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DIST. 11 REGION

W.P. No. 89-88-01

CONT. No. 95-220

W. O. No.

STR. SITE No. 44-139

HWY. No. 518

LOCATION Hwy 518 & Bear Creek

No. of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

G.I.-30 SEPT. 1976

OVERSIZE DRAWING

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 95-220

Ontario

Ministry of
Transportation

INDEX

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

EXPLANATION OF TERMS USED IN REPORT

'N' VALUE : THE STANDARD PENETRATION TEST (SPT) 'N' VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m 'N' VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE 'N' VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST : CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY : COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u : kPa	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS : COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT 'N' VALUES AS FOLLOWS:

'N' BLOWS/0.3m	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY : SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY : SUM OF THOSE INTACT CORE PIECES 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING :

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T.W. ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T.W. ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	-	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	-	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	-	COMPRESSION INDEX
C_s	-	SWELLING INDEX
C_α	-	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	-	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	-	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	-, %	VOID RATIO
n	-, %	POROSITY
w	-, %	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	-	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_C	-	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	-, %	VOID RATIO IN LOOSEST STATE
e_{min}	-, %	VOID RATIO IN DENSEST STATE
I_D	-	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	-	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	-	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

FOUNDATION INVESTIGATION REPORT
FOR
CROSSING AT HIGHWAY 518 AND
BEAR CREEK
DISTRICT 11 HUNTSVILLE
W.P. 89-88-01 SITE 44-139

INTRODUCTION

This report summarizes the results of a foundation investigation for the proposed crossing of Bear Creek at Highway 518. The investigation was carried out at the request of Foundation Design Section of the Ministry of Transportation, Ontario.

This report applies to structure foundations, approach embankments and related earthworks between Sta. 21 + 540 and Sta. 21 + 585.

SITE DESCRIPTION

The site is located at the crossing of Bear Creek and proposed Highway 518, about 21 meters south of the present structure on Highway 518, in District 11, Huntsville, Ontario.

The water from the Bear Lake flows into the creek in the northerly direction. At the time of the investigation, the water in the creek was about 0.7 m deep. The existing creek bed is about 13 meters wide, with a gentle slope rising out of the creek at the west and east banks. The banks are covered by heavy bush and some trees.

The existing creek crossing is a single span concrete bridge structure.

PROCEDURE

The field investigation was carried out between the period of February 14 to 21, 1990. The fieldwork consisted of drilling six boreholes, five cone tests and one test pit. The boreholes, on land, were advanced using a track mounted auger machine equipped with 83 mm I.D. hollow stem augers and B size casing. The boreholes, in water, were advanced using drill/casing assembly mounted on a raft. Three boreholes were further advanced in the bedrock, using BXT size core bits. Due to the presence of boulders at the surface, borehole 6 was excavated by a back-hoe.

Samples were recovered by means of a 50 mm O.D. split spoon sampler driven into the soil according to the specification of the Standard penetration Test (ASTM D 1587-8). In addition, relatively undisturbed samples were retrieved by 50 mm thin walled shelby tubes. Field vane tests were carried out in the stiff to soft cohesive deposits.

Laboratory testing was carried out on representative samples to identify and determine the physical properties of the overburden including:

Natural moisture content
Grain size distribution
Atterberg Limit
Unit Weight

The elevations of the boreholes were referenced to a local geodetic benchmark, provided by the MTO local office. (rock outcrop, north west bank of existing bridge, at Elevation 316.677 m).

SITE GEOLOGY AND SUBSURFACE CONDITIONS

Physiographically, the site lies in the area known as Georgian Bay Fringe, characterized by very shallow soils and bare rock knobs and ridges. The bare rock ridges are due partly to the fact that they were washed by the waves when glacial Lake Algonquin inundated this area.

The subsoil conditions are variable across the site, from the west to the east bank. The soils on the west side of the creek consist of firm to stiff varved clayey silt to silty clay, overlying compact sand which in turn overlies on Gneiss Bedrock. However, on the east side of the creek a layer of loam, with boulders, overlies the Gneiss bedrock at shallow depths.

The boundaries of the different strata, together with the field and laboratory test results, are presented on the Record of Borehole sheets appended to this report. Also refer to the drawing and borehole sheets for the locations and elevations of the boreholes. Stratigraphical sections of the subsurface conditions are shown on Drawing 898801-A.* Detailed descriptions of the different strata are provided below.

Clayey Sandy Silt

This deposit occurs, below the topsoil, in Borehole 5. It is mottled in colour, with oxidized stains and roots, and in a moist state. The thickness of this stratum is about 1.3 m.

* Dwg No 2, (Sheet 16) of the Contract Drawings.

Clayey Silt to Silty Clay

This deposit was encountered on the west side of the creek, in Boreholes 1, 2 and 5. The deposit occurs as a surficial deposit in Boreholes 1 and 2, but is present below the clayey sandy silt layer in Borehole 5. This stratum is varved and ranges in thickness from 3.3 m to 5.9 m.

Undrained shear strength of the soil was determined both by in situ field vane tests and laboratory vane tests. The results are plotted on the Record of Borehole sheets in the Appendix and summarized as follows:

Undrained Shear Strength (kPa)	Range	Average	Sensitivity
Field Vane (8 tests)	18 - >80	51	2.5 - 11.9

Based on the above shear strength values, the consistency of this deposit ranges from stiff to soft. The sensitivity of the strata is, however, questionable, since very thin clay layers are prevalent within the more dominant silt strata, due to the varved nature of the deposit.

The results from the three Atterberg Limit test (Figure 1) performed on this material are summarized as follows:

Property	Range	Average
Natural Moisture Content (%)	37 - 57	44.5
Liquid Limit (%)	39 - 46	42.5
Plastic Limit (%)	20 - 30	26.5
Plasticity Index (%)	9 - 24	17.5
Unit Weight (kN/cu.m)	16.5 - 19.1	18.1

From the plasticity chart, this deposit is classified as inorganic clayey silt to silty clay of intermediate plasticity.

Grain size distribution tests were carried out on these materials, the results of which are plotted in Figure 2. Due to varved nature of this deposit, the grain size distribution carried out on the samples, is not indicative of the high clay content.

Loam and Boulders

On the east side of the creek, a thin veneer of loam, about 40 cm thick at Boreholes 3 and 4, increasing to 1.2 m at Borehole 6, mixed with cobbles, boulders and rock fragments was evident, as it forms the surficial soils.

Sand

This deposit was encountered above the bedrock in Boreholes 1, 2, 5 and 7. In Borehole 7, a very loose alluvial deposit of sand, silt and clay, mixed with organics, lies above the sand deposit. The thickness of the sand stratum varies from 0.5 m to 1.1 m.

The 'N' values for this material range from 3 to 20 blows, indicating a state of compaction/density described as very loose to compact. The moisture content of the sand varies from 12 % to 24 %.

Typical grain size curves are given In Figure 3. The sand is generally described as fine to medium with trace of silt.

Bedrock

Bedrock was core drilled at the locations of Boreholes 2, 3 and 4. The bedrock is identified as coarse grained gneiss of metamorphic origin. The rock is generally strong to very strong in nature. In Borehole 2, a 60 cm long vertical fissure was filled with biotite.

Core recoveries were 100 %, and the R.Q.D. ranged from 63 % to 100 %. As a result, the quality of the rock is defined as fair to excellent.

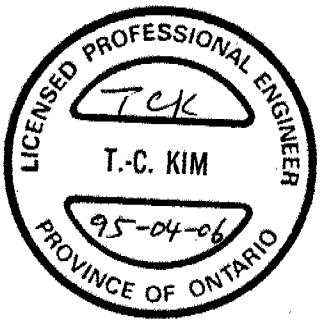
The bedrock dips down from east to west. On the east side of the creek, the bedrock is encountered at Elevation 314.5 m, dips to Elevation 312.3 m at Borehole 7, and further slopes to Elevations ranging from 309.0 m (BH 2), to 308.0 m (BH 1) along the west side of the bank. Cone tests were performed to determine the probable bedrock levels, in between the boreholes. The results of the cone tests (Boreholes 8 to 12) are given in the Appendix.

Groundwater Conditions

Observation of the groundwater level was carried out by measuring the water levels in the open boreholes. Groundwater is at creek level, i.e. Elevation 314.8 m. It should be noted, however, that the groundwater level is subject to changes with the fluctuations in the creek levels.

The project was carried out under the supervision of S. Bandukwala, P. Eng., Project Engineer. The report was prepared by S. Bandukwala, and reviewed by L.J. Rak, P. Eng., Principal Engineer.

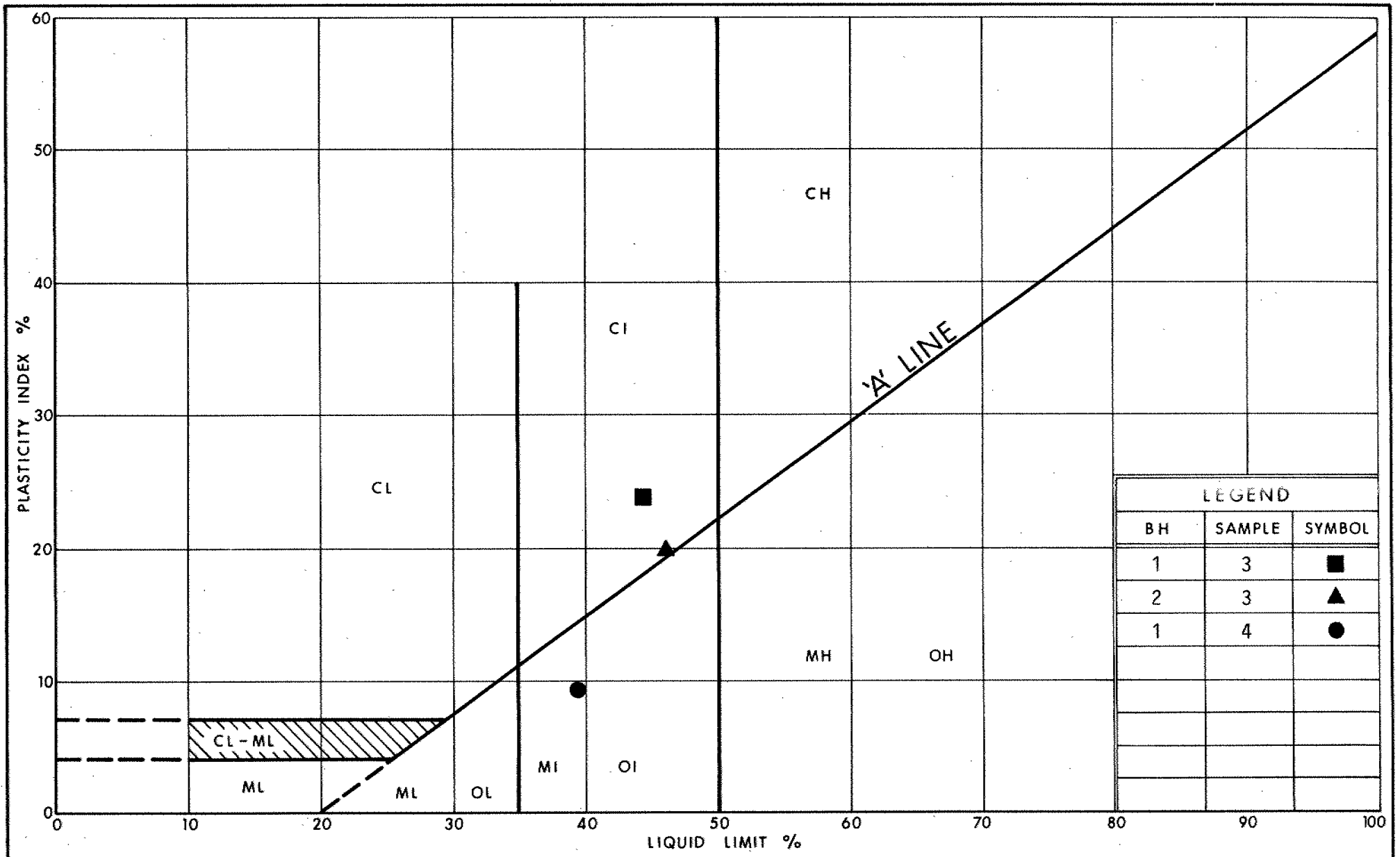
NOTE: **The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by McClymont & Rak Engineers Inc. (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.**



