GEOCRES NO: 31B-65

T11688B

REPORT TO

FENCO ENGINEERS INC.
WILLOWDALE ONTARIO

HIGHWAY 416
KEMPTVILLE ONTARIO
FOUNDATION INVESTIGATION
PROPOSED BEACH ROAD UNDERPASS
(WP 372-89-03; Site No. 16-316)
DISTRICT 9, KINGSTON

GEOCRES # 31B-65

Distribution:

15 copies - Fenco Engineers Inc.
Willowdale, Ontario
(Attn: Mr. David Moncrieff, P.Eng.)

1 copy - Geocon (1991) Inc.
Mississauga, Ontario

GEOCON (1991) INC.
December, 1991

TABLE OF CONTENTS

Page

1.0 INTRODUCTION

Presented herein are the results of a geotechnical subsurface investigation conducted at the above site to establish the prevalent subsurface geotechnical conditions for the design and construction of the proposed bridge and approach fills. Geocon (1991) Inc. (Geocon) was retained by Fenco Engineers Inc. to perform this work.

The field work for the initial alignment of the bridge was conducted between October 24 and October 29, 1991, and consisted of 7 boreholes (Boreholes 9-1 to 9-7) and 1 test pit. The bridge was subsequently realigned, and the fieldwork for this portion of the project was conducted between July 31 and August 1, 1991 and consisted of 4 boreholes (Boreholes 9-8 to 9-11). The fieldwork was conducted using a CME 55 drill rig equipped with 200 mm diameter hollow stem augers. The overburden was split spoon sampled, in conjunction with the Standard Penetration Test (SPT) and the underlying bedrock was cored using NXL and BXL size core barrels. Four standpipe piezometers were installed to monitor the groundwater levels. A test pit was excavated with a backhoe to obtain block samples for density determinations and to confirm the hard nature of the silty sand till.

The locations of the boreholes and one test pit are shown on Drawing 3728903-A. A record of the encountered subsurface conditions at each location is given on the Record of Borehole Sheets in Appendix A.

2.0 SITE DESCRIPTION AND GEOLOGY

The proposed Beach Road underpass is located just north of the intersection of Beach Road and Highway 16 approximately 4 kilometres south of Kemptville, Ontario (Figure 1). The proposed underpass will comprise of two spans supported on a central pier and two abutments with approach fills of 6 to 7 m in height.

The ground surface is undulating and in general rises from east to west across the site. The site slopes toward the northwest and the northeast at about the location of the proposed west abutment. The east span of the proposed bridge will straddle the existing Highway 16, which is contained within a shallow earth cut. Shallow ditches are present on either side of the Highway 16 and Beach Road, respectively. The proposed alignment is located within agricultural pastureland in the west and open ground with scattered trees to the east. Private properties are found within a short distance from the proposed underpass.

The proposed Highway 416 is located within the physiographic region of the Ottawa-St. Lawrence lowland. During the last Ice Age this area was glaciated which resulted in the deposition of a layer of till over much of the proposed alignment (Sharpe, 1979). In general the till is comprised of a bouldery cobbly silty sand to sandy silt.

Subsequent to glaciation the Ottawa-St. Lawrence lowland was inundated by the Champlain Sea. At the location of the proposed Highway 416 alignment the depth of water was shallow and in general resulted only in minor wave action modification of the surface of the underlying till. However, in localized low lying areas deeper deposits (up to 10 m) of fine grained clayey silt material may be present.

Available surficial geological information at the location of the proposed Beach Road underpass (OGS Map 2387) indicates that the area is underlain by a bouldery cobbly sand to sandy silt till (Fort Covington Till). However, a short distance to the north of the

proposed site, the prevalent subsurface condition are anticipated to change to fine grain marine deposits associated with the Champlain Sea overlying glacial till deposits. The underlying bedrock at the site is anticipated to comprise of dolostone of the Oxford Formation of the Beekmonton Group.

3.0 SUBSURFACE CONDITIONS

3.1 General

The subsurface conditions for the proposed underpass structure comprise primarily of a thin layer of topsoil, sand and clayey silt overlying glacial sandy silt till, which in turn overlies bedrock. The factual information which was used to interpret the soil conditions is given in Appendix A and B and Drawing No. 3728903-A. The subsurface conditions encountered within the proposed underpass area are described below:

3.2 Topsoil

A thin layer of topsoil was encountered at all the borehole and test pit locations and ranged from 0.1 m to 0.5 m in thickness. The topsoil is silty sand containing roots and trace organics. At Test Pit 9-1 the topsoil was underlain by 0.6 m of brown sand.

3.3 Clayey Silt

A layer of clayey silt underlying the topsoil and sand was encountered in Borehole 9-6 and Test Pit 9-1 and ranged from 0.7 to 2.4 m in thickness, respectively.

The results of two grain size distributions analyses infer that this stratum may be described as a clayey silt with trace to some sand and a trace gravel. The clayey silt is of low plasticity as indicated by the result of an Atterberg Limit Test.

3.4 Sandy Silt Till

By far the dominant material on site, glacial till was encountered below the surficial topsoil, sand and clayey silt and was found to extend to bedrock at about El. 97.0 m. Where fully penetrated, the observed thickness ranged from 5.8 m to 4.0 m at the proposed west and east abutment locations, respectively.

Based on the results of six grain size distribution analyses (Figures B2 and B3), the material may be described as a sand and silt with some gravel and a trace clay. Cobbles and boulders are also present within this deposit and appear to increase in content with depth.

SPT 'N' values recorded within this layer are high and variable with practical refusal recorded at many locations before the full test penetration of the split spoon could be obtained. Based on the measured SPT 'N' values at this and other locations it is concluded that the till is very dense. This result is consistent with measured in situ density of 23.0 kN/m^3 at 3.8 m depth at Test Pit 9-1. Measured water contents within the glacial till typically varied from 3 to 8%.

3.5 Bedrock

Bedrock was established between El 97.0 to El 98.0 m, which is about 4.0 m to 5.0 m below existing ground surface. The bedrock was proven by coring about 3.1 m, 1.2, 2.8 and 3.5 m in Boreholes 9-2, 9-4, 9-6 and 9-10 respectively. The bedrock is judged by core recovery and RQD percentage to be of fair to excellent quality.

3.6 Groundwater

Groundwater was measured by means of four standpipe piezometers installed in Boreholes 9-2, 9-4, 9-6 and 9-10. The groundwater was measured between 1 to 15 days after installation of the piezometers and were observed to be between El. 101.0 m to El. 99.0 m, which is about 1.5 m to 4.0 m below existing ground surface, respectively. Groundwater level could be expected to vary seasonally.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 General

The proposed underpass will have two spans supported on two abutments and a central pier. It is understood that open style abutments perched above the roadway are favoured. At this site, it is anticipated that this will result in the abutments being placed within the 6 to 7 m high approach fills adjacent to the abutments. As discussed in the following sections, the use of spread footings placed on an engineered fill is recommended for both abutments. Spread footings placed within the glacial till are recommended for the central pier. Embankments constructed with coventional 2 Horizontal to 1 Vertical side slopes will remain stable.

4.2 Underpass Foundations

The underpass consist of two abutments and one central pier. Recommendations for each structure are discussed separately below.

4.2.1 Abutments

The subsurface conditions at both abutment locations consists of a thin layer of topsoil, sand and clayey silt overlying competent glacial till. In light of this and the favoured open abutment concept, spread footings placed on engineered fill may be used to support the proposed abutments. Alternatively, spread footings placed within the glacial till may be considered and is also discussed.

4.2.1.1 Spread Footings Placed on Engineered Fill

For the assumed geometry of this foundation solution (Figure 2), the recommended bearing pressures at the Serviceability Limit State (SLS) and factored Ultimate Limit State (ULS) conditions are 400 kPa and 800 kPa, respectively.

