7 m below ground surface (Elevation 163.2 m) in open borehole on completion of drilling.											

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

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

PROJECT		1786658		RECORD OF BOREHOLE				No NW-7		SHEET 1 OF 1		METRIC					
G.W.P.		2135-20-00		LOCATION		N 4844625.5; E 294463.5 MTM NAD 83 ZONE 10 (LAT. 43.741522; LONG. -79.628334)				ORIGINATED BY		BL					
DIST		Central		HWY		427		BOREHOLE TYPE		Power Auger, 70 mm I.D., 150 mm O.D. Hollow Stem Augers				COMPILED BY		CC	
DATUM		Geodetic (CGVD-1928)		DATE		November 4, 2020				CHECKED BY		KJB					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
171.5	GROUND SURFACE																
170.9	TOPSOIL (70 mm)		1	SS	7		171										
170.6	SILTY CLAY (Cl), trace sand, trace rootlets (FILL)		2	SS	23												
169.3	Firm Brown Moist																
169.3	CLAYEY SILT (CL), some sand, trace gravel (TILL)		3	SS	18		170										
169.3	Very stiff Moist																
169.3	- Oxidation staining between a depth of 1.5 m and 2.1 m (Elev. 170.0 m and 169.4 m)																
168.5	Sandy SILT (ML), some gravel, some plastic fines (TILL)		4	SS	43		169								12 28 45 15		
168.5	Dense Brown Moist																
167.8	Sandy CLAYEY SILT (CL), trace gravel, oxidation staining (TILL)		5	SS	38		168										
167.8	Hard Brown Moist																
167.8	CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML), trace to some sand, trace gravel (TILL)		6	SS	33		167								7 17 51 25		
167.8	Very stiff to hard Grey Moist																
167.8	- Augers grinding between a depth of 3.8 m and 5.2 m (Elev. 167.7 m and 166.3 m)																
166.3							166										
166.3																	
165.0			8	SS	21		165										
165.0																	
164.4							164										
164.4																	
163.3	END OF BOREHOLE		9	SS	16												
163.3	NOTES:																
163.3	1. Borehole caved to a depth of 7.1 m below ground surface (Elevation 164.4 m) upon removal of augers.																
163.3	2. Groundwater measured at 6.7 m below ground surface (Elevation 164.8 m) in open borehole on completion of drilling.																

GTA-MTO 001 S:\CLIENTS\MTOWHY_427_NOISE_WALL\02_DATA\GINT\HWY_427_NOISE_WALL.GPJ GAL-GTA.GDT 6/8/21

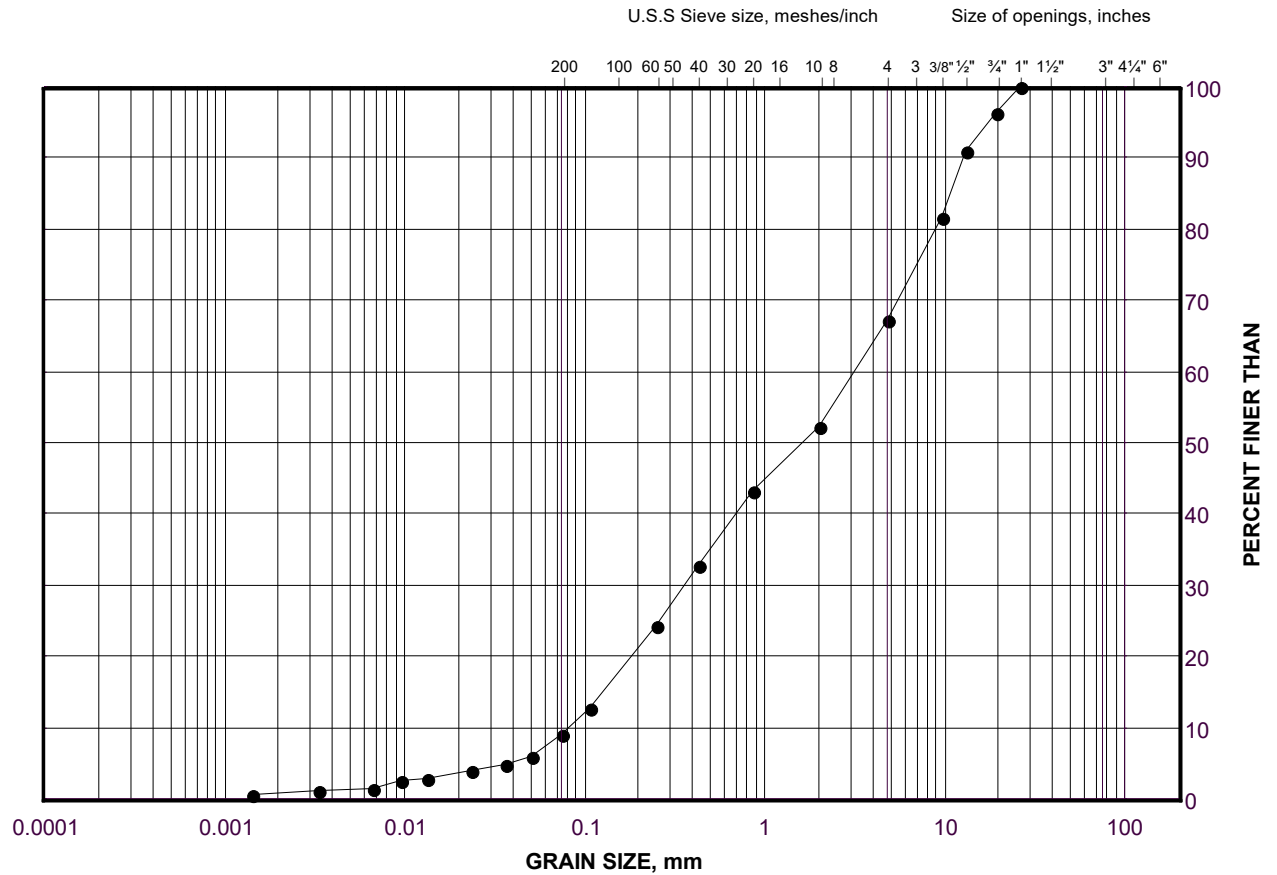
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Gravelly SAND (SW-SM) (FILL)

