GEOCRES No:
31G-208

T11688D

REPORT TO

FENCO ENGINEERS INC.
WILLOWDALE ONTARIO

HIGHWAY 416
KEMPTVILLE ONTARIO
FOUNDATION INVESTIGATION
PROPOSED CPR OVERHEAD
(WP 372-89-04; Site 16-193)
DISTRICT 9, KINGSTON
GEOCRES # 31G-208

Distribution:

15 copies - Fenco Engineers Inc.
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Mississauga, Ontario

GEOCON (1991) INC.
January, 1992

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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 this project was conducted between October 18th and October 24th, 1990 using a CME 55 drill rig equipped with 200 mm diameter hollow stem augers. The investigation consisted of 11 boreholes and 2 test pits of depths ranging from 4.5 m to 11.3 m. In addition, three dynamic Cone Penetration Tests (CPT) were performed. The soil overburden was sampled using thin walled Shelby tubes and a 51 mm diameter split spoon in conjunction with the Standard Penetration Tests (SPT). The underlying bedrock was cored in NXL size. In situ undrained shear strength determinations using, the M.T.O. standard size field vane, were also performed at various location in the underlying silty clay. Three standpipe piezometers were installed to monitor the groundwater levels.

The locations of the boreholes are shown on Drawing 3728904-A. A record of the encountered subsurface conditions at each borehole and test pits, is given in Appendix A.

2.0 SITE DESCRIPTION AND GEOLOGY

The proposed overhead is located at the crossing of the CPR track and Highway 16 approximately 3 km south of Kemptville, Ontario (Figure 1). The overhead will consist of a three span structure supported on two central piers and abutments placed on approach fills.

The site is relatively flat and poorly drained with several marshy areas. South of the tracks the alignment is densely covered with small to medium sized trees. Grassland, with occasional shrubs, gives way to agricultural land on the north side of the tracks. A 20 m wide, 5 m high, granular fill embankment is located approximately 175 m north of the tracks just west of the proposed Highway 416 southbound lane. Mature trees are present on the 125 m long granular fill. Approximately 45 m east of the proposed alignment are the overhead structure and approach fills of the existing Highway 16. The proposed/existing structure is about 10-12 m above existing ground level.

The site is drained by a small stream which flows from the southwest and passes under the railway embankment about 50 m west of the proposed highway centre-line. Approximately 150 m north of the tracks water discharges from a 1.2 m culvert, located within the existing Highway 16 embankment fill, and enters a westerly flowing drainage ditch which intersects the proposed alignment at right angles. Two shallow side ditches, located either side of the railway embankment, flow to the west.

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 comprises 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 only resulted 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 may be present.

Available surficial geology information (Ontario Geological Survey Map 2387) indicates that the proposed CPR overhead site is underlain by a uniform medium sand deposited in a shallow water environment. These deposits are anticipated to overlie deposits of fine grained clayey silt.

The bedrock in the area is a massive grey dolostone known as the Oxford Formation of the Beekmonton Group.

3.0 SUBSURFACE CONDITIONS

3.1 General

The stratigraphy at the site comprises of thin layers of peat, topsoil and silty sand overlying a thick deposit of silty clay which in turn overlies a gravelly sand till deposit. The till deposit is underlain by dolostone bedrock. Details of the encountered subsurface conditions at each of the borehole and test pit location are presented in Appendix A.

3.2 Gravelly Sand (Fill)

A granular fill embankment is located approximately 175 m north of the railroad tracks. The embankment is 5 m high, 125 m long and 20 m wide. Based on information obtained at the test pit locations and at Borehole 10-8, drilled at the toe of the fill, the fill is comprised of brown gravelly sand with some cobbles, boulders and pockets of organics.

3.3 Peat and Topsoil

A thin layer of peat and/or silty sand topsoil was encountered in all boreholes and ranged from 0.1 m to 0.5 m in thickness.

3.4 Silty Sand

Underlying the topsoil or fill at all borehole locations is a thin layer of grey silty sand to sand, some silt. This stratum ranged from 0.4 m to 1.1 m in thickness. Based on the

results of one grain size distribution analysis this layer may be described as a silty sand with a trace clay. SPT N values obtained from this layer ranged from 2 to 14 inferring a very loose to compact density.

3.5 Silty Clay, Varved

Underlying the peat, topsoil and silty sand is a layer of grey silty clay at all borehole locations. This stratum ranged from 4.4 m to 6.4 m in thickness. The upper surface of this stratum is found at about El. 95 m which is approximately 1 m below ground surface. The stratum is approximately 6 m thick at the location of the proposed overpass.

Atterberg limit test results indicate a general reduction in the plasticity index with depth (Figure B3). The measured liquid limit of the material ranged from 22% to 58% (average 41%), plastic limits of the 18% to 29% (average 23%) and associated plasticity indices of 4% to 32% with an average value of 18%. A plot of the Atterberg limits (Figure B4) indicates that the soil is inorganic clay of variable plasticity (CL to CH). The results of 4 grain size distribution analyses (Figure B2) indicate that this strata lies within the silty clay range with an increasing silt content with depth.

Based on the summary of in-situ test results and laboratory data obtained for the silty clay layer (Figure B3), the following general comments may be made about its engineering properties:

Water Content

The water contents ranged from 22% to 35% with a decreasing trend with depth and one anomalous value of 51% (Borehole 10-8; Sample 4). This decreasing trend is consistent

with the increasing silt content with depth. Generally, the water contents are slightly above the plastic limit.

Standard Penetration Test (SPT)

SPT N values obtained from this stratum ranged from 2 to 13, and is in the form of a parabolic distribution with a peak value at about 1 m below the top of the layer (Figure B4). Lower SPT values in the upper 1 m are likely caused by either localized softening due to surface water ponding or the affect of freeze/thaw action in the frost zone.

Undrained Shear Strength

The undrained strengths for this strata were obtained by in-situ vane tests, laboratory vane tests and undrained quick (UU) triaxial tests. Based on the combined undrained shear strength and SPT data, it is concluded that the stratum can be described as having a very stiff consistency above El. 90 m. However, there are some localized zones of firm to stiff material. Below this elevation, the deposit can be described as having a firm to stiff consistency.

The results of one in-situ field vane test and one UU triaxial test performed at El. 94.7 m at Borehole 10-5 and on a sample recovered from El. 89.3 m in Borehole 10-6, respectively, are considered unrepresentative because of probable disturbance of the samples.

Sensitivity

Sensitivity values, defined as the ratio of peak to remolded undrained shear strength ranged from 1 to 26 with a typical range of between 5 and 8. Based on these values, the deposit is considered to be sensitive.

Consolidation Data

The results of the four consolidation tests (Table 1, Appendix B) indicate that the silty clay is overconsolidated with estimated pre-consolidation pressures (Pc) in excess of 400 kPa and associated over-consolidation ratios (OCR) ranging from 7 to 28. The general trend of decreasing Pc values with depth is consistent with that exhibited by the SPT "N" values and the undrained shear strength data.

Recompression indices (C_r) and compression indices (C_c) ranged from 0.007 to 0.025 (average value 0.015) and from 0.16 to 0.200 (average value 0.18), respectively. Coefficient of Consolidation (C_v) values, applicable to the reloading portion of the tests, vary from 34 m^2/yr to 68 m^2/yr (average value 47 m^2/yr).

3.6 Gravelly Sand (Glacial Till)

A layer of non-cohesive gravelly sand till was encountered below the silty clay stratum at all borehole locations. The stratum ranged from 1.3 m to 1.6 m in thickness at Boreholes 10-4 and 10-6, respectively. Based on auger refusal data obtained at other boreholes locations, the thickness of this layer is inferred to range from 0.5 m to 3.6 m with an average thickness of 1.5 m.

The results of one grain size distribution analysis indicates that the glacial till is a well graded mixture of sand and gravel with some silt. Occasional cobbles and boulders may also be present within this layer.

SPT N values obtained for this stratum ranged from 17 to 26, inferring a compact state of density. An N value of 2 at Borehole 10-7 is believed to have been influenced by upward flow of groundwater in the auger hole prior to the test and is considered unrepresentative.

Water contents within the till ranged from 7 to 9%.

3.7 Bedrock

Bedrock was confirmed at about El.87.5 m which is approximately 8.0 m below ground surface and was cored for a total depth of 2.9 m and 2.7 m at Boreholes 10-4 and 10-6, respectively. The bedrock is a dark grey fine grained dolostone with occasional intrusions of calcite and closely spaced thin (1 to 2 mm) stringers of black shale. The rock is massive with core recovery of 87 to 100% and RQD values ranging from 87 to 93% inferring good to excellent quality bedrock.

Unconfined compression tests performed on two samples of core retrieved from Boreholes 10-4 and 10-6 yielded strength values of 85 and 67 MPa, respectively.

3.8 Groundwater Conditions

Groundwater levels were measured by standpipe piezometers installed in the underlying glacial till at Boreholes 10-3 , 10-5 and 10-7. The groundwater levels were measured

approximately 17 days after drilling and were observed at El. 95.8 to El. 96.3 m. These water level elevations infer that a small artesian pressure is present within the glacial till layer, which is consistent with general observations made during drilling. The measured water level within the surficial topsoil and silty sand layers is at or close to the ground surface.

Groundwater level could expect to vary seasonally.

4.0 ENGINEERING DISCUSSION AND RECOMMENDATIONS

4.1 General

It is understood that the proposed overhead structure will comprise of three spans supported on two central piers positioned on either side of the existing railway track and two perched abutments within approach fills. As discussed in the following sections, end bearing steel H-piles driven to bedrock are recommended for support of the central piers and the abutments. Design recommendations for conventional spread footings bearing on engineered fill are also given for the abutments. Embankments constructed with conventional 2 Horizontal to 1 Vertical side slopes will remain stable. Approach fills of up to 12 m in height are anticipated.

4.2 Overhead Foundation

4.2.1 Central Piers

Based on the observed soil stratigraphy at the location of the proposed overhead, the following foundation solutions for the piers may be considered:

1) End Bearing Piles Driven to Bedrock
2) Conventional Spread Footings

4.2.1.1 End Bearing Piles Driven to Bedrock

Steel H piles driven through the silty clay and till strata to practical refusal in the underlying bedrock occurring at about El. 87.5 m are recommended for support of the

central piers. Allowable loads of 1100 kN and 1550 kN may be used for the SLS and ULS conditions, respectively for HP 310 x 110 steel piles. These loads have taken into consideration any possible effects of negative skin friction being developed. It is recommended that the loads be checked against the structural capacity of the steel piles used. Settlements of the pile cap will be governed by the elastic compression of the pile units. If the installation of the piles is delayed until at least 2 months after complete placement of the approach fills, at which time 90% consolidation settlement of the silty clay layer is expected to occur, the effects of negative skin friction forces may be ignored.

It is recommended that the H Piles be equipped with driving shoes. For the purpose of easy driving of the piles, it is recommended that fill placed within the area of pile installation should not exceed 75 mm in particle size. Pile design installation details such as termination resistance and the rated energy capacity of the pile hammer would largely depend on the pile type chosen. For preliminary design purposes, HP 310 x 110 steel piles may be driven to a set of 10 blows for the last 25 mm of penetration using a hammer transferring about 60 kilojoules of energy per blow to the pile. We would be pleased to review the pile installation details once the pile type has been chosen. Consideration should be given to re-striking the piles if relaxation is observed. It is further recommended that lateral loads on the abutments and central piers be resisted by batter piles. Frost protection of 1.8 m of earth cover or equivalent will be required for the pile caps.

4.2.1.2 Conventional Spread Footings

Based on average undrained shear strength of 100 kPa, the recommended bearing pressure at the Ultimate Limit State (ULS) for foundations placed at least 0.5 m below the surface of the silty clay stratum (El 94.5 m) is 260 kPa. The recommended bearing

pressure at the Serviceability Limit State (SLS) for a 3 m wide footing is 165 kPa for anticipated footing settlements of 25 mm. The design loads proposed may make the used of spread footing uneconomical.

4.2.2 Abutments

The following foundation solutions are considered suitable for the support of the perched abutments within the approach fills.

1) Spread Footings Placed on Engineered Fill
2) End Bearing Piles Driven to Bedrock

4.2.2.1 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 Ultimate Limit State (ULS) conditions are 250 kPa and 400 kPa, respectively. These recommended bearing pressures are governed by the internal stability of the embankment with 2 horizontal to 1 vertical slopes and allowable settlement.

The SLS design load is the load at which the estimated settlement of the footing will be of the order of 25 mm which for the purposes of this design has been assumed as the maximum settlement that may be tolerated. This settlement is comprised of 5 mm within the engineered fill and 20 mm within the silty clay stratum. Both elements of settlement will be largely elastic and will occur mostly during initial loading of the foundations. It is anticipated that ninety percent of the settlements will take place over a 2 to 3 month period.

In the calculation of the footing settlement, it has been assumed that settlement of the underlying silty clay resulting from the imposed embankment loading will be essentially completed prior to construction and loading of the footings. The magnitude of the embankment induced settlements are anticipated to be about 50 mm and will be 90% completed over a time period of 2 months after complete fill placement. It has been assumed that construction of the embankment in advance of major structural works could be readily accommodated within the overall contract schedule. It is recommended that settlement of the fill be monitored to confirm that 90% of the consolidation settlement has occurred prior to construction of the abutment foundation.

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 measures for spread footing on engineered fill should be in accordance with Figure 2.

The magnitude of the proposed loads may prove uneconomical for the design of spread footings and should be given little consideration.

4.2.2.2 End Bearing Piles

In order to create a foundation system with similar deformation characteristics as the central piers, it is recommended that end bearing steel H Piles be driven to support the proposed perched abutments. The piles should be driven through the embankment fill and overburden silty clay to practical refusal into the underlying bedrock which occurs at about El. 87.5 m. Allowable loads of 1100 kN and 1550 kN may be used at the SLS and ULS conditions, respectively, for HP 310 x 110 steel piles and have taken into consideration the possible effects of negative skin friction being developed . These loads should, however, be checked against the structural capacity of the steel piles used. Settlements of the pile cap will be governed by the elastic compression of the pile units.

If the installation of the piles is delayed until at least 2 months after complete placement of the approach fills, at which time 90% consolidation settlement of the silty clay layer is expected to occur, the effects of negative skin friction forces may be ignored.

It is recommended that the H-Piles be equipped with driving shoes. For the purpose of easy driving of the piles, it is recommended that fill paced within the area of pile installation should not exceed 75 mm in particle size. Pile design installation details such as termination resistance and the rated energy capacity of the pile hammer would largely depend on the pile type chosen. For preliminary design purposes, HP 310 x 110 steel piles may be driven to a set of 10 blows for the last 25 mm of penetration using a hammer transferring about 60 kilojoules of energy per blow to the pile. We would be pleased to review the pile installation details once the pile type has been chosen. Consideration should be given to re-striking the piles if relaxation is observed. Frost protection of 1.8 m of earth cover or equivalent will be required for the pile caps.

4.3 Embankment Recommendations

4.3.1 General

It is understood that approach fills of the order of 12 m high above the existing ground surface are required adjacent to the proposed CPR overhead and that will extend for a distance of the order of 600 m north and south of the overhead at a grade of approximately of - 0.4%.

4.3.2 Stability

Based on the observed stratigraphy at the borehole locations, the stability of the proposed approach fill embankments will be governed by the silty clay layer. Stability analyses of a 12 m high embankment design and containing abutment footings according to MTO Drawing (Figure 2) WP 372-89-04 assuming an undrained strength of 90 kPa and foundation pressure of 300 kPa indicate a factor of safety of 1.6. The stability of the embankment without the abutment footings is considerably greater than the previous case. The favourable stability of the proposed embankment is in keeping with the observed performance of the existing adjacent Highway 16 embankment fill. 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 in the outer zones, the embankment side slopes should be 2.5 Horizontal to 1 Vertical or flatter. The embankment slopes should be provided with suitable erosion protection.

Prior to the placement of any imported fill materials, the subgrade should be stripped of all topsoil and organics and any other deleterious material which may be present. The receiving subgrade, comprising of sand to silty sand, should be proof-rolled and any soft areas excavated and replaced with compacted granular material.

4.3.3 Settlement

The consolidation settlement of the silty clay layer under the influence of a 12 m high fill is estimated to be of the order of 50 mm. Additional small settlements will occur within the upper silty sand layer and the underlying glacial till. However, because of the granular nature of both of these materials the settlements are anticipated to be immediate.

Based on the consolidation data of the silty clay layer (Table 1) it is anticipated that 90% of the consolidation settlement will occur over a 2 month period after complete placement of the fill.

4.4 General Design Recommendations

4.4.1 Excavations

Shallow temporary excavations in natural soils at the site are anticipated to be within the upper silty sand layer and the underlying silty clay layer. Excavations within the silty sand layer will generally remain stable if excavated with side slopes no steeper than 2 Horizontal to 1 Vertical. Due to the high groundwater table some sloughing of the silty sand stratum could be expected necessitating flatter slopes in local areas. Excavations within the underlying silty clay will remain stable up to 1.0 m depth if excavated with vertical sides.

In the event foundation concrete will not be placed within 4 hours of excavation to final grade, it is recommended that a 50 mm thick lean concrete mud mat be immediately placed at the base upon completion of excavations to prevent deterioration of the base due to wetting and construction activity.

Excavations within the placed fill materials will remain stable if constructed with side slopes no steeper than 1.5 Horizontal to 1 Vertical. All excavations shall be in compliance with the Ontario Health and Safety Act regulations or other governing regulations within the area.

4.4.2 Dewatering

Moderate groundwater flows into open excavations are anticipated and will primarily originate from the strata overlying the silty clay. The anticipated groundwater flow may be handled by a system of ditches leading to a central sump and pump arrangement.

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. An unyielding foundation condition may be assumed for the computations. If, however, movement of the top of the retaining walls is permitted and allowed to exceed 0.05% of the overall height of the wall, a yielding condition may be assumed for 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 fill, an unfactored coefficient of friction value of tan 30° may be assumed for the estimation of the sliding resistance.

4.4.4 Construction Monitoring

Various design recommendations presented within this report require that the consolidation of the silty clay layer under the influence of the imposed embankment

loading be complete prior to the construction or installation of key foundation elements. Therefore, it is recommended that the surface settlement of the fill be surveyed monitored on a regular basis after placement to confirm the end of the primary consolidation phase of the silty clay layer.

4.4.5 Frost Penetration

The anticipated maximum depth of frost penetration at the site is 1.8 m (Canadian Foundation Engineering Manual). All foundation units should be provided with at least this depth of soil or equivalent cover below finished grade. Also, embankment fills should be comprise of non frost susceptible material to within 1.8 m from the top of pavement to ensure satisfactory performance of the pavement structure. This aspect of the design will be addressed in more detail in the Pavement Design Report.

4.4.6 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 and monitoring are followed. It is recommended, therefore, that the foundation and earthworks construction be carried out under suitably qualified geotechnical engineering supervision.

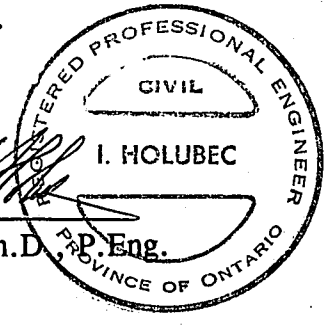
5.0 CLOSURE

The field work portion for the investigation was carried out 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.; checked by Mr. R.W. Browne 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

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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

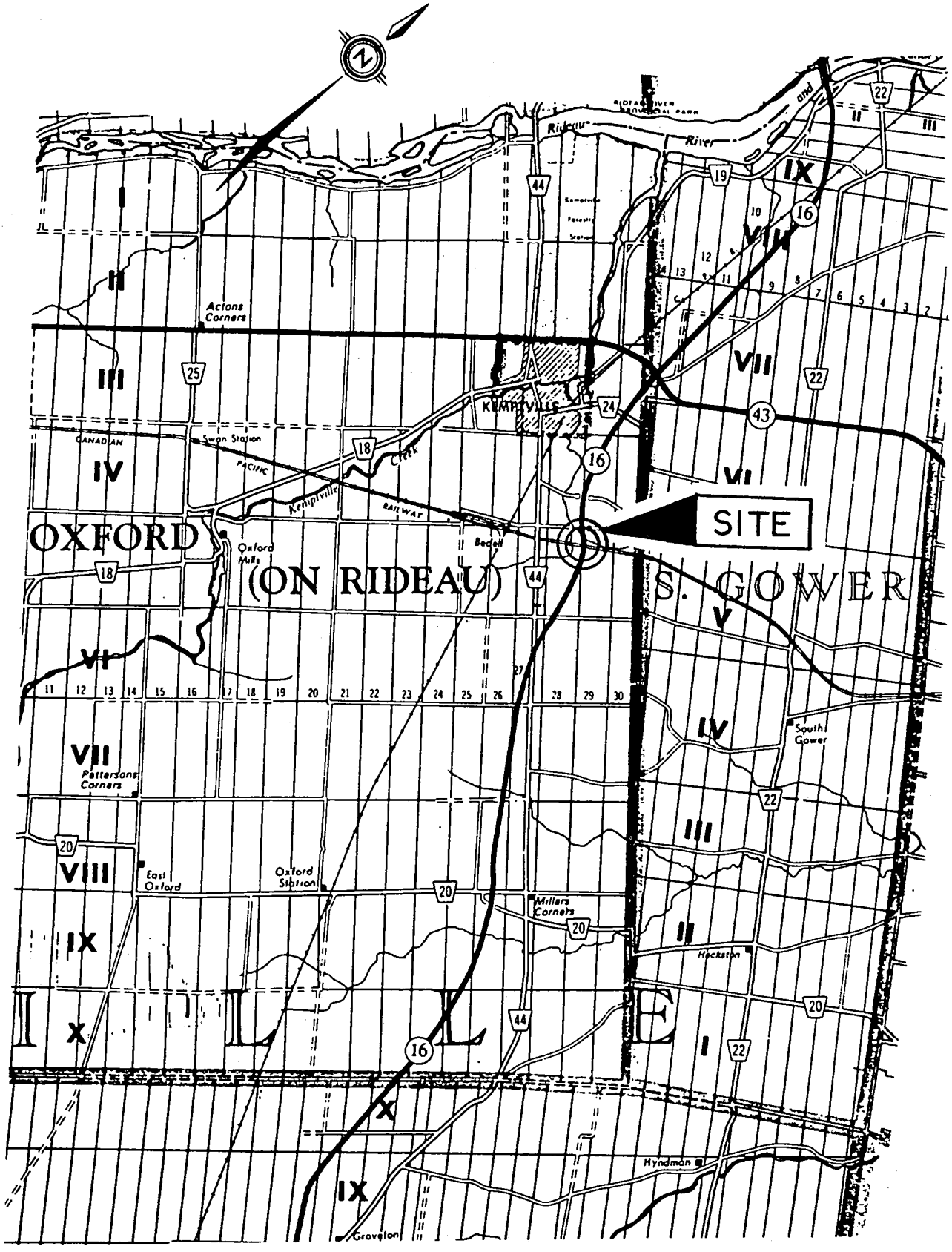
Canadian Foundation Engineering Manual, 1985. Second Edition. Part 1: Fundamentals; Part 2: Shallow Foundations; Part 3: Deep Foundations; Part 4: Excavations and Retaining Structures Part 5: References. Canadian Geotechnical Society, Technical Committee on Foundations, 456 pp.

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.

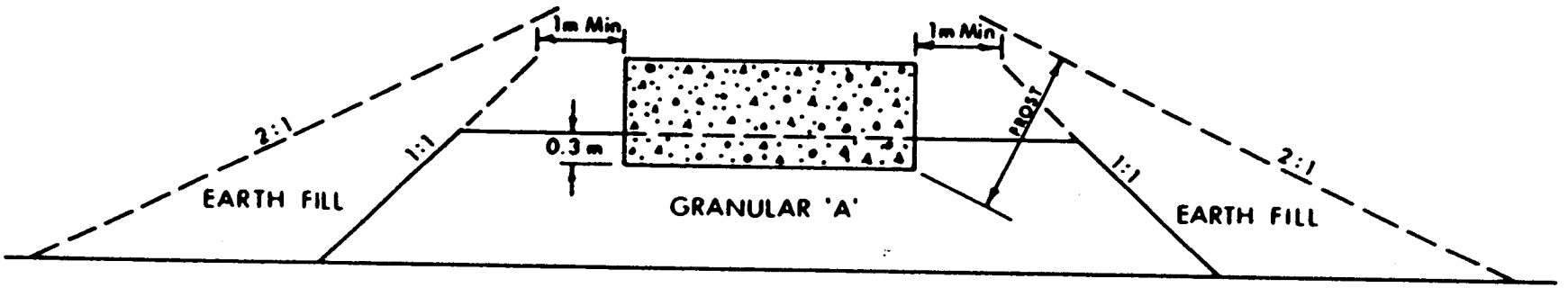
Totten Sims Hubicki Associates (1981) Limited Consultants 1990 Structure Data Report, Highway 416 from 0.7 km north of Hwy 401 northerly to 1.0 km north of Hwy 43, District 9 Ottawa. Report prepared for Ministry of Transportation, Ontario.

KEY PLAN

APPENDIX
FIGURE 1
PROJECT WP 372 89 04



GEOCON



X SECTION

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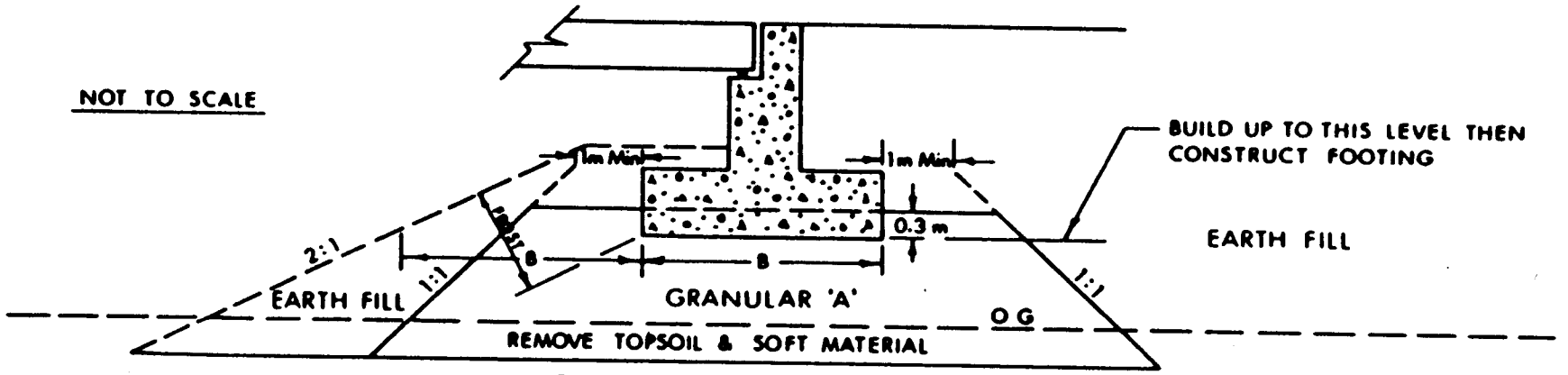

LONGITUDINAL SECTION

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 04

APPENDIX A

Explanation of Terms used in this Report
Explanation of the Term Rock Quality Designation (RQD)
Record of Borehole Sheets (10-1 to 10-11)
Test Pit Logs

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

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 10-1 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,512.6 N; 374,551.3 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE October 22, 1990 CHECKED BY I.C.

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) (25 50 75 100 125)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.2	Ground Surface										
0.0	Peat and Topsoil Soft					Head	96				
96.0	Silty Sand		1	SS	2				○		0 62 36 2
0.2	Very Loose Grey										
95.3											
0.9	Silty Clay (Varved) occasional shell fragments		2	SS	7						
	Very stiff Grey		3	SS	8		94		○		
			4	SS	13						
			5	TW	PH			● (177)	×5 ○		19.5 0 2 58 40
							92				
			6	SS	5				○		
90.9						▽ Artesian water encountered					
5.3	Sand and Gravel some silt (Glacial Till)						90				
	Compact Grey		7	SS	24						38 39 21 2
87.2							88				
9.0	End of Borehole Auger Refusal										
	Initial auger refusal encountered at 4.3 m. Stratigraphy below this depth obtained by redrilling a short distance from the original borehole location.										
	Magnitude of Artesian Pressure Head not established.										

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 10-2 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,682.3 N; 374,444.5 E ORIGINATED BY N.K.

DIST 9 nWY 416 BOREHOLE TYPE Hollow Stem Augers & Cone Test COMPILED BY N.K.

DATUM Geodetic DATE October 19, 1990 CHECKED BY I.C.

OFFICE REPORT ON SOIL EXPLORATION

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
96.0	Ground Surface						
0.0	Peat and Topsoil Soft		1	SS	3	Head	
95.7							
0.3	Silty Sand						
95.1	Very Loose to Loose Grey		2	SS	6		
0.9	Silty Clay (Varved)						
	Very Stiff to Stiff Grey		3	TW	PH		94
			4	SS	12		
			5	SS	8		92
			6	TW	PH		
							90
	Firm		7	SS	3		
88.7						Artesian water encountered	
7.3	Sand and Gravel some silt, trace clay (Glacial Till)		8	SS	20		88
87.5	Compact Grey						
8.5	End of Borehole Auger Refusal						
86.0							
10.0	End of Penetration Test						

Note:
Cone Test performed 3.5 m south of Borehole 10-2

Magnitude of Artesian Pressure Head not established.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
25 50 75 100 125

PLASTIC LIMIT W_p — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%) 20 40 60

100/215 mm

UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
19.0	0 2 54 44

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

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 10-3 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,697.7 N; 374,439.8 E ORIGINATED BY N.K.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers COMPILED BY N.K.
DATUM Geodetic DATE October 19, 1990 CHECKED BY I.C.

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 ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 25 50 75 100 125	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.1	Ground Surface										
0.0 / 95.6	Peat Soft Black		1	SS	3		96				
0.5 / 95.0	Silty Sand Loose Grey		2	SS	5						
1.1	Silty Clay (Varved) silt content increasing with depth Very Stiff Grey		3	SS	6		94		○		
			4	SS	10				○		
			5	SS	10						
			6	TW	PH		92		✓	○	19.5
			7	SS	10						
89.4			8	TW	PH		90		×26	HO	20.6	0 2 94 4
6.7	Sand and Gravel trace to some silt (Glacial Till) Compact Grey		9	SS	26		88			○	
87.5											
8.6	End of Borehole Auger Refusal Note: Water level in standpipe piezometer measured at elevation 96.2 m on November 9, 1990.										

OFFICE REPORT ON SOIL EXPLORATION

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 10-4 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,692.1 N; 374,430.7 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 18, and 19, 1990 CHECKED BY I.C.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ 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
95.8	Ground Surface							20 40 60 80 100 / 25 50 75 100 125	20 40 60		
0.0	Peat Soft Black										
95.5	Sand, some silt										
0.3	Very Loose Grey										
94.9							94				
0.9	Silty Clay (Varved)		1	SS	3						
	Very Stiff to Stiff Grey		2	SS	6						
			3	SS	9				○		
			4	SS	7		92				
								+ (>96 kPa)			
			5	SS	5				○		
								+ (>96 kPa)			
			6	SS	2		90				
88.7								5			
7.1	Gravelly Sand, some silt (Glacial Till)										
	Compact Grey		7	SS	17		88		○		
87.4					Rec%			RQD%			
8.4	Dolostone fine grained, closely to moderately jointed, occasional thin (1-2mm) stringers of shale. Occasional Calcite Crystals		8	RC NXL	100			93			
			9	RC NXL	87			87			UCS = 85 MPa
							86				
	Dark Grey		10	RC NXL	88			88			
84.5											
11.3	End of Borehole										

Notes:

1) Water level in Hollow Stem Augers 0.1 m above surface on morning of Oct. 19/90

2) Lost rock core believed to have dropped out of core barrel.

+3, ×5 : Numbers refer to Sensitivity

15 ◇ 20/10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 10-5

METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,718.7 N ; 374,413.5 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 I.C.

