Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing

GEOCRES No: 30M12-317

- DRAFT -

FOUNDATION INVESTIGATION REPORT
PROPOSED CROSSING AT
KENNEDY ROAD AND HIGHWAY 410
SITE No. 24-739
MTO W.P. 105-00-00

GEOCRES NO. XXXXX-XX

PREPARED FOR: Giffels Associates Limited
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Toronto, Ontario
M9W 5P3

ATTENTION: Mr. Stephen Chui, P.Eng.
Project Manager

File No. 1-00-0350

March 24, 2003

DISTRIBUTION:

4 copies - Giffels Associates Limited, Toronto
1 copy - Terraprobe Limited, Brampton

TABLE OF CONTENTS

FOREWORD

This report presents the results of a geotechnical foundation investigation that was completed by Terraprobe for the proposed construction of an underpass structure at Kennedy Road and future Highway 410 in Caledon, Ontario as shown on the attached Figure 1.

In accordance with MTO standards for this type of project, this report has been prepared in two distinct sections:

Part A - Foundation Investigation Report, and
Part B - Foundation Design Report.

Part A addresses only the factual data aspects of the project whereas Part B addresses the design aspects of the project.

PART A - FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

Terraprobe Limited was retained by Giffels Associates Limited to conduct a geotechnical foundation investigation and design report for the proposed underpass structure at Kennedy Road and the future Highway 410 in Caledon, Ontario. The work was completed in accordance with our proposal, dated July 24, 2000, and the MTO Request for Proposal (RFP).

The purpose of the investigation was to assess the existing subsurface conditions in the area of the proposed bridge in order to provide geotechnical engineering recommendations for design of the proposed underpass structure. Comments are also provided on the anticipated construction conditions.

2. SITE & PROJECT DESCRIPTION

The proposed Kennedy Road underpass structure is located along Phase III of the Highway 410 Extension Project. The site is located on Kennedy Road, just north of Mayfield Road in Caledon, Ontario. A site plan is attached as Figure 1.

The proposed bridge is located in a rural setting, surrounded by predominantly agricultural lands and the Etobicoke Creek valley to the west. The local topography is gently rolling and gently sloped towards the Etobicoke Creek valley located to the west. To the east and south-west of the proposed structure are agricultural lands. To the west of the proposed structure is a significant elevation drop to the Etobicoke Creek valley which is densely vegetated with trees and shrubs.

Based on the available geological mapping for this area, the soil conditions consist of glacial till of the Halton Till Formation. Bedrock in this area is Georgian Bay Formation, predominately shale, located at depths of about 20 m or greater.

The proposed two-span structure will elevate Kennedy Road over the future Highway 410. It is understood that Kennedy Road will be raised in the order of 3.0 and 5.5 m at the north and south abutments of the bridge, respectively. The finished elevation for the future Highway 410 will be in the order of 4 to 8 metres below the existing ground level of Kennedy Road, with the centre-line of future Highway 410 at about Elevation 256 m.

3. INVESTIGATION PROCEDURES

The field investigation for the project was conducted on November 11 and 12, 2002. Two (2) exploratory boreholes were drilled at the abutment foundation locations to depths of 12.2 metres each, two (2) exploratory boreholes were drilled at the central pier location to depths of 12.2 metres each, and two (2) exploratory boreholes were drilled along the approach embankments to depths of 3.5 and 2.8 metres. The borehole locations are shown on the attached Figure 2.

The borings were drilled using a truck mounted BOA 5M power auger. The borings were advanced using 100 mm diameter solid stem augers. During auger drilling, Standard Penetration Tests (SPT) and associated split spoon soil sampling were completed at regular intervals of depth (0.76 m down to 3 m, and 1.5 m thereafter) (ASTM D 1586).

The field work was supervised throughout by a member of our technical staff, who directed the drilling and sampling operations, and transported the samples to our laboratory. The samples were stored in plastic containers and transported to the laboratory for detailed examination and testing. All of the borehole samples were examined (tactile) in detail by the project engineer, and classified according to visual and index properties.

Ground water observations were made in the boreholes as drilling proceeded. Additionally, standpipe type piezometers were sealed into Boreholes K2 and K5, in order to permit long-term observation of ground water levels. The standpipes consist of 12 mm I.D. CPVC tubing, with a 3.7 m screen section near the base, and fitted with a sand filter, bentonite seal and grout, as shown on the accompanying Borehole Logs. The remaining deep Boreholes K3 and K4 were grouted to just below ground surface, then hole plug was added.

The locations of the borings were surveyed by Giffels Associates Limited, with borehole elevations determined relative to a Geodetic datum.

Geotechnical laboratory testing consisted of water content determination on each sample, and a total of twelve (12) grain size distribution analyses and six (6) Atterberg limit determinations on select samples. Laboratory testing also included soluble sulphate testing on a total of two (2) samples. The results of this testing are summarized on the attached Borehole logs of Appendix A, with complete grain size distribution curves and Atterberg Limit plots in the attached Appendix B.

These investigations have been carried out using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by Terraprobe and other engineering practitioners, working under similar conditions and subject to the time, financial and physical constraints applicable to this project. The discussions and recommendations that have been presented are based on the factual data obtained from these investigations.

4. SUBSURFACE CONDITIONS

The soil conditions encountered during the investigation are detailed on the attached Borehole Logs in Appendix 'A', and are summarized in more detail in the following sections. It should be noted that the subsurface conditions are confirmed at the borehole locations only, and may vary at other locations. It may not be possible to drill a sufficient number of boreholes or sample and report them in a way that would provide all the subsurface information that could affect construction costs, techniques, equipment and scheduling.

4.1 Fill Materials

The six (6) boreholes were each advanced from the road shoulder. Each of the boreholes encountered a layer of sand and gravel fill which extended to depths of 0.4 to 0.7 m.

The sand and gravel fill was underlain by earth fill material at each borehole, except Borehole K4. Earth fill material within Borehole K1 consisted of compact sandy silt material and extended to a depth of 1.4 m below existing grades. Earth fill material within Boreholes K2, K3, K5 and K6 consisted of firm to stiff clayey silt materials which extended to depths of 0.7 to 1.4 m below existing grades. A thin layer of topsoil was observed above the clayey silt earth fill of Borehole K5.

4.2 Glacial Till

Underlying the surficial fill materials, native glacial till was encountered within each of the six boreholes to the bottom of the sampled holes. Glacial till with a silty clay to a silt and clay matrix was encountered in Borehole K1 and the upper portion of Boreholes K2 through K5. Borehole K6 and the lower portion of Boreholes K2 through K5 encountered glacial till with a sand and silt matrix.

The glacial till with a silty clay to a silt and clay matrix extended to depths of 8.0 to 8.5 m below existing grades within Boreholes K2 through K5, and to the maximum depth of investigation within Borehole K1 (3.5 m). SPT 'N' values within this glacial till varied from 10 to greater than 100 blows per 0.3 m, with an average of 40 blows per 0.3 m. The strength typically increases with depth. However, a weaker zone was encountered at a depth of about 6.1 to 6.5 m within the deep boreholes where the 'N' values ranged from 11 to 26 blows per 0.3 m. This depth coincides with the depth at which the glacial till changes from brown to grey in colour. Natural water contents of this material were measured as 8 to 27 percent by weight.

The glacial till with a sand and silt matrix encountered within Borehole K6 extended to the maximum depth of investigation (2.8 m). The SPT 'N' values of this sand and silt till were 13 and 44 blows per 0.3 m, indicating a compact to dense state. Natural water contents of this material were measured as 16 to 19 percent by weight.

The glacial till with a sand and silt matrix encountered within the lower portions of Boreholes K2 through K5 extended from a depth of 8.0 to 8.5 m down to the maximum depth of investigation (12.2 m). The SPT 'N' values of the sand and silt till in Boreholes K2 through K6 were greater than 100 blows per 0.3 m, indicating a very dense state. Natural water contents of this material were measured from 4 to 11 percent by weight.

Embedded gravel was evident in the till samples, and cobbles and boulders are probably present but would not be representatively sampled with the equipment used for this investigation. Further details on the textural variation of these materials can be obtained by review of the grain size distribution data and the Atterberg Limits results plotted on an "A-line" graph, as presented in the attached Appendix B. The following table summarizes the grain size distribution and Atterberg Limits data for the tested glacial till.

