

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 40I14-110

DIST. 2 REGION

W.P. No. 139-86-03

CONT. No. 89-11

W. O. No.

STR. SITE No. 19-94-371

HWY. No. 401

LOCATION West of 126

No of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



Ministry of
Transportation and
Communications

FILE No. _____ DATE _____

REMARKS _____

Call regarding where to send appendments
Ed Stevenson London Ext 3011

or John Heyink

April 7 "contract" control office
(sent to printing)

Tender June construction July/August.

METRIC

DIST. 2 HWY. 401

CONT No
WP No 139-86-03

C.N.R. OVERHEAD WIDENING
(1.6km W. OF HWY. 125)
GENERAL ARRANGEMENT



SHEET

NOTES

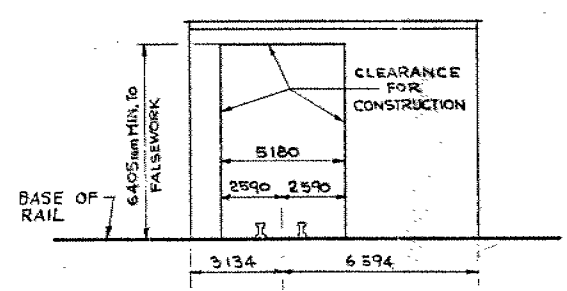
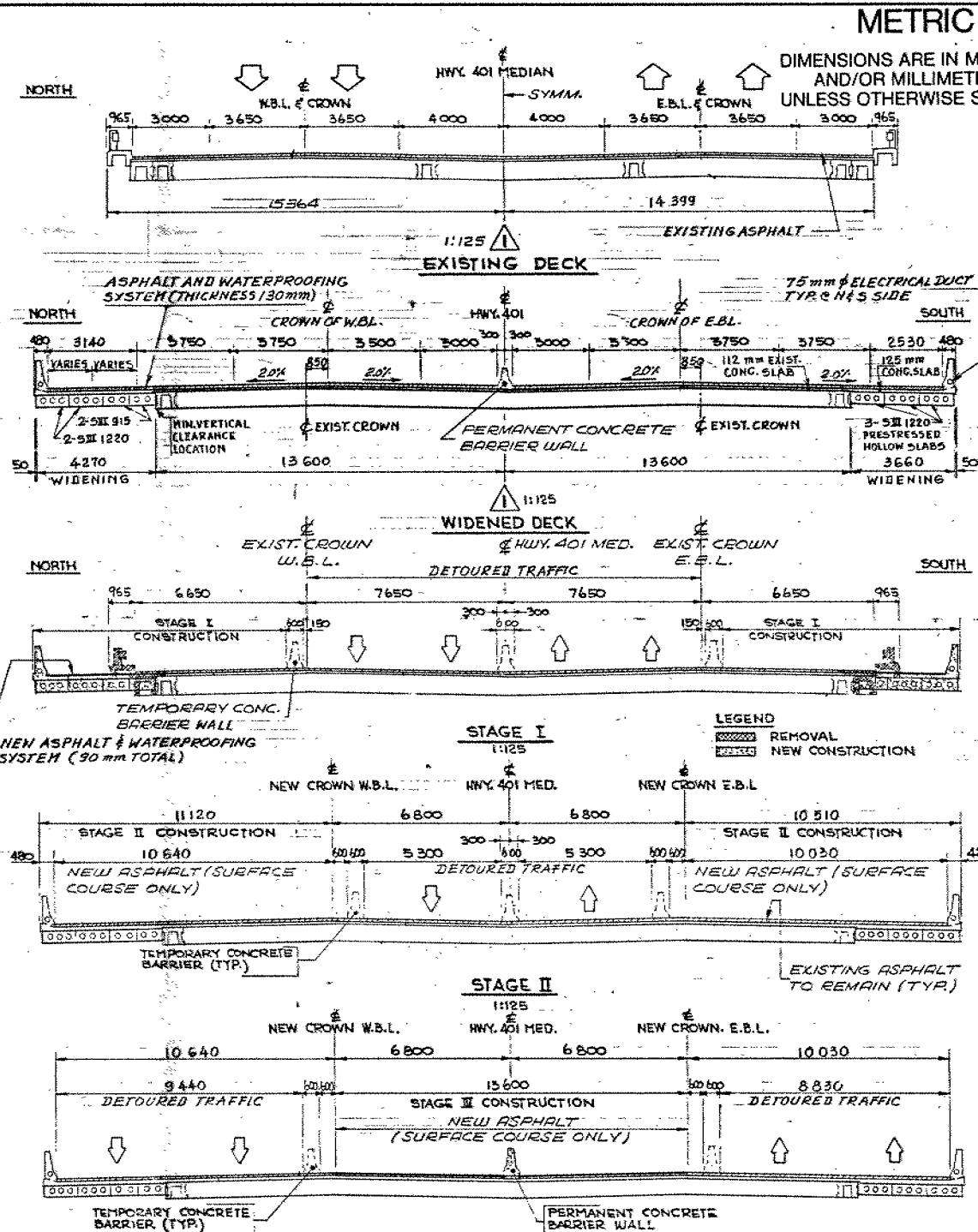
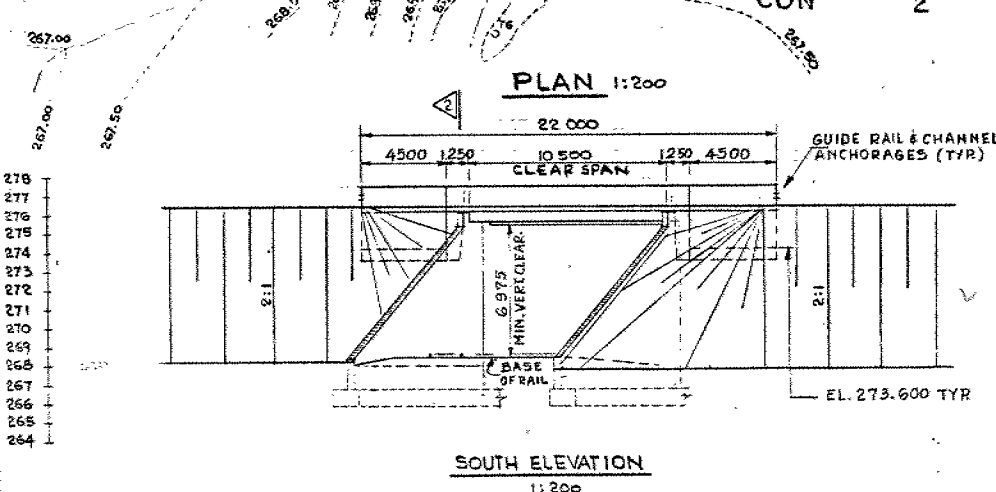
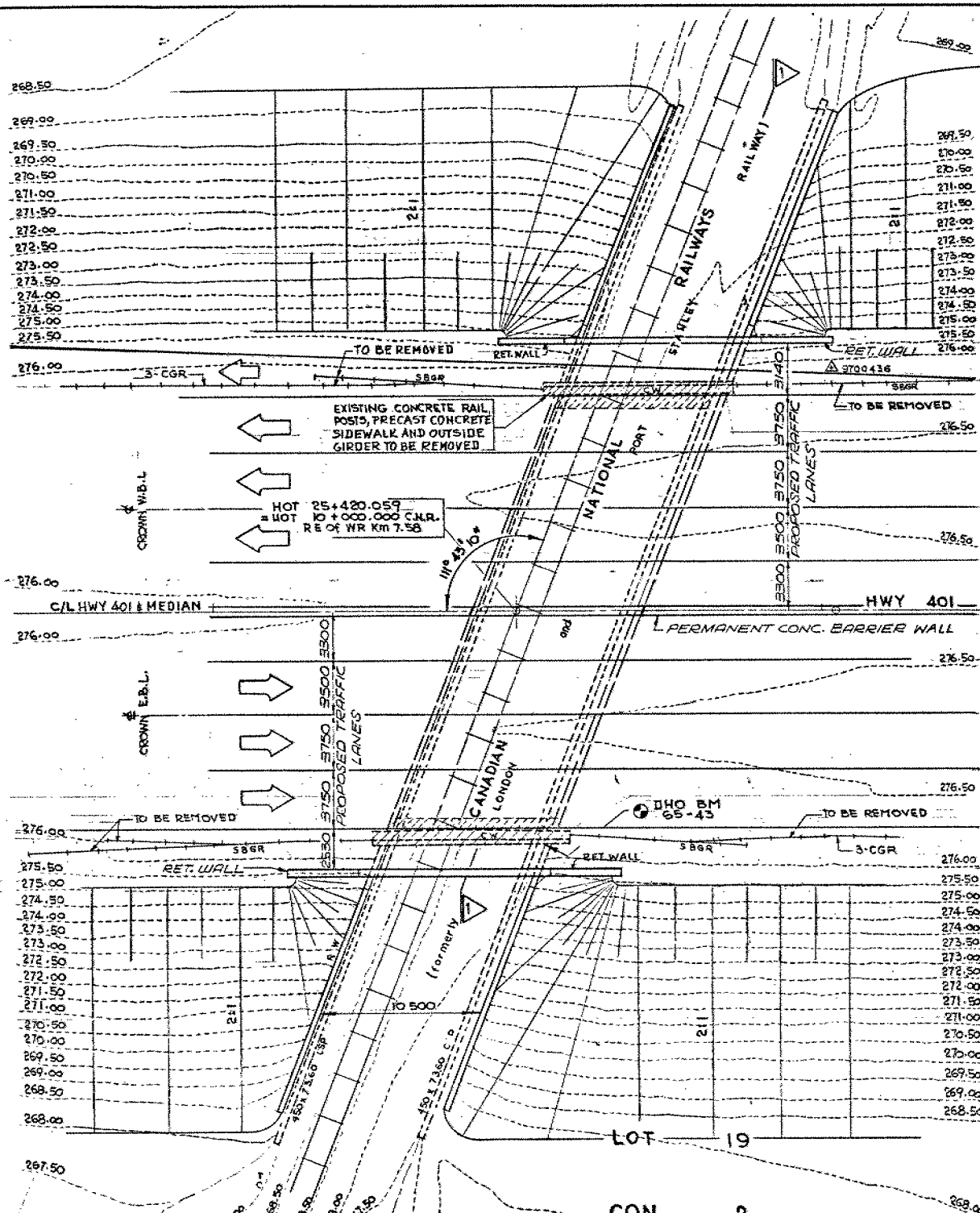
- CLASS OF CONCRETE**
 PRESTRESSED HOLLOW SLABS 35 MPa
 RETAINING WALL FOOTINGS 20 MPa
 REMAINDER UNLESS OTHERWISE NOTED 30 MPa
- REINFORCING STEEL GRADE:**
 REINFORCING STEEL SHALL BE GRADE 400
 UNLESS OTHERWISE SPECIFIED, BAR MARKS WITH SUFFIX 'C'
 DENOTE COATED BARS.
- CLEAR COVER TO REINFORCING STEEL:**
 FOOTINGS 100 mm
 ABUTMENTS & RETAINING WALLS
 FRONT FACE 80 mm
 BACK FACE 70 mm
 DECK TOP 70 mm
 REMAINDER UNLESS OTHERWISE NOTED 70 mm