The SLS value is the design load at which the estimated settlement of the footing will be of the order of 25 mm which has been assumed as the maximum settlement that may be tolerated. This settlement is comprised of 20 mm within the engineered fill and 5 mm within the native overburden materials. Both of these elements of settlement will be largely elastic and will occur mostly during initial loading of the foundations. An integral part of this proposed foundation design is the construction of an engineered fill on which to place the footing (Figure 2). Frost protection for the footings should be in accordance with Figure 2.

4.2.1.2 Spread Footings on Till

Provided the base of the proposed footing is located at least 0.5 m below the surface of the very dense competent glacial till, allowable design bearing pressures of 500 kPa and 900 kPa may be assumed at the SLS and factored ULS conditions, respectively. Settlements at the SLS condition are anticipated to be of the order of 10 mm.

4.2.2 Central Pier

At this location, the subsurface conditions comprise a thin cover of topsoil overlying very dense glacial till. Therefore, spread footings placed at least 0.5 m below the surface of the very dense competent glacial till may be designed for an allowable bearing pressures

of 500 kPa and 900 kPa at the SLS and factored ULS conditions, respectively. Settlements at the SLS condition are anticipated to be of the order of 10 mm.

4.2.3 Differential Settlement

Maximum differential settlement between abutments founded in engineered fill and the central pier founded in glacial till will be of the order of 15 mm at the SLS condition. Lower differential settlements between the central pier foundation and the abutments may be achieved by adopting a lower abutment bearing pressure at the SLS condition.

4.3 Embankment Recommendations

Based on the observed subsurface conditions and the anticipated maximum embankment height of 7 m, it is concluded that embankments constructed with side slopes of 2 Horizontal to 1 Vertical will remain stable.

Embankment fill should meet the requirements of OPSS 212 for borrow material and should be placed and compacted in accordance with OPSS 206. Slopes of 2 Horizontal to 1 Vertical are applicable for sandy earth borrows, rock borrow or select subgrade fill material. If silty or clayey earth borrow is used, the embankment side slope should be 2.5 Horizontal to 1 Vertical or flatter and are to be confirmed by engineering analyses. The timely installation of erosion control measures should also be considered over exposed face of slopes.

Prior to the placement of any imported fill materials, the subgrade area should be stripped of all topsoil and organics and any other deleterious material which may be present. The subgrade foundation, comprising glacial till, sand, or clayey silt should be proof-rolled

and any soft areas excavated and replaced with compacted granular material. Settlements of the main approach embankment are estimated to be of the order of 10 mm which will primarily occur during initial loading of the embankments.

4.4 General Design Recommendations

4.4.1 Dewatering

It is anticipated that excavation below groundwater level will be quite shallow and water inflow into the excavation may be handled by a system of ditches leading to a central sump and a pump.

4.4.2 Excavations

Temporary excavations will be primarily within the glacial till layer. Excavations of more than 1.5 m depth within this layer shall be cut with 1.5 Horizontal to 1 Vertical slopes. The excavation slopes shall be in compliance with the Ontario Health and Safety Act regulations or other governing regulations within the area. The base of the excavation shall be inspected for any soft areas. If soft soil is encountered, it shall be excavated and replaced with compacted granular fill.

4.4.3 Earth Backfill Pressures

The earth pressure for the design of the abutments should be computed as per Section 6.1.2 of the O.H.B.D.C., and an unyielding foundation condition may be assumed for the computations. If, however, movement of the top of the wall is permitted and is

greater than 0.05% of the overall height of the wall, then a yielding condition may be used in the computations. The Granular 'A' or 'B' backfill should be in accordance with the MTO Special Provision No. 109F03. The following parameters are recommended for the granular backfill:

	Granular 'A'	Granular 'B'
Angle of Internal Friction	$\phi = 35°$	$\phi = 30°$
Unit Weight (kN/m^3)	$\gamma = 22.8$	$\gamma = 21.2$

If the footings are placed on compacted granular backfill, an unfactored coefficient of friction value of tan 30° may be assumed for the estimation of the sliding resistance. However, if the footings are placed on the glacial till, an unfactored coefficient of friction of tan 25° may be used.

4.4.4 Frost Penetration

The anticipated maximum depth of frost penetration at the site is 1.8 m (Canadian Foundation Engineering Manual). Because of the moderately frost susceptible nature of the glacial till at the site, all foundation units should be provided with at least this depth of soil or equivalent cover below finished grade. In addition, where approach fill embankments are less than the anticipated depth of frost penetration additional design measures will be required to ensure the satisfactory performance of the pavement. This aspect of the design will be addressed in more detail in the Pavement Design Report.

4.4.5 Site Supervision

The recommendations given in this report are based on the assumptions that the assumed soil conditions will be verified in any engineered fill and excavations and that all construction recommendations are followed. It is recommended, therefore, that the foundation and earthworks construction be carried out under suitably qualified geotechnical engineering supervision.

5.0 CLOSURE

The field work portion for the investigation was done under the supervision of Mr. N. Khan, P.Eng. The report was written by Mr. I. Corbett, P.Eng. and Mr. N. Khan, P.Eng. and reviewed by Dr. I. Holubec, P.Eng.

This report is subject to the attached General Conditions and Limitations.

Yours very truly
GEOCON (1991) INC.

N. Khan, P.Eng.
Project Engineer

Igor Holubec, Ph.D., P.Eng.
Vice-President

IH:dtj
T11688/15530

GEOCON (1991) INC.

GEOTECHNICAL REPORT

GENERAL CONDITIONS AND LIMITATIONS

A. USE OF THE REPORT

A.1 The factual data,interpretations and recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location or elevation or if the project is not initiated within eighteen months of the date of the report Geocon (1991) Inc. (Geocon) should be given an opportunity to confirm that the recommendations are still valid.

A.2 The comments given in this report are intended only for the guidance of the design engineer. The number of test holes to determine all the relevant underground conditions which may affect construction costs, techniques and equipment choice, scheduling and sequence of operations would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual test hole data, as to how subsurface conditions may affect their work.

B. FOLLOW-UP

B.1 All details of the design and proposed construction may not be known at the time of submission of Geocon's report. It is recommended that Geocon be retained during the final design stage to review the design drawings and specifications related to foundations, earthworks, retaining systems and drainage, to determine that they are consistent with the intent of Geocon's report.

B.2 Retention of Geocon during construction is recommended to confirm and document that the subsurface conditions throughout the site do not materially differ from those given in Geocon's report and to confirm and document that construction activities did not adversely affect the design intent of Geocon's recommendations.

C. SOIL AND ROCK CONDITIONS

C.1 Soils and rock descriptions in this report are based on commonly accepted methods of classification and identification employed in professional geotechnical practice. Classification and identification of soil and rock involves judgement and Geocon does not guarantee descriptions as exact, but infers accuracy only to the extent that is common in current geotechnical practice.

C.2 The soils and rock conditions described in this report are those observed at the time of the study. Unless otherwise noted, those conditions form the basis of the recommendations in the report. The condition of the soil and rock may be significantly altered by construction activities (traffic, excavation, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil and rock must be protected from these changes or disturbances during construction.

D. LOGS OF TEST HOLES AND SUBSURFACE INTERPRETATIONS

D.1 Soil and rock formations are variable to a greater or lesser extent. The test hole logs indicate the approximate subsurface conditions only at the locations of the test holes. Boundaries between zones on the logs are often not distinct, but rather are transitional and have been interpreted. The precision with which subsurface conditions are indicated depends on the method of boring, the frequency of sampling, the method of sampling and the uniformity of subsurface conditions. The spacing of test holes, frequency of sampling and type of boring also reflect budget and schedule considerations.

D.2 Subsurface conditions between test holes are inferred and may vary significantly from conditions encountered at the test holes.

D.3 Groundwater conditions described in this report refer only to those observed at the place and time of observation noted in the report. These conditions may vary seasonally or as a consequence of construction activities on the site or adjacent sites.

E. CHANGED CONDITIONS

E.1 Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of the use or reliance by the client of this report that Geocon is notified of the changes and provided with an opportunity to review the recommendation of this report. Recognition of changed soil and rock conditions requires experience and it is recommended that an experienced geotechnical engineer be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

F. DRAINAGE

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage can have serious consequences. Geocon can take no responsibility for the effects of drainage unless Geocon is specifically involved in the detailed design and follow-up site services during construction of the system.

