FINAL REPORT

September 09, 2016

PRELIMINARY FOUNDATION INVESTIGATION REPORT

MAPLEVIEW DRIVE OVERPASS, SITE NO. 30-179
HIGHWAY 400 WIDENING
FROM 1 KM SOUTH OF HIGHWAY 89 TO JUNCTION OF HIGHWAY 11
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P. 06-20016

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GEOCRES NO: 31D-656

Report Number: 14-1111-0002-7

Distribution:

1 Copy – Ministry of Transportation, Ontario – Foundations Section
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Table of Contents

PART A – PRELIMINARY FOUNDATION INVESTIGATION REPORT

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Golder Associates

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM (formerly URS Canada Inc.) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the preliminary design for the widening of the Mapleview Drive Overpass in the City of Barrie. The proposed work is part of the preliminary and design-build ready design associated with the Highway 400 widening from 1 km south of Highway 89 to the junction of Highway 11 in Simcoe County, Ontario.

This report addresses the proposed widening of the Mapleview Drive Overpass (MTO Structure Site No. 30-179) and the associated approach embankments only.

The terms of reference and scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated July 2013. Golder's scope of work for foundation engineering services associated with the Mapleview Drive rehabilitation is contained in Section 5.8 of AECOM's (previously URS Canada) Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated January 20, 2014.

2.0 SITE DESCRIPTION

The Mapleview Drive Overpass, which is part of the Highway 400-Mapleview Drive (formerly Molson Park Drive) Interchange, is located approximately 3.2 km south of the Essa Road Interchange, in the City of Barrie. The existing Mapleview Drive Overpass is an about 49 m wide by 39 m long single-span structure with integral abutments supported on driven steel H-piles. An approximately 13.4 m wide detour structure parallels the west side of the southbound lanes (SBL).

The overall surface topography in the vicinity of the site is relatively flat and consists of commercial developments and an industrial area to the west and east of Highway 400, respectively. The natural ground surface at the site ranges between approximately Elevations 301 m and 299 m. At this structure site, Highway 400 has been constructed on an up to 5.5 m high embankment and has an existing grade of about Elevation 304.5 m to 304 m. Mapleview Drive was constructed in a cut with an existing road grade of about Elevation 297 m.

3.0 INVESTIGATION PROCEDURES

3.1 Previous Borehole Investigation

Nine boreholes were advanced at this site as part of a MTO geotechnical investigation in 1997 (MTO, 1997 and 2002) for the replacement of the existing Mapleview Drive Overpass structure, associated with the widening of Highway 400. Boreholes 1, 2, 5 and 6 were advanced at the proposed north abutment and Boreholes 3, 4, and 7 to 9 were advanced at the proposed south abutment, to depths between 18.7 m and 27.7 m below ground surface. Additionally, Direct Cone Penetration Tests (DCPT) were advanced directly adjacent to each borehole, and met refusal at much shallower depths than the boreholes were terminated at. The borehole locations are shown on Drawing 1.

The boreholes were advanced using 82 mm inside diameter (I.D.) continuous flight hollow stem augers and soil samples were obtained at intervals of depth of about 0.75 m, 1.5 m, and 3.0 m using a 50 mm outer diameter split-spoon sampler driven by a manual hammer in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586).

The water level in the open boreholes was observed during and following the drilling operations. Laboratory index and classification testing were carried out on select soil samples.

The borehole locations in MTM NAD83 northing and easting coordinates, ground surface elevations reference to Geodetic datum and drilled depths are summarized below.

Borehole Number	Location (MTM NAD83)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
1	4,910,629.3	290,009.5	300.9	24.8
2	4,910,614.6	290,013.0	296.1	18.7
3	4,910,591.1	290,015.3	296.1	21.8
4	4,910,569.8	290,021.0	300.4	27.7
5	4,910,630.5	290,044.8	301.8	24.0
6	4,910,650.4	290,078.7	302.0	24.2
7	4,910,593.7	290,050.8	301.3	24.8
8	4,910,608.4	290,088.2	301.3	18.7
9	4,910,586.7	290,097.7	300.2	24.7

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario*[1], this section of Highway 400 from 6 km south of Highway 89 to the junction of Highway 11 traverses, generally in a south–north direction, the following physiographic regions: the Peterborough Drumlin Field; the Simcoe Lowlands; and the Simcoe Uplands. Along Highway 400, the Peterborough Drumlin Field is present from the southern limit of the project site to south of Line 13 of the Township of Bradford West Gwillimbury, as well as between about 1 km north of Highway 89 to about Essa Road. The Simcoe Lowlands covers the area from south of Line 13 to approximately 1 km north of Highway 89 and from about Essa Road to just north of Anne Street. The Simcoe Uplands extends from just north of Anne Street to beyond the northern limit of this project site.

The surficial soils in the western portion of the Peterborough Drumlin Field, which encompasses the Mapleview Drive site, consist primarily of sandy till deposits and sand to sand and gravel deposits. Deposits of silt, clay or peat may also be found in the low-lying areas between drumlins and eskers.

Along Highway 400, the Simcoe Lowlands include: the Holland River valley; the lowlands of the Lake Simcoe basin to the east; the lowlands of the Nottawasaga basin to the west, which includes Innisfil Creek and the Nottawasaga River to the south and west of the project limits, respectively. The Lake Simcoe and Nottawasaga basins are connected by a flat floored valley through Barrie which extends from the shores of Kempenfelt Bay west generally along Highway 90. The Simcoe Lowlands are generally characterized by deep deposits of deltaic or lacustrine silts, sands and clays associated with glacial Lake Algonquin.

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

The Simcoe Uplands consist of till plains and ancient shorelines. The till deposits range from clayey to silty and generally become more sandy and containing more boulders in the north. The low-lying areas of this region may also contain shallow deposits of sand and gravel associated with former glacial lake shorelines.

4.2 Subsurface Conditions

The Record of Borehole sheets and laboratory testing results from the MTO 1997 investigation are presented in Appendix A. The interpreted stratigraphic profile and cross-sections are shown on Drawings 1 and 2.

The results of the in situ field tests (i.e. SPT 'N'-values) carried out during the previous investigation as presented on the Record of Borehole sheets and in Section 4.2 are uncorrected. According to the Canadian Foundation Engineering Manual (*CFEM*, 2006), the energy delivered to the drill rod varies with the hammer release system, hammer type, anvil and operator characteristics.

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

In general, the subsurface conditions at the site consist of a layer of topsoil and/or fill underlain by a silty sand deposit, which is underlain by a silt deposit, which is underlain by a clayey silt to silty clay deposit, which is in turn underlain by a silty sand to sand to gravelly sand deposit which extends to the refusal condition.

A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Topsoil

Topsoil was encountered at ground surface in Boreholes 1, 4 and 6.

4.2.2 Silty Sand Fill

A 1.0 m to 1.9 m thick deposit of fill comprised of silty sand was encountered at ground surface in Boreholes 5 and 7 to 9 and below the topsoil in Borehole 6. Organic material was encountered at the base or below the fill layer in Boreholes 5, 7 and 8.

The SPT 'N'-values measured within the fill deposit range from 7 blows to 27 blows per 0.3 m of penetration, indicating a loose to compact relative density.

4.2.3 Silty Sand

A 0.8 m to 6.9 m thick deposit of silty sand was encountered between Elevations 300.9 m and 296.1 m in all boreholes advanced on site. The deposit was encountered at ground surface in Boreholes 2 and 3, below the topsoil in Boreholes 1 and 4 and below the fill in Boreholes 5 to 9. Additionally, refusal to further penetration was encountered in this deposit in DCPT's drilled directly adjacent to Boreholes 3 to 9.

The SPT 'N'-values measured within the silty sand deposit generally range from 21 blows to 269 blows per 0.3 m of penetration, indicating a compact to very dense relative density. The SPT 'N'-value measured near the top of the deposit, below the fill deposit range from 3 blows to 14 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The resulting envelope of grain size distribution tests completed on samples of the silty sand deposit are shown on Figure 1 in Appendix A.

4.2.4 Silt

A 1.5 m to 3.4 m thick deposit of silt was encountered below the silty sand deposit between Elevation 299.4 m and 239.0 m in all boreholes advanced on site. A hard, clayey silt crust was encountered at the top of this deposit in Borehole 3.

The SPT 'N'-values measured within the silt deposit generally range from 23 blows to 63 blows per 0.3 m of penetration, indicating a compact to very dense relative density. The SPT 'N'-values of the silt deposit encountered near the surface, in Borehole 1, measured 9 blows and 11 blows per 0.3 m penetration indicating a loose to compact relative density, whereas in Borehole 6, SPT "N"-values of 103 blows per 0.3 m of penetration and 162 blows per 0.25 m of penetration were measured. The SPT 'N'-value measured in the clayey silt crust in Borehole 3 is 43 blows per 0.3 m of penetration, suggesting a hard consistency.

The natural water content measured on a sample of the clayey silt crust is about 18 per cent.

The resulting envelope of the grain size distribution tests completed on samples of the silt deposit are shown on Figure 2 in Appendix A. One grain size distribution test completed on the clayey silt crust indicates a gradation comprised of 5 per cent sand and 95 per cent fines.

An Atterberg limits test carried out a sample of the clayey silt crust measured a liquid limit of about 26 per cent, a plastic limit of about 15 per cent, corresponding to a plasticity index of about 11 per cent, indication that the crust is comprised of clayey silt of low plasticity. The results of the Atterberg limits test is shown on Figure 4 in Appendix A.