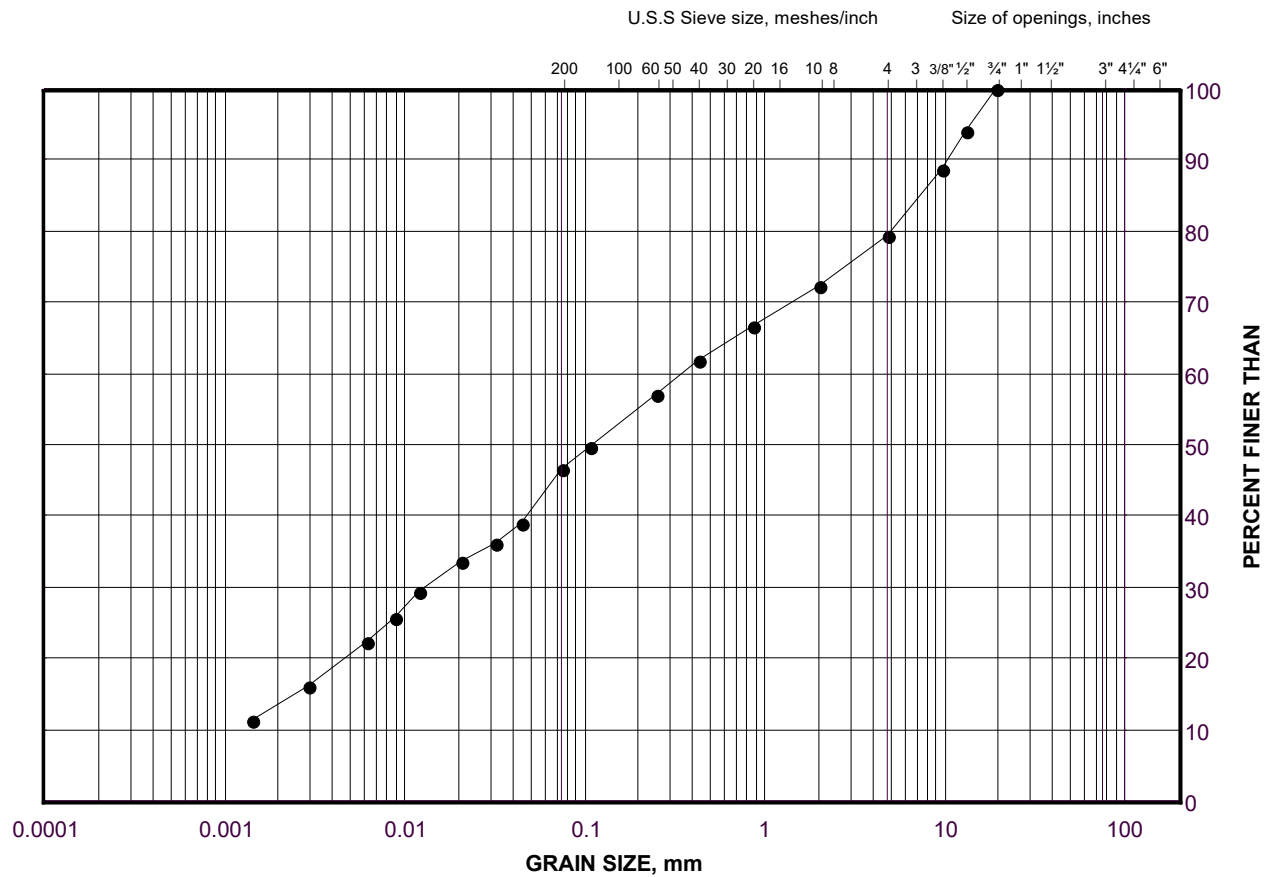
FIGURE B1



GRAIN SIZE DISTRIBUTION

Sandy Gravelly CLAYEY SILT (CL) (FILL)

FIGURE B2



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

LEGEND

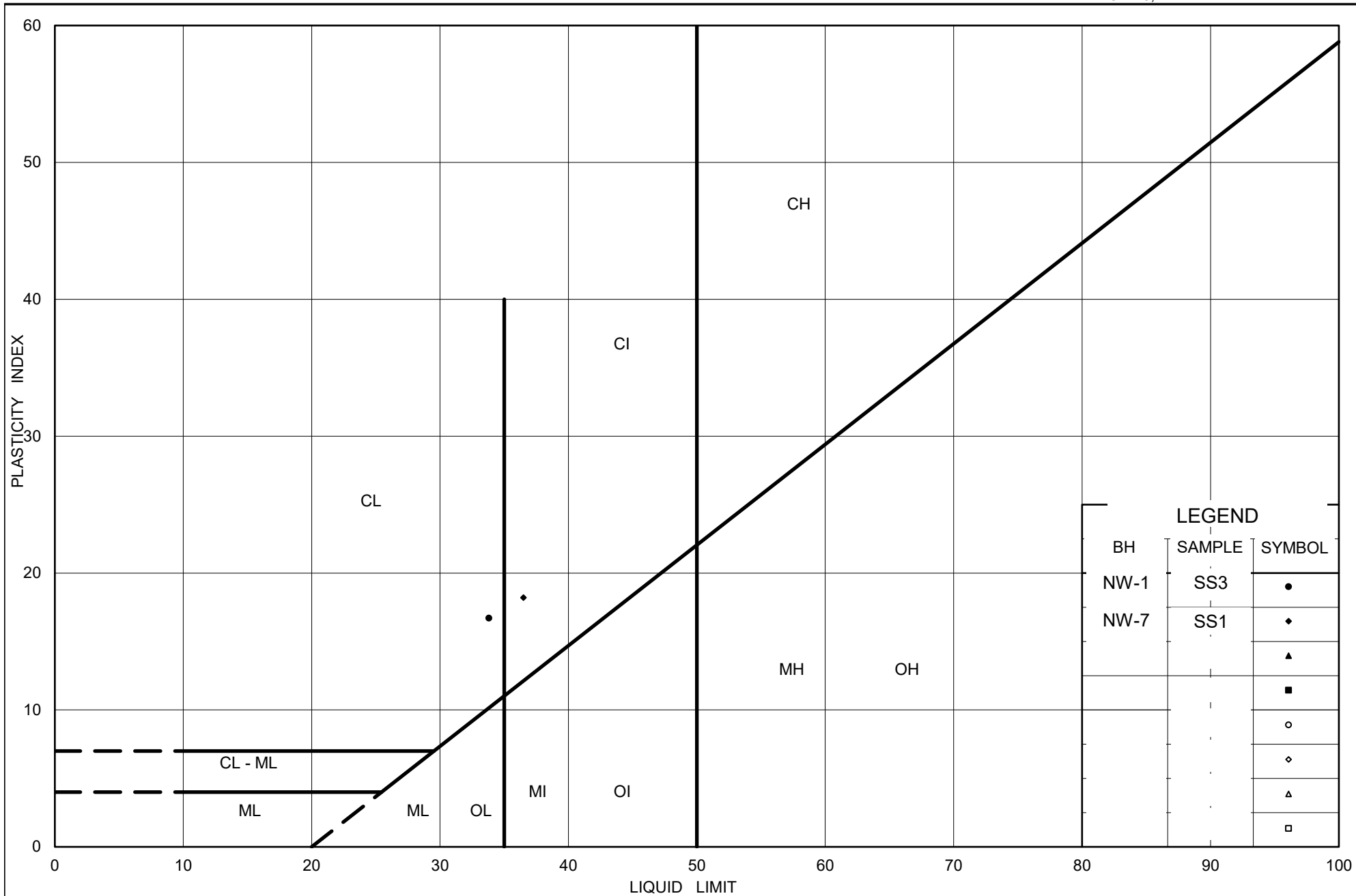
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
•	NW-1	SS2	167.3

