FOUNDATION INVESTIGATION REPORT

CONTRACT NO 89-226

Ministry of
Transportation and
Communications
Ontario

INDEX

NOTE: The preceding report supersedes all other reports prepared by or for the Ministry in connection with the above-boted 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.

FOUNDATION INVESTIGATION REPORT
MARTEN RIVER BRIDGE REPLACEMENT
W.P. 130-83-01; Site 43-005
Hwy. 11, District 13, North Bay

1.0 INTRODUCTION

This report describes the findings of a foundation investigation carried out at the site of the proposed replacement of the Marten River Bridge at Highway 11, approximately 60 km north of North Bay (Bridge Site 43-005, District 13, North Bay).

The investigation was requested by the Ontario Ministry of Transportation and Communications, and authorization to proceed with the work was received from M.S. Devata, P.Eng., Chief Foundations Engineer (East), Foundation Design Section of the Ministry.

The purpose of the investigation has been to determine the subsurface conditions at the site; to define the relevant engineering properties of the sub-strata; to make recommendations pertaining to the design of the foundations of the proposed structure, and to comment on the anticipated construction conditions.

The field work was carried out during the period of August 26-September 7, 1985, and consisted of drilling thirteen (13) boreholes to depths ranging between 4.3 and 9.7 m below the prevailing water level in the river. The locations of the boreholes, along with stratigraphic sections and profiles are shown on Drawings Nos. 1308301 - A and B,** and the subsurface conditions encountered are presented on the Record of Borehole Sheets, Enclosures 1 to 13, inclusive.

** NOTE: REFER TO DRAWINGS NO. 2 & 2A OF THE CONTRACT DRAWINGS.

.../...

2.0 SITE DESCRIPTION & GEOLOGY

The topography in the general area is undulating and rock outcrops are visible both to the north and south of the bridge site. The approach fills for the bridge consist of rock fill and the flow of water in the river is generally slow.

Published information shows that, in the general area, bedrock is frequently exposed and generally consists of Middle Precambrian gneissic metaconglomerates with frequent granitic intrusive rocks and gneissic granite pegmatite dikes.

3.0 SUBSURFACE CONDITIONS

3.1 General

The water in the river at the time of the investigation was at Elevation 286.4 m, and the river bottom at the borehole locations was contacted at elevations ranging between 284.4 and 281.2 m. The river bottom is generally covered with a layer of organic silt (muck), however, those boreholes located near the existing structure and the approach fills were extended through rock fill which was generally found to have displaced and/or penetrated into this 'muck' layer. Below the rock fill or 'muck', the majority of the boreholes encountered a layer of silt with some silty clay and sandy silt layers or lenses. This deposit is generally 0.5 to 0.9 m thick and is, in turn, underlain by a thin mantle of coarse grained glacial till over the bedrock surface. The surface of the bedrock was encountered at elevations ranging between 283.2 and 276.7 m and appears to be dipping from the banks towards the riverbed.

Details of the subsurface conditions encountered in the boreholes are shown on the Record of Borehole Sheets, and stratigraphic sections are presented on Drawing No. 1308301-B.** The individual strata are briefly described in the following paragraphs.

** NOTE: REFER TO DRAWING NO. 2A OF THE CONTRACT DRAWINGS.

.../...

3.2 Rock Fill

Rock fill placed for the existing bridge and the approach fill was encountered at the location of Boreholes 1 through 4. At the location of Boreholes 1 and 2A it is underlain by a layer of gravelly sand fill overlying the organic riverbed deposits. The rock fill was also found to have penetrated the river bottom 'muck' and, in some cases, into the underlying silt stratum. The rock fill consists of rock fragments of up to approximately 1.5 m in diameter.

3.3 Organic Silt (Muck)

A layer of organic river bottom deposits was encountered in all the boreholes at depths ranging between 2.0 and 5.2 m below the water level, except for Borehole 5 where instead a weak silty clay deposit was contacted. The thickness of the organic deposit typically ranges from 0.3 to 0.7 m (although at Borehole 11 it is 1.4 m thick) and the material is considered to be very soft. At several of the boreholes the muck is intermixed with rock fill, indicating that the rock pieces have penetrated this layer, and are transferring load to the underlying strata directly. Three samples of this material were tested in the laboratory for organic content and these gave values ranging between 5.2 and 12.6%.

3.4 Silty Clay

Boreholes 5 and 11 encountered a 0.4 and 1.4 m thick layer of silty clay, respectively. Laboratory tests carried out on a sample from Borehole 5 gave the following index values:

Liquid Limit	=	26%
Plastic Limit	=	10%
Plasticity Index	=	16
Moisture Content	=	46%

From these values, together with the results of field tests and a visual examination of the samples, this material is considered to be very soft and it is probably 'underconsolidated'.

3.5 Silt

The majority of the boreholes contacted a layer of silt below the rock fill and the organic silt. The thickness of this deposit ranges from 0.2 to 1.8 m but is generally 0.4 to 0.9 m thick. The grain size distribution of typical samples is shown in Figures 1 and 2, and these curves show 2 to 22% sand, 64 to 92% silt, and 6 to 13% clay size particles. Occasionally the deposit is also interbedded with sand and thin clay seams or lenses.

From 'N'-values ranging between 7 and 26 blows/0.3 m, the material is considered to be generally 'loose' to 'compact'.

3.6 Till

The rock surface at the site is covered with a thin mantle of coarse grained glacial till, generally consisting of gravelly sand with some silt. The presence of cobbles and boulders in this stratum is also expected. The grain size distribution of a sample from the glacial till is presented in Figure 3. From this curve and a visual examination of the samples, this deposit is considered to be relatively more pervious than the overlying silts. The thickness of the deposit at the borehole locations ranges from 0.2 to 1.3 m, and is generally of the order of 0.3 to 0.7 m thick. This material is considered to be generally 'dense'.

3.7 Bedrock

Refusal to further normal washboring was encountered at the borehole locations at depths ranging between 3.2 and 9.7 m below the water level, i.e. at elevations ranging between 283.2 and 276.7 m. At the locations of Boreholes 1 to 10, the rock was cored to depths ranging between 0.9 and 3.1 m and BX size cores were obtained. The percentage of core recovery ranges from 47 to 100% and R.Q.D values of the cores range from 17 to 100%. The rock consists of grey coloured gneiss and an examination of the cores indicates that it is frequently fractured. There are thin layers within the rock where the mica content is very high and these represent planes of weaknesses. Two relatively intact core samples were tested in unconfined compression and these gave compressive strength values of 63 and 67 MPa. Thus, while in its intact form the rock would exhibit a relatively high strength, the presence of mica-rich layers and structural discontinuities indicate that the mass properties of the rock are only 'fair'.

In the general area rock outcrops were noted about 150 m south and 200 m north of the bridge and also at a point approximately 30 m north of Borehole 12.

From the borehole results the surface of the rock generally appears to be dipping down towards the riverbed and, to a certain extent, along the south side from west to east. Between the borehole locations, the difference in bedrock surface elevations indicate a dip angle of generally between 5 and 10^{o} to the horizontal (i.e. approximately 1:12 to 1:6), although it is likely to be dipping at steeper angles towards the centre of the river.

3.8 Groundwater Conditions

The water level at the site is controlled by the water level in the river which, at the time of the investigation (August 28-September 7, 1985), was at Elevation 286.4 m. The drawings suppplied to us show that the water level was at Elevation 286.1 m on January 16, 1985.

.../...

Note: The preceding report is a copy of the factual information from the Foundation Investigation Report prepared by Dominion Soil Investigation Inc. (consulting geotechnical engineers for this project), under the technical supervision of the Foundation Design Section.

REGISTERED PROFESSIONAL ENGINEER
D. H. DUNDAS
88 04 21
PROVINCE OF ONTARIO

D. H. Dundas, P. Eng.
Sr. Foundations Engineer

M. Devata, P. Eng.
Chief Foundations Engineer
(East)

A P P E N D I X 'A'

APPENDIX A

PROCEDURES

The field work was carried out during the period of August 26 and September 7, 1985. During this period a total of thirteen (13) boreholes were drilled at the positions shown on the Borehole Location Plan, Drawing No. 1308301-A. **

The boreholes were advanced to depths ranging between 4.3 and 9.7 m below the water level (or 1.9 to 6.8 m below the river bottom), using a conventional diamond drilling unit adapted for soil sampling.

Within the overburden, the boreholes were cased with N-size (89 mm o.d.) casing and extended by washboring methods and, where necessary, a tri-cone bit. Sampling in the overburden was effected by the Standard Penetration test method and from the test results, recorded as 'N'-values or penetration resistances, relative density or the consistency of the strata was inferred. The bedrock was cored using a BXL-size core barrel. Where the boreholes were located close to the existing structure or approach fills, the borehole had to be advanced through the rock fill which was generally achieved by finding an opening through the cavities between rocks. In many cases this was achieved after many trials and, in some cases, resulted in a slightly inclined or constricted drill hole. This, and the fact that the only drill rig available at the time was a screw head type diamond drill, resulted in slower than usual operations.

The raft and the drilling equipment were owned and operated by Atcost Soil Drilling Inc. and the field work was carried out under the supervision of a Geotechnical Engineer from Dominion Soil Investigation Inc.

** NOTE: REFER TO DRAWING NO. 2 OF THE CONTRACT DRAWINGS.

Upon completion of the field work the soil samples and the rock cores were shipped to our laboratory where they were examined by the Project Engineer and the Geologist, and a laboratory testing programme consisting of moisture and organic content tests, sieve and hydrometer analyses and Atterberg Limit determinations was carried out on representative soil samples. Percentage of recovery and the R.Q.D. values of the rock cores were established and unconfined compression tests were performed on two representative samples of the rock.

The elevations used in this report were determined with reference to the top of concrete pier foundation of the existing bridge at Station 11+160, west edge, 4.60 m below the top of the bridge deck (Elevation 287.61 m).

APPENDIX 'B'

RECORD OF BOREHOLE No 1

METRIC

W P 130-83-01 LOCATION STA. 11 +130; 0/S 14 m Rt. ℄ HWY. 11 ORIGINATED BY R.M.

DIST 13 HWY 11 BOREHOLE TYPE WASHBORING AND BX ROCK CORE COMPILED BY R.M.

DATUM GEODETIC DATE 1985 09 05 CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4	WATER LEVEL							
0.0 / 282.9	WATER					286, 285, 284, 283		
3.5 / 281.5	Rock Fill	1	SS	—*		282		Sample No. 1: No recovery *Scratching rock fill- N-value not applicable
4.9 / 281.2	Fill - gravelly sand							
5.2 / 280.7	Organic silt (muck) dark grey, v.soft	2	SS	—*		281	o	Org. Content 5.2%
5.7 / 279.8	Silty sand mixed with rock fragments and organics	3	SS	50/8 cm		280		
6.6 / 279.2	Silt, some sand grey							
7.2 / 278.7	Sand, some silt & gravel (Till) dense, grey	4	SS	50		279		18 59 20 3
7.7	Gneiss Bedrock	5	RC BX	98%		278		RQD = 98%
276.8		6	RC BX	64%	**	277		RQD = 41%
9.6	End of Borehole							** Some rock core fell off core barrel

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT W_p, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ; STRAT PLOT.

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 2

METRIC

W P 130-83-01 | LOCATION STA. 11 + 157; O/S 14 m Rt ¢ HWY. 11 | ORIGINATED BY R.M.
DIST 13 HWY 11 | BOREHOLE TYPE WASHBORING | COMPILED BY R.M.
DATUM GEODETIC | DATE 1985 09 06 | CHECKED BY [illegible]

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, × 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						
286.4	WATER LEVEL										
0.0	WATER						286				
285.2 / 1.2	Rock Fill		1	SS	27		285				Sample No. 1: No recovery
							284				
282.9 / 3.5	Fill - organic silt mixed with rock fill and sand		2	SS	14		283				
281.7			3	SS	75/	15 cm	282				Sample No. 3: No recovery
4.7	End of Borehole										Refusal to driving casing @ 4.7 m. Extend core barrel. Casing & core barrel driven inclined through rockfill. Abandon borehole & move to 2A.

RECORD OF BOREHOLE No 2A

METRIC

W P 130-83-01 LOCATION STA. 11 + 154; O/S 14 m Rt ℄ HWY. 11 ORIGINATED BY R.M.

DIST 13 HWY 11 BOREHOLE TYPE WASHBORING AND BX ROCK CORE COMPILED BY R.M.

DATUM GEODETIC DATE 1095 09 06 to 1985 09 07 CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	SAMPLE TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × 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
286.4	WATER LEVEL										
0.0	WATER						286				
							285				
284.1 / 2.3	Rock Fill						284				
							283				
281.9 / 4.5	Fill - Gravelly sand, silty						282				
281.2 / 5.2	Organic silt (muck) v.soft, dark brown		1	WS	—		281				
280.5 / 5.9	Silt, some sand grey										
280.0 / 6.4	Gravelly sand, some silt (Till) grey, dense to v.dense		2	SS	94		280				
279.5 / 6.9	Gneiss Bedrock		3	RC BX	79%		279				RQD = 79%
			4	RC BX	93%						RQD = 53%
278.5 / 7.9	End of Borehole										

RECORD OF BOREHOLE No 3

METRIC

W P 130-83-01 | LOCATION STA. 11 + 130; O/S 15 m Lt ℄ HWY. 11 | ORIGINATED BY R.M.

DIST 13 HWY 11 | BOREHOLE TYPE WASHBORING AND BX ROCK CORE | COMPILED BY R.M.