Borehole No.	Sample No.	Depth (m)	Grain Size Data				Atterberg Limit Data	
			Gr	Sa	Si	Cl	Wl	Ip
K1	4	2.3	10	29	42	19	24.8	9.9
K2	7	6.1	0	31	57	12	22.4	4.4
K2	9	9.1	3	6	(35)			
K2	10	10.7	8	44	40	8		
K3	4	2.3	4	32	46	18		
K3	7	6.1	1	6	75	19	20.5	6.6
K3	10	10.7	7	45	(48)			
K4	4	2.6	9	29	43	20	25.2	8.4
K4	11	12.2	8	41	43	9		
K5	5	3.0	5	30	46	19	25.2	9.0
K5	9	9.1	5	46	40	8		
K6	4	2.3	3	50	30	17	24.8	10.5

4.3 Ground Water

During and upon completion of drilling, ground water conditions within the boreholes were noted. All boreholes remained dry and open upon completion of drilling, with the exception of Borehole K3. Borehole K3 caved to a depth of 11.7 m and had water at a depth of 11.6 m, upon completion of drilling.

Standpipe piezometers were installed within Boreholes K2 and K5 to permit monitoring of long term ground water conditions. Details of the piezometer installations are provided on the appended Borehole Logs. Water levels within the peizometers were measured on November 25, 2002, some two weeks after installation as follows:

Borehole No.	Depth to water	Water Level Elevation
K2	9.60 m	225.8 m
K5	11.16 m	254.8 m

It should be noted that ground water levels may vary seasonally.

4.4 Sulphate Analysis

Soluble sulphate testing was conducted on two (2) soil samples, as summarized in the following table and on the attached Borehole logs.

Borehole No.	Sample No.	Depth (m)	Sulphate (mg/kg)
K3	8	7.6	195.1
K5	9	9.1	191.2

PART B - FOUNDATION DESIGN REPORT

5. DISCUSSION AND RECOMMENDATIONS

The following discussions and recommendations are based on the factual data obtained from the investigation, and are presented for guidance of the design professionals only. The comments pertain to a specific project and location. If significant parts of the project change, they should be reviewed by Terraprobe to determine the effect of the changes on the recommendations.

Comments about construction are presented only to bring attention to aspects which might impact the design. Contractors bidding on or conducting work associated with this project should review the factual data presented in the preceding sections of the report, to assess their effect on proposed construction methods and scheduling.

span lengths

5.1 Structure Foundations Design Recommendations

The proposed two-span structure will elevate Kennedy Road over the future Highway 410. It is understood that Kennedy Road will be raised in the order of 3.0 and 5.5 m at the north and south abutments of the bridge, respectively. The finished elevation for the future Highway 410 will be in the order of 4 to 8 metres below the existing ground level of Kennedy Road, with the centre-line of future Highway 410 at about Elevation 256 m. The total span of the bridge is approximately 45 m and the structure is about 13.7 m in width.

The estimated depth of frost penetration at the site is 1.2 m. Foundation elements should be provided with this minimum depth of soil cover or equivalent exterior-grade insulation.

elev at N & at S abut?

The subsurface soils at the site are favourable for support of the bridge using one of the following foundation systems.

Perched

1) Conventional Shallow Spread Footings design on the underlying native glacial till; or
2) End bearing Steel H Piles driven to practical refusal into the non-yielding glacial till; or
3) End bearing drilled caissons founded into the non-yielding glacial till.

Non-yielding glacial till was encountered at a depth of about 7.0 to 8.5 m below existing grades (approximately Elevation 258 to 257 m). Selection of the most appropriate foundation system should be based on cost and site accessibility considerations. The most appropriate and economical foundation system is considered to be shallow spread footings, unless an integral abutment design is proposed. Appropriate foundation design recommendations are presented in the following sections.

5.1.1 Spread Footing Foundations

what depth of exc required

The bridge can be founded on shallow spread footings. Based on the proposed bridge design, the bridge foundations will be established at Elevation 254 m or below. At this elevation and below, the advanced boreholes encountered either hard or very dense glacial till. Design of conventional shallow spread footings may be completed in accordance with the following recommended geotechnical resistance values, provided they are formed at least 0.2 m into native glacial till and below the anticipated depth of frost penetration (minimum 1.2 m depth):

Factored bearing resistance at ultimate limit states (Q_u)	850 kPa
Bearing resistance at serviceability limit states (Q_s)	300 kPa

30 blows?

XX too conservative ~~[illegible]~~

Anticipated settlements at the SLS condition should not exceed 25 mm and should occur within about 3 to 6 months after load application. Differential settlements between adjacent elements should not exceed 50% of this value.

Prior to placing concrete for foundations, the foundation areas must be cleaned of all deleterious materials such as topsoil, fill, softened, disturbed or caved materials, as well as any standing water. The foundation bases must be evaluated by Terraprobe prior to placing concrete to ensure that the founding soil exposed at the excavation base is consistent with the design bearing intended by the geotechnical engineer.

It should be noted that the native silty clay glacial till is susceptible to disturbance and loss of strength, particularly in the presence of water. A thin skim coat of concrete may be placed on the foundation subgrade immediately after excavation to provide protection from disturbance and weathering.

Exterior foundations should be provided with a minimum soil cover of 1.2 m or equivalent insulation, for frost protection purposes. If construction proceeds during freezing weather conditions, adequate temporary frost protection must be provided to the footing bases and concrete.

The coefficient of friction, *f*, for assessing sliding resistance between cast-in-place concrete and the soil subgrade is recommended as 0.6 (unfactored).

5.1.2 End Bearing Steel 'H' Piles

Alternatively, the bridge structure may be founded on end bearing steel 'H' piles driven to practical refusal into the underlying hard or very dense glacial till below depths of about 7.0 to 8.5 m (below about Elevation 258 m for the north abutment and below about Elevation 257 m for the central pier and south abutment). When founded in the "non-yielding" hard or very dense glacial till, the following typical steel HP sections, could be designed for the values in the following table:

	HP 310 x 110	HP 310 x 79
factored axial resistance at ULS	2,000 kN	1,450 kN
axial resistance at SLS	1,450 kN	1,050 kN

The above SLS values are based on an estimated settlement of about 10 mm.

It is required that pile driving be monitored and the "setting" of the piles be controlled by reference to the Hiley Dynamic Pile Driving Formula, in accordance with MTO Standards SS103-11, assuming:

	HP 310 x 110	HP 310 x 79
ultimate resistance of piles	3,800 kN	2,700 kN

During the driving of the piles there should be an increase in driving resistance expected when the tip of the pile encounters the underlying hard or very dense glacial till below depths of about 7.0 to 8.5 m. For the purposes of estimating pile driving lengths, extrapolation can be made between the available borehole data. However, actual installed pile lengths and set must be determined in the field based on continuous monitoring of the piling operations.

contrary to Hiley

Piles should be driven to a final set of 25 blows per 25 mm. In this regard, care should be taken in selecting the driving hammer so that driving stresses in the piles are limited to less than 90% of the yield strength.

Since the glacial till deposits likely contain cobbles and boulders, it is recommended that the pile tips be reinforced with steel plates per MTO Standard DD-3301.

Based on the borehole information, the subgrade surrounding the piles should be considered to be predominately hard cohesive materials. Therefore, based on Table C6-8.7.1 (a) of the Canadian Highway Bridge Design Code for this material type, the factored lateral resistance is as follows for various pile types:

	HP 360 x 108	HP 310 x 79
horizontal passive resistance - ULS	320 kN	260 kN
horizontal passive resistance- SLS	240 kN	200 kN

Based on the encountered stratigraphy, downdrag or negative skin friction loads are not anticipated to be significant for this structure.

3000 x 20

2000 300

5.1.3 End Bearing Drilled Caissons

Another alternative is large diameter caissons (greater than 0.9 m) which may be designed to rest on the "non-yielding" glacial till below depths of about 7.0 to 8.5 m (Elev. 257 to 258 m). Based on the available borehole information, the highest permissible founding elevation will be about 258 m at the north abutment and about 257 m at the central pier and south abutment.

For end bearing caissons founded within the "non-yielding" glacial till, the following geotechnical resistance values are recommended for design:

Factored bearing resistance at ultimate limit states (Q_u)	3,000 kPa
Bearing resistance at serviceability limit states (Q_s)	1,000 kPa.