T. Kim, P. Eng.
Senior Foundation Engineer

APPENDIX

Oct 75, FF-S-21



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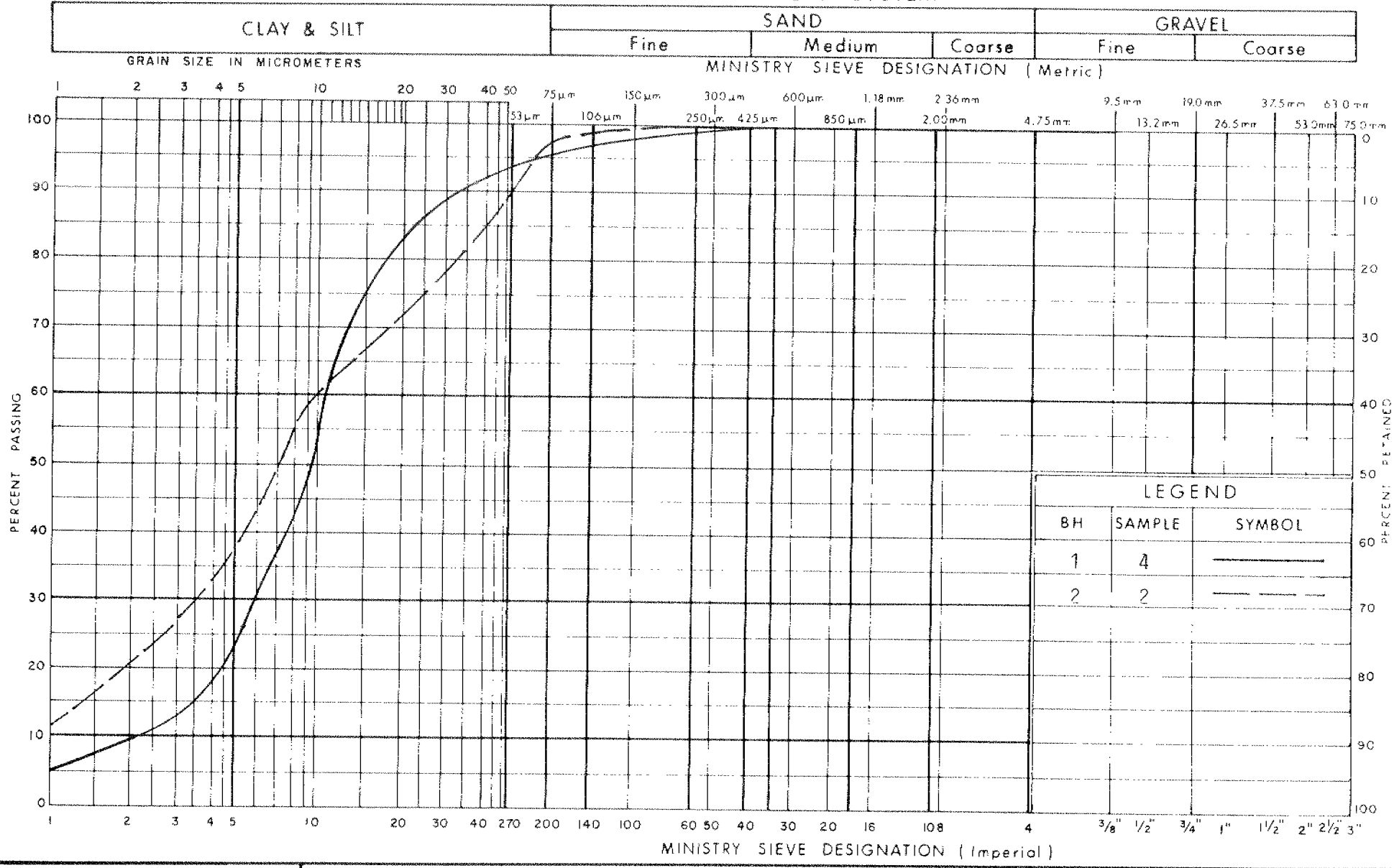
PLASTICITY CHART
CLAYEY SILT TO SILTY CLAY

FIG No 1
W P 89-88-01
6

UNIFIED SOIL CLASSIFICATION SYSTEM



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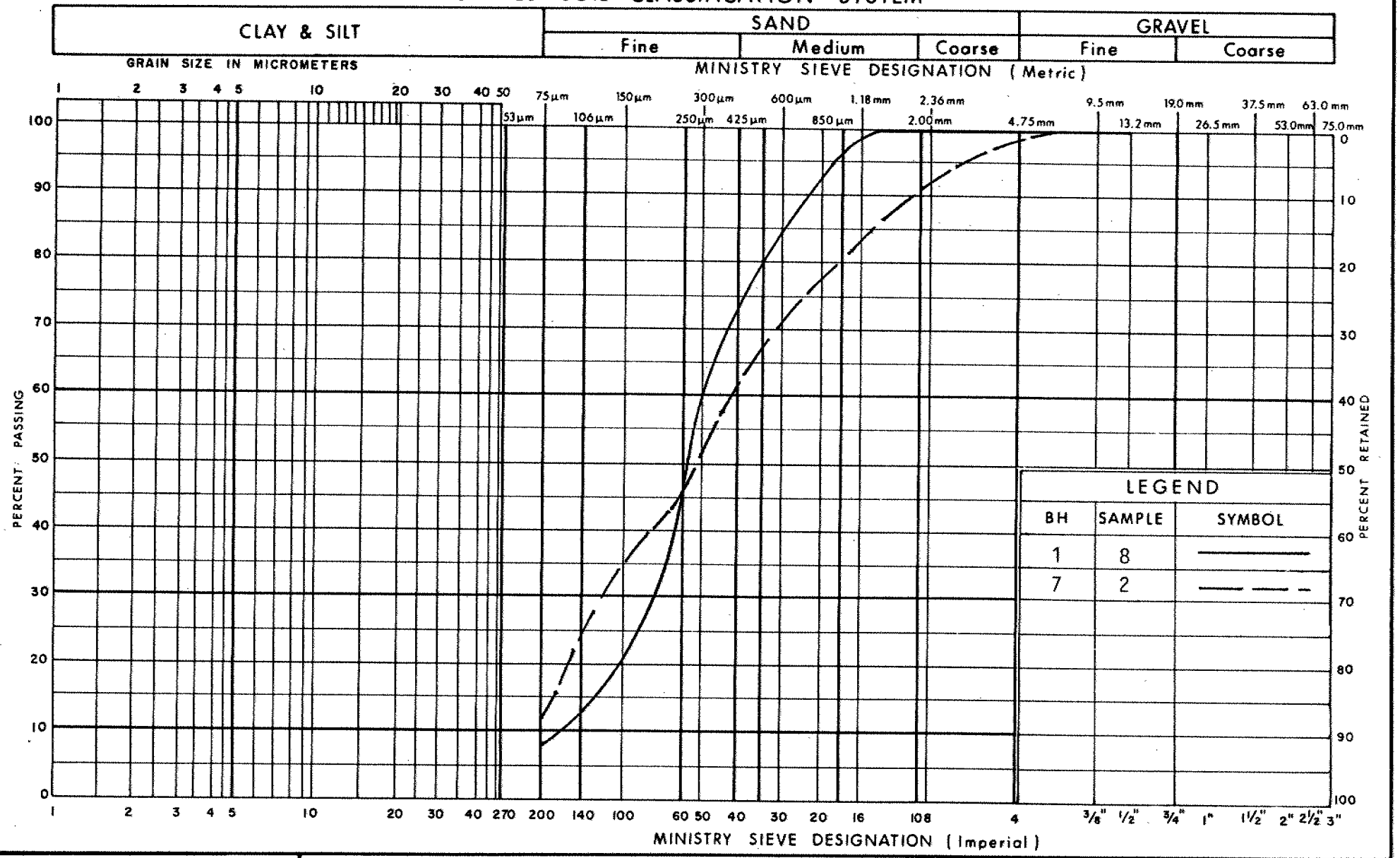
GRAIN SIZE DISTRIBUTION
CLAYEY SILT TO SILTY CLAY

FIG No 2
W P 89-88-01

10

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

SAND, TRACE TO SOME SILT

FIG No 3

W P 89-88-01

11

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RECORD OF BOREHOLE No 1 METRIC

W P 89-88-01 LOCATION Sta. 21+588.1 m, 5.0 m Lt of ℄ of Pro. Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SM

DATUM Geodetic DATE February 16, 1990 CHECKED BY SB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (50 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
315.0	Ground Surface										
0.0	Topsoil: 300 mm (frozen) SILTY CLAY TO CLAYEY SILT		1	SS	18	▼					
			2	SS	12		314		o	19.2	
	brown-grey / grey varved stiff to soft		3	TW	PM		313	× S=5.7 +	a	18.7	
			4	SS	4		312		o	19.1	0 3 88 9
			5	TW	PM		311				
			6	SS	2		310	+ S=2.5	o		
309.1			7	TW	PM			×	o	16.7	
5.9	SAND fine to medium, trace silt, grey, compact		8	SS	20		309		o		0 91 (9)
308.0	Probable bedrock @ 7 m		9	SS	50		308		o		
7.0	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 2 METRIC

W P 89-88-01 LOCATION Sta. 21+556.8 m, 5.0 m Rt of ℄ of Pro. Hwy 518 ORIGINATED BY SB
DIST 11 HWY 518 BOREHOLE TYPE Hollow Stem Auger and BXT Rock Cone COMPILED BY SM
DATUM Geodetic DATE February 14 and 15, 1990 CHECKED BY SB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 50 100	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.6	Ground Surface										
0.0	Topsoil: 200 mm										
	CLAYEY SILT TO SILTY CLAY varved, grey, firm						314				
			S	SS	3				○	18.5	
							313		○		
			S	SS	2					16.7	0 2 77 21
								+ S=7.5			
			3	SS	3		312		○	16.5	
								+ S=8.9			
			4	SS	6				○	18.8	
							311				
			5	SS	2				○	18.9	
310.0								+ S=8.3			
4.6	SAND fine to medium, grey, compact						310				
			6	SS	16				○		
309.0			7	SS	75				○		
5.6	GNEISS BEDROCK grey with pink feldspar, strong, coarse grained, vertical fissure filled with biotite, fair quality		8	RC BXT	REC 100%		309				RQD 63%
307.7							308				
6.9	End of Borehole										

*Creek level, 20cm above ground level, at elevation 314.8 m.

