December 2016

PRELIMINARY FOUNDATION INVESTIGATION REPORT

Commercial Vehicle Inspection Facility
1.3 km East of Cliffe Road on
Highway 401 Gananoque
W.P. No. 4046-10-01
Purchase Order Number: 4010-E-0034

Submitted to:
Ms. Tanya Cross, P.Eng.
Dillon Consulting Limited
130 Dufferin Avenue
London, Ontario
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REPORT

A world of capabilities delivered locally

Report Number: 1651503

Geocres No. 31C-254

Latitude 44.360647, Longitude -76.079842

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PART A

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Dillon Consulting Limited (Dillon) on behalf of the Ministry of Transportation, Ontario (MTO), Eastern Region, to carry out a preliminary foundation investigation as part of the preliminary design stage assignment for the design of the proposed eastbound (south) Gananoque Commercial Vehicle Inspection Facility (CVIF) located at the existing Highway 401 Gananoque South Truck Inspection Station (TIS) near Gananoque, Ontario. The site is located about 1.3 km east of Cliffe Road, south of the Highway 401 eastbound lanes, as shown on the Key Plan on Drawing 1.

The purpose of the investigation was to determine the subsurface conditions at the location of the proposed Gananoque CVIF. A subsurface investigation was previously carried out in 1991 for the existing Gananoque facility (GEOCRES Number 31C-150). In July 2016, two additional boreholes were drilled within the vicinity of the proposed landscaped area adjacent to the proposed building to determine the general soil conditions for the preliminary design of the proposed sewage system. The scope of work for this report was outlined in Golder's proposal dated February 24, 2016.

2.0 SITE DESCRIPTION AND GEOLOGY

2.1 General

The new eastbound (south) CVIF is to be located just south of Highway 401 between Cliffe Road and Highway 3 near Gananoque, Ontario, as shown on the Key Plan on Drawing 1.

Based on the available information, the ground surface elevation at the site ranges from about 94 to 95 m.

The site is situated at the existing Gananoque TIS, south of the Highway 401 eastbound lanes, and primarily consists of concrete asphalt surfaced areas for parking and driving lanes, with landscaped areas within the vicinity of the on-site building and along the southern portion of the property. The adjacent land use is primarily agricultural.

It is understood that the new CVIF will contain driving lanes and parking, a triage area, a static scale, an inspection bay, and a building.

2.2 Regional Geological Conditions

As delineated in *The Physiography of Southern Ontario*[1], the study area for this assignment lies within the physiographic region known as Leeds Knobs and Flats.

The Leeds Knobs and Flats is in an area consisting of Precambrian rock knobs and channels which were filled with clay flats by the waters of Lake Iroquois during the Pleistocene age. Surficial deposits of clay or sand and gravel and/or glacial till generally overly the bedrock.

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

3.0 SITE INVESTIGATIONS

As part of the preliminary design stage, the general soil conditions at the site were determined following a review of the 1991 investigation completed at the site and a geotechnical investigation for the sewage disposals system completed in July 2016 for the proposed Gananoque CVIF as described in detail below.

The field work for the proposed preliminary investigation for the septic system was completed on July 29, 2016 during which time two boreholes (i.e., Borehole 16-1 and 16-2) were advanced at the approximate locations shown on Drawing 1.

For the historical data, the subsurface information used in the preparation of this report was obtained from a previous Foundation Investigation Report available from the MTO GEOCRES database, as described below:

- Foundation Investigation Report titled “Weigh Scale at the Gananoque Truck Inspection Stations” dated July 24, 1991 (GEOCRES Reference 31C-150).

As part of the 1991 investigation, two boreholes (i.e., boreholes 1 and 2) were advanced at the approximate locations shown on Drawing 1. Relevant Record of Borehole sheets and laboratory test results from the MTO GEOCRES library for this site are included in Appendix B.

The July 2016 investigation was carried out using a CME 75 truck mounted power auger supplied and operated by a specialist drilling contractor. In each borehole, samples of the overburden were obtained at 0.79 m non-continuous intervals to the termination of each borehole using 50 mm outside diameter split spoon sampling equipment in accordance with the standard penetration test (SPT) procedures. The boreholes were terminated at about 5.2 m below the existing ground surface.

Groundwater conditions in the boreholes were observed throughout the drilling operations. Following completion of drilling and sampling, the boreholes were backfilled in accordance with current MTO procedures and Ontario Regulation 903, as amended.

The boreholes were backfilled with bentonite pellets, mixed with native soils, and the site conditions restored following completion of the work.

The field work was monitored on a full-time basis by an experienced member of our geotechnical engineering staff who located the boreholes in the field, monitored the drilling, sampling and in situ testing operations and logged the boreholes. The samples were identified in the field, placed in labelled containers and transported to our Ottawa laboratory for further examination and testing. Index and classification tests, consisting of water content determinations and grain size distribution analyses, were carried out on selected samples. All of the laboratory tests were carried out to MTO and/or ASTM Standards as appropriate. The results of the testing are shown on the Record of Borehole sheets and in Appendix A.

The table below provides the borehole locations, ground surface elevations at the borehole locations, and the depths of the boreholes for the available boreholes at the site. The borehole locations, including MTM NAD 83 northing and easting coordinates, and ground surface elevations are referenced to geodetic datum,

Borehole Number	Borehole Location, MTM NAD 83, Zone 9		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
1	4913477.8[1]	338210.3[1]	95.3	9.2
2	4913489.6[1]	338234.1[1]	95.3	12.5
16-1	4913455.2	338291.6	94.6	5.2
16-2	4913467.3	338312.4	94.7	5.2

Note 1: Coordinates for Boreholes 1 and 2 from the 1991 investigation were converted to the MTM NAD 83, Zone 9, coordinate system for use in the current report (including Drawing 1).

The table below provides the borehole locations, ground surface elevations at the borehole locations, and the depths of the boreholes for the two boreholes advanced at the site during the 1991 subsurface investigation, as presented in the GEOCRES report using the MTM NAD 27 coordinate system.

Borehole Number	Borehole Location, MTM NAD 27		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
1	4913254.7	338186.2	95.3	9.2
2	4913266.5	338207.0	95.3	12.5

4.0 SITE STRATIGRAPHY

The borehole locations and ground surface elevations from both the present investigation and MTO's 1991 subsurface investigation (GEOCRES No. 31G-150) are shown on Drawing 1.

The detailed subsurface soil and groundwater conditions encountered in the boreholes advanced at this site, together with the results of the in situ testing and the laboratory testing carried out on selected samples, are given on the attached Record of Borehole sheets and laboratory test results in Appendices A and B.

The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous samples and observations of drilling resistance and, therefore, may represent transitions between soil types rather than exact planes of geological change. Further, the subsurface conditions will vary between and beyond the borehole locations.

In general, the boreholes encountered surficial layers of asphalt, topsoil and/or fill over a thin layer of silty clay over silt, and sandy silt to silty sand and sand, underlain by bedrock at about Elevation 86 m.