1600

Settlements for the above SLS should not exceed 25 mm, with differential settlements limited to less than about 50% of this value.

Minimal ground water seepage is anticipated since the encountered stratigraphy consists of low permeability glacial till. Wall instability problems are not expected. However, in order to permit downhole inspection and cleaning of the caisson base, the contractor should be instructed to have suitably sized temporary casing on site. All manned entry to the caissons to be in accordance with the latest edition of the Ontario Health and Safety Guidelines for Construction Projects. Any casing installed to maintain excavation stability should be removed during concreting in such a fashion that the level of concrete within the casing is no less than 0.5 m above the tip of the casing or, if water is present, at such a level that the pressure exerted by the concrete at the tip of the casing is at least 10% greater than the water pressure outside the casing.

5.2 Abutments

If integral abutments are considered, the anticipated horizontal movements should be compared with the allowable horizontal movements from the surrounding soils. If the surrounding soils do not allow for the anticipated movements, consideration should be given to the use of CSPs filled with loose sand to allow for the horizontal movement. The horizontal modulus of subgrade reaction is provided for each of the anticipated soil types (as per Boreholes K2 and K5), as follows:

Strata	Horizontal Modulus of Subgrade Reaction
Earth Fill, firm/ compact; to 0.7 to 0.8 m depths	0.5 MN/cu.m.
Silty Clay Glacial Till, very stiff; to 1.4 m depths	12 MN/cu.m.
Silty Clay Glacial Till, hard; to 5.5 m depths	20 MN/cu.m.
Silty Clay / Clay and Silt Glacial Till, stiff to very stiff; to 7.0 m depths	12 MN/cu.m.
Silty Clay Glacial Till, hard; to 8.0 to 8.5 m depths	20 MN/cu.m.
Sand and Silt Glacial Till, very dense; more than 10 to 9.7 m depths	20 MN/cu.m.

n_h for non-cohesive only
k_h for cohesive

5.2.1 Abutment Backfill

Backfill to the abutments should be completed with free-draining granular fill such as OPSS Granular 'A' or 'B' compacted to achieve at least 95% of its Standard Proctor Maximum Dry Density (SPMDD). The granular backfill should be placed in a wedge-shaped zone extending from 1.2 m behind the base of the abutment and rising upward at an inclination of 1 horizontal to 1.5 vertical to the horizontal. The granular backfill should extend at least 0.6 m out from the structure, with a frost taper. The backfill should be drained by providing perforated or weep holes. The outlets should not be subject to freezing or flooding.

Heavy compaction equipment should not be used immediately behind the abutment or retaining walls within the lateral distance equal to the height of the backfill being compacted. The use of heavy compaction equipment close to the abutment or retaining walls may cause deflection or damage.

Provided the granular backfill is used, the following earth parameters are recommended for design in estimating lateral earth pressures on the abutments or retaining walls:

	Granular 'A'	**Granular 'B'**
Effective Angle of Internal Friction (Unfactored)	35°	32°
Soil unit weight	22.8 kN/m^3	21.2 kN/m^3
Active Earth Pressure Co-efficient, K_a	0.27	0.31
At Rest Earth Pressure Co-efficient, K_o	0.43	0.47

The active values should be used where the top of the wall is not fixed and can move slightly outward. The at rest values should be used where the top of the wall is fixed and cannot move.

All fill materials placed beneath the roadway areas should be compacted to a minimum of 95 percent of Standard Proctor Maximum Dry Density (SPMDD). The fill should be placed in lift thicknesses not exceeding 200 mm.

The abutment backfill should be benched into the cut slopes in accordance with OPSD 208.01.

5.3 Temporary Excavations

Temporary open excavations at the site are expected to extend to a maximum depth of about 2 m for spread footings. Pile caps or grade beams are expected to be higher than the current ground level and are not anticipated to include temporary excavations. Excavations to a maximum of 2 m deep from about Elevation 257 m are expected to encounter hard or very dense glacial tills, and are expected to remain stable if excavated with near vertical side slopes.

It is expected that only small volumes of ground water will enter temporary excavations, and that this seepage may be controlled by pumping from local filtered sumps at the base of the excavation.

Where workmen must enter excavations carried deeper than 1.2 m, the excavations should be inspected and certified by a geotechnical engineer, or suitably sloped and\or braced in accordance with the Occupational Health and Safety Act. The Occupational Health and Safety Act recognizes four (4) broad classifications of soils, as follows:

TYPE 1 SOIL
a. is hard, solid, only able to be penetrated by a small sharp object with difficulty;
b. can only be excavated by mechanical equipment;
c. shows no sign of visible cracks after excavation;
d. exhibits a dry, shiny appearance after excavation; and
e. possesses a low moisture content and a high degree of internal strength.

TYPE 2 SOIL
a. cracks or crumbles;
b. can be penetrated by small sharp objects easily;
c. can be excavated by hand tools with moderate difficulty;
d. exhibits signs of surface cracking;
e. exhibits a damp appearance after excavation; and
f. possesses a low to medium moisture content and a medium degree of internal strength.

TYPE 3 SOIL
a. is loose, soft, sandy, or previously excavated;
b. can be excavated with hand tools easily;
c. will run easily into a well defined conical pile if dry;

d. will flow or shift unless supported if wet; and
e. possesses a low degree of internal strength.

TYPE 4 SOIL
a. is wet or muddy;
b. will run easily or flow unless completely supported immediately after excavation;
c. exerts substantial fluid pressure upon its supporting system; and
d. possesses almost no internal strength.

The existing fill materials at the site may be assumed to be Type 3 soils above the water table and Type 4 soils below it. The stiff to very stiff glacial till soils should be assumed to be Type 2 soil. The deeper hard or very dense glacial till should be assumed to be Type 1 soils

5.4 Sulphate Attack

Soluble sulphate testing was conducted on two (2) soil samples, as summarized on the attached Borehole Logs. Based on the tested soil samples, there should not be any significant sulphate attack on a concrete structure. However, this should be confirmed by the Structural Engineer.

5.5 Slope Stability

Seen failures along 410?

It is anticipated that the existing grades along the Highway 410 alignment will be cut as deep as 9 m at the proposed underpass structure. Slopes cut into the native glacial till, up to 9 m in height, may be designed at a slope inclination of 2 to 1 (horiz. to vert.) or flatter. Vegetation of any cut side slopes must be established.

5.6 Embankment Construction

It is anticipated that the existing grades along the Highway 410 alignment will be raised as much as 5.5 m at the proposed underpass structure. Ii is recommended that prior to placement of any fill materials, the existing subgrade conditions be cleared of any organic or deleterious materials and be inspected to confirm adequate support conditions. All fill materials placed beneath the roadway areas should be compacted to a minimum of 95 percent of Standard Proctor Maximum Dry Density (SPMDD). The fill should be placed in lift thicknesses not exceeding 200 mm.

6.0 CLOSURE

It is recommended that the foundation preparation works (construction) be completed with regular and frequent inspection by an experienced geotechnical inspector, to check if the construction details are consistent with the recommended design parameters enclosed within. Routine quality control testing of the foundation concrete and fill placement is also recommended.

We trust that this report is sufficient for your present requirements. If you have any questions or require clarification on any matter, please do not hesitate to contact us.

