DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 31F-104

DIST. 9 REGION

W.P. No. 3-80-01

CONT. No.

W. O. No.

STR. SITE No.

HWY. No. 60

LOCATION CULVERT REPLACEMENT AT BROWNS CREEK

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FILE COPY

Ontario

Ministry of
Transportation and
Communications

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 3-80-01 DIST 9

HWY 60 STR SITE

Brown's Creek Culvert Replacement

DISTRIBUTION

T. C. Kingsland (2)
T. W. Murphy
J. W. Reid
M. J. Bernhardt
K. G. Bassi
J. H. Peer
R. Hore (M.O.E.)
L. Saulnier (Cover Only)
T. J. Kovich (Cover Only)

GEOCRES 31F-104 DATE 1985 07 12

FOUNDATION INVESTIGATION REPORT

For

Brown's Creek Culvert Replacement

W.P. 03-80-01

Hwy. 60, District 9, Ottawa

INTRODUCTION

The Foundation Design Section was requested by the Eastern Region Structural Section to investigate the subsurface conditions at the above-noted site for the replacement of two existing culverts by a 96 inch diameter C.S.P.

The proposed 96 inch culvert will replace an existing 36 inch C.S.P. culvert and a 48 inch C.S.P. overflow culvert. In the past, several washouts of the existing culverts have occured. The washouts were a result of either spring flows or breaking of beaver dams upstream.

This report summarizes the factual information obtained from a foundation investigation carried out at the above-mentioned site on 85-07-03. The fieldwork consisted of 2 sampled boreholes advanced by means of hollow stem augers to depths of 5.8 and 8.6 m below the existing ground surface.

SITE DESCRIPTION

The site is located on Hwy 60, approximately 2.3 km east of the Bonnechere River in the town of Deacon, township of N.Algona. The site is situated approximately 150 m north of the Golden Lake shoreline and is geologically situated in a sand plain.

Specifically, the site is at the crossing of Brown's Creek of Hwy 60. Visually, at the time of the field investigation, no signs of instability were evident. However, signs of erosion were visible at the culvert outlets particularly in the vicinity of the smaller culvert outlet which constantly has a flow. It also appears that some new fill was placed on the south side of Hwy 60 at the culvert outlets as no vegetation is present on the embankment slope.

SUBSURFACE CONDITIONS

Two boreholes were advanced at the site. A drawing indicating the location of the boreholes is included in the Appendix. Borehole BH 1 located in the vicinity of the proposed culvert inlet (north side of Hwy 60), extended to a depth of 5.8 m below the existing ground surface. Borehole BH 2, located in the vicinity of the proposed culvert outlet (south side of Hwy 60), extended to a depth of 8.6 m below the existing ground surface.

The soil conditions at both boreholes are similar. The Record of Borehole sheets are included in the Appendix for reference. No laboratory tests were conducted on any samples of soil. The following is a brief description of the soils encountered in each of the two boreholes. (It is to be noted that the fill material used for the existing Hwy 60 embankment was not investigated.)

BH 1, Sta. 15 + 888, 13.0 m Lt

A thin surficial cover of peat in the order of 0.2 m thick is encountered in the vicinity of this borehole. Immediately underlying this compressible organic material and extending down to a depth of 0.6 m (Elev. 70.1) from the ground surface is a mixture of dark brown silty sand and peat. This non-cohesive deposit also contains traces of gravel, clay. This material is in a very loose state as interpreted by the Standard Penetration Test (S.P.T.) 'N' value of 1 blow/0.3 m. When this material is subjected to an unbalanced hydrostatic pressure, "boiling" will occur.

Below this silty sand and peat mixture is a 3.1 m± thick deposit of brown sand extending down to Elev. 67. Based on visual observations this stratum contains some gravel, silt and traces of clay. It is also noted that with depth the sand of this non-cohesive deposit becomes finer while the silt content increases. Several thin silt seams are also present within this material. Based on S.P.T. 'N' values ranging from 4 - 15 blows/0.3 m this deposit is considered to be in a very loose to compact state. It is to be noted that "boiling" of this material will occur when subjected to an unbalanced hydrostatic pressure.

Extending down from Elev. 67.0 to an undetermined depth is a deposit of grey silt some sand, clay. Although this material is considered to be non-cohesive, slight plasticity is exhibited. Within this deposit are found seams of fine sand. Based on 'N' values ranging from 10-12 blows/ 0.3 m, this material is in a compact state. When this material is subjected to an unbalanced hydrostatic pressure, "boiling" will occur.