OFFICE REPORT ON SOIL EXPLORATION

+³, ×⁵ : Numbers refer to Sensitivity

15 ⟨ 20 / 10 ⟩ 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 3 METRIC

W P 89-88-01 LOCATION Sta. 21+573.6 m, 5.0 m Lt of ℄ of Pro. Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE BXT Rock Core COMPILED BY SM

DATUM Geodetic DATE February 19, 1990 CHECKED BY SB

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.9	Ground Surface										
0.0 314.5	Topsoil: 150 mm loam with fragments and boulders										
0.4	**GNEISS BEDROCK** biotite, coarse crystalline gneissic layering, grey with pink feldspax, some transparent quartz, strong to very strong, excellent quality		1	RC BXT	REC 100%		314				RQD 100%
			2	RC BXT	REC 100%		313				RQD 96.5%
			3	RC BXT	REC 100%		312				RQD 95.4%
310.8							311				
4.1	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 4 METRIC

W P 89-88-01 LOCATION Sta. 21+572.0 m, 5.0 m Rt of ℄ of Pro. Hwy 518 ORIGINATED BY SB
DIST 11 HWY 518 BOREHOLE TYPE BXT Rock Core COMPILED BY SM
DATUM Geodetic DATE February 20, 1990 CHECKED BY SB

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.9	Ground Surface										
0.0 314.5	Topsoil: 150 mm loam, boulders					▼					
0.4 313.0	GNEISS BEDROCK strong to very strong, fair quality		1	RC BXT	REC 100%		314 313				RQD 65%
1.9	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 5 METRIC

W P 89-88-01 LOCATION Sta. 21+547.8 m, ℄ of Proposed Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Hollow Stem Auger and BXT Rock Core COMPILED BY SM

DATUM Geodetic DATE February 19, 1990 CHECKED BY SB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (50 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
315.2	Ground Surface										
0.0	Topsoil (Silt with organics): 310 mm **CLAYEY SANDY SILT** roots, oxidized, yellow-grey, compact		1	SS	16		315		○		
313.8							314				
1.4	**CLAYEY SILT TO SILTY CLAY** varved, grey, stiff to firm		2	SS	4		313		○		
			3	SS	4		312		○		
			4	TW	PM		311	× + S=11.9			
310.5											
4.7	**SAND** fine to medium, grey, compact		5	CS			310		○		
310.0											
5.2	Probable bedrock @ 5.2m End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

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

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

Ministry of Transportation
Ontario

RECORD OF TEST-PIT No 6

METRIC

W P 89-88-01 LOCATION Sta. 21+581.6 m, ℄ of Proposed Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Test Pit by Backhoe COMPILED BY SM

DATUM Geodetic DATE February 14, 1990 CHECKED BY SB

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl / WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
315.6	Ground Surface										
0.0	Topsoil: 250 mm SANDY LOAM cobbles, boulders, rock fragments						315				
			1	CS					○		
314.4	Probable bedrock @ 1.2										
1.2	End of Test Pit										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 7

METRIC

W P 89-88-01 LOCATION Sta. 21+566.2 m, ℄ of Proposed Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Wash Boring from Raft COMPILED BY SM

DATUM Geodetic DATE February 21, 1990 CHECKED BY SB

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 50 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.1	Creek Bottom										
0.0	**ALLUVIAL SAND, SILT AND CLAY** wood pieces, organics, black-grey, very loose						314				
313.2											
0.9	**SAND** some silt, grey, very loose		1	SS	3		313		○		
312.3	Probable bedrock @ 1.8		2	SS	50				○		
1.8	End of Borehole										

*Creek level, 70 cm above ground level, at elevation 314.8 m.

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 8 METRIC

W P 89-88-01 LOCATION Sta. 21+557.2 m, ℄ of Proposed Hwy 518 ORIGINATED BY SB
DIST 11 HWY 518 BOREHOLE TYPE Cone Test COMPILED BY SM
DATUM Geodetic DATE February 19, 1990 CHECKED BY SB

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.5	Ground Surface										
0.0	Probable varved clayey silt to silty clay						314				
							313				
							312				
							311				
309.6							310				
4.9	Probable sand										
308.8	Probable bedrock						309				
5.7	End of Cone Test							(Rod bouncing)			

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20
15 ⊹ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9 METRIC

W P 89-88-01 LOCATION Sta. 21+566.2 m, 7.0 m Lt of ℄ of Pro. Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Cone Test COMPILED BY SM

DATUM Geodetic DATE February 21, 1990 CHECKED BY SB

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPo ○ UNCONFINED + 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
314.2	Creek Bottom										
0.0	Probable alluvial deposit (sandy, silt and clay) very loose to loose						314				
							313				
312.2	Probable bedrock										
2.0	End of Cone Test							(Rod bouncing)			

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 10 METRIC

W P 89-88-01 LOCATION Sta. 21+566.2 m, 7.0 m Rt of ℄ of Pro. Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Cone Test COMPILED BY SM

DATUM Geodetic DATE February 21, 1990 CHECKED BY SB

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.1	Creek Bottom										
0.0	Probable alluvial deposit (sand, silt and clay) very loose to loose						314				
							313				
312.0	Probable bedrock						312				
2.1	End of Cone Test							(Rod bouncing)			

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No II

METRIC

W P 89-88-01 LOCATION Sta. 21+562.2 m, ℄ of Proposed Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Cone Test COMPILED BY SM

DATUM Geodetic DATE February 21, 1990 CHECKED BY SB

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.3	Creek Bottom										
0.0	Probable alluvial deposit (sand, silt and clay)						314				
							313				
	Probable varved clayey to silty clay						312				
							311				
310.3											
4.0	Probable sand compact						310				
309.4	Probable bedrock										
4.9	End of Cone Test							(Rod bouncing)			

+3, ×5 ; Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 12 METRIC

W P 89-88-01 LOCATION Sta. 21+564.4 m, ℄ of Proposed Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Cone Test COMPILED BY SM

DATUM Geodetic DATE February 21, 1990 CHECKED BY SB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.3	Creek Bottom										
0.0	Probable alluvial deposit (sand, silt and clay)						314				
312.8							313				
1.5	Probable varved clayey silt to silty clay						312				
310.6							311				
3.7	Probable sand compact						310				
309.4	Probable bedrock										
4.9	End of Cone Test							(Rod bouncing)			

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

OFFICE REPORT ON SOIL EXPLORATION

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

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

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MC CLYMONT & RAK ENGINEERS, INC.

GEOTECHNICAL CONSULTANTS

C1110 MARCH 1990

FOUNDATION INVESTIGATION REPORT
FOR
CROSSING AT HIGHWAY 518 AND
BEAR CREEK
DISTRICT 11 HUNTSVILLE
W.P. 89-88-~~00~~ 01 SITE 44-139

CONT 95-220

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FOUNDATION INVESTIGATION REPORT
FOR
CROSSING AT HIGHWAY 518 AND
BEAR CREEK
DISTRICT 11 HUNTSVILLE
W.P. 89-88-00 SITE 44-139

INTRODUCTION

This report summarizes the results of a foundation investigation for the proposed crossing of Bear Creek at Highway 518. The investigation was carried out at the request of Foundation Design Section of the Ministry of Transportation, Ontario.

This report applies to structure foundations, approach embankments and related earthworks between Sta. 21 + 540 and Sta. 21 + 585. Beyond these limits, there still may be concerns regarding settlement of the subgrade due to the weight of the embankment fill. Reference is therefore made to the Regional Geotechnical Section for recommendations to ensure smooth transition.

SITE DESCRIPTION

The site is located at the crossing of Bear Creek and proposed Highway 518, about 21 meters south of the present structure on Highway 518, in District 11, Huntsville, Ontario.

The water from the Bear Lake flows into the creek in the northerly direction. At the time of the investigation, the water in the creek was about 0.7 m deep. The existing creek bed is about 13 meters wide, with a gentle slope rising out of the creek at the west and east banks. The banks are covered by heavy bush and some trees.

The existing creek crossing is a single span concrete bridge structure.

PROCEDURE

The field investigation was carried out between the period of February 14 to 21, 1990. The fieldwork consisted of drilling six boreholes, five cone tests and one test pit. The boreholes, on land, were advanced using a track mounted auger machine equipped with 83 mm I.D. hollow stem augers and B size casing. The boreholes, in water, were advanced using drill/casing assembly mounted on a raft. Three boreholes were further advanced in the bedrock, using BXT size core bits. Due to the presence of boulders at the surface, borehole 6 was excavated by a back-hoe.

Samples were recovered by means of a 50 mm O.D. split spoon sampler driven into the soil according to the specification of the Standard penetration Test (ASTM D 1587-8). In addition, relatively undisturbed samples were retrieved by 50 mm thin walled shelby tubes. Field vane tests were carried out in the stiff to soft cohesive deposits.

Laboratory testing was carried out on representative samples to identify and determine the physical properties of the overburden including:

- Natural moisture content
- Grain size distribution
- Atterberg Limit
- Unit Weight

The elevations of the boreholes were referenced to a local geodetic benchmark, provided by the MTO local office. (rock outcrop, north west bank of existing bridge, at Elevation 316.677 m).

SITE GEOLOGY AND SUBSURFACE CONDITIONS

Physiographically, the site lies in the area known as Georgian Bay Fringe, characterized by very shallow soils and bare rock knobs and ridges. The bare rock ridges are due partly to the fact that they were washed by the waves when glacial Lake Algonquin inundated this area.

The subsoil conditions are variable across the site, from the west to the east bank. The soils on the west side of the creek consist of firm to stiff varved clayey silt to silty clay, overlying compact sand which in turn overlies on Gneiss Bedrock. However, on the east side of the creek a layer of loam, with boulders, overlies the Gneiss bedrock at shallow depths.

The boundaries of the different strata, together with the field and laboratory test results, are presented on the Record of Borehole sheets appended to this report. Also refer to the drawing and borehole sheets for the locations and elevations of the boreholes. Stratigraphical sections of the subsurface conditions are shown on Drawing 898800-A. Detailed descriptions of the different strata are provided below.

Clayey Sandy Silt

This deposit occurs, below the topsoil, in Borehole 5. It is mottled in colour, with oxidized stains and roots, and in a moist state. The thickness of this stratum is about 1.3 m.

Clayey Silt to Silty Clay

This deposit was encountered on the west side of the creek, in Boreholes 1, 2 and 5. The deposit occurs as a surficial deposit in Boreholes 1 and 2, but is present below the clayey sandy silt layer in Borehole 5. This stratum is varved and ranges in thickness from 3.3 m to 5.9 m.

Undrained shear strength of the soil was determined both by in situ field vane tests and laboratory vane tests. The results are plotted on the Record of Borehole sheets in the Appendix and summarized as follows:

Undrained Shear Strength (kPa)	Range	Average	Sensitivity
Field Vane (8 tests)	18 - >80	51	2.5 - 11.9

Based on the above shear strength values, the consistency of this deposit ranges from stiff to soft. The sensitivity of the strata is, however, questionable, since very thin clay layers are prevalent within the more dominant silt strata, due to the varved nature of the deposit.

The results from the three Atterberg Limit test (Figure 1) performed on this material are summarized as follows:

Property	Range	Average
Natural Moisture Content (%)	37 - 57	44.5
Liquid Limit (%)	39 - 46	42.5
Plastic Limit (%)	20 - 30	26.5
Plasticity Index (%)	9 - 24	17.5
Unit Weight (kN/cu.m)	16.5 - 19.1	18.1

From the plasticity chart, this deposit is classified as inorganic clayey silt to silty clay of intermediate plasticity.

Grain size distribution tests were carried out on these materials, the results of which are plotted in Figure 2. Due to varved nature of this deposit, the grain size distribution carried out on the samples, is not indicative of the high clay content.

Loam and Boulders

On the east side of the creek, a thin veneer of loam, about 40 cm thick at Boreholes 3 and 4, increasing to 1.2 m at Borehole 6, mixed with cobbles, boulders and rock fragments was evident, as it forms the surficial soils.

Sand

This deposit was encountered above the bedrock in Boreholes 1, 2, 5 and 7. In Borehole 7, a very loose alluvial deposit of sand, silt and clay, mixed with organics, lies above the sand deposit. The thickness of the sand stratum varies from 0.5 m to 1.1 m.

The 'N' values for this material range from 3 to 20 blows, indicating a state of compaction/density described as very loose to compact. The moisture content of the sand varies from 12 % to 24 %.

Typical grain size curves are given In Figure 3. The sand is generally described as fine to medium with trace of silt.

Bedrock

Bedrock was core drilled at the locations of Boreholes 2, 3 and 4. The bedrock is identified as coarse grained gneiss of metamorphic origin. The rock is generally strong to very strong in nature. In Borehole 2, a 60 cm long vertical fissure was filled with biotite.