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 / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.7	Ground Surface										
0.0 / 95.6	Peat and Topsoil Soft										
0.1 / 95.1	Silty Sand Very Loose Grey		1	SS	2						
0.6	Silty Clay (Varved) silt content increasing with depth, trace sand Very Stiff Grey		2	TW	PH		94				
			3	SS	9						
			4	SS	9		92				
			5	TW	PH			(157)		19.8	0 2 80 18
			6	SS	8		90				
89.2								(>96 kPa)			
6.5	Gravelly Sand, some silt (Glacial Till) Compact Grey		7	SS	9						
87.6			8	SS	547/265 mm		88				
8.1	End of Borehole Auger Refusal										

Note:
Water level in standpipe piezometer measured at elevation 95.8 m on November 9, 1990.

+3, x5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 10-6 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,720.2 N; 374,424.1 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 23 and 24, 1990 CHECKED BY I.C.

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 kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 25 50 75 100 125	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.5	Ground Surface										
95.4 / 0.1	Topsoil Soft										
95.0 / 0.5	Fine Sand, some silt Very Loose Grey		1	SS	2	Head			○		
94.1	Silty Clay, trace sand Soft Grey		2	SS	3		94		○		
1.4	Silty Clay (Varved) silt content increasing with depth Very Stiff Grey		3	SS	10			+ (>96 kPa)			
			4	SS	11		92		○		
			5	SS	9						
			6	SS	7			+ (>96 kPa)	○		
89.1			7	TW	PH	Artesian water encountered	90		⊢○		18.5
6.4	Gravelly Sand some silt (Glacial Till) Compact Grey		8	SS	24				○		
87.6			9	SS	7/150 mm		88	ROD% 0			
8.0	Dolostone fine grained, closely to moderately jointed, occasional thin (1-2mm) stringers of shale. Occasional Calcite Crystals Dark Grey		10	NXL	71						
			11	RC NXL	99			91			
			12	RC NXL	98		86	88			UCS = 67 MPa
84.8											
10.7	End of Borehole				Rec %						

+³, ×⁵ : Numbers refer to Sensitivity

15 10 20 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 10-7

METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,728.6 N; 374,412.8 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE October 23, 1990 CHECKED BY I.C.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
96.2	Ground Surface						
0.0 / 96.1	Topsoil Soft		1	SS	4		96
0.1	Silty Sand trace organics						
95.0	Loose Grey		2	SS	9		
1.2	Silty Clay (Varved) trace sand		3	SS	5		
	Very Stiff to Stiff Grey		4	SS	11		94
			5	SS	12		
							92
			6	TW	PH		
			7	SS	4		
90.1							90
6.1	Gravelly Sand some silt (Glacial Till)		8	SS	2		
89.2	Probably Compact Grey						
7.0	End of Borehole Auger Refusal						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
25 50 75 100 125

(+ 96 kPa)

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L

WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Note:

Blow-up of material into the augers is believed to have affected the "N" value of Sample 8.

Water level in standpipe piezometer measured at elevation 96.3 m on November 9, 1990.

OFFICE REPORT ON SOIL EXPLORATION

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

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

Ministry of Transportation
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OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 10-8

METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,850.6 N; 374,321.4 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE October 22, 1990 CHECKED BY I.C.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
96.5	Ground Surface						
0.0 / 96.4	Topsoil Soft		1	SS	3		96
0.1 / 95.7	Fill - Silty Sand, trace organics and roots Very Loose Brown						
0.8 / 95.3	Silty Sand Compact Brown Grey		2	SS	14		
1.2	Silty Clay (Varved) silt content increasing with depth Stiff Grey		3	SS	10		
			4	SS	12		94
			5	SS	14		
			6	TW	PH		
			7	SS	8		92
			8	SS	4		90
89.2							
7.3	Sand and Gravel some silt (Glacial Till) Compact Grey		9	SS	23		
87.3	Blow-up of material within auger @ 7.5 m						88
9.2	End of Borehole Auger Refusal						

Note: Water in open borehole measured at elevation 95.9 m on October 24, 1990.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE
25 50 75 100 125

PLASTIC LIMIT Wp — NATURAL MOISTURE CONTENT W — LIQUID LIMIT Wl
WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³: 19.2

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+3, ×5 : Numbers refer to Sensitivity

15 ◇ 5 (%) STRAIN AT FAILURE (20, 10)

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 10-9

METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,604.2 N; 374,498.4 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY N.K.

DATUM Geodetic DATE October 22, 1990 CHECKED BY I.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPo: o UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
95.9	Ground Surface										
0.0 / 95.7	Peat and Topsoil Soft										
0.2 / 95.0	Probably Silty Sand										
0.9 / 90.1	Probably Silty Clay (Varved)						94, 92				
5.8 / 88.6	Probably Gravelly Sand some silt (Glacial Till)						90				
7.3	End of Penetration Test 100/265 mm Note: Soil Stratigraphy is inferred based on extrapolated borehole data.										

+3, ×5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 10-10 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,776.2 N; 374,378.9 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY N.K.

DATUM Geodetic DATE October 23, 1990 CHECKED BY I.C.

SOIL PROFILE 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 WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.0	Ground Surface										
0.0 / 95.7	Peat and Topsoil Soft										
0.3 / 94.8	Probably Silty Sand										
1.2 / 89.3	Probably Silty Clay						94 / 92 / 90				
6.7 / 88.1	Probably Gravelly Sand some silt (Glacial Till)										
7.8	End of Penetration Test Note: Soil Stratigraphy is inferred based on extrapolated borehole data.							100/230 mm			

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 10-11 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,947.4 N; 374,242.7 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY N.K.

DATUM Geodetic DATE October 24, 1990 CHECKED BY I.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W_p W W_l	γ	GR SA SI CL
96.2	Ground Surface							SHEAR STRENGTH kPa	WATER CONTENT (%)		
0.0	Topsoil Soft							○ UNCONFINED + FIELD VANE			
96.0	Silty Sand (Probably)						96	● QUICK TRIAXIAL × LAB VANE			
0.2											
95.6	Probably Silty Clay						94				
0.6											
90.1							92				
6.1	Probably Gravelly Sand some silt (Glacial Till)						90				
88.3											
7.9	End of Penetration Test										

Note:

Soil Stratigraphy is inferred based on extrapolated borehole data.

OFFICE REPORT ON SOIL EXPLORATION

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

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

RECORD OF TEST PITS

Test Pit #1	Co-ords: N 4984863.5; E 374292.5; Sta 20+210 ; 15 m Left Ground Surface Elevation 101.5 m (±)
0.0 - 1.5 m	Dark Brown Heterogenous Mixture of Boulders, Cobbles, Sand and Silt Trace Topsoil Some pieces of Asphalt (FILL).
1.5 - 5.5 m	Light Brown Gravelly Sand Some Silt Some Cobbles and Boulders (FILL) Boulders generally less than 0.5 m in Diameter
5.5 - 5.8 m	Black Peat and Topsoil
5.8 m	End of Test Pit

Test Pit #2	Co-ords: N 4984899.0; E 374271.0; Sta 20+250 ; 10 m Left Ground Surface Elevation 101.5 m (±)
0.0 - 4.0 m	Brown Gravelly Sand Some Silt Some Cobbles and Boulders Occasional Pockets of Topsoil (FILL)
4.0 - 4.5 m	Black Topsoil
4.5 m	End of Test Pit

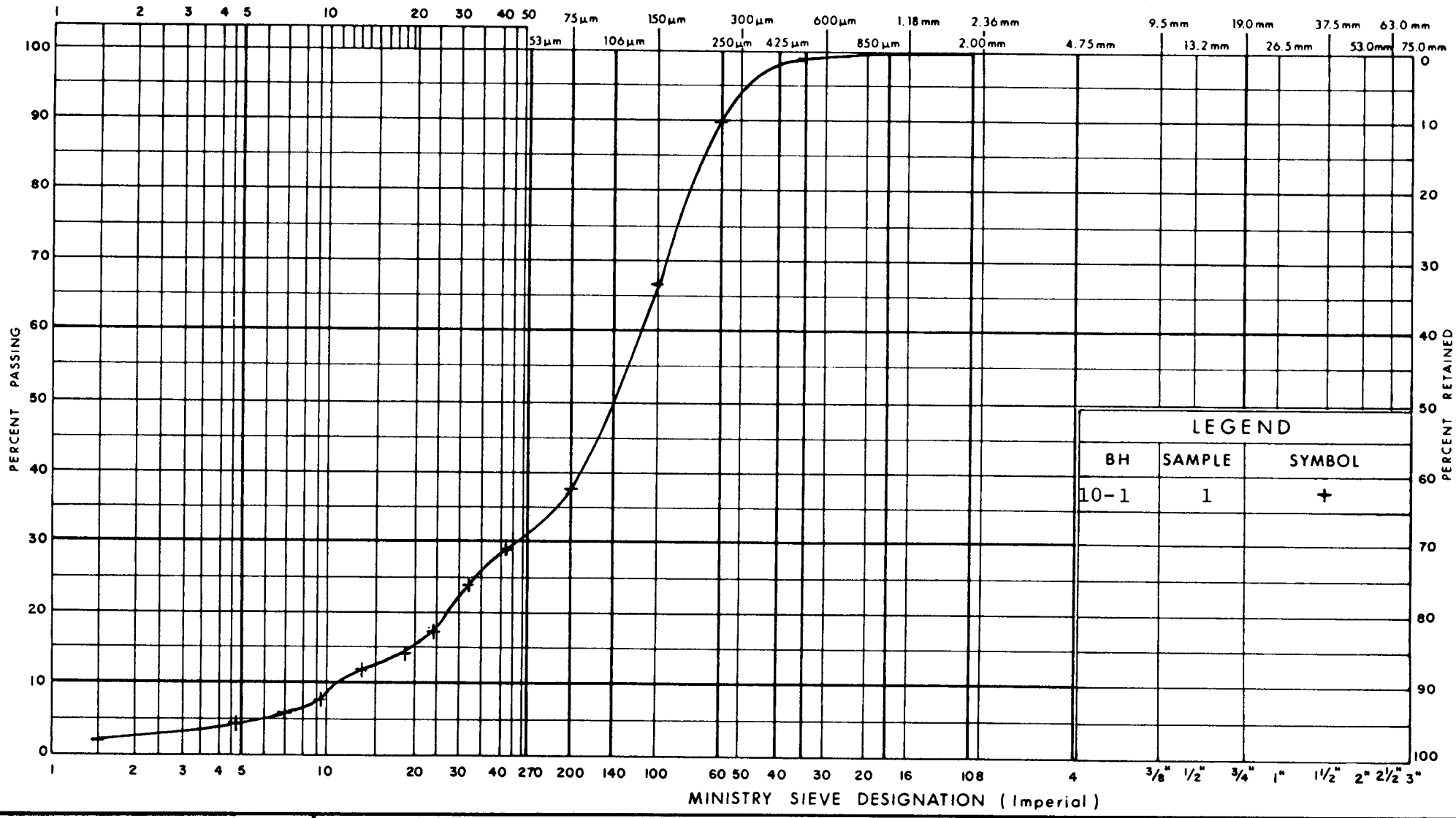
APPENDIX B

Laboratory Test Data

Figures B1 to B3	- Grain Size Curves
Figure B4	- Plasticity Chart - Silty Clay
Figure B5 & B6	- Consolidation Test e vs log p Curves
Table 1	- Summary of Consolidation Test Data

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Ministry of Transportation
Ontario

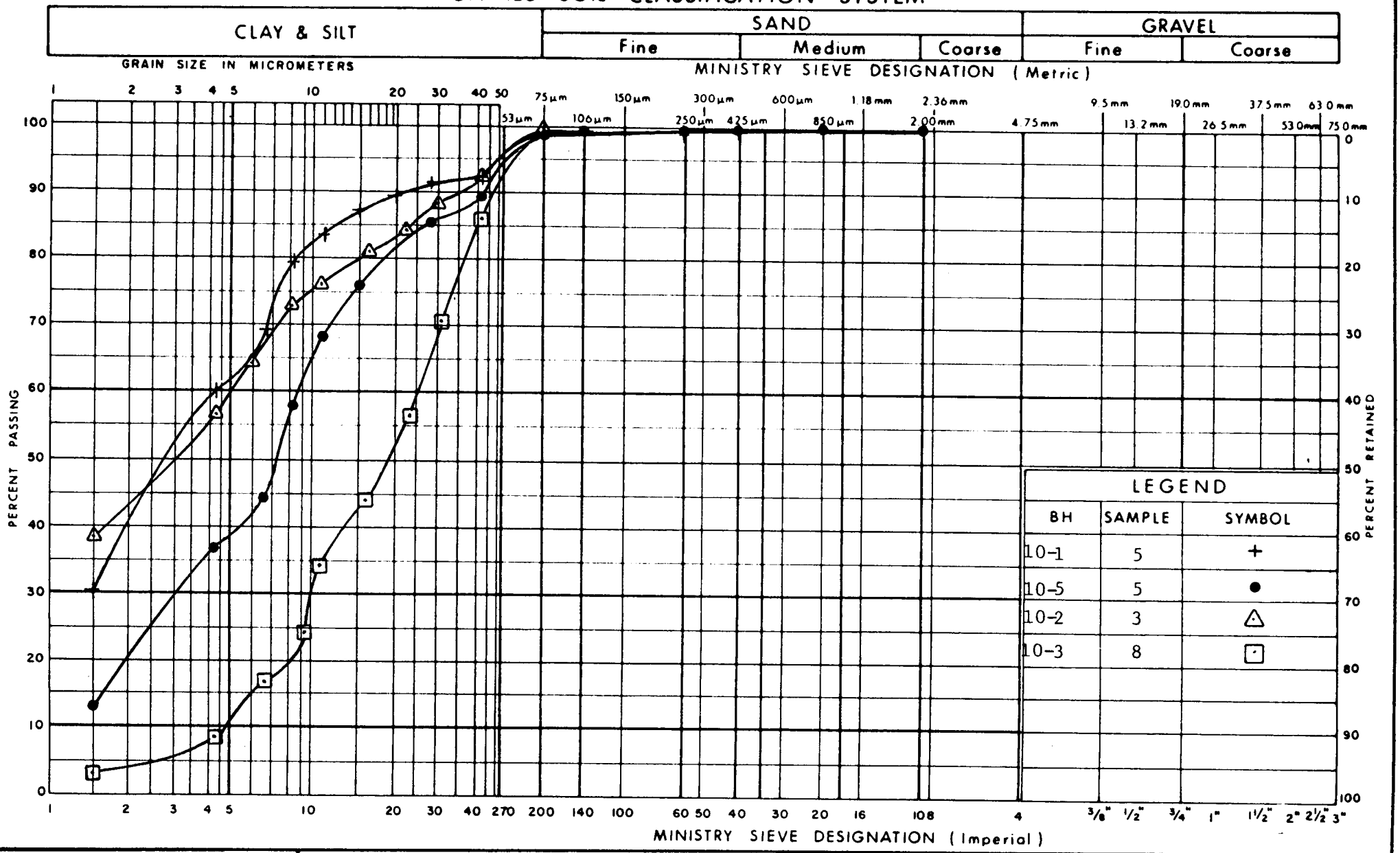
GRAIN SIZE DISTRIBUTION

Silty Sand

FIG No B1

W P 372-89-04

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

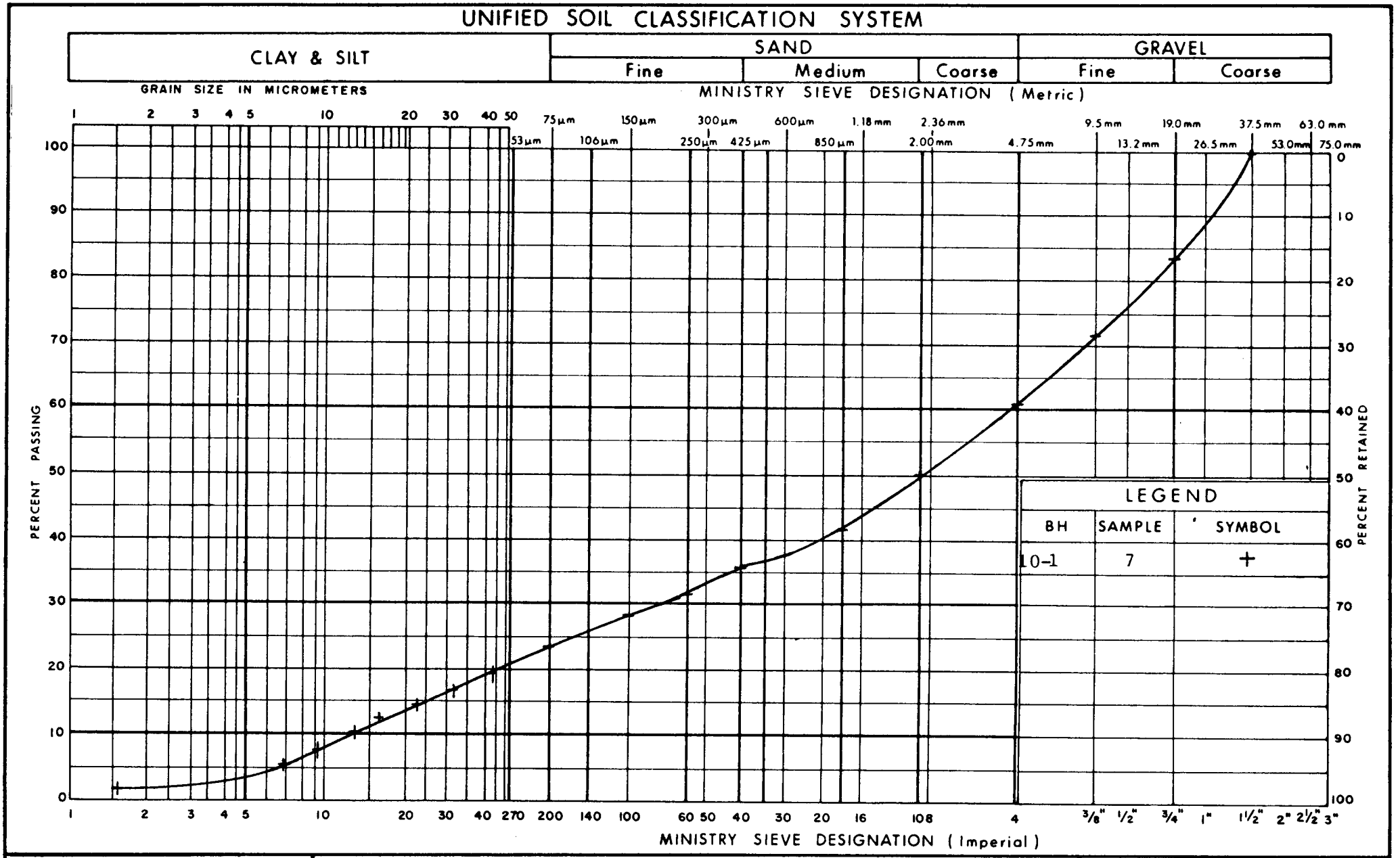
GRAIN SIZE DISTRIBUTION

Silty Clay

FIG No B2

W P 372-89-04

78 12 M



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Ontario

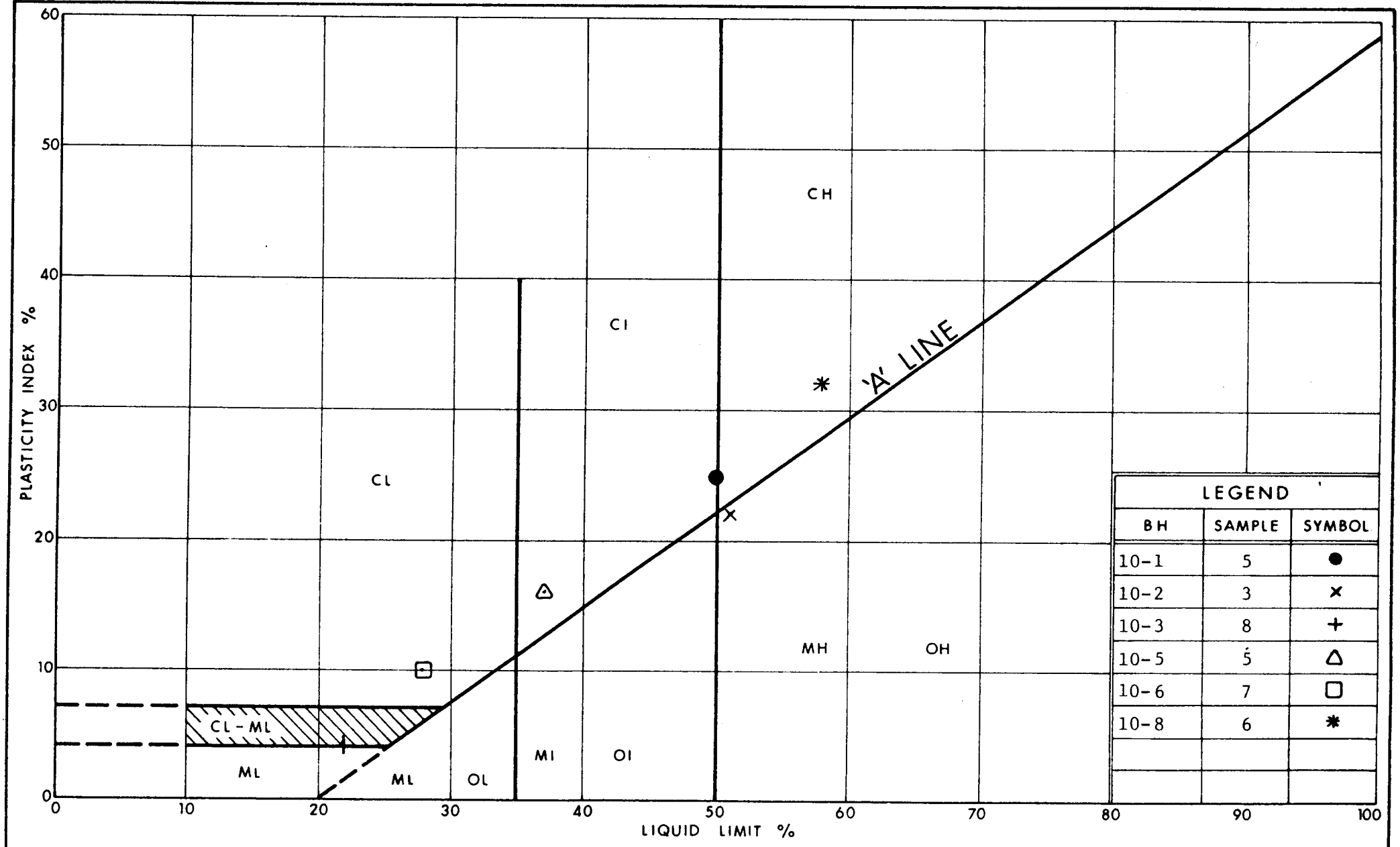
GRAIN SIZE DISTRIBUTION

Sand and Gravel (Glacial Till)

FIG No B3

W P 372-89-04

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
10-1	5	●
10-2	3	×
10-3	8	+
10-5	5	△
10-6	7	□
10-8	6	✱

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Ontario

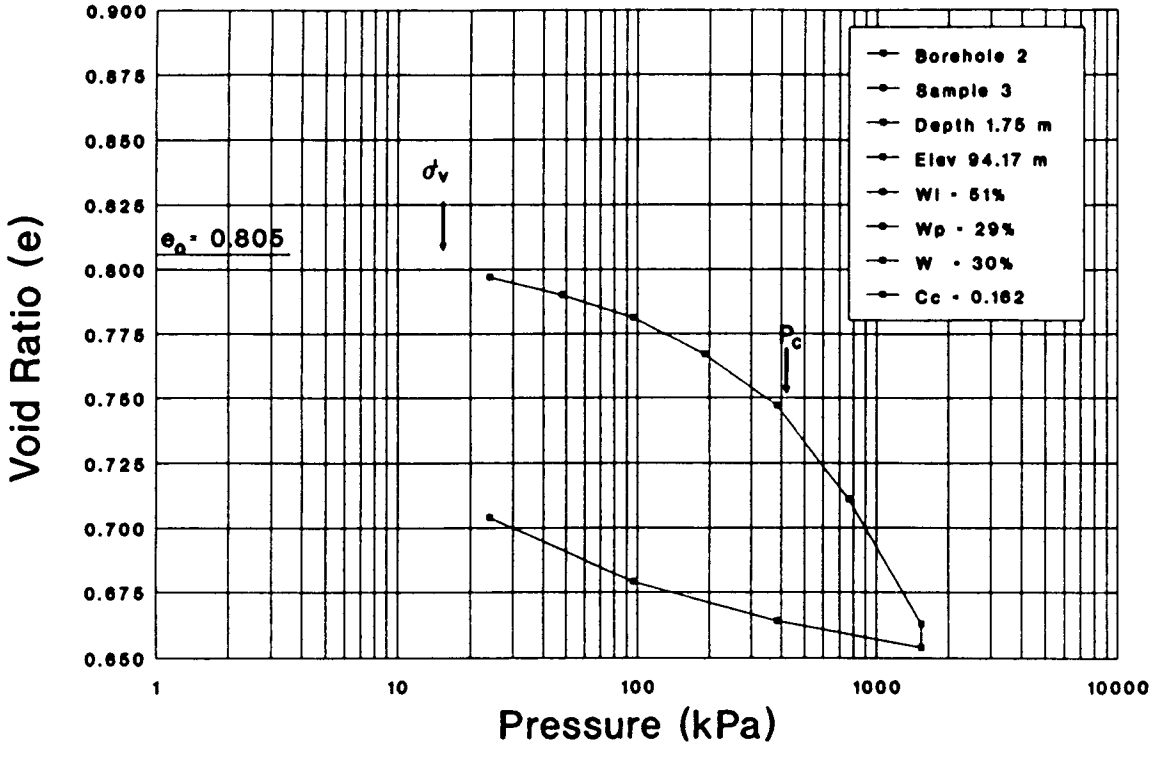
PLASTICITY CHART

Silty Clay (Varved)

FIG No B4

W P 372-89-04

VOID RATIO - PRESSURE CURVES



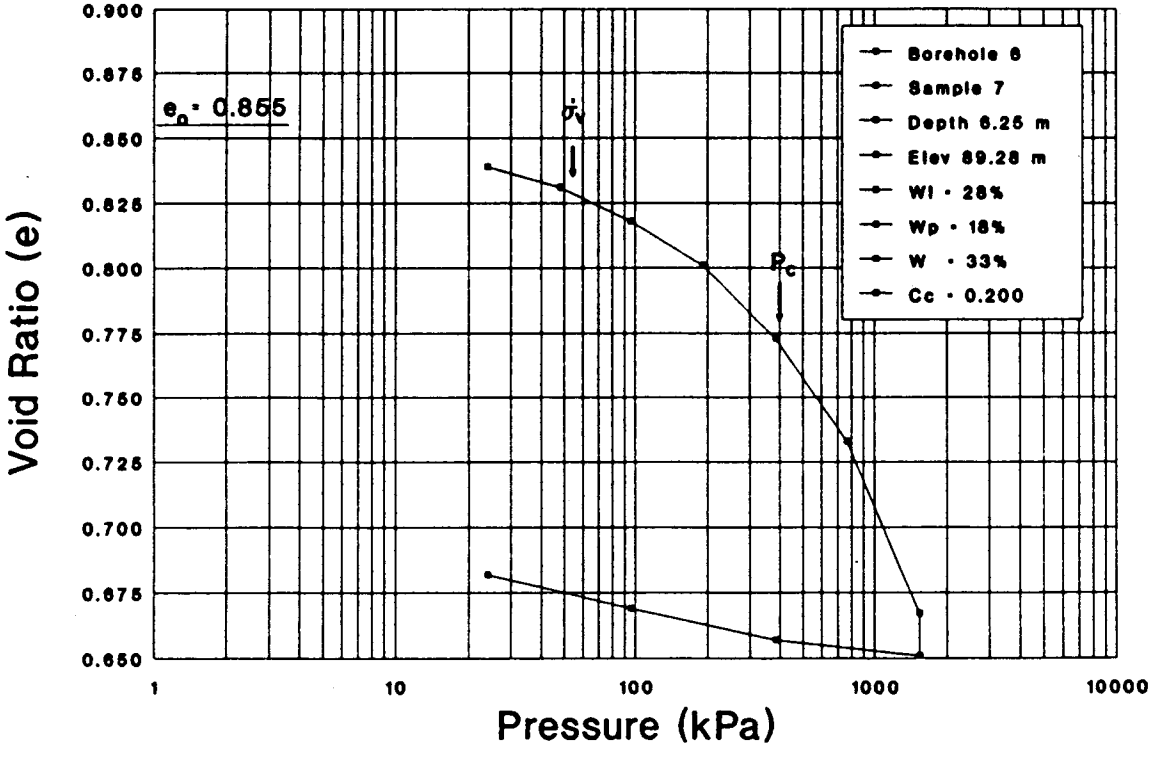
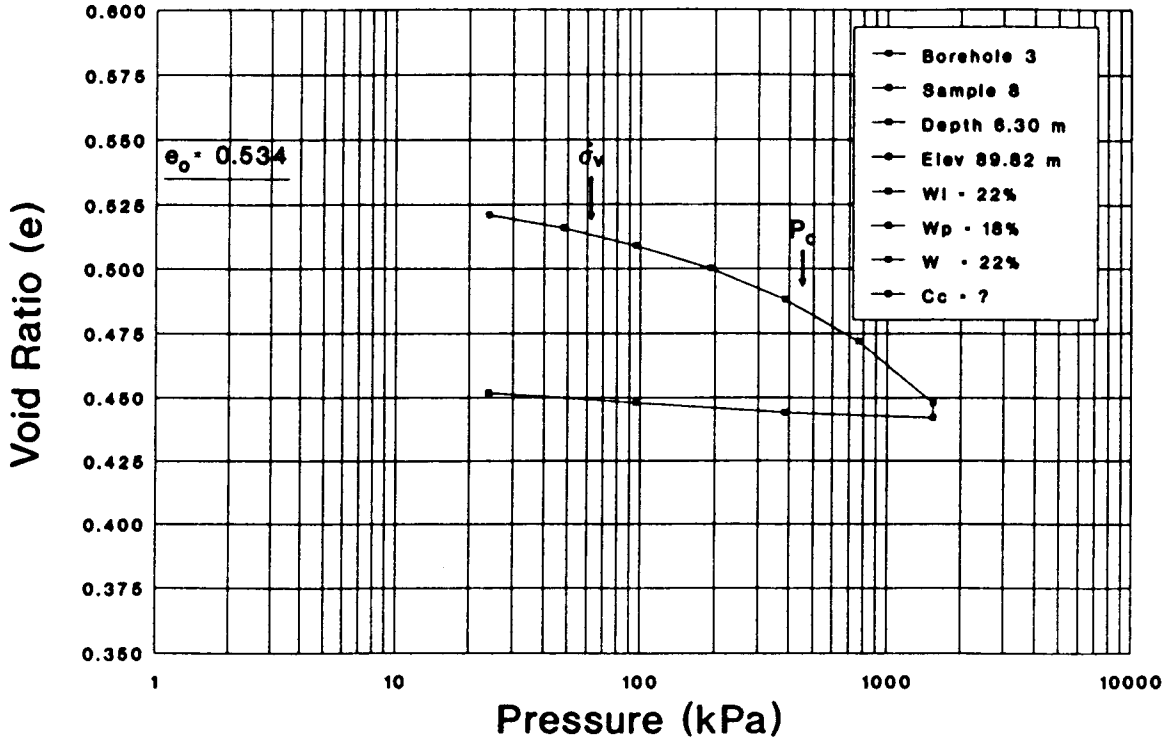


FIGURE B5

WP 372-89-04

VOID RATIO - PRESSURE CURVES



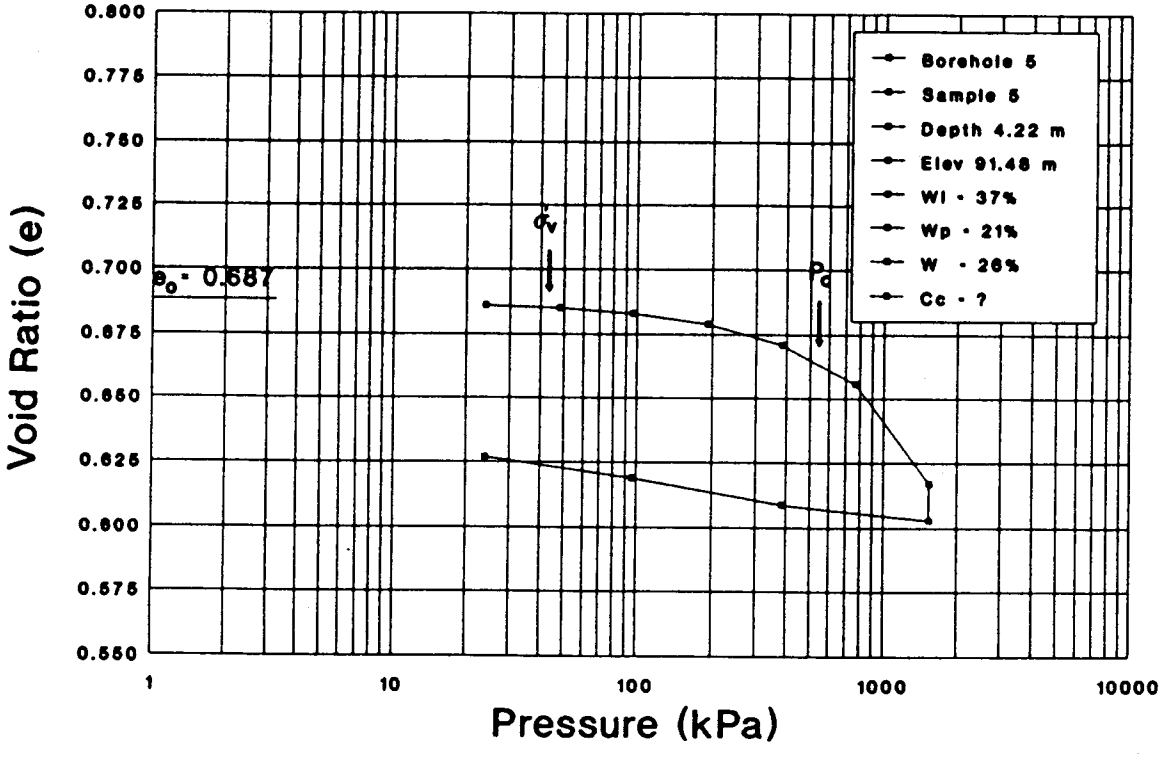


FIGURE B6 WP 372-89-04

APPENDIX B

TABLE 1

HWY 416 FOUNDATION PROGRAM - WP 372-89-00
STRUCTURE NO. 10 - CPR OVERHEAD
SUMMARY OF CONSOLIDATION TEST DATA

			Sample Locations		Loading Data			Compression Data			
Test #	BH	Sample #	Depth (m)	Elevation (m)	σ_v' (kPa)	Pc (kPa)	OCR	Cr	Cc	Cv m^2/yr	e_o
1	2	3	1.8	94.2	15	415	28	0.025	0.162	34.0	0.805
2	3	8	6.3	89.8	62	440	7	0.007	-	50.9	0.534
3	5	5	4.2	91.5	41	580	14	0.012	-	67.9	0.687
4	6	7	6.3	89.3	54	400	7	0.017	0.200	34.0	0.855

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

METRIC

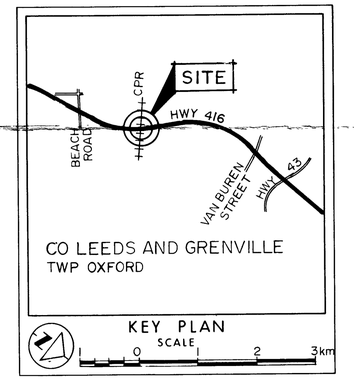
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN STATIONS IN KILOMETRES + METRES.