BH 2, Sta 15 + 880, 12.5 m Rt

In the vicinity of the borehole, surficially strewn cobbles and occasional boulders are evident particularly on the embankment slope and along the creek channel.

Extending down from the ground surface to Elev. 65.3 is a brown (or grey from Elev. 66.8 down) sand deposit which includes some gravel and trace of silt. It is noted that with depth the sand of this non-cohesive deposit becomes finer while the silt content increases.

Several thin silt seams are found within this deposit as is a sandy gravel seam at approximately Elev. 68. Based on 'N' values ranging between 6 - 15 blows/0.3 m this material is considered to be in a loose to compact state. When this material is subjected to an unbalanced hydrostatic pressure "boiling" will occur.

Extending down from Elev. 65.3 to an undetermined depth is a grey deposit of silt, trace to some sand, clay. Although this material is considered to be non-cohesive, slight plasticity is exibited. Within this deposit are found seams of fine sand. Based on the results of Standard Penetration tests, this deposit is generally in a compact state. It is to be noted that when this material is subjected to an unbalanced hydrostatic pressure "boiling" will occur.

Borehole BH 2 was terminated because the split-spoon was refused probably due to a boulder at a depth of 8.6 m or at Elev. 61.9.

Groundwater

Because of the proximity to the creek and the permeable nature of the subsoils the groundwater level at the location of the boreholes is governed by the level of water in the creek. At the time of the investigation the groundwater level at BH 1 was Elev. 70.2 and at BH 2 was at Elev. 69.4. Both these levels correspond to the water level in the creek.

RECOMMENDATIONS

Because of recurring washouts, it is proposed to replace the existing 36 inch and 48 inch diameter C.S.P.'s by a 96 inch diameter C.S.P. In addition it is proposed to provide sheet-pile cut-off walls at the ends and channel bed and bank protection. The proposed invert elevations for the 28 m long culvert are approximately Elev. 70.0 and 69.2 for the inlet and outlet respectively.

The following recommendations pertain to the design and installation of the 96 inch diameter C.S.P. culvert:

1. Dewatering will be required for the installation. The groundwater level in the vicinity of the creek is the same or slightly higher than the water level in the creek. Because of the granular nature of the subsoils, the groundwater level will fluctuate as does the level in the creek. At the time of the investigation (85-07-03) the groundwater level at BH 1 was at Elev. 70.2 and at BH 2 was at Elv. 69.4.

   The proposed invert elevations are approximately at the same elevation as the existing inverts of the 36 inch diameter C.S.P. Therefore, the proposed invert elevations are 70.0± and 69.2± at the inlet and outlet respectively. The required excavations will extend below the groundwater level. The depth below the groundwater level will depend on the creek water level at the time. The deeper the excavation extends below the prevailing groundwater level, the more severe the problem of boiling will be.

   If an adequate dewatering scheme is not implemented boiling and consequently loosening, of the subsoils will occur. Given the extent of the dewatering required, or item should be included in the tender.

2. Taking into consideration the granular nature of the subsoils across the site, it will not be necessary to provide any additional bedding.

3. A thin veneer of organic material was encountered in BH 2. All compressible organics should be removed and replaced with compacted granular material. The organics should be removed to 1.5 m from the plan limits of the culvert.

4. For the design of the cut-off walls at the ends of the culvert, the following parameters apply:

   Ka = 0.33
   Kp = 0.30
   = 19.6 kN/m^3

   The depth of the cut-off walls is determined by the anticipated scour action. This hdyrological effect should be considered prior to the designing the depth of these walls.

5. At the culvert inlet, a seal of cohesive material (CI-CH clay) with a minimum thickness of 0.6 m should be provided to prevent erosion of the underlying non-cohesive material. The requirements of this seal are shown on Fig. 1 on the following page.