Core recoveries were 100 %, and the R.Q.D. ranged from 63 % to 100 %. As a result, the quality of the rock is defined as fair to excellent.

The bedrock dips down from east to west. On the east side of the creek, the bedrock is encountered at Elevation 314.5 m, dips to Elevation 312.3 m at Borehole 7, and further slopes to Elevations ranging from 309.0 m (BH 2), to 308.0 m (BH 1) along the west side of the bank. Cone tests were performed to determine the probable bedrock levels, in between the boreholes. The results of the cone tests (Boreholes 8 to 12) are given in the Appendix.

Groundwater Conditions

Observation of the groundwater level was carried out by measuring the water levels in the open boreholes. Groundwater is at creek level, i.e. Elevation 314.8 m. It should be noted, however, that the groundwater level is subject to changes with the fluctuations in the creek levels.

DISCUSSIONS AND RECOMMENDATIONS

It is proposed to upgrade the existing road to the current MTO standards. This requires a new crossing to the south of the exiting concrete bridge structure. At present, two alternative schemes are being considered:

1) 6.0 to 8.0 m concrete box culvert
2) 12.0 m single span bridge structure

The proposed profile grade, in the vicinity of the crossing, will be at approximate Elevation 317.7 m. The approach fills will thus have a maximum height of 3.5 m above the elevation of the creek bottom.

Based on the subsoil conditions, a box culvert, located at the east bank will be the most suitable structure from both cost, as well as, construction efficiency point of view. However, the foundation recommendations for the design of concrete box culvert, as well as, bridge structure are presented in the following text:

Structure Foundations for Concrete Culvert

The subsoil conditions at the west side of the creek are not favorable for supporting the foundations for the culvert, and therefore it is recommended that the structure be founded directly on the bedrock, and on the east side of the channel. This will, however, require a re-alignment of the creek bed, to the east of the existing location.

The underside of the culvert is expected to be at approximate Elevation 314.0 m. It should be noted that the bedrock at Borehole 7 (Sta. 21 + 566.2 m), is at Elevation 312.3 m and rises to Elevation 314.5 m at Boreholes 3 and 4 (east of Sta. 21 + 572 m). As a result, it is recommended that the proposed culvert be located to the east of Sta. 21 + 572 m.

If this is not possible, then the overlying alluvium, and the very loose sand, should be removed and replaced by compacted rock fill or mass concrete. Should mass concrete be considered, all soils overlying the bedrock should be removed.

Material	Bearing Capacity at S.L.S. Type II (kPa)	Factored Bearing Capacity at U.L.S. (kPa)
Gneiss Bedrock	*	10,000
Rock Fill	250	600
Mass Concrete	*	5,000

* - Design of shallow foundations will not be governed by settlements, since the load required to produce detrimental settlements will be much larger than factored capacity at ultimate limit state.

If the proposed culvert is partly founded on rock fill and partly on bedrock, it is recommended that the top 30 cm of the bedrock should be shattered, so uniform settlements can occur. In this case the bearing capacity of the bedrock should be reduced to 250 kPa and 600 kPa, for the S.L.S. and U.L.S. respectively.

Structure Foundations For Bridge Structure

It is unlikely that the bridge structure will be used for the crossing. However, the design parameters are provided for cost comparison purposes. As stated above, the overburden soils are not suitable for supporting any structure, and therefore about 5.0 m of clayey silt to silty clay, for the west abutment, must be removed and replaced by compacted rock fill. However, the east abutment can be founded on bedrock at anticipated founding levels. The bridge should be designed to accommodate differential settlements between the bedrock and rockfill.

The bearing capacities of the bedrock and rock fill are given in the preceding section. The rock fill should extend out at least 2.0 m from the footing edges in the plane of the footing tops. The slope of the rock fill is expected to be stable, when placed at 1.0 H to 1.0 V or flatter. The rock fill in the upper 1.0 m depth, below the footings, should be limited to 300 mm in size. It is recommended that the surface of the rockfill should be covered by a concrete slab, of low slump concrete, to provide a good working base.

The settlement of the rock fill is estimated to be about 1.0 percent of the height of the fill, i.e. about 5.0 cm. In order to minimize the amount of settlement it is recommended that the fill be placed at least 3 months prior to the construction of the abutments. Considerations can be given to rolling surcharge, 1.0 to 1.5 m high, in order to minimize the settlements and the time period prior to the construction of the abutments.

OTHER CONSIDERATIONS

Approach Fills

The height of fill required to achieve the proposed profile grade of Highway 518, in the vicinity of the structure, is in the order of 3.5 m. For the east approach area, removal of surficial topsoil, or organics, is required. However, for the west approach area, sub excavation of alluvial deposits, and very loose sand to 1.3 m depth at Borehole 7, and removal of firm clayey silt to 3.0 m depth at Borehole 2, will be required. This material should be removed within the plan limits of the approach embankments. The stations, and the depths, for sub-excavation for the west approach area are as follows:

Borehole No.	Station/offset	Sub-excavation (m) Depth	Elevation
5	21 + 547.8/C.L	0.4	314.8
2	21 + 556.8/5.0 m RT	3.0	311.6
1	21 + 588.1/5.0 m LT	0.3	314.7
7	21 + 566.2/C.L	1.3	312.8

The sub-excavated material should be replaced with rock fill or granular fill. Temporary excavations should be sloped at 2 H : 1 V or flatter.

Due to the varved nature of the underlying deposit, it is difficult to predict the total settlement. To minimize post construction settlements, it is recommended that the fill be placed at least 3 months prior to the construction of the approach slab.

No stability problems are anticipated for the proposed height of permanent embankment constructed to a 1.5 H to 1.0 V geometry.

Lateral earth pressure

Free draining granular material such as Granular 'A' or 'B' is recommended as appropriate backfill to the culvert or abutment walls to prevent hydrostatic pressure build-up.

Lateral earth pressures should be computed in accordance with Section 6.6.1.2 of the O.H.B.D.C. The design parameters are as follows:

	Granular A	Granular B	RockFill
Angle of Internal Friction (degrees)	35	30	35
Unit Weight (KN\cu.m.)	22.8	21.2	18.4

The earth pressure coefficient at rest is to be used in design, if the culvert structure is rigid and unyielding.

Dewatering

The proposed culvert, located east of Sta. 21 + 572 m, can be constructed in relatively dry conditions. However, within the proposed construction area, no major dewatering difficulties are anticipated due to the relatively low permeability of the cohesive deposits. Water entering into the excavations can be controlled by perimeter sumps and ditches. As an alternative, the base slab of the proposed culvert could be constructed by tremie concrete method.

Creek diversion

Depending on the location of the proposed structure, diversion of the creek may be required for construction of the structure/approach embankments. The required temporary creek diversion may be achieved by constructing earth dykes. The on site excavated cohesive soils, or a local borrow, could be utilized in dyke construction.

Alternatively, due to the relatively sharp turning radius of the proposed diversion, especially downstream of the proposed culvert location, a combination of earth dykes and corrugated steel culverts could be used. The selected contractor should, however, present a drawing showing the proposed temporary works.

Frost Protection

The footings require an equivalent of minimum of 1.8 m of soil cover for frost protection. The insulation value of rockfill is half of a soil cover. Alternatively, the culvert should be structurally designed to withstand frost pressures.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of S. Magdolen, Geologist. The equipment was owned and operated by Merleux Engineering, North Bay.

The project was carried out under the supervision of S. Bandukwala, P.Eng., Project Engineer. The report was prepared by S. Bandukwala, and reviewed by L.J. Rak, P.Eng., Principal Engineer.

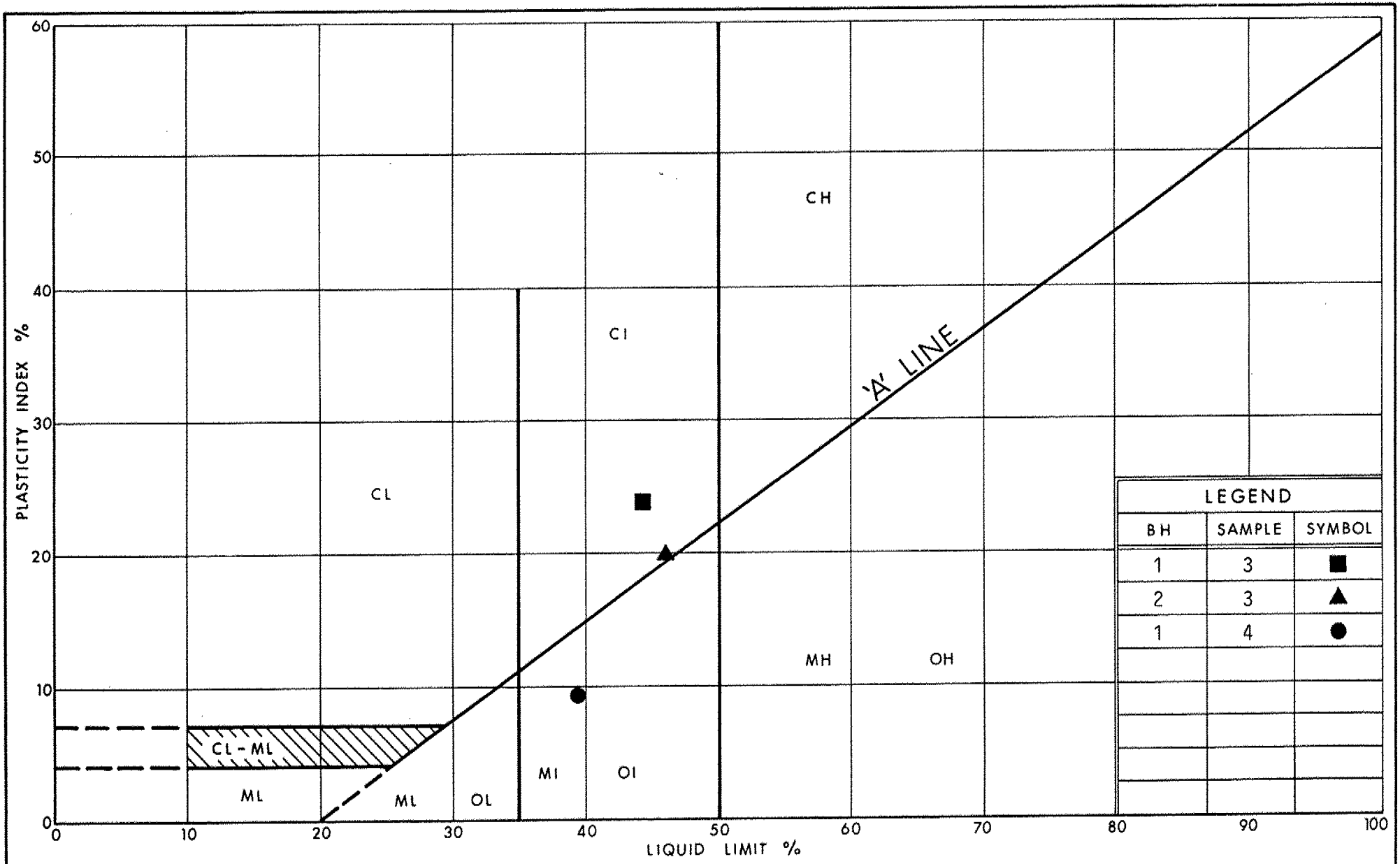
Submitted by

MCCLYMONT AND RAK ENGINEERS INC.

S. Bandukwala, M.Eng., P.Eng.

L.J. Rak, M.Eng., P.Eng.