4.1 Asphalt, Topsoil and Fill Material

A layer of asphalt approximately 600 mm was encountered at the ground surface at Boreholes 1 and 2 in 1991. At these locations, the asphalt was underlain by fine sand fill material to about 1.9 and 2.1 m depth (i.e., Elevation 93.4 and 93.2 m), respectively.

A layer of topsoil measuring 200 and 130 mm in thickness was encountered at the ground surface at Boreholes 16-1 and 16-2, respectively, during the current field investigation.

The fill material encountered in Boreholes 1 and 2 had 'N' values, as determined by the standard penetration tests, between 11 and 50 blows per 0.3 m of penetration indicating it to be compact to dense. The results of the grain size distribution testing carried out on one sample of the sand fill from Borehole 1 are provided on Figure 1 in Appendix B.

4.2 Silty Clay

Beneath the topsoil or fill material, all of the boreholes encountered a layer of silty clay. The silty clay layer was grey to brown in colour and ranged in thickness from about 0.6 to 1.9 m, extending to depths of 0.7 and 1.5 m on the south end of the site (i.e., Elevations 93.2 and 93.9 metres), and extending to a depth of 4 m on the north end of the site (i.e., Elevations 91.3 and 91.9 metres). The thicker deposit of silty clay was encountered at the boreholes advanced on the north end of the site, closer to Highway 401, during the 1991 investigation.

Standard penetration test 'N' values for the silty clay ranged from 4 to 17 blows per 0.3 m of penetration, indicating it to be firm to very stiff.

Measured water contents in this deposit were 24 and 25 percent. The results of the Atterberg limit testing carried out on two samples of silty clay gave plasticity index values of about 23 and 24 percent and liquid limit values of 42 and 44 percent, indicating a silty clay of intermediate plasticity. The results of the Atterberg limit testing and grain size distribution testing carried out on the silty clay during the 1991 investigation are provided on Figures 4 and 5 in Appendix B.

4.3 Silt, Sandy Silt and Silty Sand

A layer of silt, sandy silt and silty sand was encountered beneath the silty clay at all of the borehole locations. This layer ranges in thickness from about 0.8 and 3.6 m and extends down to elevations ranging from about 87.7 to 92.4 m at the borehole locations.

Standard penetration test 'N' values in the layer of silt, sandy silt and silty sand ranged from 1 to 42 blows per 0.3 m of penetration, indicating a very loose to dense state of packing. More generally, the deposit was loose to compact.

Measured water contents in this deposit were 21 and 25 percent. The results of the grain size analyses carried out on one sample of the silt from Borehole 16-1 are provided on Figure 2 in Appendix A, and the results of the grain size analyses carried out on two samples of the sandy silt to silty sand from Boreholes 1 and 2 are provided on Figure 6 in Appendix B.

4.4 Sand

Beneath the layer of silt, sandy silt and silty sand, all of the boreholes encountered a stratum of sand at elevations ranging from 87.7 to 92.4 m. The sand deposit encountered at Boreholes 1 and 2 was described to contain some gravel and occasional boulders, while the sand deposit encountered at Boreholes 16-1 and 16-2 contains some silt. The sand layer was penetrated in Borehole 2, extending to a depth of 9.4 m below the ground surface (i.e., Elevation 85.9 m).

Standard penetration test 'N' values in the sand range from 3 to 125 blows per 0.3 m of penetrations, indicating a very loose to very dense state of packing, although the higher 'N' values could reflect the presence of cobbles and boulders, rather than the state of packing of the soil matrix.

Measured water contents in this deposit were 10 and 13 percent. The results of the grain size analyses carried out on one sample of the sand from Borehole 16-1 are provided on Figure 3 in Appendix A, and the results of the grain size analyses carried out on two samples of the sand from Boreholes 1 and 2 are provided on Figure 7 in Appendix B.

4.5 Refusal and Bedrock

Practical refusal to augering was encountered at Boreholes 1 and 2 during the 1991 field investigation. The bedrock surface was confirmed at 9.4 m depth (i.e., Elevation 85.9 m) at borehole 2, which was extended into the bedrock for a depth of 3.1 m using rotary diamond drill techniques to retrieve the core. The depths and elevations of the refusal and bedrock surface as encountered in the boreholes, as well as the ground surface depths and elevations, are provided in the following table.

Borehole Number	Ground Surface Elevation (m)	Bedrock Surface	
		Depth (m)	Elevation (m)
1	95.3	9.2[1]	86.1[1]
2	95.3	9.4	85.9

Note 1: Refusal to auger advancement.

4.6 Groundwater Conditions

Groundwater levels were measured in all four open boreholes upon completion of the drilling program and are summarized in the following table.

Borehole Number	Date	Ground Surface Elevation (m)	Depth to Groundwater (m)	Groundwater Elevation (m)
1	April 25, 1991	95.3	2.9	92.4
2	April 24, 1991	95.3	1.7	93.6
16-1	July 29, 2016	94.6	3.2	91.4
16-2	July 29, 2016	94.7	3.4	91.3

It should be noted that groundwater levels in the area are subject to fluctuations both seasonally and with precipitation events.

5.0 CLOSURE

This Preliminary Foundation Investigation Report was prepared by Ms. Kim Lesage, P.Eng. and was reviewed by Mr. Fintan Heffernan, P.Eng., the Designated MTO Foundations Contact for Golder for this assignment.

Yours truly,

GOLDER ASSOCIATES LTD.