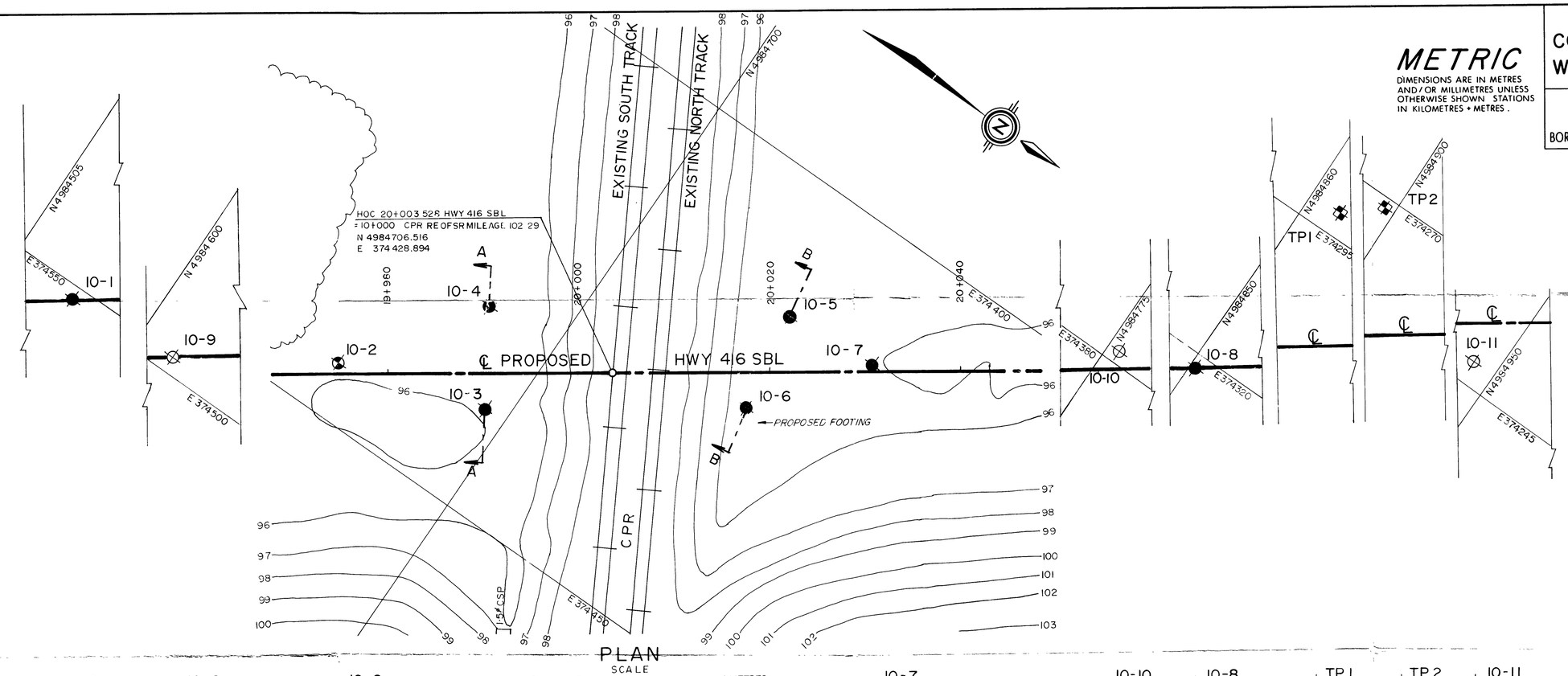
CONT No
WP No 372-89-04

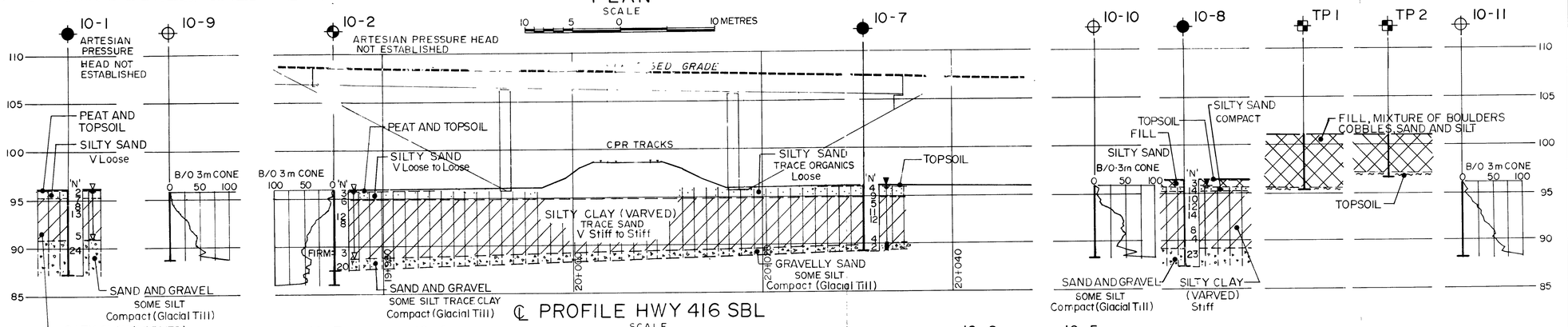
CPR OVERHEAD
(2.5 km SOUTH OF KEMPTVILLE)
BORE HOLE LOCATIONS & SOIL STRATA

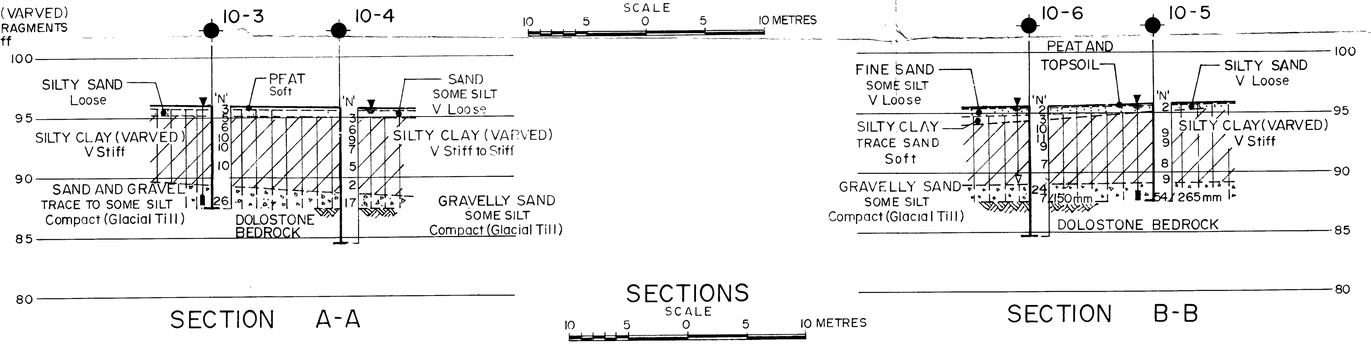
SHEET

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 Oct /Nov /91 Head / Artesian Water Encountered
- Piezometer
- Test Pit

No	ELEVATION	CO-ORDINATES NORTH	EAST
10-1	96.2	4984512.6	374551.3
10-2	96.1	4984682.3	374444.5
10-3	96.1	4984697.7	374439.8
10-4	95.8	4984692.1	374430.7
10-5	95.7	4984718.7	374413.5
10-6	95.5	4984720.2	374424.1
10-7	96.2	4984728.6	374412.8
10-8	96.5	4984850.6	374321.4
10-9	95.9	4984604.2	374498.4
10-10	96.0	4984776.2	374378.9
10-11	96.2	4984947.4	374242.7
TP1	101.5±	4984863.5	374292.5
TP2	101.5±	4984899.0	374271.0

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

REGISTERED PROFESSIONAL ENGINEER L. HOUSEE PROVINCE OF ONTARIO

Geocres No 31G-208

HWY No 416 SBL			DIST 9
SUBM'D NK	CHECKED NK	DATE 1991 08 26	SITE 16-193
DRAWN MCZ	CHECKED RB	APPROVED	DWG 3728903-A

REF No E-53-416-2, 91-04

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 97-19

Ontario

Ministry of Transportation

INDEX

Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above-mentioned project.

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

T11688A

REPORT TO

FENCO ENGINEERS INC.
WILLOWDALE ONTARIO

HIGHWAY 416
KEMPTVILLE ONTARIO
FOUNDATION INVESTIGATION
PROPOSED COUNTY ROAD 44 UNDERPASS
WP 372-89-02; Site 16-315
DISTRICT 9, KINGSTON

GEOCON (1991) INC.
December, 1991

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, approach fills and Highway 44 realignment. Geocon (1991) Inc. (Geocon) was retained by Fenco Engineers Inc. to perform this work.

The field work for this project was conducted between November 12th and November 14th, 1990 using a CME 55 drill rig equipped with 200 mm diameter hollow stem augers. The investigation consisted of 5 boreholes of depths ranging from 3.5 m to 11.5 m. The soil overburden was augered then sampled using the Standard Penetration Tests (SPT) and the underlying bedrock was cored in NXL size. Two standpipe piezometers were installed to monitor the groundwater levels.

The locations of the boreholes are shown on Drawing 3728902-A.* A record of the encountered subsurface conditions at each borehole and the single test pit, are given on the Record of Borehole Sheets in Appendix A.

* Dwg. No. 2, Sheet 265, of the Contract Drawings.

2.0 SITE DESCRIPTION AND GEOLOGY

The proposed Highway 44 underpass is located just south of the intersection of Highway 44 and Highway 16 approximately 5 kilometers 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 4.0 to 6.0 m in height. The proposed underpass will traverse Highway 416 at a skewed angle trending southeast to northwest. The proposed east span of the underpass straddles the existing Highway 16 which is contained within a 3 m deep rock cut.

The proposed interchange is located on a bedrock high with bedrock outcrops at many locations. Based on site mapping of existing soil and rock cuts, the underlying bedrock gives way to glacial till deposits to the north near the intersection of County Road 44 and Highway 16. East of Highway 16 the site is typically grassland with some trees. The ground surface is undulating and generally slopes towards the south. To the west of Highway 16 the ground slopes towards the northwest and is densely covered with large trees. In the northwest quadrant of the proposed interchange a low lying poorly drained area with standing surface water may be found.

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 comprises 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 only resulted 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 geology information (OGS Map 2387) indicates that the site is located on a bedrock outcrop of massive grey dolostone known as the Oxford Formation of the Beekmonton Group. The bedrock is overlain by a wave washed pebbly sandy layer generally less that 1 m thick (Sharpe 1979).

3.0 SUBSURFACE CONDITIONS

3.1 General

The subsurface conditions at the site of the proposed underpass are characterized generally by a thin cover of overburden overlying bedrock. However, between the proposed location of the central pier and west abutment the bedrock is deeper with corresponding thicker overburden.

The factual information which was used to interpret the soil conditions is given in Appendix A and B and Drawing No. 3728902-A.* A summary of borehole depths and elevations is given in Table 1 of Appendix A. The subsurface conditions encountered within the proposed underpass area are described below:

3.2 Topsoil and Peat

A thin surficial layer of topsoil and peat, of up to 0.2 m in thickness, was encountered within the underpass area. However, peat thicknesses of up to 0.8 m were encountered at the location of the proposed western ramps.

3.3 Silty Sand to Sandy Silt and Sandy Gravel

Underlying the topsoil and peat is a thin layer of cohesionless material. This stratum consists of 0.5 m to 1.0 m of sandy silt with some gravel and occasional cobbles at the east abutment, about 0.4 m of gravelly sand some silt at the central pier, and 1.0 m of

* Dwg. No. 2, Sheet 265, of the Contract Drawings.

silty sand with trace gravel, which in turn overlies 0.5 m of sandy gravel with some silt, at the west abutment.

3.4 Clayey Silt

The cohesionless stratum is underlain by a layer of grey clayey silt with trace to some sand, at the west abutment location only and ranged from 1.4 to 2.5 m in thickness. Based on the results of two grain size analyses performed on split spoon samples (Figure B2) the material may be described as clayey silt with trace to some sand.

SPT 'N" values within this layer vary from 20 to 31 inferring a strata of very stiff to hard consistency.

Atterberg Limits tests performed on two soil samples indicate the liquid limit to range from 27 to 29%, with plastic limits and natural water contents of 17% for both samples.

3.5 Glacial Till

Glacial till was encountered below the clayey silt layer at the west abutment location and ranged from 0.6 to 0.9 m in thickness. Based on a single grain size analysis the till may be described as a sand and silt with trace to some gravel and trace clay. SPT 'N' values within the layer ranged from 78 to refusal inferring a very dense stratum.

A single moisture content of 11% was determined for this layer.

3.6 Bedrock

Dolostone bedrock was encountered at about El. 109.0 m at the east end of the proposed underpass and dips to El. 103.4 m at the western end. These elevations are equivalent to about 0.6 m to 5.0 m below existing ground surface, respectively. The bedrock was proven in all five boreholes by coring from 2.9 m to 6.3 m into dolostone. The bedrock is judged by core recovery and RQD percentages, to be of good quality. However, at Borehole 8-3, the bedrock was of very poor to fair quality. Borehole 8-3 is located adjacent to the existing Highway 16 road cut. The lower rock quality at this location may in part be the result of blasting activities during excavation of the cut.

The bedrock is of dark grey fine to medium dolostone, characterized by very tight, very closely spaced to close spaced thin shale interbeds. In addition, randomly located oval shaped discontinuous vugs are present. Unconfined compressive strength tests performed on selected core samples indicate compressive strengths ranging from 49 MPa to 139 MPa.

3.7 Groundwater

Groundwater elevation was measured by means of two standpipe piezometers installed in Boreholes 8-1 and 8-4 at the east and west abutments, respectively. The groundwater levels were measured approximately 18 days after installation of piezometers and were observed to be at El. 106.6 m (2.7 m below ground surface) at Borehole 8-4 and El. 107.3 m (1.7 m below ground surface) at Borehole 8-1. Groundwater levels could be expected to vary seasonally.

5.0 CLOSURE

The field work portion for the investigation was done under the supervision of Mr. G.C. Yule. 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

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Geocon (1991) Inc. (consulting geotechnical engineers for this project), and signed and sealed by N. Khan, P.Eng. and I. Holubec, Ph.D., P.Eng. The project was carried out under the technical supervision of Fenco Engineers Inc., the supervising consultant for this project.

D. Dundas, P. Eng.
Senior Foundation Engineer

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

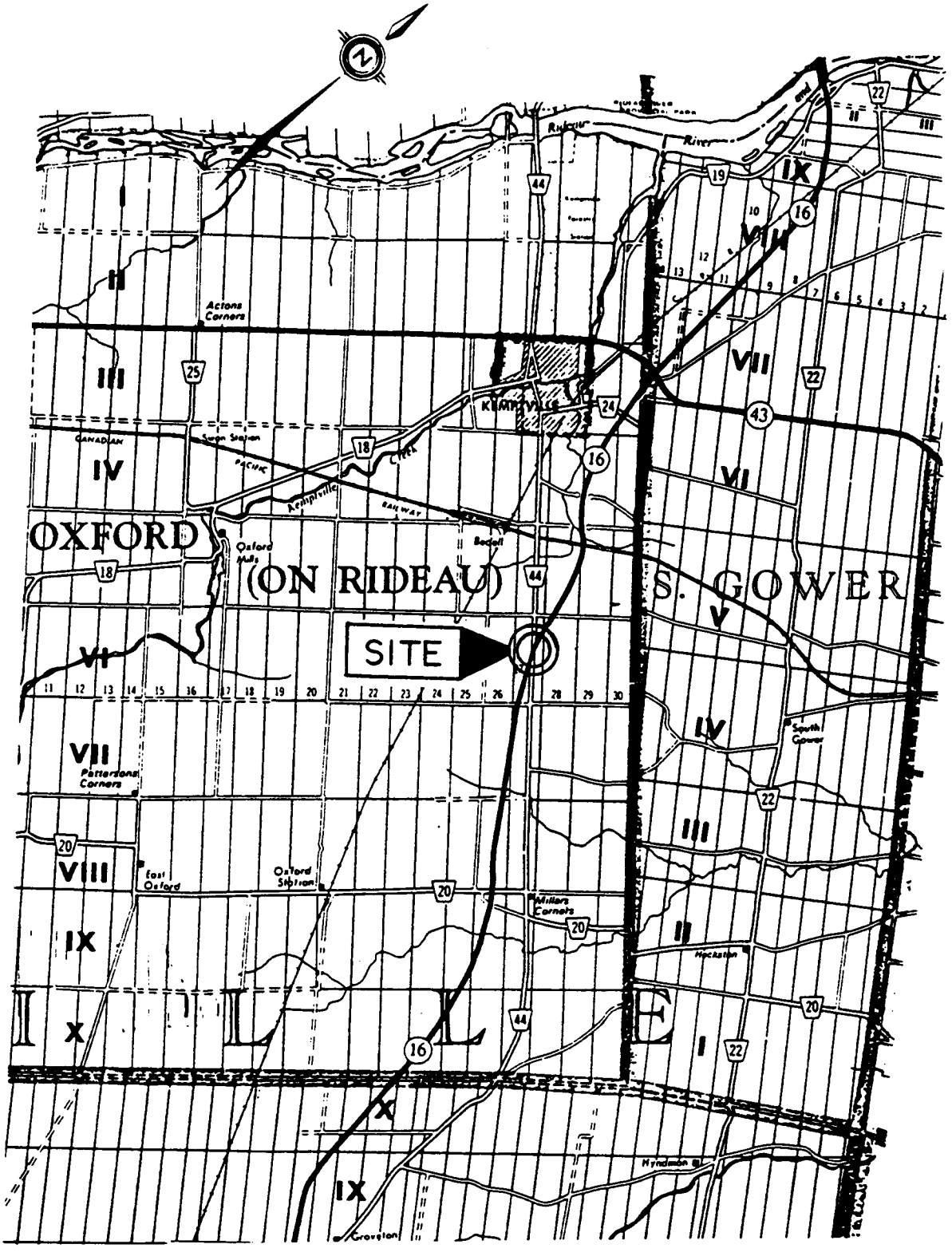
Canadian Foundation Engineering Manual, 1985. Second Edition. Part 1: Fundamentals; Part 2: Shallow Foundations; Part 3: Deep Foundations; Part 4: Excavations and Retaining Structures Part 5: References. Canadian Geotechnical Society, Technical Committee on Foundations, 456 pp.

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 372-89-02



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GEOCON

APPENDIX A

Borehole Information

Explanation of Term Rock Quality Designation (RQD)
Table 1 - Summary of Borehole Information
Record of Borehole Sheets (Boreholes 8-1 to 8-5)

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.

TABLE 1

HIGHWAY 416 - FOUNDATION INVESTIGATION
COUNTY ROAD 44 UNDERPASS
SUMMARY OF BOREHOLE INFORMATION

Borehole No.	Borehole Location		Borehole Details					Piezometer Details	
	Station km + m	Offset (m)	Ground Surface Elevation (m)	Total Depth (m)	Overburden Depth (m)	Bedrock Surface Elevation (m)	Depth of Bedrock Drilled (m)	Tip Elevation (m)	Groundwater Elevation (m)
8-1	10+026.7	3.5 Right	108.5	11.4	5.0	103.4	6.3	97.1	106.6
8-2	10+026.6	3.1 Left	108.4	6.9	3.7	104.7	3.1	Not installed	
8-3	9+976.9	0.0	109.7	3.5	0.6	109.1	2.9	Not installed	
8-4	9+927.3	3.4 Right	110.0	4.0	1.1	108.9	2.9	106.9	107.3
8-5	9+926.9	3.4 Left	109.5	6.9	0.7	108.8	6.3	Not installed	

Notes:

1. Station values refer to those of the proposed County Road 44 re-alignment.
2. For more detailed borehole information refer to the Record of Borehole Sheets.
3. Groundwater elevations were recorded on December 4, 1990.
4. Quoted elevations are geodetic.

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 8-1 METRIC

W P 372-89-02 LOCATION Co-ords: 4,982,678.7 N; 374,923.5 ORIGINATED BY N.K.

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

DATUM Geodetic DATE November 12 and 13, 1990 CHECKED BY I.C.

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 (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
108.5	Ground Surface										
0.0 / 108.2	Black Fibrous Peat						108				
0.2 / 107.4	Silty Sand, fine Trace Gravel Brown										
1.1 / 106.9	Sandy Gravel, Some Silt Brown										
1.6 / 104.4	Clayey Silt. Some Sand Very Stiff to Hard Grey		1	SS	20		Bentonite Seal 106				
			2	SS	31						2 16 66 16
4.1 / 103.4	Silty Sand. Some Gravel, trace clay (Glacial Till) Very Dense Grey		3	SS	78 Recs		104				
5.1	Dolostone Dark Grey Fine to medium grained with closely to moderately spaced thin (1mm) black shale interbeds. Core readily breaks along the shale interbeds to expose a smooth, highly irregular interface. Vugs with calcite crystals at: 6.3m; 6.4m; 6.6m; 6.7m; 8.8m; 9.1m; 10.1m. Vugs are generally small with some contained wholely within the dimensions of the core. Small discontinuous solution cavities between 8.7 - 8.8 m.		4	RC NXL	100			RQD% 0			
			5	RC BXL	100		102	97			UCS = 139MPa
			6	RC BXL	100		Backfill 98				
			7	RC BXL	100		100	100			UCS = 49MPa
			8	RC BXL	93		98	93			
97.1							Piezometer				
11.4	End of Borehole Water level in piezometer measured at elevation 106.56m on December 4, 1990. * Denotes unconfined compression strength										

+3, ×5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 8-2

METRIC

W P 372-89-02 LOCATION Co-ords: 4,982,672.9 N; 374,920.3 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE November 13, 1990 CHECKED BY I.C.

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						
108.4	Ground Surface										
0.00 / 108.2	Black Fibrous Peat					Not Noted	108				
0.2 / 107.2	Sand, medium. Some Silt Red/Brown										
1.2 / 106.7	Sandy Gravel Loose Brown		1	SS	31						0 4 83 13
1.7 / 105.3	Clayey Silt, Trace Sand Hard Grey						106				
3.1 / 104.7	Sand and Silt. Tr Gravel, Tr Clay (Glacial Till) Very Dense Grey		2	SS	40/ Rec%	150 mm		RQD%			8 45 43 4
3.7 / 101.5	Dolostone Dark Grey Fine to medium grained with closely to moderately spaced thin (1mm) black shale interbeds. Core breaks readily along the shale interbeds to expose a smooth highly irregular surface		3	RC BXL	98		104	98			
			4	RC BXL	57		102	57			
6.9	End of Borehole										

Note:

Core lost down the borehole at the end of the second core run due to malfunctioning retainer spring.

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 8-3 METRIC

W P 372-89-02 LOCATION Co-ords: 4,982,651.1 N; 374,965.1 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Washboring, BXL Rock Core COMPILED BY N.K.

DATUM Geodetic DATE November 12, 1990 CHECKED BY I.C.

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 W_L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
109.7	Ground Surface										
0.00 / 109.5	Topsoil Black					Not Noted					
0.2 / 109.1	Gravelly Sand, Some Silt Brown				Rec%			RQD%			
0.6	Dolostone Dark Grey Fine to medium grained highly fractured. Reddish brown staining on sub-vertical fractures. Between 1.2m and 1.5m core has many small discontinuous solution cavities. Rock becoming sound at 2.6m.		1	RC BXL	82			0			
			2	RC BXL	100		108	22			
			3	RC BXL	100			52			
106.2	13mm diameter Vug infilled with calcite at 3.4m.										
3.5	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

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

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 8-4 METRIC

W P 372-89-02 LOCATION Co-ords: 4,982,629.7 N; 375,010.0 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Washboring, BXL Rock Core COMPILED BY N.K.

DATUM Geodetic DATE November 14, 1990 CHECKED BY I.C.

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 ○ 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
110.0	Ground Surface										
0.0 / 109.8	Silty Sand Topsoil						100				
0.2 / 108.9	Sandy Silt. Some Gravel, occasional cobble. Brown				Rec%		Bentonite Seal	RQD%			
1.1	Dolostone Dark Grey Fine to medium grained, with closely spaced thin (1mm) shale interbeds. Core breaks readily along the shale interbeds to expose a smooth highly irregular surface. Joint infilled with Sand at 1.8m.		1	RC BXL	96		108	67			
106.0			2	RC BXL	101		Backfill 106	95		UCS = 49MPa	
4.0	End of Borehole Water level in piezometer measured at elevation 107.3m on December 4, 1990.						Piezometer				

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 8-5 METRIC

W P 372-89-02 LOCATION Co-ords: 4,982,623.5 N; 375,006.9 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Washboring, BXL Rock Core COMPILED BY N.K.

DATUM Geodetic DATE November 14, 1990 CHECKED BY I.C.