REFERENCES

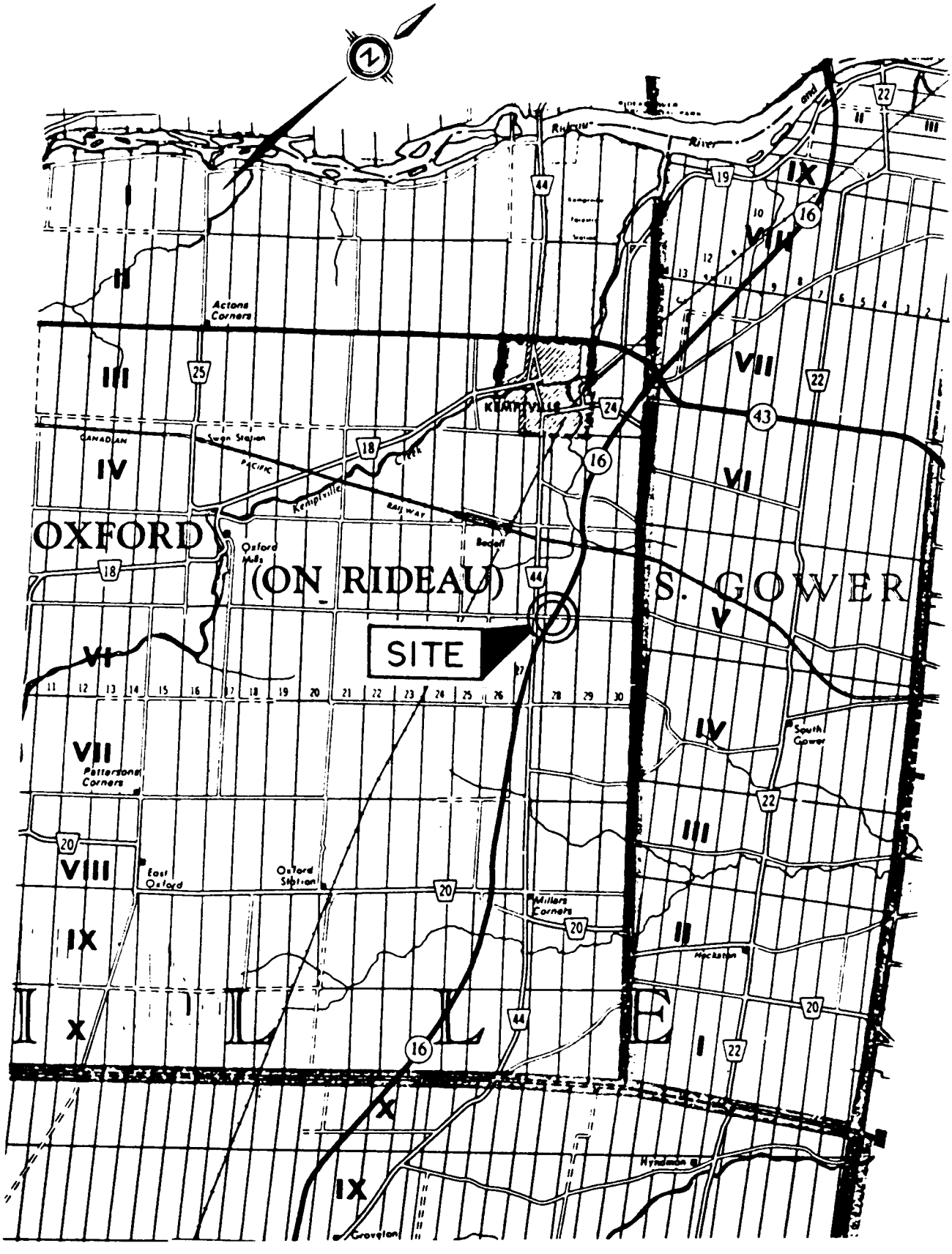
Canadian Foundation Engineering Manual, 1985. Second Edition. Part 1: Fundamentals; Part 2: Shallow Foundations; Part 3: Deep Foundations; Part 4: Excavations and Retaining Structures Part 5: References. Canadian Geotechnical Society, Technical Committee on Foundations, 456 pp.

Sharpe, D.R., 1979. Quaternary Geology of the Merrickville Area, Southern Ontario. Ontario Geological Survey, Report 180, 54P. Accompanied by Maps 2387 and 2388, scale 1:50,000.

Totten Sims Hubicki Associates (1981) Limited Consultants 1990 Structure Data Report, Highway 416 from 0.7 km north of Hwy 401 northerly to 1.0 km north of Hwy 43, District 9 Ottawa. Report prepared for Ministry of Transportation, Ontario.

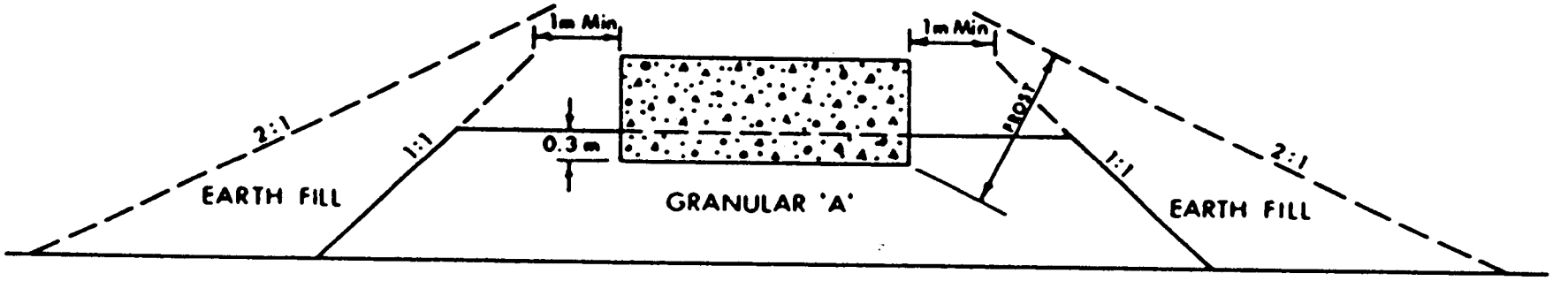
KEY PLAN

APPENDIX
FIGURE 1
PROJECT WP-372-89-03



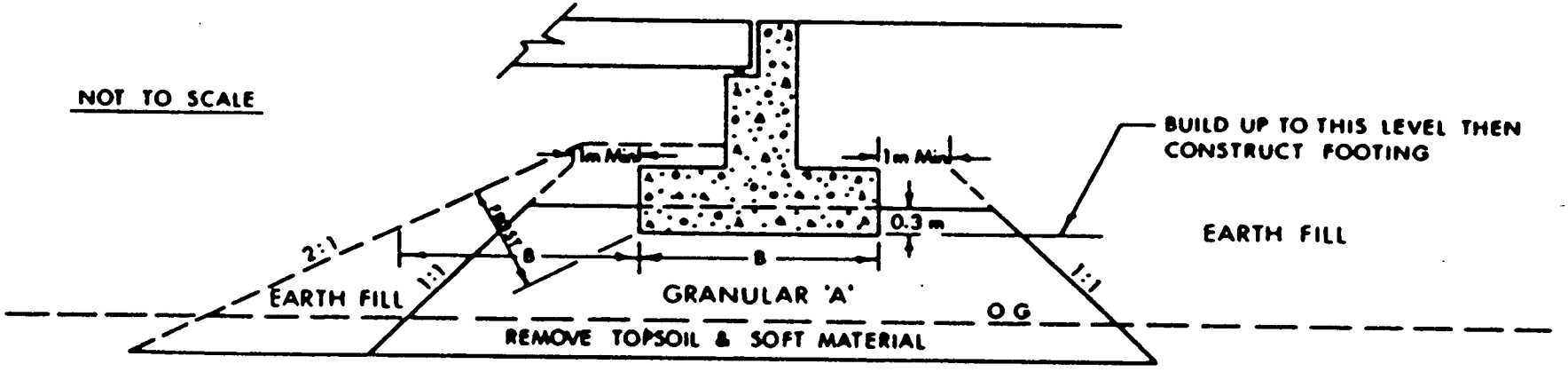
SCALE 1:100000

GEOCON



X SECTION

NOT TO SCALE



LONGITUDINAL SECTION

NOTES:

1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.