Respectfully submitted,

Terraprobe Limited

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Michael Tanos, P.Eng.
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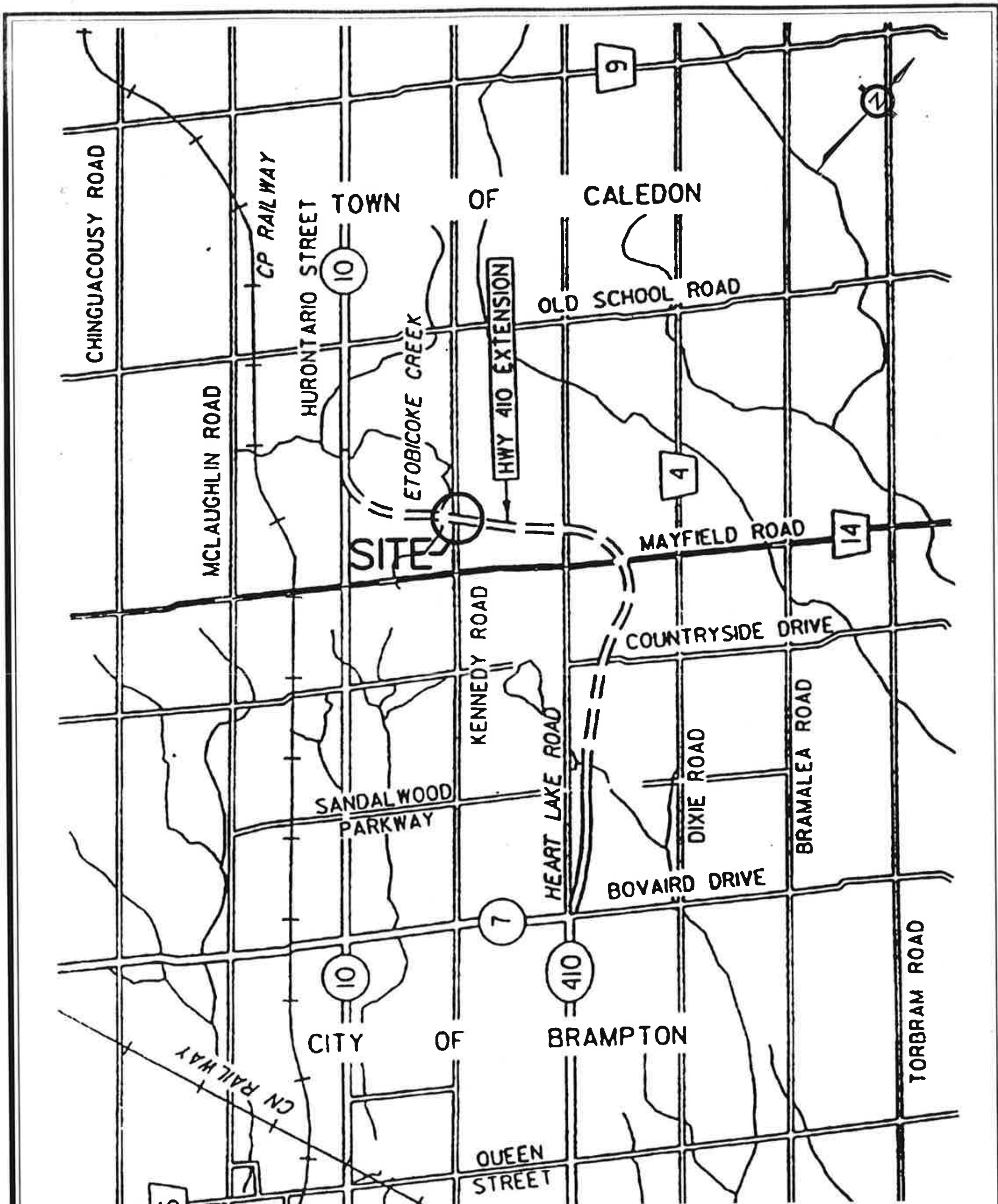
they don't have seal prelim

FIGURES

Terraprobe Limited

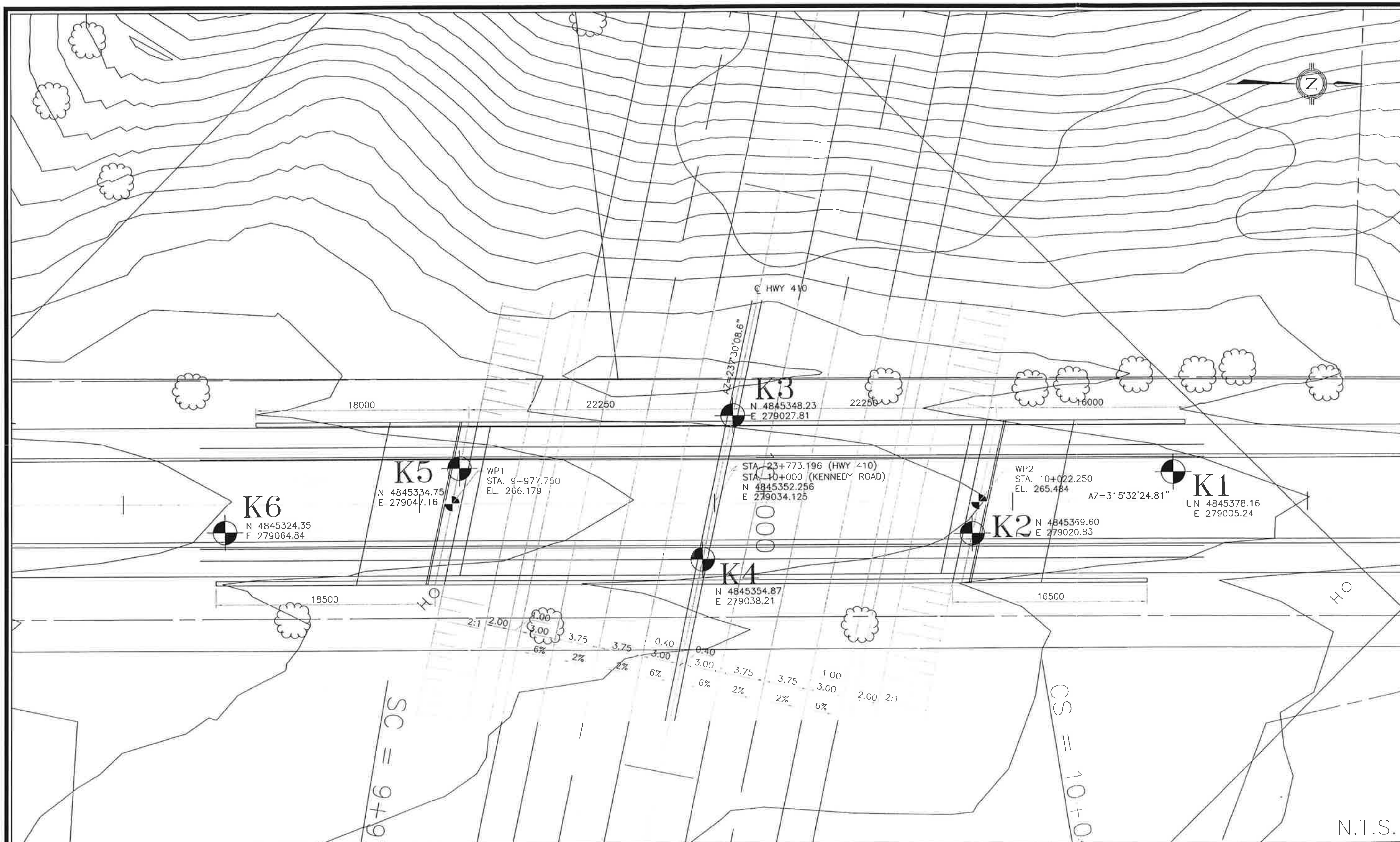


SITE LOCATION PLAN

TERRAPROBE

File No. 1-00-0350

FIGURE 1



BOIREHOLE LOCATION PLAN

TERRAPROBE

File No. 1-00-0350

FIGURE 2

APPENDIX A

Terraprobe Limited

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No K1

METRIC

W.P. 105-00-00 LOCATION Co-ords. 4,845,376.472 N; 279,003.510 E. ORIGINATED BY A.S.

DIST ___ HWY 410 BOREHOLE TYPE Truck BOA 5M COMPILED BY J.B.

DATUM Geodetic DATE 11.12.02 CHECKED BY J.N.

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
265.0	Ground Surface												
0.0	Fill - Sand And Gravel Loose Brown		1	SS	9								
264.3 0.7	Fill / Disturbed Sandy Silt Trace Clay, Gravel & Roots Compact Brown		2	SS	15		264						
263.6 1.4	Silty Clay Till Sandy, Trace to Some Gravel (Low Plasticity) Compact Brown		3	SS	28		263						
			4	SS	25					10	29	42	19
262.1 2.9	Clayey Silt Till Some Sand, Trace Gravel (Low Plasticity) Hard Brown		5	SS	31		262						
261.5 3.5	End of Borehole												

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

REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No K2

METRIC

W.P. 105-00-00	LOCATION Co-ords. 4,845,371,274 N; 279,022,306 E		ORIGINATED BY A.S.
DIST	HWY 410	BOREHOLE TYPE Truck BOA 5M	COMPILED BY J.B.
DATUM Geodetic	DATE 11.11.02		CHECKED BY J.N.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
265.4	Ground Surface						
0.0	Fill - Sand, Some Gravel; Compact, Brown	1	SS	10	265	o	
264.9 / 0.5	Fill / Disturbed Clayey Silt, Some Sand, Trace Gravel; Stiff, Brown/Grey					o	
264.7 / 0.7	Silty Clay Till, Some Sand, Trace Gravel (Low Plasticity); Very Stiff, Brown	2	SS	25		o	
	--------------- Hard	3	SS	34	264	o	
		4	SS	47	263	o	
		5	SS	41	262	o	
		6	SS	54	261	o	
259.9 / 5.5	Clay And Silt Till, Sandy (Low Plasticity); Stiff, Grey				260		
		7	SS	11	259	├┤o	0 31 57 12
258.4							

Column headings: SOIL PROFILE (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: 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.