DATUM GEODETIC | DATE 1985 08 30 and 1985 09 03 | CHECKED BY ~~eso~~

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4	WATER LEVEL						
0.0	WATER					286, 285, 284	
283.1 / 3.3	Rock Fill					283	
282.3 / 4.1	Organic silt (muck) with embedded rock fill						Org. Content = 6.4%
282.0 / 4.4	Sandy silt mixed with rock fill	1	SS	7		282	
281.1 / 5.3	Sand, gravelly some silt (Till) grey, v.dense	2	SS	57		281	
		3	SS	50/ 10 cm			
280.4 / 6.0	Gneiss (probably highly weathered bedrock)	4	RC BX	47%		280	RQD = 17%; Loss of water return @ 7 m
279.6 / 6.8	Dark grey sand (prob. decomposed rock) with broken rock pieces	5	SS	—			
		6	SS	100/ 8 cm			
279.2 / 7.2	Gneiss Bedrock	7	RC BX	94%		279, 278	RQD = 94%
277.6 / 8.8	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE
PLASTIC LIMIT W_p, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ

RECORD OF BOREHOLE No 4

METRIC

W P 130-83-01 LOCATION STA. 11 + 160; O/S 18 m Lt ℄ HWY. 11 ORIGINATED BY R.M.

DIST 13 HWY 11 BOREHOLE TYPE WASHBORING AND BX ROCK CORE COMPILED BY R.M.

DATUM GEODETIC DATE 1985 08 28 to 1985 08 29 CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × 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
286.4	WATER LEVEL										
0.0	WATER						286				
							285				
283.7							284				
2.7	ROCK FILL		1	SS	27		283				
281.6			2	SS	48		282				
281.2 / 4.8	Organic silt (muck) sandy, v.soft										
280.7 / 5.2	Silt, some sand, dense grey		3	SS	69		281				
280.0 / 5.7	Silty sand, some gravel (Till) very dense, grey		4	SS	50/10 cm						
6.4	Gneiss bedrock highly micaceous and fractured		5	RC BX	75%		280, 279				RQD = 55% Some core lost
276.9			6	RC BX	80%		278, 277				RQD = 38%
9.5	End of Borehole										

RECORD OF BOREHOLE No 5 METRIC

W P 130-83-01 LOCATION STA. 11 + 129; O/S 27 m Lt. ℄ HWY. 11 ORIGINATED BY R.M.

DIST 13 HWY 11 BOREHOLE TYPE WASHBORING AND BX ROCK CORE COMPILED BY R.M.

DATUM GEODETIC DATE 1985 09 03 to 1985 09 04 CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	SAMPLE TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4	WATER LEVEL						
0.0	WATER					286	
						285	
						284	
						283	
282.3 / 4.1	Silty clay v.soft, grey						
281.9 / 4.5	Silty sand till, grey, v.dense	1	SS	50/13 cm		282	
281.6 / 4.8	Gneiss Bedrock	2	RC BX	98%		281	RQD = 57%
						280	
		3	RC BX	100%		279	RQD = 100%
278.5 / 7.9	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH: O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE

PLASTIC LIMIT W_p, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ

RECORD OF BOREHOLE No 6

METRIC

W P 180-83-01 LOCATION STA. 11 + 160; O/S 28 m Lt. ℄ HWY. 11 ORIGINATED BY R.M.

DIST 13 HWY 11 BOREHOLE TYPE WASHBORING AND BX ROCK CORE COMPILED BY R.M.

DATUM GEODETIC DATE 1985 08 29 CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4	WATER LEVEL					
0.0	WATER				286, 285, 284, 283, 282	
281.6 / 4.8	Organic silt (muck) v.soft, dark brown				281	
280.9 / 5.5	Silt loose to compact, grey	1	SS	11		0 12 78 10
		2	SS	7	280	0 2 86 12
279.8 / 6.6	Gravelly sand some silt (Till) compact to v.dense grey	3	SS	22		
		4	SS	105/25 cm	279	
278.5 / 7.9	Gneiss Bedrock	5	RC BX	97%	278, 277	RQD = 67%
276.8 / 9.6	End of Borehole					

Column headings: 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 × LAB VANE; PLASTIC LIMIT W_p NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%); UNIT WEIGHT γ; STRAT PLOT.

RECORD OF BOREHOLE No 7

METRIC

W P 130-83-01 LOCATION STA. 11 + 105; O/S 21 m Lt ₵ HWY. 11 ORIGINATED BY R.M.
DIST 13 HWY 11 BOREHOLE TYPE WASHBORING AND BX ROCK CORE COMPILED BY R.M.
DATUM GEODETIC DATE 1985 09 04 to 1985 09 05 CHECKED BY [illegible]

ELEV / DEPTH (286.4)	DESCRIPTION (WATER LEVEL)	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × 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
0.0	WATER						286				
							285				
284.0 / 2.4	Organic silt (muck)						284				
283.7 / 2.7	Silt compact, grey		1	SS	16		283				0 2 92 6
282.8 / 3.6	Gravelly sand till		2	SS	60/15 cm						
282.5 / 3.9	Gneiss Bedrock		3	RC BX	94%		282				RQD = 94%
281.0 / 5.4	End of Borehole										

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Ontario

Enclosure 9

RECORD OF BOREHOLE No 8

METRIC

W P 130-83-01 LOCATION STA. 11 + 116; O/S 34 m Lt ₵ HWY. 11 ORIGINATED BY R.M.

DIST 13 HWY 11 BOREHOLE TYPE WASHBORING AND BX ROCK CORE COMPILED BY R.M.

DATUM GEODETIC DATE 1985 09 04 CHECKED BY [illegible]

ELEV / DEPTH (286.4)	DESCRIPTION / WATER LEVEL	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 (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × 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
0.0	WATER						286				
							285				
283.8							284				
2.6 / 283.3	Organic silt (muck) v.soft, dark brown										
3.1 / 282.9	Silt, some sand loose to compact, grey		1	SS	21		283				
3.5 / 282.7	Silty sand, gravelly (fill)										
3.7 / 281.1	Gneiss Bedrock		2	RC BX	94%		282				RQD = 94%
5.3	End of Borehole										

RECORD OF BOREHOLE No 9

METRIC

W P 130-83-01 | LOCATION STA. 11 + 165; O/S 39 m Lt. ℄ HWY. 11 | ORIGINATED BY R.M.

DIST 13 HWY 11 | BOREHOLE TYPE WASHBORING AND BX ROCK CORE | COMPILED BY R.M.

DATUM GEODETIC | DATE 1985 08 29 to 1985 08 30 | CHECKED BY [illegible]

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, × 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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
286.4	WATER LEVEL										
0.0	WATER						286				
							285				
							284				
							283				
281.8							282				Boulder adjacent to borehole.
4.6 / 281.4	Organic silt (muck)										
5.0 / 280.5	Silt with silty sand and silty clay seams compact, grey		1	SS	26		281				1 22 64 13
			2	SS	60/	15 cm					Cobble @ 5.9m Sa. 2: No rec.
5.9 / 280.0	Silty sand, gravelly (Till) occasional cobbles						280				
6.4 / 278.4	Gneiss Bedrock		3	RC BX	98%		279				RQD = 68%
8.0	End of Borehole										

RECORD OF BOREHOLE No 10

METRIC

W P 130-83-01 LOCATION STA. 11 + 191; O/S 25.6 m Lt ℄ HWY. 11 ORIGINATED BY R.M.

DIST 13 HWY 11 BOREHOLE TYPE WASHBORING AND BX ROCK CORE COMPILED BY R.M.

DATUM GEODETIC DATE 1985 08 28 CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × 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
286.4	WATER LEVEL										
0.0							286				
	WATER						285				
284.4 / 2.0	Organic silt (muck) v.soft, dark brown						284				
283.7 / 2.7	Silt, sandy, compact grey		1	SS	20				○		Org. Content = 12.6%
283.5 / 2.9	Gravelly sand till with cobbles										
283.2 / 3.2	Gneiss Bedrock		2	RC BX	81%		283				RQD = 56%
282.1 / 4.3	End of Borehole										

RECORD OF BOREHOLE No 11

METRIC

W P 130-83-01 LOCATION STA. 11 + 124; O/S 26 m Rt. ℄ HWY. 11 ORIGINATED BY R.M.
DIST 13 HWY 11 BOREHOLE TYPE WASHBORING COMPILED BY R.M.
DATUM GEODETIC DATE 1985 09 07 CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4	WATER LEVEL					
0.0	WATER					
282.2 / 4.2	Organic silt (muck) v.soft, dark brown					
280.8 / 5.6	Silty clay v.soft, grey	1	SS	1		
279.4 / 7.0	v.loose / Silt compact, grey	2	SS	19		0 3 86 11
277.6 / 8.8	Gravelly sand some silt (Till) dense to v.dense, grey	3	SS	75/15 cm		Refusal to driving of casing @ 9.7 m
276.7 / 9.7	End of Borehole					

Elevation scale: 286, 285, 284, 283, 282, 281, 280, 279, 278, 277

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT W_p NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L — WATER CONTENT (%)

UNIT WEIGHT γ

RECORD OF BOREHOLE No 12

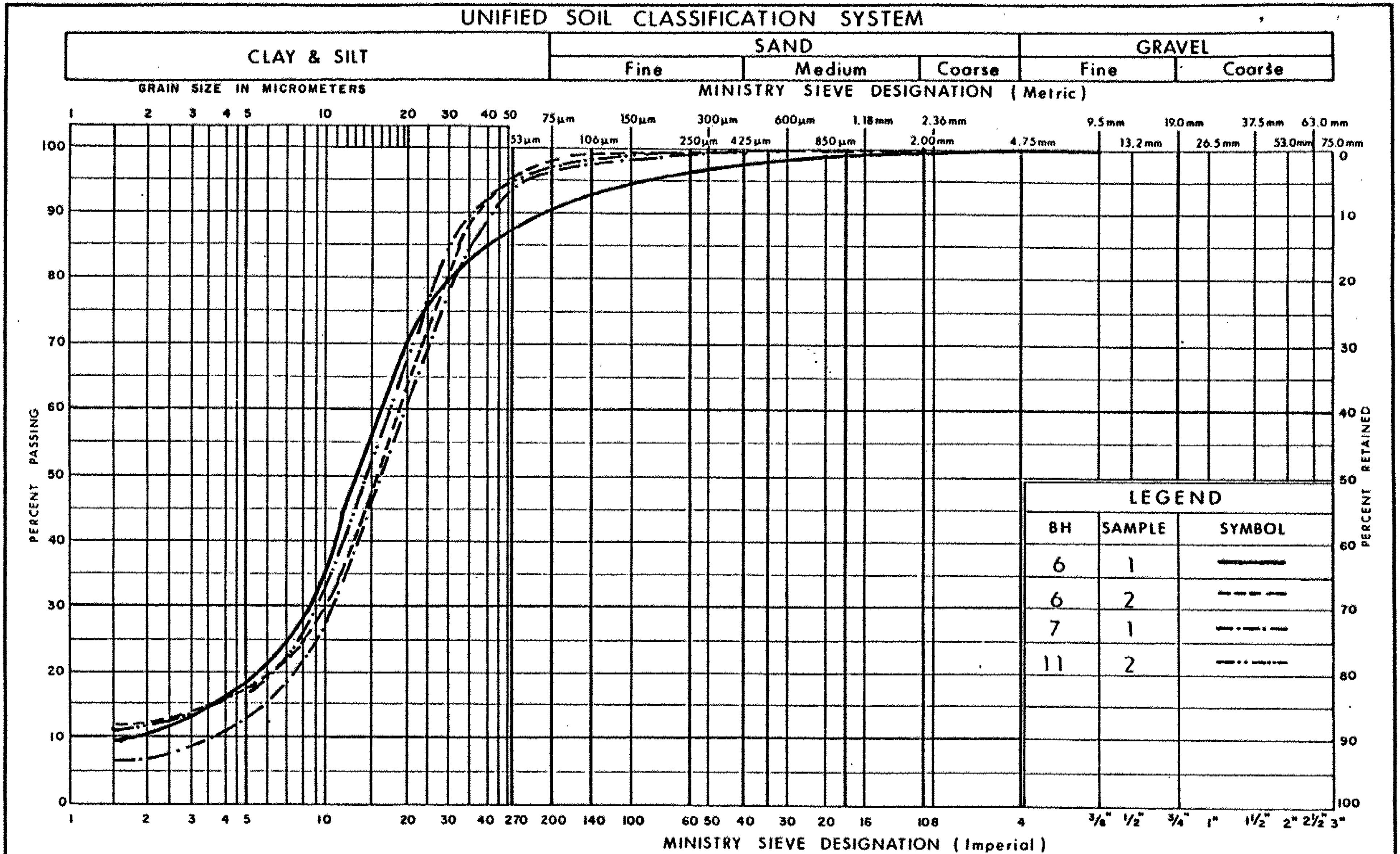
METRIC

W P 130-83-01 LOCATION STA. 11 + 163; O/S 26 m Rt. ℄ HWY. 11 ORIGINATED BY R.M.

DIST 13 HWY 11 BOREHOLE TYPE WASHBORING COMPILED BY R.M.