Oct 75, FF-S-21



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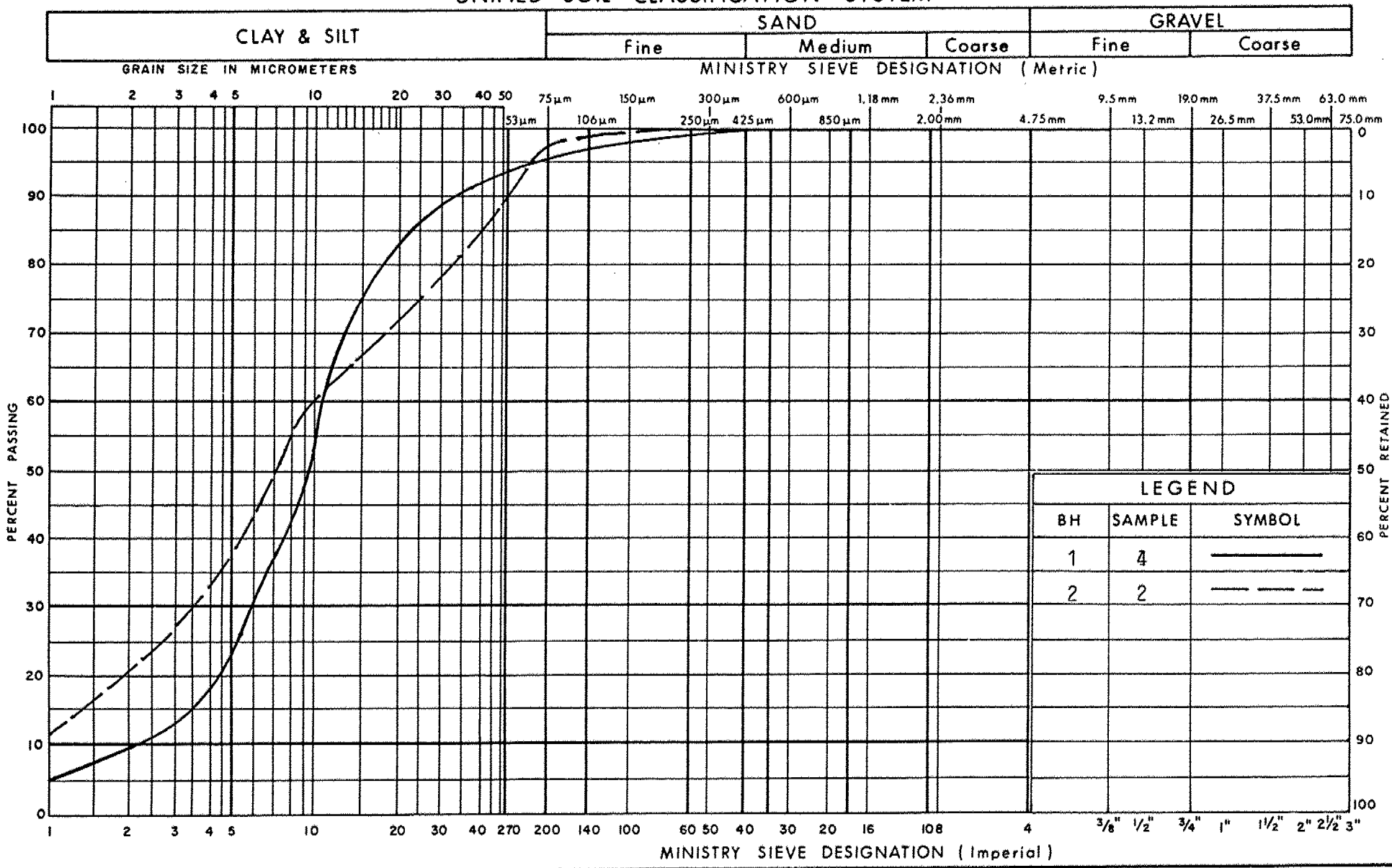
PLASTICITY CHART

FIG No 1
W P 89-88-00

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



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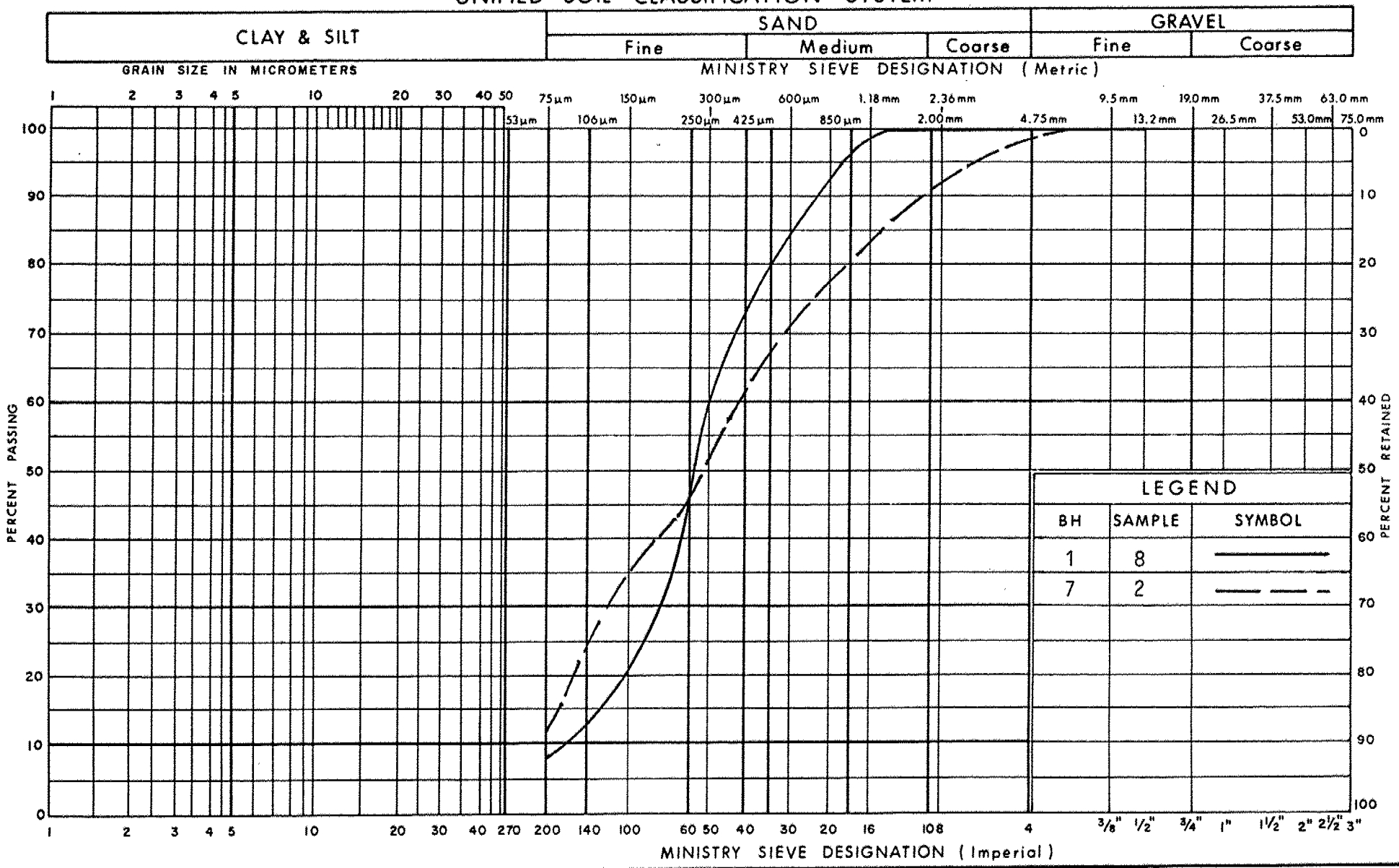
GRAIN SIZE DISTRIBUTION

FIG No 2

W P 89-88-00

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

FIG No 3

W P 89-88-00

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 1 — METRIC

W P 89-88-00 LOCATION Sta. 21+588.1 m, 5.0 m Lt of ℄ of Pro. Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SM

DATUM Geodetic DATE February 16, 1990 CHECKED BY SB

OFFICE REPORT ON SOIL EXPLORATION

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPo (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 50 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
315.0	Ground Surface										
0.0	Topsoil: 300 mm (frozen) SILTY CLAY TO CLAYEY SILT		1	SS	18	▼					
			2	SS	12		314			19.2	
	brown-grey / grey varved stiff to soft						313				
			3	TW	PM			S=5.7		18.7	
			4	SS	4		312			19.1	0 3 88 9
			5	TW	PM		311				
			6	SS	2		310	S=2.5			
309.1			7	TW	PM					16.7	
5.9	SAND fine to medium, trace silt, grey, compact		8	SS	20		309				0 91 (9)
308.0	Probable bedrock @ 7 m		9	SS	50		308				
7.0	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 2 METRIC

W P 89-88-00 LOCATION Sta. 21+556.8 m, 5.0 m Rt of ℄ of Pro. Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Hollow Stem Auger and BXT Rock Cone COMPILED BY SM

DATUM Geodetic DATE February 14 and 15, 1990 CHECKED BY SB

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 50 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.6	Ground Surface										
0.0	Topsoil: 200 mm										
	CLAYEY SILT TO SILTY CLAY varved, grey, firm		S	SS	3		314		○	18.5	
			S	SS	2		313	+ S=7.5	○	16.7	0 2 77 21
			3	SS	3		312	+ S=8.9	○	16.5	
			4	SS	6		311		○	18.8	
			5	SS	2			+ S=8.3	○	18.9	
310.0							310				
4.6	SAND fine to medium, grey, compact		6	SS	16				○		
309.0			7	SS	75		309		○		
5.6	GNEISS BEDROCK grey with pink feldspar, strong, coarse grained, vertical fissure filled with biotite, fair quality		8	RC BXT	REC 100%						RQD 63%
307.7							308				
6.9	End of Borehole *Creek level, 20cm above ground level, at elevation 314.8 m.										

OFFICE REPORT ON SOIL EXPLORATION

+³, ×⁵ : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 3 METRIC

W P 89-88-00 LOCATION Sta. 21+573.6 m, 5.0 m Lt of ℄ of Pro. Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE BXT Rock Core COMPILED BY SM

DATUM Geodetic DATE February 19, 1990 CHECKED BY SB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.9	Ground Surface										
0.0 314.5	Topsoil: 150 mm loam with fragments and boulders										
0.4	GNEISS BEDROCK biotite, coarse crystalline gneissic layering, grey with pink feldspax, some transparent quartz, strong to very strong, excellent quality		1	RC BXT	REC 100%		314				RQD 100%
			2	RC BXT	REC 100%		313				RQD 96.5%
			3	RC BXT	REC 100%		312				RQD 95.4%
310.8							311				
4.1	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 4 METRIC

W P 89-88-00 LOCATION Sta. 21+572.0 m, 5.0 m Rt of ℄ of Pro. Hwy 518 ORIGINATED BY SB
DIST 11 HWY 518 BOREHOLE TYPE BXT Rock Core COMPILED BY SM
DATUM Geodetic DATE February 20, 1990 CHECKED BY SB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.9	Ground Surface										
0.0 314.5	Topsoil: 150 mm loam, boulders					▼					
0.4	GNEISS BEDROCK strong to very strong, fair quality		1	RC BXT	REC 100%		314				RQD 65%
313.0							313				
1.9	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 5

METRIC

W P 89-88-00 LOCATION Sta. 21+547.8 m, ℄ of Proposed Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Hollow Stem Auger and BXT Rock Core COMPILED BY SM

DATUM Geodetic DATE February 19, 1990 CHECKED BY SB

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPo (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 50 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
315.2	Ground Surface						315				
0.0	Topsoil (Silt with organics): 310 mm CLAYEY SANDY SILT roots, oxidized, yellow-grey, compact		1	SS	16				○		
313.8							314				
1.4	CLAYEY SILT TO SILTY CLAY varved, grey, stiff to firm		2	SS	4					○	
							313	+			
			3	SS	4		312		○		
			4	TW	PH		311	× + S=11.9			
310.5											
4.7	SAND fine to medium, grey, compact		5	CS					○		
310.0							310				
5.2	Probable bedrock @ 5.2 End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

RECORD OF TEST-PIT No 6

METRIC

W P 89-88-00 LOCATION Sta. 21+581.6 m, ℄ of Proposed Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Test Pit by Backhoe COMPILED BY SM

DATUM Geodetic DATE February 14, 1990 CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT N (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl; WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
315.6	Ground Surface										
0.0	Topsoil: 250 mm SANDY LOAM cobbles, boulders, rock fragments		1	GS			315		○		
314.4	Probable bedrock @ 1.2										
1.2	End of Test Pit										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 7 METRIC

W P 89-88-00 LOCATION Sta. 21+566.2 m, ℄ of Proposed Hwy 518 ORIGINATED BY SB
DIST 11 HWY 518 BOREHOLE TYPE Wash Boring from Raft COMPILED BY SM
DATUM Geodetic DATE February 21, 1990 CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 50 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl / WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
314.1	Creek Bottom										
0.0	ALLUVIAL SAND, SILT AND CLAY wood pieces, organics, black-grey,						314				
313.2	very loose										
0.9	SAND some silt, grey, very loose		1	SS	3		313		○		
312.3	Probable bedrock @ 1.8		2	SS	50				○		
1.8	End of Borehole										

*Creek level, 70 cm above ground level, at elevation 314.8 m.