Kim Lesage, P.Eng.
Geotechnical Engineer

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

DH/KSL/FJH/ob
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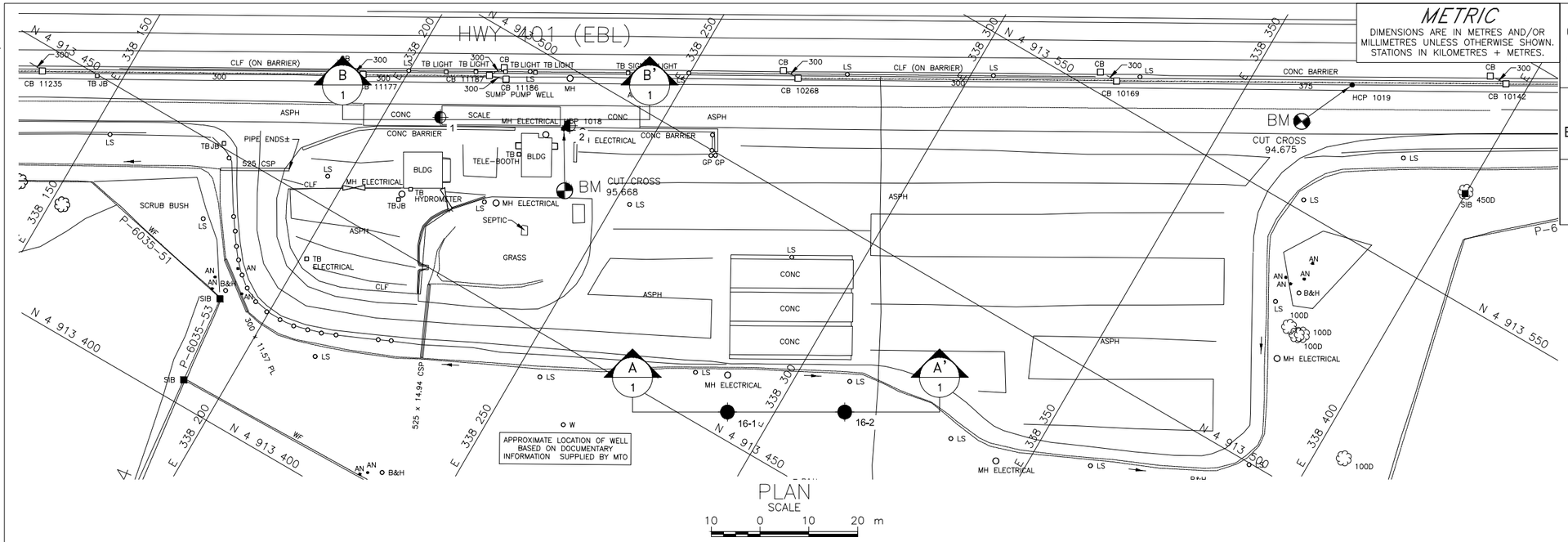
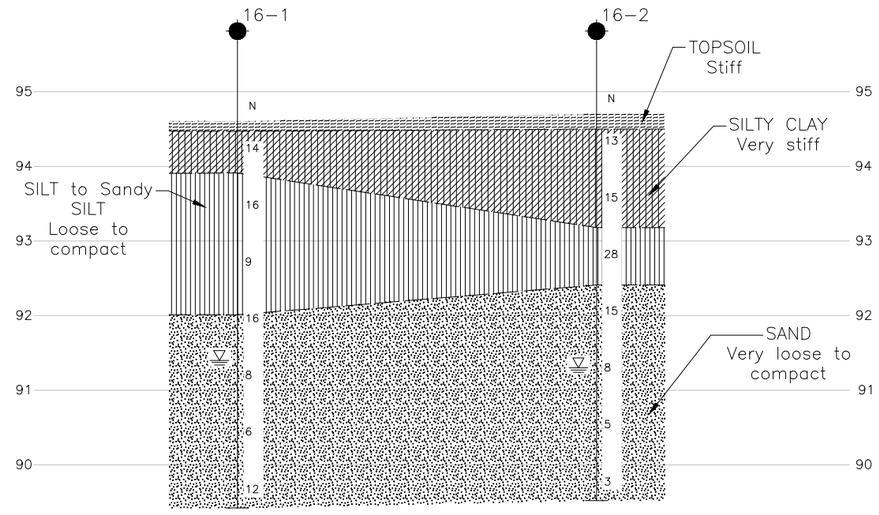
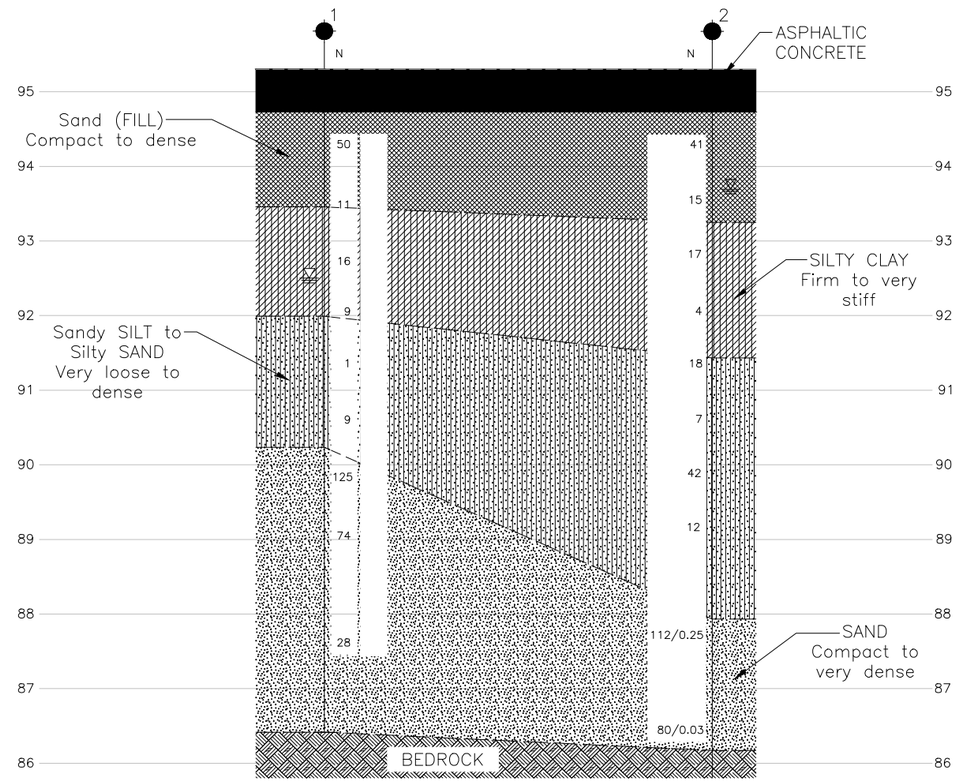
MINISTRY OF TRANSPORTATION, ONTARIO





HORIZ. SCALE 1:200 m
VERT. SCALE 1:40 m
A–A'
1
SECTION

HORIZONTAL SCALE
4 0 4 8 m
0.8 0 0.8 1.6 m
VERTICAL SCALE



HORIZ. SCALE 1:200 m
VERT. SCALE 1:40 m
B–B'
1
SECTION

HORIZONTAL SCALE
4 0 4 8 m
0.8 0 0.8 1.6 m
VERTICAL SCALE

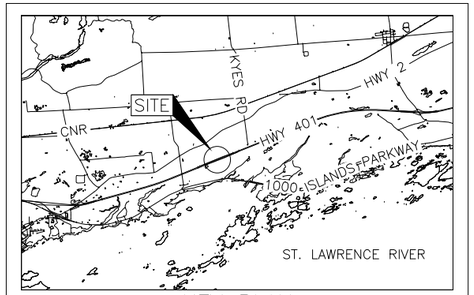
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 4046-10-01

SHEET

GANANOQUE
HIGHWAY 401
BOREHOLE LOCATIONS AND SOIL STRATA
LAT: 44.360647 LONG: -76.079842

Golder Associates



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole – Current Investigation
- Borehole – Previous 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
1	95.3	4913477.8	338210.3
2	95.3	4913489.6	338234.1
16-1	94.6	4913455.2	338291.6
16-2	94.7	4913467.3	338312.4

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.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by Dillon Consulting, drawing file nos. 4046-Base.dwg, received Aug 19, 2016.