WORK DESCRIPTION AND STAGING

- STAGE I**
- ERECT TEMPORARY CONCRETE BARRIERS AS SHOWN ON SECTION FOR STAGE I.
 - REMOVE CONCRETE RAIL, POSTS, PRECAST CONCRETE SIDEWALK AND OUTSIDE GIRDER ON BOTH N&S SIDES.
 - WIDEN EXISTING STRUCTURE ON BOTH NORTH AND SOUTH SIDES.
 - PLACE ASPHALT & WATERPROOFING (30 mm TOTAL) OVER WIDENING BOTH NORTH AND SOUTH SIDE.
- STAGE II**
- RELOCATE TEMPORARY CONCRETE BARRIER AS SHOWN ON SECTION FOR STAGE II AND RESTRICT TRAFFIC TO ONE LANE IN EACH DIRECTION.
 - PLACE SURFACE COURSE ASPHALT BY FORMING THE NEW CROWN ON BOTH EAST BOUND & WEST BOUND LANES.
- STAGE III**
- RELOCATE TEMPORARY CONCRETE BARRIER AS SHOWN ON SECTION FOR STAGE III AND DIVERT TRAFFIC.
 - CONSTRUCT CONCRETE BARRIER WALL IN MEDIAN.
 - REPAVE EXISTING SURFACE TO ACCOMMODATE CROSSFALL ON ASPHALT PAVEMENT.
 - REMOVE TEMPORARY CONCRETE BARRIERS AND OPEN THE ENTIRE STRUCTURE TO TRAFFIC.

LIST OF DRAWINGS

- 19-94-371-1 GENERAL ARRANGEMENT
 -2 BORE HOLE LOCATIONS & SOILS STRATA
 -3 REMOVALS
 -4 ABUTMENTS
 -5 RETAINING WALLS
 -6 DECK
 -7 BARRIER WALLS
 -8 AS CONSTRUCTED ELEV. & DIMENSIONS
 -9 BRIDGE DATE & SITE NUMBER DATA
 -10 QUANTITIES - STRUCTURE



CONSTRUCTION CLEARANCE DIAGRAM
 DIMENSIONS ARE PERPENDICULAR TO C OF TRACKS

DWO BM 65-43 276.327
 GEODETIC DATUM
 TABLET SET IN S. FACE OF S CONC.
 ABUTMENT IN CONC. BRIDGE OVER HWY.
 401 15.2 RT 25+422.0 ROUTE 6 LONDON



DRAWING NOT TO BE SCALED
 100 mm ON ORIGINAL DRAWING

DATE	BY	DESCRIPTION	DATE
DESIGN 7.52	CHECK 2.1X	LOADING 14.5.20-44	DATE SEPT. 97
DRAWING 4.4	CHECK 3.32	SITE No 19-94-371/R2	DWG 1

METRIC

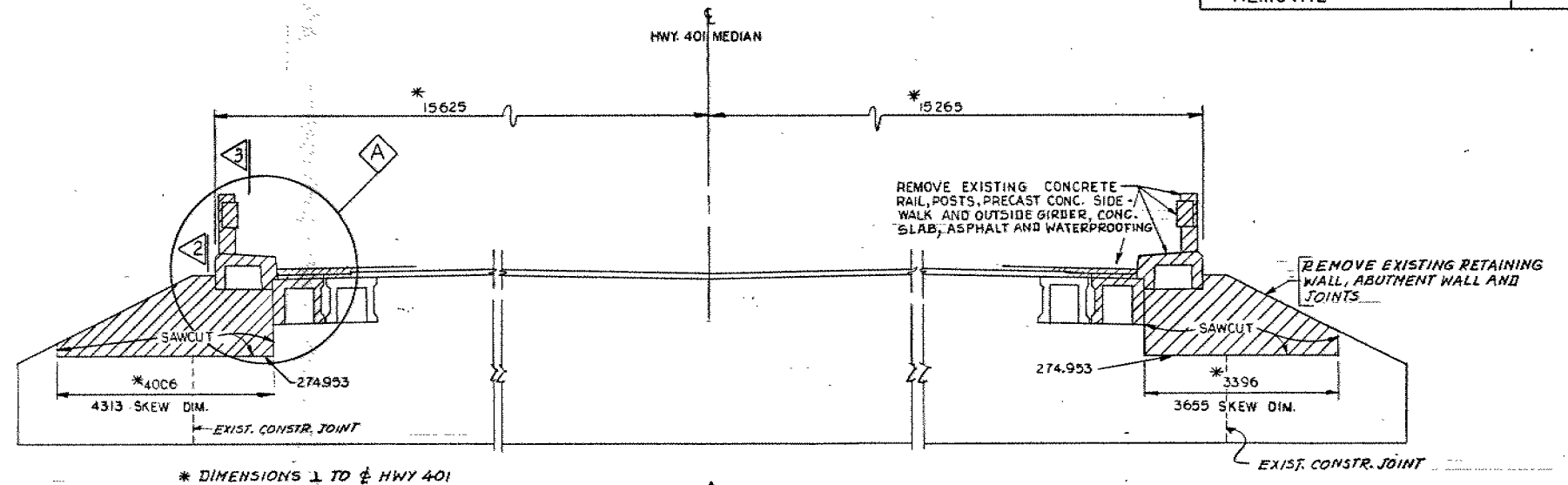
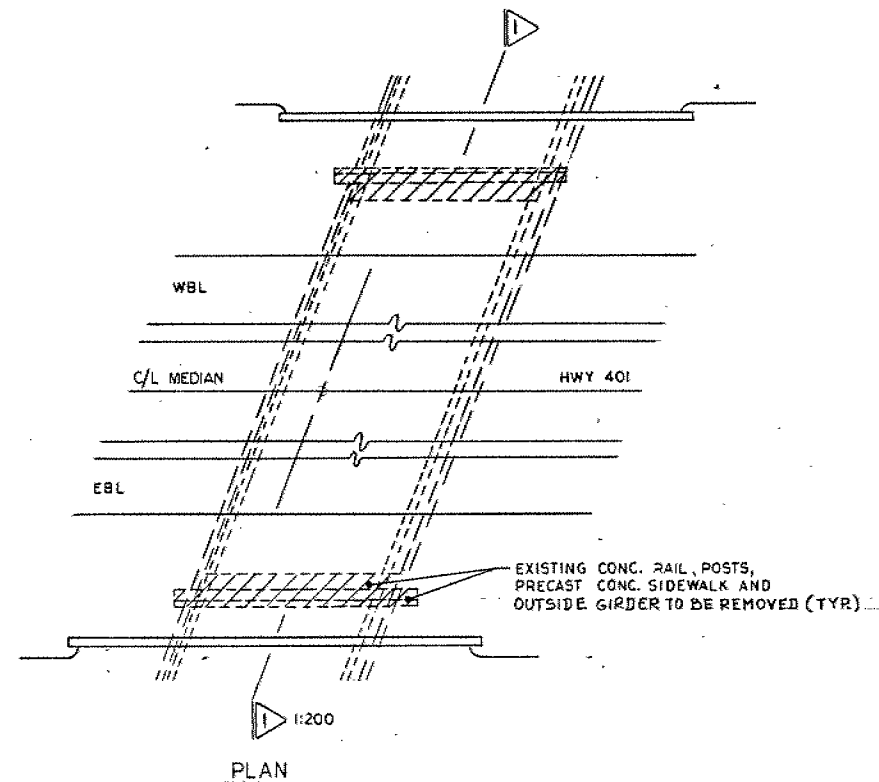
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 139-86-03