Project Number: 1786658

Checked By: KJB

Golder Associates

Date: 28-Apr-21



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Ontario

PLASTICITY CHART SILTY CLAY (CI) to CLAYEY SILT (CL) (FILL)

Figure No. B3

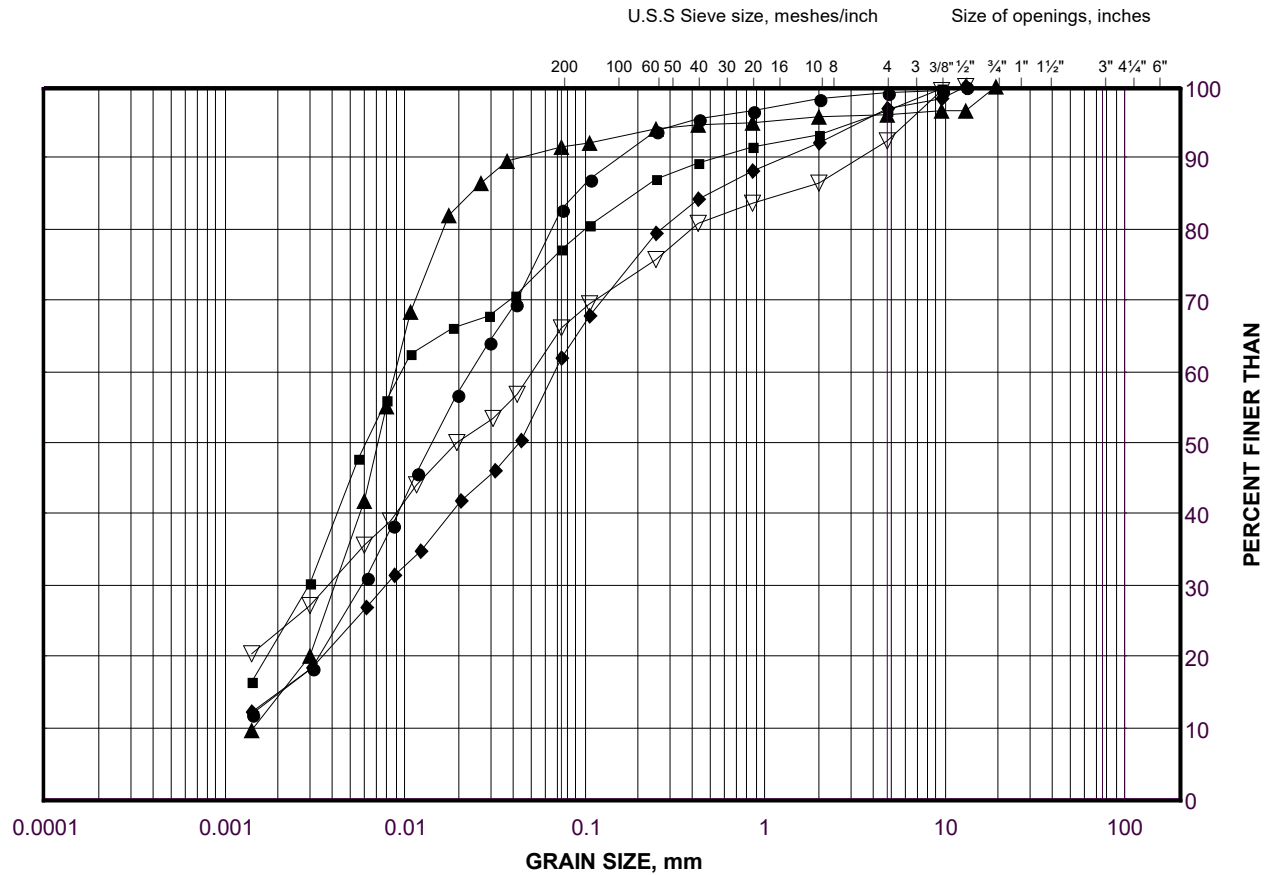
Project No. 1786658 (WO 040)

Checked By: KJB

GRAIN SIZE DISTRIBUTION

CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) (TILL)

FIGURE B4A



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	NW-4	SS3	167.4
■	NW-3	SS6	166.2
◆	NW-4	SS6	165.1
▲	NW-5	SS6	165.8
▽	NW-1	SS7A	163.4