LICENSED PROFESSIONAL ENGINEER
K. S. LESAGE
100131993
Nov 11/16
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
F. J. HEFFERNAN
Nov 4/16
PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31C-254

HWY. 401		PROJECT NO. 1651503	DIST. 8
SUBM'D. KSL	CHKD. KSL	DATE: 6/14/2013	SITE: .
DRAWN: JJL	CHKD. FJH	APPD. FJH	DWG. 1

PLOT DATE: December 9, 2016
FILENAME: N:\Active\Spatial_IM\Dillon_Consulting\Gananoque_Lancaster_CVP\VBA_PROJ\1651503_Dillon_Sewage(Disposal)\1651503_Gananoque.dwg

APPENDIX A

List of Abbreviations and Symbols
Record of Borehole Sheets and
Laboratory Test Results
2016 Investigation

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ 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, 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

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

Density Index	N
Relative Density	**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 With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

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RECORD OF BOREHOLE No 16-1

1 OF 1 **METRIC**

PROJECT 1651503 | G.W.P. 4046-10-01 | LOCATION N 4913455.2; E 338291.6 | ORIGINATED BY RI

DIST 8 | HWY 401 | BOREHOLE TYPE Hollow Stem Auger, Truck Mounted | COMPILED BY KL

DATUM GEODETIC | DATE July 29, 2016 | CHECKED BY

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 (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.6	GROUND SURFACE									
0.0	TOPSOIL, trace to some sand, trace grave									
0.1	Stiff Brown		1	SS	14					
93.9	Moist						94			
0.7	SILTY CLAY, trace sand Very stiff Brown to grey Dry to moist		2	SS	16					
	SILT to Sandy SILT, trace clay Loose to compact Brown Moist to wet		3	SS	9		93			
92.0			4	SS	16		92			
2.6	SAND, some silt Loose to compact Brown Wet		5	SS	8	▽	91			
			6	SS	6					
89.4			7	SS	12		90			
5.2	END OF BOREHOLE Note: 1. Water level at a depth of 3.2 m below ground surface (Elev. 91.4 m) upon completion of drilling.									

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

SUD-MTO 001 1651503.GPJ GAL-MISS.GDT 24/08/16 DATA INPUT:

Golder Associates

RECORD OF BOREHOLE No 16-2

1 OF 1 **METRIC**

PROJECT 1651503 | G.W.P. 4046-10-01 | LOCATION N 4913467.3; E 338312.4 | ORIGINATED BY RI

DIST 8 | HWY 401 | BOREHOLE TYPE Hollow Stem Auger, Truck Mounted | COMPILED BY KL

DATUM GEODETIC | DATE July 29, 2016 | CHECKED BY

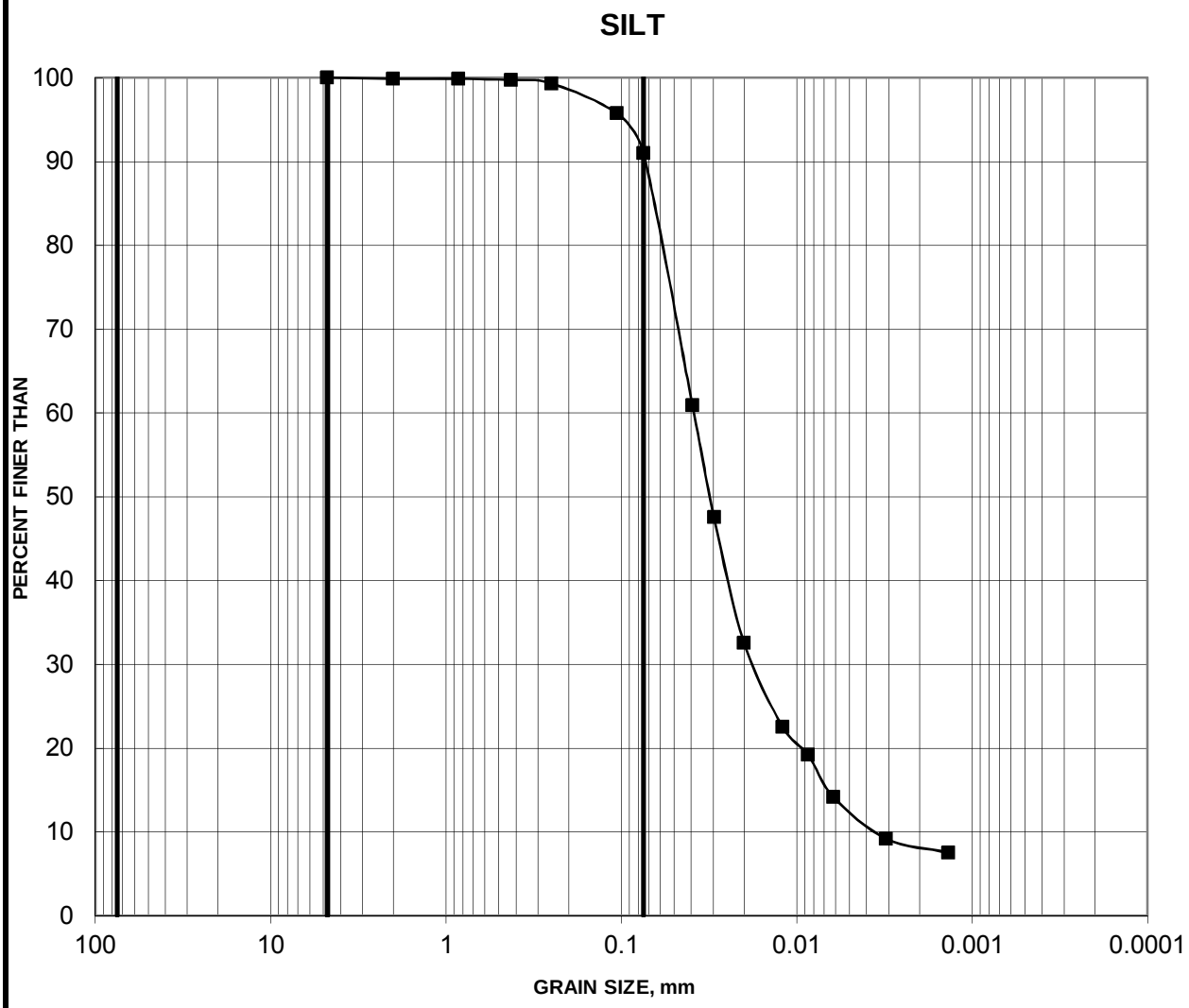
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.7	GROUND SURFACE										
0.0	TOPSOIL, trace to some sand Very stiff Dark brown Moist		1	SS	13						
0.2	SILTY CLAY, trace to some sand Very stiff Brown to grey Dry to moist		2	SS	15		94				
93.2											
1.5	SILT to Sandy SILT Compact Brown Moist to wet		3	SS	28		93				0 9 83 8
92.4											
2.3	SAND, some silt Very loose to compact Brown Moist to wet		4	SS	15		92				
			5	SS	8	▽					0 82 (18)
			6	SS	5		91				
			7	SS	3		90				
89.5											
5.2	END OF BOREHOLE Note: 1. Water level at a depth of 3.4 m below ground surface (Elev. 91.3 m) upon completion of drilling.										