CNR OVERHEAD WIDENING
(1.6 Km W. OF HWY. 126)
REMOVAL



SHEET

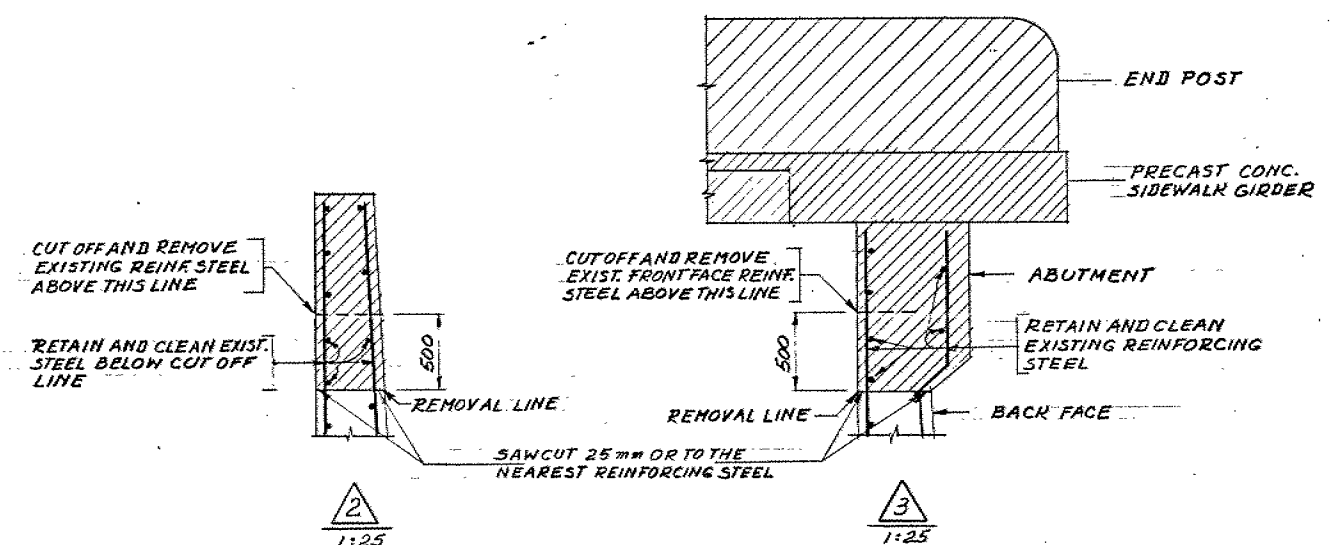
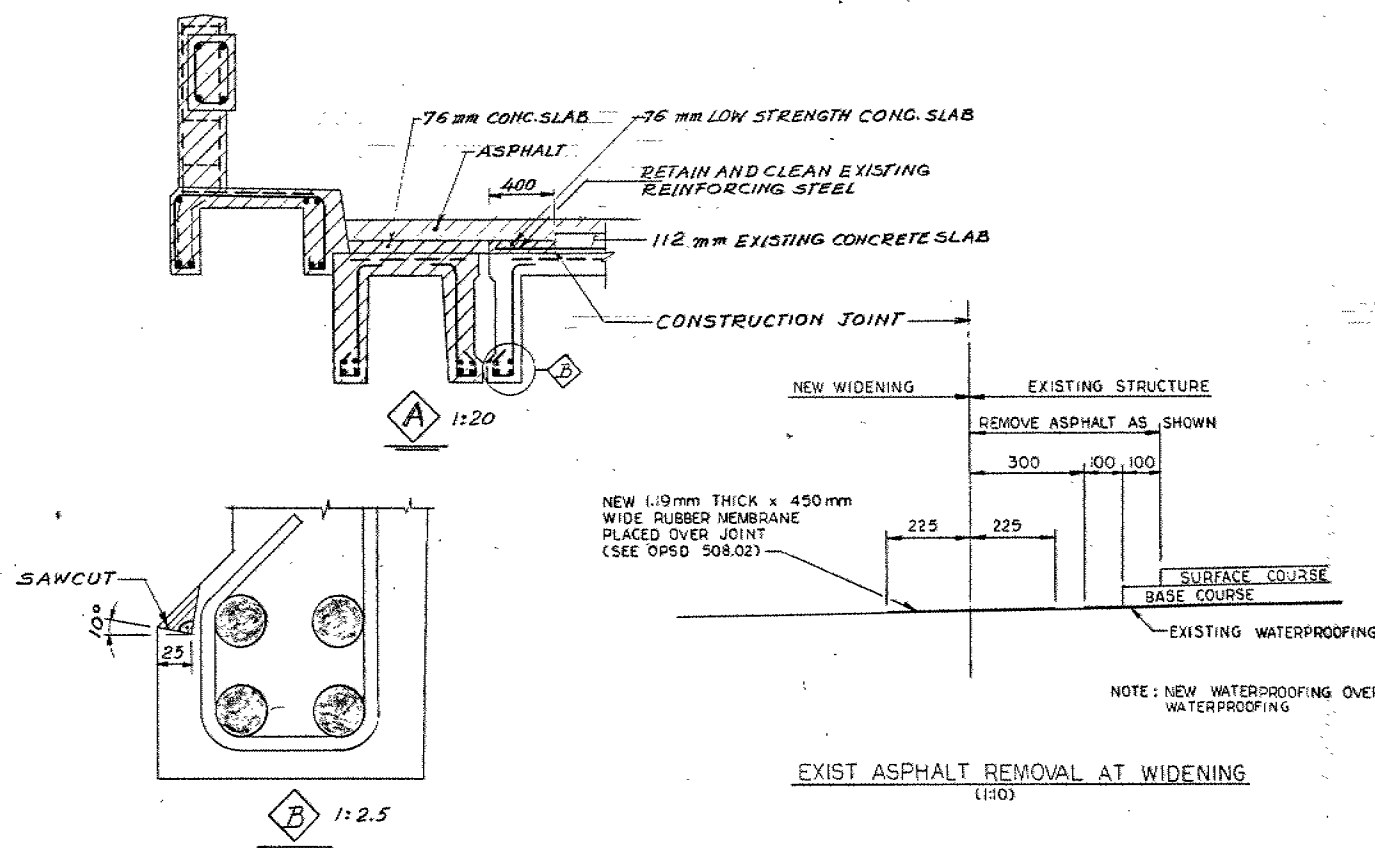


NOTES:

- 1 ABRASIVE BLAST ALL EXPOSED REBAR SHOWN LEFT IN PLACE AND CONSTRUCTION JOINTS.
- 2 APPLY A THIN COATING OF NEAT CEMENT PASTE TO CONSTRUCTION JOINT SURFACES IMMEDIATELY BEFORE PLACING NEW CONCRETE

LEGEND

REMOVAL



NOTE: NEW WATERPROOFING OVERLAPS EXISTING
WATERPROOFING

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWINGS



REVISIONS	DATE	BY	DESCRIPTION	DATE
DESIGN	J. Sz	CHECK	RVT	LOADING
DRAWING	FAB	CHECK	J. Sz	SITE No 19-94-371/R2
				DWG 3



Ministry of
Transportation and
Communications

CONT - 89-11

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 139-86-03

DIST 2

HWY 401

STR SITE 19-94-371

C.N.R. Overhead Widening

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FOUNDATION INVESTIGATION REPORT
For
CNR Overhead Widening
W.P. 139-86-03; Str. Site 19-94-371
Highway 401, District #2, London

INTRODUCTION

This report contains the results of a Foundation Investigation carried out for the proposed widening of the existing structure and approaches. The fieldwork consisted of five sampled boreholes and dynamic cone penetration tests located adjacent to the bridge and retaining wall footings advanced by hollow stem auger (8.3 cm I.D.) using a machine mounted on a bombardier. In addition, one sampled borehole was made through the approach embankment at the southeast corner of the bridge advanced by NX casing using a diamond drill. Sampling was performed to a maximum depth of 37.2 m to an approximate elevation of 230.6 m and the cone tests to a maximum depth of 4.6 m to an approximate elevation 263.4 m.

SITE DESCRIPTION

The site is located south of London in the County of Middlesex, Township of Westminster just west of Ponds Mills Road at the crossing of Hwy. 401 and the CNR. The terrain in the immediate vicinity is flat with a raised highway. The physiographic region is the Stratford Till Plains (undrumlinized). The land use in the area is commercial.

SUBSURFACE CONDITIONS

General

The subsoil at the approach fills consist of about 8 m of compact to very dense gravelly sand with some silt. The original ground consist of about 1.4 to 2 m of stiff to very stiff organic clay with some, to traces of sand followed by layers of dense to very dense silt to very stiff to hard silty clay extending to the maximum depth tested, 37 m at El. 230. The layers are in random occurrence and range in thickness from about 3 to 16 m.

It should be noted that in areas where excavation for structure footings has been done and within the railway right-of-way the surficial organic clay deposit has been wholly or partially removed and replaced with non-cohesive fill material.

A brief description of the different soil types is given below.

Fill Material

Fill material consisting of gravelly sand some silt and silty sand, some gravel was encountered in the approach in BH #103 at the surface to a depth of 7.5 m, elevation 268.7 m and at BH's 6 and 7 from ground level to 1.8 m to 2.7 m below to elevation 265.6 m.

The natural moisture content of the material ranges from 14% under the structure to 7% in the approach fill. The grain size distribution for this material is shown in envelope form in Figure 1, in the appendix. The denseness of the fill material ranges from very loose to compact in boreholes 6 and 7 and from compact to very dense in borehole 103.

A deposit of gravelly sand, some silt was also found in BH #103 beneath the silty clay deposit at elevation 267.2 m. The natural moisture content was 9%. The grain size distribution was gravel 35%, sand 44% and fines 21%. The denseness of the deposit was very dense.

Organic Clay

Organic clay, trace to with sand, traces of wood fibres was found at the surface to an approximate elevation 266.2 at BH's 8 and 9, up to 2.1 m thick. At BH #7 a thin 0.5 m layer was encountered under the fill approximately 2 m below the existing ground surface. The natural moisture content of the material was approximately 32%. The liquid limit 54% and the plastic limit 28%. The grain size distribution for this material was sand 27%, silt and clay 73%. The consistency varied from stiff to very stiff.

Silty Clay, to With Sand

This material has occasional silt pockets at the bottom of the 5 to 6 m thick deposit encountered at ground level in BH #10 and beneath the organic clay 1.4 to 2.3 m below the surface at BH's 7, 8, and 9. It is also in a 1.5 to 3 m thick deposit beneath the fill material at BH #6 and 103 located 2.7 to 7.5 m below the surface. In BH's 7 and 8 additional deposits (6 to 14 m+ thick) were found alternating with deposits of silt.

The physical properties of the material as determined by field and laboratory tests are summarized below:

		<u>Mean</u>	<u>Range</u>
Natural Moisture Content (w)		18.4%	14.5 to 22.5%
Liquid Limit	(W _L)	28.9%	22 to 38.5%
Plastic Limit	(W _p)	14.2%	12.5 to 16%

The consistency of the deposits ranged from firm to hard. The grain size distribution is shown in Figure 2 in the Appendix in envelope form and Figure 3 indicates that the deposit plots predominantly as a CL on the Plasticity chart.

Silt

This material was found beneath the silty clay deposits in boreholes 6, 7, 8, 9 and 10, in varying thickness from 3 to 16 m. Traces of sand, gravel and occasional silty clay layers were found in some of the holes. The upper silt deposit was located 7.2 m below the surface at BH #7, 8 and 9 and 5.3 m below at BH #6 and 10. The lower deposit of silt was found at elevation 250.9, 17 m below the surface.