2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T O STANDARDS.

3 - CONSTRUCT CONCRETE FOOTING.

4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.

Ministry of Transportation Ontario	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE	FIG No 2
		W P 372-89-03

APPENDIX A

Borehole and Test Pit Information

Explanation of Terms used in this Report
Explanation of the Term Rock Quality Designation (RQD)
Record of Borehole Sheets (9-1 to 9-11)
Test Pit Log (TP 9-1)

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:

R Q D (%)	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

EXPLANATION OF THE TERM

ROCK QUALITY DESIGNATION (RQD)

The description of bedrock quality for engineering purposes can be inferred from a modified core recovery logging procedure designated as RQD, developed by D.U. Deere.* This classification is based on a modified diamond drill core recovery percentage in which only the pieces of sound core over 4 inches (10 cm) long are counted as recovery. The core must be carefully examined to discount fresh irregular breaks caused by the drilling process (fresh broken pieces are fitted together and counted as one piece). The remaining fragments less than 4 inches (10 cm) length are considered to be due to very close bedding, jointing, fracturing, shearing, or weathering in the rock mass and are not counted. The procedure penalizes the rock where recovery is poor. This is appropriate because poor core recovery usually depicts poor quality rock. In the case of certain shaley sedimentary or thinly foliated metamorphic rocks, the method is not as exact as for other rock types and rock quality requires interpretation by a specialist for the particular engineering application. To minimize the occurrence of core breaks from drilling procedures RQD logging is normally run on core obtained by double or triple tube core barrels and generally of "N" size or greater.

The table below may be used as a general indicator to correlate (RQD) and rock mass quality.

RQD	DESCRIPTION OF ROCK QUALITY
90 - 100	Excellent - intact, very sound, massive
75 - 90	Good - moderately jointed or sound
50 - 75	Fair - blocky and seamy, fractured
25 - 50	Poor - shattered and very seamy or blocky, severely fractured
0 - 25	Very poor - crushed, very severely fractured

*See, for instance:

K.G. Stagg and O.C. Zienkiewicz, "Rock Mechanics in Engineering Practice". New York, Wiley, 1968, Chapter I.

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 9-1

METRIC

W P 372-89-03 LOCATION Co-ords: 4,983,464.8 N; 374,825.9 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.K.

DATUM Geodetic DATE October 24, 1990 CHECKED BY M.H.

SOIL PROFILE			SAMPLES			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)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
105.0	Ground Surface										
0.0	Topsoil										
104.9			1	SS	12	Dry					
0.1	Sand and Silt. Some Gravel, occasional Cobbles (Glacial Till)										
			2	SS	31		104				
	Dense to Very Dense Brown										
			3	SS	51				○		22 40 38 0
102.4			4	SS	22/175mm				○		
2.6	End of Borehole Auger Refusal										

OFFICE REPORT ON SOIL EXPLORATION

+[3], ×[5] : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 9-2

METRIC

W P 372-89-03 LOCATION Co-ords: 4,983,477.1 N; 374,851.3E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers, Tri-Cone, NXL Rock Core COMPILED BY N.K.

DATUM Geodetic DATE October 25, 1990 CHECKED BY M.H.

OFFICE REPORT ON SOIL EXPLORATION

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 kPo (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
103.8	Ground Surface										
0.0 / 103.6	Topsoil Soft										
0.2	Sand and Silt. Some gravel occasional cobbles (Glacial Till) Compact to Very Dense Brown		1	SS	9				○		
			2	SS	68		Bentonite Seal				
			3	SS	72		102				
			4	SS	62*				○		15 44 41 0
			5	SS	82/215mm						
99.9							100				
3.9	Sand and Silt. Some gravel occasional cobbles and boulders (Glacial Till) Boulder content increasing with depth Probably Very Dense Grey						Backfill				
97.7					Rec%		98	RQD%			
6.1	Dolostone Light to medium grey fine grained, hardness ≃4, closely jointed (< 0.3m). Joint surfaces rough, fresh, some clay fill. Joint orientation 70 to 90° to core axis		6	RC NXL	87			63			
			7	RC NXL	81			47			
			8	RC NXL	100		96	81			
94.6							Piezometer				
9.2	End of Borehole										

Note:

* SPT value based on first 0.3m of penetration

(1) Auger refusal 3.9m below ground surface.

(2) Boring advanced from 3.9m to 6.1m using NXL core barrel and tri-cone.

(3) Water level in standpipe piezometer measured at elevation 101.0 m on November 11, 1990.

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 9-3 METRIC

W P 372-89-03 LOCATION Co-ords: 4,983,484.4 N; 374,851.1 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.K.

DATUM Geodetic DATE October 25, 1990 CHECKED BY M.H.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPo (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
103.6	Ground Surface										
0.0	Topsoil										
103.4			1	SS	6	Dry			○		11 32 57 0
0.2	Sand and Silt. Some gravel, occasional cobbles (Glacial Till)		2	SS	78						
	Very Dense Brown		3	SS	16/ 10mm		102				
101.2			4	SS	23/ 75mm				○		
2.4	End of Borehole										
	Auger Refusal										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9-4 METRIC

W P 372-89-03 LOCATION Co-ords: 4,983,499.0 N; 374,880.4 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers, NXL Rock Core COMPILED BY N.K.

DATUM Geodetic DATE October 25, 1990 CHECKED BY M.H.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
102.9	Ground Surface							20 40 60 80 100	10 20 30		
0.0 / 102.7	Topsoil										
0.2	Sand and Silt. Some gravel occasional cobbles and boulders (Glacial Till) Very Dense Brown		1	SS	31		Bentonite Seal		o		19 46 35 0
			2	SS	65		102		o		
			3	SS	86/290mm						
			4	SS	32/65mm						
			5	SS	53/140mm		100 Backfill				
99.1											
3.8	Gravelly Sandy Silt occasional cobbles and boulders (Glacial Till) Very Dense Grey		6	SS	36/150mm				o		
			7	SS	91		98				
			8	SS	61/275mm Rec%		Piezometer	RQD%	o		
97.0											
5.9	Dolostone Light to medium grey fine grained, hardness ≈ 4 few calcite stringers		9	RC NXL	100			93			
95.8			10	RC NXL	100		96	15			
7.1	End of Borehole										

Note:

1) Auger refusal 5.9 m below ground surface

2) Water level in standpipe piezometer measured at elevation 98.9m on October 28, 1990.

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 9-5 METRIC

W P 372-89-03 LOCATION Co-ords: 4,983,516.7 N; 374,918.2 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.K.

DATUM Geodetic DATE October 29, 1990 CHECKED BY M.H.

SOIL PROFILE			SAMPLES			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)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
101.7	Ground Surface										
0.0 / 101.6	Topsoil										
0.1	Sand and Silt. Some gravel occasional cobbles and boulders (Glacial Till)		1	SS	6	Not Noted			○		20 42 34 4
			2	SS	36/175mm						
	Very Dense Brown		3	SS	83/200mm		100		○		
			4	SS	102/225mm						
98.8											
2.9	Sandy Silt. Some gravel occasional cobbles and boulders (Glacial Till)		5	SS	60/150mm				○		
			6	SS	60/150mm		98				
97.5	Very Dense Grey										
4.2	End of Borehole Auger Refusal										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9-6 METRIC

W P 372-89-03 LOCATION Co-ords: 4,983,524.5 N; 374,917.6 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers, Tri-Cone, NXL Rock Core COMPILED BY N.K.

DATUM Geodetic DATE October 26, 1990 CHECKED BY M.H.