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

SUD-MTO 001 1651503.GPJ GAL-MISS.GDT 24/08/16 DATA INPUT:

GRAIN SIZE DISTRIBUTION

Figure 2



Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
16-1	3	1.52-2.13

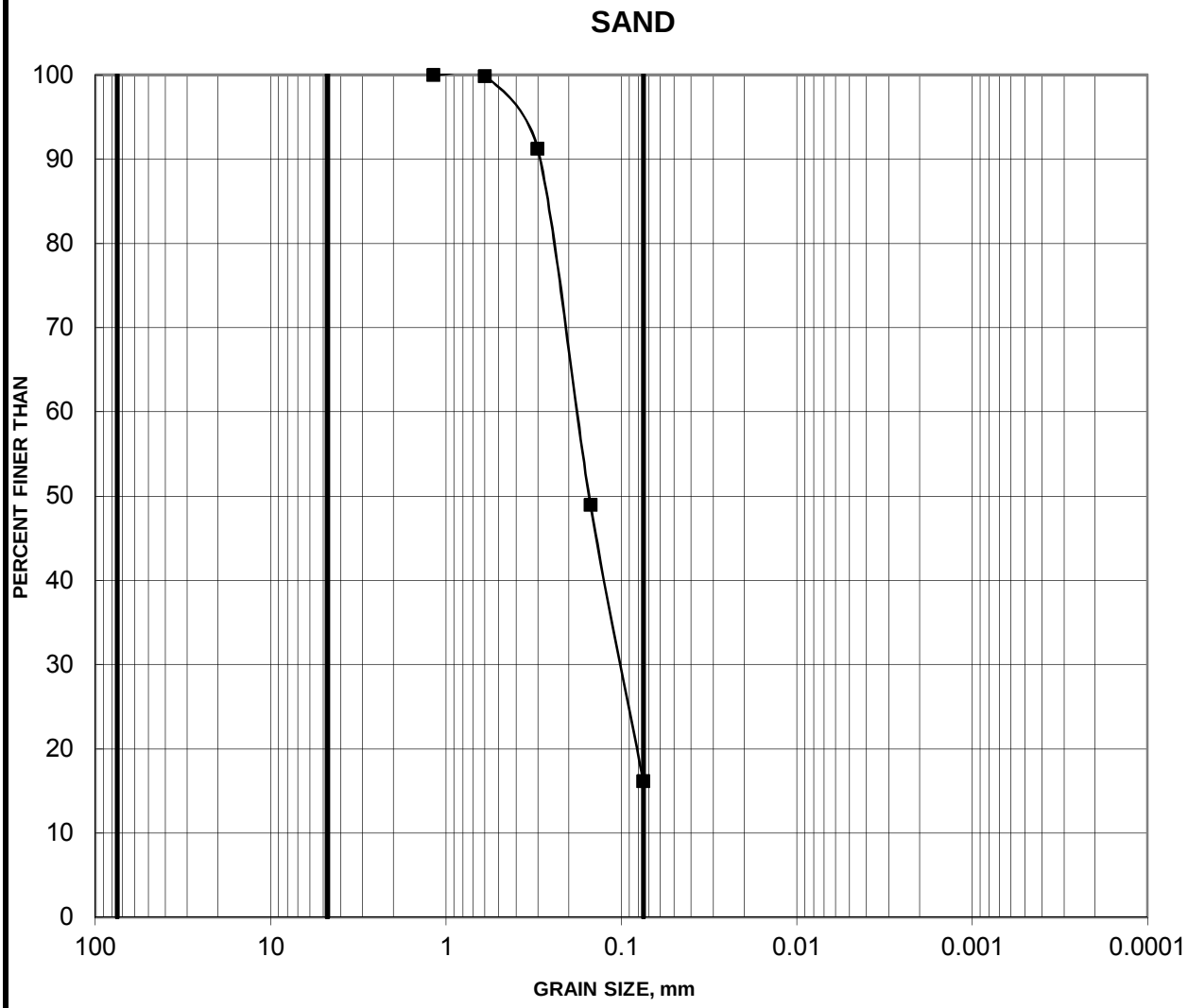
Project: 1651503

Golder Associates

Created by: CNM
Checked by: AC

GRAIN SIZE DISTRIBUTION

Figure 3



Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
16-1	5	3.05-3.66

Project: 1651503

Golder Associates

Created by: CNM
Checked by: AC

APPENDIX B

Record of Borehole Sheets and Laboratory Test Results 1991 Investigation, GEOCRES No. 31C-150

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_p	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_p	%	PLASTICITY INDEX = $w_L - w_p$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE

e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

RECORD OF BOREHOLE No 1 — 1 OF 1 — METRIC

W.P. 2501-91-01/02 — LOCATION Co-ords: N 4 913 254.7; E 338 186.2 — ORIGINATED BY G.D

DIST 8 — HWY 401 — BOREHOLE TYPE H S Auger and Cone Test — COMPILED BY L.D

DATUM Geodetic — DATE 91 04 25 — CHECKED BY T.K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
95.3	Ground Surface						
0.0 / 94.7	Asphalt						
0.6 / 93.4	Fine Sand, some silt (Fill) Compact to Dense — Brown		1	SS	50		
			2	SS	11		
1.9 / 91.9	Silty Clay, some sand, trace of organics — Grey Firm to V. Stiff — Grey		3	SS	16	▼	
			4	SS	9		
3.4 / 90.1	Sandy Silt to Silty Sand — Brown V. Loose		5	SS	1		
			6	SS	9		
5.2 / 86.1	Sand, some gravel occ. boulders Compact to V. Dense		7	SS	125		
			8	SS	74		
			9	SS	28		
9.2	End of Borehole at probable Bedrock						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE; 20 40 60 80 100

AUGER

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

42

UNIT WEIGHT 7 kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
	1	79	13	7
	0	9	51	40
	0	19	70	11
	13	75	(12)	

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 2501-91-01/02 LOCATION Co-ords: N 4 913 266.5; E 338 207.0 ORIGINATED BY G.D

DIST 8 HWY 401 BOREHOLE TYPE H S Auger, BXL Rock Coring & Cone Test COMPILED BY L.D