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 8 METRIC

W P 89-88-00 LOCATION Sta. 21+557.2 m, ℄ of Proposed Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Cone Test COMPILED BY SM

DATUM Geodetic DATE February 19, 1990 CHECKED BY SB

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT W_p NATURAL MOISTURE CONTENT W LIQUID LIMIT W_l WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
314.5	Ground Surface										
0.0	Probable varved clayey silt to silty clay						314				
							313				
							312				
							311				
							310				
309.6											
4.9	Probable sand										
308.8	Probable bedrock						309				
5.7	End of Cone Test							(Rod bouncing)			

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 9 METRIC

W P 89-88-00 LOCATION Sta. 21+566.2 m, 7.0 m Lt of ℄ of Pro. Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Cone Test COMPILED BY SM

DATUM Geodetic DATE February 21, 1990 CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
314.2	Creek Bottom										
0.0	Probable alluvial deposit (sandy, silt and clay) very loose to loose						314				
							313				
312.2	Probable bedrock										
2.0	End of Cone Test							(Rod bouncing)			

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 10 METRIC

W P 89-88-00 LOCATION Sta. 21+566.2 m, 7.0 m Rt of ℄ of Pro. Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Cone Test COMPILED BY SM

DATUM Geodetic DATE February 21, 1990 CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPo: o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
314.1	Creek Bottom										
0.0	Probable alluvial deposit (sand, silt and clay) very loose to loose						314				
							313				
312.0	Probable bedrock						312				
2.1	End of Cone Test							(Rod bouncing)			

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No II

METRIC

W P 89-88-00 LOCATION Sta. 21+562.2 m, ℄ of Proposed Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Cone Test COMPILED BY SM

DATUM Geodetic DATE February 21, 1990 CHECKED BY SB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT Wp / 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 SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	WATER CONTENT (%)		GR SA SI CL
314.3	Creek Bottom										
0.0	Probable alluvial deposit (sand, silt and clay)						314				
							313				
	Probable varved clayey to silty clay						312				
							311				
310.3											
4.0	Probable sand compact						310				
309.4	Probable bedrock										
4.9	End of Cone Test							(Rod bouncing)			

OFFICE REPORT ON SOIL EXPLORATION

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

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 12

METRIC

W P 89-88-00 LOCATION Sta. 21+564.4 m, ℄ of Proposed Hwy 518 ORIGINATED BY SB

DIST 11 HWY 518 BOREHOLE TYPE Cone Test COMPILED BY SM

DATUM Geodetic DATE February 21, 1990 CHECKED BY SB

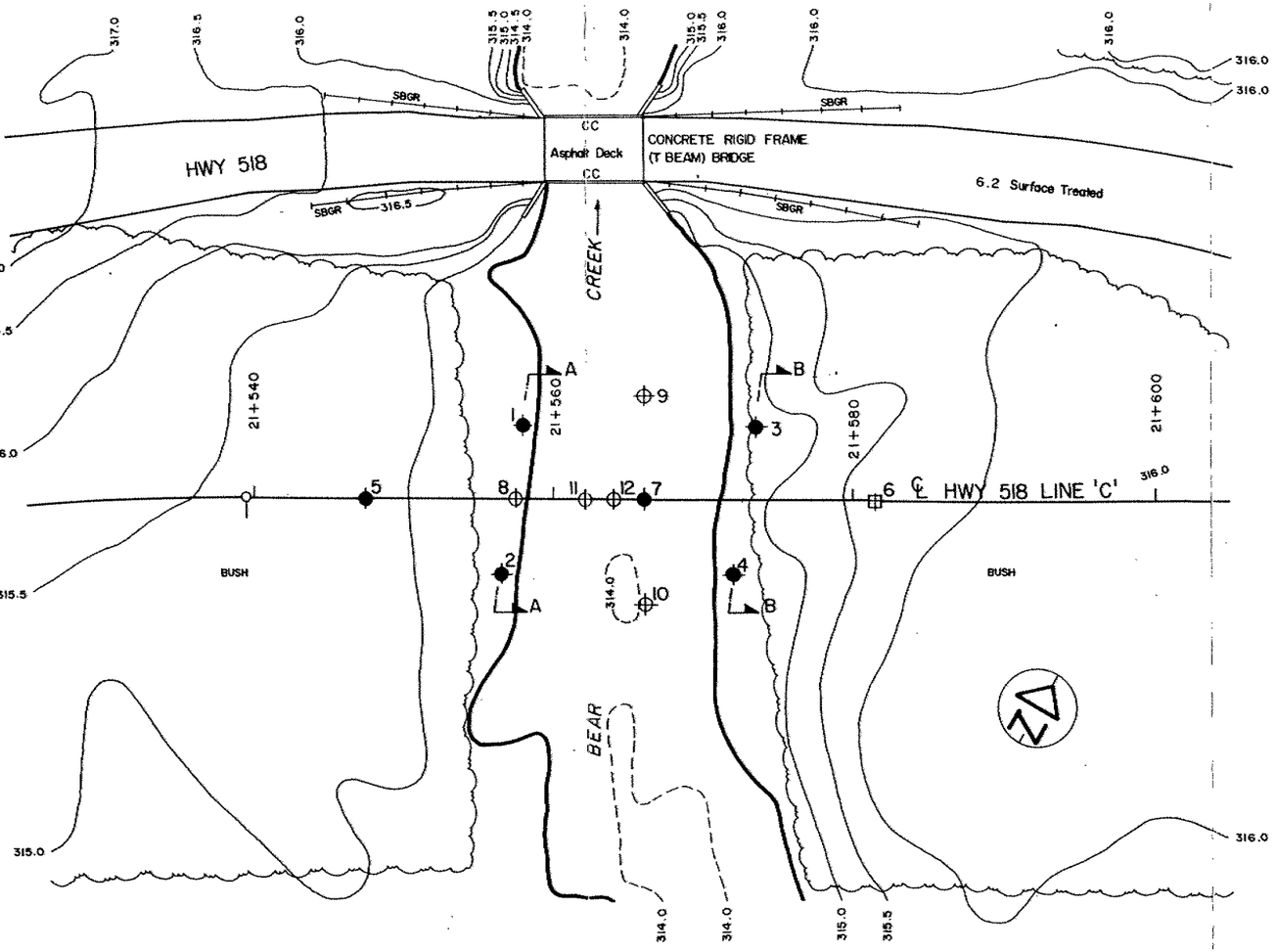
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPa: o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
314.3	Creek Bottom										
0.0	Probable alluvial deposit (sand, silt and clay)						314				
312.8							313				
1.5	Probable varved clayey silt to silty clay						312				
310.6							311				
3.7	Probable sand compact						310				
309.4	Probable bedrock										
4.9	End of Cone Test							(Rod bouncing)			

OFFICE REPORT ON SOIL EXPLORATION

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

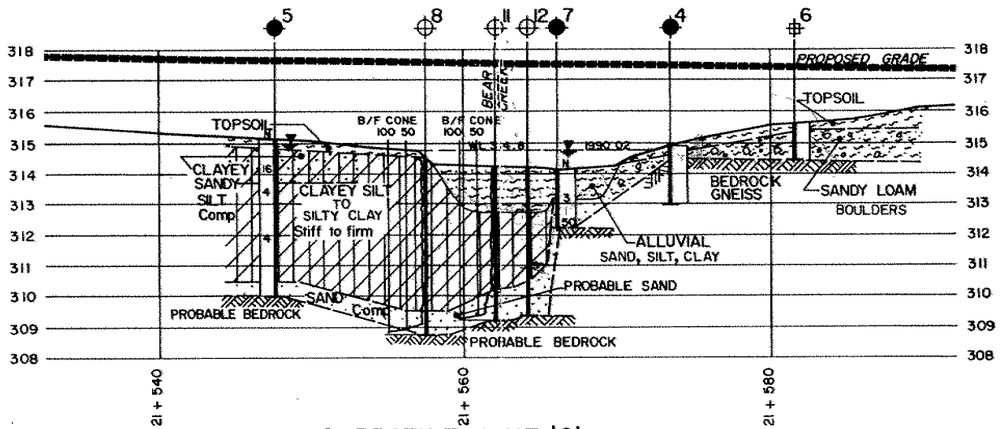
20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

MINISTRY OF TRANSPORTATION, ONTARIO PH-0-207 88.10



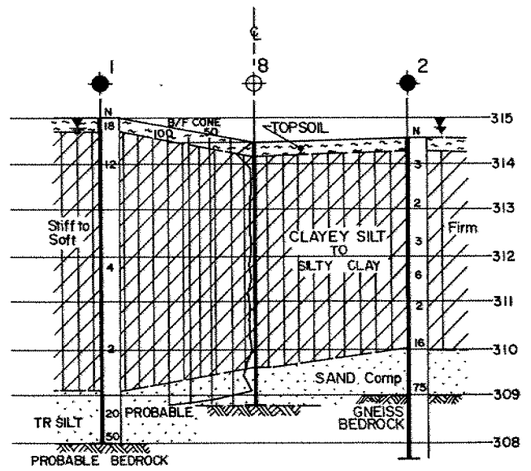
PLAN

SCALE 5m 0 5m



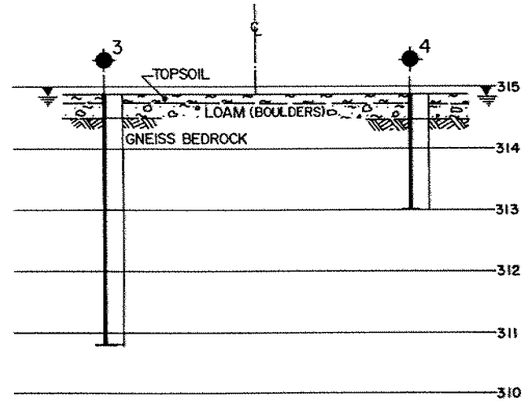
℄ PROFILE LINE 'C'

SCALE 5m 0 5m



SECTION A–A

SCALE 5m 0 5m



SECTION B–B

SCALE 5m 0 5m

METRIC

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

CONT No

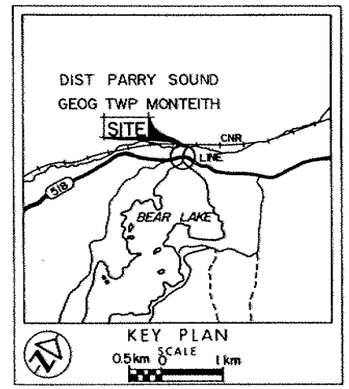
WP No 89-88-00

BEAR CREEK

BORE HOLE LOCATIONS & SOIL STRATA

SHEET

MC CLYMONT & RAK ENGINEERS, 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 Feb 1990
- Test Pit

No	ELEVATION	STATION	OFFSET
1	315.0	21 + 588.1	5.0m LT
2	314.6	21 + 556.8	5.0m RT
3	314.9	21 + 573.6	5.0m LT
4	314.9	21 + 572.0	5.0m RT
5	315.2	21 + 547.8	℄
6	315.6	21 + 581.6	℄
7	314.1	21 + 566.2	℄
8	314.5	21 + 557.2	℄
9	314.2	21 + 566.2	7.0m LT
10	314.1	21 + 566.2	7.0m RT
11	314.3	21 + 562.2	℄
12	314.3	21 + 564.4	℄

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 31E-105

HWY No 518			DIST 11
SUBM'D	CHECKED	DATE MAR 7 1990	SITE 44-139
DRAWN	CHECKED	APPROVED	DWG 898800

REF No E-1086-518-1 1989/05

memorandum

Ontario

To: P. Furst, P. Eng.
Head, Structural Section
Northern Region

Date: 95 04 27

Attn: P. Stuart, P. Eng.