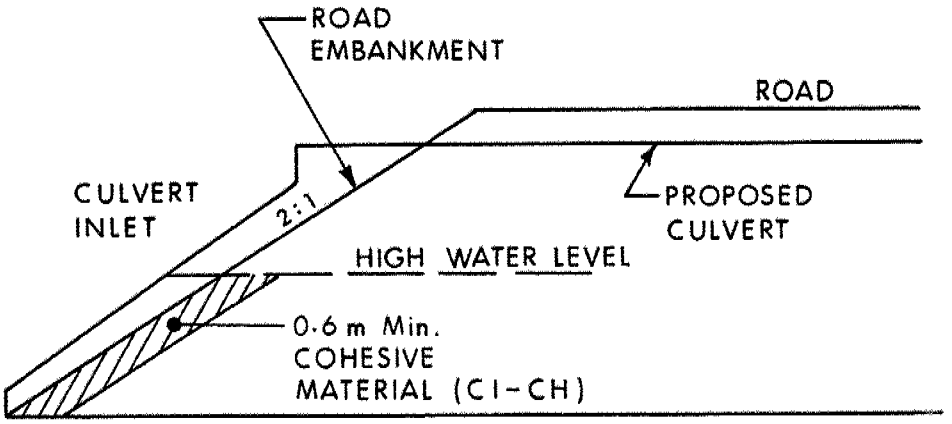
6. Because of the erosion-suceptible nature of the non-cohesive soils at the site, gabion baskets and/or rip-rap should be used to protect the channel bed and banks. The protection should extend up to the high water level and up to 8 - 10 m downstream from the outlet and from 3 - 5 m upstream to the inlet.

7. The backfill operations should be carried out simultaneously on both sides of the C.S.P. as per MTC specifications.

8. All fill placed below the prevailing groundwater level should be of a non-cohesive, granular type.

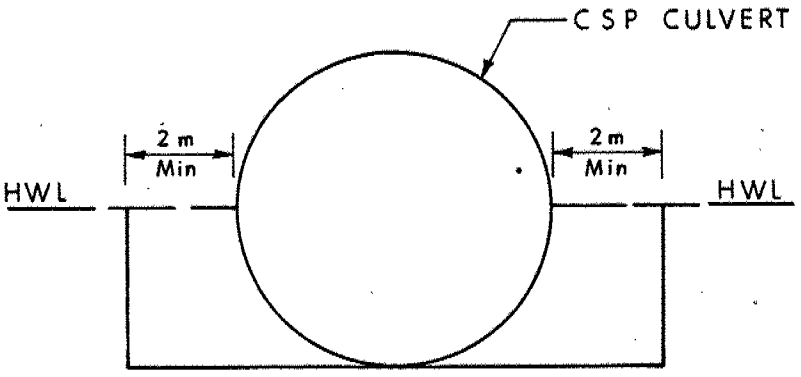
9. Temporary construction slopes of 1.5:1 will be stable. However, washouts and surface erosion can be anticipated after rainfalls.

10. Permanent slopes should be constructed at 2:1 and be protected from surface erosion and washouts by providing topsoil and grass vegetation, particularly if the fill material used is non-cohesive.



N T S

LONGITUDINAL SECTION



N T S

FRONT VIEW

Fig 1 - Culvert Inlet Seal

WP 3-80-01

MISCELLANEOUS

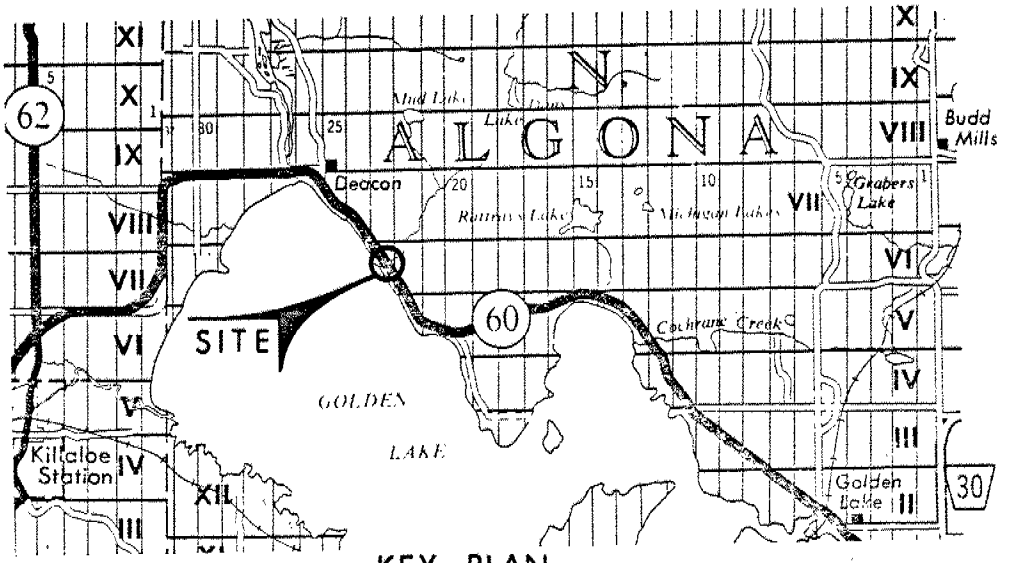
The fieldwork for this investigation was carried out under the supervision of L. Politano, Project Foundations Engineer utilizing equipment owned and operated by Marathon Drilling Inc. Ltd. of Ottawa. This report was written by L. Politano and reviewed by M. Devata, Chief Foundations Engineer (East).