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)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
101.6	Ground Surface										
0.0 / 101.5	Topsoil										
0.1 / 100.8	Clayey Silt. Trace sand and gravel. Firm Brown		1	SS	4						2 5 77 16
0.8	Sandy Silt. Trace clay, trace to some gravel occasional cobbles (Glacial Till) Dense Brown		2	SS	31		Bentonite Seal		○		
99.3			3	SS	38		100				
2.3	Sand Silt. Trace to some gravel, occasional cobbles and boulders (Glacial Till) Boulder content increases with depth Very Dense Grey		4	SS	40/ 190mm		Backfill		○		
			5	SS	60/ 125mm		98				
96.8					Rec%		Piezometer	RQD%			
4.8	Dolostone Light to medium grey, fine grained, hardness ≈ 4, joint spacing <225mm some calcite stringers, joint surface rough clay infilled occasional interbedded shale layers (3mm thick)		6	RC NXL	100			87			
							96				
			7	RC NXL	100			57			
94.0											
7.6	End of Borehole										

Note:

(1) Auger refusal 3.5 m below ground surface

(2) Boring advanced from 3.5 m to 4.7 m using NXL core barrel and tricone

(3) Water level in standpipe piezometers measured at elevation 99.9 m on October 29, 1990.

+3, x5 : Numbers refer to Sensitivity

15 20 10 ◇ 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 9-7 METRIC

W P 372-89-03 LOCATION Co-ords: 4,983,544.8 N; 374,955.9E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.K.

DATUM Geodetic DATE October 29, 1990 CHECKED BY M.H.

SOIL PROFILE			SAMPLES			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)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
102.2	Ground Surface										
0.0	Topsoil										
102.0 / 0.2	Sandy Silt. Some gravel occasional cobbles (Glacial Till) Dense to Very Dense Brown		1	SS	7	Dry	102		o		
			2	SS	36						
			3	SS	49		100				
			4	SS	91/225mm				o		
			5	SS	60/140mm						
98.4 / 3.8	Sand and Silt Some gravel, trace Clay Occasional cobbles and boulders (Glacial Till)										
98.1 / 4.1	Very Dense Grey End of Borehole Auger Refusal		6	SS	87/265mm				o		19 39 37 5

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9-8 METRIC

W P 372-89-03 LOCATION Co-ords: 4,983,499.8 N; 374,848.7 E ORIGINATED BY NK

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers, BX Rock Core COMPILED BY NK

DATUM Geodetic DATE July 31, 1991 CHECKED BY NK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
103.1	Ground Surface										
0.0	Topsoil										
102.9											
0.2	Sand and Silt Some gravel occasional cobbles (Glacial Till) Very Dense Brown		1	SS	50/ 125mm		102		○		
			2	SS	50*/ 110mm						
			3	SS	43*/ 100mm				○		12 43 42 3
			4	SS	50*/ 90mm		100				
			5	SS	94				○		
98.6											
4.5	End of Borehole Auger Refusal										

Note:

00* Indicate SPT values based on first 0.3m penetration advanced. Full penetration not achieved.

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 9-9 METRIC

W P 372-89-03 LOCATION Co-ords: 4,983,530.0 N; 374,879.5 E ORIGINATED BY NK
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers, BX Rock Core COMPILED BY NK
DATUM Geodetic DATE July 31, 1991 CHECKED BY NK

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 kPo ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
101.3	Ground Surface										
0.0	Topsoil										
101.1											
0.2	Sand and Silt with gravel occasional cobbles and boulders (Glacial Till) Very Dense Brown		1	SS	50*/ 100mm		100				
			2	SS	50*/ 50mm				○		
			3	SS	50/ 30mm						
			4	SS	50*/ 130mm		98		○		
			5	SS	90				○		24 41 33 2
95.9			6	SS	50/ 100mm		96				
5.4	End of Borehole Auger Refusal Inferred Bedrock										

Note:

00* Indicates SPT value based on first 0.3 m advanced. Full penetration not achieved.

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9-10 METRIC

W P 372-89-03 LOCATION Co-ords: 4,983,557.5N; 374,910.9 E ORIGINATED BY NK

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers, BX Rock Core COMPILED BY NK

DATUM Geodetic DATE August 1, 1991 CHECKED BY NK

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	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
100.4	Ground Surface										
0.0	Topsoil										
100.2											
0.2	Silty Sand with gravel occasional cobbles and boulders (Glacial Till) Boulder and gravel content increasing with depth. Very Dense Brown		1	SS	50*/ 150mm		100		○		
			2	SS	50*/ 30mm						
			3	SS	50/ 100mm		98		○		43 38 18 2
96.6			4	SS	25*/ 10mm			RQD%			
3.8	Dolostone Light to medium grey fine grained, closely jointed (0.3m). Joint surfaces rough, fresh.			RC				29			
			5	BX	Rec 57%		96				
			6	RC BX	Rec 100%			73			
			7	RC BX	Rec 100%		94	84			
93.1											
7.3	End of Borehole										

Notes:

1. 00* Indicates SPT value based on first 0.3m advanced. Full penetration not achieved.
2. Boring advanced from 3.0 m to 3.7m using BX core barrel.
3. Water level in standpipe piezometer measured at Elevation 98.9m. on August 2, 1991

+3, ×5 : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9-11

METRIC

W P 372-89-03 LOCATION Co-ords: 4,983,584.3N; 374,950.7E ORIGINATED BY NK

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers COMPILED BY NK

DATUM Geodetic DATE August 1, 1991 CHECKED BY NK

SOIL PROFILE			SAMPLES			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	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl; WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
100.3	Ground Surface										
0.0 / 100.1	Topsoil						100				
0.2	Silty Sand with gravel occasional cobbles and boulders (Glacial Till) Boulder content increasing with depth. Very Dense Brown		1	SS	50*/ 140mm						34 36 20
			2	SS	45*/ 100mm				o		
			3	SS	50*/ 80mm		98				
			4	SS	45* 100mm				o		
			5	SS	10*/ 30mm						
95.7			6	SS	R*		96				
4.6	End of Borehole Auger Refusal Note: 00* Indicates SPT value based on the first 0.3m advanced. Full penetration not achieved.										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