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 (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
109.5	Ground Surface										
0.0	Silty Sand Topsoil					Not Noted					
109.3 0.2 108.8	Sandy Silt, Some Gravel Occasional Cobble Brown				Rec%			RQDZ			
0.7	Dolostone Dark Grey		1	RC BXL	75			0			
	Fine to medium grained with very close to closely spaced thin (1mm) shale interbeds. Core breaks readily along shale interbeds to expose a smooth, highly irregular surface.		2	RC BXL	89		108	83			
	Rock is light Grey between 5.9 - 6.5 m.		3	RC BXL	100		106	100			
	Approximately 13mm diameter vugs with some calcite infilling at: 2.9m; 4.3m; 4.9m; 6.3m; 6.9m.		4	RC BXL	100			100			
102.6			5	RC BXL	97		104	97		UCS = 79MPa	
6.9	End of Borehole										
	* USC denotes unconfined compressive strength										

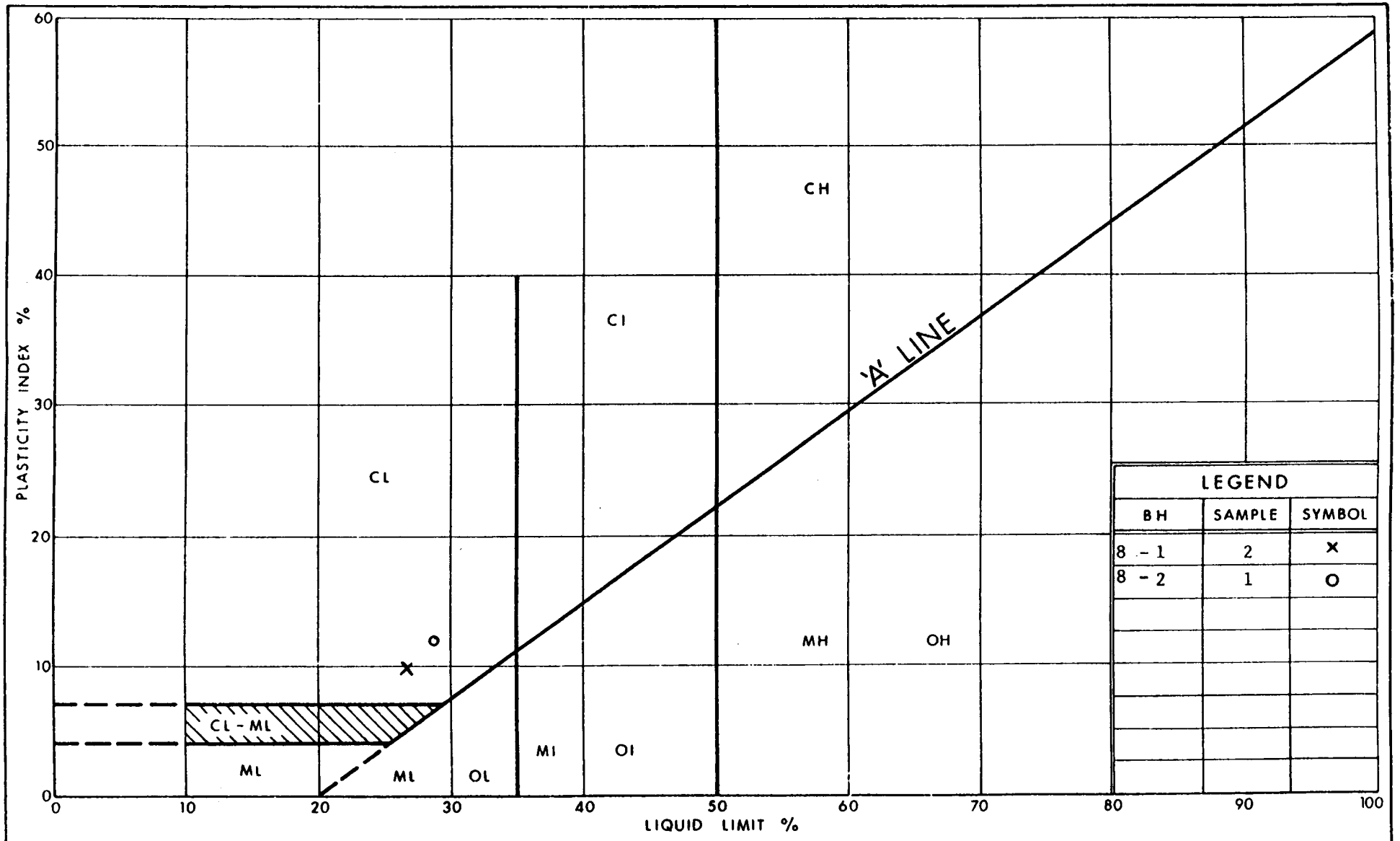
OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

APPENDIX B

Laboratory Test Data



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Ontario

PLASTICITY CHART

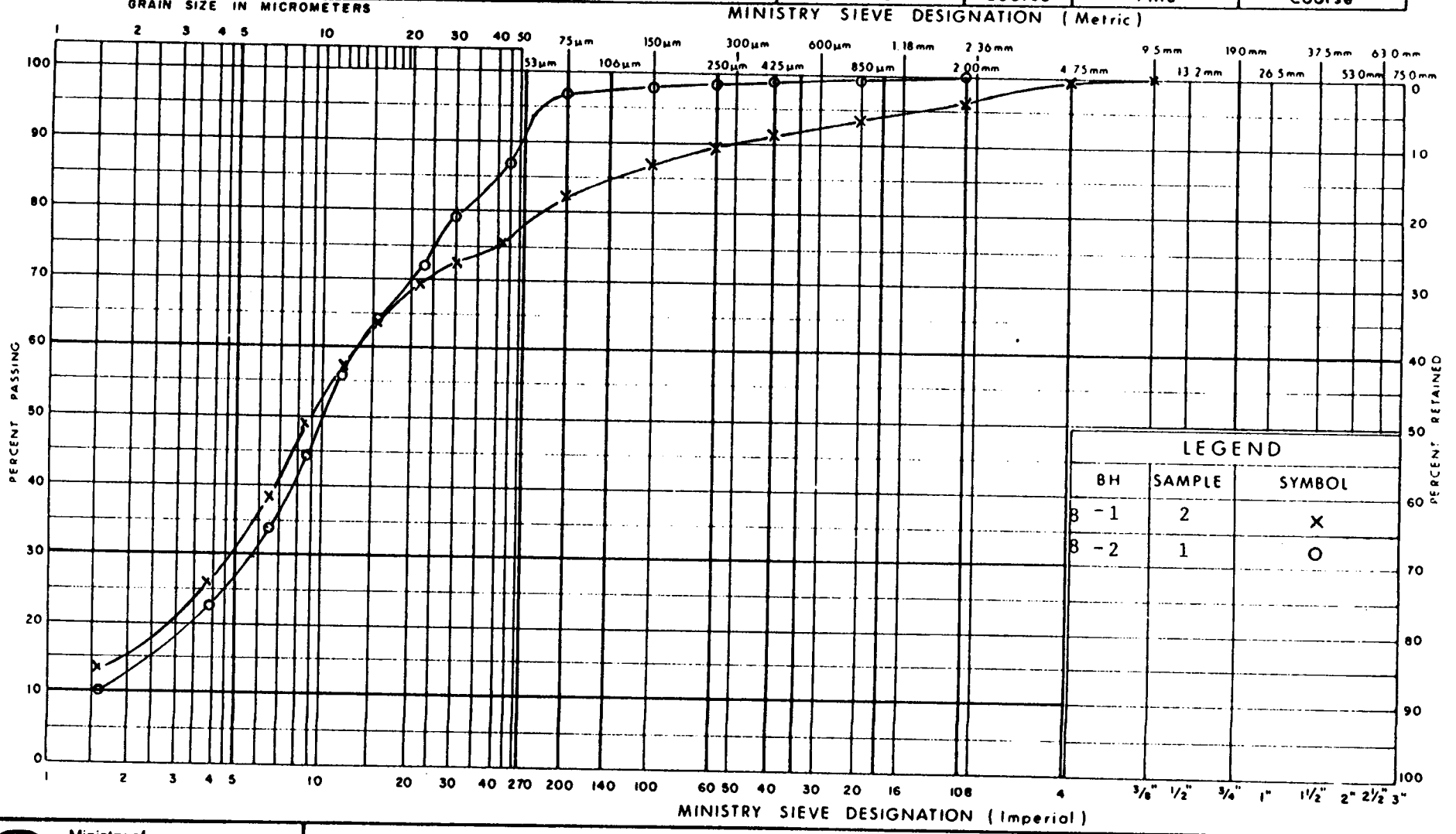
Clayey Silt

FIG No B1

W P 372-89-02

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



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Ontario

GRAIN SIZE DISTRIBUTION

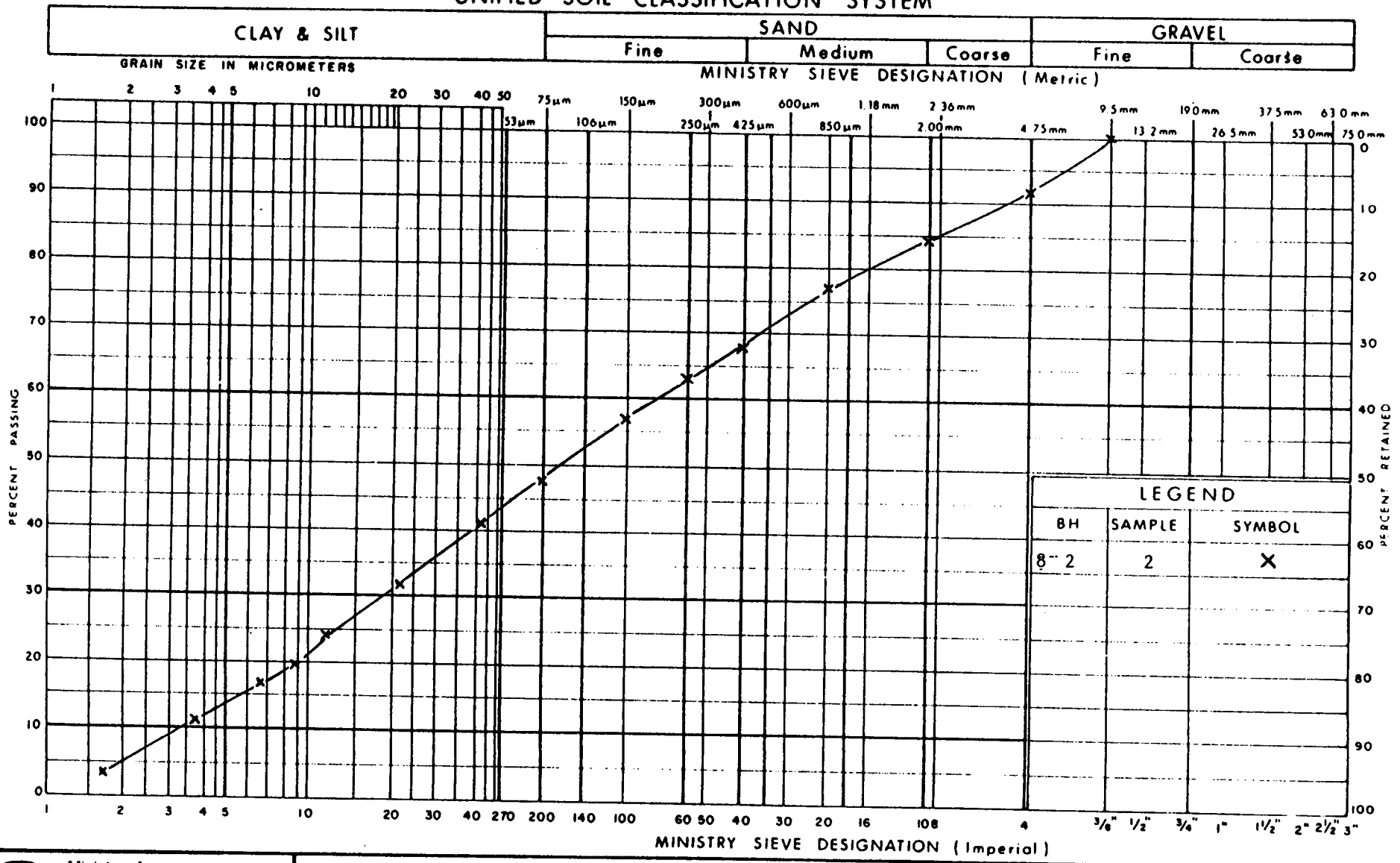
Clayey Silt, Trace to Some Sand

FIG No B2

W P 372-89-02

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

Glacial Till

FIG No B3

W P 372-89-02

27

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

GEOCON (1991) INC.
December, 1991

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.

* Dwg. No. 2, Sheet 287, of the Contract Drawings.

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.

* Dwg. No. 2, Sheet 287, of the Contract Drawings.

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.

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.

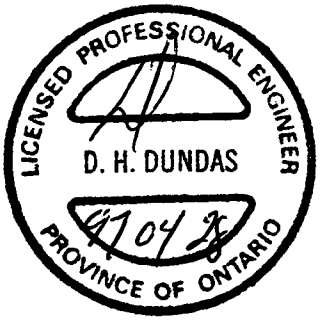
Yours very truly
GEOCON (1991) INC.

N. Khan, P.Eng.
Project Engineer

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

IH:dtj
T11688/15530

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Geocon (1991) Inc. (consulting geotechnical engineers for this project), and signed and sealed by N. Khan, P.Eng. and I. Holubec, Ph.D., P.Eng. The project was carried out under the technical supervision of Fenco Engineers Inc., the supervising consultant for this project.



D. Dundas, P. Eng.
Senior Foundation Engineer

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

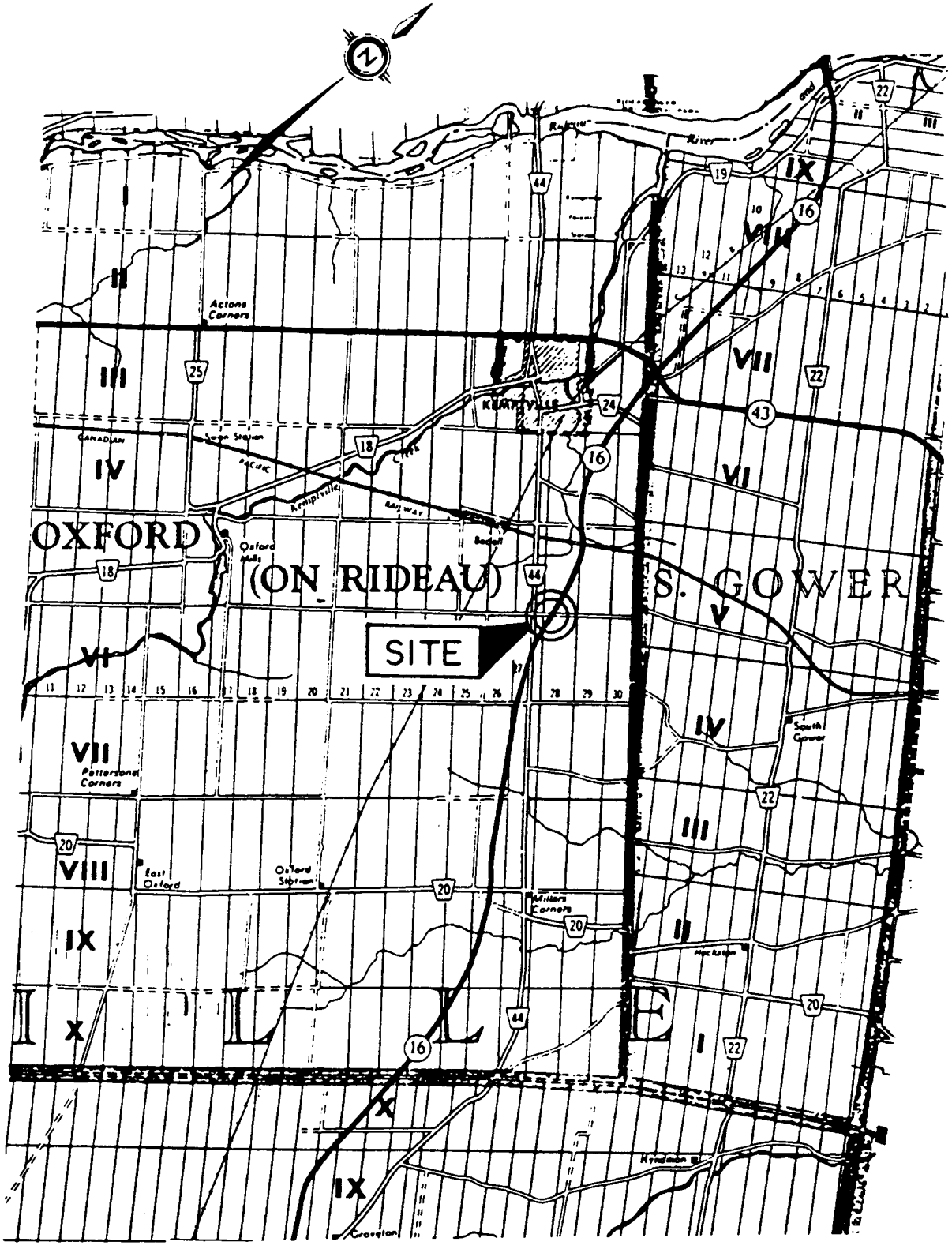
Canadian Foundation Engineering Manual, 1985. Second Edition. Part 1: Fundamentals; Part 2: Shallow Foundations; Part 3: Deep Foundations; Part 4: Excavations and Retaining Structures Part 5: References. Canadian Geotechnical Society, Technical Committee on Foundations, 456 pp.

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



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GEOCON

APPENDIX A

Borehole and Test Pit Information

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 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 / 0.0	Ground Surface										
	Topsoil										
104.9 / 0.1	Sand and Silt. Some Gravel, occasional Cobbles (Glacial Till)		1	SS	12	Dry					
			2	SS	31		104				
	Dense to Very Dense Brown		3	SS	51				○		22 40 38 0
102.4			4	SS	227/175mm				○		
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.

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 (○ 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
103.8	Ground Surface							20 40 60 80 100	10 20 30		
0.0 / 103.6	Topsoil Soft		1	SS	9						
0.2	Sand and Silt. Some gravel occasional cobbles (Glacial Till) Compact to Very Dense Brown		2	SS	68		Bentonite Seal		○		
			3	SS	72		102				
			4	SS	62*				○		15 44 41 0
99.9			5	SS	82/215mm		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	31			
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

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

OFFICE REPORT ON SOIL EXPLORATION

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.

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
103.6	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

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

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

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.

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 ○ 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
102.9	Ground Surface										
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				
			2	SS	65		102		○		
			3	SS	86/290mm				○		19 46 35 0
			4	SS	32/65mm						
			5	SS	53/140mm		100				
99.1							Backfill				
3.8	Gravelly Sandy Silt occasional cobbles and boulders (Glacial Till) Very Dense Grey		6	SS	36/150mm				○		
			7	SS	91		98				
			8	SS	61/275mm Rec%		Piezometer	RQD%	○		
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 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	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
101.7	Ground Surface										
0.0	Topsoil										
101.6 0.1	Sand and Silt. Some gravel occasional cobbles and boulders (Glacial Till) Very Dense Brown		1	SS	6	Not Noted			○		20 42 34 4
			2	SS	36/175mm						
			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 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
101.6	Ground Surface										
0.0	Topsoil										
101.5 / 0.1 / 100.8	Clayey Silt. Trace sand and gravel. Firm Brown		1	SS	4		Bentonite Seal				2 5 77 16
0.8	Sandy Silt. Trace clay trace to some gravel occasional cobbles (Glacial Till) Dense Brown		2	SS	31						
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	407 / 190mm		Backfill				
			5	SS	607 / 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.

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

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 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 W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
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		○		
			2	SS	36						
			3	SS	49						
			4	SS	91/225mm		100		○		
			5	SS	607/140mm						
98.4 / 3.8	Sand and Silt Some gravel, trace Clay Occasional cobbles and boulders (Glacial Till) Very Dense Grey		6	SS	877/265mm				○		19 39 37 5
98.1 / 4.1	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 9-8 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 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	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
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 (%) STRAIN AT FAILURE
10

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

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
101.3	Ground Surface										
0.0 / 101.1	Topsoil										
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.

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

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 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
100.4	Ground Surface										
0.0 / 100.2	Topsoil										
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*/ 80mm						
			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.		5	RC BX	Rec 57%			29			
			6	RC BX	Rec 100%		96	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

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

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

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	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPo; ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	WATER CONTENT (%) 10 20 30		GR SA SI CL
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						
			3	SS	50*/ 80mm		98		○		
			4	SS	45* 100mm						
			5	SS	10*/ 30mm						
95.7							96				
4.6	End of Borehole Auger Refusal <u>Note</u>: 00* Indicates SPT value based on the first 0.3m advanced. Full penetration not achieved.		6	SS	R*						

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 - %

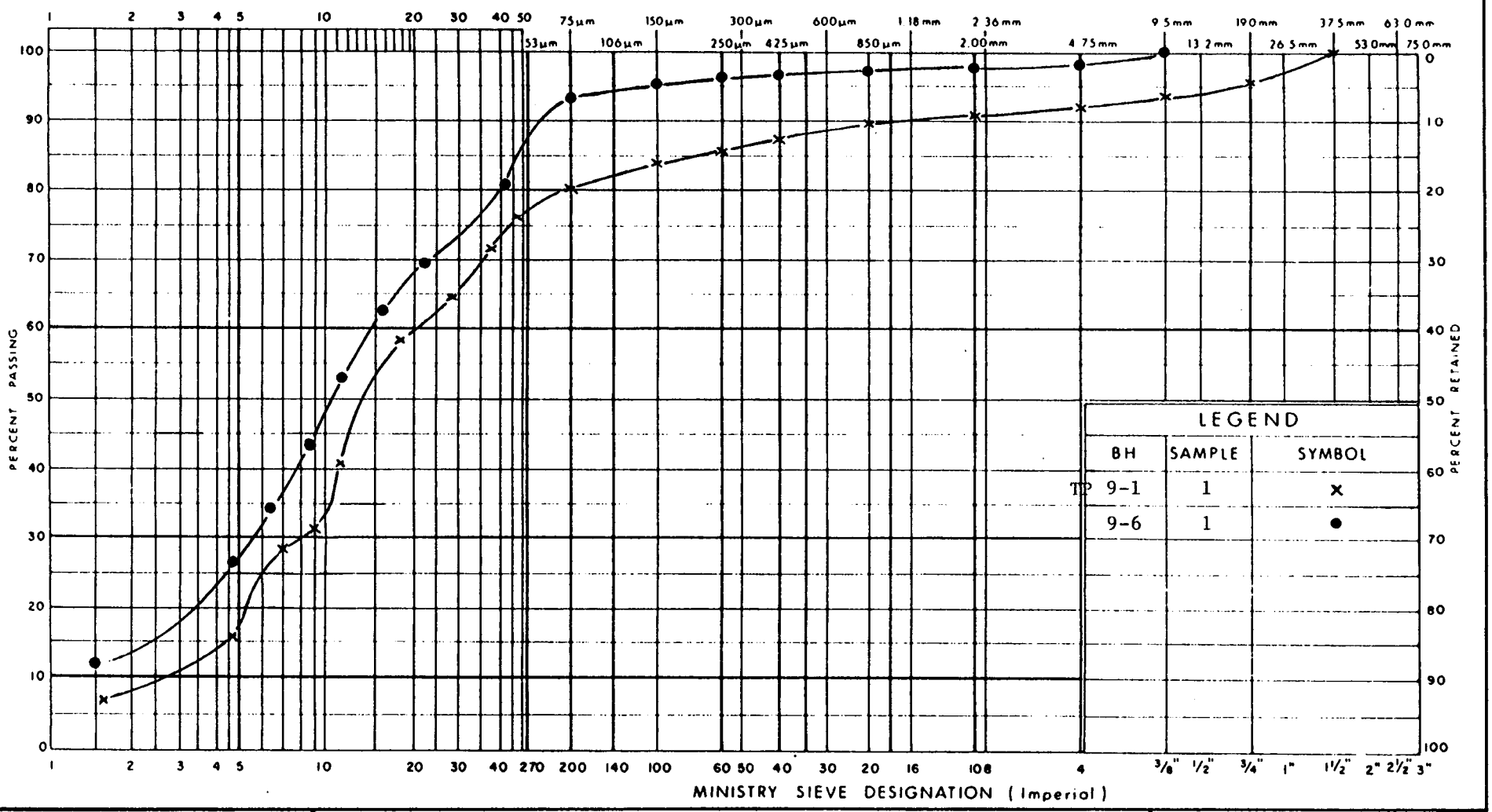
DEPTH - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	SAMPLES: CONDITION	SAMPLES: NUMBER	TESTS: RESULTS (Gr Sa Si Cl)
0.0	101.1	Ground Surface				
	0.0	Silty Sand Topsoil Dark Brown				
	100.6					
	0.5	Sand, Fine to Medium, Trace Silt Brown				
1.0	100.0					
	1.1	Clayey Silt, Some Sand Trace Gravel 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

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Ministry of Transportation and Communications
Ontario

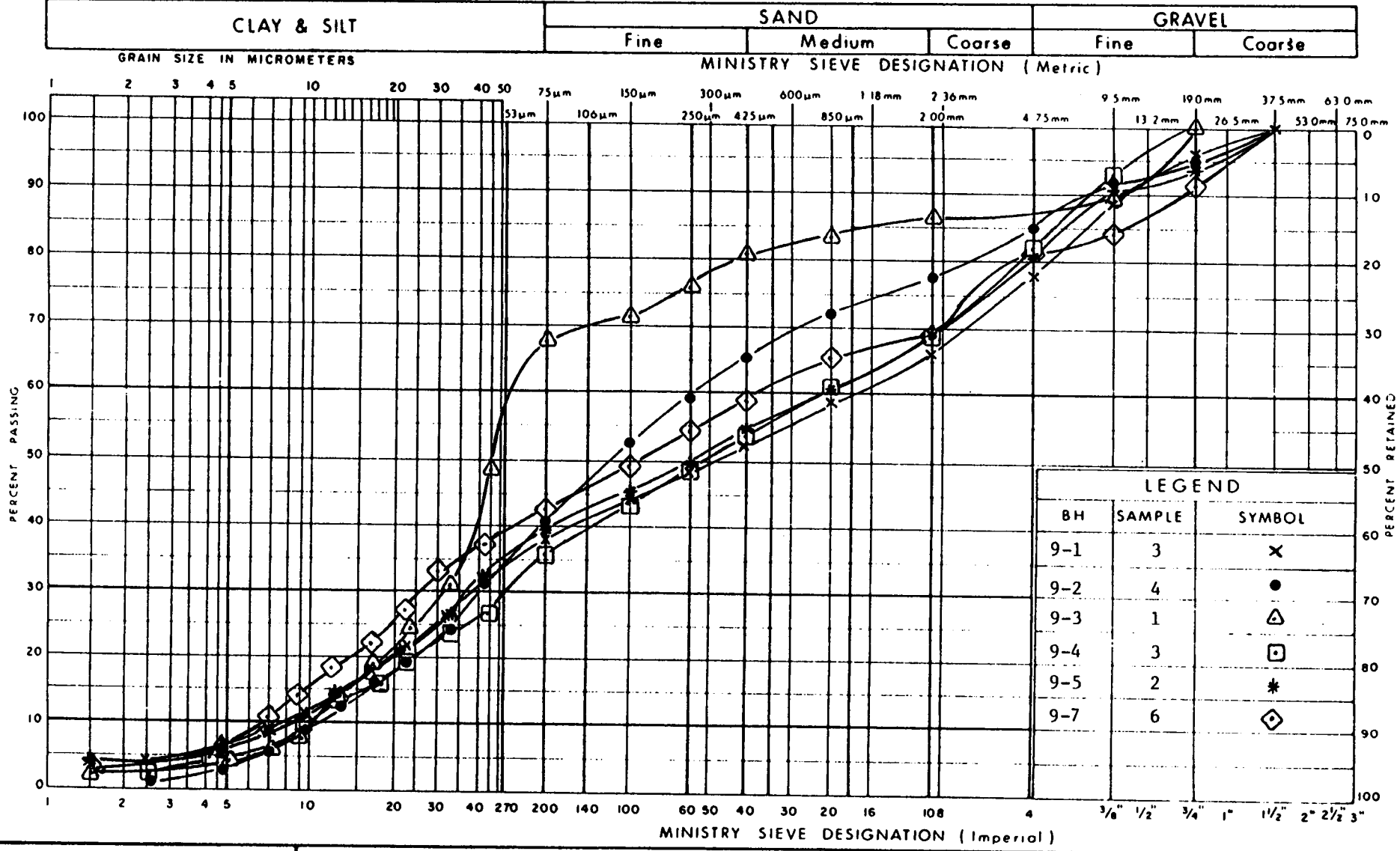
GRAIN SIZE DISTRIBUTION

Clayey Silt, trace sand and gravel

FIG No B1
W P 372-89-03

56

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

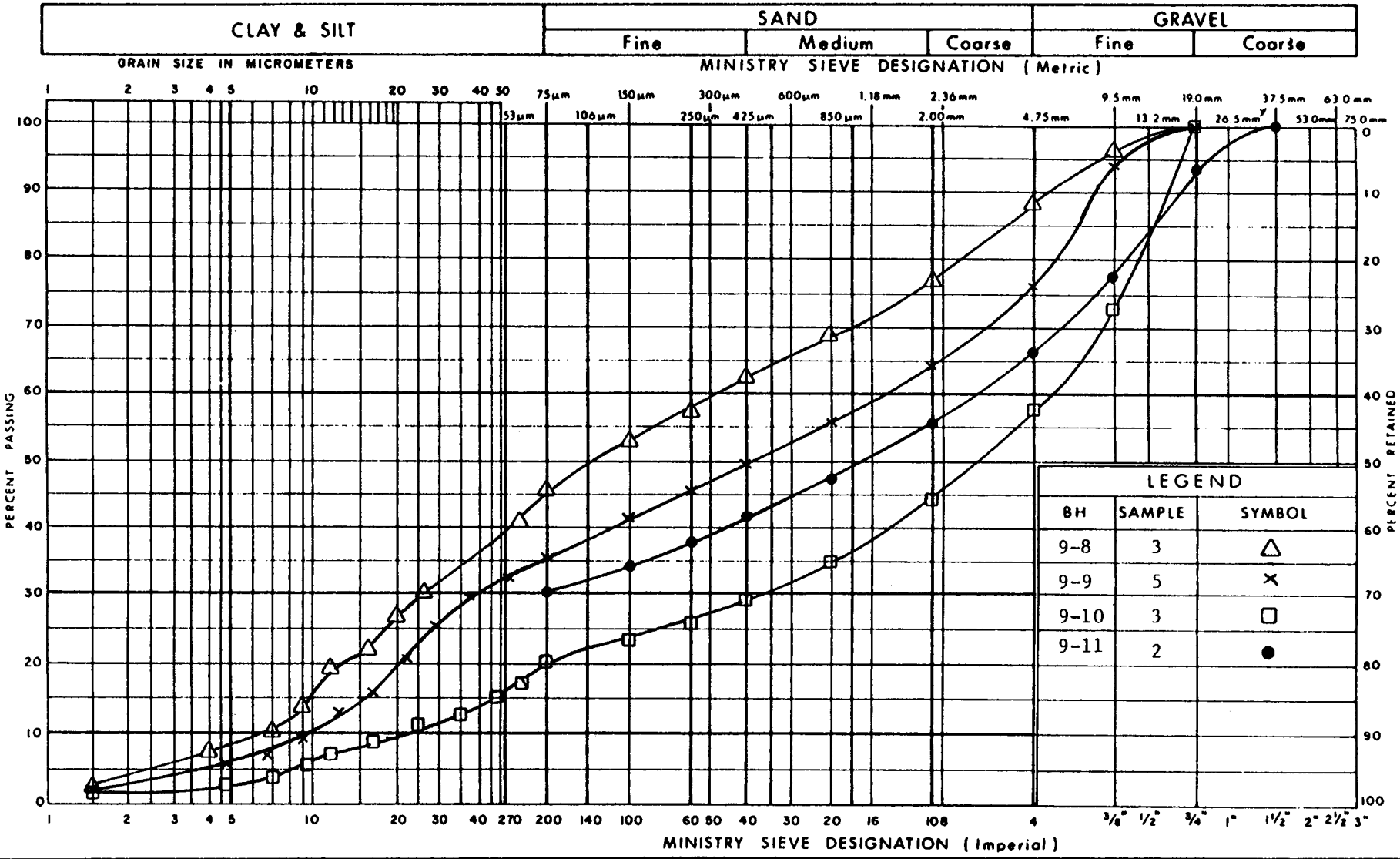
Glacial Till

FIG No B2

W P 372-89-03

57

UNIFIED SOIL CLASSIFICATION SYSTEM



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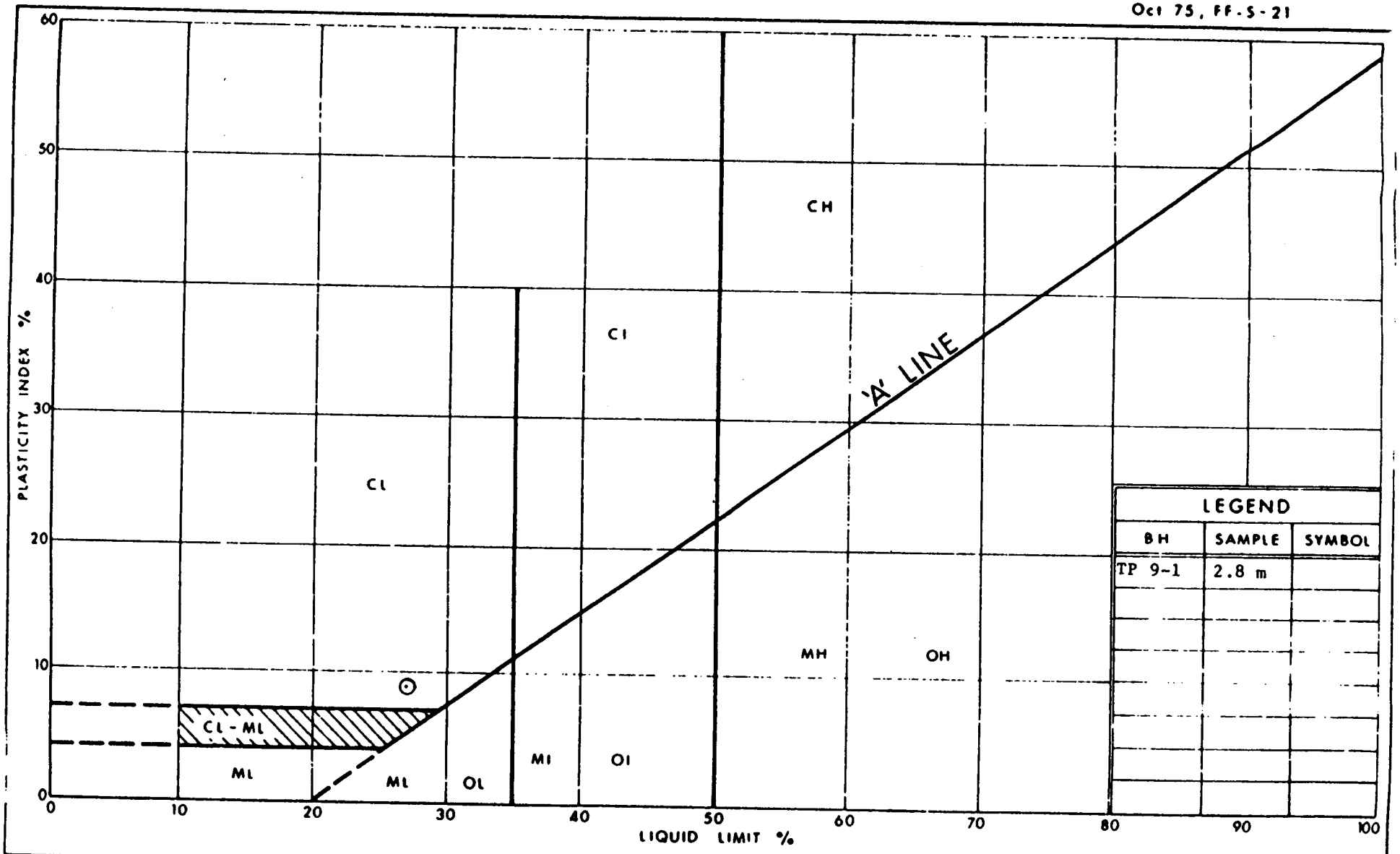
GRAIN SIZE DISTRIBUTION

GLACIAL TILL

FIG No B3

W P 372-89-03



LEGEND		
BH	SAMPLE	SYMBOL
TP 9-1	2.8 m	

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Ontario

PLASTICITY CHART

CLAYEY SILT

FIG No B4

W P 372-89-03

59

T11688D

REPORT TO

FENCO ENGINEERS INC.
WILLOWDALE ONTARIO

HIGHWAY 416
KEMPTVILLE ONTARIO
FOUNDATION INVESTIGATION
PROPOSED CPR OVERHEAD
(WP 372-89-04; Site 16-193)
DISTRICT 9, KINGSTON

GEOCON (1991) INC.
January, 1992

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 this project was conducted between October 18th and October 24th, 1990 using a CME 55 drill rig equipped with 200 mm diameter hollow stem augers. The investigation consisted of 11 boreholes and 2 test pits of depths ranging from 4.5 m to 11.3 m. In addition, three dynamic Cone Penetration Tests (CPT) were performed. The soil overburden was sampled using thin walled Shelby tubes and a 51 mm diameter split spoon in conjunction with the Standard Penetration Tests (SPT). The underlying bedrock was cored in NXL size. In situ undrained shear strength determinations using, the M.T.O. standard size field vane, were also performed at various location in the underlying silty clay. Three standpipe piezometers were installed to monitor the groundwater levels.