Project Number: 1786658

Checked By: SRÓ

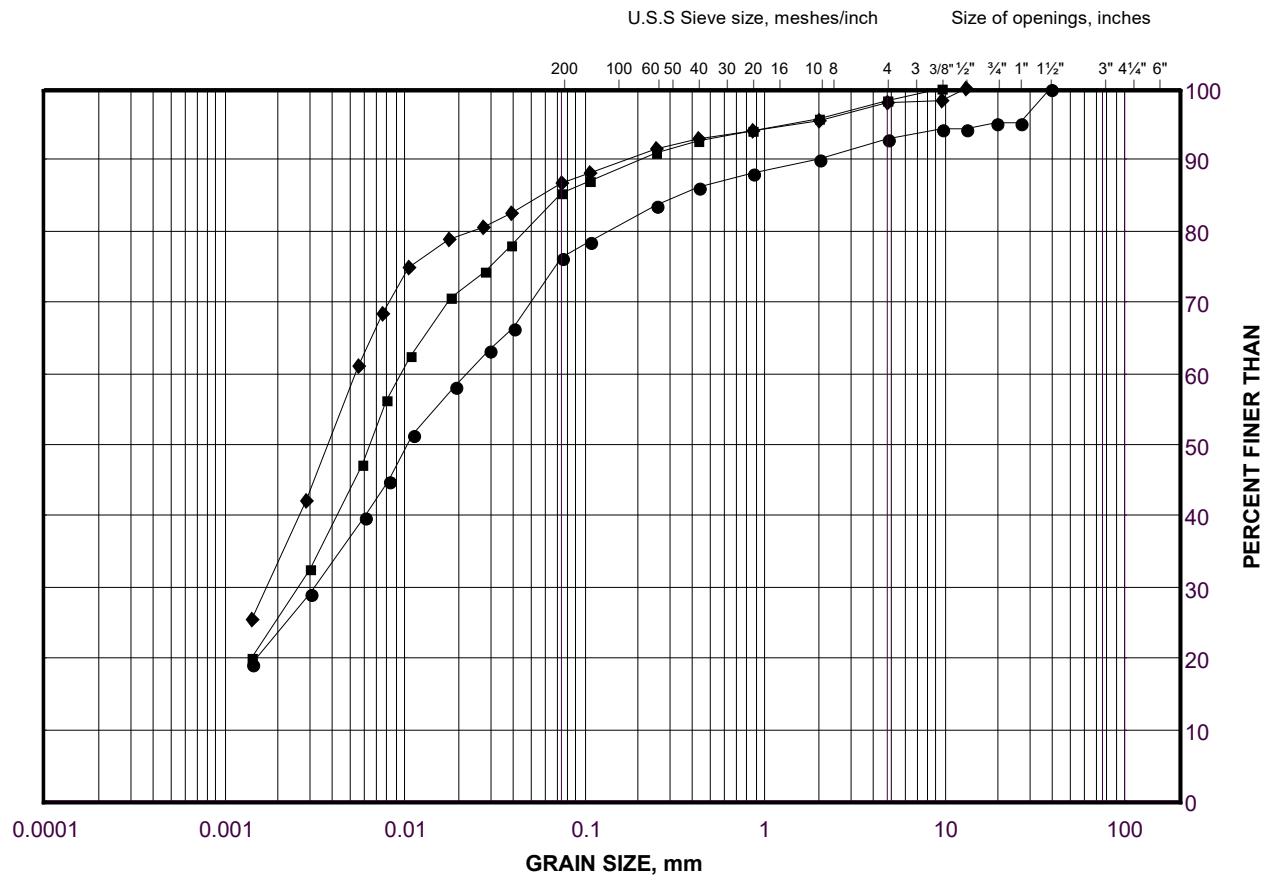
Golder Associates

Date: 30-Apr-21

GRAIN SIZE DISTRIBUTION

CLAYEY SILT (CL) to CLAYEY SILT-SILT (CL-ML) (TILL)

FIGURE B4B



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

LEGEND

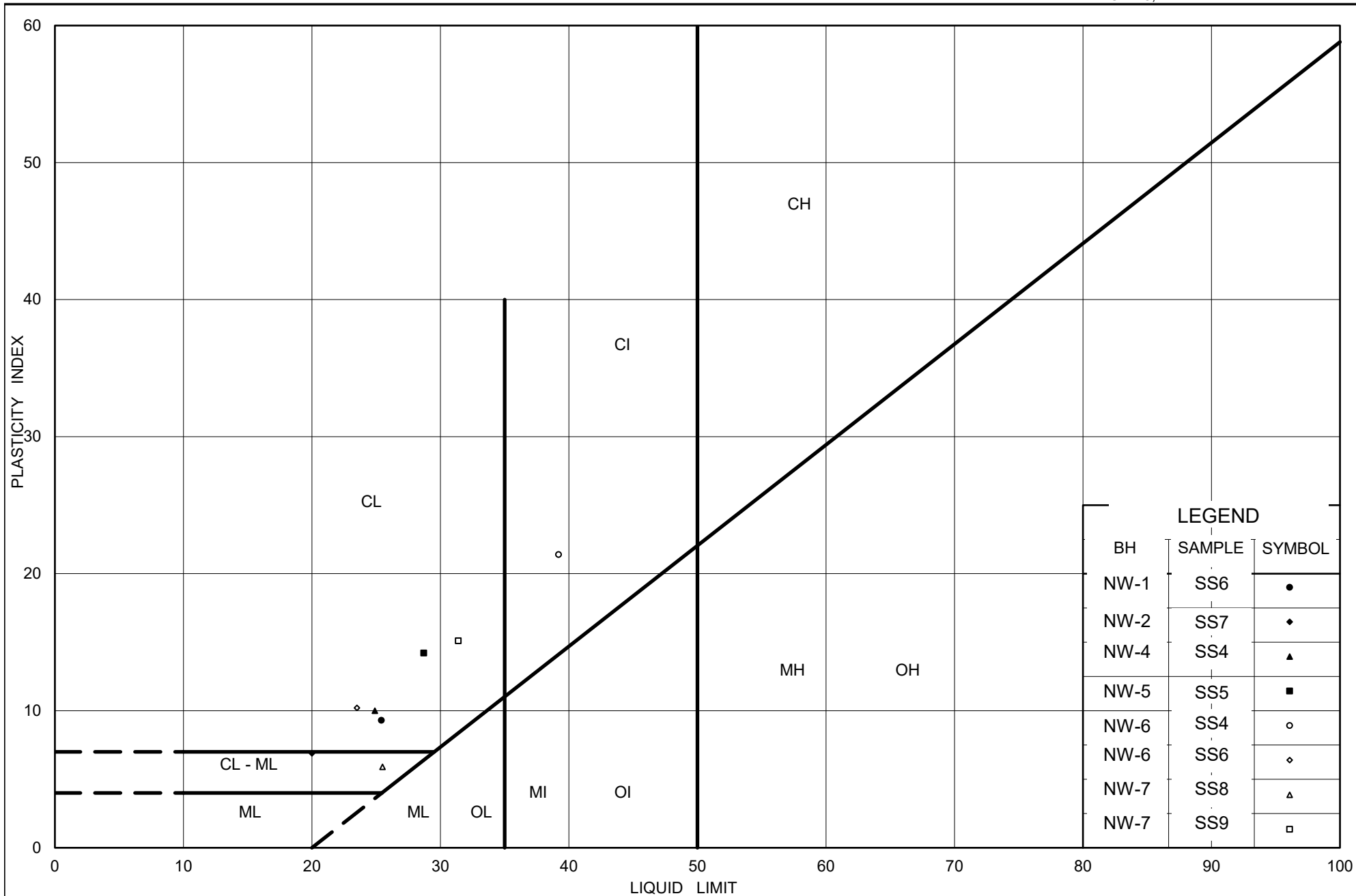
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	NW-7	SS6	167.4
■	NW-6	SS7	166.0
◆	NW-5	SS8	163.5