4.2.5 Clayey Silt to Silty Clay

A 0.9 m to 2.5 m thick deposit of clayey silt to silty clay was encountered between Elevations 296.2 m and 290.1 m below the silt deposit in all boreholes advanced at the site.

The SPT 'N'-values measured within the clayey silt to silty clay deposit generally range from 13 blows to 69 blows per 0.3 m of penetration, suggesting a stiff to hard consistency. A SPT 'N'-value of 133 blows per 0.23 m of penetration was measured at the interface between the cohesive deposit and underlying non-cohesive deposit in Borehole 4.

The natural water content measured on samples of the clayey silt to silty clay range from about 18 per cent to 27 per cent.

Atterberg limits test carried out on eleven samples of the clayey silt to silty clay deposit measured liquid limits ranging between about 31 per cent and 47 per cent, plastic limits between about 16 per cent and 21 per cent and

plasticity indices between about 14 per cent and 27 per cent, indicating that the cohesive deposit is comprised of clayey silt of low plasticity to silty clay of intermediate plasticity, as shown on Figures 3 and 4 in Appendix A.

4.2.6 Silty Sand to Sand to Gravelly Sand

A silty sand to sand deposit was encountered in all of the boreholes, below the clayey silt to silty clay deposit between Elevations 295.0 m and 288.5 m, and was penetrated for 7.5 m to 18.9 m before termination of boreholes in refusal conditions. Gravelly sand was encountered within the upper 2.5 m of the silty sand to sand deposit in Boreholes 1, 2, 4, 5, 7 and 8. Additionally, refusal to further penetration was encountered in this deposit in DCPT's drilled directly adjacent to Boreholes 1 and 2.

The SPT 'N'-values measured within the silty sand to sand to gravelly sand deposit range from 85 blows per 0.3 m of penetration to 136 blows per 0.05 m of penetration, indicating a very dense relative density.

The resulting envelope of the grain size distribution tests completed on samples of the silty sand to sand component of the deposit and on samples of the gravelly sand component of the deposit are shown on Figures 5 and 6, respectively, in Appendix A.

4.3 Groundwater Conditions

Perched water was encountered at all borehole locations between about Elevation 297.5 m and 294 m, typically above the silt layer within the silty sand deposit (in Boreholes 2 to 4 and 6 to 9), and within the silt deposit (in Boreholes 1 and 5). It is considered that this shallow water table is perched by the clayey silt to silty clay deposit underlying the silty sand and silt deposits. Below the clayey silt to silty clay deposit, the groundwater level upon completion of drilling was measured at a depth of 27.6 m in Borehole 4, corresponding to Elevation 272.8 m. All other boreholes advanced on site were dry upon completion of drilling.

The water level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and periods of precipitation.

5.0 CLOSURE

This report was prepared by Ms. Madison Kennedy, B.A.Sc., a member of the geotechnical engineering group, and was reviewed by Mr. Christopher Ng, P.Eng., a senior geotechnical engineer and Associate of Golder. Mr. Jorge M. A. Costa, P.Eng., a Senior Consultant with Golder and Designated MTO Foundations Contact, conducted an independent quality control review of this report.

GOLDER ASSOCIATES LTD.

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Geotechnical Engineering Group

Christopher Ng, P.Eng.
Senior Geotechnical Engineer, Associate

Jorge M. A. Costa, P.Eng.
Designated MTO Foundations Contact, Senior Consultant

MCK/CN/JMAC/mck

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REFERENCES

Canadian Geotechnical Society, 2006. *Canadian Foundation Engineering Manual*, 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.

Chapman, L. J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.

Ministry of Transportation, Ontario. 1997. *Foundation Investigation and Design Report; Molson Park Drive Replacement Bridge; Highway 400 Widening from 1 km South of Highway 89 to Highway 11, Structure Site 30-179, W.P. 26-96-01*, GEOCRES No. 31D00-362, prepared by Engineering Materials Office, Foundation Design Section, Ministry of Transportation, Ontario.

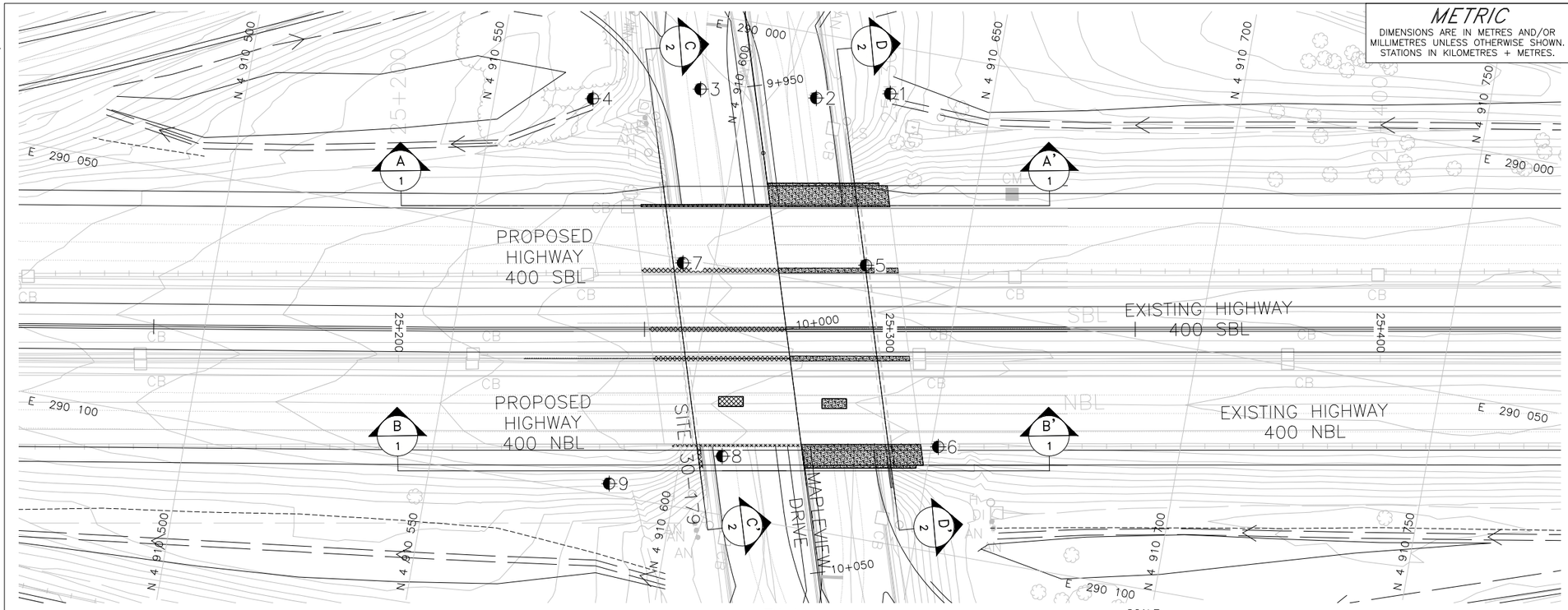
Ministry of Transportation, Ontario. 2002. *Preliminary Foundation Investigation and Design Report; Molson Park Drive Overpass, Structure Site 30-179; Highway 400 Widening from 1 km South of Highway 89 to Highway 11, G.W.P. 30-95-00*, GEOCRES No. 31D00-471, prepared by Golder Associates Ltd.

ASTM International:

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

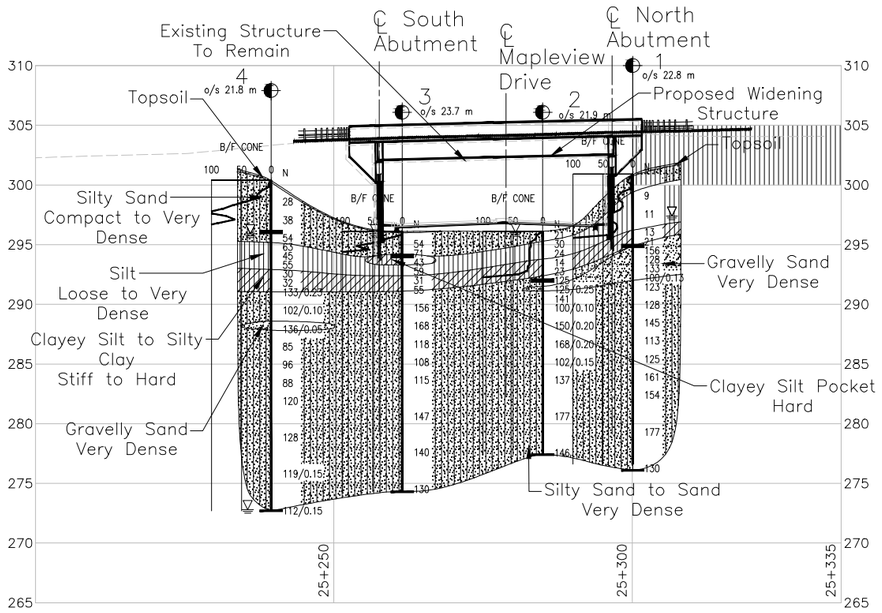
DRAWINGS

MINISTRY OF TRANSPORTATION, ONTARIO



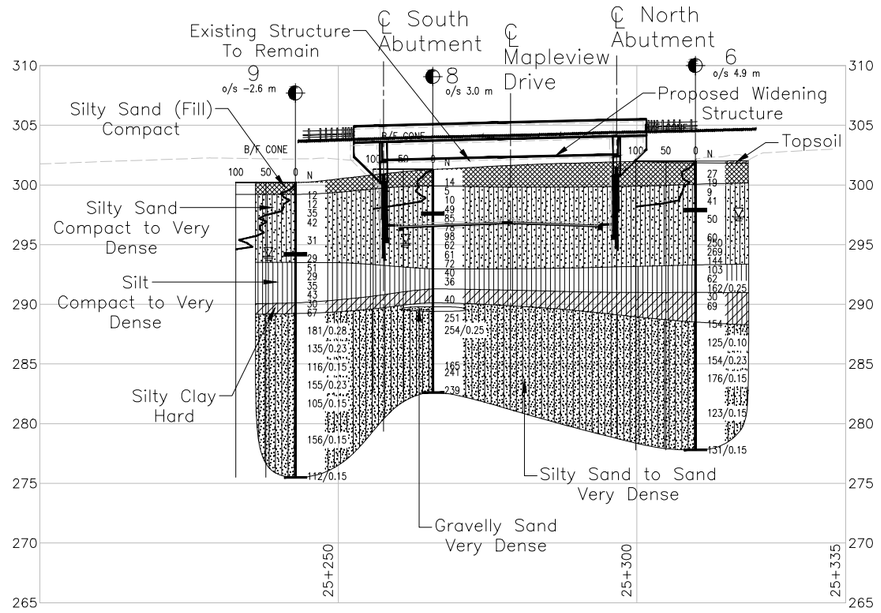
PLAN

SCALE
10 0 10 20 m



A-A' 1 SBL PROFILE
WEST SIDE OF OVERPASS

HORIZONTAL SCALE
10 0 10 20 m



B-B' 1 NBL PROFILE
EAST SIDE OF OVERPASS

VERTICAL SCALE
5 0 5 10 m

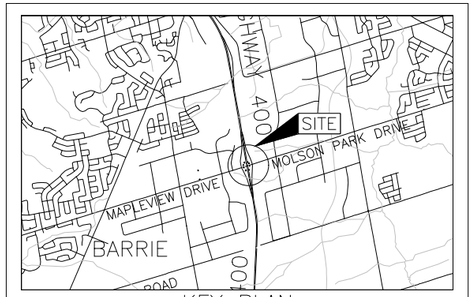
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 06-20016

MAPLEVIEW DRIVE OVERPASS
HIGHWAY 400 WIDENING
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Golder Associates



KEY PLAN
SCALE
1 0 1 2 km

LEGEND

- Borehole – Previous Investigation (Geocress No. 31D00-362)
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling, or perched

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
1	300.9	4910629.3	290009.5
2	296.1	4910614.6	290013.0
3	296.1	4910591.1	290015.3
4	300.4	4910569.8	290021.0
5	301.8	4910630.5	290044.8
6	302.0	4910651.4	290078.7
7	301.3	4910593.7	290050.8
8	301.3	4910608.4	290088.2
9	300.2	4910586.7	290097.7

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

Design plans, base plans, profile and surface data provided in digital format by AECOM, drawing file nos. "01_Mapleview Drive_GA.dwg", "4-Mapleview Dr.dwg", with associated reference files, received May 11, 2016, "X-Base_All.dwg", received January 27, 2016 and "X-Design_4th Line_Interim.dwg", received June 22, 2015.

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTER Sept. 9, 2016 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER C.C. NG 100086170 Sept. 9, 2016 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31D-656

HWY. 400	PROJECT NO. 14-1111-0002		DIST. .
SUBM'D. MCK	CHKD. MCK	DATE: 5/25/2016	SITE: 30-179
DRAWN: MR	CHKD. CN	APPD. JMAC	DWG. 1

PLOT DATE: September 8, 2016
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MINISTRY OF TRANSPORTATION, ONTARIO

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

CONT No.
GWP No. 06–20016

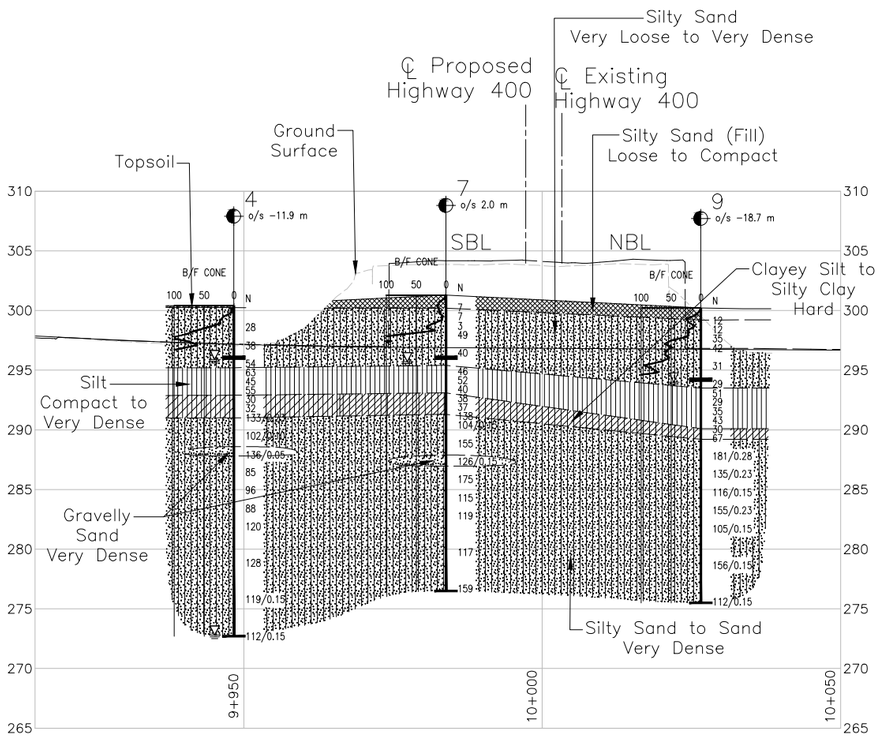
MAPLEVIEW DRIVE OVERPASS
HIGHWAY 400 WIDENING

SOIL STRATA

SHEET

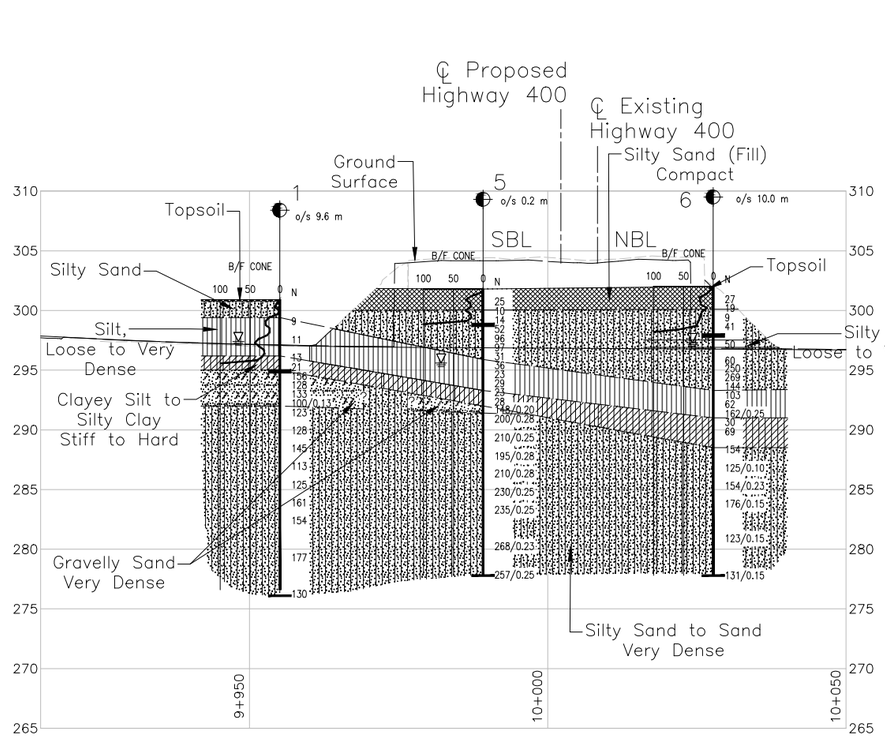
Golder Associates

KEY PLAN
SCALE
1 0 1 2 km



C–C
1
SOUTH ABUTMENT AREA
CROSS–SECTION

HORIZONTAL SCALE
10 0 10 20 m



D–D
1
NORTH ABUTMENT AREA
CROSS–SECTION

VERTICAL SCALE
5 0 5 10 m

LEGEND

- Borehole – Previous Investigation (Geocress No. 31D00–362)
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling, or perched

BOREHOLE CO–ORDINATES

No.	ELEVATION	NORTHING	EASTING
1	300.9	4910629.3	290009.5
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Sept. 9, 2016
PROVINCE OF ONTARIO

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Sept. 9, 2016
PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31D–656

HWY. 400		PROJECT NO. 14–1111–0002	DIST. .
SUBM'D. MCK	CHKD. MCK	DATE: 5/25/2016	SITE: 30–179
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APPENDIX A

Record of Boreholes and Laboratory Test Results – MTO 1997 Investigation (GEOCRES No. 31D00-362)