Continued Next Page

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No K2

METRIC

W.P. 105-00-00 | LOCATION Co-ords. 4,845,371,274 N; 279,022,306 E. | ORIGINATED BY A.S.

DIST | HWY 410 | BOREHOLE TYPE Truck BOA 5M | COMPILED BY J.B.

DATUM Geodetic | DATE 11.11.02 | CHECKED BY J.N.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
7.0	Silty Clay Till, Some Sand, Trace Gravel (Low Plasticity). Hard, Grey & Brown				258		
		8	SS	100/ 23cm		o	
257.4 / 8.0	Silt And Sand Till, Trace to Some Gravel, Trace Clay (Low Plasticity). Very Dense, Brown				257		
		9	SS	100/ 13cm	256	o	3 62 (35)
	Grey				255		
		10	SS	100/ 8cm	254	o	8 44 40 8
253.2		11	SS	100/ 14cm		o	
12.2	End of Borehole						

Water Level in piezometer November 25, 2002 (9.6m bgs)

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X 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 (%)

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No K3

METRIC

W.P. 105-00-00 LOCATION Co-ords. 4,845,349.698 N, 279,029.203 E ORIGINATED BY A.S.

DIST ____ HWY 410 BOREHOLE TYPE Truck BOA 5M COMPILED BY J.B.

DATUM Geodetic DATE 11.12.02 CHECKED BY J.N.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
265.7	Ground Surface					
0.0	Fill - Sand And Gravel Loose Brown	1	SS	8		
265.2 0.5	Fill - Clayey Silt, Some Sand Trace Gravel Firm Brown				265	
265.0 0.7	Clay And Silt Till Sandy, Trace Gravel (Low Plasticity) Stiff to Hard Brown	2	SS	14		
		3	SS	24	264	
		4	SS	33	263	4 32 46 18
262.8 2.9	Clay And Silt Till Trace Sand, Trace Gravel (Low Plasticity) Hard Brown	5	SS	49	262	
		6	SS	72	261	
	Very Stiff Grey				260	
		7	SS	23	259	1 6 75 19

Continued Next Page

Other column headings: STRAT PLOT; GROUND WATER CONDITIONS; 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

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

RECORD OF BOREHOLE No K3

METRIC

W.P. 105-00-00 | LOCATION Co-ords. 4,845,349.698 N; 279,029.203 E. | ORIGINATED BY A.S.

DIST | HWY 410 | BOREHOLE TYPE Truck BOA 5M | COMPILED BY J.B.

DATUM Geodetic | DATE 11.12.02 | CHECKED BY J.N.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	Clay And Silt Till, Trace Sand, Trace Gravel (Low Plasticity) *(continued)*					
	Hard, Grey	8	SS	86	258	Sulphate 0.02%
257.2 / 8.5	Sand And Silt Till, Trace Gravel (Non-Plastic)				257	
	Very Dense, Grey	9	SS	100/ 8cm		
		10	SS	100/ 13cm	256, 255	GR 7, SA 45, SI+CL (48)
	Trace Clay (Low Plasticity)	11	SS	100/ 14cm	254	
253.5 / 12.2	End of Borehole					

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

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

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RECORD OF BOREHOLE No K4

METRIC

W.P. 105-00-00	LOCATION Co-ords. 4,845,354,855 N; 279,038,152 E		ORIGINATED BY A.S.
DIST ___ HWY 410	BOREHOLE TYPE Truck BOA 5M		COMPILED BY J.B.
DATUM Geodetic	DATE 11.12.02		CHECKED BY J.N.

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

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
265.8	Ground Surface								
0.0	Fill - Sand And Gravel; Dense, Brown	1	SS	37					
265.1 / 0.7	Silty Clay Till, Sandy, Trace Gravel (Low Plasticity); Stiff, Brown	2	SS	10	265				
	Hard	3	SS	30	264				
		4	SS	35		9	29	43	20
		5	SS	59	263				
		6	SS	50	262 / 261				
	Very Stiff, Grey	7	SS	21	260				
					259				

Continued Next Page

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

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RECORD OF BOREHOLE No K4

METRIC

W.P. 105-00-00 | LOCATION Co-ords. 4,845,354,855 N; 279,038,152 E | ORIGINATED BY A.S.

DIST ____ HWY 410 | BOREHOLE TYPE Truck BOA 5M | COMPILED BY J.B.

DATUM Geodetic | DATE 11.12.02 | CHECKED BY J.N.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty Clay Till Sandy, Trace Gravel (Low Plasticity) *(continued)*						
	Hard Brown	8	SS	64		258	
257.3 / 8.5	Sand And Silt Till Trace Gravel, Trace Clay (Low Plasticity)					257	
	Very Dense Grey	9	SS	100/ 8cm			
						256	
		10	SS	100/ 13cm		255	
	Occ. Clay					254	
253.6		11	SS	100/ 13cm			8 41 43 9
12.2	End of Borehole						

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

+³, ×³: Numbers refer to Sensitivity   O³% STRAIN AT FAILURE

RECORD OF BOREHOLE No K5

 METRIC

W.P. 105-00-00 | LOCATION Co-ords. 4,845,333,065 N; 279,045,099 E. | ORIGINATED BY A.S.

DIST ____ HWY 410 | BOREHOLE TYPE Truck BOA 5M | COMPILED BY J.B.

DATUM Geodetic | DATE 11.11.02 | CHECKED BY J.N.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
266.0	Ground Surface					
0.0	Fill - Sand and Gravel	1	SS	11		
265.6 / 0.4	Topsoil					
0.5	Fill - Clayey Silt, Some Sand, Trace Gravel Stiff Brown					
265.2 / 0.8	Silty Clay Till Sandy, Trace Gravel (Low Plasticity) Very Stiff Brown	2	SS	17	265	
	Hard	3	SS	34	264	
		4	SS	35	263	
		5	SS	45		5 30 46 19
					262	
		6	SS	47	261	
	Very Stiff Grey				260	
		7	SS	26		

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X 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

Continued Next Page

+³, ×³: Numbers refer to Sensitivity   O³% STRAIN AT FAILURE

RECORD OF BOREHOLE No K5

METRIC

W.P. 105-00-00	LOCATION Co-ords. 4,845,333.065 N; 279,045.099 E.		ORIGINATED BY A.S.
DIST ___ HWY 410	BOREHOLE TYPE Truck BOA 5M		COMPILED BY J.B.
DATUM Geodetic	DATE 11.11.02		CHECKED BY J.N.

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty Clay Till, Sandy, Trace Gravel (Low Plasticity) *(continued)* Hard Grey	8	SS	55	258	~10	Sulphate 0.02%
257.5 / 8.5	Sand And Silt Till, Trace Gravel (Non-Plastic) Very Dense Grey	9	SS	100/ 8cm	257	~7	5 46 40 8
					256		
		10	SS	100/ 5cm	255	~5	
	Occ. Clay (Low Plasticity)				254		
253.8 / 12.2	End of Borehole	11	SS	100/ 10cm		~7	

Water level in piezometer November 25, 2002 (11.16m bgs)

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

$+^3, \times^3$: Numbers refer to Sensitivity — $O^{3\%}$ STRAIN AT FAILURE

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RECORD OF BOREHOLE No K6

METRIC

W.P. 105-00-00 LOCATION Co-ords. 4,845,326,365 N; 279,067,027 E. ORIGINATED BY A.S.

DIST HWY 410 BOREHOLE TYPE Truck BOA 5M COMPILED BY J.B.

DATUM Geodetic DATE 11.12.02 CHECKED BY J.N.