The locations of the boreholes are shown on Drawing 3728904-A.* A record of the encountered subsurface conditions at each borehole and test pits, is given in Appendix A.

* Dwg. No. 2, Sheet 310, of the Contract Drawings.

2.0 SITE DESCRIPTION AND GEOLOGY

The proposed overhead is located at the crossing of the CPR track and Highway 16 approximately 3 km south of Kemptville, Ontario (Figure 1). The overhead will consist of a three span structure supported on two central piers and abutments placed on approach fills.

The site is relatively flat and poorly drained with several marshy areas. South of the tracks the alignment is densely covered with small to medium sized trees. Grassland, with occasional shrubs, gives way to agricultural land on the north side of the tracks. A 20 m wide, 5 m high, granular fill embankment is located approximately 175 m north of the tracks just west of the proposed Highway 416 southbound lane. Mature trees are present on the 125 m long granular fill. Approximately 45 m east of the proposed alignment are the overhead structure and approach fills of the existing Highway 16. The proposed/existing structure is about 10-12 m above existing ground level.

The site is drained by a small stream which flows from the southwest and passes under the railway embankment about 50 m west of the proposed highway centre-line. Approximately 150 m north of the tracks water discharges from a 1.2 m culvert, located within the existing Highway 16 embankment fill, and enters a westerly flowing drainage ditch which intersects the proposed alignment at right angles. Two shallow side ditches, located either side of the railway embankment, flow to the west.

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 comprises 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 only resulted 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 may be present.

Available surficial geology information (Ontario Geological Survey Map 2387) indicates that the proposed CPR overhead site is underlain by a uniform medium sand deposited in a shallow water environment. These deposits are anticipated to overlie deposits of fine grained clayey silt.

The bedrock in the area is a massive grey dolostone known as the Oxford Formation of the Beekmonton Group.

3.0 SUBSURFACE CONDITIONS

3.1 General

The stratigraphy at the site comprises of thin layers of peat, topsoil and silty sand overlying a thick deposit of silty clay which in turn overlies a gravelly sand till deposit. The till deposit is underlain by dolostone bedrock. Details of the encountered subsurface conditions at each of the borehole and test pit location are presented in Appendix A.

3.2 Gravelly Sand (Fill)

A granular fill embankment is located approximately 175 m north of the railroad tracks. The embankment is 5 m high, 125 m long and 20 m wide. Based on information obtained at the test pit locations and at Borehole 10-8, drilled at the toe of the fill, the fill is comprised of brown gravelly sand with some cobbles, boulders and pockets of organics.

3.3 Peat and Topsoil

A thin layer of peat and/or silty sand topsoil was encountered in all boreholes and ranged from 0.1 m to 0.5 m in thickness.

3.4 Silty Sand

Underlying the topsoil or fill at all borehole locations is a thin layer of grey silty sand to sand, some silt. This stratum ranged from 0.4 m to 1.1 m in thickness. Based on the

results of one grain size distribution analysis this layer may be described as a silty sand with a trace clay. SPT N values obtained from this layer ranged from 2 to 14 inferring a very loose to compact density.

3.5 Silty Clay, Varved

Underlying the peat, topsoil and silty sand is a layer of grey silty clay at all borehole locations. This stratum ranged from 4.4 m to 6.4 m in thickness. The upper surface of this stratum is found at about El. 95 m which is approximately 1 m below ground surface. The stratum is approximately 6 m thick at the location of the proposed overpass.

Atterberg limit test results indicate a general reduction in the plasticity index with depth (Figure B3). The measured liquid limit of the material ranged from 22% to 58% (average 41%), plastic limits of the 18% to 29% (average 23%) and associated plasticity indices of 4% to 32% with an average value of 18%. A plot of the Atterberg limits (Figure B4) indicates that the soil is inorganic clay of variable plasticity (CL to CH). The results of 4 grain size distribution analyses (Figure B2) indicate that this strata lies within the silty clay range with an increasing silt content with depth.

Based on the summary of in-situ test results and laboratory data obtained for the silty clay layer (Figure B3), the following general comments may be made about its engineering properties:

Water Content

The water contents ranged from 22% to 35% with a decreasing trend with depth and one anomalous value of 51% (Borehole 10-8; Sample 4). This decreasing trend is consistent

with the increasing silt content with depth. Generally, the water contents are slightly above the plastic limit.

Standard Penetration Test (SPT)

SPT N values obtained from this stratum ranged from 2 to 13, and is in the form of a parabolic distribution with a peak value at about 1 m below the top of the layer (Figure B4). Lower SPT values in the upper 1 m are likely caused by either localized softening due to surface water ponding or the affect of freeze/thaw action in the frost zone.

Undrained Shear Strength

The undrained strengths for this strata were obtained by in-situ vane tests, laboratory vane tests and undrained quick (UU) triaxial tests. Based on the combined undrained shear strength and SPT data, it is concluded that the stratum can be described as having a very stiff consistency above El. 90 m. However, there are some localized zones of firm to stiff material. Below this elevation, the deposit can be described as having a firm to stiff consistency.

The results of one in-situ field vane test and one UU triaxial test performed at El. 94.7 m at Borehole 10-5 and on a sample recovered from El. 89.3 m in Borehole 10-6, respectively, are considered unrepresentative because of probable disturbance of the samples.

Sensitivity

Sensitivity values, defined as the ratio of peak to remolded undrained shear strength ranged from 1 to 26 with a typical range of between 5 and 8. Based on these values, the deposit is considered to be sensitive.

Consolidation Data

The results of the four consolidation tests (Table 1, Appendix B) indicate that the silty clay is overconsolidated with estimated pre-consolidation pressures (Pc) in excess of 400 kPa and associated over-consolidation ratios (OCR) ranging from 7 to 28. The general trend of decreasing Pc values with depth is consistent with that exhibited by the SPT "N" values and the undrained shear strength data.

Recompression indices (C_r) and compression indices (C_c) ranged from 0.007 to 0.025 (average value 0.015) and from 0.16 to 0.200 (average value 0.18), respectively. Coefficient of Consolidation (C_v) values, applicable to the reloading portion of the tests, vary from 34 m^2/yr to 68 m^2/yr (average value 47 m^2/yr).

3.6 Gravelly Sand (Glacial Till)

A layer of non-cohesive gravelly sand till was encountered below the silty clay stratum at all borehole locations. The stratum ranged from 1.3 m to 1.6 m in thickness at Boreholes 10-4 and 10-6, respectively. Based on auger refusal data obtained at other boreholes locations, the thickness of this layer is inferred to range from 0.5 m to 3.6 m with an average thickness of 1.5 m.

The results of one grain size distribution analysis indicates that the glacial till is a well graded mixture of sand and gravel with some silt. Occasional cobbles and boulders may also be present within this layer.

SPT N values obtained for this stratum ranged from 17 to 26, inferring a compact state of density. An N value of 2 at Borehole 10-7 is believed to have been influenced by upward flow of groundwater in the auger hole prior to the test and is considered unrepresentative.

Water contents within the till ranged from 7 to 9%.

3.7 Bedrock

Bedrock was confirmed at about El.87.5 m which is approximately 8.0 m below ground surface and was cored for a total depth of 2.9 m and 2.7 m at Boreholes 10-4 and 10-6, respectively. The bedrock is a dark grey fine grained dolostone with occasional intrusions of calcite and closely spaced thin (1 to 2 mm) stringers of black shale. The rock is massive with core recovery of 87 to 100% and RQD values ranging from 87 to 93% inferring good to excellent quality bedrock.

Unconfined compression tests performed on two samples of core retrieved from Boreholes 10-4 and 10-6 yielded strength values of 85 and 67 MPa, respectively.

3.8 Groundwater Conditions

Groundwater levels were measured by standpipe piezometers installed in the underlying glacial till at Boreholes 10-3 , 10-5 and 10-7. The groundwater levels were measured

approximately 17 days after drilling and were observed at El. 95.8 to El. 96.3 m. These water level elevations infer that a small artesian pressure is present within the glacial till layer, which is consistent with general observations made during drilling. The measured water level within the surficial topsoil and silty sand layers is at or close to the ground surface.

Groundwater level could expect to vary seasonally.

5.0 CLOSURE

The field work portion for the investigation was carried out 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.; checked by Mr. R.W. Browne and reviewed by Dr. I. Holubec, P.Eng.

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

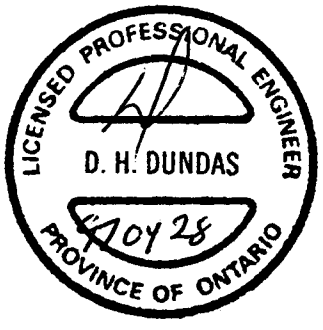
Yours very truly
GEOCON (1991) INC.

N. Khan, P.Eng.
Project Engineer

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

IH:dtj
T11688/15530

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Geocon (1991) Inc. (consulting geotechnical engineers for this project), and signed and sealed by N. Khan, P.Eng. and I. Holubec, Ph.D., P.Eng. The project was carried out under the technical supervision of Fenco Engineers Inc., the supervising consultant for this project.



D. Dundas, P. Eng.
Senior Foundation Engineer

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

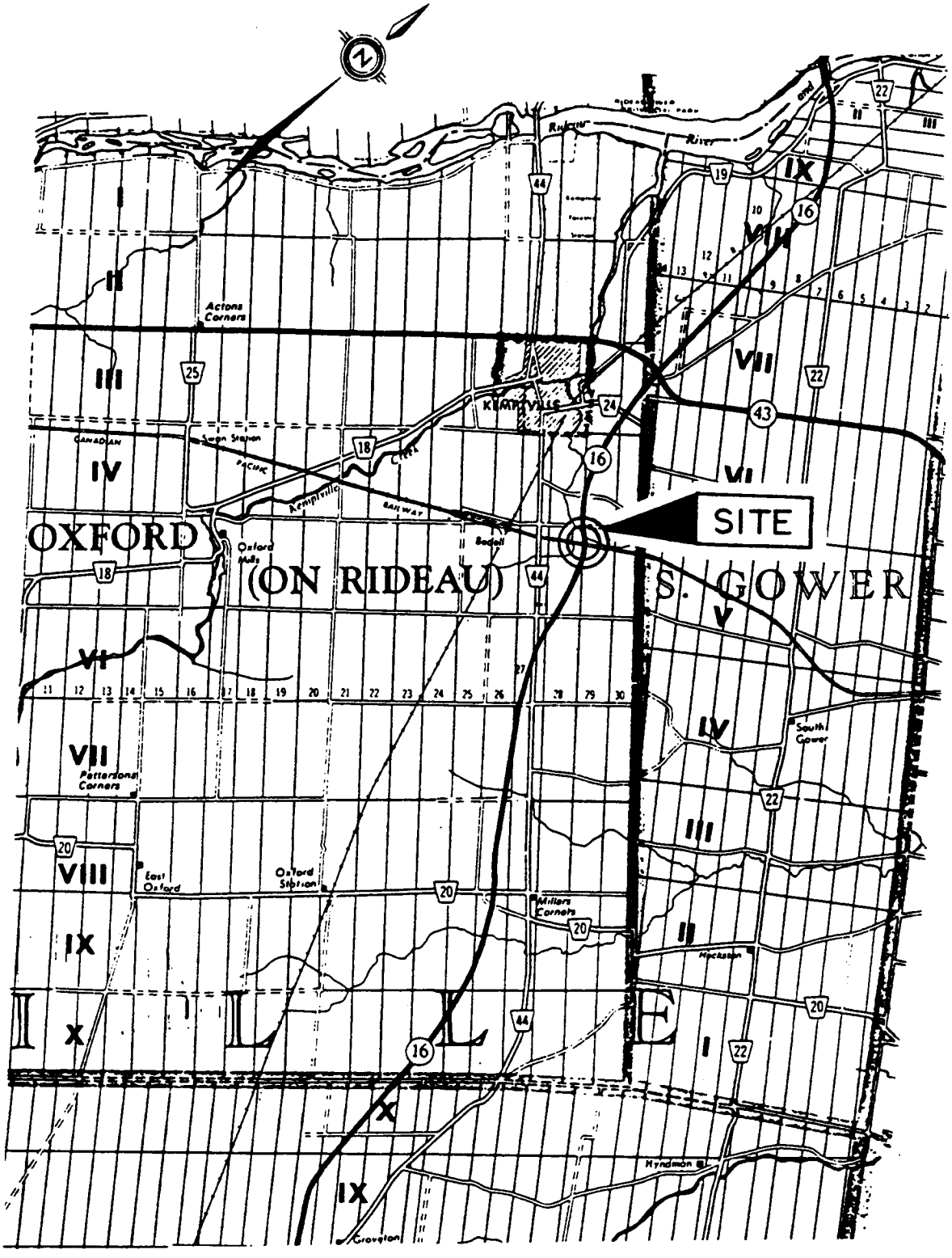
Canadian Foundation Engineering Manual, 1985. Second Edition. Part 1: Fundamentals; Part 2: Shallow Foundations; Part 3: Deep Foundations; Part 4: Excavations and Retaining Structures Part 5: References. Canadian Geotechnical Society, Technical Committee on Foundations, 456 pp.

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 04



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GEOCON

APPENDIX A

Explanation of the Term Rock Quality Designation (RQD)
Record of Borehole Sheets (10-1 to 10-11)
Test Pit Logs

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 10-1 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,512.6 N; 374,551.3 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE October 22, 1990 CHECKED BY I.C.

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 ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 25 50 75 100 125	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.2	Ground Surface										
0.0	Peat and Topsoil Soft										
96.0	Silty Sand		1	SS	2		96				0 62 36 2
0.2	Very Loose Grey										
95.3											
0.9	Silty Clay (Varved) occasional shell fragments		2	SS	7						
	Very stiff Grey		3	SS	8		94				
			4	SS	13						
			5	TW	PH			$(177)^{5}$		19.5	0 2 58 40
							92				
			6	SS	5						
90.9						Artesian water encountered					
5.3	Sand and Gravel some silt (Glacial Till)						90				
	Compact Grey		7	SS	24						38 39 21 2
							88				
87.2											
9.0	End of Borehole Auger Refusal										
	Initial auger refusal encountered at 4.3 m. Stratigraphy below this depth obtained by redrilling a short distance from the original borehole location.										
	Magnitude of Artesian Pressure Head not established.										

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

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 10-2 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,682.3 N; 374,444.5 E ORIGINATED BY N.K.

DIST 9 nWY 416 BOREHOLE TYPE Hollow Stem Augers & Cone Test COMPILED BY N.K.

DATUM Geodetic DATE October 19, 1990 CHECKED BY I.C.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.0	Ground Surface								
0.0 / 95.7	Peat and Topsoil Soft		1	SS	3				
0.3 / 95.1	Silty Sand Very Loose to Loose Grey								
0.9	Silty Clay (Varved) Very Stiff to Stiff Grey		2	SS	6				
			3	TW	PH		94	19.0	0 2 54 44
			4	SS	12				
			5	SS	8		92		
			6	TW	PH				
	Firm		7	SS	3		90		
88.7						Artesian water encountered			
7.3	Sand and Gravel some silt, trace clay (Glacial Till)		8	SS	20		88		
87.5	Compact Grey								
8.5	End of Borehole Auger Refusal								
86.0									
10.4	End of Penetration Test								

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPo ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 25 50 75 100 125

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60

100/215 mm

Note: Cone Test performed 3.5 m south of Borehole 10-2

Magnitude of Artesian Pressure Head not established.

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

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 10-3 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,697.7 N; 374,439.8 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE October 19, 1990 CHECKED BY I.C.

OFFICE REPORT ON SOIL EXPLORATION

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; 25 50 75 100 125)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.1	Ground Surface										
0.0 / 95.6	Peat Soft Black		1	SS	3		96				
0.5 / 95.0	Silty Sand Loose Grey		2	SS	5						
1.1	Silty Clay (Varved) silt content increasing with depth Very Stiff Grey		3	SS	6		94		○		
			4	SS	10				○		
			5	SS	10						
			6	TW	PH		92		○	19.5	
			7	SS	10						
89.4			8	TW	PH		90	×26	HO	20.6	0 2 94 4
6.7	Sand and Gravel trace to some silt (Glacial Till) Compact Grey		9	SS	26		88		○		
87.5											
8.6	End of Borehole Auger Refusal										

Note:
Water level in standpipe piezometer measured at elevation 96.2m on November 9, 1990.

+³, ×⁵ : Numbers refer to Sensitivity

15 20 10 ◇ 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 10-4 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,692.1 N; 374,430.7 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 18, and 19, 1990 CHECKED BY I.C.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%) Wp W WL	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.8	Ground Surface										
0.0	Peat Soft Black										
95.5	Sand, some silt										
0.3	Very Loose Grey										
94.9											
0.9	Silty Clay (Varved)		1	SS	3						
	Very Stiff to Stiff Grey		2	SS	6		94				
			3	SS	9						
			4	SS	7		92	(>96 kPa)			
			5	SS	5						
							90	(>96 kPa)			
			6	SS	2			5			
88.7											
7.1	Gravelly Sand, some silt (Glacial Till)		7	SS	17		88				
	Compact Grey				Rec%			RQD%			
87.4			8	RC NXL	100			93			
84	Dolostone fine grained, closely to moderately jointed, occasional thin (1-2mm) stringers of shale. Occasional Calcite Crystals		9	RC NXL	87			87			UCS = 85 MPa
	Dark Grey		10	RC NXL	88		86	88			
84.5											
11.3	End of Borehole										

Notes:

1) Water level in Hollow Stem Augers 0.1 m above surface on morning of Oct. 19/90

2) Lost rock core believed to have dropped out of core barrel.

+3, x5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 10-5 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,718.7 N ; 374,413.5 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 I.C.

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 25 50 75 100 125	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.7	Ground Surface										
0.0 / 95.6	Peat and Topsoil Soft										
0.1 / 95.1	Silty Sand Very Loose Grey		1	SS	2			+1	○		
0.6	Silty Clay (Varved) silt content increasing with depth, trace sand Very Stiff Grey		2	TW	PH		94				
			3	SS	9						
			4	SS	9		92				
			5	TW	PH			(157)	●	19.8	0 2 80 18
			6	SS	8						
89.2							90	+(96 kPa)			
6.5	Gravelly Sand, some silt (Glacial Till) Compact Grey		7	SS	9						
87.6			8	SS	54/265 mm		88				
8.1	End of Borehole Auger Refusal										

Note: Water level in standpipe piezometer measured at elevation 95.8 m on November 9, 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 10-6 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,720.2 N; 374,424.1 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 23 and 24, 1990 CHECKED BY I.C.

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 ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 25 50 75 100 125	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_l WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.5	Ground Surface										
95.4 0.1	Topsoil Soft										
95.0 0.5	Fine Sand, some silt Very Loose Grey		1	SS	2	Head					
94.1	Silty Clay, trace sand Soft Grey		2	SS	3						
1.4	Silty Clay (Varved) silt content increasing with depth Very Stiff Grey		3	SS	10		94				
			4	SS	11			+ (>96 kPa)			
			5	SS	9		92				
			6	SS	7						
89.1			7	TW	PH		90	+ (>96 kPa)			
6.4	Gravelly Sand some silt (Glacial Till) Compact Grey		8	SS	24	Artesian water encountered				18.5	
87.6			9	SS	7/150 mm		88	RQD%			
8.0	Dolostone fine grained, closely to moderately jointed, occasional thin (1-2mm) stringers of shale. Occasional Calcite Crystals Dark Grey		10	NXL	71			0			
			11	RC NXL	99			91			
			12	RC NXL	98		86	88		UCS = 67 MPa	
84.8											
10.7	End of Borehole				Rec =						

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 10-7

METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,728.6 N; 374,412.8 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE October 23, 1990 CHECKED BY I.C.

ELEV / DEPTH	SOIL PROFILE 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 (25 50 75 100 125) o UNCONFINED • QUICK TRIAXIAL + FIELD VANE x LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.2	Ground Surface									
0.0 / 96.1	Topsoil Soft		1	SS	4		96			
0.1 / 95.0	Silty Sand trace organics Loose Grey		2	SS	9					
1.2	Silty Clay (Varved) trace sand Very Stiff to Stiff Grey		3	SS	5		94			
			4	SS	11			(>96 kPa)		
			5	SS	12					
			6	TW	PH		92			
			7	SS	4					
90.1										
6.1 / 89.2	Gravelly Sand some silt (Glacial Till) Probably Compact Grey		8	SS	2		90			
7.0	End of Borehole Auger Refusal									

Note:

Blow-up of material into the augers is believed to have affected the "N" value of Sample 8.

Water level in standpipe piezometer measured at elevation 96.3 m on November 9, 1990.

$+^3$, x^5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 10-8 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,850.6 N; 374,321.4 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE October 22, 1990 CHECKED BY I.C.

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 ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 25 50 75 100 125	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.5	Ground Surface										
0.0 / 96.4	Topsoil Soft		1	SS	3	▼	96				
0.1 / 95.7	Fill - Silty Sand, trace organics and roots Very Loose Brown										
0.8 / 95.3	Silty Sand Compact Brown Grey		2	SS	14						
1.2	Silty Clay (Varved) silt content increasing with depth Stiff Grey		3	SS	10						
			4	SS	12		94		○		
			5	SS	14						
			6	TW	PH				●	○——○	19.2
			7	SS	8		92				
			8	SS	4		90	+5			
89.2											
7.3	Sand and Gravel some silt (Glacial Till) Compact Grey		9	SS	23					○	
87.3	Blow-up of material within auger @ 7.5 m						88				
9.2	End of Borehole Auger Refusal										

Note:

Water in open borehole measured at elevation 95.9 m on October 24, 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 10-9

METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,604.2 N; 374,498.4 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY N.K.

DATUM Geodetic DATE October 22, 1990 CHECKED BY I.C.

SOIL PROFILE 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 W_L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.9	Ground Surface										
0.0 / 95.7	Peat and Topsoil Soft										
0.2 / 95.0	Probably Silty Sand										
0.9	Probably Silty Clay (Varved)						94				
							92				
90.1							90				
5.8 / 88.6	Probably Gravelly Sand some silt (Glacial Till)										
7.3	End of Penetration Test							100/265 mm			

Note:
Soil Stratigraphy is inferred based on extrapolated borehole data.

OFFICE REPORT ON SOIL EXPLORATION

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

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 10-10 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,776.2 N; 374,378.9 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY N.K.

DATUM Geodetic DATE October 23, 1990 CHECKED BY I.C.

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 W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
96.0	Ground Surface										
0.0 / 95.7	Peat and Topsoil Soft										
0.3 / 94.8	Probably Silty Sand										
1.2 / 89.3	Probably Silty Clay						94 92 90				
6.7 / 88.1	Probably Gravelly Sand some silt (Glacial Till)										
7.8	End of Penetration Test							100/230 mm			

Note:

Soil Stratigraphy is inferred based on extrapolated borehole data.

OFFICE REPORT ON SOIL EXPLORATION

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

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 10-11 METRIC

W P 372-89-04 LOCATION Co-ords: 4,984,947.4 N; 374,242.7 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY N.K.

DATUM Geodetic DATE October 24, 1990 CHECKED BY I.C.

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 WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.2	Ground Surface										
0.0	Topsoil Soft	~~					96				
96.0 / 0.2	Silty Sand (Probably)										
95.6 / 0.6	Probably Silty Clay						94				
							92				
90.1 / 6.1	Probably Gravelly Sand some silt (Glacial Till)						90				
88.3 / 7.9	End of Penetration Test Note: Soil Stratigraphy is inferred based on extrapolated borehole data.										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF TEST PITS

Test Pit #1 Co-ords: N 4984863.5; E 374292.5; Sta 20+210 ; 15 m Left
Ground Surface Elevation 101.5 m (±)

0.0 - 1.5 m	Dark Brown Heterogenous Mixture of Boulders, Cobbles, Sand and Silt Trace Topsoil Some pieces of Asphalt (FILL).
1.5 - 5.5 m	Light Brown Gravelly Sand Some Silt Some Cobbles and Boulders (FILL) Boulders generally less than 0.5 m in Diameter
5.5 - 5.8 m	Black Peat and Topsoil
5.8 m	End of Test Pit

Test Pit #2 Co-ords: N 4984899.0; E 374271.0; Sta 20+250 ; 10 m Left
Ground Surface Elevation 101.5 m (±)

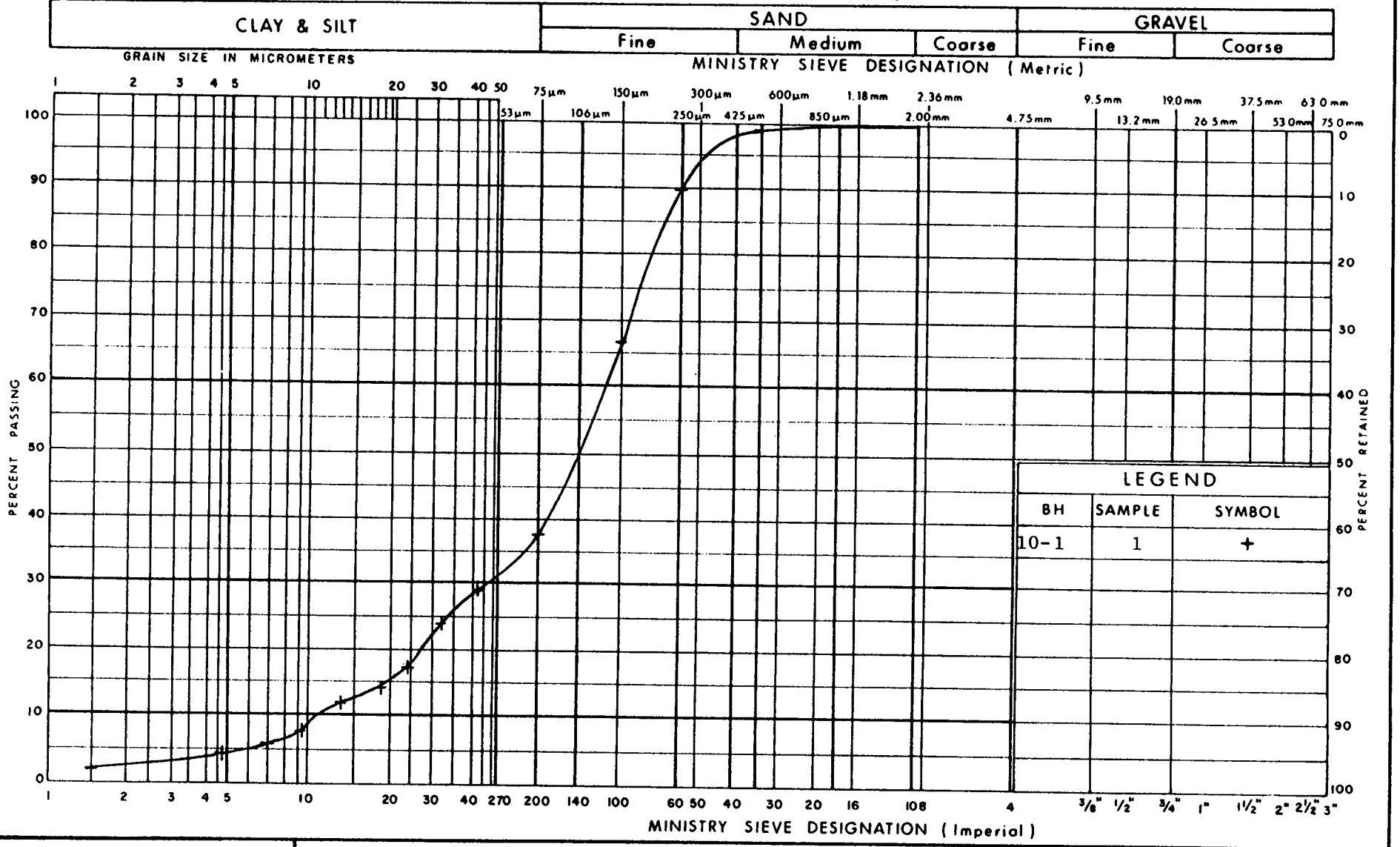
0.0 - 4.0 m	Brown Gravelly Sand Some Silt Some Cobbles and Boulders Occasional Pockets of Topsoil (FILL)
4.0 - 4.5 m	Black Topsoil
4.5 m	End of Test Pit

APPENDIX B

Laboratory Test Data

Figures B1 to B3	- Grain Size Curves
Figure B4	- Plasticity Chart - Silty Clay
Figure B5 & B6	- Consolidation Test e vs log p Curves
Table 1	- Summary of Consolidation Test Data