The physical properties of the material as determined by laboratory tests are as follows:

		<u>Mean</u>	<u>Range</u>
Natural Moisture Content (w)		16.6%	13 to 20%
Liquid Limit	(W _L)	23.1%	19 to 29%
Plastic Limit	(W _p)	15.8%	14.5 to 18.5%

The denseness of the deposit ranged from compact to very dense. The grain size distribution is shown in Figure 4 in the Appendix in envelope form. Figure 5 indicates that the deposit plots as a (ML-CL) on the plasticity chart.

GROUNDWATER CONDITIONS

The following groundwater conditions were observed during the field investigations.

<u>Borehole</u>	<u>Elevation (m)</u>
6	267.9
7	267.7
8	Artesian conditions encountered at Elev. 230.6, head to 273.0 m.
9	267.6
10	267.9
103	268.1

The boreholes indicate the groundwater level to be in general about 0.3 m below the ground (original) level at Elev. 268 m. This level will most likely vary seasonally. Artesian water was encountered in BH #8 at Elev. 230 m with a head to Elev. 273 m (5.2 m above the ground level).

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to widen the existing bridge on the north and the south sides by 3.48 m. This will require removal at the existing retaining walls at the four corners of the bridge, construction of extensions to the abutments and rebuilding of retaining walls on the same alignment as the existing ones or construction of wing walls, parallel to Hwy. 401.

Existing Structure and Foundations

The existing structure was built under Contract 54-27 and is a simply supported single span (9.6 m) precast concrete beam bridge. Foundations consist of 482.6 mm shaft dia. expanded base Franki piles having a design capacity of 0.89 MN each. From available records of Cont. 54-27 it is estimated that the elevation of the bottom of the expanded bases is approximately El. 260.00. It should be noted that the original design for the structure showed 406.4 mm shaft dia. piles with a design capacity of 0.534 MN for the retaining wall foundations, however, during construction the shaft diameter was changed to 482.6 mm. We have not been able to determine whether the design capacity was also changed. During installation of the Franki piles it was observed that lateral displacements of already installed piles were occurring and that the railway track was also being similarly affected. This was attributed at the time to the fill being placed for the bridge approaches and some restrictions were imposed on the grading contractor. In the view of the writer, however, the displacements were entirely due to the ground heave effect which occurs when large displacement piles are driven into the type of soil such as is present at this site.

As a further consequence of the pile displacements, it was decided by the designers to install concrete struts between the footings to provide resistance to lateral forces. Eighteen of these were installed at 3708 mm centres. The cross section of the struts is 914 mm x 914 mm approximately.

New Foundations

Entirely new footings which do not coincide with existing footings such as for the wing walls or for the possible extensions of the present retaining

walls may be founded on steel H piles driven to El. 248 at which depth it is estimated that a design capacity of 0.55 MN will be achieved. Pile driving should be in accordance with Standards SS-103-10/11. For purposes of the O.H.B.D.C. the following design values are recommended:

HP 310 x 79 Steel H Piles

Factored capacity at ULS	1.00 MN
Capacity at SLS Type II	0.55 MN
Ultimate Capacity	1.65 MN

New footings which coincide with existing footings may be constructed after demolishing the existing ones together with the top 0.5 m of the Franki piles below. Foundation support may also be provided by steel H piles as described above, however, it will be necessary to preauger these piles down to El. 260 in order to avoid striking the Franki pile bases which are estimated to be one metre or more in diameter. After placing piles in the augered holes the later should be filled with Granular 'A' and the level maintained at the ground surface as driving proceeds.

It may be possible to provide support for the structure widening by adding to the existing footings and driving additional piling. This would require a structural evaluation of the present concrete design and evaluation of the capacity of the Franki piles. If you wish to consider this approach the various aspects should be discussed in detail between yourself and us before specific recommendations can be provided.

Lateral Forces

For the new wingwalls, if constructed, lateral forces should be resisted by suitably battered piles. For the new abutment extensions and for the retaining walls if rebuilt at their present locations, lateral resistance should be provided by the existing struts which should be joined to the new or modified footings. At the extremities of the retaining walls where there are no struts lateral resistance should be provided by battered piles. Backfill to the abutment extensions and to the new wingwalls or retaining walls should consist of Granular 'A' or 'B' in accordance with SPP No. 121 Oct. 1983. Earth pressures may be computed in accordance with Section 6.6.1.2.1 of the O.H.B.D.C. assuming a yielding foundation in which case

the "active" condition applies. The physical properties to be assumed for the backfill, are as follows:

$$\begin{array}{ll} \text{Granular 'A'} & \phi = 35^\circ \quad \gamma = 22.0 \text{ kN/m}^3 \\ \text{Granular 'B'} & \phi = 30^\circ \quad \gamma = 21.2 \text{ kN/m}^3 \end{array}$$

Backfill to retaining walls and abutment extensions facing each other should be placed simultaneously and to equal levels progressively.

Road Protection

It will be necessary to provide road protection during the period when the soil behind the existing retaining walls is removed to construct the new abutment extensions and new retaining walls or wing walls. This can be achieved by constructing temporary walls of interlocking sheet piling or anchor piles placed in pre-augered holes, with timber lagging. Design parameters for either scheme will be provided on request when the desired locations of the walls are known. The steepest temporary slope in the fill material (which is non-cohesive) should be 1-1/2 horizontal to 1 vertical. Exposed surfaces of temporary slopes will require protection such as polyethylene sheeting against erosion. Since all lateral forces on the structure and retaining walls are presently resisted by struts between east and west sides, it will be necessary to remove backfill simultaneously and to equal levels behind the northwest and northeast walls and also behind the southwest and southeast walls. If this is not done collapse of a wall could occur.

Track Protection

It will be necessary to provide protection for the railway track during excavation for the new footings for the bridge and retaining walls. This can be achieved by constructing temporary walls as for the road protection. Due to the close proximity of the west retaining wall to the track west rail (2.5 m) and the required depth of excavation (2.6 m) it will probably be necessary to temporarily relocate the track while construction on the west side is being carried out.

Dewatering

Groundwater level during the investigation (Nov. 1986) was found to be at approximate El. 268 just below the ground surface. Excavations down to El. 265.9 or lower will be required, therefore it will be necessary to provide a scheme for dewatering. The subsoil below El. 266 generally is cohesive in nature and above this level is non-cohesive fill material therefore it should be sufficient to provide protective sheeting around the sides of the excavation and remove any encountered water by pumping it out.

Frost Protection

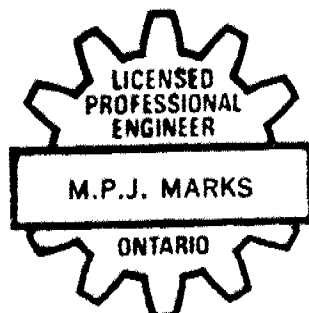
All footings and/or pile caps require a minimum of 1.2 m of earth cover for frost protection.

Embankment Widenings

New fill for the widening should be placed in accordance with appropriate MTC standards. All topsoil and other organic soil should be removed from slopes before placing the new fill.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Mr. D. Moore and Mr. D. Carr, Waterloo Co-op Students, who were directed by Mr. P. Payer. The equipment was owned and operated by Master Soil Investigations Ltd. This report was prepared by Mrs. Pamela Marks and Mr. K. Selby.



Pamela Marks
P. Marks, P.Eng.
Project Foundation Engineer

K. G. Selby
K. G. Selby, P.Eng.
Chief Foundation Engineer (West)

A P P E N D I X

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 (RQD), 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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_a	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_y	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

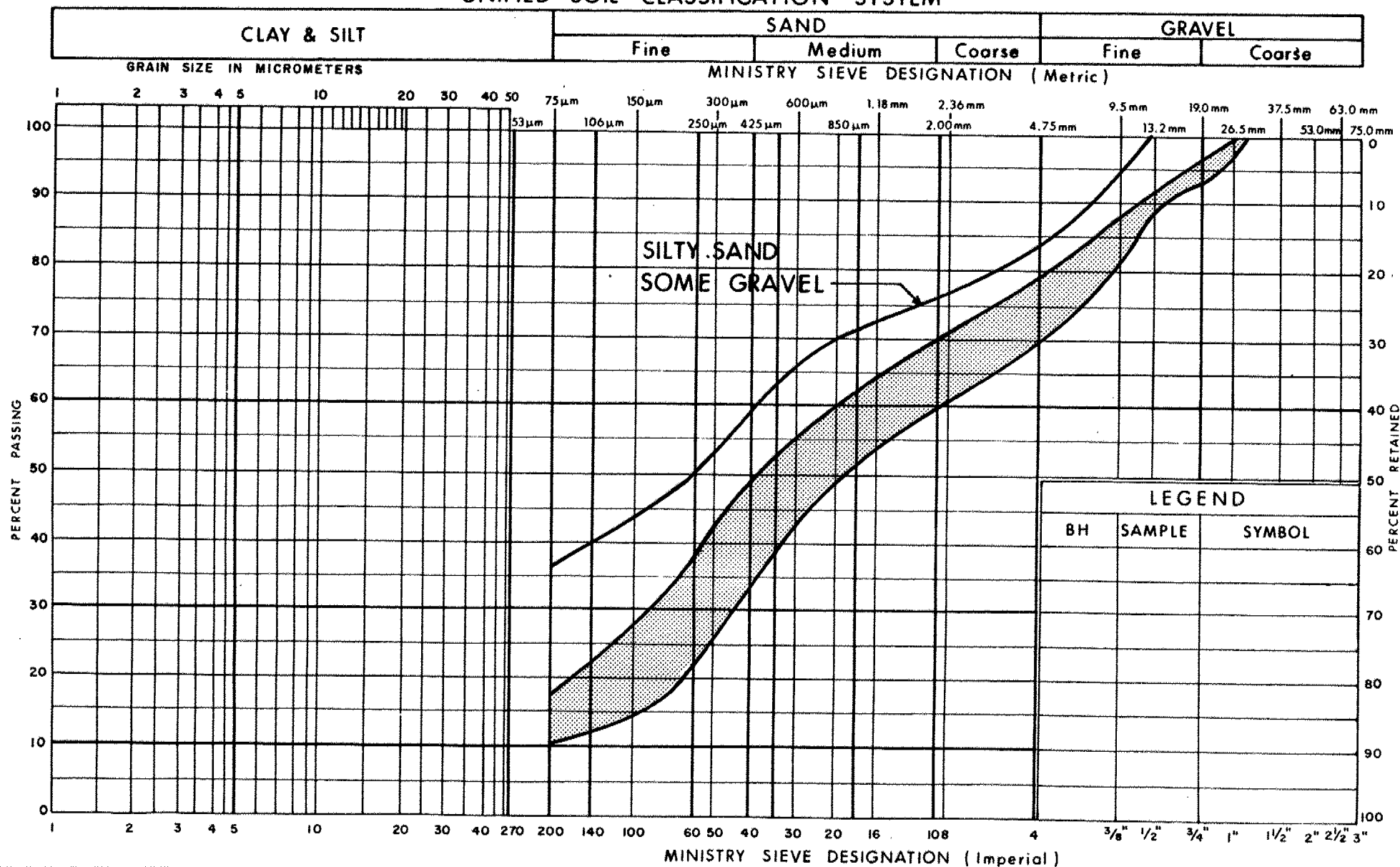
STRESS AND STRAIN

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	KN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	KN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	KN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	KN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	KN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	KN/m^2	SEEPAGE FORCE
γ'	KN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