DATUM GEODETIC DATE 1985 09 07 CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	WATER CONTENT (%) (PLASTIC LIMIT Wp, NATURAL MOISTURE CONTENT W, LIQUID LIMIT WL)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4	WATER LEVEL										
0.0	WATER						286				
							285				
283.6							284				
2.8	Organic silt (muck) sandy some gravel & cobbles										
282.9 / 3.5	Silty sand, gravelly (Till) grey, compact to v.dense						283				
							282				Refusal to driving of casing @ 4.7 m
281.7			1	SS	78/28 cm						
4.7	End of Borehole										



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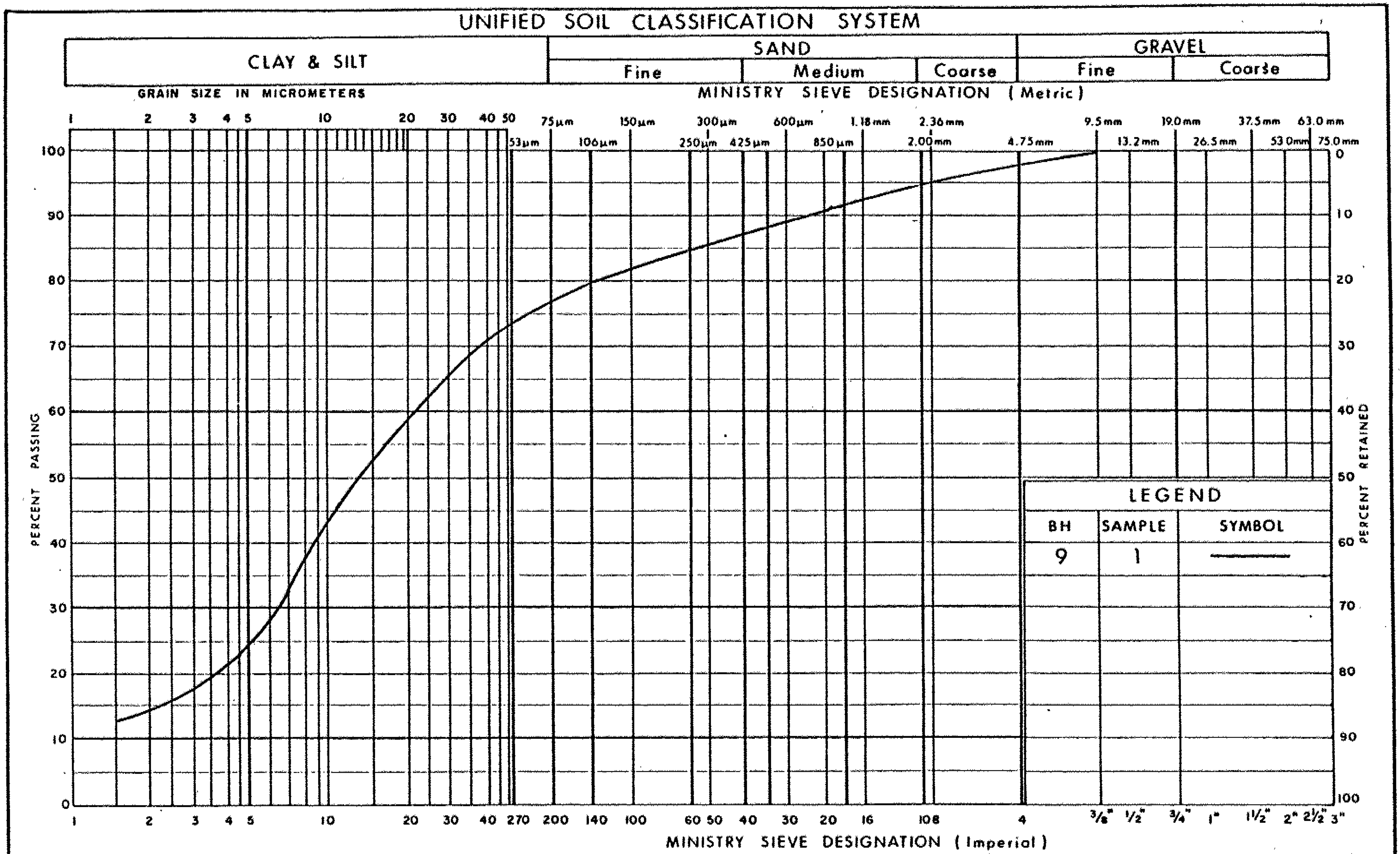
GRAIN SIZE DISTRIBUTION

SILT

FIG No 1

W P 130-83-01

Enclosure 14



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GRAIN SIZE DISTRIBUTION

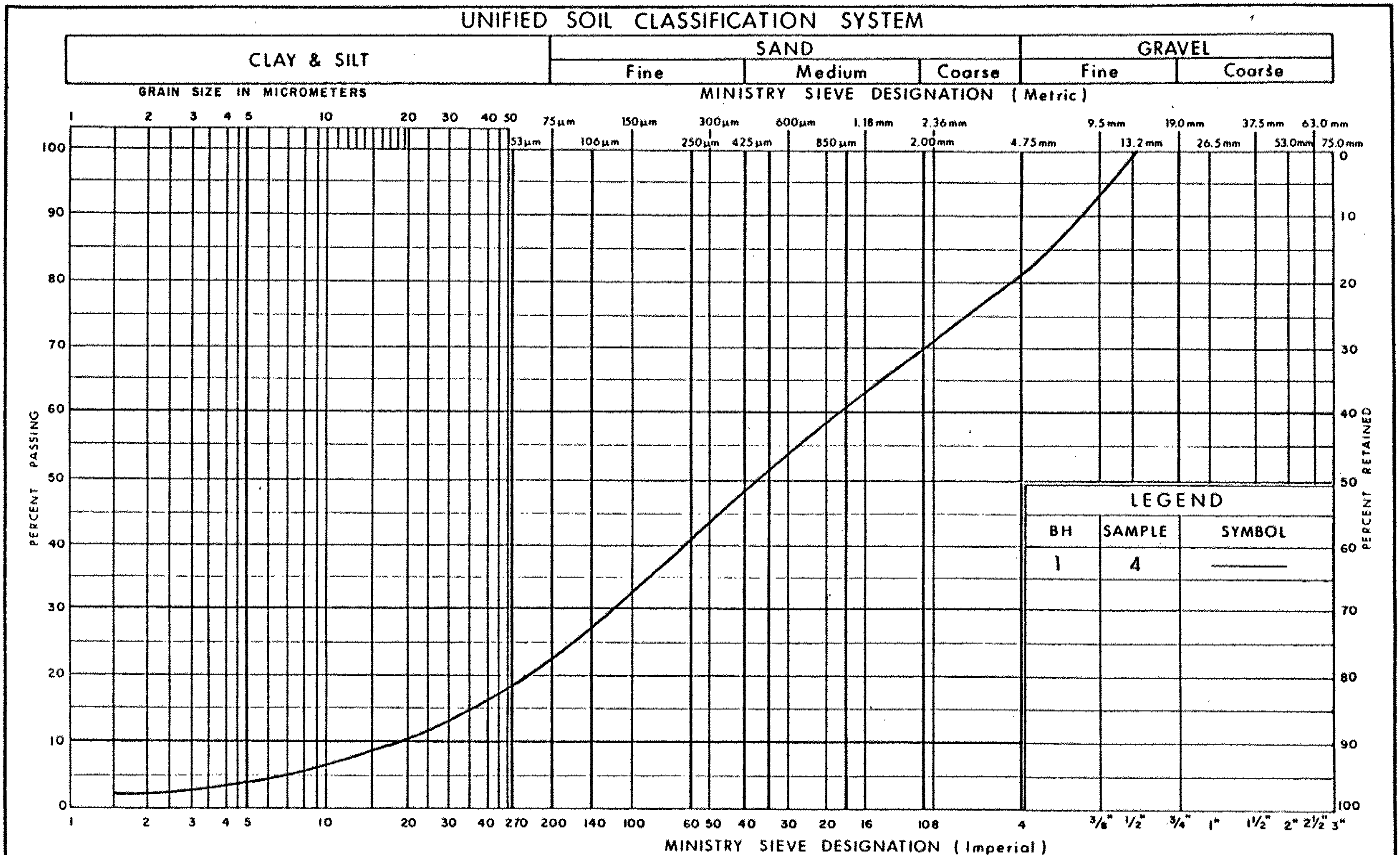
SANDY SILT, some Clay

FIG No 2

W P 130-83-01

Enclosure 15

78 12 M



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GRAIN SIZE DISTRIBUTION

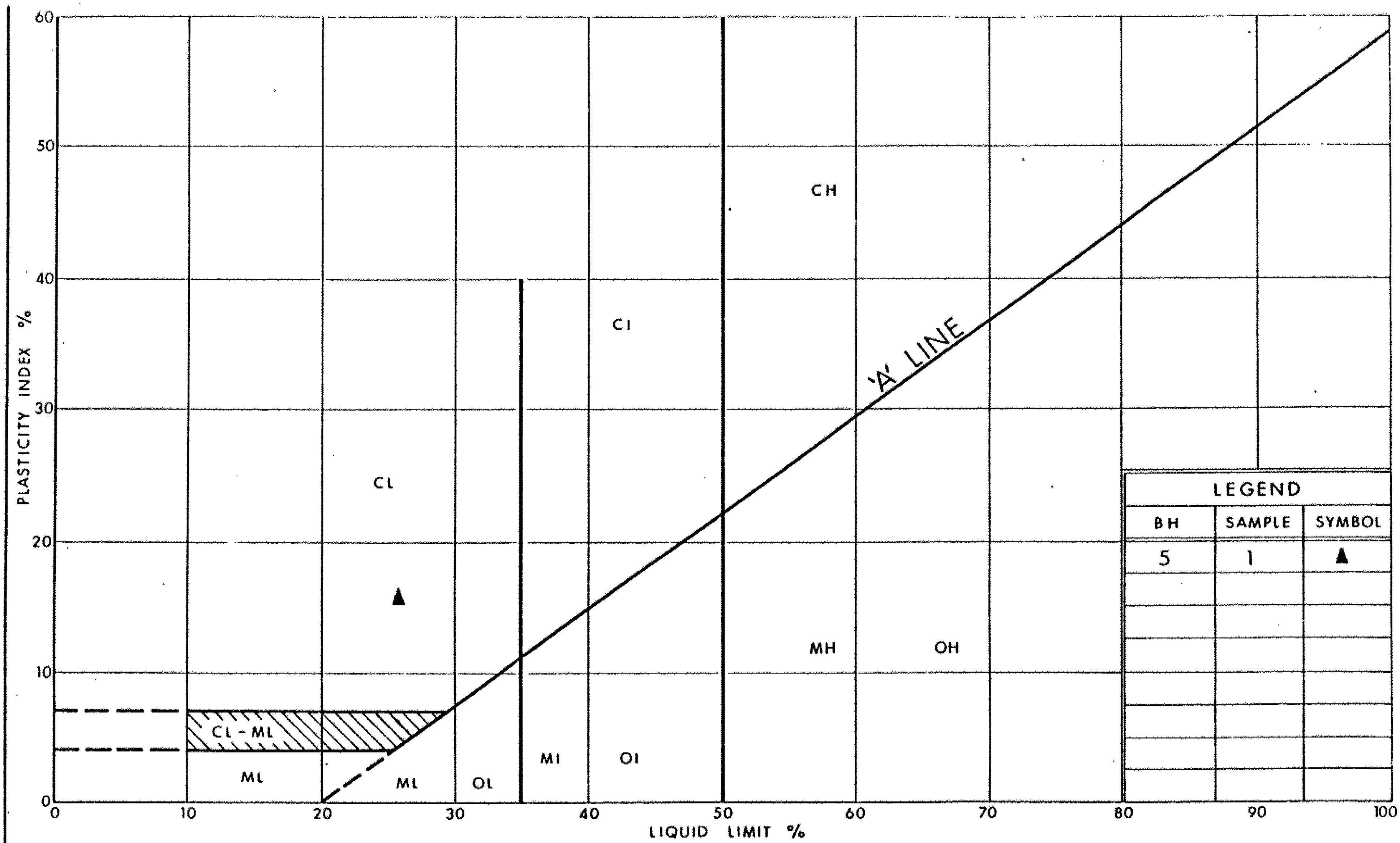
SAND, some gravel & silt. (TILL)

FIG No 3

W P 130-83-01

Enclosure 16

30



LEGEND		
BH	SAMPLE	SYMBOL
5	1	▲

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PLASTICITY CHART

SILTY CLAY

FIG No 4

W P 130-83-01

Enclosure 17

DOMINION SOIL INVESTIGATION INC.

FOUNDATION INVESTIGATION

MARTEN RIVER BRIDGE REPLACEMENT

HIGHWAY 11 - SITE 43-005

DISTRICT 13 - NORTH BAY

W.P. 130-83-01

Ref. No: 85-8-4

SEPTEMBER, 1985

PREPARED FOR:
Ministry of Transportation & Communications
Foundation Design Section
Central Building
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8

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DOMINION SOIL INVESTIGATION INC.

CONTENTS

APPENDICES

ENCLOSURES

1.0 INTRODUCTION

This report describes the findings of a foundation investigation carried out at the site of the proposed replacement of the Marten River Bridge at Highway 11, approximately 60 km north of North Bay (Bridge Site 43-005, District 13, North Bay).

The investigation was requested by the Ontario Ministry of Transportation and Communications, and authorization to proceed with the work was received from M.S. Devata, P.Eng., Chief Foundations Engineer (East), Foundation Design Section of the Ministry.