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
σ_1, σ_2, σ_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, 60º cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

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

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

III. SOIL DESCRIPTION

(a) Non-Cohesive Soils

Density Index / Relative Density	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils
Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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

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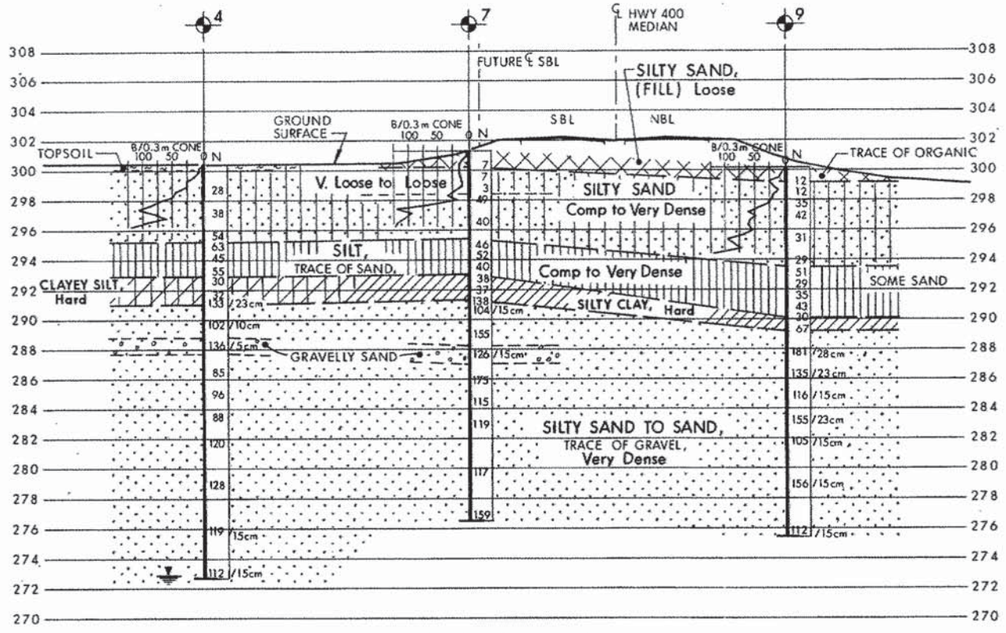
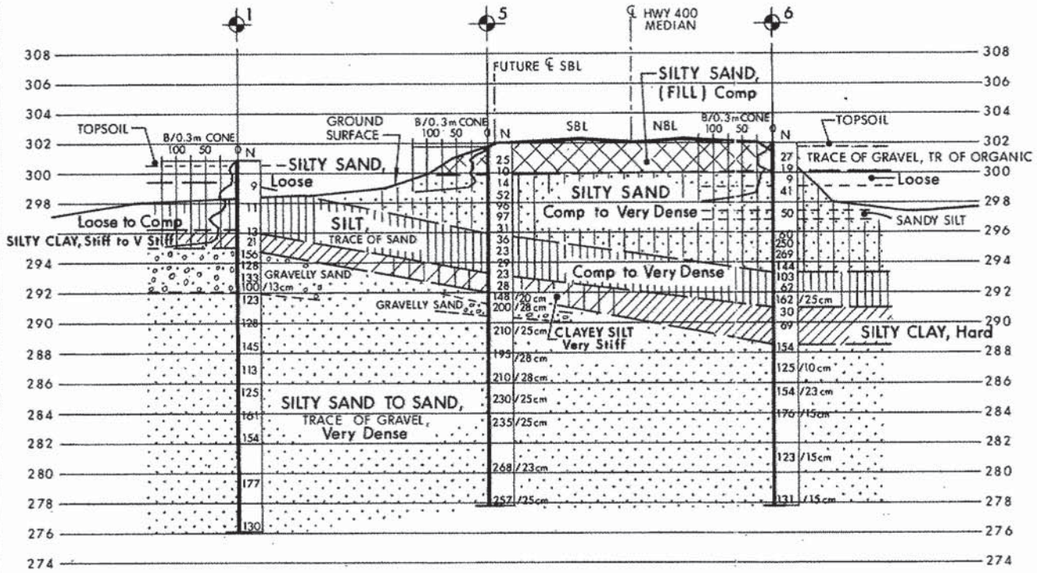


SECTION A-A



SECTION B-B

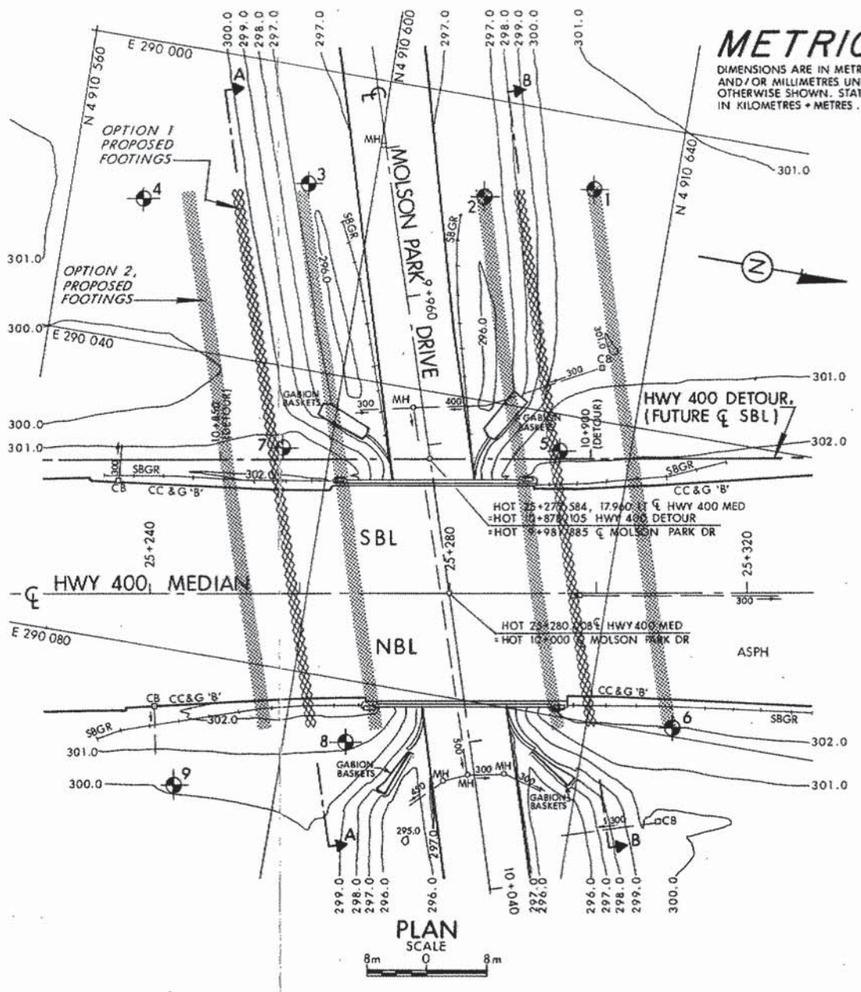
SCALES
8m 0 8m HOR
4m 0 4m VERT

NOTES :

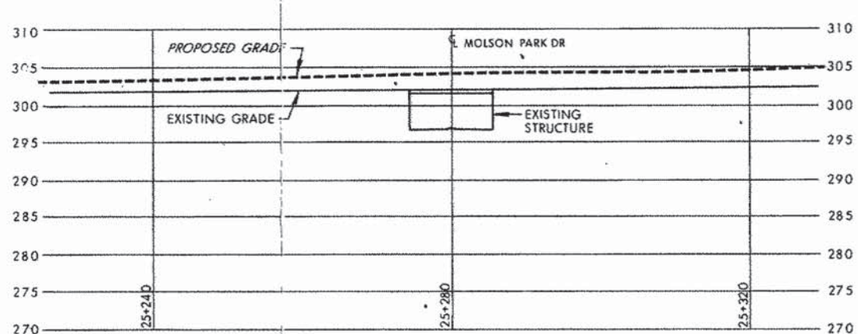
a) For Subsoil information of BH's 2, 3 & 8 refer to Record of Borehole Sheets.

b) All Boreholes, with the exception of No 4 were dry on completion.

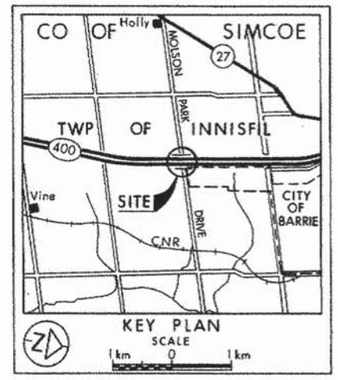
c) For Perched Water information refer to Record of Borehole Sheets.



PLAN
SCALE
8m 0 8m



℄ PROFILE HWY 400 MEDIAN
SCALE
8m 0 8m



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation 1997 04

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	300.9	4 910 629.3	290 009.5
2	296.1	4 910 614.6	290 013.0
3	296.1	4 910 591.1	290 015.3
4	300.4	4 910 569.8	290 021.0
5	301.8	4 910 630.5	290 044.8
6	302.0	4 910 651.4	290 078.7
7	301.3	4 910 593.7	290 050.8
8	301.3	4 910 608.4	290 088.2
9	300.2	4 910 586.7	290 097.7

NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen.Cond.