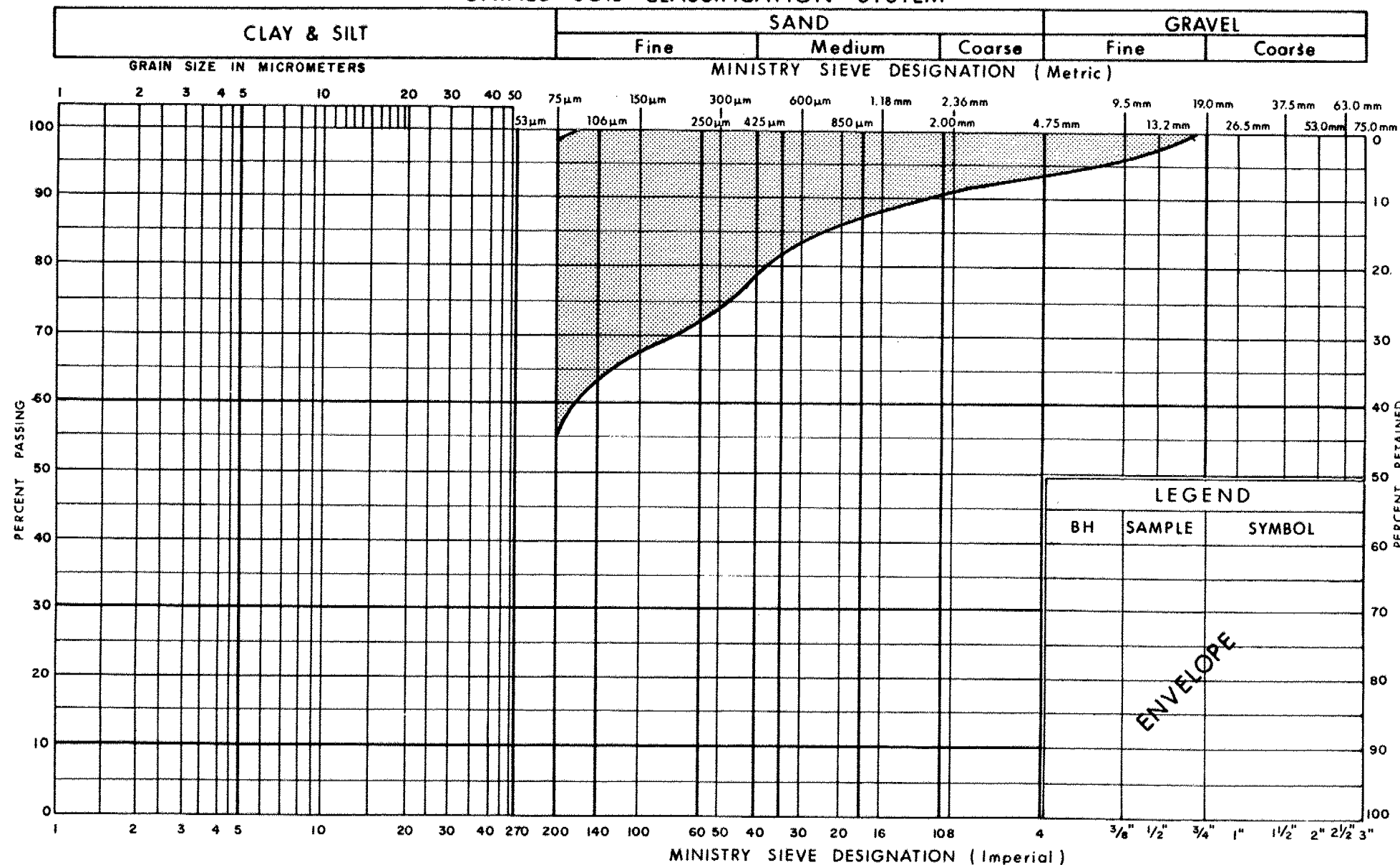
**Ministry of
Transportation and
Communications**

GRAIN SIZE DISTRIBUTION
GRAVELLY SAND SOME SILT (FILL MATERIAL)

FIG No 1

W P 139 - 86 - 03

UNIFIED SOIL CLASSIFICATION SYSTEM



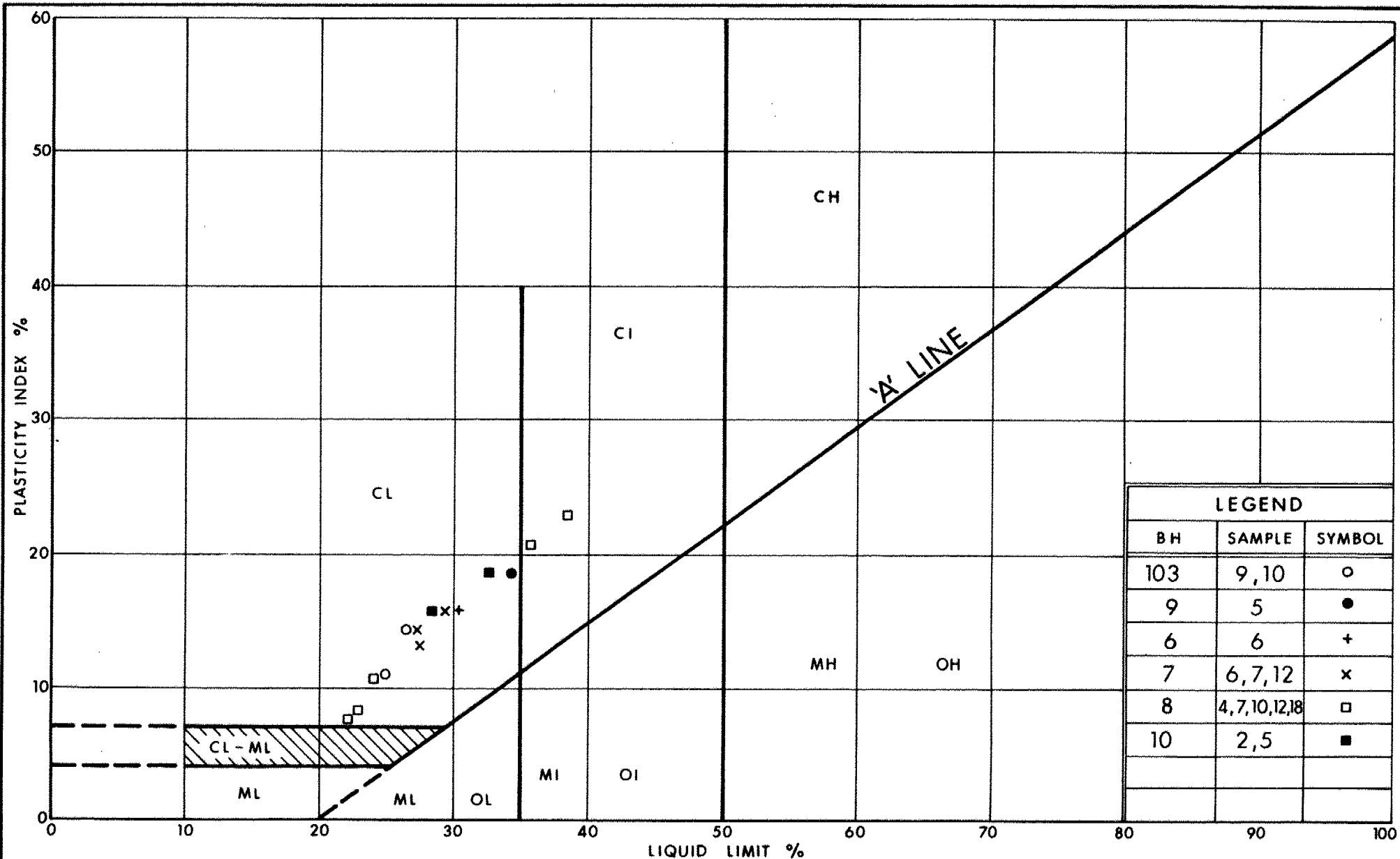
Ontario

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Transportation and
Communications