The purpose of the investigation has been to determine the subsurface conditions at the site; to define the relevant engineering properties of the sub-strata; to make recommendations pertaining to the design of the foundations of the proposed structure, and to comment on the anticipated construction conditions.

The field work was carried out during the period of August 26-September 7, 1985, and consisted of drilling thirteen (13) boreholes to depths ranging between 4.3 and 9.7 m below the prevailing water level in the river. The locations of the boreholes, along with stratigraphic sections and profiles are shown on Drawings Nos. 1308301 - A and B, and the subsurface conditions encountered are presented on the Record of Borehole Sheets, Enclosures 1 to 13, inclusive.

.../...

2.0 SITE DESCRIPTION & GEOLOGY

The topography in the general area is undulating and rock outcrops are visible both to the north and south of the bridge site. The approach fills for the bridge consist of rock fill and the flow of water in the river is generally slow.

Published information shows that, in the general area, bedrock is frequently exposed and generally consists of Middle Precambrian gneissic metaconglomerates with frequent granitic intrusive rocks and gneissic granite pegmatite dikes.

.../...

3.0 SUBSURFACE CONDITIONS

3.1 General

The water in the river at the time of the investigation was at Elevation 286.4 m, and the river bottom at the borehole locations was contacted at elevations ranging between 284.4 and 281.2 m. The river bottom is generally covered with a layer of organic silt (muck), however, those boreholes located near the existing structure and the approach fills were extended through rock fill which was generally found to have displaced and/or penetrated into this 'muck' layer. Below the rock fill or 'muck', the majority of the boreholes encountered a layer of silt with some silty clay and sandy silt layers or lenses. This deposit is generally 0.5 to 0.9 m thick and is, in turn, underlain by a thin mantle of coarse grained glacial till over the bedrock surface. The surface of the bedrock was encountered at elevations ranging between 283.2 and 276.7 m and appears to be dipping from the banks towards the riverbed.

Details of the subsurface conditions encountered in the boreholes are shown on the Record of Borehole Sheets, and stratigraphic sections are presented on Drawing No. 1308301-B. The individual strata are briefly described in the following paragraphs.

.../...

3.2 Rock Fill

Rock fill placed for the existing bridge and the approach fill was encountered at the location of Boreholes 1 through 4. At the location of Boreholes 1 and 2A it is underlain by a layer of gravelly sand fill overlying the organic riverbed deposits. The rock fill was also found to have penetrated the river bottom 'muck' and, in some cases, into the underlying silt stratum. The rock fill consists of rock fragments of up to approximately 1.5 m in diameter.

3.3 Organic Silt (Muck)

A layer of organic river bottom deposits was encountered in all the boreholes at depths ranging between 2.0 and 5.2 m below the water level, except for Borehole 5 where instead a weak silty clay deposit was contacted. The thickness of the organic deposit typically ranges from 0.3 to 0.7 m (although at Borehole 11 it is 1.4 m thick) and the material is considered to be very soft. At several of the boreholes the muck is intermixed with rock fill, indicating that the rock pieces have penetrated this layer, and are transferring load to the underlying strata directly. Three samples of this material were tested in the laboratory for organic content and these gave values ranging between 5.2 and 12.6%.

.../...

3.4 Silty Clay

Boreholes 5 and 11 encountered a 0.4 and 1.4 m thick layer of silty clay, respectively. Laboratory tests carried out on a sample from Borehole 5 gave the following index values:

Liquid Limit	=	26%
Plastic Limit	=	10%
Plasticity Index	=	16
Moisture Content	=	46%

From these values, together with the results of field tests and a visual examination of the samples, this material is considered to be very soft and it is probably 'underconsolidated'.

3.5 Silt

The majority of the boreholes contacted a layer of silt below the rock fill and the organic silt. The thickness of this deposit ranges from 0.2 to 1.8 m but is generally 0.4 to 0.9 m thick. The grain size distribution of typical samples is shown in Figures 1 and 2, and these curves show 2 to 22% sand, 64 to 92% silt, and 6 to 13% clay size particles. Occasionally the deposit is also interbedded with sand and thin clay seams or lenses.

From 'N'-values ranging between 7 and 26 blows/0.3 m, the material is considered to be generally 'loose' to 'compact'.

.../...

3.6 Till

The rock surface at the site is covered with a thin mantle of coarse grained glacial till, generally consisting of gravelly sand with some silt. The presence of cobbles and boulders in this stratum is also expected. The grain size distribution of a sample from the glacial till is presented in Figure 3. From this curve and a visual examination of the samples, this deposit is considered to be relatively more pervious than the overlying silts. The thickness of the deposit at the borehole locations ranges from 0.2 to 1.3 m, and is generally of the order of 0.3 to 0.7 m thick. This material is considered to be generally 'dense'.

3.7 Bedrock

Refusal to further normal washboring was encountered at the borehole locations at depths ranging between 3.2 and 9.7 m below the water level, i.e. at elevations ranging between 283.2 and 276.7 m. At the locations of Boreholes 1 to 10, the rock was cored to depths ranging between 0.9 and 3.1 m and BX size cores were obtained. The percentage of core recovery ranges from 47 to 100% and R.Q.D values of the cores range from 17 to 100%. The rock consists of grey coloured gneiss and an examination of the cores indicates that it is frequently fractured. There are thin layers within the rock where the mica content is very high and these represent planes of weaknesses. Two relatively intact core samples were tested in unconfined

.../...

compression and these gave compressive strength values of 63 and 67 MPa. Thus, while in its intact form the rock would exhibit a relatively high strength, the presence of mica-rich layers and structural discontinuities indicate that the mass properties of the rock are only 'fair'.

In the general area rock outcrops were noted about 150 m south and 200 m north of the bridge and also at a point approximately 30 m north of Borehole 12.

From the borehole results the surface of the rock generally appears to be dipping down towards the riverbed and, to a certain extent, along the south side from west to east. Between the borehole locations, the difference in bedrock surface elevations indicate a dip angle of generally between 5 and 10^{0} to the horizontal (i.e. approximately 1:12 to 1:6), although it is likely to be dipping at steeper angles towards the centre of the river.

3.8 Groundwater Conditions

The water level at the site is controlled by the water level in the river which, at the time of the investigation (August 28-September 7, 1985), was at Elevation 286.4 m. The drawings suppplied to us show that the water level was at Elevation 286.1 m on January 16, 1985.

.../...

4.0 DISCUSSION & RECOMMENDATIONS

The existing bridge over the Marten River at Highway 11 will be replaced with a new bridge. Two alternatives are being considered for the replacement; these are, the construction of a bridge on Revision Line 'A' or the replacement of the bridge along the existing alignment.

Boreholes were drilled to provide subsurface information relevant to both alternatives. These test results have shown that the surface of the gneiss bedrock at the borehole locations lies approximately 3 to 10 m below the water line (i.e. Elevations 283 to 276 m, approximately). The rock surface has a coarse and bouldery glacial till cover ranging from 0.2 to 1.3 m in thickness, which is, in turn, overlain by a generally loose to compact silt deposit which is 0.2 to 1.8 m thick. An organic river bottom deposit approximately 0.5 m thick overlies the silt. The existing bridge approach embankments have been constructed of rock fill, and the rock appears to have penetrated and/or displaced the muck during construction.

4.1 Alternative I

The first alternative consists of a 30 m long and 12.5 m wide single-span bridge which would be located on Revision Line 'A' about 21 m west of the existing alignment.

.../...

4.1.1 Foundations

Spread footing foundations on the surface of the bedrock could be considered but in view of the relatively deep water level and associated high cost of constructing facilitating temporary works, this alternative is not believed to be practical.

It is our opinion that founding the structure on deep foundations on the surface of the bedrock would be a more practical solution or, alternatively, the abutments could be supported on rock fill. These are discussed below.

4.1.1.1 Driven Piles

The structure could be supported on steel piles driven to refusal on the surface of the bedrock. In this case steel-H piles equipped with cast steel shoes capable of penetrating the bedrock surface would be the most suitable. All rock fill at the abutment locations would have to be removed to facilitate the driving of the piles, taking into account that some of the piles will be battered. Furthermore, a suitable fill should be used (i.e. free of cobbles and oversized material) to replace the rock fill within the zone of the approach fill through which the piles will be driven. This fill should be adequately protected to prevent its erosion.

.../...

The estimated pile capacities for some common heavier sizes of steel H-piles driven to refusal on the surface of the bedrock, are tabulated below:

ESTIMATED PILE CAPACITY (kN)

Pile Type	Size	Factored Capacity at Ultimate Limit States (Q_f)	Capacity at Serviceability Limit States - Type II (Q_s)
Steel H	HP 310 x 110	1600	1150
	HP 310 x 79	1150	850

In view of the sloping rock surface, presence of cobbles and the relatively thin overburden cover, careful field procedures may be required to prevent the sliding or 'walking' of the piles on the sloping and possibly 'humpy' surface of the rock. Unbalanced horizontal forces should be resisted by battered piles. For frost protection, the underside of the pile caps should be established at least 2 m below the finished grade. It is also recommended that the piles be equipped with a reinforcing shoe, as noted above.

4.1.1.2 Abutments on Rock Fill

The abutments could be established on rock fill placed after removing the weak overburden materials or, alternatively, allowing some time for possible settlements to take place after placing the fill.

.../...

It is estimated that new rock fill will penetrate through the organic silt and partially into the underlying silt. Once the fill has been placed, depending on the location (i.e. thickness of the overburden), some settlements could be expected unless the weak overburden soil is removed prior to placing the fill. These settlements, due to the compression of the overburden under the weight of the fill, can be expected to be substantially completed within a short period of time of fill placement (i.e. within several weeks of placing the fill). Some settlements due to the adjustment of the rock fill could also occur, especially if the rock fill is not suitably graded to prevent a downward migration and shifting of the smaller sized particles into the cavities in between larger rock sizes. These settlements, which could occur over a period of many years as well as immediately after construction, are largely a matter of material and construction control. We recommend possible settlements should be taken into account in the design, should this system be considered to be feasible.

In order to provide a satisfactory foundation in rock fill, the fill must be compacted in layers. The subgrade should be at least 1 m below the underside of footing, and the grade should be raised to underside of footing using material meeting Granular 'A' specifications; this fill should be compacted in thin lifts to not less than 100% of Standard Proctor maximum dry density. Migration of the Granular 'A' into the rock fill should be prevented by installing a suitable separating geotextile membrane. The rock fill

.../...

immediately below the geotextile membrane should consist of selected, suitable rock sizes to prevent the puncturing of the membrane during the placement and compaction of the foundation granular fill (i.e. the underlying rock fill should consist of sufficiently small rock sizes but should be properly graded to prevent a downward migration of the individual particles). The edge of the footing should be located at least 3 m from the side slope of the embankment.

For foundations meeting the above requirements, the Factored Bearing Capacity at Ultimate Limit States (q_f) is 600 kPa and the Bearing Capacity at Serviceability Limit States, Type II, is 250 kPa. The footing should have a suitable cover against frost.

4.1.1.3 Approach Fills

As discussed in the preceding section, it is expected that the 'muck' will be displaced with the fill materials, especially since rock fill will likely be used, and that the rock fill will penetrate to a certain extent into the underlying silt deposits. While some long term settlements can be expected under the weight of the fill, the design of the approach fills at the borehole locations will, however, not be limited by the strength of the foundation materials underlying the site.

.../...

Settlements due to the compression of the overburden materials are expected to be less than 60 mm, and should take place fairly rapidly. We estimate that 80% of the settlements will take place within several weeks. Depending on the material quality (i.e. particle size distribution, etc.), and construction procedures (method of placement, construction control, etc.) some settlements could also occur due to the shifting and adjusting of the individual particles within the rock fill.

The safe slopes for the embankments will be governed by the material used for construction and, in case of rock fill, 1.5 horizontal in 1 vertical slopes will be acceptable. In the case of pile supported perched abutments, rock fill should not be used in that part of the embankment through which piles will be driven. This fill should be protected by providing a suitable filter zone between it and the coarser rock fill. It is recommended that, as much as practicable, the embankments be constructed prior to the pile driving and abutment construction. This will reduce the extent of differential settlements between the fill and the structural elements of the bridge.

The slopes of the embankments should be adequately protected against surface erosion and the end slopes should also be protected by rip rap against river scour.

.../...

4.2 Alternative II

This alternative consists of replacing the existing structure on the existing alignment of Highway 11 with a single-span bridge which would be approximately 30 m long and 12.5 m wide. In this case, the traffic flow during the construction period would be carried on a single-span, 43 m long bailey bridge which would be located about 22 m east of the existing bridge alignment.

4.2.1 Foundations

Because of the relatively deep water level in the river and associated high cost of constructing facilitating temporary works, it is believed that the use of spread footing foundations for this project would not be practical. It is our opinion that founding the structure on deep foundations on the surface of the bedrock would be a more practical solution or, alternatively, the abutments could be supported on rock fill as discussed below.

4.2.1.1 Driven Piles

The structure could be supported on steel piles driven to refusal on the surface of the bedrock. In this case steel H-piles equipped with cast steel shoes capable of penetrating the bedrock surface would be the most suitable. All rock fill at the abutment locations would have to be removed to facilitate the driving of the piles, taking into account that some of the piles will be

.../...

battered. Furthermore, a suitable fill should be used (i.e. free of cobbles and oversized material) to replace the rock fill within the zone of the approach fill through which the piles will be driven. This fill will have to be adequately protected to prevent its erosion.