Project Number: 1786658

Checked By: SRÓ

Golder Associates

Date: 30-Apr-21



Ministry of Transportation

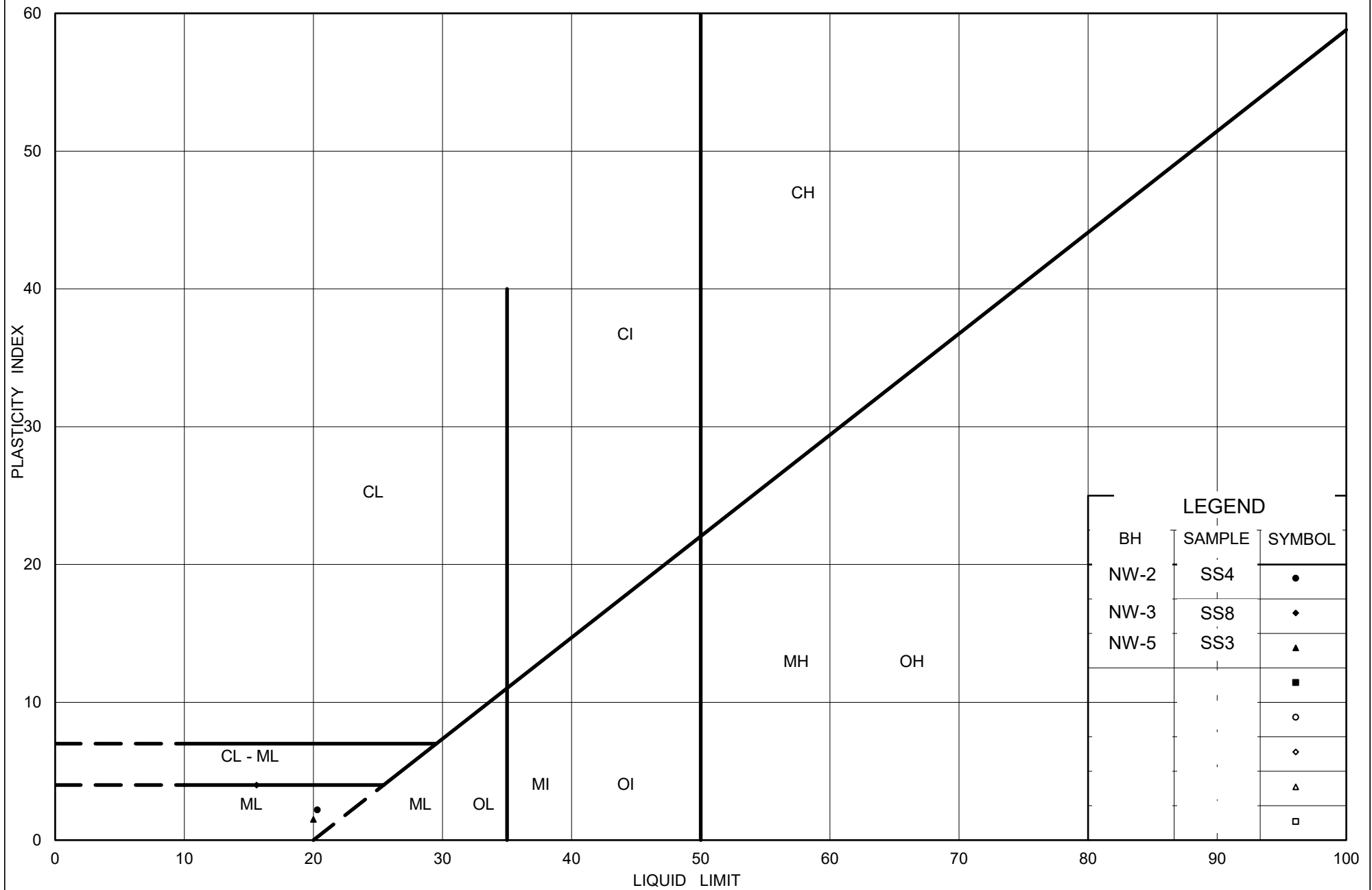
Ontario

PLASTICITY CHART **SILTY CLAY (CI) to CLAYEY SILT-SILT (CL-ML) (TILL)**

Figure No. B5A

Project No. 1786658 (WO015F)

Checked By: KJB



Ministry of Transportation

Ontario

PLASTICITY CHART SILT (ML) - INTERLAYERS (TILL)