From: Pavements and Foundations Section
Room 315, Central Building

Tel: (416)235-3731
Fax: (416)235-5240

Subject: Hwy 518
W.P. 89-88-00, Site No. 44-139
Crossing at Bear Creek
District 52, Huntsville

We refer to your memorandum dated 95 04 19. Items 2,3 and 5 are noted. Regarding item 1, you have indicated 'Excavation of alluvial soil will be to firm bottom with the actual limits determined in the field'. We still have concerns on specifying excavation of alluvial soils. According to the consultant's foundation report, alluvial deposit was found in only half of a sample and the rest of the subsurface profile on alluvial soils was apparently based on speculations from dynamic cone test results. To remove soft material to firm bottom, excavation may have to be taken down to El. 311 $\pm$m according to BHs 11 and 12. If no or very little alluvial material is encountered during construction and excavation is taken down to firm bottom at great depths, this may lead us into a claim situation since there are major variations in the contract. In our opinion, it is more advisable to specify a partial excavation elevation, say El. 312.8 m. There will still be some soft silty clay left but as you have indicated, this is a low volume highway and some settlements are tolerable and can be rectified by subsequent maintenance works.

David Kwok, P. Eng.
Project Foundation Engineer
for
Tae Kim, P. Eng.
Senior Foundation Engineer

c.c. A. Devolin

Ministry of Transportation
Ontario

m e m o r a n d u m

April 19, 1995

To: Tae C. Kim, P. Eng.
Senior Foundation Engineer
Pavements & Foundations
Downsview

From: Structural Section
Northern Region

Subject: Bear Lake Culvert, W.P. 89-88-00
Site 44-139, Highway No. 518

In response to your letter on this project, I make the following response. A copy of the contract package was sent to the Pavement and Foundation Section (see attached invoice). It may have been reviewed by one of your predecessors or lost in the section when one of the changes in responsibilities was made. Comments on specific points in your letter follows:

1. Excavation of alluvial soil will be to firm bottom with the actual limits determined in the field.

2. We recognized the possibility of excessive settlement west of the culvert. Environmental constraints make it impossible to schedule a significant preload period. Our rational was that this was a low volume surface treated road. If settlement was excessive we would repair the following summer by fine grading and applying new surface treatment.

3. The contract shows the approach fill as earth and references the OPSD 200 series which defines the slopes as 2 to 1.

5. You have the original for the soil stratigraphy drawing.

Peter Stuart, P. Eng.
Structural Engineer

cc A. Devolin
PS/pk

memorandum

Ontario

To: P. Furst, P. Eng.
Head, Structural Section
Northern Region

Date: 95 04 10

Attn: P. Stuart, P. Eng.

From: Pavements and Foundations Section
Room 315, Central Building

Tel: (416)235-3731
Fax: (416)235-5240

Subject: Hwy 518
W.P. 89-88-00, Site No. 44-139
Crossing at Bear Creek
District 52, Huntsville

We have recently been asked by Contract Management Office to prepare some contract document for the above project. Our records indicate that we have not done any drawing review on this project (preliminary or final). We have therefore obtained a set of drawings from CMO and based on our review, we have the following comments:

1. Typical Sections on sheet 2 indicate subexcavation of alluvial deposits. Taking a close look at the subsoil investigation data, it appears that the boundary between alluvial deposits and the underlying subsoils is 'guestimated' based on cone tests from BHs 8 to 12. There is only half a sample in BH 7 that contains alluvial materials. Due to the lack of data to properly define the extent of the deposit, it is recommended to specify the scope of excavation in terms of elevations. Bottom of the excavation should be taken down to elevation 312.8 $\pm$m. The extent of the excavation in cross-section should be defined by a 1H:1V excavation slope that extends from the bottom of excavation to the existing ground surface.

2. With the culvert sitting on bedrock, the above subexcavation between Sta. 21+555 to 21+570 and no excavation further west, there will be some differential settlements between the west approach and the structure. The current recommended subexcavation will serve as a transition zone. However, to minimize the differential settlements, it is recommended that the west approach be constructed at an early stage of the construction and preloaded for as long as possible prior to construction of the approach slab and the final paving. For the east approach, removal of surficial organic materials is required prior to placement of fill.

3. Rock fill slopes can be constructed to 1.5H:1V. For earth fill, 2H:1V slopes are recommended. The proposed slope geometry should be indicated in the typical sections. A 300 mm thick Granular 'A' layer can be used to replace the geotextile

behind the rip-rap as a filter. There are concerns on the long term performance of the geotextile and the possibility of it forming a potential slip surface.

4. No major dewatering measure is required for the construction of the culvert. The existing overburden is generally of low permeability and water in the excavation can be removed by conventional sump pumping. However, in view that the water level in the creek is close to the excavation level and in case that there is excessive flow into the excavation, a cohesive lining can be constructed on the west side using on site clayey material to minimize the seepage. Alternatively, tremie concrete can be used for under water concreting.

5. The drawing that shows the subsoil stratigraphy is not available for comments. Please send this drawing together with the final drawings for review when the above required amendments are made.

Taechul Kim

Tae Kim, P. Eng.
Senior Foundation Engineer

memorandum

Ontario

To: P. Furst
Head, Structural Section
Northern Region

Date: 1990 03 23

Atten: P. Stuart

From: Foundation Design Section
Room 315, Central Building

Re: Foundation Investigation and Design Report For
Bear Creek Structure
W.P. 89-88-00, Site 44-139
Hwy. 518, District 11, Huntsville

The Foundation Design Section retained McClymont and Rak Engineering Inc., consulting geotechnical engineers, to carry out a foundation investigation for the above-noted project. The Foundation Investigation and Design Report is forwarded under cover of this memo.

After preparing the consultant agreement, this office provided technical supervision including the establishment of terms of reference and careful review of the consultant's proposals and progress at all stages of the project. Several meetings were held with the consultant during which our comments were incorporated into his report. The Foundation Investigation (factual) portion of the report was reviewed only for format, and its accuracy and completeness are the responsibility of the consultant. The Foundation Design (recommendation) portion of the report has been carefully reviewed by this office based on the subsurface information provided by the consultant.

The following comments supersede the Foundation Investigation and Design Report:

1) Regarding 'Structure Foundtions for Bridge Structure' on Page 7, rock fills should be 1.5 H:1V or flatter above the ground surface. Rock fill below the ground surface may be as steep as practical.

2) Regarding 'Approach Fills' on pages 6 and 7 it is understood that this is a secondary road and that minor settlements can be tolerated. In this case the approach fills should be constructed directly on top of the existing ground surface. Total settlements may be up to 0.3 m, but over half of this should occur during the preload. If no settlement can be tolerated, the overburden under the plan limits of the fill should be subexcavated to bedrock.

3) Regarding 'Lateral Earth Pressure' on Page 7, rock fill may be used as backfill to structures. Also the active earth pressure coeffient will apply if the structures are yielding. If the structures are unyielding the at-rest earth pressure coefficient will apply.

If there are any questions regarding the report or during the design please contact this office.

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

for

M. Devata, P. Eng.
Chief Foundation Engineer

DD/mmj

Distribution

c.c. - P. Furst (2)
J. McDougall
K. Williams
S. Wilson (2)
K. Bassi
S. Dunham
G. Szekreny
File