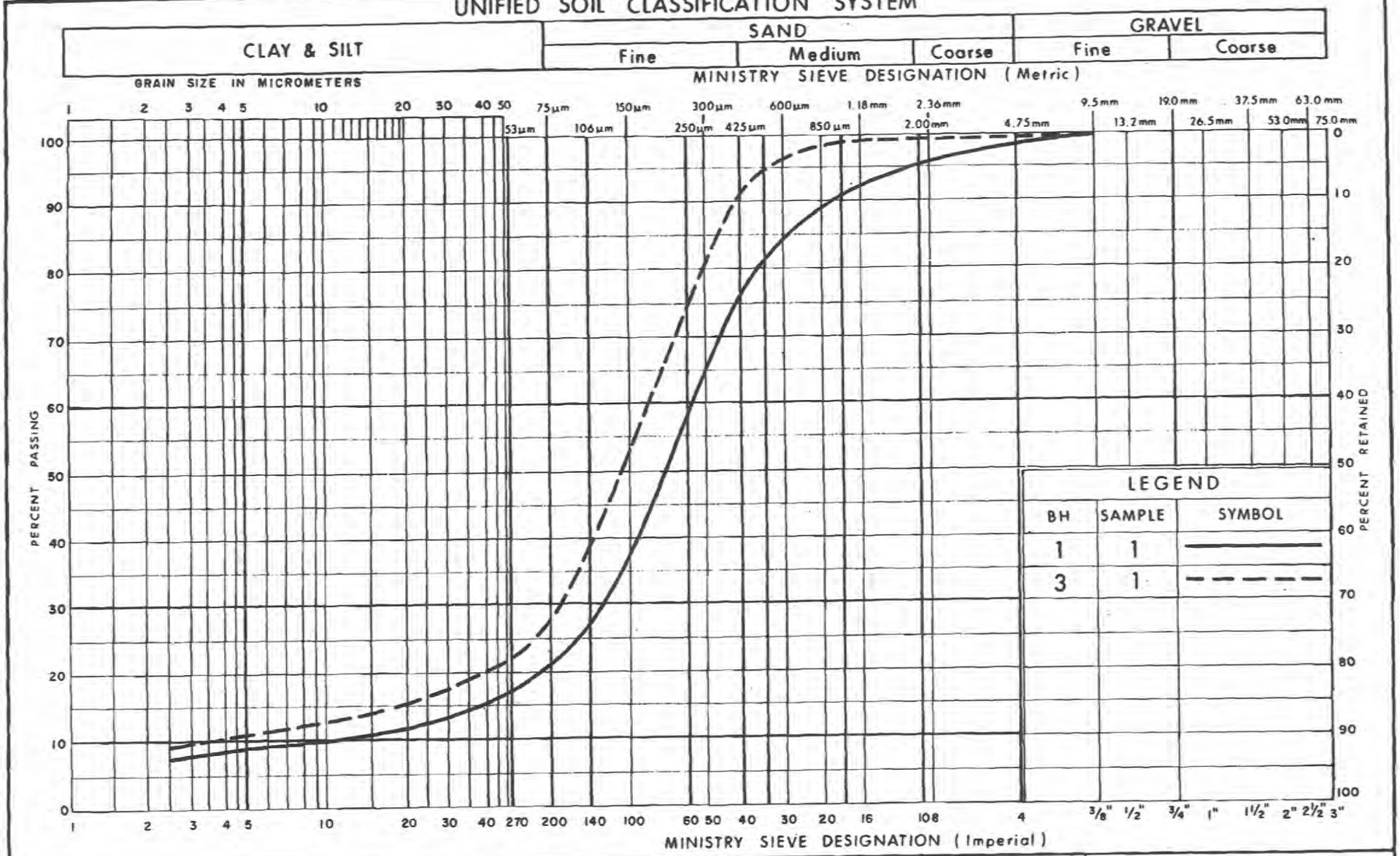
DATUM Geodetic DATE 91 04 24 CHECKED BY T.K

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 o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.3	Ground Surface										
0.0 / 94.7	Asphalt							AUGER			
0.6 / 93.2	Fine Sand, some silt (Fill) Compact to Dense — Brown		1	SS	41						
			2	SS	15	▼					
2.1 / 91.3	Silty Clay, some sand, trace of organics Firm to V. Stiff — Grey		3	SS	17				44		0 11 55 34
			4	SS	4						
4.0 / 87.7	Sandy Silt to Silty Sand Loose to Dense — Brown		5	SS	18						
			6	SS	7						
			7	SS	42						0 53 39 8
			8	SS	12						
7.6 / 85.9	Sand, some gravel Occ. boulders V. Dense		9	SS	112 /25cm				124		23 69 (8)
			10	SS	50 /3cm						
9.4 / 82.8	Bedrock Hornblende-Biotite Gneiss with Granite of the Grenville Province		11	RC	REC 100%						RQD 92%
			12	RC	REC 87%						RQD 70%
			13	RC	REC 100%						RQD 74%
12.5	End of Borehole										

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

20 / 15 ◇ 5 (%) STRAIN AT FAILURE / 10

UNIFIED SOIL CLASSIFICATION SYSTEM



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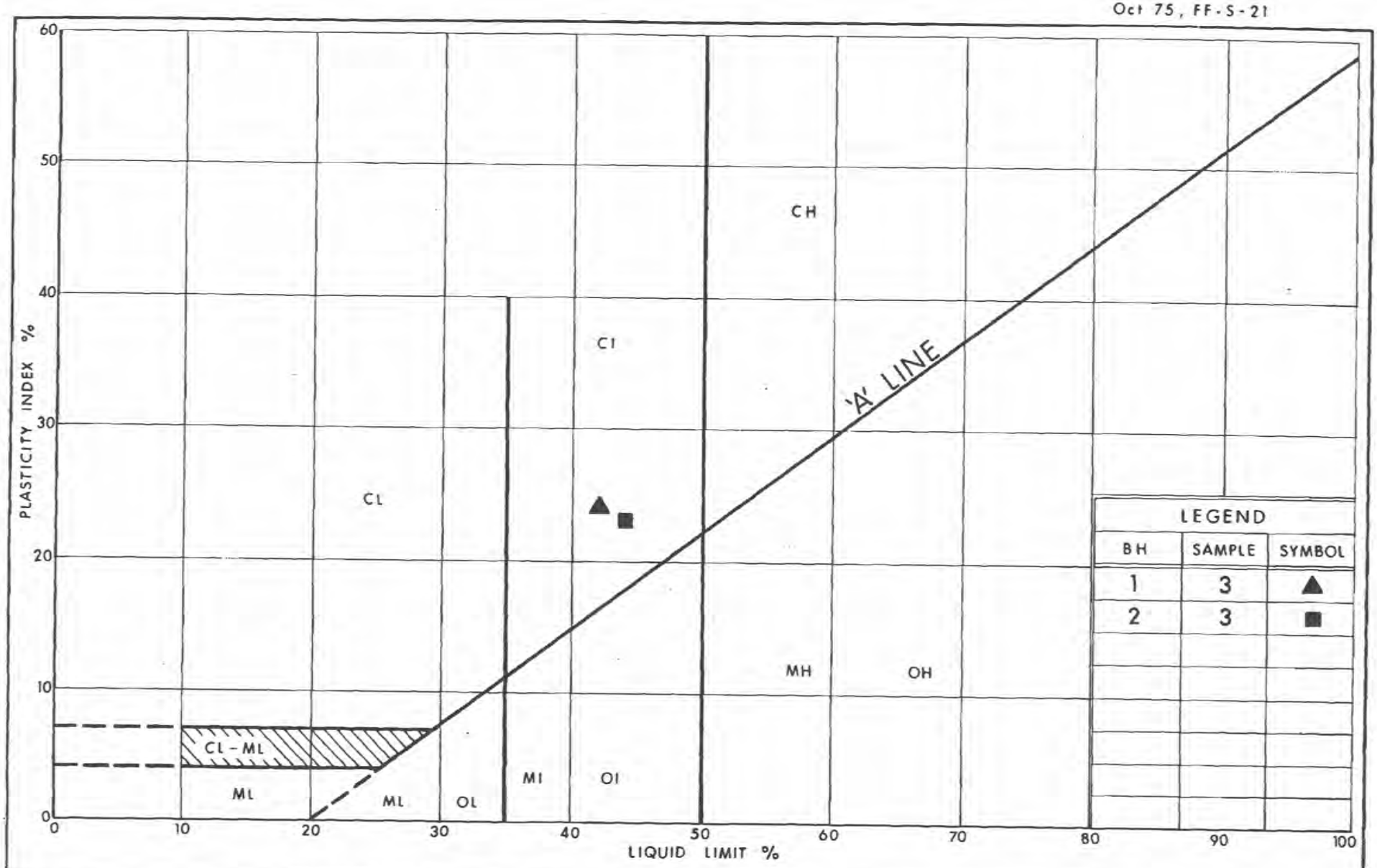
GRAIN SIZE DISTRIBUTION