REV.	DATE	BY	DESCRIPTION

Geocres No 31D-362

HWY No 400			DIST 33
SUBM'D M.V	CHECKED	DATE 1997 06 12	SITE 30-179
DRAWN R.S	CHECKED	APPROVED	DWG 269601-A

REF No E-77-400-1 Plates 1 of 2 and 2 of 2, 96 06

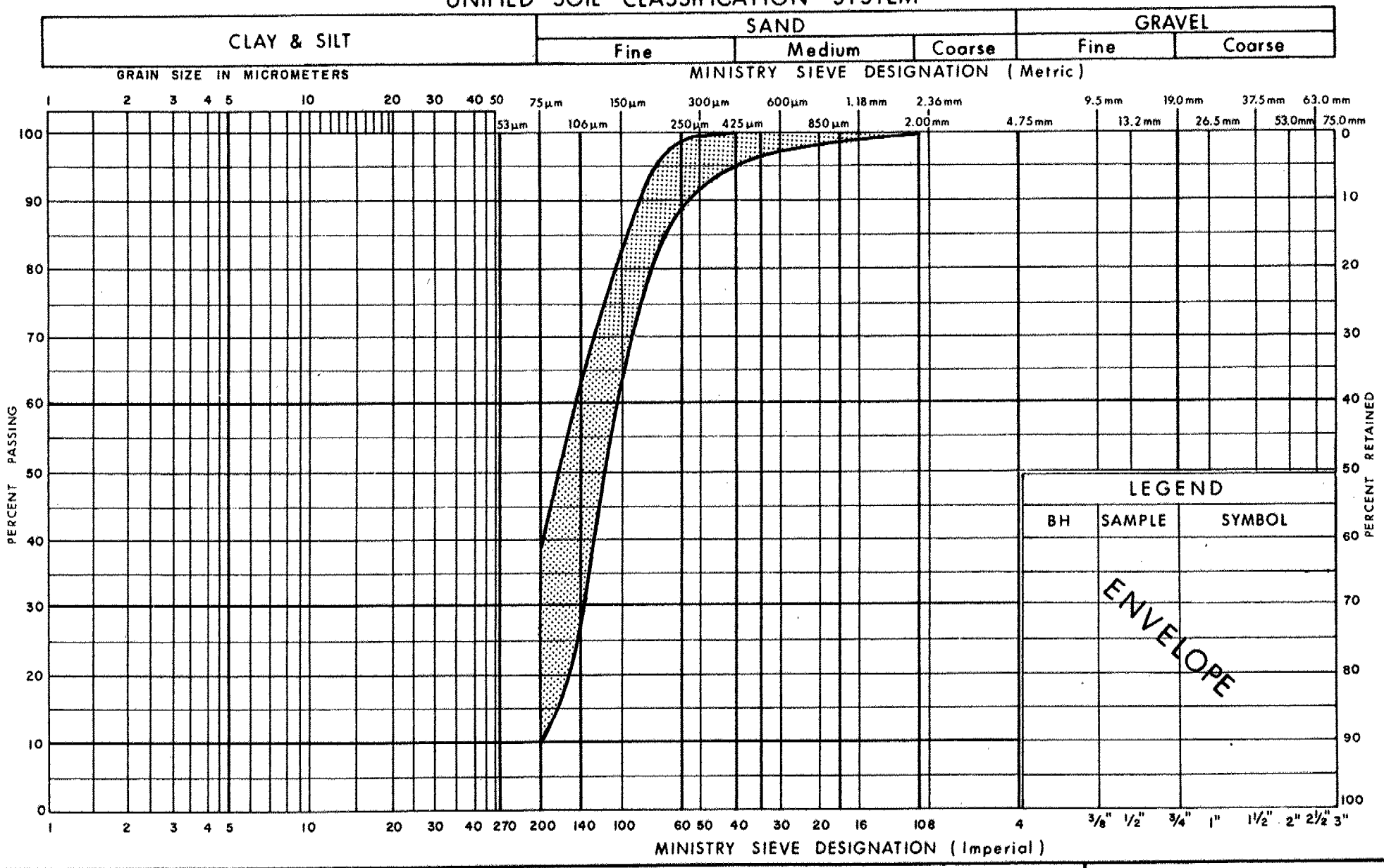
CONT No
WP No 26-96-01

MOLSON PARK DRIVE

BORE HOLE LOCATIONS & SOIL STRATA

SHEET

UNIFIED SOIL CLASSIFICATION SYSTEM



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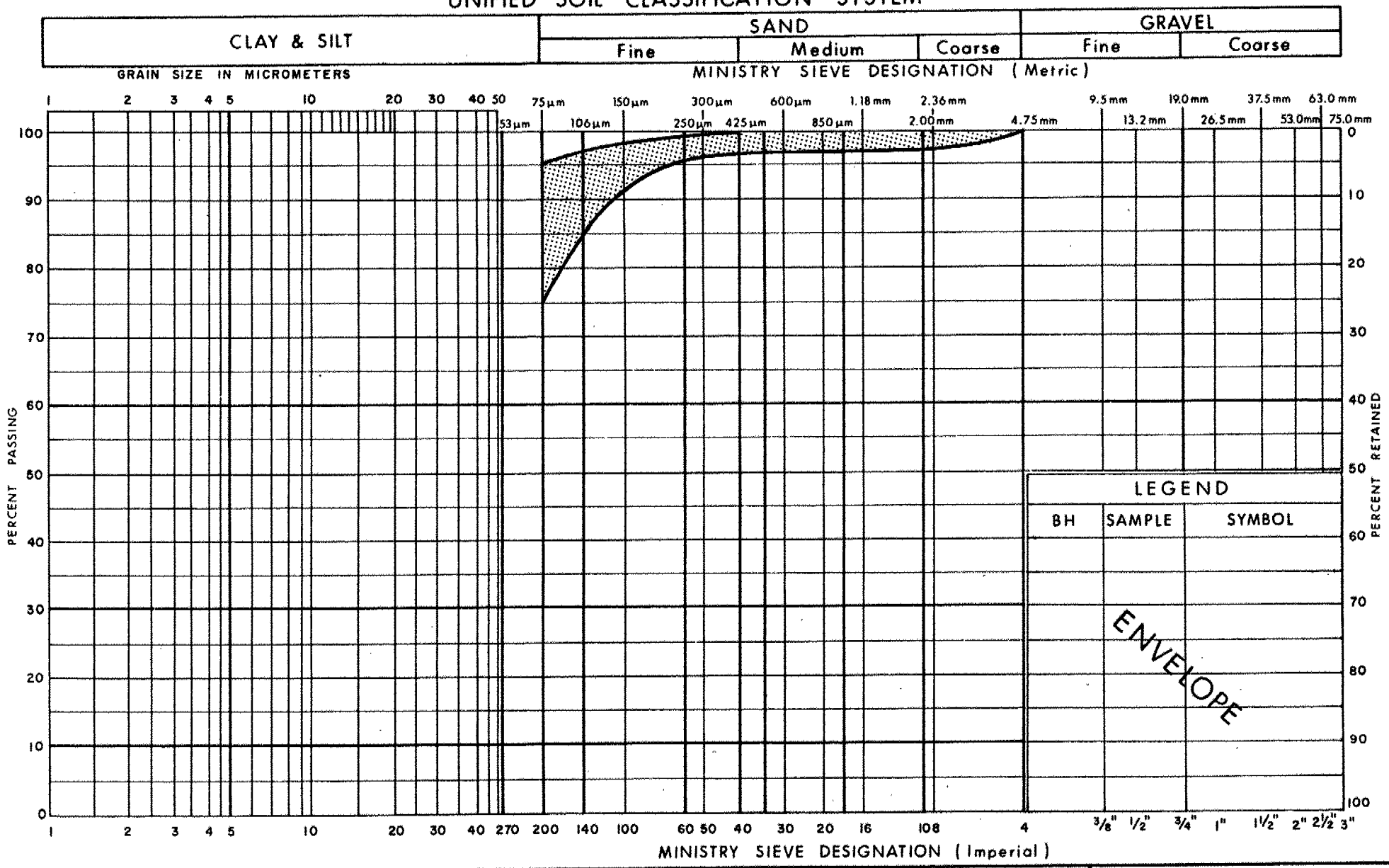
GRAIN SIZE DISTRIBUTION
SILTY SAND