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
266.3	Ground Surface							
0.0	Fill - Sand And Gravel Compact Brown		1	SS	17		266	
265.7 0.6	Fill / Disturbed Clayey Silt, Some Sand, Trace Gravel Firm Brown		2	SS	5		265	
264.9 1.4	Sand And Silt Till Trace Clay, Trace Gravel (Low Plasticity) Compact to Dense Brown & Grey Brown		3	SS	13		264	
			4	SS	44			3 50 30 17
263.5 2.8	End of Borehole							

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/m^3

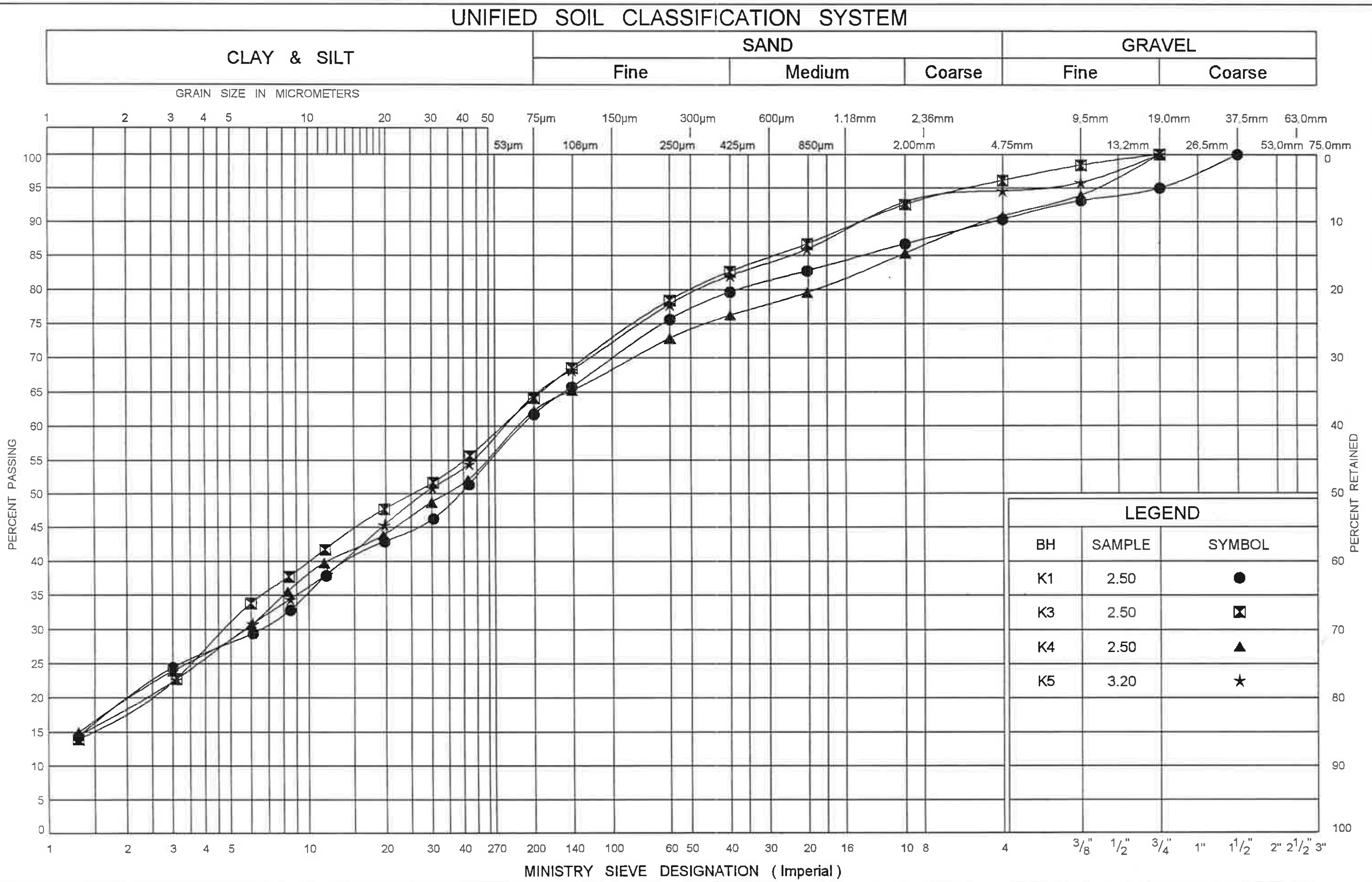
ONTARIO MOT 1-00-0350 HIGHWAY 410.GPJ ONTARIO MOT.GDT 17/01/03

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

APPENDIX B

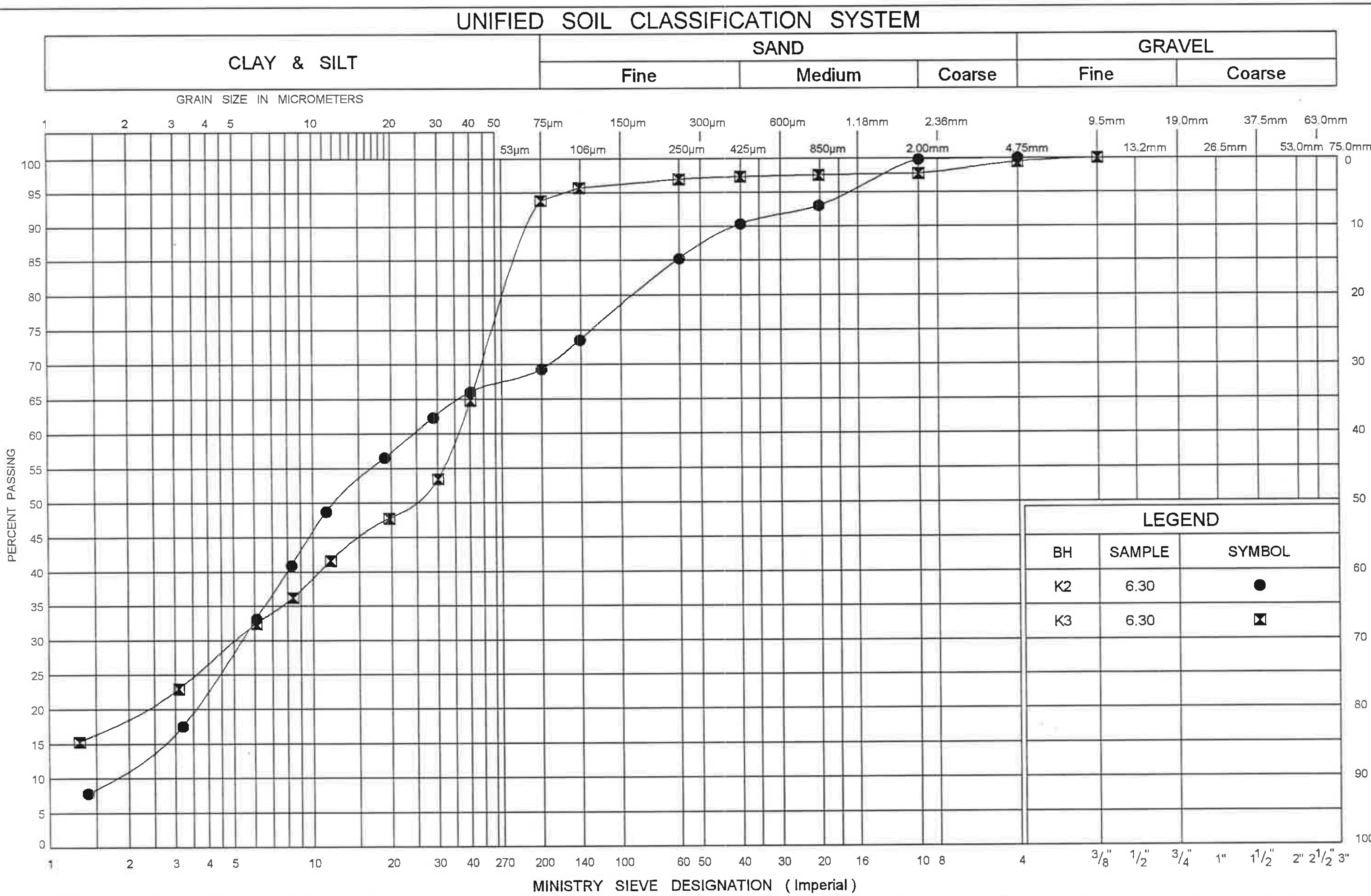
Terraprobe Limited

78 12 M



Ministry of Transportation Ontario	GRAIN SIZE DISTRIBUTION SILTY CLAY TILL	FIG No 1 W P 105-00-00