SAND, SOME SILT (Fill)

FIG No 1

W P 2501-91-01/02

Oct 75, FF-S-21



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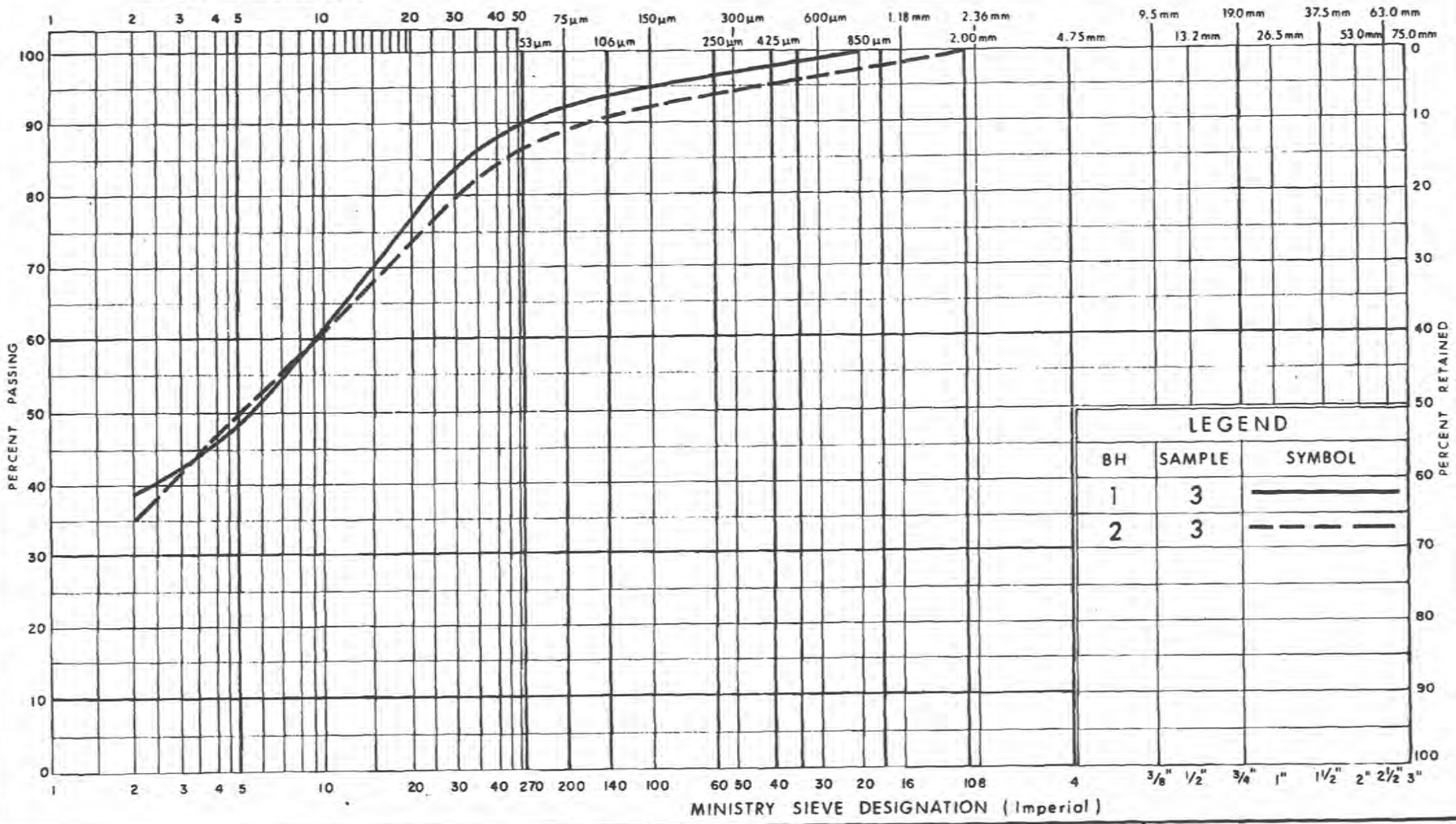
PLASTICITY CHART
SILTY CLAY, SOME SAND