FIG No 1
W P 26-96-01

UNIFIED SOIL CLASSIFICATION SYSTEM



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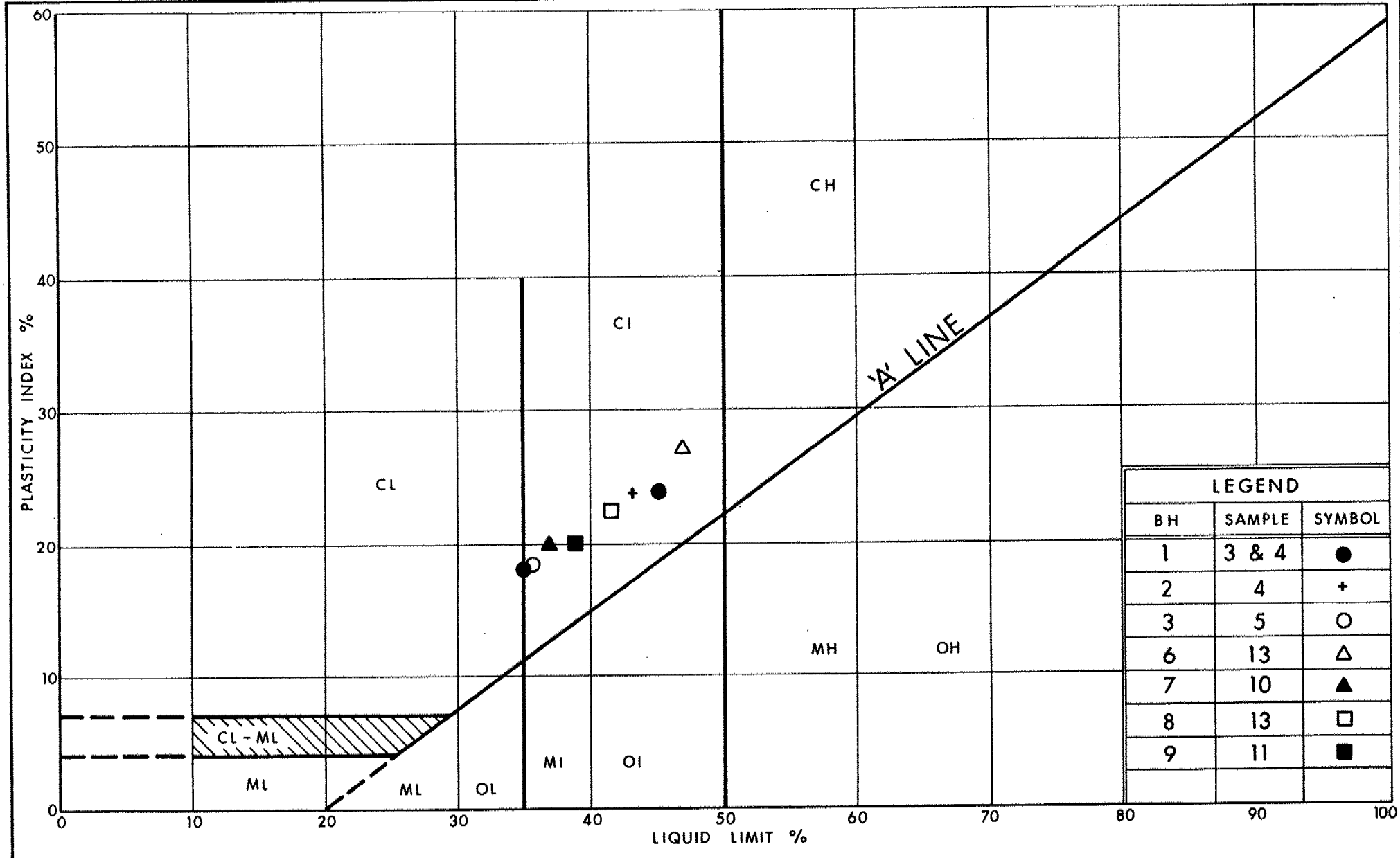
GRAIN SIZE DISTRIBUTION

SILT, TRACE / SOME SAND

FIG No 2

W P 26-96-01



LEGEND		
BH	SAMPLE	SYMBOL
1	3 & 4	●
2	4	+
3	5	○
6	13	△
7	10	▲
8	13	□
9	11	■

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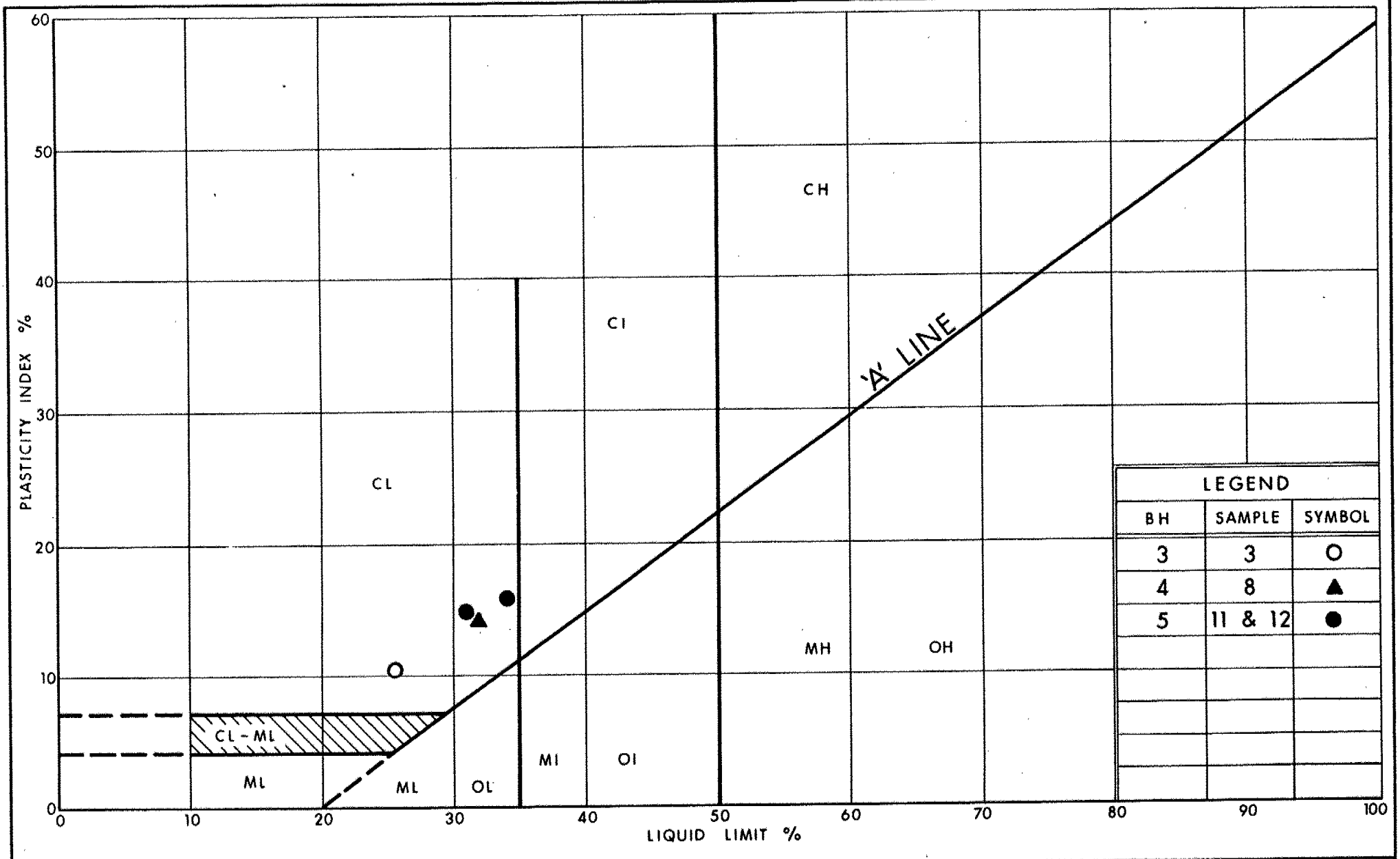
Ontario

PLASTICITY CHART
SILTY CLAY

FIG No 3
W P 26-96-01

Oct 75, FF-S-21



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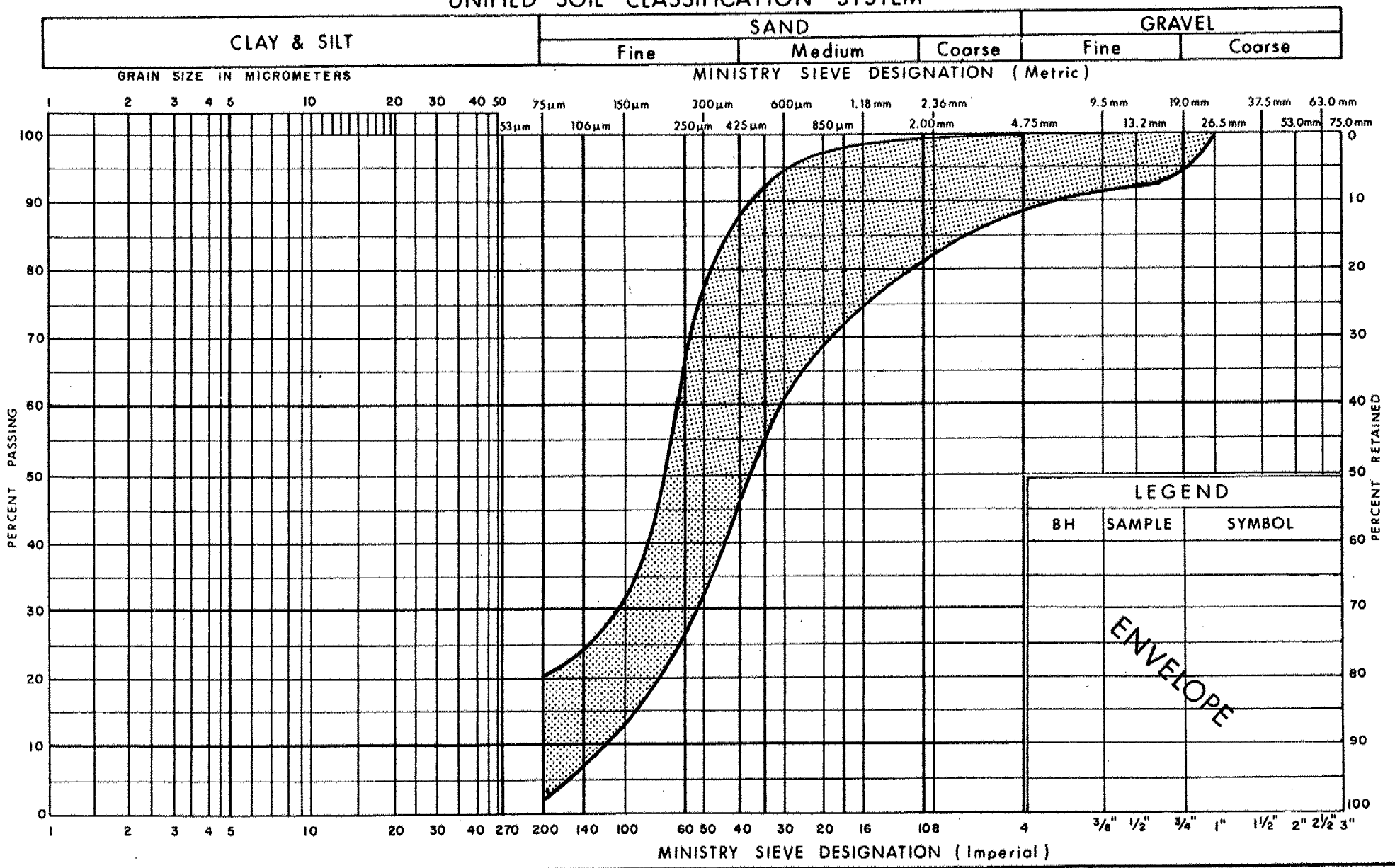
PLASTICITY CHART
CLAYEY SILT