Figure No. B5B

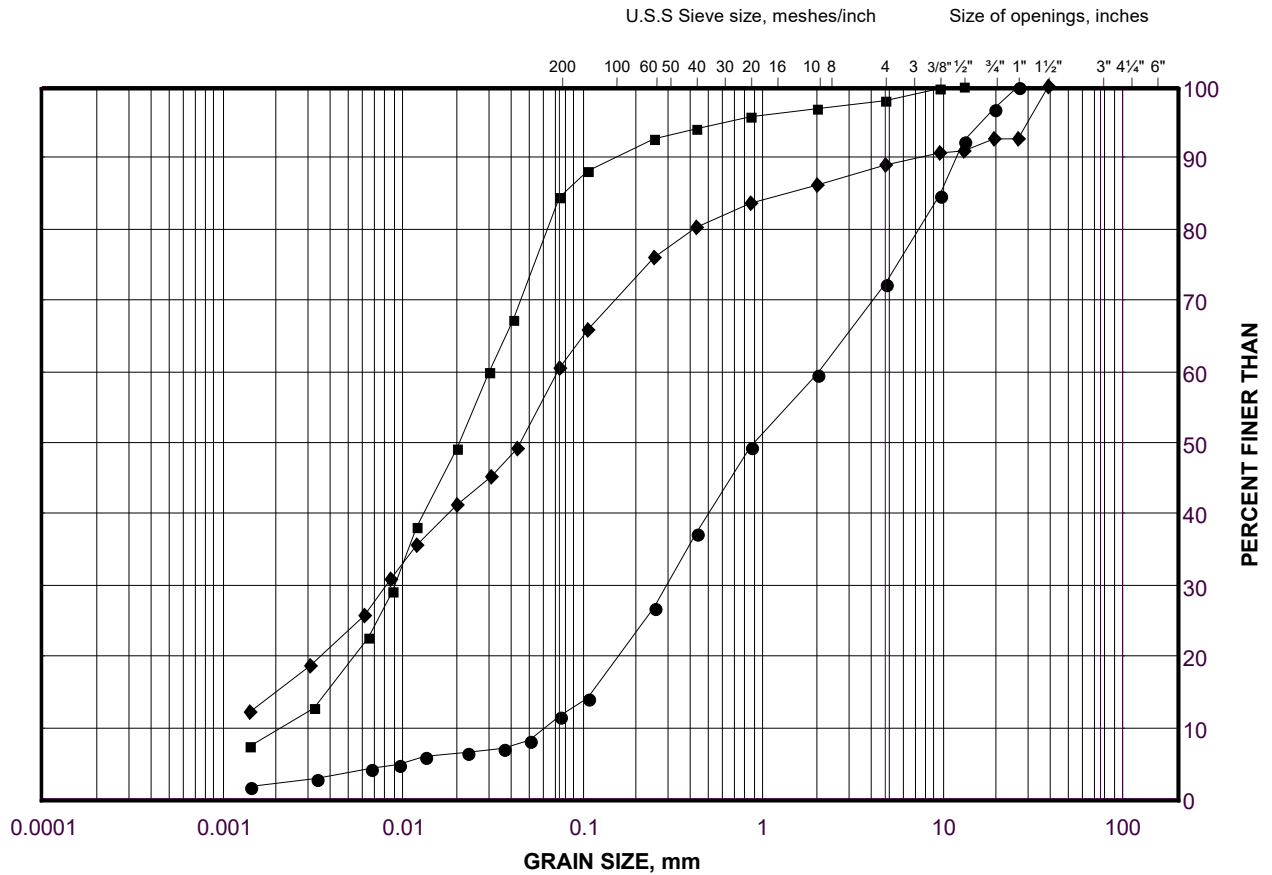
Project No. 1786658 (WO015F)

Checked By: KJB

GRAIN SIZE DISTRIBUTION

SILT (ML) to Gravelly SAND (SP) (TILL) - Interlayers

FIGURE B6



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	NW-6	SS2	170.0
■	NW-5	SS3	168.1
◆	NW-7	SS4	168.9

Project Number: 1786658

Checked By: SRÓ

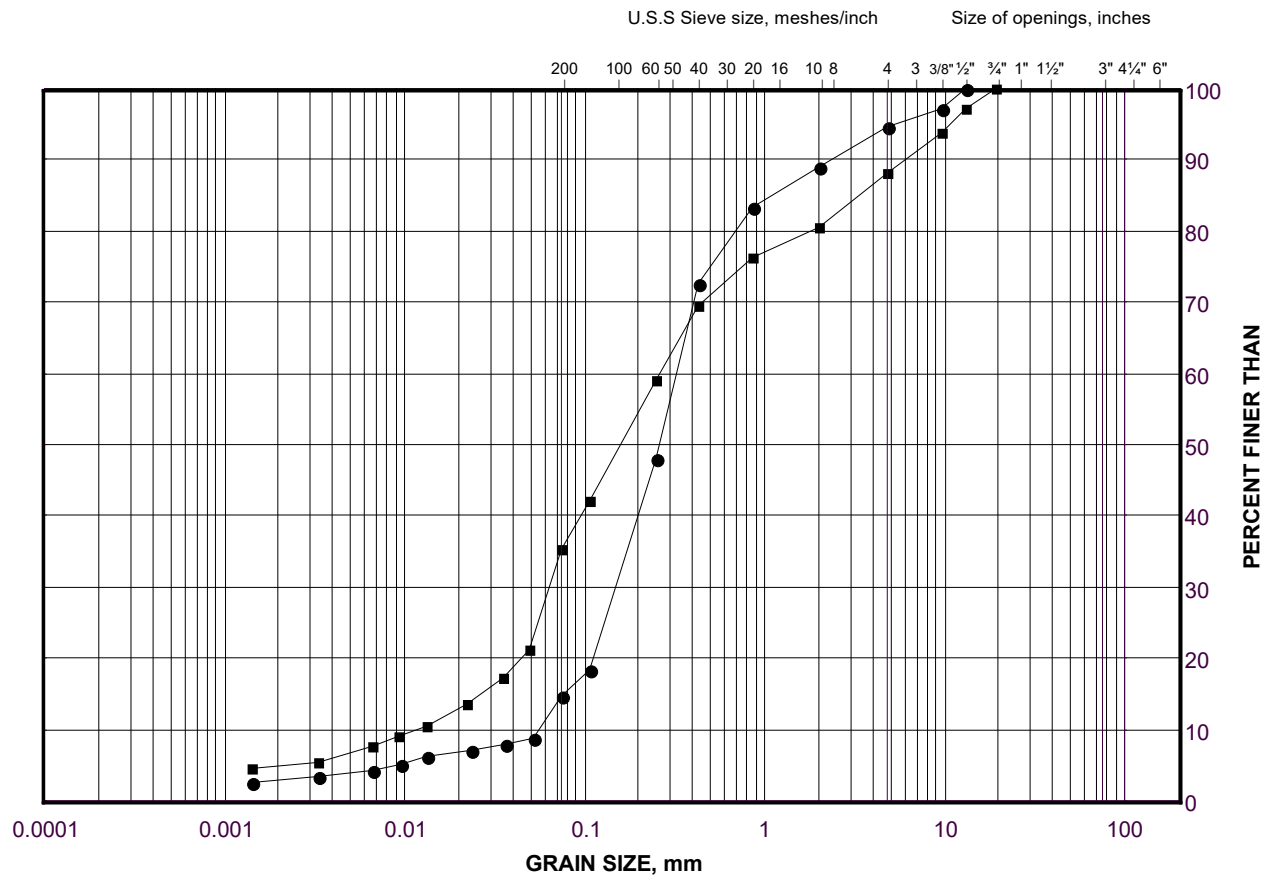
Golder Associates

Date: 30-Apr-21

GRAIN SIZE DISTRIBUTION

SILTY SAND (SM)