The estimated pile capacities for some common heavier sizes of steel H-piles driven to refusal on the surface of the bedrock, are tabulated below:

ESTIMATED PILE CAPACITY (kN)

Pile Type	Size	Factored Capacity at Ultimate Limit States (Q_f)	Capacity at Serviceability Limit States - Type II (Q_s)
Steel H	HP 310 x 110	1600	1150
	HP 310 x 79	1150	850

In view of the sloping rock surface, presence of cobbles and the relatively thin overburden cover, careful field procedures may be required to prevent the sliding or 'walking' of the piles on the sloping and possibly 'humpy' surface of the rock. Unbalanced horizontal forces should be resisted by battered piles. For frost protection, the underside of the pile caps should be established at least 2 m below the finished grade. It is also recommended that the piles be equipped with a reinforcing shoe, as noted above.

.../...

4.2.1.2 Abutments on Rock Fill

The abutments could be supported on rock fill placed after removing the weak overburden materials or, alternatively, allowing some time for possible settlements to take place after placing the fill. This method would be especially suitable at the present alignment location as the rock fill is already in place and since little or no grade changes are proposed, only minor adjustments will be required to widen the embankment.

It is estimated that new rock fill will penetrate through the organic silt and partially into the underlying silt. Once the fill has been placed, depending on the location (i.e. thickness of the overburden), some settlements will occur due to the weight of the fill unless the weak overburden soil has been removed prior to placing the fill. These settlements, due to the compression of the overburden, can be expected to be substantially completed within several weeks of placing the fill. Some settlements due to the adjustment of the rock fill could also occur, especially if the rock fill is not suitably graded to prevent a downward migration and shifting of the smaller sized particles into the cavities in between larger rock sizes. These settlements, which could occur over a period of many years as well as immediately after construction, are largely a matter of material and construction control. We recommend possible settlements should be taken into account in the design, especially along the detour alignment, should this system be considered to be feasible.

.../...

In order to provide a satisfactory foundation in rock fill, the fill must be compacted in layers. The subgrade should be at least 1 m below the underside of footing, and the grade should be raised to underside of footing using material meeting Granular 'A' specifications; this fill should be compacted in thin lifts to not less than 100% of Standard Proctor maximum dry density. Migration of the Granular 'A' into the rock fill should be prevented by installing a suitable separating geotextile membrane between the rock fill and the finer granular fill. Furthermore, the rock fill immediately below the geotextile separator should consist of selected, suitable rock sizes to prevent the puncturing of the membrane during the placement and compaction of the granular fill. The individual rock sizes beneath the membrane should consist of sufficiently small sizes which should be properly graded to prevent the downward migration of the individual particles.

For foundations meeting the above requirements, the Factored Bearing Capacity at Ultimate Limit States (q_f) is 600 kPa and the Bearing Capacity at Serviceability Limit States, Type II, is 250 kPa. The footing should have a suitable cover against frost.

.../...

4.2.1.3 Approach Fills

As discussed in the preceding sections, it is expected that the 'muck' will be displaced with the fill materials, especially since rock fill will likely be used, and that the rock fill will penetrate to a certain extent into the underlying silt deposits. While some long term settlements can be expected under the weight of the fill, the design of the approach fills at the borehole locations will, however, not be limited by the strength of the foundation materials underlying the site.

Settlements due to the compression of the overburden materials are expected to be less than 60 mm, except at the south approach of the proposed detour line where this value could be of the order of 120 mm. In general, these settlements can be expected to take place fairly rapidly. We estimate that 80% of the settlements will take place within several weeks. Depending on the material quality (i.e. particle size distribution, etc.), and construction procedures (method of placement, construction control, etc.) some settlements could also occur due to the shifting and adjusting of the individual particles within the rock fill.

The safe slopes for the embankments will be governed by the material used for construction and, in case of rock fill, 1.5 horizontal in 1 vertical slopes will be acceptable. In the case of pile supported perched abutments, rock

.../...

fill should not be used in that part of the embankment through which piles will be driven. This fill should be protected by providing a suitable filter zone between it and the coarser rock fill. It is recommended that, as much as practicable, the embankments be constructed prior to the pile driving and abutment construction. This will reduce the extent of differential settlements between the fill and the structural elements of the bridge.

The slopes of the embankments should be adequately protected against surface erosion and the end slopes should also be protected by rip rap against river scour.

5.0 CLOSURE

The Limitations of Report, as quoted in the Appendix, is an integral part of this report.

DOMINION SOIL INVESTIGATION INC.

REGISTERED PROFESSIONAL ENGINEER
Z. S. OZDEN
PROVINCE OF ONTARIO

R. A. Jarrett

Z.S. Ozden, P.Eng. ppC. Alston, P.Eng.

ZSO:bh

A P P E N D I C E S

Ref. No. 85-8-4

APPENDIX A

PROCEDURES

The field work was carried out during the period of August 26 and September 7, 1985. During this period a total of thirteen (13) boreholes were drilled at the positions shown on the Borehole Location Plan, Drawing No. 1308301-A.

The boreholes were advanced to depths ranging between 4.3 and 9.7 m below the water level (or 1.9 to 6.8 m below the river bottom), using a conventional diamond drilling unit adapted for soil sampling.

Within the overburden, the boreholes were cased with N-size (89 mm o.d.) casing and extended by washboring methods and, where necessary, a tri-cone bit. Sampling in the overburden was effected by the Standard Penetration test method and from the test results, recorded as 'N'-values or penetration resistances, relative density or the consistency of the strata was inferred. The bedrock was cored using a BXL-size core barrel. Where the boreholes were located close to the existing structure or approach fills, the borehole had to be advanced through the rock fill which was generally achieved by finding an opening through the cavities between rocks. In many cases this was achieved after many trials and, in some cases, resulted in a slightly inclined or constricted drill hole. This, and the fact that the only drill rig available at the time was a screw head type diamond drill, resulted in slower than usual operations.

The raft and the drilling equipment were owned and operated by Atcost Soil Drilling Inc. and the field work was carried out under the supervision of a Geotechnical Engineer from Dominion Soil Investigation Inc.

.../...

Upon completion of the field work the soil samples and the rock cores were shipped to our laboratory where they were examined by the Project Engineer and the Geologist, and a laboratory testing programme consisting of moisture and organic content tests, sieve and hydrometer analyses and Atterberg Limit determinations was carried out on representative soil samples. Percentage of recovery and the R.Q.D. values of the rock cores were established and unconfined compression tests were performed on two representative samples of the rock.

The elevations used in this report were determined with reference to the top of concrete pier foundation of the existing bridge at Station 11+160, west edge, 4.60 m below the top of the bridge deck (Elevation 287.61 m).

APPENDIX 'B'

LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the testhole locations. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Soils Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work.

E N C L O S U R E S

Ministry of Transportation and Communications Ontario | Ref. No. 85-8-4 | DOMINION SOIL INVESTIGATION INC. | Enclosure 1

RECORD OF BOREHOLE No 1 — METRIC

W P 130-83-01 | LOCATION STA. 11 +130; O/S 14 m Rt. ℄ HWY. 11 | ORIGINATED BY R.M.

DIST 13 HWY 11 | BOREHOLE TYPE WASHBORING AND BX ROCK CORE | COMPILED BY R.M.

DATUM GEODETIC | DATE 1985 09 05 | CHECKED BY [signature]

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4 / 0.0	WATER LEVEL; WATER						
282.9 / 3.5	Rock Fill	1	SS	—*			Sample No. 1: No recovery; *Scratching rock fill- N-value not applicable
281.5 / 4.9	Fill - gravelly sand						
281.2 / 5.2	Organic silt (muck) dark grey, v.soft	2	SS	—*		≈43	Org. Content 5.2%
280.7 / 5.7	Silty sand mixed with rock fragments and organics	3	SS	50/ 8 cm			
279.8 / 6.6	Silt, some sand grey						
279.2 / 7.2	Sand, some silt & gravel (Till) dense, grey	4	SS	50			18 59 20 3
278.7 / 7.7	Gneiss Bedrock	5	RC BX	98%			RQD = 98%
		6	RC BX	64%	**		RQD = 41%
276.8 / 9.6	End of Borehole						** Some rock core fell off core barrel

Elevation scale: 286, 285, 284, 283, 282, 281, 280, 279, 278, 277

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT Wp — NATURAL MOISTURE CONTENT W — LIQUID LIMIT WL; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ

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

Ministry of Transportation and Communications Ontario — Ref. No. 85-8-4 — DOMINION SOIL INVESTIGATION INC. — Enclosure 2

RECORD OF BOREHOLE No 2

METRIC

W P 130-83-01 — LOCATION STA. 11 + 157; O/S 14 m Rt ℄ HWY. 11 — ORIGINATED BY R.M.

DIST 13 HWY 11 — BOREHOLE TYPE WASHBORING — COMPILED BY R.M.

DATUM GEODETIC — DATE 1985 09 06 — CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × 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
286.4	WATER LEVEL										
0.0	WATER						286				
285.2											
1.2	Rock Fill						285				
			1	SS	27						Sample No. 1: No recovery
							284				
282.9							283				
3.5	Fill - organic silt mixed with rock fill and sand		2	SS	14						
281.7			3	SS	75/	15 cm	282				Sample No. 3: No recovery
4.7	End of Borehole										Refusal to driving casing @ 4.7 m. Extend core barrel. Casing & core barrel driven inclined through rockfill. Abandon borehole & move to 2A.

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

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

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2A

METRIC

W P 130-83-01 LOCATION STA. 11 + 154; O/S 14 m Rt ℄ HWY. 11 ORIGINATED BY R.M.

DIST 13 HWY 11 BOREHOLE TYPE WASHBORING AND BX ROCK CORE COMPILED BY R.M.

DATUM GEODETIC DATE 1095 09 06 to 1985 09 07 CHECKED BY ___

ELEV DEPTH (286.4)	DESCRIPTION / WATER LEVEL	NUMBER	TYPE	'N' VALUES	REMARKS
0.0 / 284.1	WATER				
2.3 / 281.9	Rock Fill				
4.5 / 281.2	Fill - Gravelly sand, silty				
5.2 / 280.5	Organic silt (muck) v.soft, dark brown	1	WS	—	
5.9 / 280.0	Silt, some sand grey				
6.4 / 279.5	Gravelly sand, some silt (Till) grey, dense to v.dense	2	SS	94	
6.9 / 278.5	Gneiss Bedrock	3	RC BX	79%	RQD = 79%
		4	RC BX	93%	RQD = 53%
7.9	End of Borehole				

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (286, 285, 284, 283, 282, 281, 280, 279); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × 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

$+^3$, $\times^5$: Numbers refer to Sensitivity   15 ⌖ 5 (20/10) (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

W P 130-83-01 LOCATION STA. 11 + 130; O/S 15 m Lt ¢ HWY. 11 ORIGINATED BY R.M.

DIST 13 HWY 11 BOREHOLE TYPE WASHBORING AND BX ROCK CORE COMPILED BY R.M.

DATUM GEODETIC DATE 1985 08 30 and 1985 09 03 CHECKED BY [illegible]

ELEV / DEPTH (286.4)	DESCRIPTION / WATER LEVEL	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0	WATER					286, 285, 284		
283.1 / 3.3	Rock Fill					283		
282.3 / 4.1	Organic silt (muck) with embedded rock fill							
282.0 / 4.4	Sandy silt mixed with rock fill	1	SS	7		282	o	Org. Content = 6.4%
281.1 / 5.3	Sand, gravelly some silt (Till) grey, v.dense	2	SS	57		281		
		3	SS	50/10 cm				
280.4 / 6.0	Gneiss (probably highly weathered bedrock)	4	RC BX	47%		280		RQD = 17% Loss of water return @ 7 m
279.6 / 6.8	Dark grey sand (prob. decomposed rock) with broken rock pieces	5	SS	—				
		6	SS	100/8 cm				
279.2 / 7.2	Gneiss Bedrock	7	RC BX	94%		279, 278		RQD = 94%
277.6 / 8.8	End of Borehole							

Dynamic cone penetration resistance plot: 20 40 60 80 100. Shear strength: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. Plastic limit W_p, natural moisture content W, liquid limit W_L; water content (%) 20 40 60. Unit weight γ.

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 4

METRIC

W P 130-83-01 LOCATION STA. 11 + 160; O/S 18 m Lt ℄ HWY. 11 ORIGINATED BY R.M.

DIST 13 HWY 11 BOREHOLE TYPE WASHBORING AND BX ROCK CORE COMPILED BY R.M.

DATUM GEODETIC DATE 1985 08 28 to 1985 08 29 CHECKED BY

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4	WATER LEVEL					
0.0	WATER					
283.7 / 2.7	ROCK FILL	1	SS	27		
		2	SS	48		
281.6 / 4.8	Organic silt (muck) sandy, v.soft					
281.2 / 5.2	Silt, some sand, dense grey	3	SS	69		
280.7 / 5.7	Silty sand, some gravel (Till) very dense, grey	4	SS	50/10 cm		
280.0 / 6.4	Gneiss bedrock highly micaceous and fractured	5	RC BX	75%		RQD = 55% Some core lost
		6	RC BX	80%		RQD = 38%
276.9 / 9.5	End of Borehole					

Elevation scale: 286, 285, 284, 283, 282, 281, 280, 279, 278, 277

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT W_p NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L — WATER CONTENT (%)

UNIT WEIGHT γ

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

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

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5

METRIC

W P 130-83-01 LOCATION STA. 11 + 129; O/S 27 m Lt. ℄ HWY. 11 ORIGINATED BY R.M.