FIG No 4
W P 2501-91-01/02

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



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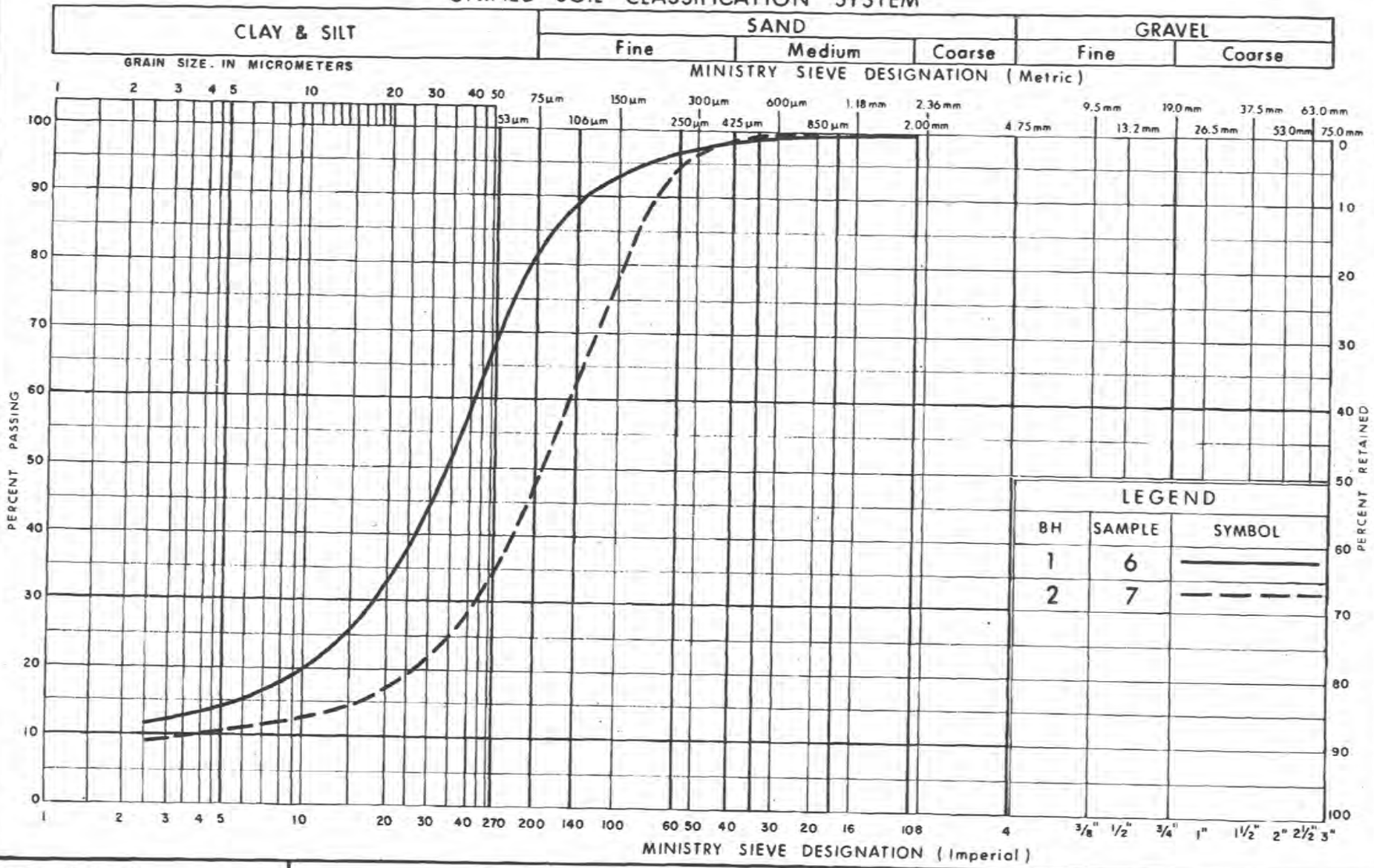
GRAIN SIZE DISTRIBUTION

SILTY CLAY, SOME SAND

FIG No 5

W P 2501-91-01/02

UNIFIED SOIL CLASSIFICATION SYSTEM



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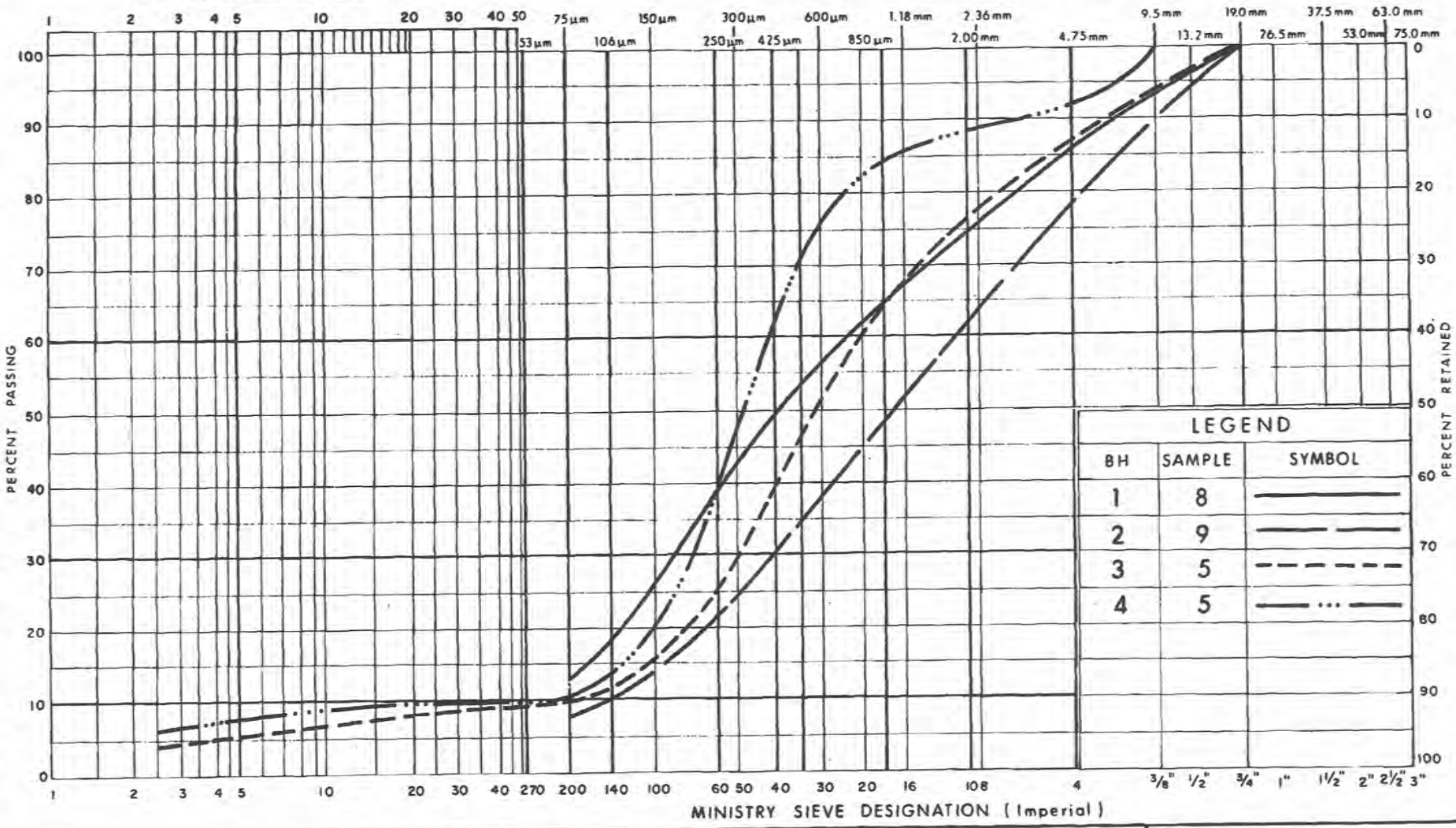
GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND

FIG No 6
W P 2501-91-01/02

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



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GRAIN SIZE DISTRIBUTION

SAND, SOME GRAVEL

FIG No 7

W P 2501-91-01/02

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