FIG No 4
W P 26-96-01

UNIFIED SOIL CLASSIFICATION SYSTEM



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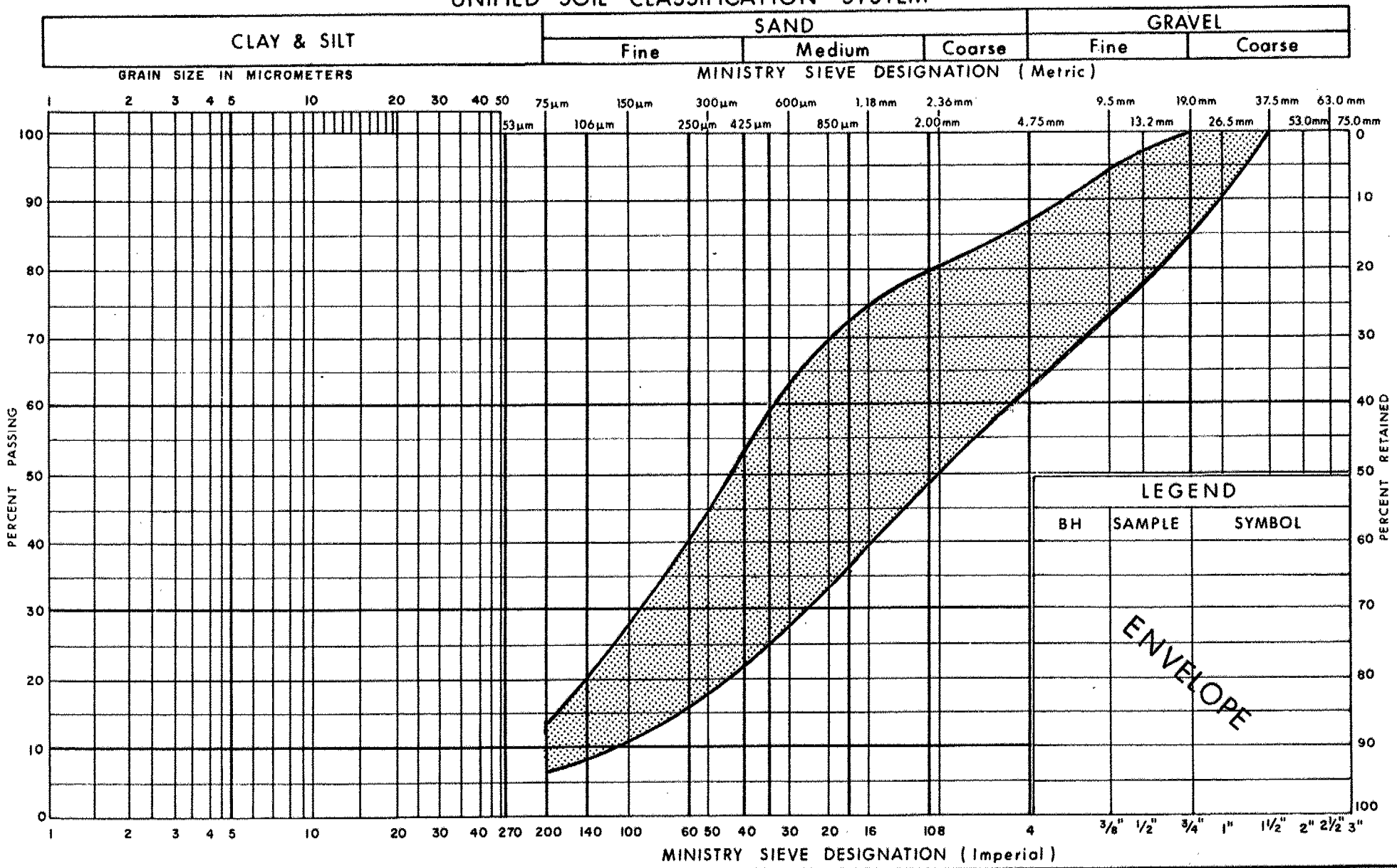
GRAIN SIZE DISTRIBUTION
SILTY SAND TO SAND,
TRACE OF GRAVEL

FIG No 5
W P 26-96-01

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

GRAVELLY SAND

FIG No 6

W P 26-96-01

RECORD OF BOREHOLE No 1 1 OF 1 METRIC

W.P. 26 - 96 - 01 LOCATION CO - ORDS: N 4 910 629.3; E 290 009.5 ORIGINATED BY M V&P C

DIST 33 HWY 400 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 1997 04 02 CHECKED BY T C 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, * QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
300.9	Ground Surface										
0.0	Topsoil					*	300				
299.4	SILTY SAND, Loose		1	SS	9						
1.5	SILT, Trace of Sand, Loose to Compact		2	SS	11		298				0 5 (95)
296.2			3	SS	13		296				
4.7	SILTY CLAY, Stiff to Very Stiff		4	SS	21			120/18cm			
5.9	Gravelly Sand		5	SS	156						24 66 (10)
			6	SS	128		294				
			7	SS	133						
			8	SS	100	/13cm					31 52 (17)
			9	SS	123		292				
			10	SS	128		290				
			11	SS	145						
			12	SS	113		288				
	SILTY SAND TO SAND, Trace of Gravel, Very Dense		13	SS	125		286				
			14	SS	161						
			15	SS	154		284				
			16	SS	177		282				4 86 (10)
276.1			17	SS	130		280				
24.8	End of Borehole						278				

* Note:
Borehole Dry on Completion
Perched Water Level Encountered at El. 297.4

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15◇5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 26 - 96 - 01 LOCATION CO - ORDS: N 4 910 614.6; E 290 013.0 ORIGINATED BY M V

DIST 33 HWY 400 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 1997 04 01 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
296.1	Drainage Ditch						
0.0 295.3	SILTY SAND, Trace of Organic, Compact		1	SS	21	*	
0.8	SILT, Some Sand,		2	SS	30		
293.8	Compact		3	SS	24		
2.3	SILTY CLAY,		4	SS	14		
292.4	Stiff to Very Stiff		5	SS	23		
3.7			6	SS	125		
			7	SS	125	/25cm	
	Gravelly Sand		8	SS	141		
			9	SS	100	/10cm	
			10	SS	150	/20cm	
			11	SS	168	/20cm	
			12	SS	102	/15cm	
	SILTY SAND TO SAND, Trace of Gravel, Very Dense		13	SS	137		
			14	SS	177		
277.4			15	SS	146		
18.7	End of Borehole						

* Note:
Borhole Dry on Completion
Perched Water Level Encountered at El. 296.0

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

120/28cm

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 15 30 45

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
	2	18	(80)	
	5	81	(14)	
	15	71	(14)	
	3	86	(11)	

$+^3$, $\times^5$: Numbers refer to Sensitivity

$15 \diamond^{20}_{10} 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 26 - 96 - 01 LOCATION CO - ORDS: N 4 910 591.1; E 290 015.3 ORIGINATED BY M V

DIST 33 HWY 400 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 1997 04 14 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
296.1	Drainage Ditch										
0.0	Silt and Organic										
	SILTY SAND, Very Dense		1	SS	54	*					0 79 (21)
294.2			2	SS	71		294				
1.9	Clayey Silt, Hard		3	SS	43				120/23cm		0 5 (95)
	SILT, Trace of Sand, Dense to Very Dense		4	SS	59						
3.7	SILTY CLAY, Hard		5	SS	31		292				
291.1			6	SS	55						
5.0			7	SS	156		290				5 84 (10)
			8	SS	168		288				10 78 (12)
			9	SS	118						
			10	SS	108		286				
			11	SS	115		284				
	SILTY SAND TO SAND, Trace of Gravel, Very Dense						282				
			12	SS	147						0 94 (6)
							280				
			13	SS	140		278				
274.3			14	SS	130		276				
21.8	End of Borehole										