Geocon

TEST PIT LOG

PROJECT: Highway 416 - Beach Road Underpass — TEST PIT: TP-9-1

Location: Co-ords 4,983,533.5N; 374,923.6E — PAGE 1 OF 1

CONTRACT NO. WP 372-89-03 — DATE Dec. 12/90

DATUM Geodetic - Ground Surface 101.1 (estimated)*

SAMPLE CONDITION: ☒ DISTURBED

W_N - WATER CONTENT - %
GS - GRAIN SIZE ANALYSIS
γ - UNIT WEIGHT - kN/m^3

TYPE OF TEST
P - MODIFIED PROCTOR TEST
W_{OPT} - OPTIMUM WATER CONTENT - %
γ_{MAX} - MAX. DRY UNIT WEIGHT - kN/m^3

W_L - LIQUID LIMIT - %
W_P - PLASTIC LIMIT - %

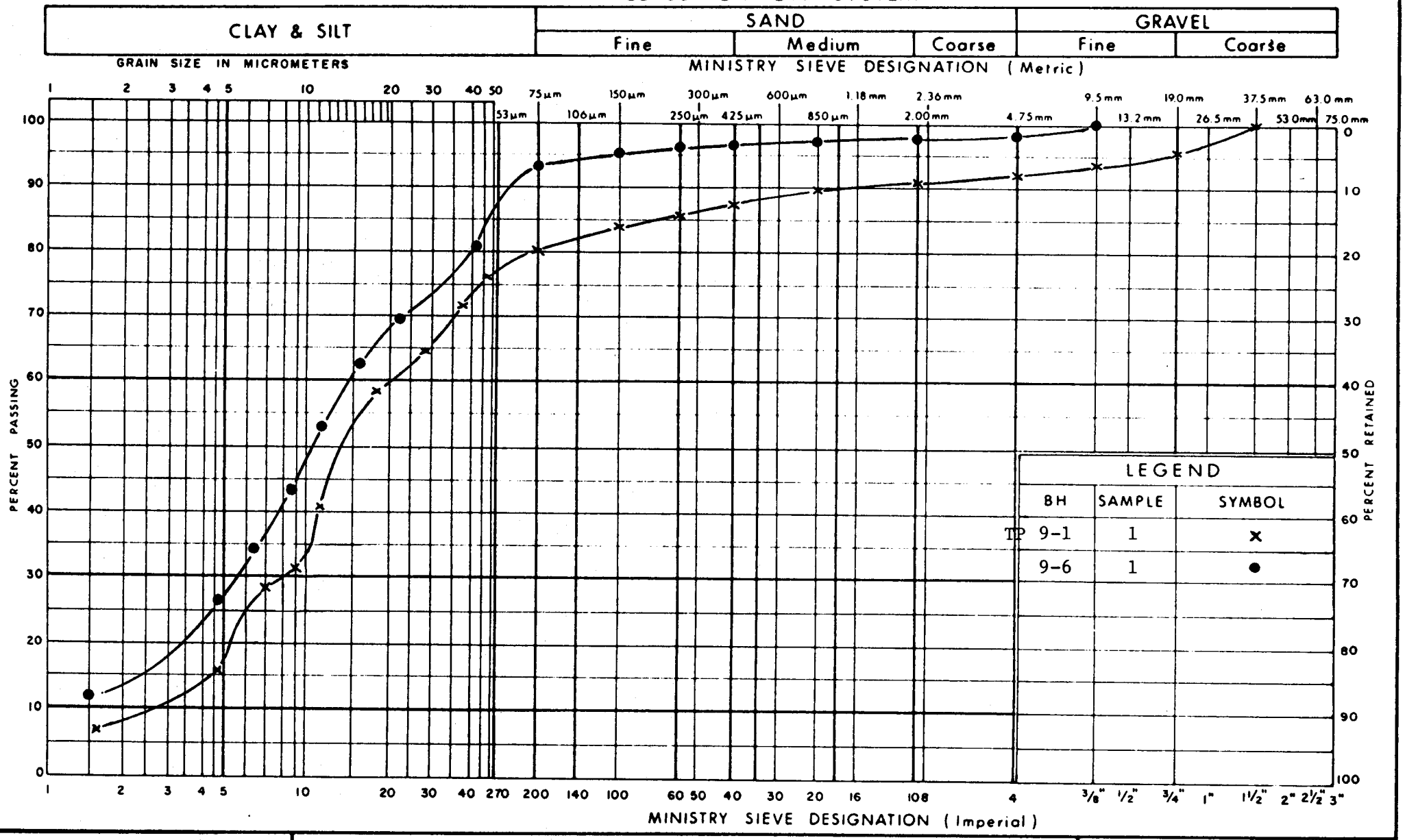
DEPTH - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	SAMPLES: CONDITION	SAMPLES: NUMBER	TESTS: RESULTS (Gr Sa Si Cl)
0.0	101.1	Ground Surface				
	0.0	Silty Sand Topsoil Dark Brown				
	100.6					
	0.5	Sand, Fine to Medium, Trace Silt Brown				
1.0	100.0					
	1.1	Clayey Silt, Some Sand Trace Gravel Grey				
2.0						γ_{dry} = 16.6kN/m³ W_{nat} = 28% S.G. = 2.8
3.0				☒	1	8 12 72 8 W_L = 27% W_P = 18%
	97.8					
	3.3	Gravelly Sand and Silt (Glacial Till) Some Cobbles and Boulders (0.9m x 0.5m boulder @ 3.5m) Very Difficult to excavate				γ_{dry} = 23.0kN/m³ W_{nat} = 6%
4.0	97.1	Grey/Brown				
	4.0	End of Test Pit Machine Refusal (Large Boulder or Bedrock) Water running into Test Pit along interface between Sand and Clayey Silt Otherwise, Test Pit dry				S.G. = 2.8

APPENDIX B

Laboratory Data

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation and Communications
Ontario

GRAIN SIZE DISTRIBUTION

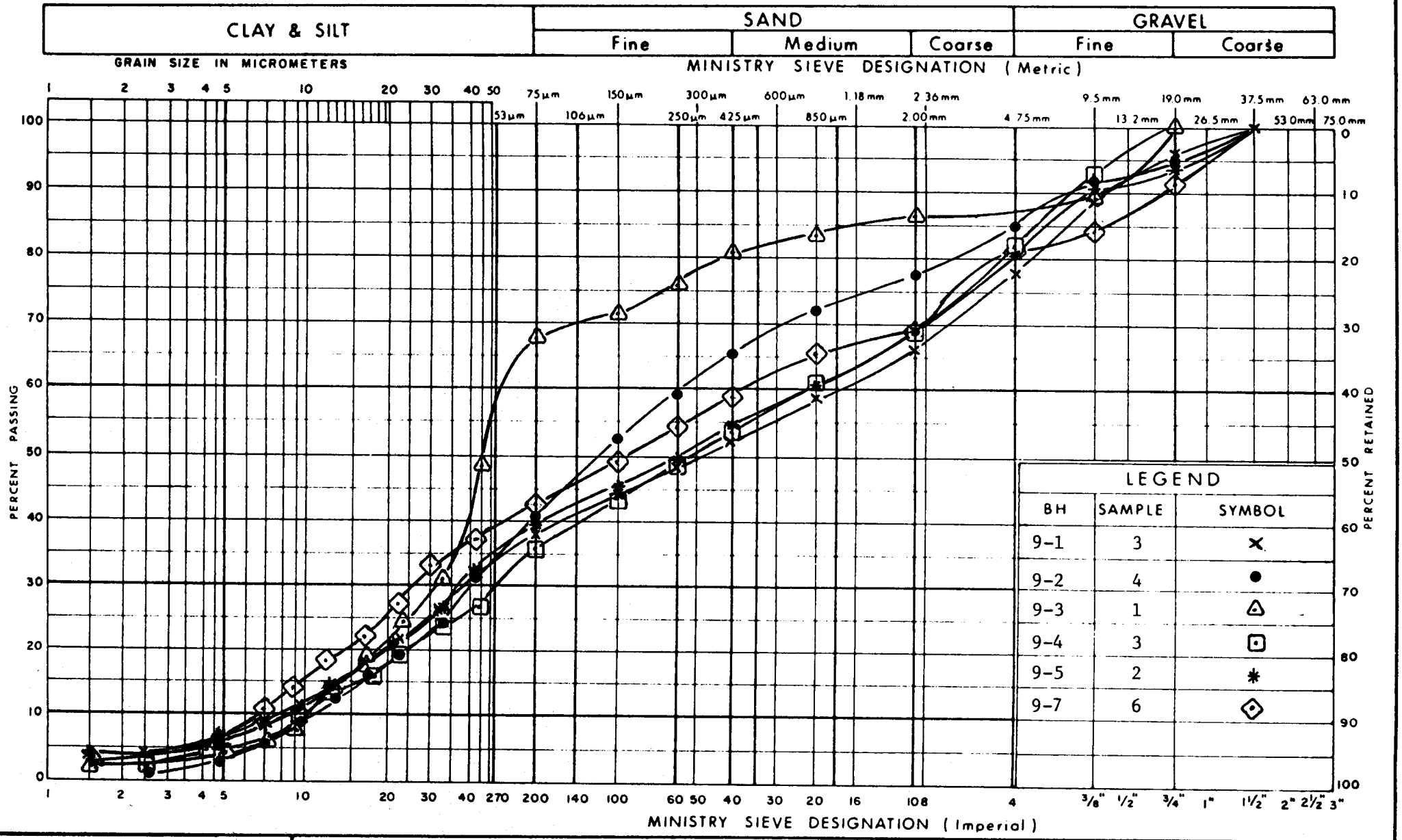
Clayey Silt, trace sand and gravel

FIG No B1

W P 372-89-03

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation and Communications
Ontario