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

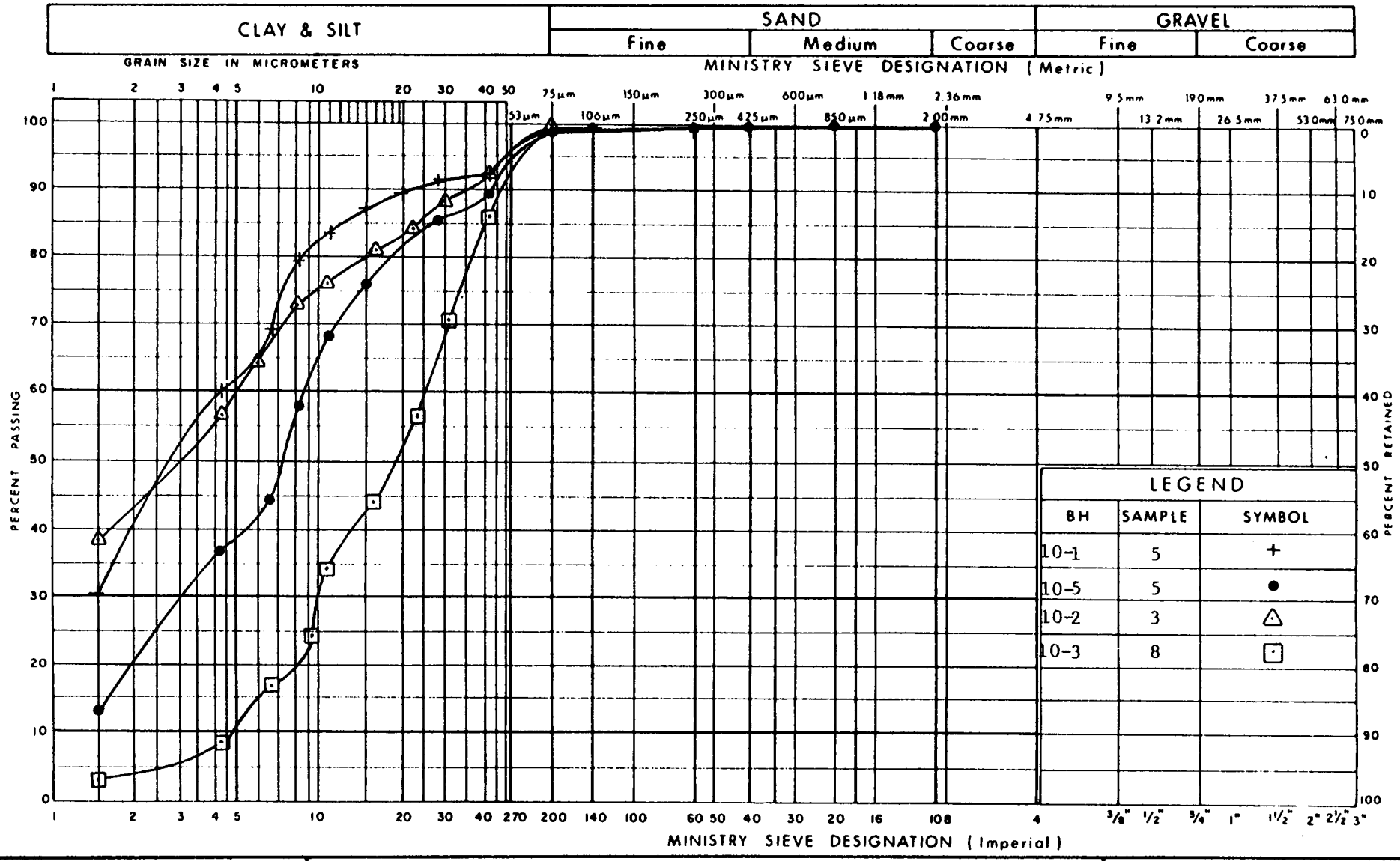
Silty Sand

FIG No B1

W P 372-89-04

16

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

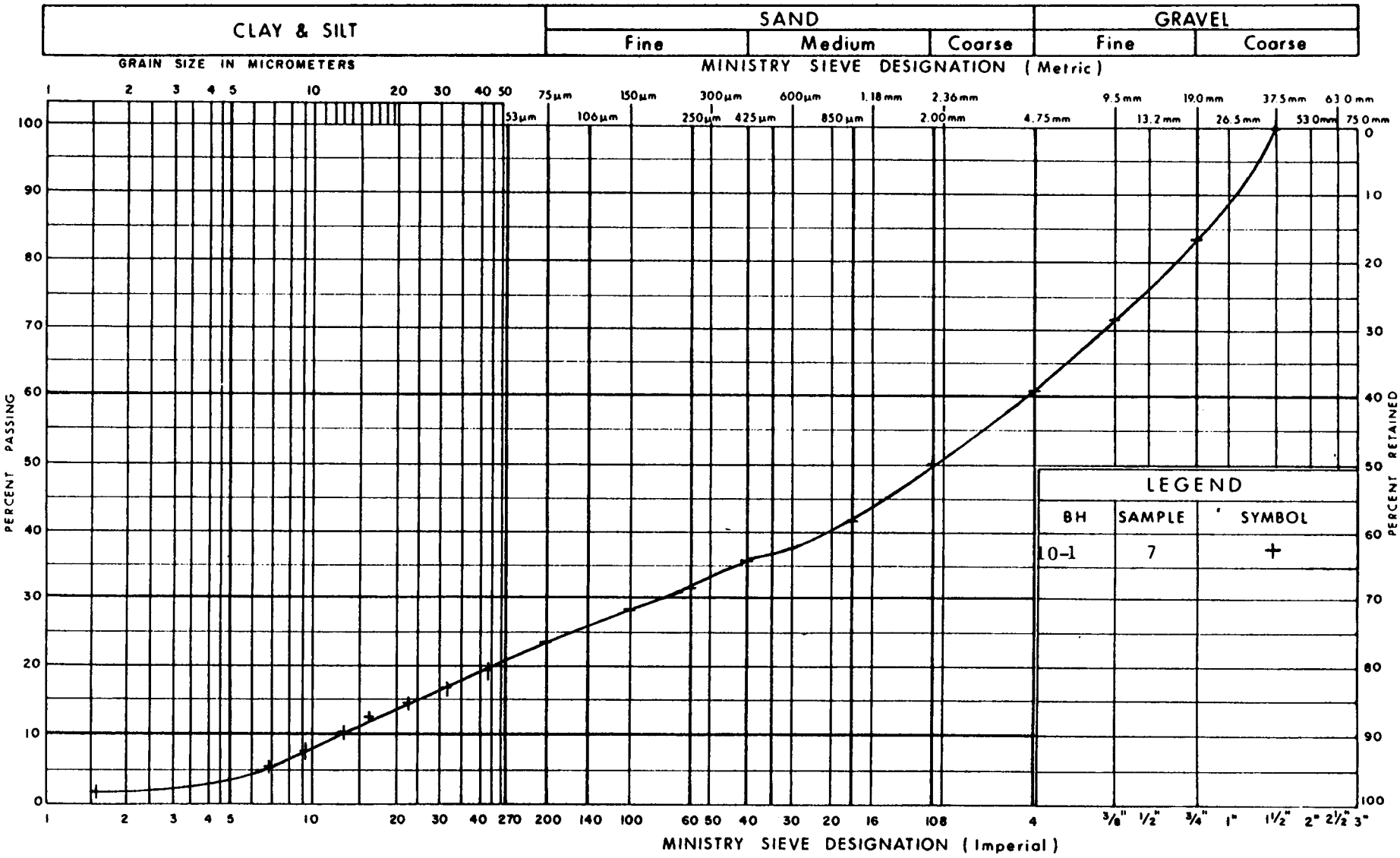
Silty Clay

FIG No B2

W P 372-89-04

92

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
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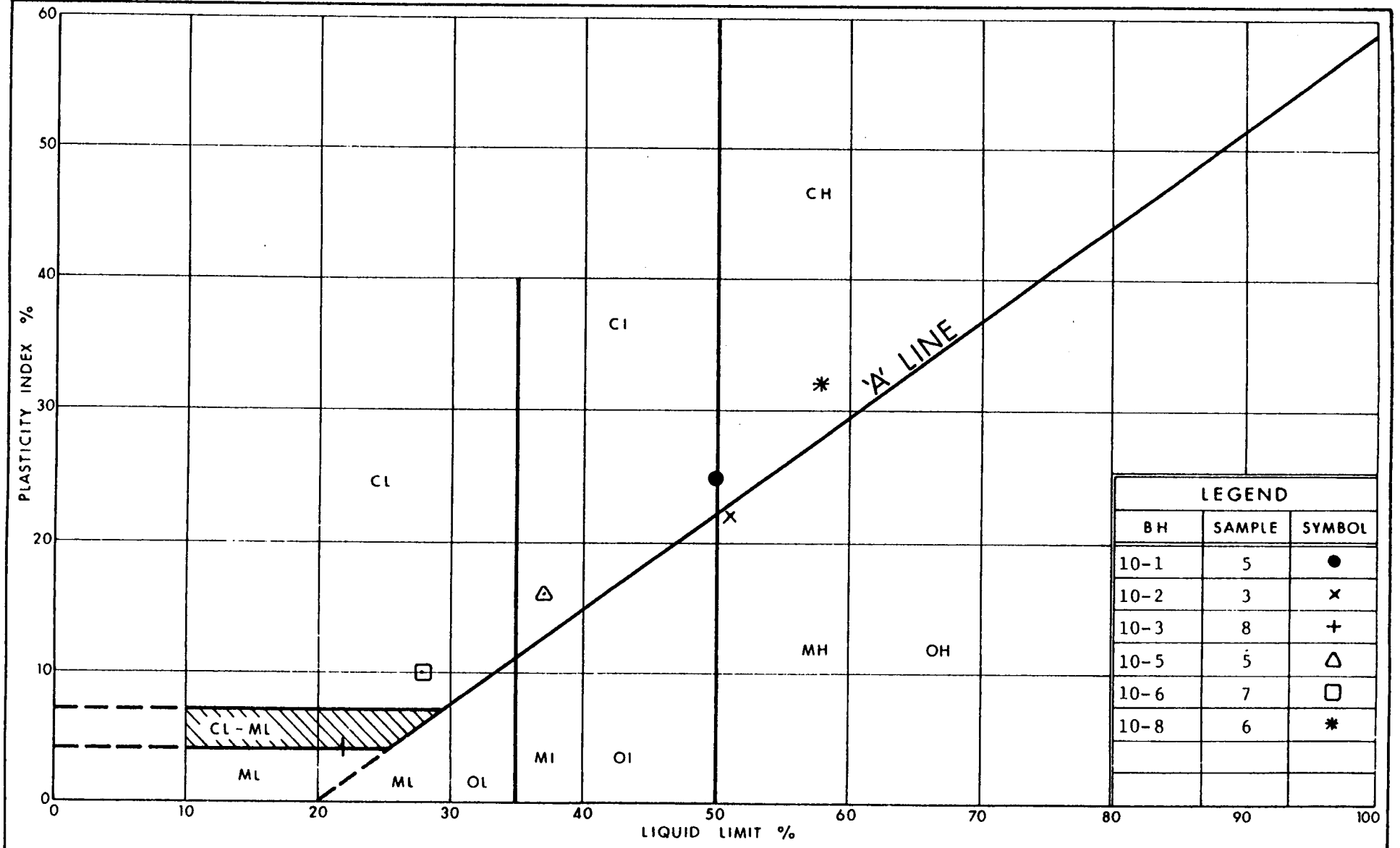
GRAIN SIZE DISTRIBUTION

Sand and Gravel (Glacial Till)

FIG No B3

W P 372-89-04

93



Ministry of Transportation and Communications
Ontario

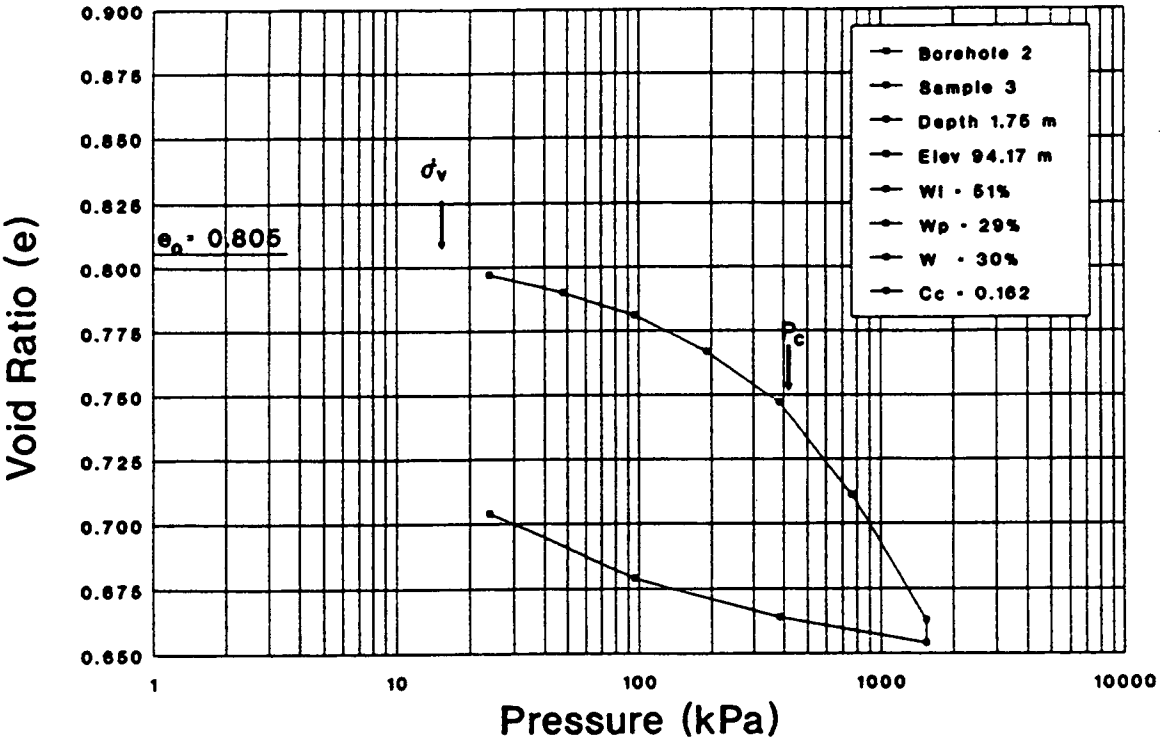
PLASTICITY CHART

Silty Clay (Varved)

FIG No B4
W P 372-89-04

94

VOID RATIO - PRESSURE CURVES



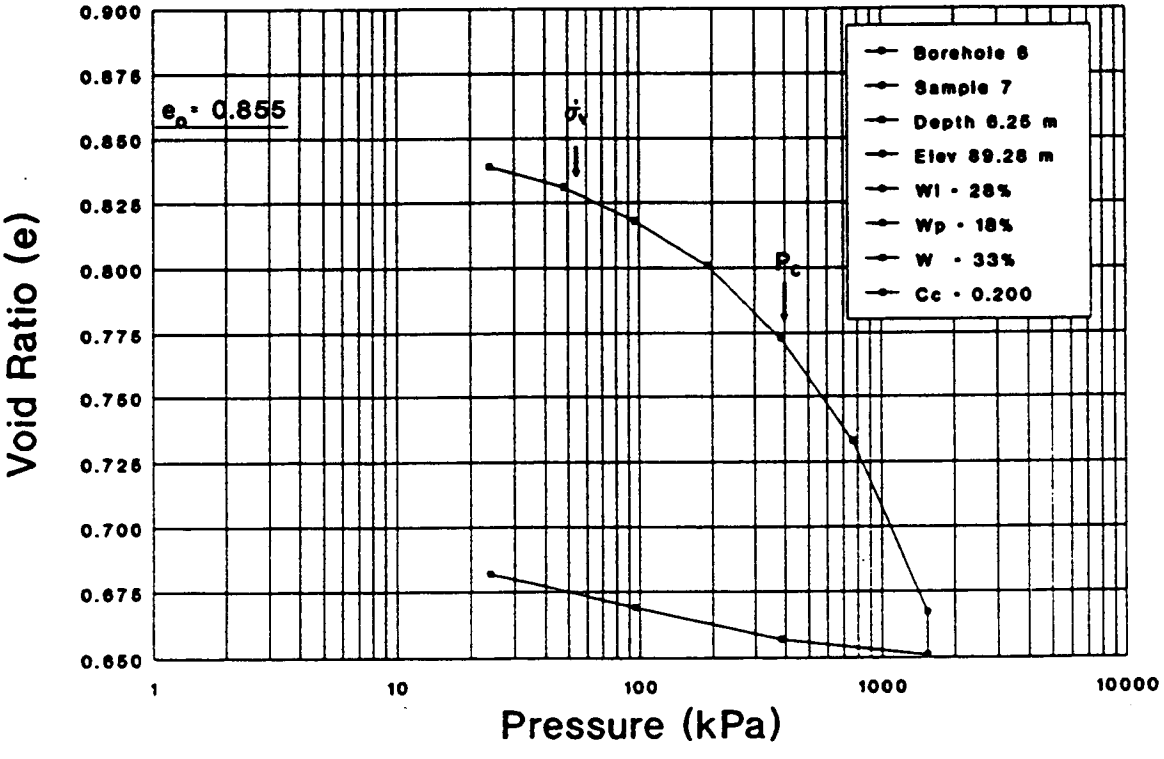
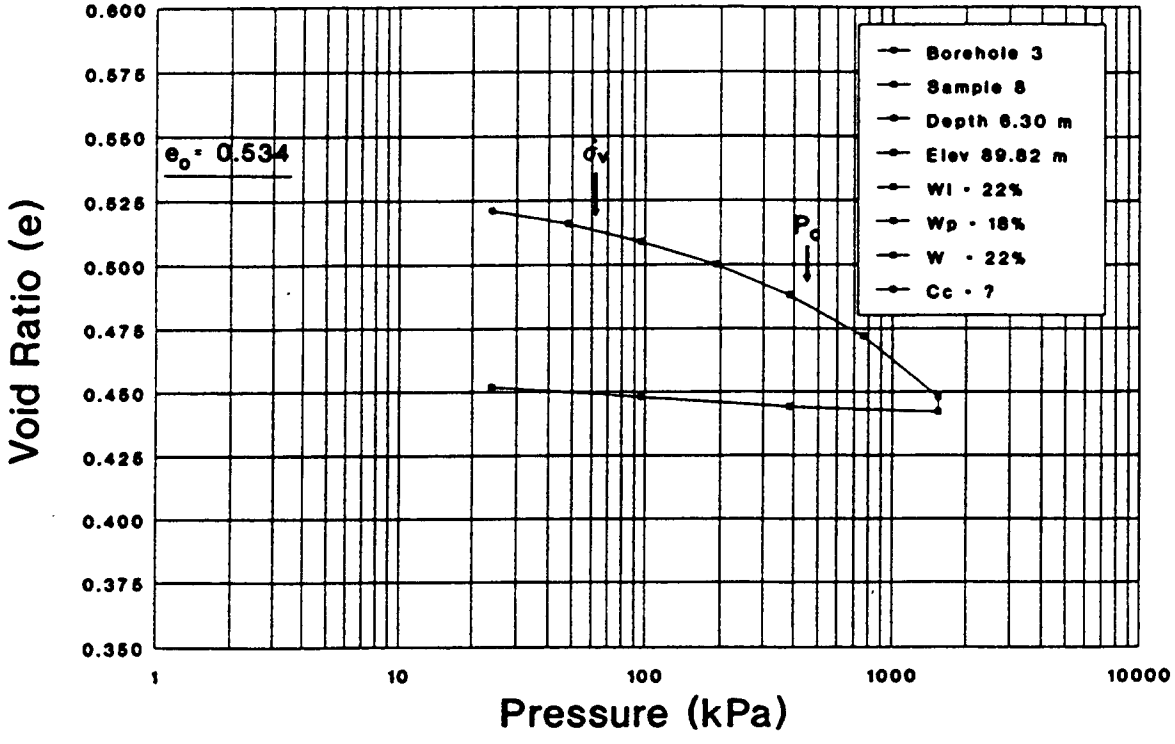


FIGURE B5

WP 372-89-04

VOID RATIO - PRESSURE CURVES



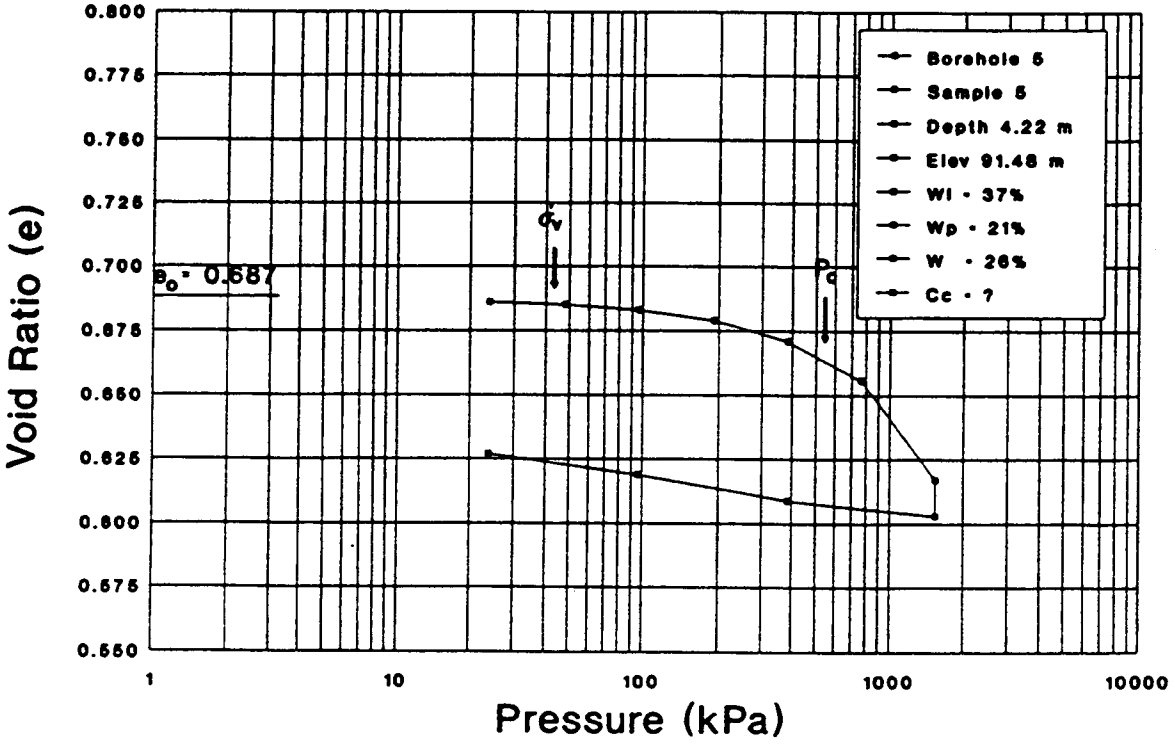


FIGURE B6

WP 372-89-04

APPENDIX B

TABLE 1

HWY 416 FOUNDATION PROGRAM - WP 372-89-00
STRUCTURE NO. 10 - CPR OVERHEAD
SUMMARY OF CONSOLIDATION TEST DATA

			Sample Locations		Loading Data			Compression Data			
Test #	BH	Sample #	Depth (m)	Elevation (m)	σ_v' (kPa)	Pc (kPa)	OCR	Cr	Cc	Cv m^2/yr	e_o
1	2	3	1.8	94.2	15	415	28	0.025	0.162	34.0	0.805
2	3	8	6.3	89.8	62	440	7	0.007	-	50.9	0.534
3	5	5	4.2	91.5	41	580	14	0.012	-	67.9	0.687
4	6	7	6.3	89.3	54	400	7	0.017	0.200	34.0	0.855

T11688D

REPORT TO

FENCO ENGINEERS INC.
WILLOWDALE ONTARIO

HIGHWAY 416
KEMPTVILLE ONTARIO
FOUNDATION INVESTIGATION
PROPOSED VAN BUREN STREET UNDERPASS
(WP 372-89-05; SITE 16-317)
DISTRICT 9, KINGSTON

GEOCON (1991)INC.
December, 1991

1.0 INTRODUCTION

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

The field work for this project was conducted between November 6th and November 16th, 1990 using a CME 55 drill rig equipped with 200 mm diameter hollow stem augers. The investigation consisted of 5 boreholes and 1 test pit. The overburden was sampled using a 52 mm diameter split spoon in conjunction with the Standard Penetration Test (SPT). The underlying bedrock was cored in NXL size. Two standpipe piezometers were installed to monitor the groundwater levels. The test pit was excavated with a backhoe to obtain samples for density determinations and to confirm the matrix and the relative density of the silty sand till stratum.

The locations of the boreholes and one test pit are shown on Drawing 3728905-A.* A record of the encountered subsurface conditions at each borehole and the test pit are given on the Record of Borehole Sheets in Appendix A. A summary of borehole depths and elevations is given on Table 1 Appendix A.

*Dwg. No. 2, Sheet 324, of the Contract Drawings.

2.0 SITE DESCRIPTION AND GEOLOGY

The proposed Van Buren Street underpass is located at the intersection of Van Buren Street and Highway 16 approximately 1.5 kilometers east of Kemptville, Ontario (Figure 1). The proposed underpass will consist of two spans supported on a central pier and two abutments.

The proposed underpass will be located near the crest of a small knoll having gentle slopes dipping from west to east. The difference in elevation across the site is about 3 m. The present Highway 16 and Van Buren Street are located within earth cuts of 1 m to 2.5 m depth. To the east, the alignment is located within agricultural pasture land with some trees. A north flowing drainage ditch intersects the alignment approximately 75 m east of Highway 16.

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 comprises 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 only resulted 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 along the proposed Van Buren Street realignment (OGS Map 1492A) indicates that it is primarily underlain by till deposits. However, east of Highway 16, the till gives way to deposits of glaciofluvial sands and

silts. In addition, fine grained Champlain Sea deposits may also be present to the east of Highway 16.

The underlying bedrock at the site consists of dolostone bedrock of the Oxford Formation of the Beekmonton Group.

3.0 SUBSURFACE CONDITIONS

The surface conditions at the proposed underpass consist of a thin layer of topsoil overlying a sandy silt till. However, a thin layer of granular roadfill and sandy silt overlie glacial till at Boreholes 11-2 and 11-4, respectively. The factual information which was used to interpret the soil conditions is given in Appendix A and B and Drawing 3728905-A* and are described in the following sections.

3.1 Peat and Topsoil

A thin veneer of topsoil, 0.1 to 0.3 m thick was encountered at Boreholes 11-1, 11-4, 11-5 and Test Pit 11-1. At Borehole 11-3, a 0.3 m thick organic deposit was encountered.

3.2 Sandy Silt Till

Sandy silt till was encountered at all boreholes and test pit locations. Where fully penetrated the till was found to be about 12.0 m thick. Based on the results of six grain size analyses performed on selected split spoon samples, this stratum may be described as a sandy silt till to silty sand till with some gravel and a trace clay. However, the results of two grain size analyses performed on bulk samples from the test pit, indicate this layer to be a heterogenous mixture of gravel, sand and silt, some cobbles, trace clay and occasional boulders. Occasional water bearing sand seams were also encountered.

SPT N values within the glacial till are high and variable with refusal recorded at many locations before full test penetration of the split spoon could be obtained. Based on the SPT N values the deposit can be described as having a dense to very dense density. The

* Dwg. No. 2, Sheet 324, of the Contract Drawings.

dense to very dense relative density of the till is consistent with the high in-situ dry densities of 19.6 kN/m^3 obtained at Test Pit 11-1.

Water contents within the till varied from 7 to 12%.

3.3 Bedrock

Dolostone bedrock was found between El. 83.0 m to El. 82.0 m, approximately 12.0 m below the existing ground surface. The bedrock was proven by coring about 2.8 and 2.6 m into the bedrock in Boreholes 11-2 and 11-4, respectively. The bedrock is judged, by core recovery and RQD percentages to be of fair to excellent quality with the exception of the upper 1.5 m in Borehole 11-2 which is of a poor quality. The cored rock samples indicate the bedrock to be unweathered, grey, fine grained, closely jointed dolostone, having occasional calcite intrusions.

3.4 Groundwater

Groundwater was measured by means of two standpipe piezometers in Boreholes 11-2 and 11-4 and visual observations in the remaining boreholes. The groundwater level was measured between 1 to 28 days after the installation of the piezometers. The groundwater level was observed to be about El. 93.0 m, which is about 1.0 m to 4.5 m below the existing ground surface. The groundwater level could be expected to vary seasonally.

5.0 CLOSURE

The field work portion for the investigation was carried out 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.

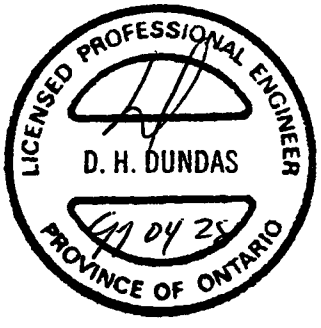
Yours very truly
GEOCON (1991) INC.

N. Khan, P.Eng.
Project Engineer

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

IH:dtj
T11688/15530

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Geocon (1991) Inc. (consulting geotechnical engineers for this project), and signed and sealed by N. Khan, P.Eng. and I. Holubec, Ph.D., P.Eng. The project was carried out under the technical supervision of Fenco Engineers Inc., the supervising consultant for this project.



D. Dundas, P. Eng.
Senior Foundation Engineer

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

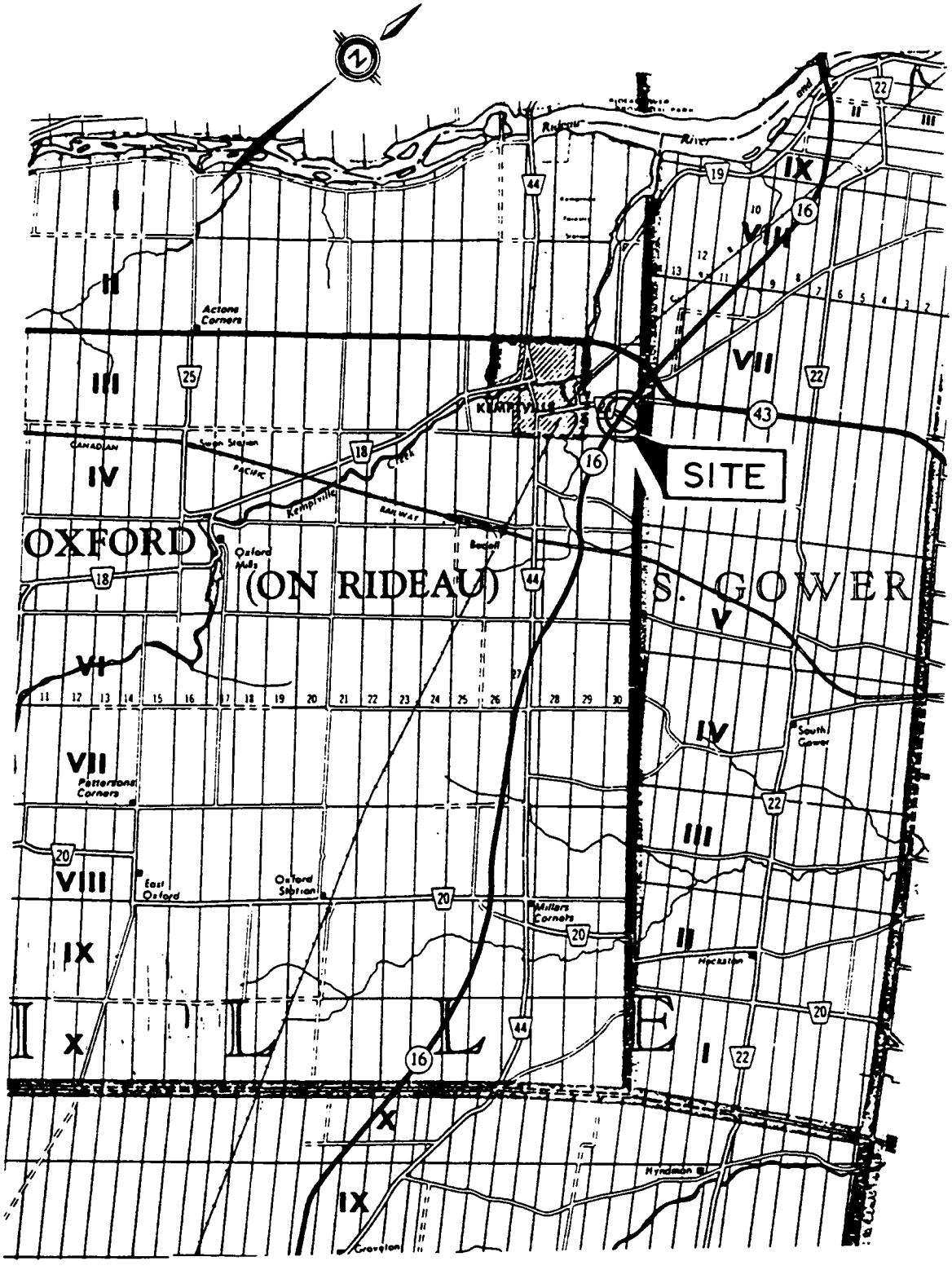
Canadian Foundation Engineering Manual, 1985. Second Edition. Part 1: Fundamentals; Part 2: Shallow Foundations; Part 3: Deep Foundations; Part 4: Excavations and Retaining Structures Part 5: References. Canadian Geotechnical Society, Technical Committee on Foundations, 456 pp.

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 1
FIGURE 1
PROJECT WP 372-89-05



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GEOCON

APPENDIX A

Borehole Information

Explanation of the Term Rock Quality Designation (RQD)
Table 1: Summary of Underpass Borehole Investigation
Record of Borehole Sheets (11-1 to 11-6)
Test Pit Log

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.

TABLE 1

HIGHWAY 416 FOUNDATION INVESTIGATION
VAN BUREN STREET UNDERPASS
SUMMARY OF UNDERPASS BOREHOLE INVESTIGATION

	General Information		Stratigraphic Upper Elevation (m) Layer Thickness in Brackets - m)			Piezometer Information	
Borehole No.	Ground Surface Elevation (m)	Total Depth (m)	Peat & Topsoil	Glacial Till	Dolostone Bedrock	Tip Elev. (m)	Groundwater Elev. (m) *
11-1	97.6	3.5	97.6 (0.2)	97.4 [3.5]	Not drilled		
11-2	95.8	15.4	See Note (1)	95.2 (12.0)	83.2 [2.8]	88.4	Piezometer damaged
11-3	94.3	6.3	94.3 (0.3)	94.0 [6.0]	Not drilled		
11-4	94.1	14.4	94.1 (0.1)	94.1 11.7	82.3 [2.6]	85.9	93.1 **
11-5	94.5	6.3	94.5 (0.1)	94.4 [6.3]	Not drilled		
Test Pit 11-1	97.6	4.5	97.6 (0.3)	97.3 [4.2]			

Notes:

1. At this location, the topsoil is replaced by a 0.61 m layer of Roadfill.
2. [ ] Layer thickness not fully penetrated.
3. * At this location Roadfill replaces the topsoil.
4. All elevations are geodetic
   For more detailed information, refer to the Record of Borehole Sheets.
5. ** As detailed in borehole log.