* Note:

Borehole Dry on Completion

Perched Water Level Encountered at El. 295.9

+³, ×⁵ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 26 - 96 - 01 LOCATION CO - ORDS: N 4 910 569.8; E 290 021.0 ORIGINATED BY M V

DIST 33 HWY 400 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 1997 04 10 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
300.4	Ground Surface						
0.0	Topsoil						
			1	SS	28		
	SILTY SAND, Compact to Very Dense		2	SS	38		
			3	SS	54		0 81 (19)
295.2							
5.2			4	SS	63		
	SILT, Trace of Sand, Dense to Very Dense		5	SS	45		
			6	SS	55		0 9 (91)
292.9							
7.5			7	SS	30		
	CLAYEY SILT, Hard		8	SS	32		
291.0			9	SS	133	/23cm	
9.4			10	SS	102	/10cm	
	Gravelly Sand		11	SS	136	/5cm	38 55 (7)
			12	SS	85		2 93 (5)
			13	SS	96		
			14	SS	88		
	SILTY SAND TO SAND, Trace of Gravel, Very Dense		15	SS	120		
			16	SS	128		
			17	SS	119	/15cm	
272.7			18	SS	112	/15cm	1 91 (8)
27.7	End of Borehole						

* Note: Water Level on Completion at El. 272.8
Perched Water Level Encountered at El. 295.9

ELEVATION SCALE: 300, 298, 296, 294, 292, 290, 288, 286, 284, 282, 280, 278, 276, 274

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

120/23cm

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%) 15 30 45

UNIT WEIGHT γ kN/m³

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5

1 OF 1 METRIC

W.P. 26 - 96 - 01 LOCATION CO - ORDS: N 4 910 630.5; E 290 044.8 ORIGINATED BY M V&P C

DIST 33 HWY 400 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 1997 04 02 & 03 CHECKED BY T C 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 (%) (15 30 45)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
301.8	Ground Surface										
0.0	SILTY SAND, Compact. (Fill)		1	SS	25	*					
299.9	Organic		2	SS	10		300				
1.9	SILTY SAND, Compact to Very Dense		3	SS	14						0 80 (20)
			4	SS	52		298				
			5	SS	96						
			6	SS	97						0 62 (38)
295.9			7	SS	31		296				
5.9	SILT, Trace of Sand, Compact to Dense		8	SS	36						
			9	SS	23						0 6 (94)
			10	SS	29		294				
293.3			11	SS	23						
8.5	CLAYEY SILT, Very Stiff		12	SS	28						
292.0			13	SS	148	/20cm	292				
9.8	Gravelly Sand		14	SS	200	/28cm					24 67 (9)
			15	SS	210	/25cm	290				
			16	SS	195	/28cm	288				
			17	SS	210	/28cm					
	SILTY SAND TO SAND, Trace of Gravel, Very Dense		18	SS	230	/25cm	286				
			19	SS	235	/25cm	284				8 72 (20)
			20	SS	268	/23cm	282				
277.8			21	SS	257	/25cm	280				
24.0	End of Borehole						278				0 92 (8)

* Note:
Borehole Dry on Completion
Perched Water Level Encountered at El. 295.6

+³, ×⁵ : Numbers refer to Sensitivity

20
15◇5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6 1 OF 1 METRIC

W.P. 26 - 96 - 01 LOCATION CO - ORDS: N 4 910 651.4; E 290 078.7 ORIGINATED BY M V

DIST 33 HWY 400 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 1997 04 08 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
302.0	Ground Surface										
0.0	Topsoil										
	SILTY SAND, Trace of Gravel, Trace of Organic, Compact (Fill)		1	SS	27	*					
300.1			2	SS	19		300				
1.9	Loose		3	SS	9						
			4	SS	41						
	Sandy Silt		5	SS	50			120/ 25cm			0 35 (65)
	SILTY SAND, Dense to Very Dense		6	SS	60		296				
			7	SS	250						
			8	SS	269						
293.3			9	SS	144		294				0 71 (29)
8.7	SILT, Trace of Sand, Very Dense		10	SS	103						
			11	SS	62						0 10 (90)
291.0			12	SS	162	/25cm	292				0 12 (88)
11.0	SILTY CLAY, Hard		13	SS	30						
			14	SS	69						
288.5							290				
13.5			15	SS	154						9 78 (13)
			16	SS	125	/10cm	288				
			17	SS	154	/23cm	286				
	SILTY SAND TO SAND, Trace of Gravel, Very Dense		18	SS	176	/15cm	284				
							282				
			19	SS	123	/15cm					
							280				
277.8			20	SS	131	/15cm	278				0 90 (10)
24.2	End of Borehole										

* Note: Borhole Dry on Completion
Perched Water Level Encountered at El. 297.3

$+^3$, $\times^5$: Numbers refer to Sensitivity

$15 \frac{20}{10} 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 7 1 OF 1 METRIC

W.P. 26 - 96 - 01 LOCATION CO - ORDS: N 4 910 593.7; E 290 050.8 ORIGINATED BY M V

DIST 33 HWY 400 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 1997 04 11 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
301.3	Ground Surface						
0.0 / 300.2	SILTY SAND, Loose (Fill)		1	SS	7	*	300
1.1	Organic		2	SS	7		
	Very Loose to Loose		3	SS	3		
			4	SS	49		298
	SILTY SAND, Dense		5	SS	40		
295.4							296
5.9			6	SS	46		
	SILT, Trace of Sand, Dense to Very Dense		7	SS	52		294
293.1			8	SS	40		
8.2	SILTY CLAY, Hard		9	SS	38		
291.3			10	SS	37		292
10.0			11	SS	138		
			12	SS	104	/15cm	290
			13	SS	155		
	Gravelly Sand		14	SS	126	/15cm	288
			15	SS	175		286
			16	SS	115		
	SILTY SAND TO SAND, Trace of Gravel, Very Dense		17	SS	119		284
							282
			18	SS	117		280
							278
276.5			19	SS	159		
24.8	End of Borehole						

* Note: Borehole Dry on Completion
Perched Water Level Encountered at El. 295.7

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

120/ 25cm

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 15 30 45

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
	0	71	(29)	
	0	16	(84)	
	0	8	(92)	
	26	63	(11)	
	6	86	(8)	

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$15 \diamond^{20}_{10} 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 8 1 OF 1 METRIC

W.P. 26 - 96 - 01 LOCATION CO - ORDS: N 4 910 608.4; E 290 088.2 ORIGINATED BY P C

DIST 33 HWY 400 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 1997 04 04 CHECKED BY T C 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 (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
301.3	Ground Surface										
0.0 / 299.9	SILTY SAND, Compact (Fill)		1	SS	14	*	300				
1.4	Organic		2	SS	5						
	Loose		3	SS	10						
			4	SS	49		298	120/8cm			
			5	SS	85						0 82 (18)
	SILTY SAND, Very Dense		6	SS	78						
			7	SS	98		296				
			8	SS	62						
			9	SS	61						
	Sandy Silt		10	SS	72		294				0 32 (68)
293.0											
8.3	SILT, Trace of Sand,		11	SS	40						0 8 (92)
	Dense		12	SS	36		292				
291.3											
10.0	SILTY CLAY,										
290.1	Hard		13	SS	40		290				
11.2											
	Gravelly Sand		14	SS	251						15 76 (9)
							288				
	SILTY SAND TO SAND, Trace of Gravel, Very Dense		15	SS	254	/25cm					
			16	SS	165		286				
			17	SS	241						
							284				
282.6			18	SS	239						0 83 (17)
18.7	End of Borehole										

+ Note:
Borehole Dry on Completion
Perched Water Level Encountered at El. 295.1

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 9 1 OF 1 METRIC

W.P. 26 - 96 - 01 LOCATION CO - ORDS: N 4 910 586.7; E 290 097.7 ORIGINATED BY M V

DIST 33 HWY 400 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 1997 04 07 CHECKED BY T C K

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
300.2	Ground Surface						300
0.0 / 299.2	SILTY SAND, Trace of Organic, Loose (Fill)		1	SS	12	*	
1.0			2	SS	12		
			3	SS	35		298
	SILTY SAND, Compact to Dense		4	SS	42		
			5	SS	31		296
293.5			6	SS	29		294
6.7			7	SS	51		
	SILT, Some Sand, Compact to Dense		8	SS	29		292
			9	SS	35		
290.1			10	SS	43		
10.1 / 289.2	SILTY CLAY, Hard		11	SS	30		290
			12	SS	67		
11.0			13	SS	181	/28cm	288
			14	SS	135	/23cm	286
			15	SS	116	/15cm	
			16	SS	155	/23cm	284
	SILTY SAND TO SAND, Trace of Gravel, Very Dense		17	SS	105	/15cm	282
			18	SS	156	/15cm	280
							278
275.5			19	SS	112	/15cm	276
24.7	End of Borehole						

+ Note: Borehole Dry on Completion
Perched Water Level Encountered at El. 294.0

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ 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 (%): 15 30 45

UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	0 88 (12)
	0 17 (83)
	0 24 (76)
	10 79 (11)
	5 80 (15)

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$15 \overset{20}{\diamond} 5$ (%) STRAIN AT FAILURE
10

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

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