DIST 13 HWY 11 BOREHOLE TYPE WASHBORING AND BX ROCK CORE COMPILED BY R.M.

DATUM GEODETIC DATE 1985 09 03 to 1985 09 04 CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH	WATER CONTENT (%) (Wp, W, WL)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4	WATER LEVEL										
0.0	WATER						286, 285, 284, 283				
282.3 / 4.1	Silty clay v.soft, grey										
281.9 / 4.5	Silty sand till, grey, v.dense		1	SS	50/13 cm		282		Wp–WL plotted; W ≈ 40		
281.6 / 4.8	Gneiss Bedrock		2	RC BX	98%		281				RQD = 57%
			3	RC BX	100%		280, 279				RQD = 100%
278.5 / 7.9	End of Borehole										

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT Wp, NATURAL MOISTURE CONTENT W, LIQUID LIMIT WL; WATER CONTENT (%) 20 40 60

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 6

METRIC

W P 180-83-01   LOCATION STA. 11 + 160; O/S 28 m Lt. ℄ HWY. 11   ORIGINATED BY R.M.

DIST 13 HWY 11   BOREHOLE TYPE WASHBORING AND BX ROCK CORE   COMPILED BY R.M.

DATUM GEODETIC   DATE 1985 08 29   CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION / WATER LEVEL	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4 / 0.0	WATER					
281.6 / 4.8	Organic silt (muck) v.soft, dark brown					
280.9 / 5.5	Silt loose to compact, grey	1	SS	11		0 12 78 10
		2	SS	7		0 2 86 12
279.8 / 6.6	Gravelly sand some silt (Till) compact to v.dense grey	3	SS	22		
		4	SS	105/25 cm		
278.5 / 7.9	Gneiss Bedrock	5	RC BX	97%		RQD = 67%
276.8 / 9.6	End of Borehole					

Elevation scale: 286, 285, 284, 283, 282, 281, 280, 279, 278, 277

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE

PLASTIC LIMIT W_p — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%)

UNIT WEIGHT γ

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

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

RECORD OF BOREHOLE No 7

METRIC

W P 130-83-01   LOCATION STA. 11 + 105; O/S 21 m Lt ℄ HWY. 11   ORIGINATED BY R.M.

DIST 13 HWY 11   BOREHOLE TYPE WASHBORING AND BX ROCK CORE   COMPILED BY R.M.

DATUM GEODETIC   DATE 1985 09 04 to 1985 09 05   CHECKED BY [illegible]

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 (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	WATER CONTENT (%) (PLASTIC LIMIT Wp, NATURAL MOISTURE CONTENT W, LIQUID LIMIT WL)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4	WATER LEVEL										
0.0	WATER						286				
							285				
284.0 / 2.4	Organic silt (muck)						284				
283.7 / 2.7	Silt compact, grey		1	SS	16						0 2 92 6
282.8 / 3.6	Gravelly sand till		2	SS	60/15 cm		283				
282.5 / 3.9	Gneiss Bedrock		3	RC BX	94%		282				RQD = 94%
281.0 / 5.4	End of Borehole										

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

15 -◊- 5 (20 above, 10 below) (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 8

METRIC

W P 130-83-01 | LOCATION STA. 11 + 116; O/S 34 m Lt ℄ HWY. 11 | ORIGINATED BY R.M.

DIST 13 HWY 11 | BOREHOLE TYPE WASHBORING AND BX ROCK CORE | COMPILED BY R.M.

DATUM GEODETIC | DATE 1985 09 04 | CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4	WATER LEVEL						
0.0	WATER					286 285 284	
283.8 / 2.6	Organic silt (muck) v.soft, dark brown						
283.3 / 3.1	Silt, some sand loose to compact, grey	1	SS	21		283	
282.9 / 3.5	Silty sand, gravelly (Till)						
282.7 / 3.7	Gneiss Bedrock	2	RC BX	94%		282	RQD = 94%
281.1 / 5.3	End of Borehole						

Other columns: STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE); PLASTIC LIMIT W_p, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%); UNIT WEIGHT γ

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

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

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9

METRIC

W P 130-83-01   LOCATION STA. 11 + 165; O/S 39 m Lt. ℄ HWY. 11   ORIGINATED BY R.M.

DIST 13 HWY 11   BOREHOLE TYPE WASHBORING AND BX ROCK CORE   COMPILED BY R.M.

DATUM GEODETIC   DATE 1985 08 29 to 1985 08 30   CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION / WATER LEVEL	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4 / 0.0	WATER					286, 285, 284, 283, 282	
281.8 / 4.6	Organic silt (muck)						Boulder adjacent to borehole.
281.4 / 5.0	Silt with silty sand and silty clay seams compact, grey	1	SS	26		281	1 22 64 13
		2	SS	60/	15 cm		Cobble @ 5.9m Sa. 2: No re[c]
280.5 / 5.9	Silty sand, gravelly (Till) occasional cobbles						
280.0 / 6.4	Gneiss Bedrock	3	RC BX	98%		280, 279	RQD = 68%
278.4 / 8.0	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE

PLASTIC LIMIT W_p, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%)

UNIT WEIGHT γ

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

Ministry of Transportation and Communications Ontario   Ref. No. 85-8-4   DOMINION SOIL INVESTIGATION INC.   Enclosure 11

RECORD OF BOREHOLE No 10

METRIC

W P 130-83-01   LOCATION STA. 11 + 191; O/S 25.6 m Lt ℄ HWY. 11   ORIGINATED BY R.M.

DIST 13 HWY 11   BOREHOLE TYPE WASHBORING AND BX ROCK CORE   COMPILED BY R.M.

DATUM GEODETIC   DATE 1985 08 28   CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH	WATER CONTENT (%) (Wp, W, WL; 20 40 60)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4	WATER LEVEL										
0.0	WATER						286, 285				
284.4 / 2.0	Organic silt (muck) v.soft, dark brown						284				
283.7 / 2.7	Silt, sandy, compact grey		1	SS	20				o		Org. Content = 12.6%
283.5 / 2.9	Gravelly sand till with cobbles										
283.2 / 3.2	Gneiss Bedrock		2	RC BX	81%		283				RQD = 56%
282.1 / 4.3	End of Borehole										

Shear strength legend: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE

$+^3$, $\times^5$: Numbers refer to Sensitivity   15 -◊- 5 (%) STRAIN AT FAILURE (20 above, 10 below)

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 11

METRIC

W P 130-83-01 LOCATION STA. 11 + 124; 0/S 26 m Rt. ℄ HWY. 11 ORIGINATED BY R.M.
DIST 13 HWY 11 BOREHOLE TYPE WASHBORING COMPILED BY R.M.
DATUM GEODETIC DATE 1985 09 07 CHECKED BY [illegible]

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4	WATER LEVEL						
0.0	WATER					286, 285, 284, 283	
282.2 / 4.2	Organic silt (muck) v.soft, dark brown					282, 281	
280.8 / 5.6	Silty clay v.soft, grey	1	SS	1		280	
279.4 / 7.0	v.loose / Silt compact, grey	2	SS	19		279, 278	0 3 86 11
277.6 / 8.8	Gravelly sand some silt (Till) dense to v.dense, grey	3	SS	75/15 cm		277	Refusal to driving of casing @ 9.7 m
276.7 / 9.7	End of Borehole						

Dynamic cone penetration resistance plot: 20 40 60 80 100
Shear strength: ○ Unconfined, + Field vane, ● Quick triaxial, × Lab vane
Plastic limit W_p, Natural moisture content W, Liquid limit W_L — Water content (%)
Unit weight γ

$+^3$, $\times^5$: Numbers refer to Sensitivity   15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 12

METRIC

W P 130-83-01 LOCATION STA. 11 + 163; O/S 26 m Rt. ℄ HWY. 11 ORIGINATED BY R.M.

DIST 13 HWY 11 BOREHOLE TYPE WASHBORING COMPILED BY R.M.

DATUM GEODETIC DATE 1985 09 07 CHECKED BY [illegible]

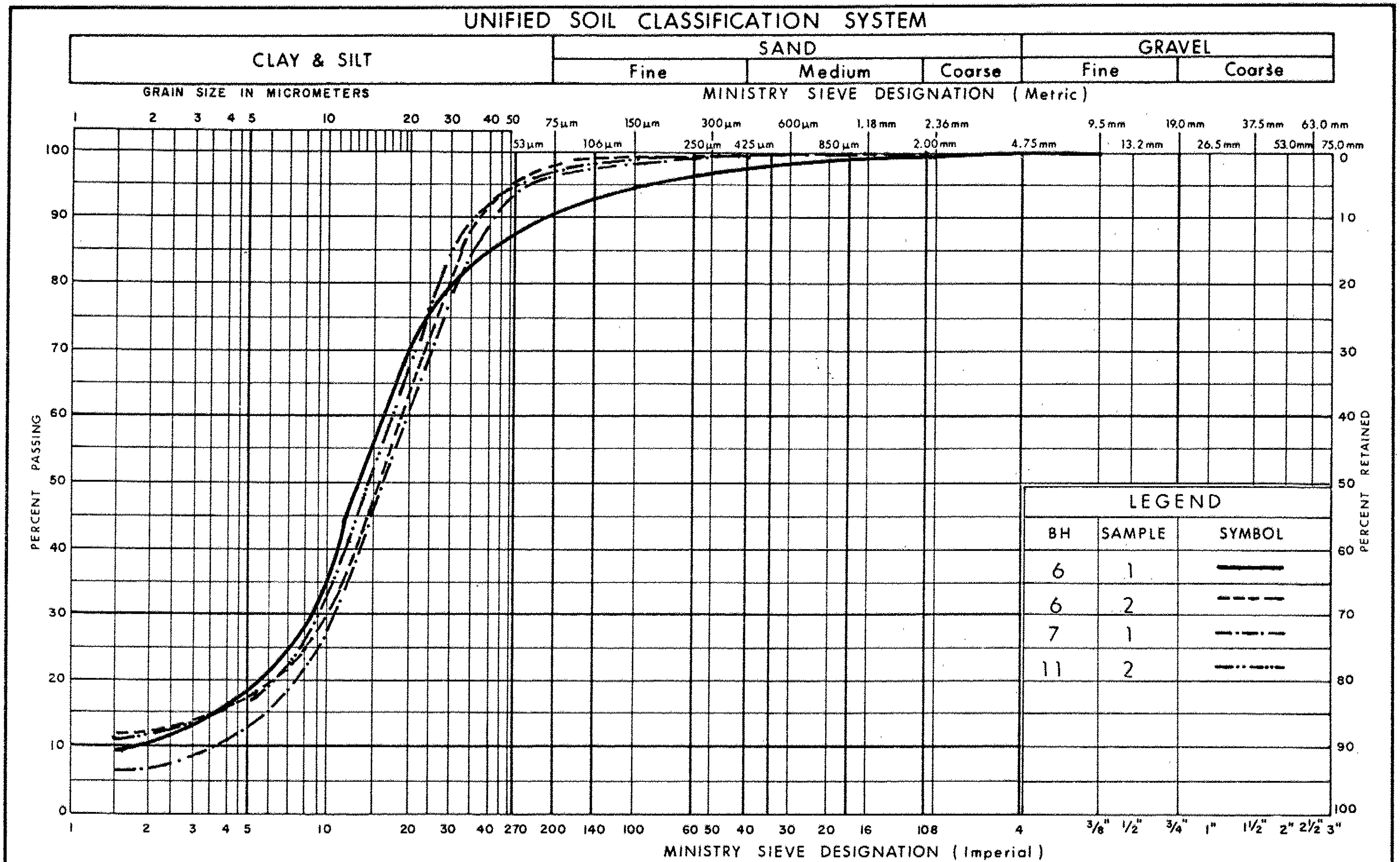
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4	WATER LEVEL										
0.0	WATER						286				
							285				
							284				
283.6 / 2.8	Organic silt (muck) sandy some gravel & cobbles						283				
282.9 / 3.5	Silty sand, gravelly (Till) grey, compact to v.dense						282				Refusal to driving of casing @ 4.7 m
281.7			1	SS	78/28 cm						
4.7	End of Borehole										

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

15 ⟡ 5 (%) STRAIN AT FAILURE (20 above, 10 below)

OFFICE REPORT ON SOIL EXPLORATION

78 12 M



Ref. No. 85-8-4

DOMINION SOIL INVESTIGATION INC.