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 11-1

METRIC

W P 372-89-05 LOCATION Co-ords: 4,987,005.7 N; 373,525.8 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE November 16, 1990 CHECKED BY I.C.

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	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
97.6	Ground Surface										
0.0 / 97.4	Topsoil Dark Brown					Dry			o		
0.2	Silt & Sand, some gravel, trace clay, occasional cobbles and boulders (Glacial Till)		1	SS	64						
	Very Dense Brown		2	SS	187/ 150mm		96				12 37 44 7
			3	SS	20/ 0mm						
94.1			4	SS	25/ 25mm				o		
3.5	End of Borehole Auger Refusal										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11-2 METRIC

W P 372-89-05 LOCATION Co-ords: 4,986,994.4 N; 373,524.3 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE November 8, 9 and 10, 1990 CHECKED BY I.C.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ 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
95.8	Ground Surface										
0.0 / 95.2	Gravelly Sand (Roadfill) Loose Brown		1	SS	9	Not Noted			○		
0.6	Sand and Silt, some gravel, trace clay, some cobbles, occasional boulders (Glacial Till) Very Dense Brown		2	SS	70*						NE 12 38 46 3
			3	SS	46/150mm	Bentonite Seal	94		○		
92.3			4	SS	76/275mm						
3.5	Sandy Silt, some gravel trace Clay. Some cobbles, occasional boulders (Glacial Till) Very Dense Grey Cored boulders from:- 3.58m - 3.97m; 7.78m - 8.82m						92				
						Backfill					
			5	SS	62				○		
							90				
			6	SS	64						13 35 57 9
						Piezometer					
			7	SS	28/150mm		88		○		
			8	SS	37/100mm						
							86				
			9	SS	50/110mm				○		
							84				
83.2					52/150mm						
12.6	Dolostone Bedrock fine grained, closely jointed, with some calcite intrusions Grey		11	RC NXL	100			RQD% 59			
			12	RC NXL	69			31			
			13	RC NXL	100			69			
			14	RC NXL	100			100			

Rec%

+3, ×3 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 11-2

METRIC

W P 372-89-05 LOCATION Co-ords: 4,986,994.4 N ; 373,524.3 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE November 16, 1990 CHECKED BY I.C.

SOIL PROFILE 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 W_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
80.8	Borehole Cont'd										
15.0 / 80.4	See Page 1 for rock Description										
15.4	End of Borehole										

Notes:

1) 00* indicates that the quoted 'N' value is based on the first 0.3m of penetration. (full penetration not achieved)

2) Borehole advanced from 2.5 m to bedrock by Triconing inside an N casing.

3) Piezometer was damaged before a water level was established.

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 11-3

METRIC

W P 372-89-05 LOCATION Co-ords: 4,987,008.9 N; 373, 564.6 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE November 15, 1990 CHECKED BY I.C.

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 ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.3	Ground Surface										
0.0	Peat & Topsoil						94				
94.0	Soft Black										
0.3	Sand and Silt, some gravel, trace clay, occasional cobbles (Glacial Till) Very Dense Brown		1	SS	41*				○		
			2	SS	66						
			3	SS	62*		92		○		14 37 42 7
			4	SS	92/200 mm						
			5	SS	41/275mm	▽			○		
90.0							90				
4.3	Sand and Silt, some gravel, trace clay. Occasional cobbles (Glacial Till) Dense Grey Water bearing sand seam at 5.3 - 5.8m		6	SS	38				○		
			7	SS	36						
88.0			8	SS	137/150mm						
6.3	End of Borehole										

Notes:

1) Water in open borehole measured at elevation 90.3 m upon completion of drilling.

2) 00* indicates quoted 'N' value is based on the first 0.3m of penetration. (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 11-4 METRIC

W P 372-89-05 LOCATION Co-ords: 4,987,020.7 N; 373,601.1 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE November 6, 1990 CHECKED BY I.C.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ 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
94.1	Ground Surface						94				
0.0 / 94.0	Topsoil										
0.1	Sandy Silt, some clay trace gravel		1	SS	4			Water level in piezometer measured at elevation 93.1 m on December 4, 1990.			
92.7	Loose to Compact Brown		2	SS	25				○		0 31 52 17
1.4	Sandy Silt, some gravel, trace clay, occasional cobbles (Glacial Till)						Bentonite Seal				
			3	SS	78*		92				
	Very Dense Brown		4	SS	64				○		
90.7			5	SS	66						
3.5	Sandy Silt, some gravel, trace clay, occasional cobbles						Backfill				
	Dense to Very Dense						90				
	(Glacial Till) Grey		6	SS	32						
	Encountered sand seams at:-		7	SS	37						
	5.01m - 5.34m; 8.13m - 8.31m		8	SS	71*		88				
			9	SS	84						
							Piezometer				
							86				
			10	SS	92/ 275mm				○		12 20 62 6
							84				
			11	SS	69/ 225mm						
82.3					Rec%			RQD%			
11.8	Dolostone Bedrock							90			
	fine grained closely jointed		12	RC NXL	95						
			13	RC NXL	90			52			
79.7	Grey		14	RC NXL	83			87			
14.4	End of Borehole										

00* indicates that the quoted 'N' value was based on the first 0.3 m of penetration (full penetration not achieved).

+3, ×5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 11-5

METRIC

W P 372-89-05 LOCATION Co-ords: 4,987,014.2 N; 373,602.2 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE November 7, 1990 CHECKED BY I.C.

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 W_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.5	Ground Surface										
0.0 / 94.4	Topsoil		1	SS	14	Not Noted	94		○		
0.1	Heterogeneous mixture of Silt, Sand and Gravel, trace clay, occasional cobbles. (Glacial Till) Very Dense Brown		2	SS	73/285mm						
			3	SS	80				○		
			4	SS	31/150mm		92				
			5	SS	80*				○		27 31 36 6
89.9							90				
4.6	Sandy Silt, some gravel, trace clay, occasional cobbles (Glacial Till) Very Dense Grey		6	SS	64						
			7	SS	65						
88.2											
6.3	End of Borehole										

Notes:

1) 00* indicates that the quoted 'N' value is based on the first 0.3m of penetration (full penetration not achieved)

OFFICE REPORT ON SOIL EXPLORATION

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

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 11-6

METRIC

W P 372-89-05 LOCATION Co-ords: 4,987,030.1 N; 373,680.4 E ORIGINATED BY G.Y.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers COMPILED BY I.C.

DATUM Geodetic DATE March 5, 1991 CHECKED BY I.C.

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, x LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
92.8	Ground Surface										
0.0 / 92.6	Peat and Topsoil Black										
0.2 / 92.0	Sand Grey						92				
0.8	Clayey Silt. Trace to Some Sand. Silt content increasing with depth. Firm to Very Soft Grey		1	SS	4						0 15 73 12
			2	SS	5						
			3	SS	7		90				0 5 89 6
89.3			4	SS	1						
3.5	Gravelly Sand and Silt Trace Clay. (Glacial Till)		5	SS	67						
87.7	Very Dense Grey		6	SS	89		88				
5.0	End of Borehole										

Notes:

1) Water level in open borehole at ground surface upon completion of drilling.

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

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

Geocon

TEST PIT LOG

PROJECT Highway 410 - Van Buren Street Underpass TEST PIT 11-1
Location: Co-ords. 4,987,015.7N; 373,528.8E PAGE 1 OF 1
CONTRACT NO. WP 372-89-05 DATE Dec. 13/91
DATUM Geodetic

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 - %

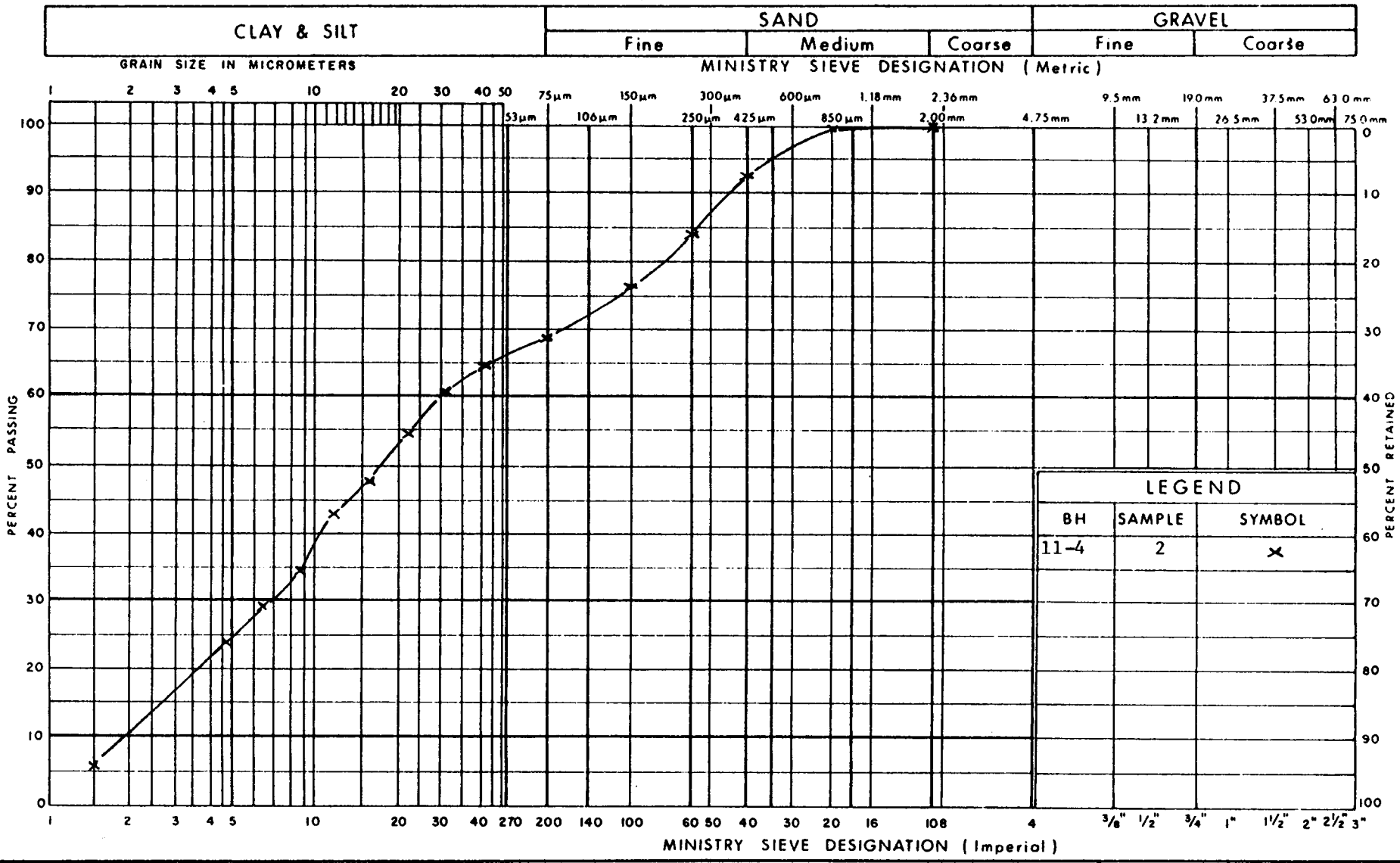
STRATIGRAPHY				SAMPLES		TESTS
DEPTH - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	CONDITION	NUMBER	RESULTS
						Gr Sa Si Cl
0	97.7	Ground Surface				
	0.0 / 97.4	Silty Fine Sand, Some Roots (Topsoil) Dark Brown				
	0.3	Heterogenous mixture of Gravel, Sand and Silt, Trace Clay, Occasional Cobbles (Glacial Till) Grey/Brown				
1				☒	1	32 30 36 2
	95.5					
2	1.9 / 95.8	Medium Gravel, Some Sand (Water Bearing) Dark Brown				
	2.0	Heterogenous mixture of Gravel, Sand and Silt, Trace Clay Some cobbles and boulders. Boulder content increasing with depth. (Glacial Till) Grey/Brown				dry @ 2.2m 19.6kN/m³ W_{nat} = 9% S.G. = 2.8
3						dry @ 3.0m 19.2kN/m³ W_{nat} = 8% S.G. = 2.8
				☒	2	32 30 30 8
4						
	92.9					
	4.8	End of Test Pit Machine Refusal				

APPENDIX B

Laboratory Test Data

Figures B1 to B4 - Grain Size Curves
Figure B5 - Plasticity Chart

UNIFIED SOIL CLASSIFICATION SYSTEM



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Ontario

GRAIN SIZE DISTRIBUTION

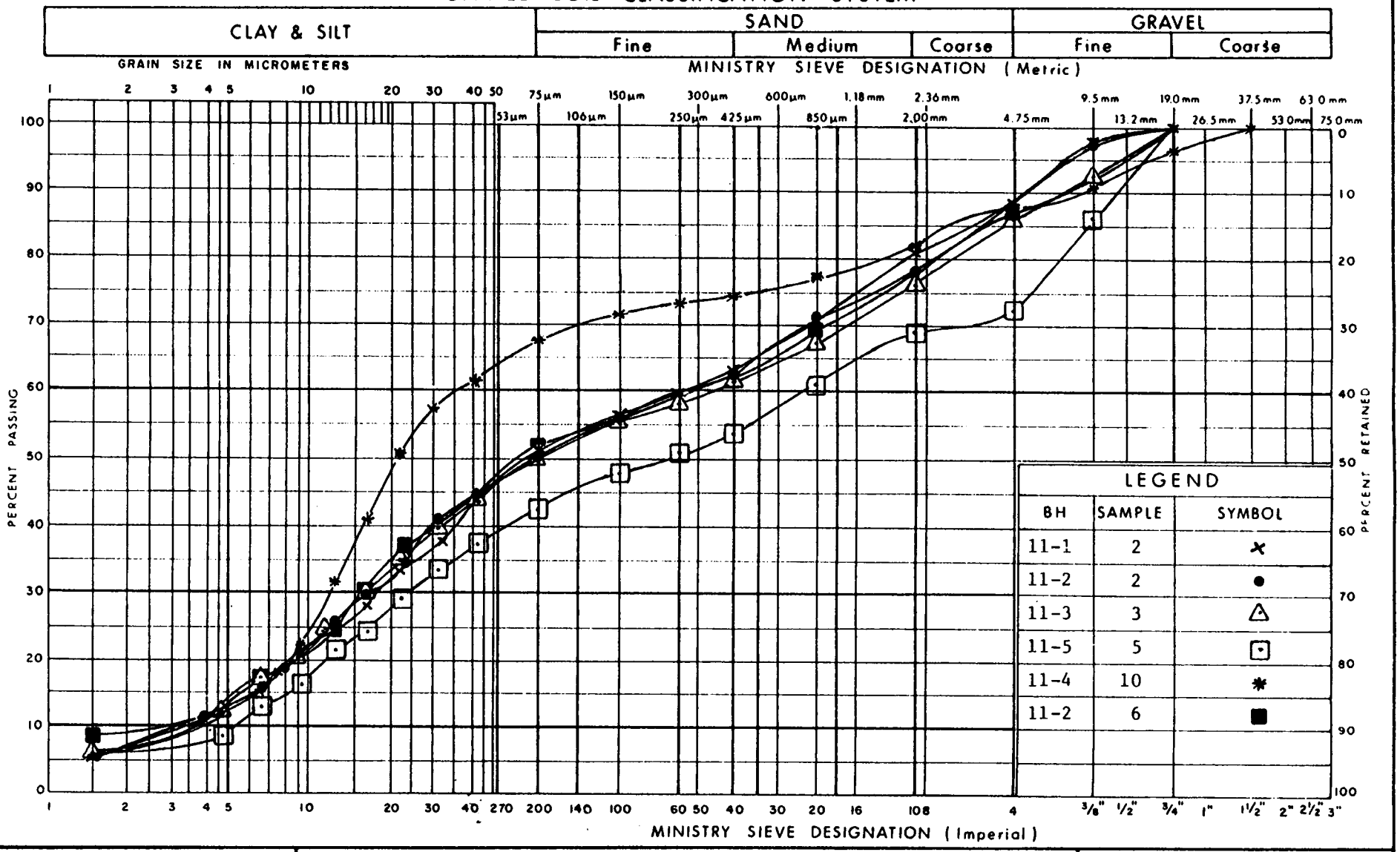
Sandy Silt, Trace Clay

FIG No B1

W P 372-89-05

122

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

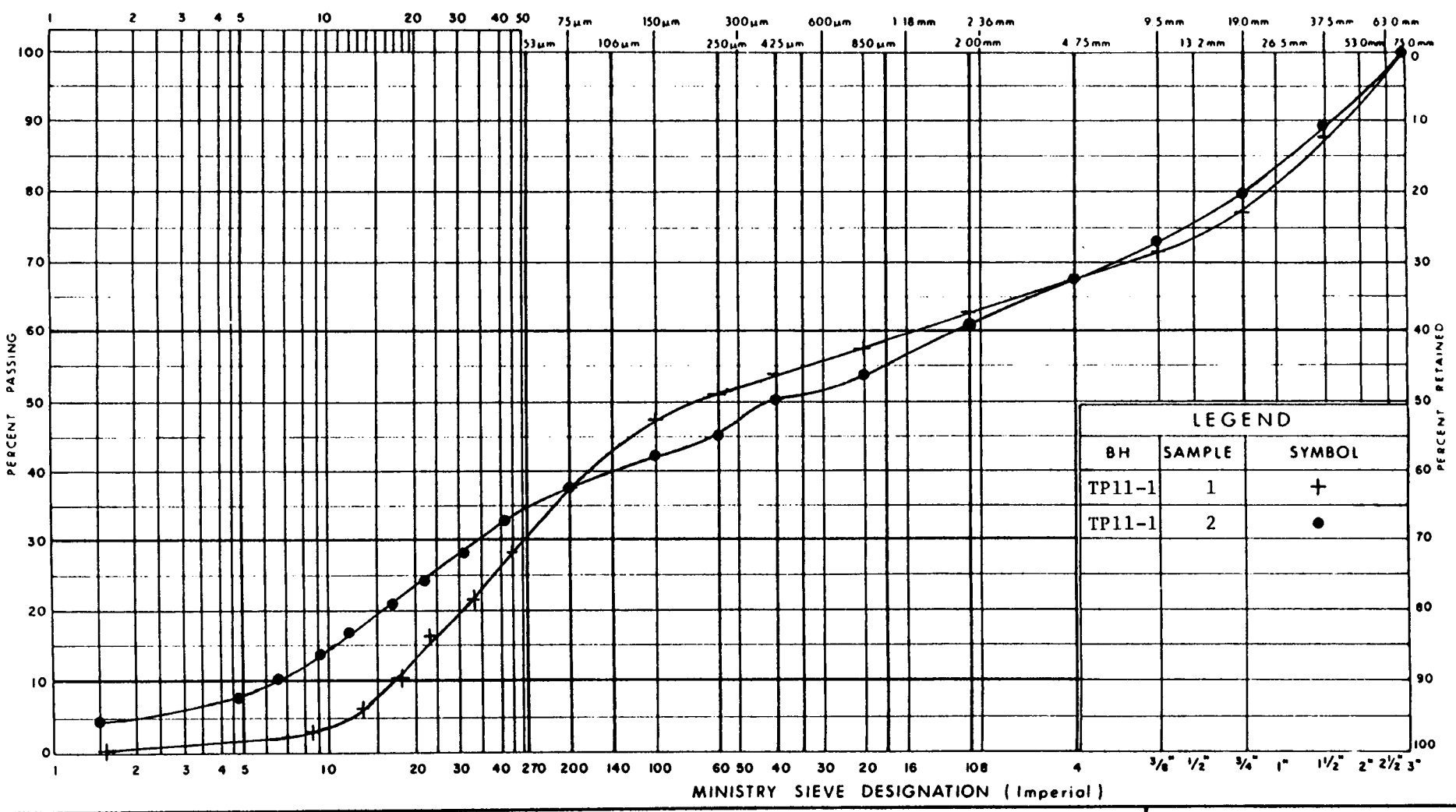
Glacial Till

FIG No B2

W P 372-89-05

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



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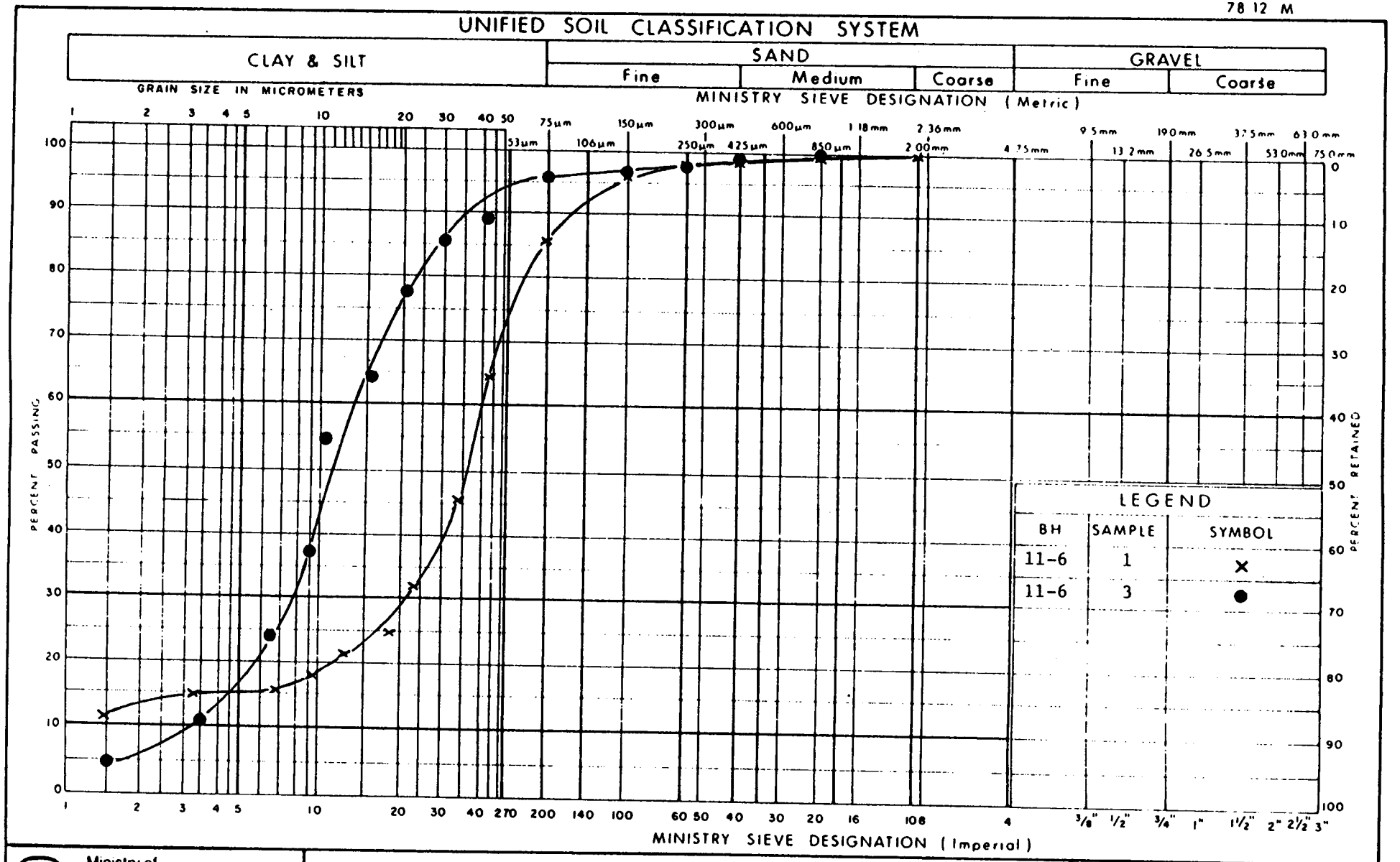
GRAIN SIZE DISTRIBUTION

Glacial Till

FIG No B3
W P 372-89-05



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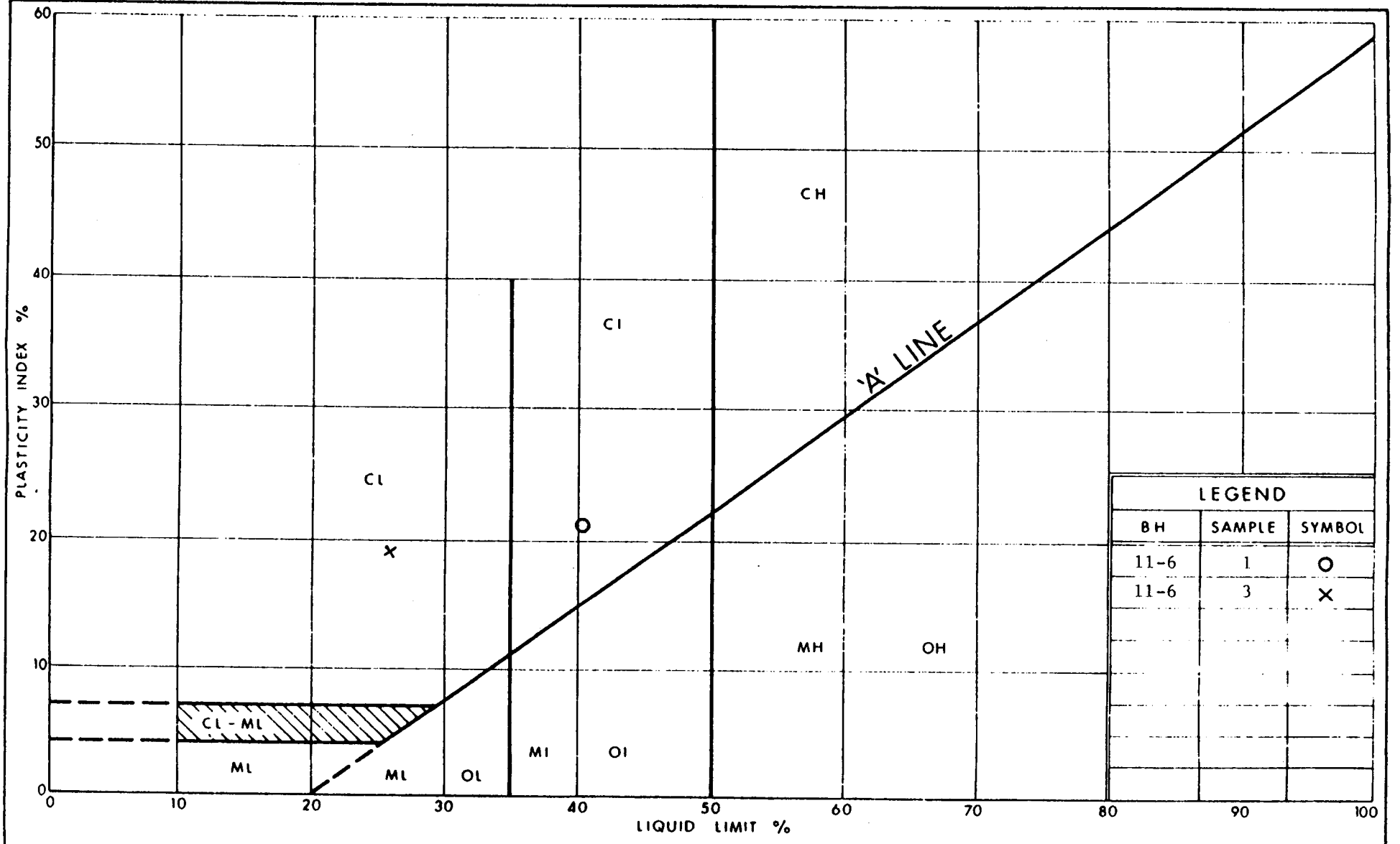
GRAIN SIZE DISTRIBUTION

Clayey Silt

FIG No B4

W P 372-89-05

125



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PLASTICITY CHART

Clayey Silt

FIG No B5

W P 372-89-05

T11688E

REPORT TO

FENCO ENGINEERS INC.
WILLOWDALE ONTARIO

FOUNDATION INVESTIGATION REPORT FOR HIGHWAY 416 UNDERPASS AND INTERCHANGE AT HIGHWAY 43, KEMPTVILLE W.P. 372-89-06, SITE 16-318 DISTRICT 9, KINGSTON

GEOCON (1991) INC.
December, 1991

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, approach fills and Highway 43 realignment. Geocon (1991) Inc. (Geocon) was retained by Fenco Engineers Inc. to perform this work.

The field work for this project was conducted between October 29th and November 1st, 1990 using a CME 55 drill rig equipped with 200 mm diameter hollow stem augers. The investigation consisted of 8 boreholes and 1 test pit. The soil overburden was augered and sampled using the Standard Penetration Tests (SPT) and the underlying bedrock was cored using NXL size core. Two standpipe piezometers were installed to monitor the groundwater levels. Finally a test pit was excavated with a backhoe to obtain field densities and confirm the hard nature of the silty sand till subsurface conditions.

The locations of the boreholes and one test pit are shown on Drawing 3728906-A* and a record of the encountered subsurface conditions at each borehole and the test pit are given on the Record of Borehole Sheets in Appendix A.

* Dwg. No. 2, Sheet 347, of the Contract Drawings.

2.0 SITE DESCRIPTION AND GEOLOGY

The proposed Highway 43 underpass is located at the intersection of Highway 43 and Highway 16 approximately 2 kilometers east of Kemptville, Ontario (Figure 1). The proposed underpass will comprise of two spans supported on a central pier and two abutments.

The site of the proposed underpass and interchange is generally undulating with several poorly drained areas. The area of the proposed underpass structure is located on top of a small rise which is surrounded by lower lying areas. Of particular interest in this regard, is the presence of a marshy area in the northeast corner of the intersection of Highway 43 and Highway 16. Other smaller marshy areas may be found throughout the entire interchange. With the exception of the southeast quadrant of the interchange, the area is heavily wooded.

A northward flowing drainage ditch intersects the proposed Highway 43 realignment approximately 400 m east of the 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 comprises 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.

More specifically, available surficial geological information at the site of the proposed Highway 43 underpass and interchange (OGS Map 1492A) indicates that it is underlain by fine to medium grained glaciofluvial sands. However, this is anticipated to overlie finer grained Champlain Sea deposits.

The underlying bedrock at the site is anticipated to comprise of dolostone bedrock of the Oxford Formation of the Beekmonton Group.

3.0 SUBSURFACE CONDITIONS

The subsurface conditions for the underpass structure and the approach embankments are discussed separately because of different subsurface conditions in these areas. These differences are caused by the undulating topography which resulted in additional soil layers in the low lying areas. The factual information which was used to interpret the soil conditions is given in Appendix A and B and Drawing No. 3728906-A.*

3.1 UNDERPASS

The underpass proper is located on top of a slight knoll which is underlain by a sandy topsoil followed by very dense gravelly sand and silt (glacial till) and finally dolostone bedrock about 9 m below the ground surface. The groundwater surface was observed to be about 0.9 m below the ground surface.

3.1.1 Topsoil

The topsoil is an organic silty sand containing roots with a thickness varying from 0.2 m to 0.5 m. At Test Pit 12-1 the topsoil was underlain by 0.2 m of sand fill.

3.1.2 Gravelly Sand and Silt Trace Clay (Glacial Till)

By far the dominant material on site, glacial till was encountered below the surficial topsoil (and fill) and was found to extend to bedrock. The thickness of this layer was determined to be 8.4 m and 9.3 m at Boreholes 12-1 and 12-4, respectively.

* Dwg. No. 2, Sheet 347, of the Contract Drawings.

Based on the results of grain size analysis performed on split spoon samples (Figures B1 and B2 - Appendix B) this material may be described as a gravelly sand and silt with a trace clay. Some cobbles and boulders are also present within this deposit.