 GRAIN SIZE DISTRIBUTION
SILTY CLAY, WITH SAND

FIG No 2

W P 139-86-03



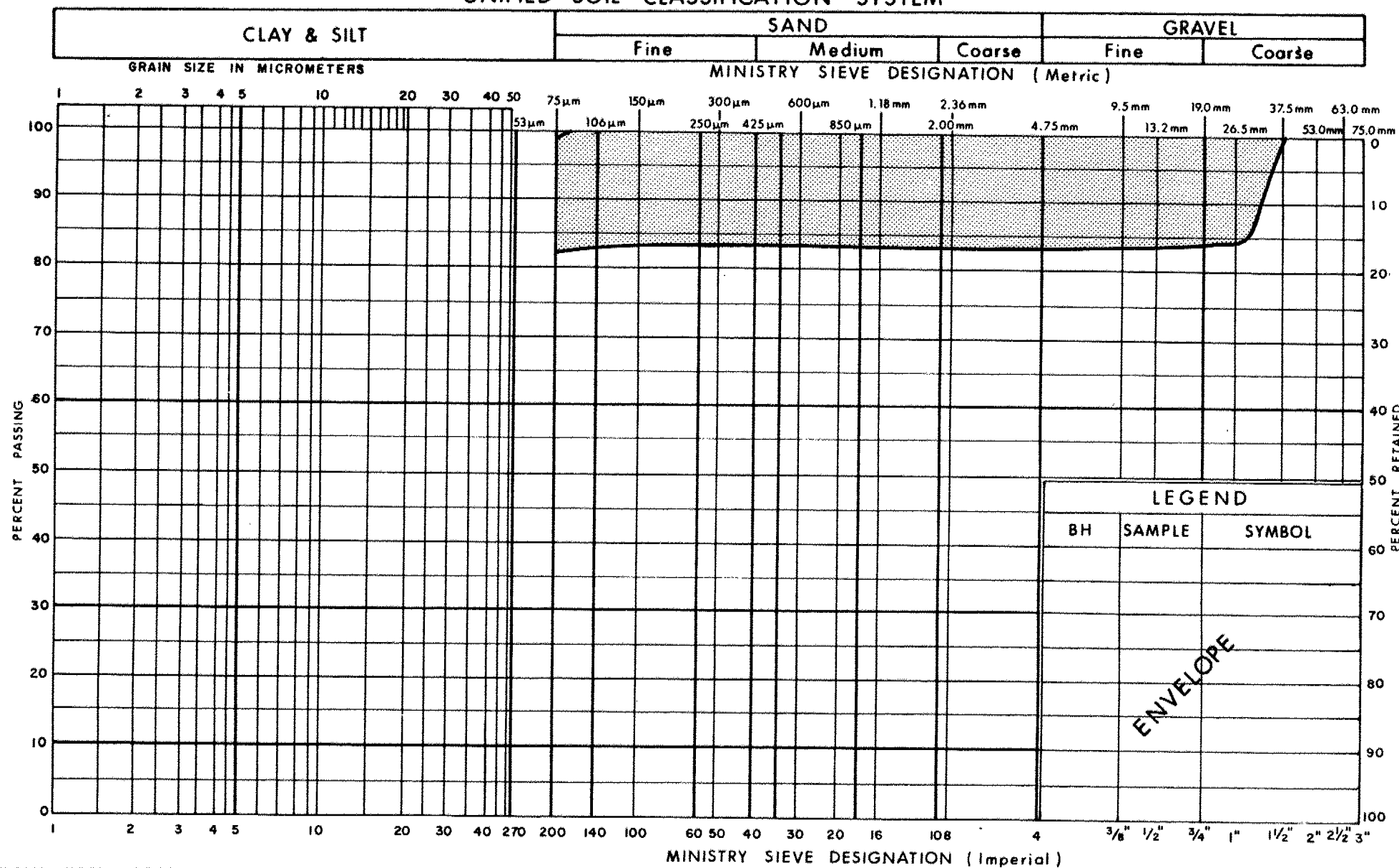
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PLASTICITY CHART SILTY CLAY, WITH SAND

FIG No 3

W P 139 - 86 - 03

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

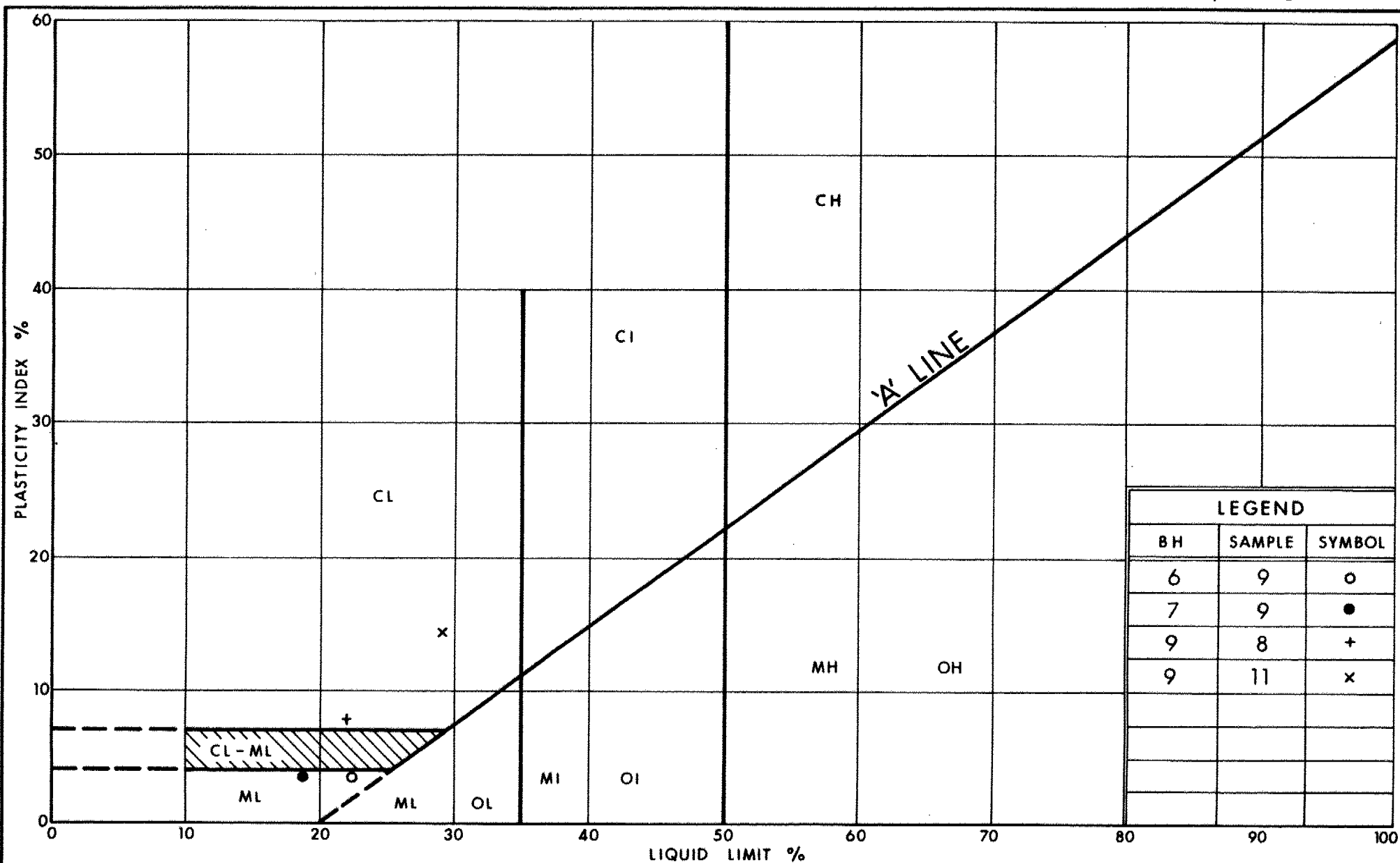
 Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION

SILT, TO SOME SAND, GRAVEL

FIG No 4

W P 139 - 86 - 03



Ministry of
Transportation and
Communications

PLASTICITY CHART
SILT, TRACE OF SAND, OCCASIONAL SILTY CLAY LAYERS

FIG No 5

W P 139-86-03



Ministry of
Transportation and
Communications
Ontario

RECORD OF BOREHOLE No 6

METRIC

W P 139-86-03 LOCATION Co-ords: N 4 755 377.8 E 411 370.6
DIST 2 HWY 401 BOREHOLE TYPE Continuous Flight Auger
DATUM Geodetic DATE 86 11 17

ORIGINATED BY DC
COMPILED BY DM
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	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								
268.3	Ground Level												
0.0	Gravelly Sand some silt Very Loose to Compact (Fill Material)		1	SS	29		268						21 67 (12)
			2	SS	5								
265.6			3	SS	3		266						30 55 (15)
2.7	Silty Clay some sand trace of gravel Very Stiff to Hard		4	SS									
			5	SS	22								
			6	SS	25								
			7	SS	43		264						6 31 (63)
262.7													
5.6	Silt some gravel trace sand Dense to Very Dense		8	SS	82		262						
			9	SS	86								
			10	SS	77		260						16 2 (82)
			11	SS	49		258						
255.6													
			12	SS	55		256						
12.7	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 7

METRIC

W P 139-86-03 LOCATION Co-ords: N 4 755 415.5 E 411 369.8
DIST 2 HWY 401 BOREHOLE TYPE Cont. Flight Auger (HS)
DATUM Geodetic DATE 86 11 18 to 86 11 19

ORIGINATED BY DC
COMPILED BY PM
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
268.0	Ground Level												
0.0	Silty Sand some gravel		1	SS	23								18 46 (36)
266.2	Very Loose to Compact (Fill Material)		2	SS	6								
1.8	Organic Clay		3	SS	11								
2.3	Silty Clay trace of sand occ. silt layers Stiff to Very Stiff		4	SS	27								
			5	SS	24								
			6	SS	20								0 1 (99)
			7	SS	19								0 0 (100)
260.8	Silt Dense		8	SS	47								
7.2			9	SS	37								0 0 (100)
			10	SS	43								
256.7	Occ. Silty Clay Layers		11	SS	35								
11.3	Silty Clay occ. silt layers Hard		12	SS	33								0 0 (100)
			13	SS	32								
250.9	Silt Dense												
17.1			14	SS	33								
249.3													
18.7													

+3, x^s: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 8

METRIC

W P 139-86-03

LOCATION Co-ords: N 4 755 363.7 E 411 373.7

ORIGINATED BY DC

DIST 2 HWY 401

BOREHOLE TYPE Continuous Flight Auger (HS) & BX Casing

COMPILED BY DM

DATUM Geodetic

DATE 86 11 19 and 86 11 20

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	WATER CONTENT (%)					
267.8	Ground Level													
0.0	Organic Clay with sand Very Stiff		1	SS	17									0 27 (73)
266.4			2	SS	7									
1.4	Silty Clay trace of sand		3	SS	27									
			4	SS	34									
	Firm to Hard		5	SS	28									
			6	SS	26									
	occasional silt layers		7	SS	24									
260.6			8	SS	37									
7.2	Silt Dense to Very Dense		9	SS	64									
257.6			10	SS	45									
10.2	Silty Clay trace of sand Hard		11	SS	34									
			12	SS	36									
250.9			13	SS	100									
16.9	Silt Some Sand Very Dense		14	SS	45/7.5cm									
244.8			15	SS	44									
23.0	Silty Clay trace of sand trace of gravel occasional silt pockets		16	SS	50									