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
K2	6.30	●
K3	6.30	⊠

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GRAIN SIZE DISTRIBUTION

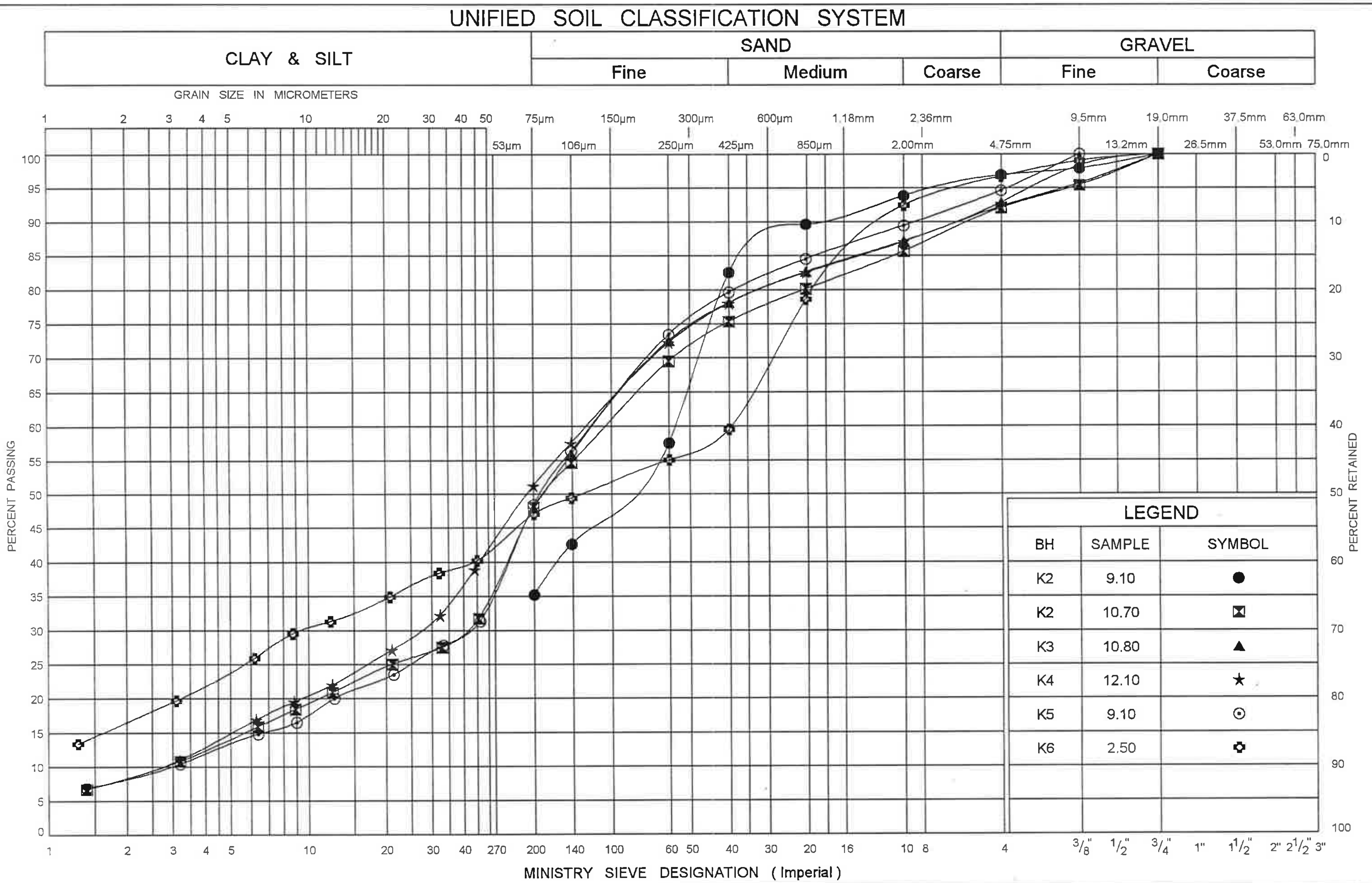
CLAY AND SILT TILL

FIG No 2

WP 105-00-00

ONTARIO MOT GRAIN SIZE 1-00-0350 HIGHWAY 410.GPJ ONTARIO MOT.GDT 17/01/03

78 12 M



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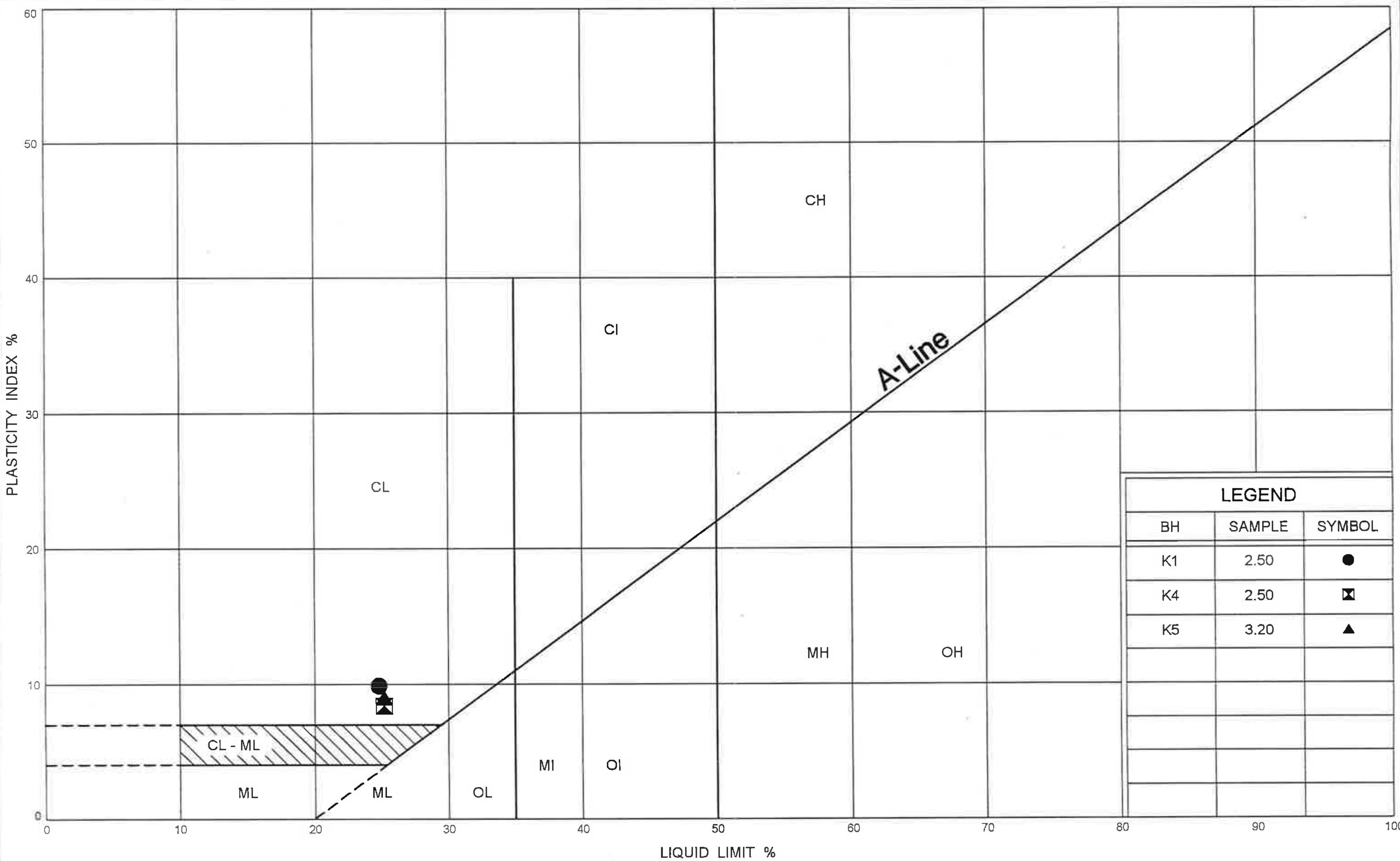
GRAIN SIZE DISTRIBUTION