Enclosure 14

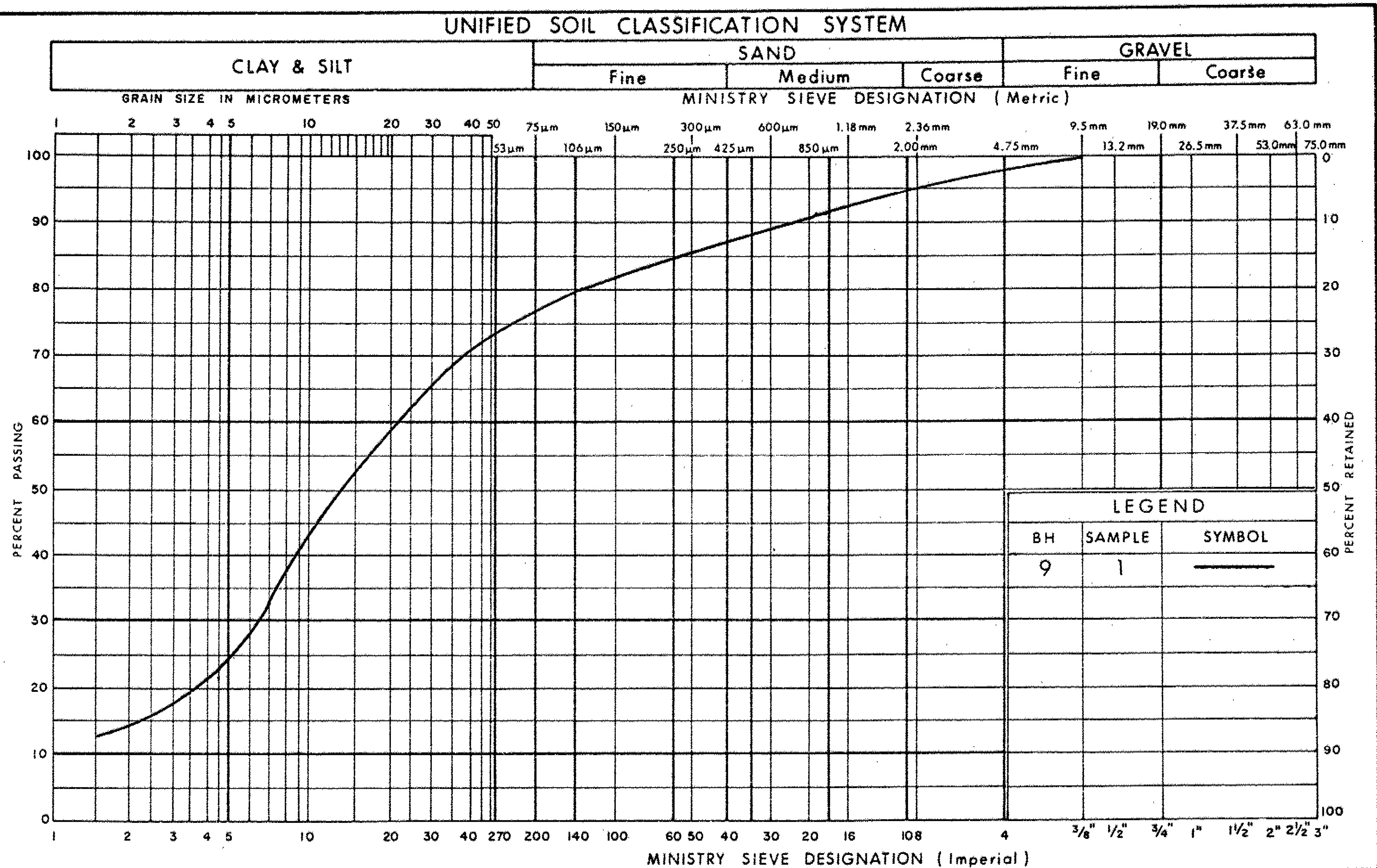
Ministry of Transportation and Communications
Ontario

GRAIN SIZE DISTRIBUTION
SILT

FIG No 1

W P 130-83-01

78 12 M



Ref. No. 85-8-4

DOMINION SOIL INVESTIGATION INC.

Enclosure 15

Ministry of Transportation and Communications
Ontario

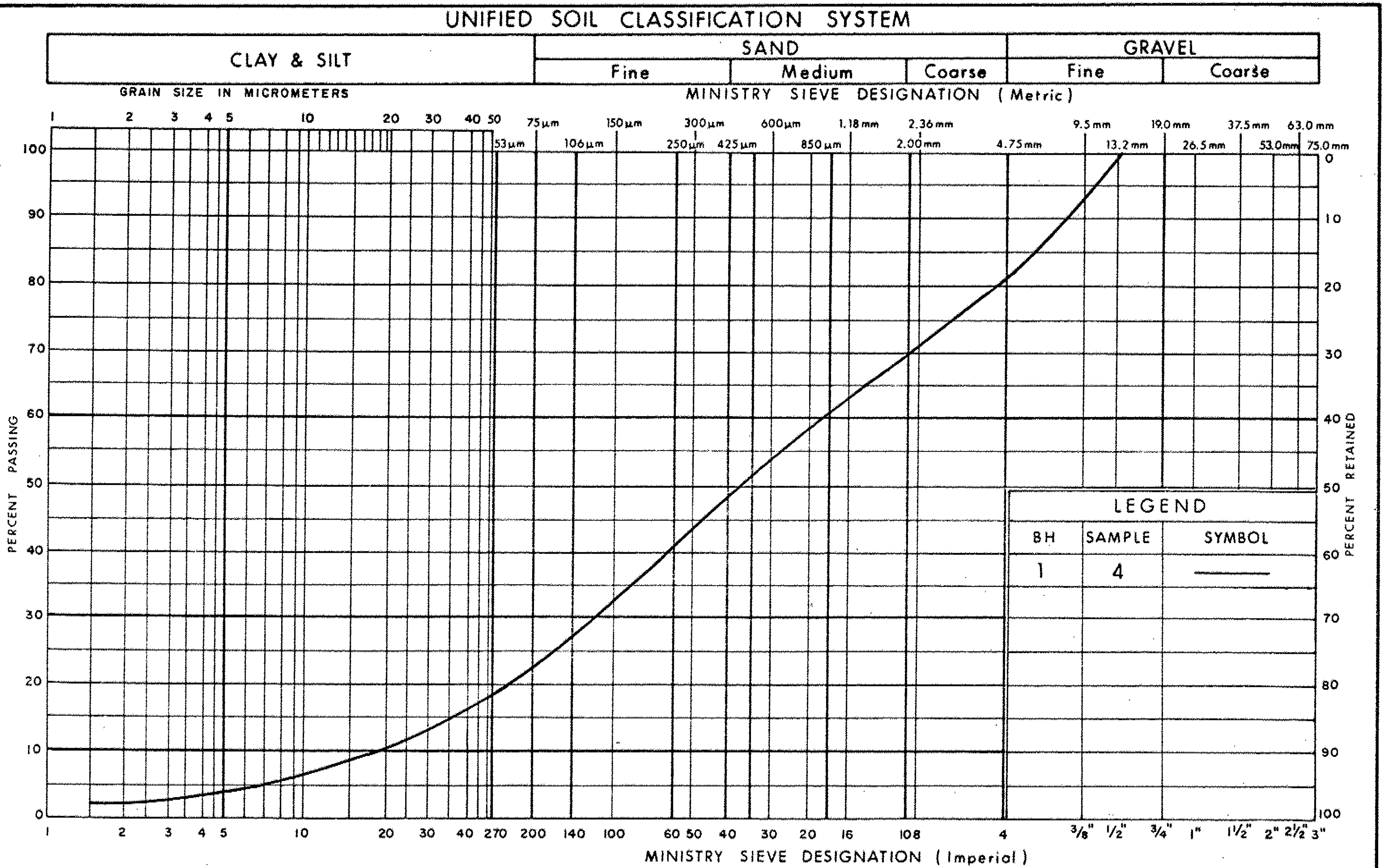
GRAIN SIZE DISTRIBUTION

SANDY SILT, some Clay

FIG No 2

W P 130-83-01

78 12 M



Ministry of Transportation and Communications

Ontario

GRAIN SIZE DISTRIBUTION

SAND, some gravel & silt. (TILL)

FIG No 3

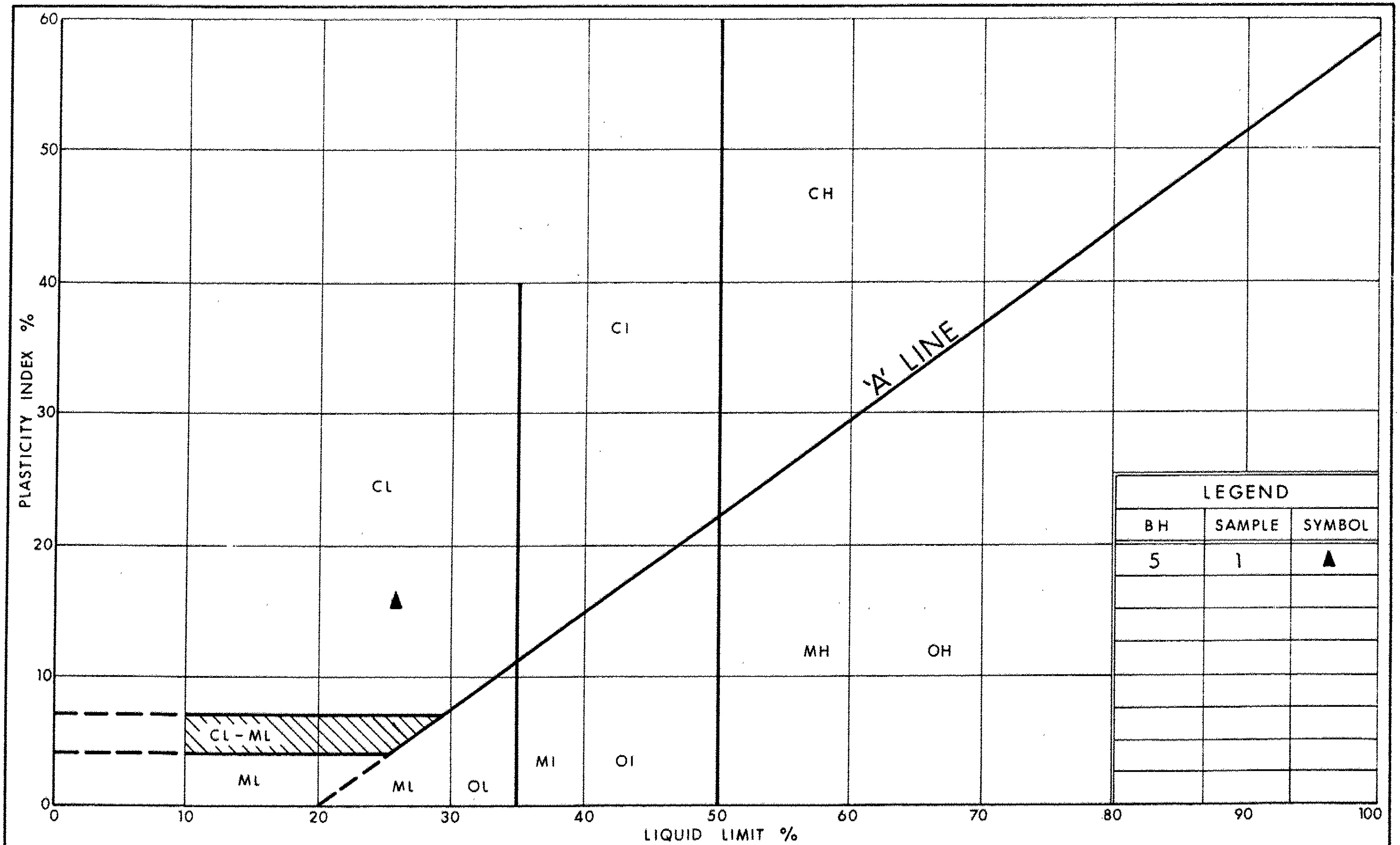
W P 130 - 83 - 01

Ref. No. 85-8-4

DOMINION SOIL INVESTIGATION INC.

Enclosure 16

Oct 75, FF-S-21



Ministry of Transportation and Communications
Ontario

PLASTICITY CHART
SILTY CLAY

FIG No 4
W P 130-83-01

Ref. No. 85-8-4
DOMINION SOIL INVESTIGATION INC.
Enclosure 17

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO PH-D-207 82 04

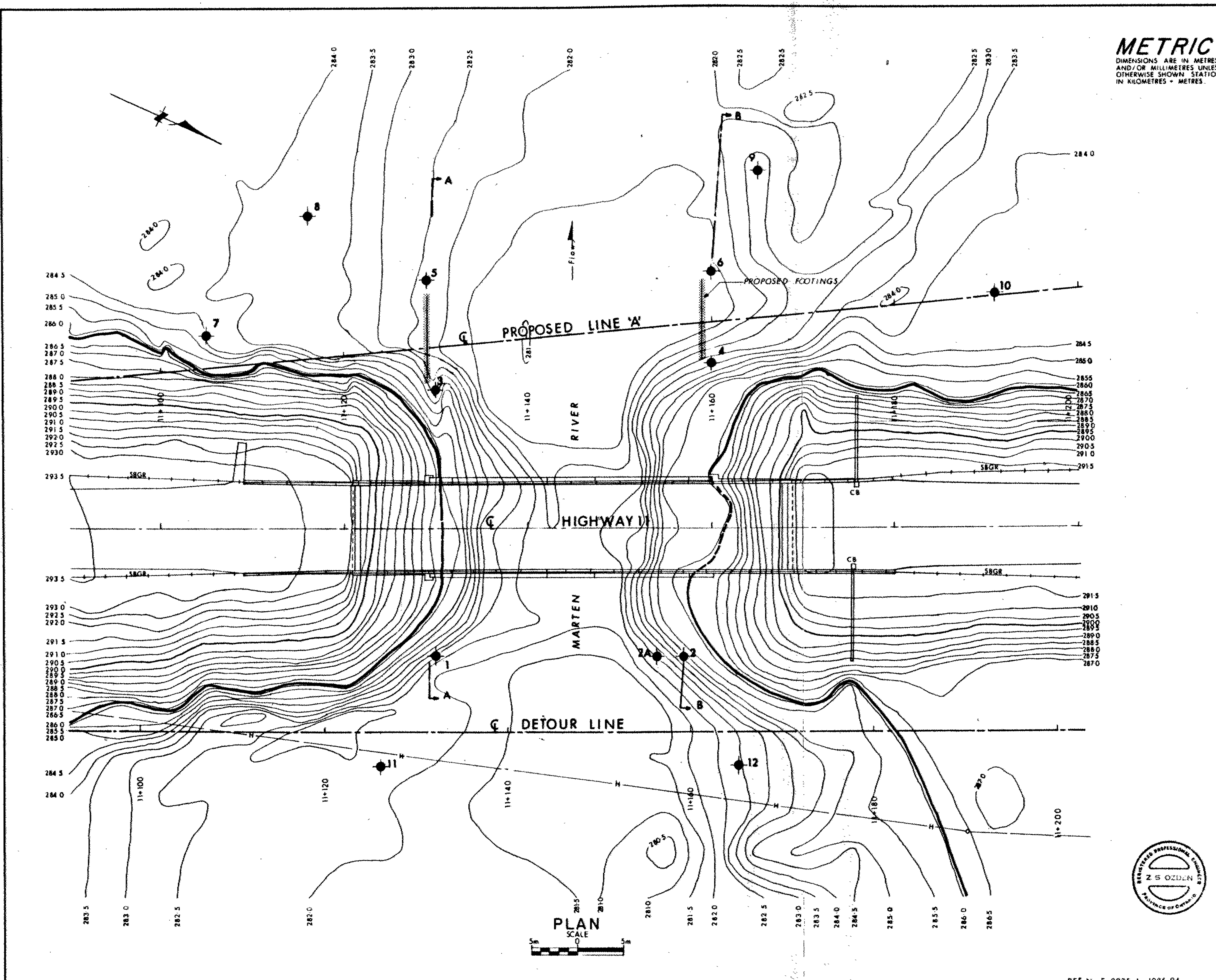
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