Continued

+3, x5 : Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

Continued



RECORD OF BOREHOLE No 8 Cont

METRIC

W P 139-86-03 LOCATION Co-ords: N 4 755 363.7 E 411 373.7 ORIGINATED BY DC
DIST 2 HWY 401 BOREHOLE TYPE Continuous Flight Auger (HS) & BX Casing COMPILED BY PM
DATUM Geodetic DATE 86 11 19 and 86 11 20 CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
237.6 30.2	Continued		17	SS	90	15 cm											
	Hard		18	SS	70												2 10 (88)
230.6			19	SS	67												
37.2	End of Borehole					Artesian Encountered El. 280.6											

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 9

METRIC

W P 139-86-03 LOCATION Co-ords: N 4 755 357.5 E 411 359.2

ORIGINATED BY DC

DIST 2 HWY 401 BOREHOLE TYPE Cont. Flight Auger (HS)

COMPILED BY PM

DATUM Geodetic DATE 86 11 28 to 86 12 01

CHECKED BY

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE								
268.3	Ground Level										
0.0	Organic Clay trace of sand traces of wood fibres Stiff	1	SS	15							
266.2		2	SS	13							
2.1	Silty Clay traces of organics trace of sand trace of gravel Very Stiff	3	SS	18							
		4	SS	25							
		5	SS	30							
		6	SS	26							
	Occasional Silt Pockets	7	SS	20							
261.1		8	SS	21							
7.2	Silt Occasional Silty Clay Layers	9	SS	39							
		10	SS	29							
		11	SS	32							
	Compact to Very Dense	12	SS	38							
249.7		13	SS	52/15 cm							
18.6	End of Borehole										

+3, x5: Numbers refer to Sensitivity
20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 10

METRIC

W P 139-86-03 LOCATION Co-ords: N 4 755 429.4 E 411 357.8 ORIGINATED BY DC
 DIST 2 HWY 401 BOREHOLE TYPE Continuous Flight Auger (HS) COMPILED BY DM
 DATUM Geodetic DATE 86 12 01 and 86 12 02 CHECKED BY DS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	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										
269.0 0.0	Ground Level													
	Silty Clay trace/with sand traces of organics		1	SS	20									0 30 (70)
	Very Stiff to Hard		2	SS	35									0 1 (99)
			3	SS	50									
			4	SS	46									
			5	SS	45									
	occasional silt pockets		6	SS	55									
263.4 5.6			7	SS	49									
	Silt		8	SS	46									0 0 (100)
	trace of sand		9	SS	44									
			10	SS	61									
	Compact to Very Dense		11	SS	101									0 3 (97)
			12	SS	38									
247.2 21.8			13	SS	22									
	End of Borehole													

+3, x5 : Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 103

METRIC

W P 139-86-03 LOCATION Co-ords: N 4 755 384.9 E 411 378.2 ORIGINATED BY DM
 DIST 2 HWY 401 BOREHOLE TYPE Washbore - BX & NX Casings COMPILED BY DM
 DATUM Geodetic DATE 86 11 25 to 86 11 28 CHECKED BY DM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100			
276.2	Ground Level													GR SA SI CL
0.0	Gravelly Sand some silt Compact to Very Dense (Fill Material)		1	SS	17	276								
			2	SS	20	274								
			3	SS	58	272								22 62 (16)
			4	SS	41	270								
			5	SS	68									
			6	SS	57									
			7	SS	68									
268.7			8	SS	32	268								
7.5	Silty Clay with/some sand trace of gravel Very Stiff		9	SS	24									0 28 (72)
267.2			10	SS	30									1 42 (57)
9.0	Gravelly Sand some Silt Very Dense		11	SS	56									35 44 (21)
266.0														
9.6	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 110

METRIC

W P 139-86-03 LOCATION Station: 25+441.6; Offset 14m Lt of C
 Co-ords: N 4 755 418.0 E 411 379.6
 DIST 2 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.)
 DATUM Geodetic DATE 89 02 28
 ORIGINATED BY PD
 COMPILED BY PM
 CHECKED BY JN

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N VALUES			20	40	60	80	100		
276.4	Ground Level													
0.0	Shoulder Material		1	SS	36		276							
	Silty Sand		2	SS	18									
	Trace of Gravel		3	SS	29		274							
	occ. Pockets of Clayey Silt (Fill)		4	SS	18									
	Dense to Loose		5	SS	23		272							0 62 (38)
			6	SS	8									
270.9			7	SS	17		270							2 24 (74)
5.5	Clayey Silt With/Trace Sand Trace of Gravel (Fill)		8	SS	14									
			9	SS	20									
			10	SS	34		268							5 38 (57)
	Sandy Silt (ML)		11	SS	9									
	Stiff to Hard		12	SS	55									6 7 48 39
266.2														
10.2	End of Borehole													

RECORD OF BOREHOLE No 111

METRIC

Co-ords: N 4 755 405.5; E 411 350.2
 W P 139-86-03 LOCATION Station: 25+409.7, Offset 14m Lt of C
 DIST 2 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.)
 DATUM Geodetic DATE 89 02 28
 ORIGINATED BY PD
 COMPILED BY PM
 CHECKED BY SDT

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
276.3	Ground Level															
0.0	Shoulder Material					276	Augered									
			1	SS	40											
	Silty Sand with Gravel (Fill)		2	SS	33											
			3	SS	47											
	Occ. Pockets of Clayey Silt		4	SS	34											
			5	SS	7											
	Dense to Loose		6	SS	10											
269.3			7	SS	20											
7.0	Clayey Silt with to Some Sand		8	SS	19											
	Trace of Gravel (Fill)		9	SS	8											
	Stiff/Very Stiff															
265.2			10	SS	31											
11.1	End of Borehole															

+3, x⁵: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

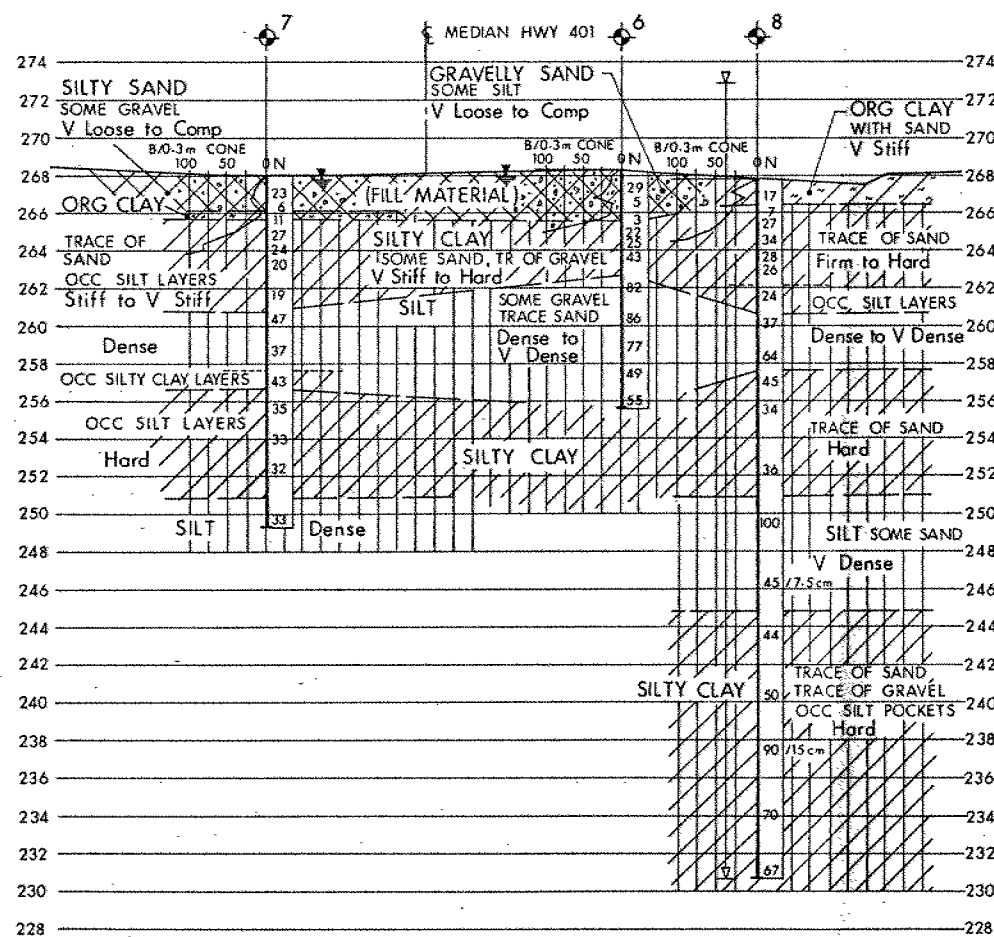
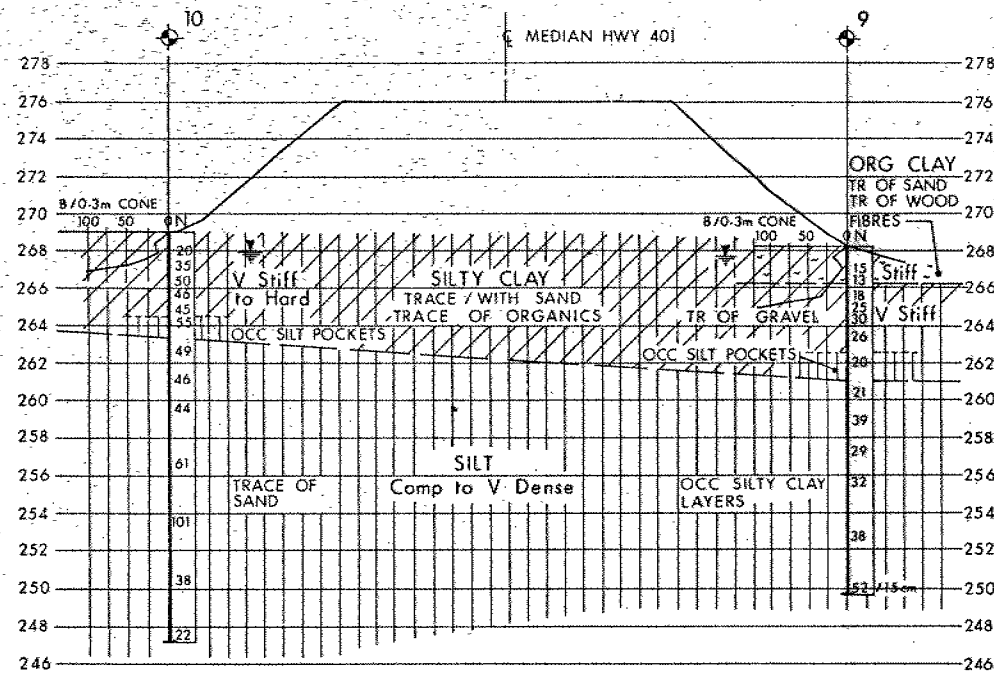
RECORD OF BOREHOLE No 112