AUG. 1989

BEAR LAKE BRIDGE 44-139

HWY 518

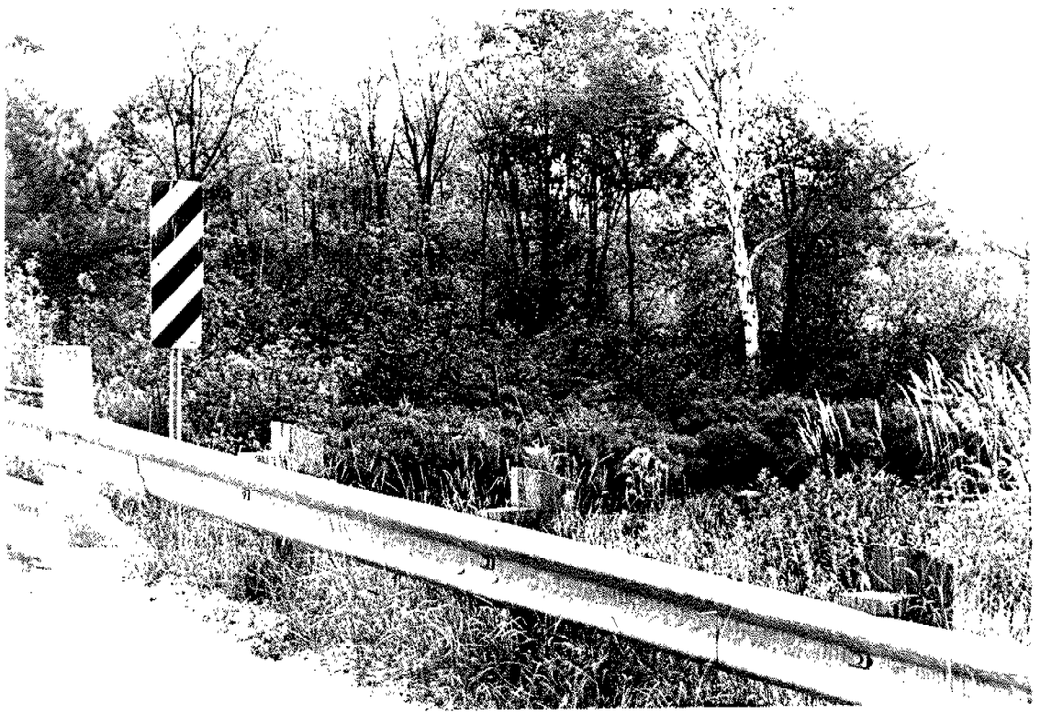
℄ LOOKING E

℄ LOOKING W

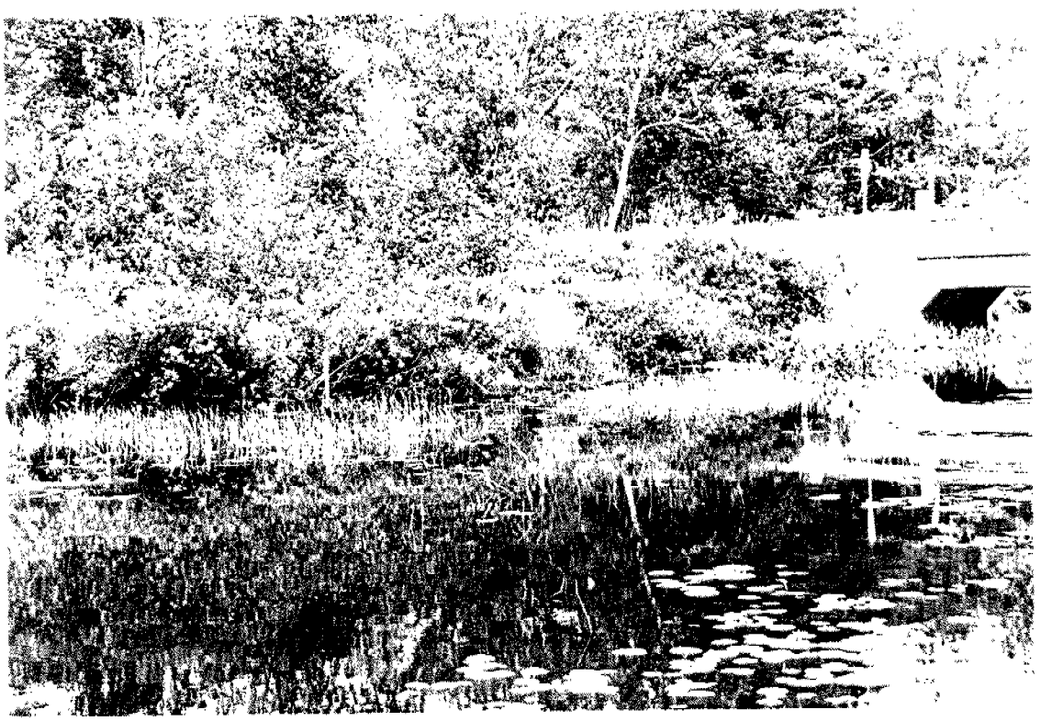
AUG. 1989

BEAR LAKE BRIDGE 44-139

HWY. 518



E. SHORE

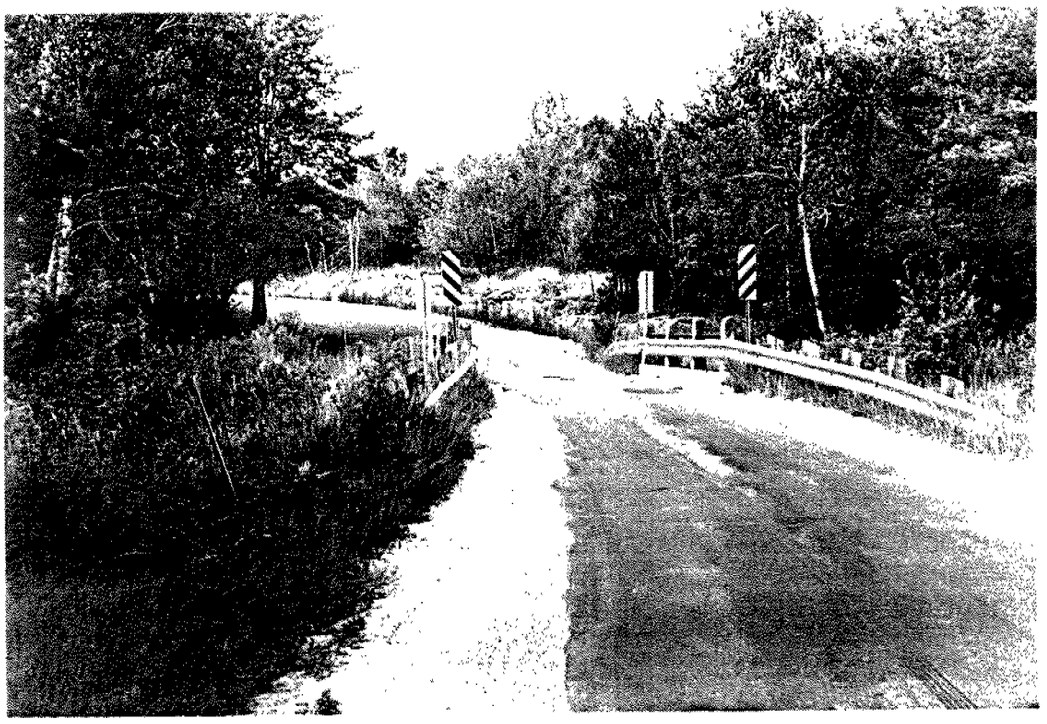


W. SHORE

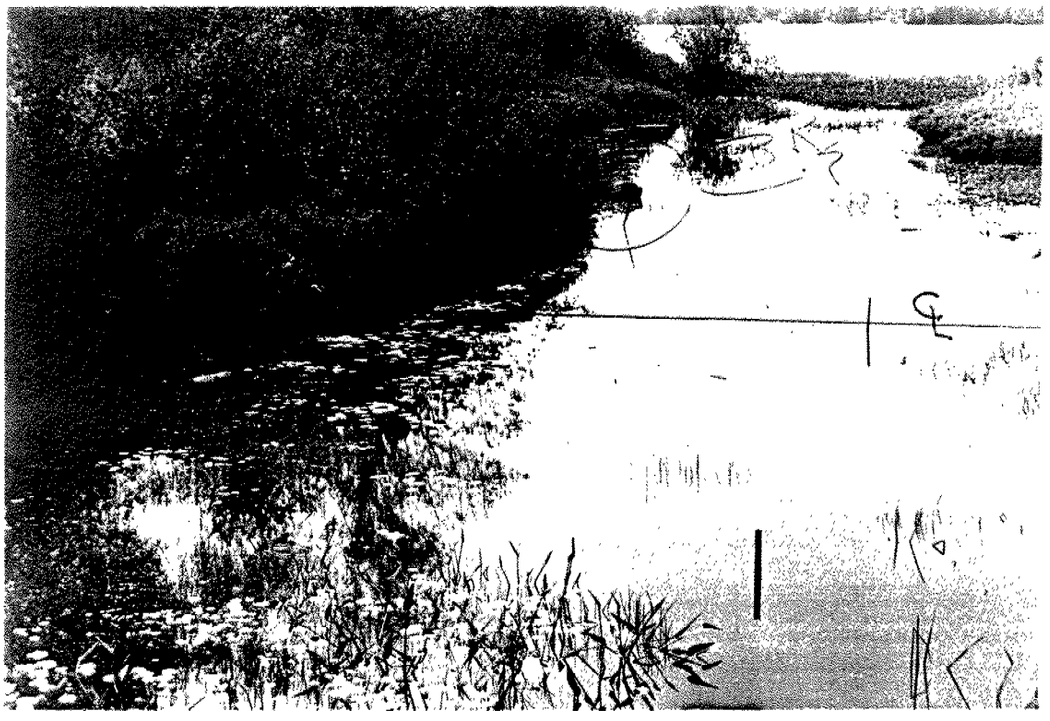
AUG. 1989

BEAR LAKE BRIDGE 44-139

HWY. 518



EXIST. BRIDGE



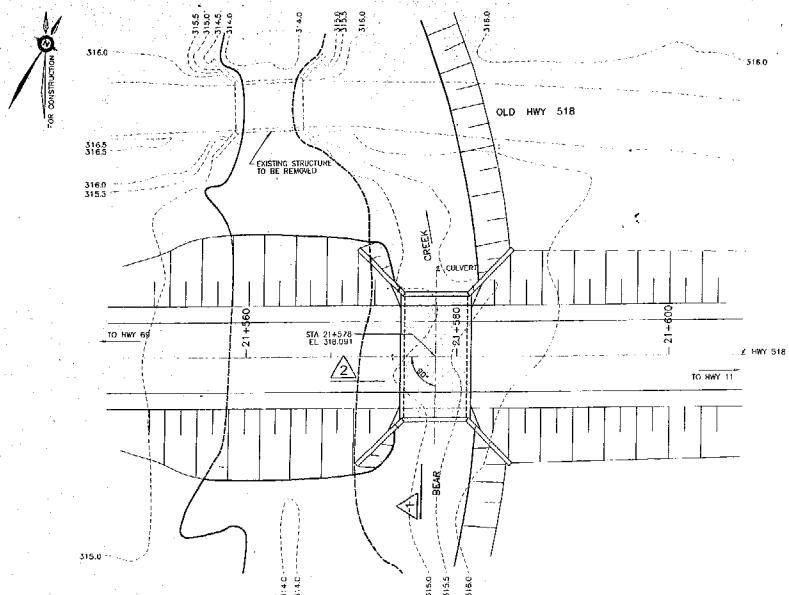
NEW ℄ from Existing Bridge

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DIST 11 HWY 518
CONT No ~~94-230~~ 93-220
WP No 89-88-01

BEAR LAKE CULVERT
GENERAL ARRANGEMENT

SHEET 15



PLAN
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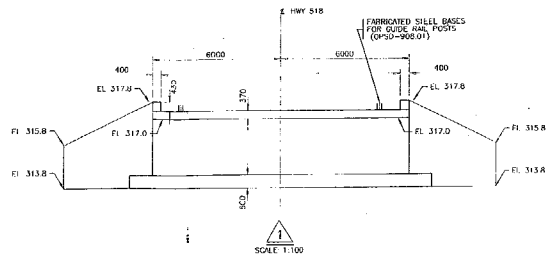

1
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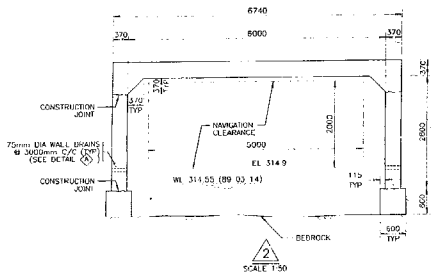
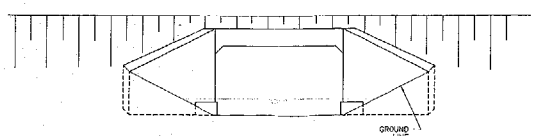
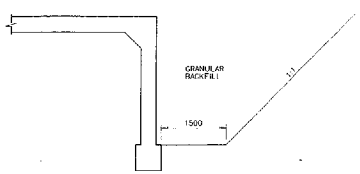


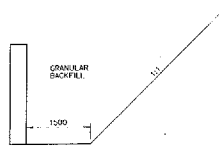
2
SCALE 1:50



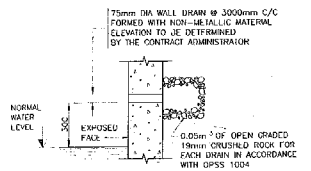
ELEVATION
SCALE 1:100



BACKFILL FOR CULVERT



BACKFILL FOR WINGWALL



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GENERAL NOTES

CLASS OF CONCRETE

ALL CONCRETE ..... 30 MPa

CLEAR COVER TO REINFORCING STEEL

FOOTINGS ..... 100±25
BOTTOM OF TOP SLAB ..... 50±10
REMAINDER ..... 70±20
(UNLESS OTHERWISE NOTED)

REINFORCING STEEL

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

CONSTRUCTION NOTES

- BACKFILL SHALL BE PLACED AT BOTH SIDES OF THE CULVERT SIMULTANEOUSLY KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME THE DIFFERENCE IN ELEVATION BE GREATER THAN 500 mm.
- WALL DRAIN OPENING SHALL BE FORMED USING NON-METALLIC MATERIAL. THE VERTICAL LOCATION OF WALL DRAINS SHALL BE VERIFIED IN THE FIELD BY THE CONTRACT ADMINISTRATOR.

LIST OF DRAWINGS

APPLICABLE STANDARD DRAWINGS

OPSD-3922.00 SUPPORTS FOR BOTTOM REINFORCING STEEL

MTC BM 788068 EL 316.677
TABLET SET VERTICALLY IN ROCK
40.8 LT 21+544.4 ROUTE 171

P.J.STUART
LICENCE OF OFFICE
7/11/94

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DESCRIPTION				
DESIGN P.S.	CHK	CODE OHBDC83	LOAD CL. A	DATE	JAN,1994
DRAWN V.Z.	CHK	SITE 44-139	STRUCT	SCHEME	DWG 1