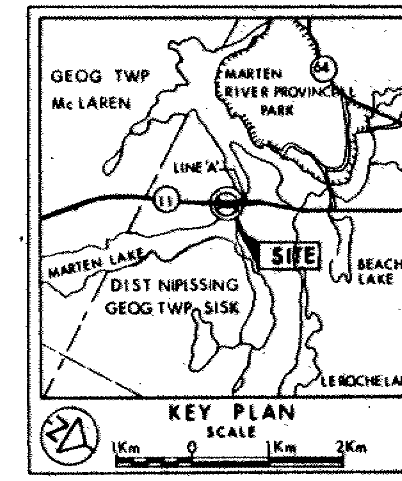
CONT No
WP No 130-83-01

SHEET

PROPOSED CROSSING AT MARTEN RIVER AND HIGHWAY 11
BORE HOLE LOCATIONS & SOIL STRATA

DOMINION SOIL INVESTIGATION 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 1985 08 and 09

No	ELEVATION	STATION	OFFSET
1	286·4	11+130	14 m RT
2	286 4	11+157	14 m RT.
2A	286 4	11+154	14 m RT.
3	286 4	11+130	15 m LT
4	286·4	11+160	18 m LT
5	286·4	11+129	27 m LT
6	286·4	11+160	28 m LT
7	286·4	11+105	21 m LT
8	286·4	11+116	34 m LT.
9	286·4	11+165	39 m LT
10	286·4	11+191	256 m LT
11	286·4	11+124	26 m RT.
12	286·4	11+163	26 m RT.

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.

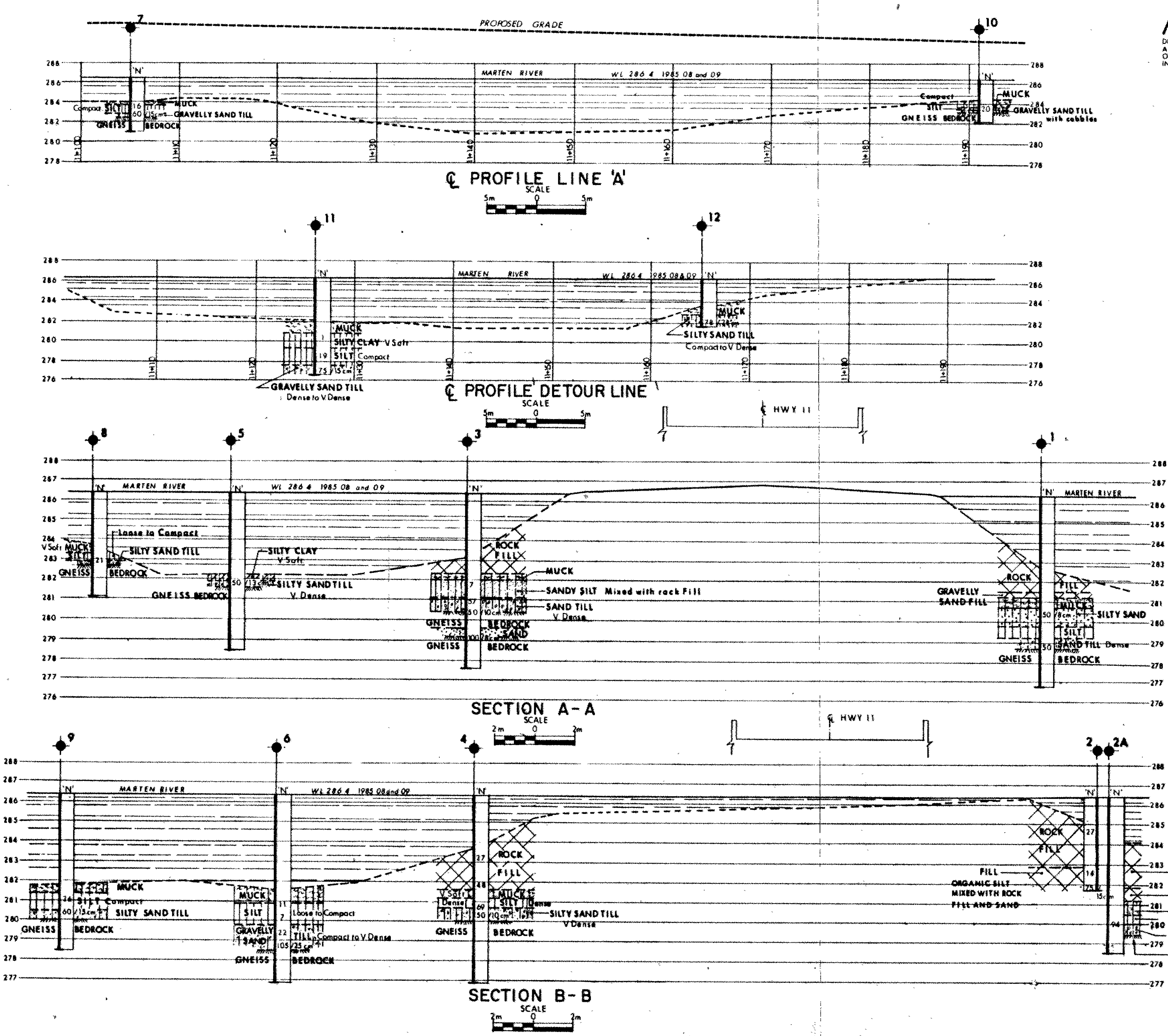
Z S OZDEN

REV	DATE	BY	DESCRIPTION

Geocres No 31L-53

HWY No 11 LINE 'A'			DIST 13
SUBM'D R.M.	CHECKED Z.O.	DATE 1985 09 11	SITE 43-005
DRAWN F.L.	CHECKED Z.O.	APPROVED	DWG 1308301-A

REF No E-9025-1 1985 04



METRIC

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

CONT No
WP No 130-83-01

SHEET

PROPOSED CROSSING AT MARTEN RIVER AND HWY. 11
BORE HOLE LOCATIONS & SOIL STRATA

DOMINION SOIL INVESTIGATION INC

SEE DWG No 1308301-A

KEY PLAN
SCALE

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 1985 08 and 09

No	ELEVATION		
	SEE DWG	No 1308301 - A	

NOTE

FOR DETAILED SUBSOIL CONDITIONS REFER TO RECORD OF BOREHOLE SHEETS

Z. S. OZDEN
REGISTERED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION

Geocres No 31L-53

HWY No 11 LINE 'A'			DIST 13
SUBM'D RM	CHECKED ZO	DATE 1985 09 11	SITE 43-005
DRAWN FL	CHECKED ZO	APPROVED	DWG 1308301-B

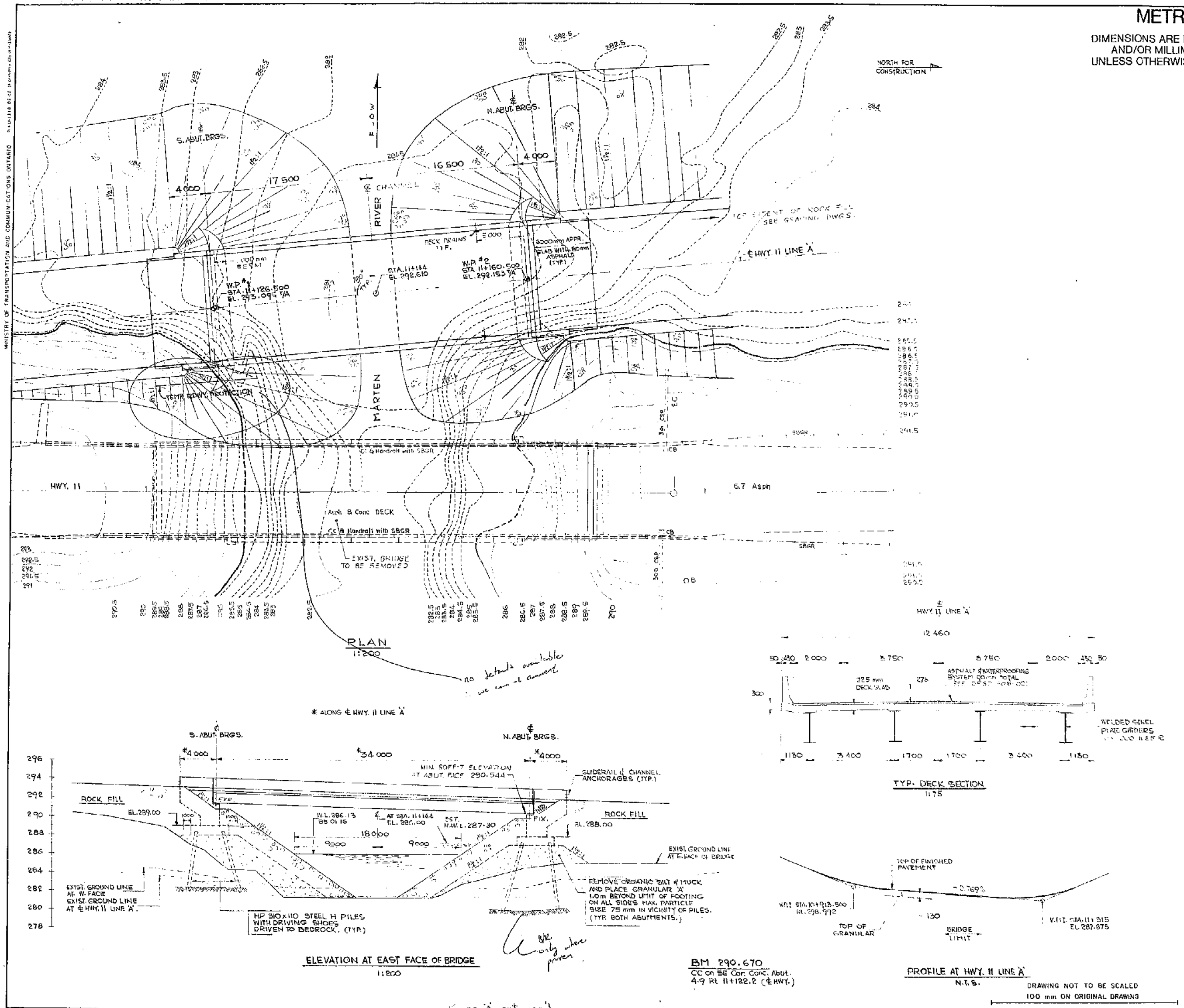
METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

DIST. 13
CONT No
WP No 130-83-01

MARTEN RIVER BRIDGE
1.9Km S.OF JCT. HWY. 11&64
GENERAL ARRANGEMENT

SHEET



NOTES

REINFORCING STEEL:
REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED.
BAR MARKS WITH SUFFIX 'C' SHALL BE COATED BARS.

CLASS OF CONCRETE:

FOOTINGS	20 MPa
REMAINDER	30 MPa

CLEAR COVER TO REINFORCING STEEL

FOOTINGS		100 ± 25mm
ABUTMENTS & WINGWALLS:	FRONT FACE:	80 ± 20 mm
	BACK FACE:	70 ± 20 mm
DECK:	TOP	70 ± 20 mm
	BOTTOM	40 ± 10 mm
BARRIER WALLS		70 ± 20 mm
APPROACH SLABS		75 ± 25 mm

UNLESS OTHERWISE NOTED ON DRAWINGS.

CONSTRUCTION NOTES:
THE CONTRACTOR SHALL FINISH THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED ELEVATIONS TO A TOLERANCE OF ± 3mm.

LIST OF DRAWINGS
43-005-1 GENERAL ARRANGEMENT

REC. MAR 26 1986

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWINGS

REVISIONS		
DATE	BY	DESCRIPTION
DESIGN	CHECK	LOADING OHBDC-A-83	DATE 86-03-16
DRAWING	CHECK	SITE No 43-005	DWG P1