GRAIN SIZE DISTRIBUTION

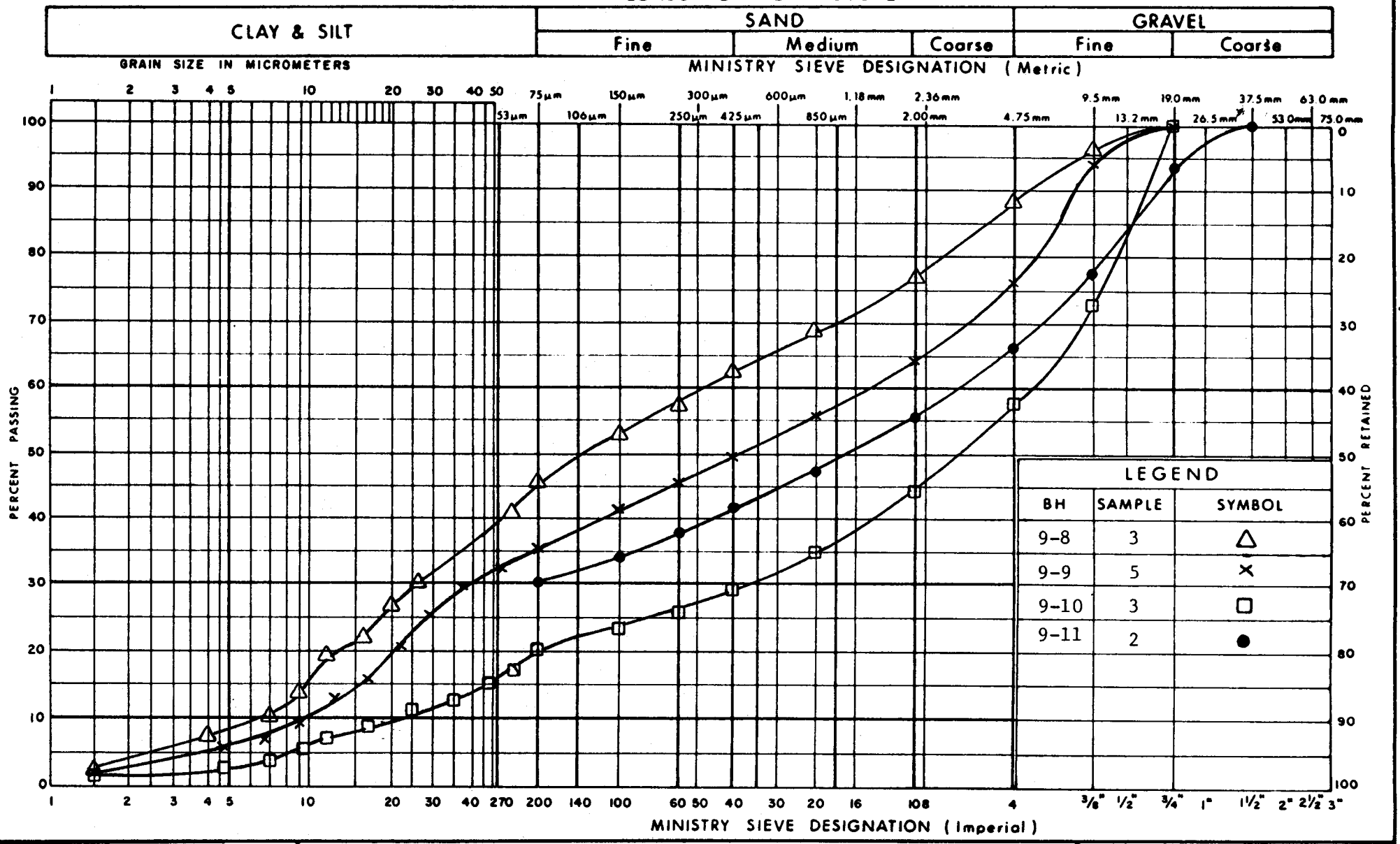
Glacial Till

FIG No B2

W P 372-89-03

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation and Communications
Ontario