SILT and SAND TILL

FIG No 3

W P 105-00-00

Oct 75, FF - S - 21



LEGEND

BH	SAMPLE	SYMBOL
K1	2.50	●
K4	2.50	⧗
K5	3.20	▲

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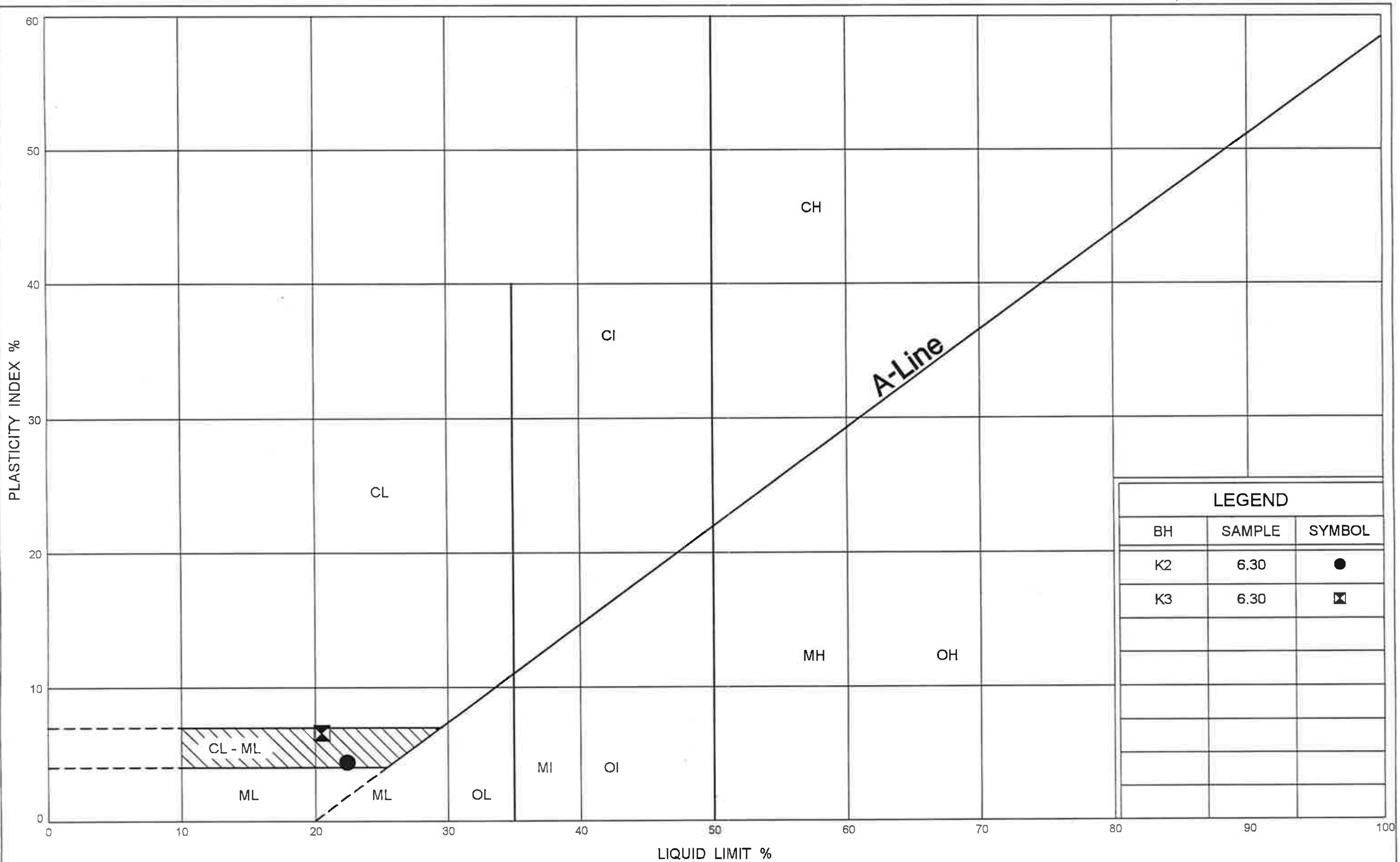
PLASTICITY CHART

SILTY CLAY TILL

FIG No 4

W P 105-00-00

Oct 75, FF - S - 21



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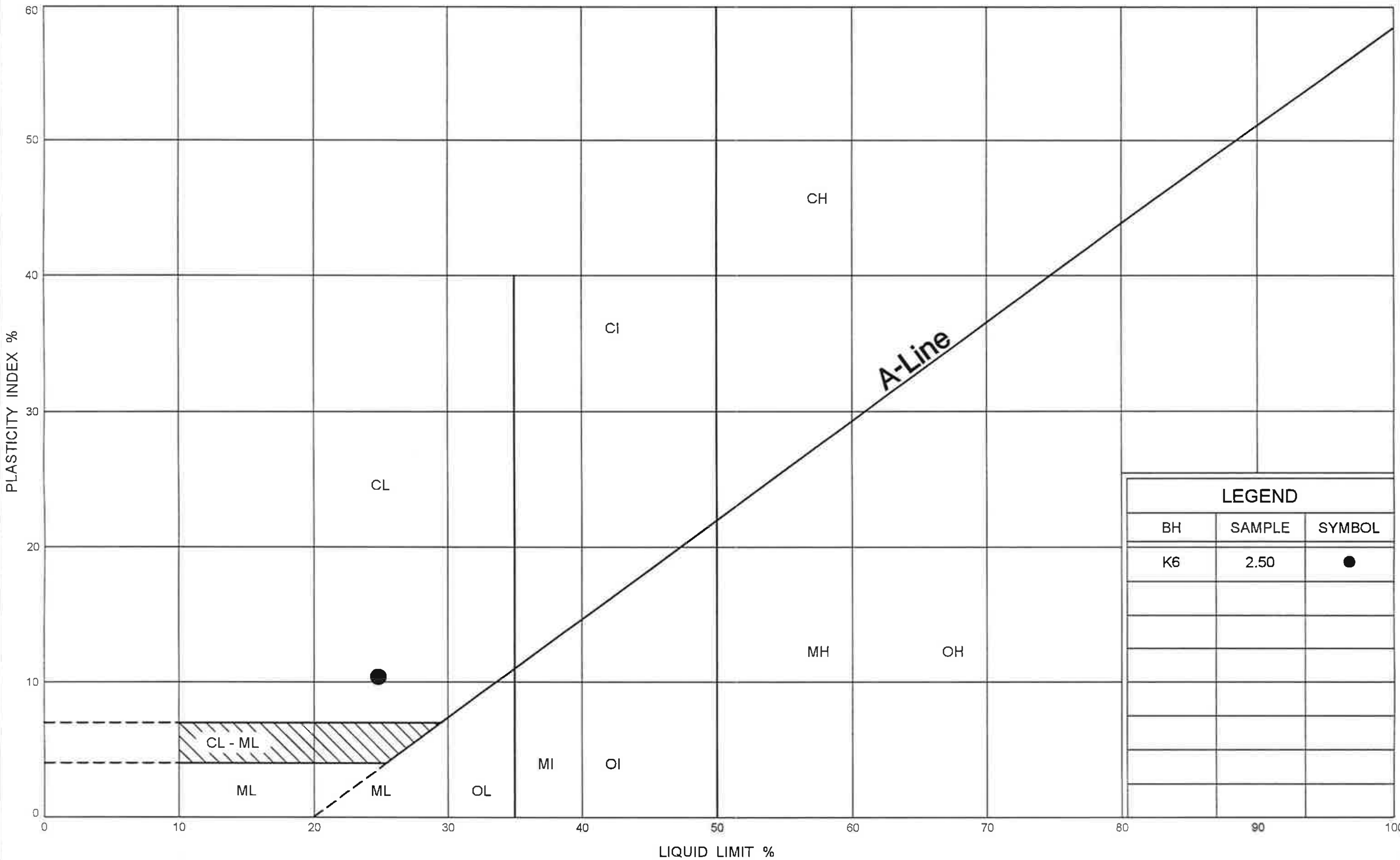
PLASTICITY CHART

CLAY AND SILT TILL

FIG No 5

W P 105-00-00

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
K6	2.50	●

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PLASTICITY CHART

SILT and SAND TILL

FIG No 6

W P 105-00-00