FIGURE B7



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	NW-2	SS8	163.0
■	NW-3	SS9	162.4

Project Number: 1786658

Checked By: KJB

Golder Associates

Date: 28-Apr-21

APPENDIX C

Analytical Laboratory Test Results



Your Project #: 1786658 WO 110
Your C.O.C. #: 794544-08-01

Attention: Carter Comish

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2021/01/27
Report #: R6496006
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C120213

Received: 2021/01/25, 11:05

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date	Date	Laboratory Method	Analytical Method
		Extracted	Analyzed		
Chloride (20:1 extract)	1	2021/01/26	2021/01/27	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	1	2021/01/26	2021/01/26	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	1	2021/01/27	2021/01/27	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	1	2021/01/25	2021/01/26	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	1	2021/01/26	2021/01/27	CAM SOP-00464	EPA 375.4 m

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in BV Labs profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.

Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.

This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.



Your Project #: 1786658 WO 110
Your C.O.C. #: 794544-08-01

Attention: Carter Comish

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2021/01/27
Report #: R6496006
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C120213

Received: 2021/01/25, 11:05

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ema Gitej, Senior Project Manager

Email: emese.gitej@bureauveritas.com

Phone# (905)817-5829

=====

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BUREAU
VERITAS

BV Labs Job #: C120213
Report Date: 2021/01/27

Golder Associates Ltd
Client Project #: 1786658 WO 110
Sampler Initials: BL

SOIL CORROSIVITY PACKAGE (SOIL)

BV Labs ID		ORK809		
Sampling Date		2020/11/02		
COC Number		794544-08-01		
	UNITS	NW-3 SA4	RDL	QC Batch
Calculated Parameters				
Resistivity	ohm-cm	500		7167172
Inorganics				
Soluble (20:1) Chloride (Cl-)	ug/g	1300	40	7168691
Conductivity	umho/cm	1990	2	7168364
Available (CaCl2) pH	pH	7.74		7170423
Soluble (20:1) Sulphate (SO4)	ug/g	210	20	7168697
RDL = Reportable Detection Limit				
QC Batch = Quality Control Batch				



BUREAU
VERITAS

BV Labs Job #: C120213
Report Date: 2021/01/27

Golder Associates Ltd
Client Project #: 1786658 WO 110
Sampler Initials: BL

TEST SUMMARY

BV Labs ID: ORK809
Sample ID: NW-3 SA4
Matrix: Soil

Collected: 2020/11/02
Shipped:
Received: 2021/01/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7168691	2021/01/26	2021/01/27	Deonarine Ramnarine
Conductivity	AT	7168364	2021/01/26	2021/01/26	Tarunpreet Kaur
pH CaCl2 EXTRACT	AT	7170423	2021/01/27	2021/01/27	Neil Dassanayake
Resistivity of Soil		7167172	2021/01/26	2021/01/26	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7168697	2021/01/26	2021/01/27	Deonarine Ramnarine



BUREAU
VERITAS

BV Labs Job #: C120213
Report Date: 2021/01/27

Golder Associates Ltd
Client Project #: 1786658 WO 110
Sampler Initials: BL

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	1.0°C
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Sample ORK809 [NW-3 SA4] : Samples received and analyzed past the recommended hold time.

Results relate only to the items tested.



**BUREAU
VERITAS**

BV Labs Job #: C120213

Report Date: 2021/01/27

QUALITY ASSURANCE REPORT

Golder Associates Ltd

Client Project #: 1786658 WO 110

Sampler Initials: BL

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
7168364	Conductivity	2021/01/26			104	90 - 110	<2	umho/cm	4.3	10
7168691	Soluble (20:1) Chloride (Cl-)	2021/01/27	NC	70 - 130	104	70 - 130	<20	ug/g	1.4	35
7168697	Soluble (20:1) Sulphate (SO4)	2021/01/27	NC	70 - 130	105	70 - 130	<20	ug/g	2.7	35
7170423	Available (CaCl2) pH	2021/01/27			99	97 - 103			0.083	N/A

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)



BUREAU
VERITAS

BV Labs Job #: C120213
Report Date: 2021/01/27

Golder Associates Ltd
Client Project #: 1786658 WO 110
Sampler Initials: BL

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).




Ewa Pranjić, M.Sc., C.Chem, Scientific Specialist

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.



Your Project #: 1786658 WO 39
Your C.O.C. #: N/A

Attention: Carter Comish

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2021/02/26
Report #: R6534384
Version: 3 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

BV LABS JOB #: C144289

Received: 2021/02/18, 16:20

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date	Date	Laboratory Method	Analytical Method
		Extracted	Analyzed		
Chloride (20:1 extract)	1	2021/02/22	2021/02/22	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	1	2021/02/23	2021/02/23	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl ₂ EXTRACT	1	2021/02/23	2021/02/23	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	1	2021/02/18	2021/02/23	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	1	2021/02/22	2021/02/22	CAM SOP-00464	EPA 375.4 m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.

Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.

This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.



Your Project #: 1786658 WO 39
Your C.O.C. #: N/A

Attention: Carter Comish

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2021/02/26
Report #: R6534384
Version: 3 - Revision

CERTIFICATE OF ANALYSIS – REVISED REPORT

BV LABS JOB #: C144289

Received: 2021/02/18, 16:20

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ema Gitej, Senior Project Manager

Email: emese.gitej@bureauveritas.com

Phone# (905)817-5829

=====

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BUREAU
VERITAS

BV Labs Job #: C144289
Report Date: 2021/02/26

Golder Associates Ltd
Client Project #: 1786658 WO 39
Sampler Initials: SK

SOIL CORROSIVITY PACKAGE (SOIL)