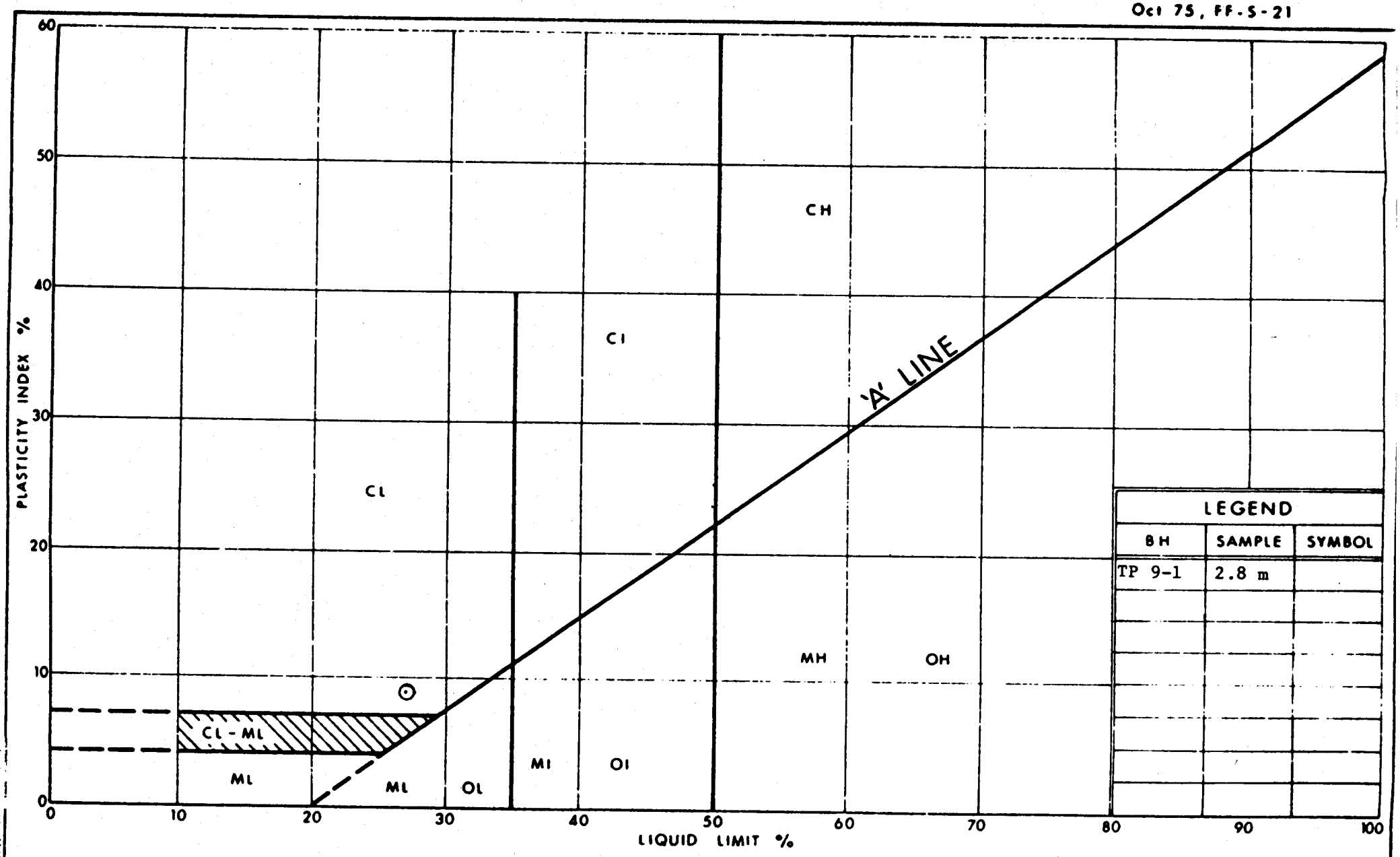
GRAIN SIZE DISTRIBUTION

GLACIAL TILL

FIG No B3

W P 372-89-03

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
TP 9-1	2.8 m	

Ministry of Transportation and Communications
Ontario

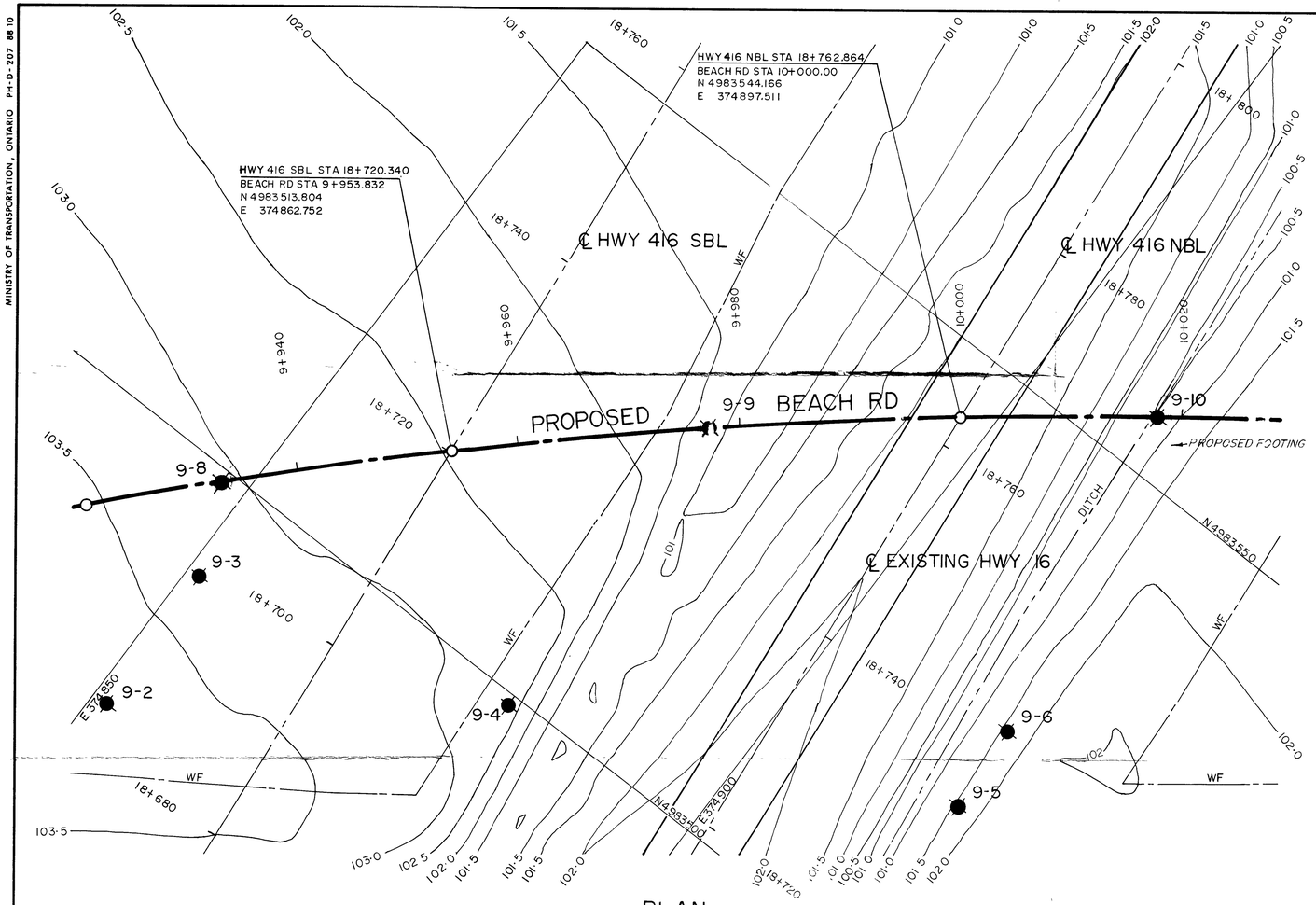
PLASTICITY CHART

CLAYEY SILT

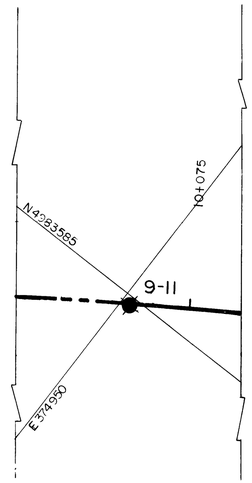
FIG No B4

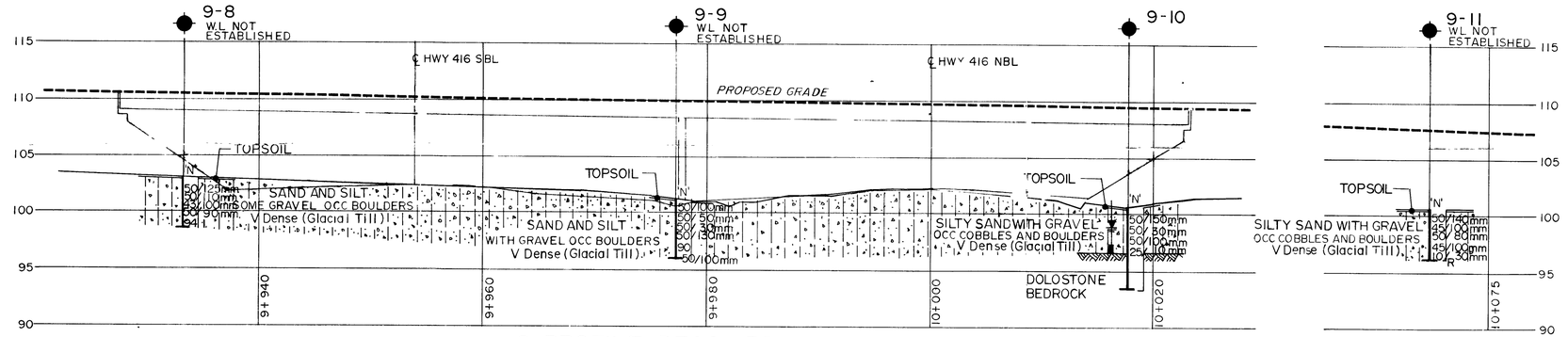
W P 372-89-03

MINISTRY OF TRANSPORTATION, ONTARIO PH-0-207 88 10



PLAN
SCALE
10 5 0 10 METERS





℄ PROFILE BEACH RD
SCALE
10 5 0 10 METERS

METRIC

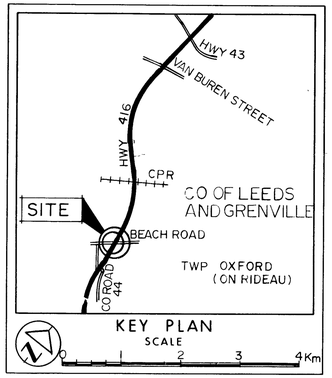
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN STATIONS IN KILOMETRES + METRES.

CONT No
WP No 372-89-03

HIGHWAY 416 UNDERPASS
(AT BEACH RD)
BORE HOLE LOCATIONS & SOIL STRATA

SHEET
A

GEOCON (1991) INC



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)
- W L at time of investigation
- Piezometer

No	ELEVATION	CO-ORDINATES NORTH	EAST
9-1	105·0	4983464·8	374 625·9
9-2	103 8	4983477 1	374 851·3
9-3	103 6	4983484 4	374851·1
9-4	102 9	4983499 0	374 880·4
9-5	101·7	4983516·7	374 918 2
9-6	101 6	4983524 5	374 917 6
9-7	102 2	4983 544 8	374 955 9
9-8	103·1	4983 499·5	374 848·7
9-9	101·3	4983 530·0	374 879 5
9-10	100 4	4983 557 5	374 910 9
9-11	100·3	4983 584·3	374 950·7

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 102 2 of Form 100

REV.	DATE	BY	DESCRIPTION

Geocres No 318-65

HWY No 416			DIST 9
SUBM'D NK	CHECKED NK	DATE 1991 10 23	SITE 16-316
DRAWN MZ	CHECKED RB	APPROVED	DWG 372S903-A

REF No E-53-416-3; 1991 05 29