METRIC

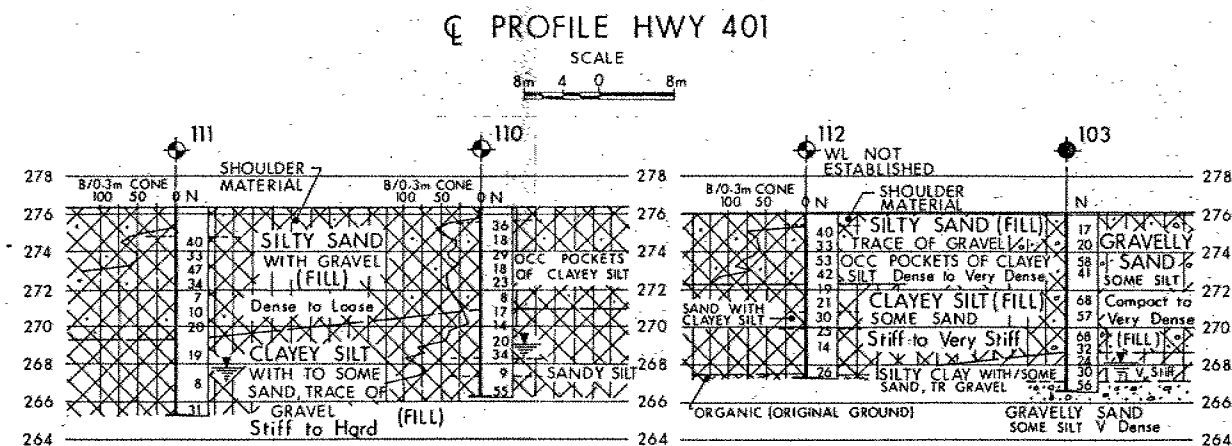
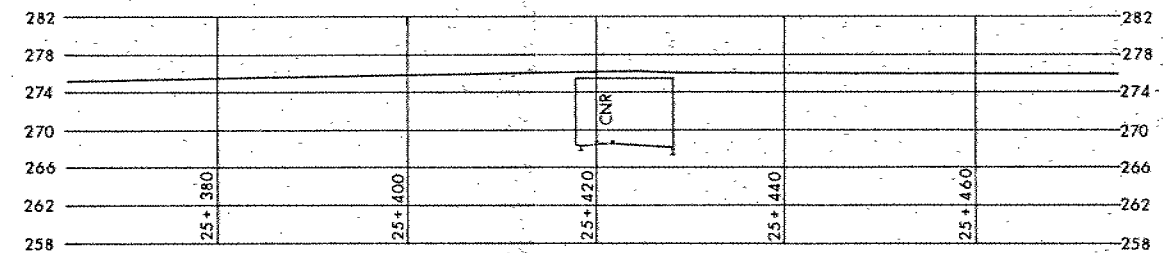
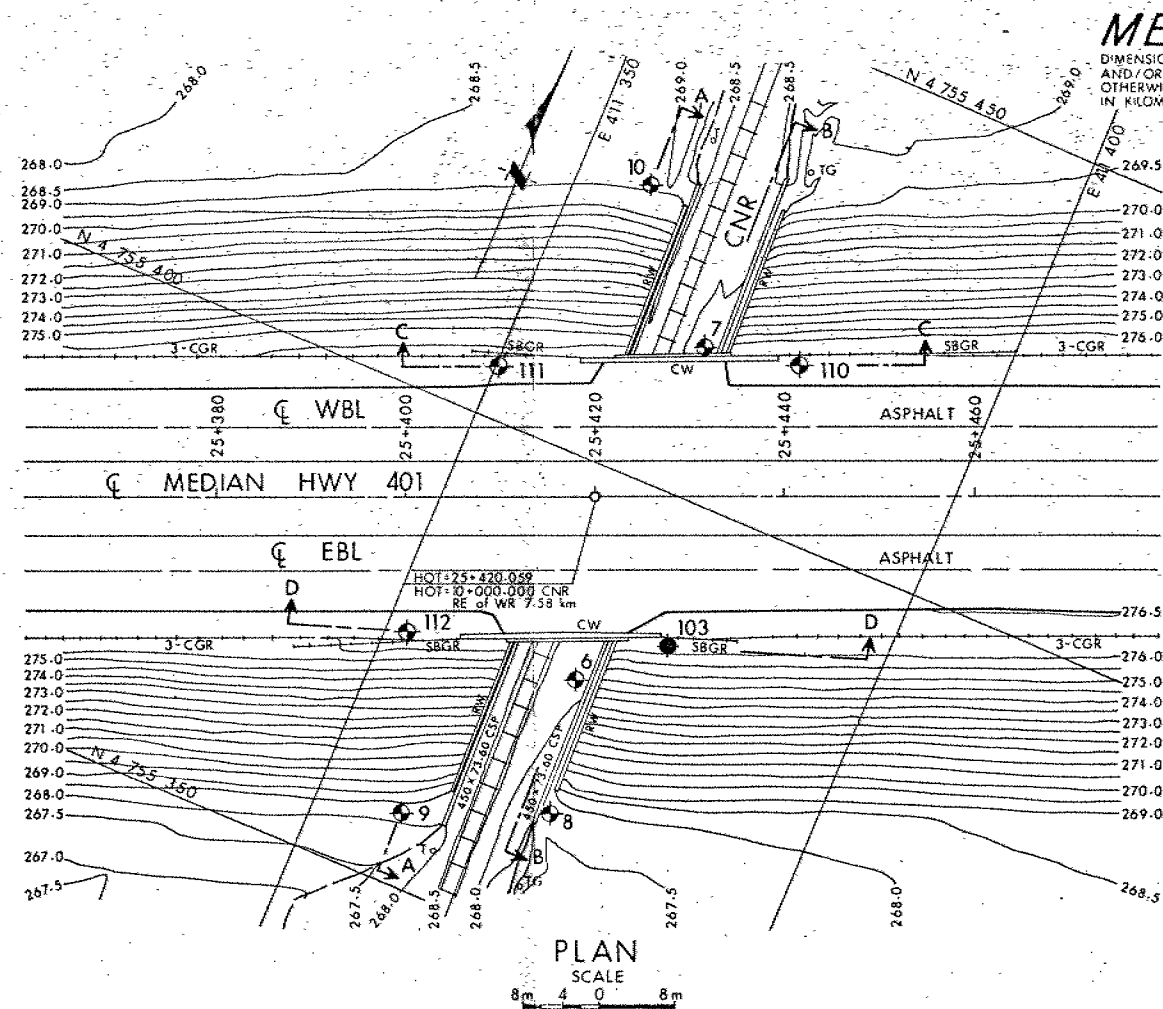
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 DIST 2 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
 DATUM Geodetic DATE 89 03 01 CHECKED BY DT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
276.0	Ground Level																
0.0	Shoulder Material		1	SS	40												
	Silty Sand		2	SS	33												
	Trace of Gravel		3	SS	53												
	Occ. Pockets of Clayey Silt		4	SS	42 *												
272.3	(Fill) Dense to Very Dense		5	SS	19												
3.7	Clayey Silt		6	SS	21												
	Some Sand		7	SS	30												
	Sand With Clayey Silt		8	SS	25												
	(Fill)		9	SS	14												
	Stiff to Very Stiff		10	SS	26												
267.2	Organic (Original Grd.)																
8.8	End of Borehole																
	* Water Level not Established																

OFFICE REPORT ON SOIL EXPLORATION



SECTIONS
SCALE
8m 4 0 8m Hor
4m 2 0 4m Vert

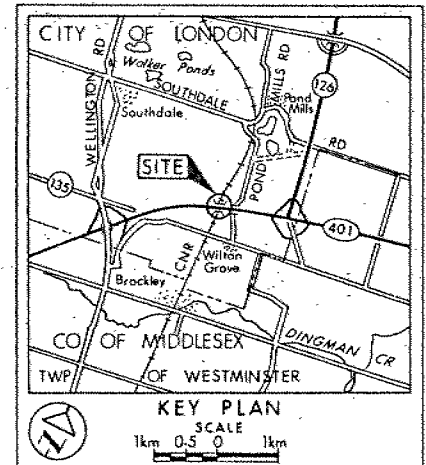


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES - METRES.

CONT No
WP No 139-86-03
CANADIAN NATIONAL RAILWAY
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



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 86 11			
↑	Head			
↓	ARTESIAN WATER			
⬇	Encountered			
No	ELEVATION	CO ORDINATES NORTH	EAST	
6	268.3	4 755 377.8	411 370.6	
7	268.0	4 755 415.5	411 369.8	
8	267.8	4 755 363.7	411 373.7	
9	268.3	4 755 357.5	411 359.2	
10	269.0	4 755 429.4	411 357.8	
103	276.2	4 755 384.9	411 378.2	
110	276.4	4 755 418.0	411 379.6	
111	276.3	4 755 405.5	411 350.2	
112	276.0	4 755 375.5	411 352.3	

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
8904	01	89'S 110 TO 112	ADDED
DATE	BY		
Geocres No 40114-110			
HWY No 401			DIST 2
SUBM'D PP	CHECKED	DATE 87 03 09	SITE 19-371
DRAWN DT	CHECKED	APPROVED	DWG 1398603-A