BV Labs ID		OWL364			OWL364	
Sampling Date		2021/02/18			2021/02/18	
COC Number		N/A			N/A	
	UNITS	W039-NW-1-SS3-5'-7'	RDL	QC Batch	W039-NW-1-SS3-5'-7' Lab-Dup	QC Batch
Calculated Parameters						
Resistivity	ohm-cm	560		7206658		
Inorganics						
Soluble (20:1) Chloride (Cl ⁻)	ug/g	890	20	7211038		
Conductivity	umho/cm	1780	2	7212717		
Available (CaCl ₂) pH	pH	7.87		7212923	7.94	7212923
Soluble (20:1) Sulphate (SO ₄)	ug/g	280	20	7211042		
RDL = Reportable Detection Limit						
QC Batch = Quality Control Batch						
Lab-Dup = Laboratory Initiated Duplicate						



BUREAU
VERITAS

BV Labs Job #: C144289
Report Date: 2021/02/26

Golder Associates Ltd
Client Project #: 1786658 WO 39
Sampler Initials: SK

TEST SUMMARY

BV Labs ID: OWL364
Sample ID: W039-NW-1-SS3-5'-7'
Matrix: Soil

Collected: 2021/02/18
Shipped:
Received: 2021/02/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7211038	2021/02/22	2021/02/22	Deonarine Ramnarine
Conductivity	AT	7212717	2021/02/23	2021/02/23	Tarunpreet Kaur
pH CaCl2 EXTRACT	AT	7212923	2021/02/23	2021/02/23	Neil Dassanayake
Resistivity of Soil		7206658	2021/02/23	2021/02/23	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7211042	2021/02/22	2021/02/22	Avneet Kour Sudan

BV Labs ID: OWL364 Dup
Sample ID: W039-NW-1-SS3-5'-7'
Matrix: Soil

Collected: 2021/02/18
Shipped:
Received: 2021/02/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	7212923	2021/02/23	2021/02/23	Neil Dassanayake



BUREAU
VERITAS

BV Labs Job #: C144289
Report Date: 2021/02/26

Golder Associates Ltd
Client Project #: 1786658 WO 39
Sampler Initials: SK

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	3.7°C
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Revised Report [2021/02/26]: Split report as per client request.

Results relate only to the items tested.



BUREAU
VERITAS

BV Labs Job #: C144289

Report Date: 2021/02/26

QUALITY ASSURANCE REPORT

Golder Associates Ltd

Client Project #: 1786658 WO 39

Sampler Initials: SK

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
7211038	Soluble (20:1) Chloride (Cl-)	2021/02/22	NC	70 - 130	101	70 - 130	<20	ug/g	11	35
7211042	Soluble (20:1) Sulphate (SO4)	2021/02/22	NC	70 - 130	109	70 - 130	<20	ug/g	NC	35
7212717	Conductivity	2021/02/23			103	90 - 110	<2	umho/cm	1.6	10
7212923	Available (CaCl2) pH	2021/02/23			101	97 - 103			0.89	N/A

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).



BUREAU
VERITAS

BV Labs Job #: C144289
Report Date: 2021/02/26

Golder Associates Ltd
Client Project #: 1786658 WO 39
Sampler Initials: SK

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Anastassia Hamanov, Scientific Specialist

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6740 Campbell Road, Mississauga, Ontario L5N 2L8
 Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266
 CAM FCD-01191/6

WORK ORDER

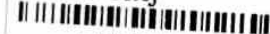
CHAIN OF CUSTODY RECORD

Page 1 of 1

Invoice Information		Report Information (if differs from invoice)		Project Information (where applicable)		Turnaround Time (TAT) Required							
Company Name: <u>Golden Associates Ltd</u>		Company Name: <u>Golden Associates Ltd</u>		Quotation #: _____		<input checked="" type="checkbox"/> Regular TAT (5-7 days) Most analyses							
Contact Name: <u>Accounts Payable</u>		Contact Name: <u>Carter Comish</u>		P.O. #/ AFE#: _____		PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS							
Address: <u>6925 Century Ave, Suite #100</u>		Address: _____		Project #: <u>1786658</u>		Rush TAT (Surcharges will be applied)							
<u>Mississauga, ON, L5N 7K2</u>		_____		Site Location: _____		<input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3-4 Days							
Phone: <u>905 567 4444</u> Fax: _____		Phone: <u>905 567 4444 x220</u> Fax: _____		Site #: _____		Date Required: _____							
Email: <u>Canada.accounts.payable@golden.com</u>		Email: <u>Carter-Comish@golden.com</u>		Site Location Province: _____		Rush Confirmation #: _____							
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BUREAU VERITAS LABORATORIES' DRINKING WATER CHAIN OF CUSTODY		Sampled By: <u>SK</u>		Analysis Requested		LABORATORY USE ONLY							
Regulation 153 <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/ Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Lomm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/ Other <input type="checkbox"/> Table _____ FOR RSC (PLEASE CIRCLE) Y / N		Other Regulations <input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> MISA <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> PWQJ <input type="checkbox"/> Region _____ <input type="checkbox"/> Other (Specify) _____ <input type="checkbox"/> REG 558 (MIN. 3 DAY TAT REQUIRED) <input type="checkbox"/> REG 406 Table _____		# OF CONTAINERS SUBMITTED FIELD FILTERED (CIRCLE) Metals / Hg / CrVI BTEX/ PHC F1 PHCs P2 - F4 VOCs REG 153 METALS & INORGANICS REG 153 ICPMS METALS REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B) <u>Conductivity Pkg.</u>		CUSTODY SEAL Y / N Present Intact COOLER TEMPERATURES <u>9/4/13</u> COOLING MEDIA PRESENT: (Y) / N COMMENTS							
Include Criteria on Certificate of Analysis: Y / N		SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BUREAU VERITAS											
SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTEX/ PHC F1	PHCs P2 - F4	VOCs	REG 153 METALS & INORGANICS	REG 153 ICPMS METALS	REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B)	Conductivity Pkg.	HOLD - DO NOT ANALYZE
1 <u>W039-NW-1-SS3-5'-7'</u>	<u>2021/02/18</u>	<u>PM</u>	<u>SOIL</u>	<u>1</u>								<u>X</u>	
2 <u>W015-VMS-2-SAB-7'6"-9'6"</u>	<u>"</u>	<u>"</u>	<u>"</u>	<u>1</u>								<u>X</u>	
3													
4													
5													
6													
7													
8													
9													
10													
RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)								
<u>Shantanu Kaur / SK</u>	<u>2021/02/18</u>	<u>3:30 PM</u>	<u>Ref / May 9 Feb</u>	<u>2021/02/18</u>	<u>16:20</u>								

18-Feb-21 16:20

Ema Gitej



C144289

ATM

ENV-1290



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