SPT 'N' values within this layer are high and variable with 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 can be described as having a very dense relative density. Measured water contents within the glacial till typically varied from 2 to 9%.

The one water content of 28%, measured in Borehole 12-7, was obtained from a sample recovered from near the above lying clayey silt and it is not representative of the glacial till.

3.1.3 Bedrock

Dolostone bedrock was found below El. 83.0 m which is about 9 m below the existing ground surface. The bedrock was proven in two boreholes by coring about 2.5 and 2.0 m into the bedrock in Boreholes 12-1 and 12-4, respectively. The bedrock is judged, by core recovery and RQD percentages to be of good to excellent quality with the exception of the first 0.6 m in Borehole 12-4 which is of a fair quality.

3.1.4 Groundwater

Groundwater was measured by means of two standpipe piezometers in Boreholes 12-1 and 12-3 and visual observations in the remaining boreholes. The groundwater was observed

to be about 0.9 m below the ground surface in the piezometers and as high as 0.3 m below the ground surface in the uncased Borehole 12-5.

3.2 APPROACH EMBANKMENTS

The approach embankments west and east of the underpass structures are located in minor depressions which have fluvial and lacustrine deposits overlying the glacial till and bedrock. The observed soil stratigraphy is as follows:

- Peat/Topsoil
- Sand, compact
- Silty Clay, soft to stiff
- Sand (in Borehole 12-8 only)
- Gravelly Sand and Silt (Glacial Till) Very Dense

The subsurface conditions at the west embankment were investigated by Borehole 12-6 which encountered a 0.3 m thick saturated peat and organic layer at the surface followed by 2.0 m of compact sand and 1.4 m of very stiff silty clay at the bottom of the 3.7 m deep borehole.

The subsurface conditions at the east embankment were investigated by Boreholes 12-7 and 12-8. The boreholes encountered a 0.3 m thick peat and topsoil stratum underlain by about 1.4 m compact sand, variable thickness of soft to firm silty clay (3.7 to 6.9 m) and finally by very dense gravelly sand and silt. At Borehole 12-8 a 1.1 m thick sand layer separated the silty clay and the underlying gravelly sand and silt strata.

At both embankment locations the groundwater was observed to be at the ground surface. Bedrock was not encountered, to the depths drilled, at the approach embankment locations.

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. with assistance from Mr. N. Khan, P.Eng. and reviewed by Dr. I. Holubec, P.Eng.

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

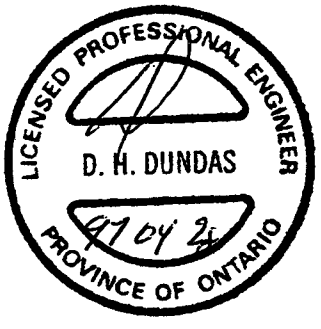
Yours very truly
GEOCON (1991) INC.

N. Khan, P.Eng.
Project Engineer

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

IH:dtj
T11688/15530

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Geocon (1991) Inc. (consulting geotechnical engineers for this project), and signed and sealed by N. Khan, P.Eng. and I. Holubec, Ph.D., P.Eng. The project was carried out under the technical supervision of Fenco Engineers Inc., the supervising consultant for this project.



D. Dundas, P. Eng.
Senior Foundation Engineer

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

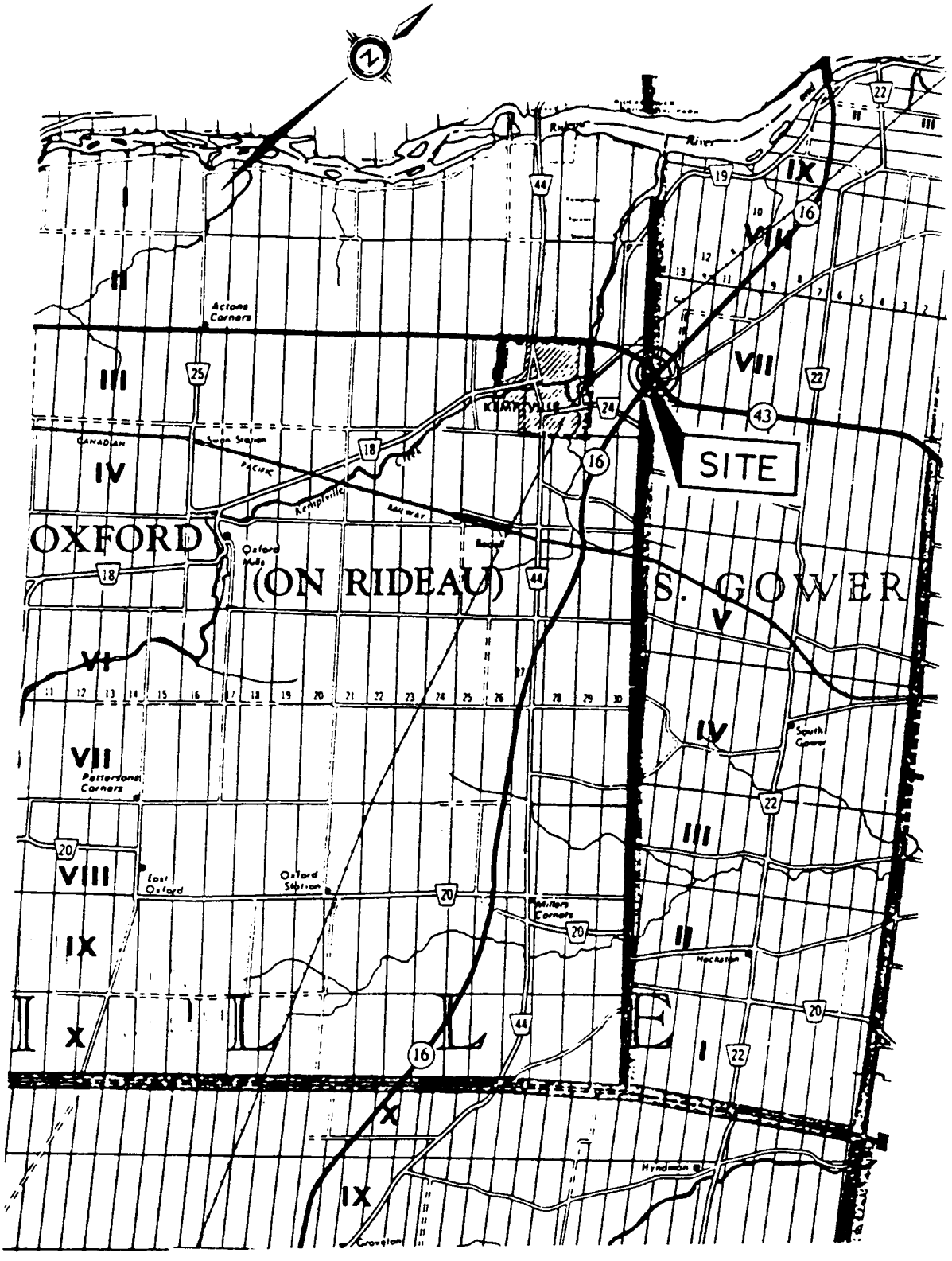
Canadian Foundation Engineering Manual, 1985. Second Edition. Part 1: Fundamentals; Part 2: Shallow Foundations; Part 3: Deep Foundations; Part 4: Excavations and Retaining Structures Part 5: References. Canadian Geotechnical Society, Technical Committee on Foundations, 456 pp.

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 372-89-06



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GEOCON

APPENDIX A

Explanation of the Term Rock Quality Designation (RQD)
Record of Borehole Sheets (12-1 to 12-8)
Test Pit Logs

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 12-1 METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,878.2 N; 373,610.0 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE October 31, 1990 CHECKED BY J.C.

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 (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
92.3	Ground Surface										
0.00 / 91.9	Silty Sand Topsoil. Some roots.		1	SS	6		92				
0.4	Loose Black										
	Gravelly Sand and Silt. Trace clay (Glacial Till)		2	SS	8				○		
	Loose to Very Dense Brown		3	SS	36/200mm		Bentonite Seal				21 37 37 5
89.9							90				
2.4	Gravelly Sand and Silt. Trace clay. Some cobbles and boulders (Glacial Till)		4	SS	50/75mm				○		
	Very Dense Grey		5	SS	97		88				
			6	SS	19/75mm		Backfill				
			7	SS	23/63mm						
			8	SS	86*		86		○		22 38 35 5
			9	SS	92/250mm						
			10	SS	50/150mm				○		
83.5					Rec%		84 Piezometer Tip	RQD%			
8.8	Dolostone Unweathered, fine grained, closely to moderately bedded.		11	RC NXL	98			95			
	Sound Grey						82				
80.9			12	RC NXL	100			100			
11.4	End of Borehole										

Notes:
1. Water level in standpipe piezometer measured at elevation 91.3 m on Dec. 9/90.
2. 00* indicates that the quoted 'N' value is based on the first 0.3 m of penetration (full penetration not achieved)
3. Borehole advanced from 4.7 m to bedrock by Triconing inside N casing.

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

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 12-2 METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,860.8 N; 373,604.3 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE November 31, 1990 CHECKED BY I.C.

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 (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
91.6	Ground Surface										
0.0 / 91.1	Silty Sand Topsoil. Some Roots and Organics Loose Black		1	SS	6	Not Noted					
0.5	Gravelly Sand and Silt. Trace clay. Some cobbles and boulders (Glacial Till) Very Dense Grey		2	SS	90		90				
			3	SS	72				o		40 31 25 4
			4	SS	73		88				
			5	SS	60/ 140mm				o		
85.6			6	SS	42/ 140mm		86				
	End of Borehole										

Notes:

1) Borehole advanced from 3.10 m to 5.95 m by Triconing inside an N casing.

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 12-3 METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,857.4 N; 373,646.6 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE October 30, 1990 CHECKED BY I.C.

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, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
93.0	Ground Surface										
0.0 / 92.6	Silty Sand Topsoil. Loose Black		1	SS	8				o		
0.4 / 92.4	Sand (Fill)										
0.6	Gravelly Sand and Silt. Trace clay. Some cobbles and boulders (Glacial Till). Dense to Very Dense		2	SS	75*		92				
			3	SS	72						28 32 35 5
			4	SS	74*				o		
							Bentonite Seal				
			5	SS	50/110mm		90				
	Brown / Grey		6	SS	53*				o		
			7	SS	47		Backfill 88				
			8	SS	87/280mm		Piezometer 86				
85.6			9	SS	397/100mm				o		
7.4	End of Borehole Auger Refusal										

Notes:

1) Water level in standpipe piezometer measured at elevation 92.09 m on Dec. 9/90.

2) 00* indicates that the quoted 'N' value is based on the first 0.3 m penetration (full penetration not achieved)

3) Borehole advanced from 5.90 m to 7.42 m by Triconing inside N casing.

+3, x5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 12-4 METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,848.9 N; 373,685.8 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE October 29, 30 and November 2, 1990 CHECKED BY L.C.

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)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
92.5	Ground Surface										
0.0 / 92.2	Silty Sand Topsoil Some roots. Black		1	SS	8		92		○		
0.3	Gravelly Sand and Silt. Trace clay. Some cobbles and boulders. (Glacial Till) Very Dense Brown		2	SS	35/150mm	▽			○		
	Grey		3	SS	83/265mm		90		○		
			4	SS	84				○		
			5	SS	R		88				
			6	SS	R						
			7	SS	83*				○		
			8	SS	42/150mm		86		○		27 35 33 5
			9	SS	42/150mm		84				
82.9					Rec%			RQD%			
9.6	Dolostone Unweathered, fine grained closely to moderately bedded. Some calcite intrusions. Sound Grey		10	RC NXL	100			55			
80.9			11	RC NXL	100			85			
			12	RC NXL	100			93			
11.6	End of Borehole										

Notes:
1) Water level in open borehole measured at elevation 91.69 m on October 30, 1990.
2) 00* indicates quoted N value based on the first 0.3 m penetration (full penetration not achieved).
3) Borehole advanced from 3.43 m to top of bedrock by Triconing inside N casing.
4) R = SPT Refusal

+3, ×5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 12-5

METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,840.6 N; 373,683.6 E ORIGINATED BY N.K.

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

DATUM Geodetic DATE October 29 and 30, 1990 CHECKED BY I.C.

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 (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
92.2	Ground Surface										
0.0 / 92.0	Silty Sand Topsoil		1	SS	7	▽	92				
0.2	Some clay and roots Black										
	Sandy Silt. Some gravel. Trace clay. Some cobbles and boulders (Glacial Till)		2	SS	95/ 250mm						
			3	SS	26/ 150mm						
	Very Dense Brown		4	SS	100		90				
	Grey		5	SS	61						15 36 58 7
							88				
							86				
							84				
83.3											
8.9	End of Borehole Casing Refusal Inferred Bedrock										

Notes:

1) Water in open borehole measured at elevation 91.9 m on morning of Oct. 30/90.

2) Borehole advance from 3.56 m to 8.92 m by Triconing inside N casing.

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 12-6 METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,897.3 N; 373,517.2 E ORIGINATED BY GY

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

DATUM Geodetic DATE February 28, 1991 CHECKED BY IC

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 ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
91.0 Ground Surface											
0.0 / 90.7	Peat and Organics Soft Black										
0.3	Medium Sand. Some silt. Compact Brown		1	SS	14		90				
89.6											
1.4	Coarse Sand. Trace silt. Compact Grey		2	SS	15						
88.7											
2.3	Silty Clay. Some sand. Very Stiff Grey		3	SS	20						0 25 54 21
							88				
			4	SS	28						
87.3											
3.7	End of Borehole Auger Refusal										

Notes:

Water level in open borehole measured at elevation 91.0 m upon completion of drilling.

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 12-7 METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,764.7 N; 373,921.0 E ORIGINATED BY GY

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

DATUM Geodetic DATE March 6, 1991 CHECKED BY IC

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 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
91.3	Ground Surface										
0.0	Peat and Topsoil Black										
91.0											
0.3	Sand										
	Compact Grey		1	SS	22		90				
89.6											
1.7	Silty Clay. Trace to Some Sand. (Weathered Crust)		2	SS	5						
	Firm Grey		3	SS	4						0 23 29 48
			4	SS	1		88				
86.7											
4.6	Clayey Silt (Varved)		5	SS	15						
86.0	Stiff Grey						86				
5.3	Gravelly Sand and Silt Trace clay. (Glacial Till)		6	SS	11						
	Compact Grey		7	SS	25						
84.7											
6.6	End of Borehole										

Notes:

1) Water level in open borehole measured at elevation 91.3 upon completion of drilling.

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 12-8 METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,734.9 N; 374,016.4 E ORIGINATED BY GY

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

DATUM Geodetic DATE March 1, 1991 CHECKED BY IC

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 (20 40 60 80 100; o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
90.7	Ground Surface										
0.0	Peat and Topsoil Black										
90.5 / 0.2	Sand. Some Silt. Compact Brown		1	SS	19		90				0 82 18 0
89.0 / 1.7	Silty Clay Some Sand (Weathered Crust) Stiff Grey		2	SS	3		88	+ (>96)			0 16 44 40
88.0 / 2.7	Silty Clay. Trace Sand. Silt content increases with depth. Soft to Firm Grey		3	SS	1/450mm			+ 8			
			4	SS	1/450mm		86	+ 8			
			5	SS	1/450mm		84				0 7 61 32
			6	SS	1/450mm			+ 4			
			7	SS	1/450mm		82	+ 7			
81.1							See Note 1.				
9.6 / 80.0	Coarse Sand Grey						80				
10.7 / 79.9 / 10.8	Gravelly Sand and Silt Trace Clay (Glacial Till) Very Dense Grey		8	SS	70/75mm						
	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

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

Geocon

TEST PIT LOG

PROJECT Highway 416 - Highway 43 Underpass TEST PIT 12-1

Location Co-ords: 4,987,858.9 N; 373,690.8 E PAGE 1 OF 1

CONTRACT NO. WP 372-89-06 DATE Dec. 13/91

DATUM Geodetic

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

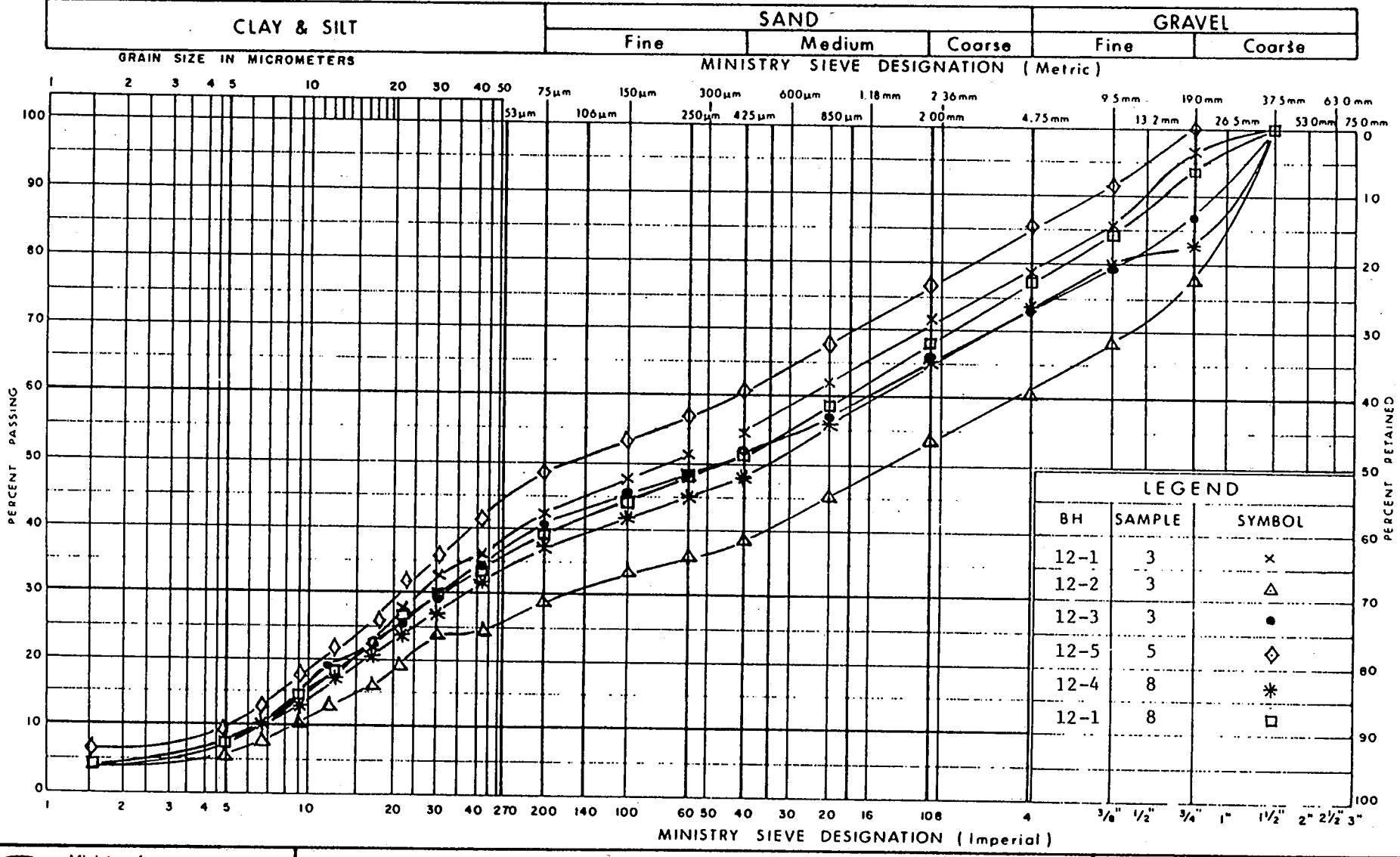
W_L - LIQUID LIMIT - %
W_P - PLASTIC LIMIT - %

STRATIGRAPHY				SAMPLES		TESTS
DEPTH - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	CONDITION	NUMBER	RESULTS
	93.5	Ground Surface				Gr Sa Si Cl
	0.0	Silty Fine Sand, Some roots (Topsoil) Dark Brown				
	93.3					
	0.2	Sand, medium to fine grained, Some silt, Tr organics Brown				
	93.1					
	0.4	Heterogeneous mixture of Gravel, Sand and Silt. Trace clay. Some Cobbles and Boulders (Glacial Till).				
		Max. size of Boulder encountered - 1.0 m diameter				
		Grey/Brown				
				X	1	34 28 32 6
	89.8					
	3.7	Heterogeneous mixture of Gravel, Sand and Silt. Trace clay. Some Cobbles and Boulders (Glacial Till).				
		Blue/Grey		X	2	26 32 34 8
	88.8					
	4.7	End of Test Pit Machine Refusal				

APPENDIX B

Figures B1 to B4 - Grain Size Curves

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

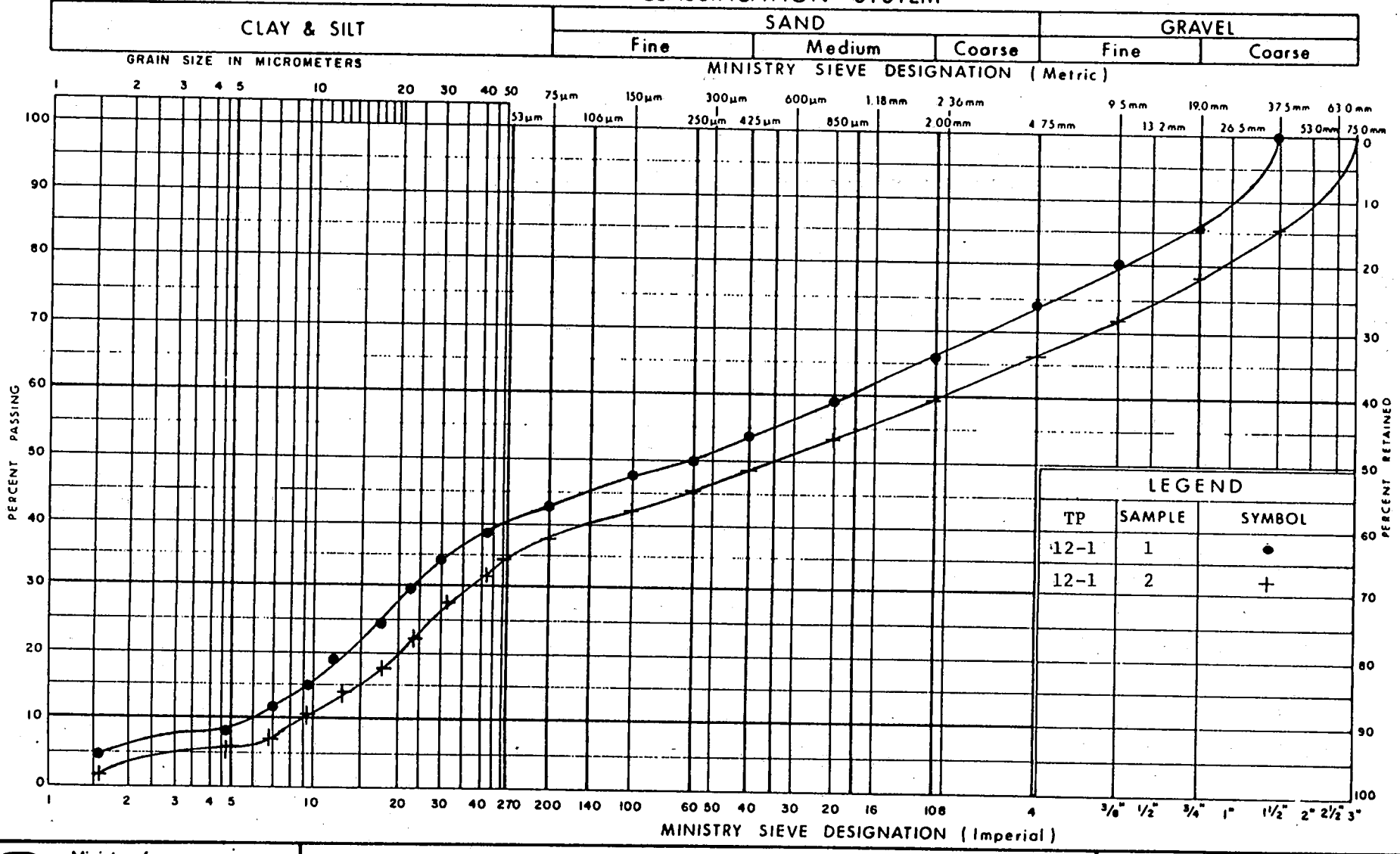
Gravelly Sand and Silt , Trace Clay (Glacial Till)

FIG No B1

W P 372-89-06

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

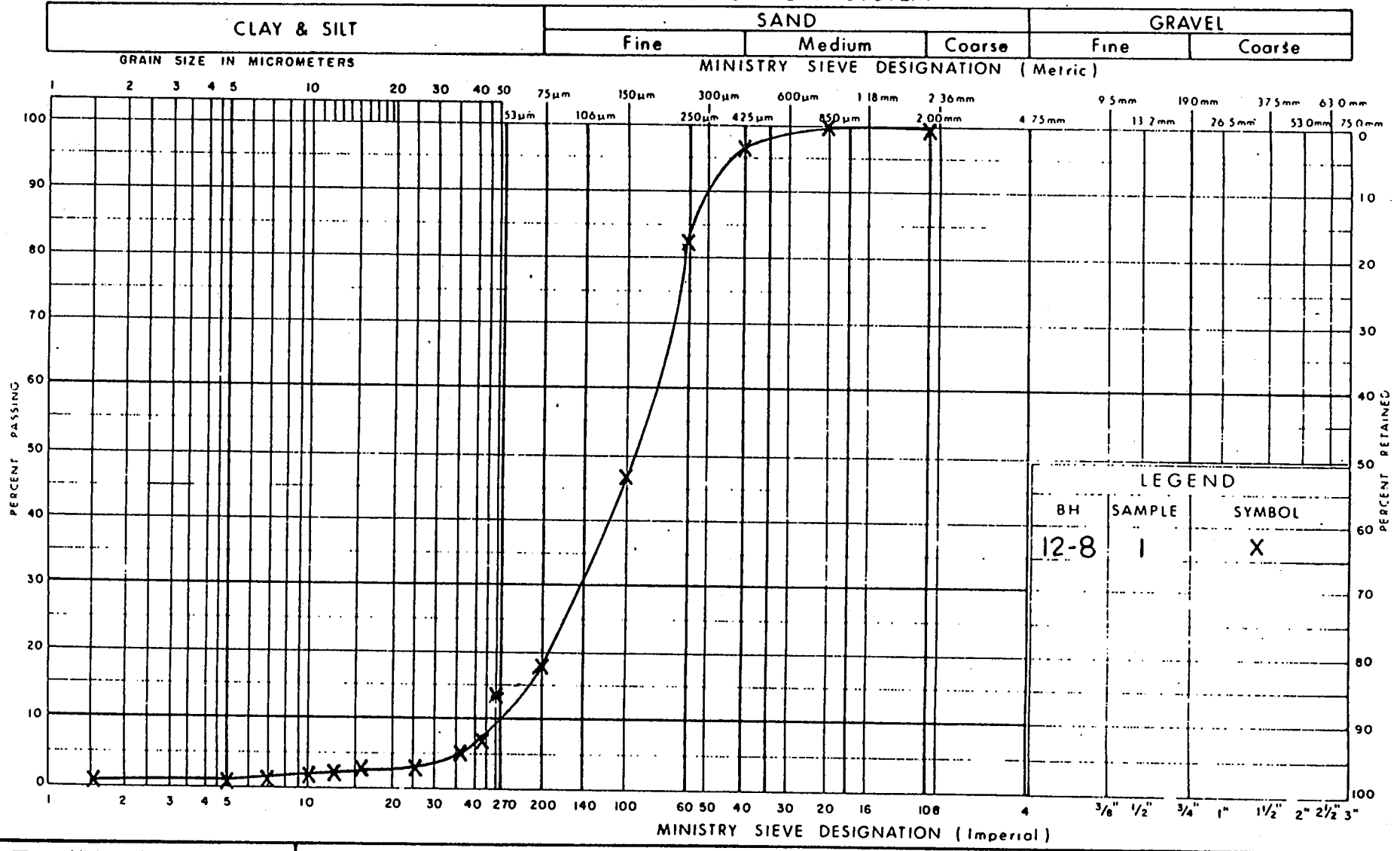
Heterogenous mixture of Gravel, Sand and Silt

FIG No B2

W P 372-89-06

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



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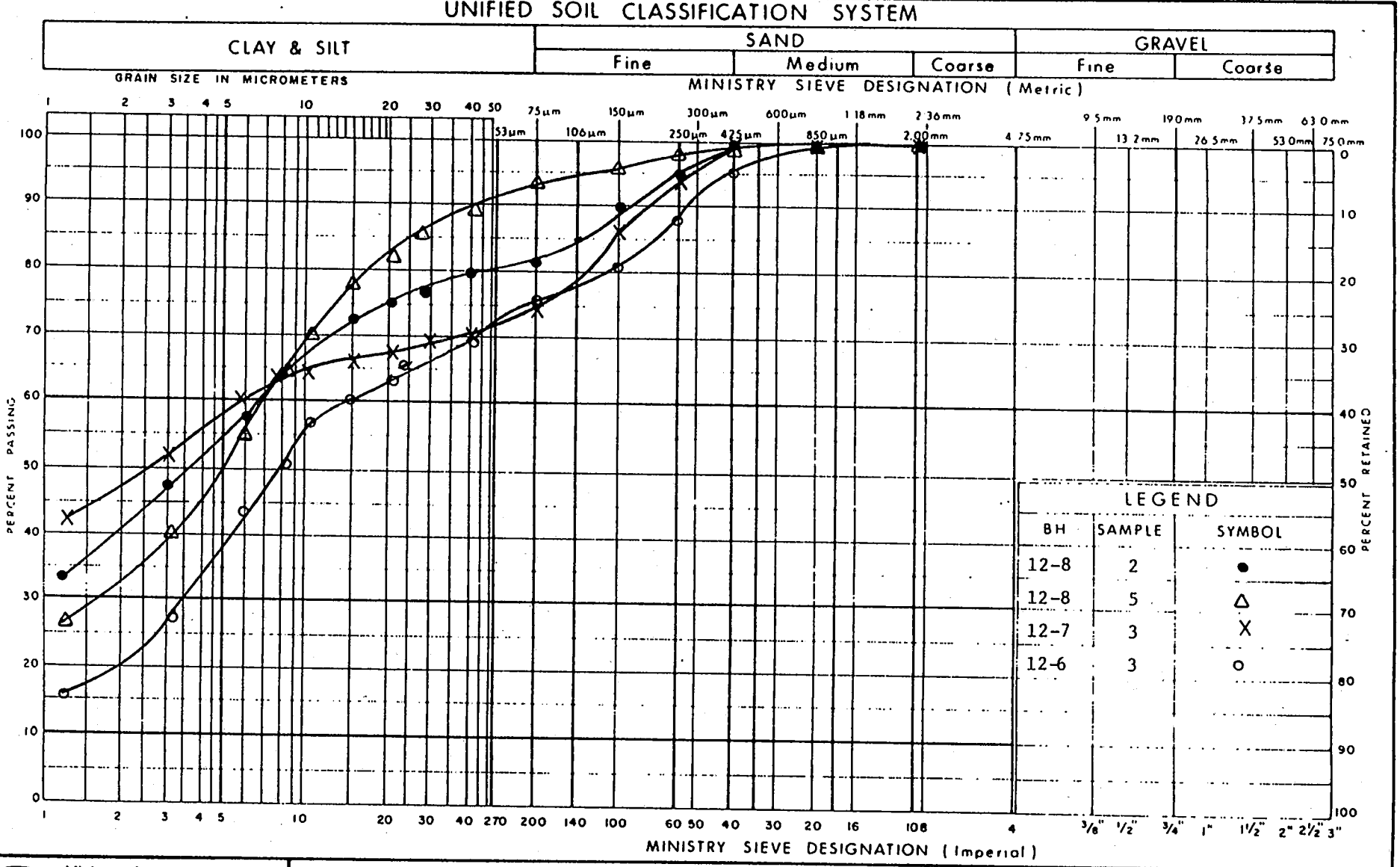
GRAIN SIZE DISTRIBUTION

Sand, Some Silt

FIG No	B3
W P	372-89-06

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

Silty Clay

FIG No B4

W P 372-89-06

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