L.R. Politano, P. Eng.
Project Foundations Engineer

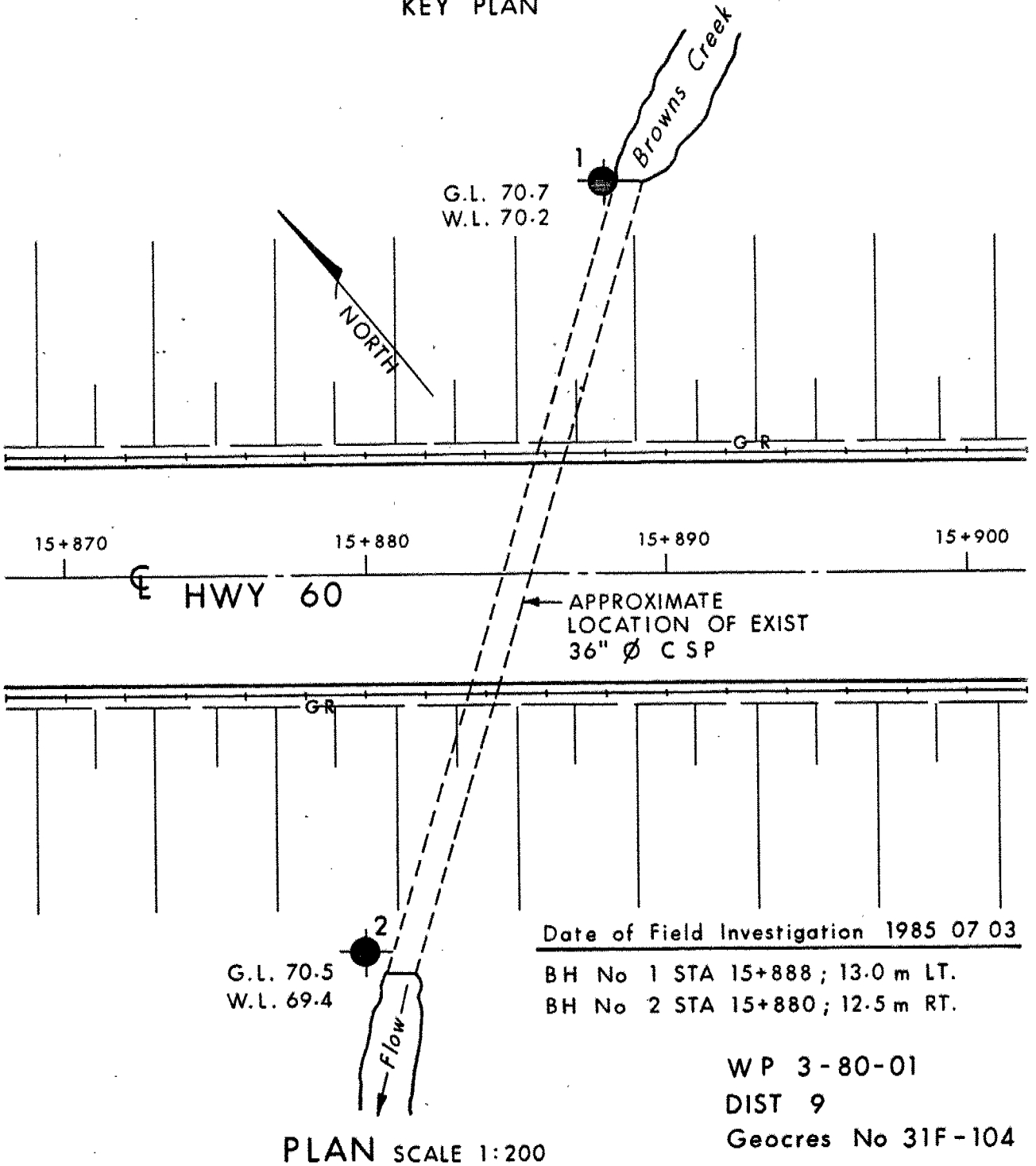
M. Devata, P. Eng.
Chief Foundations Engineer
(East)

July, 1985

APPENDIX



KEY PLAN



PLAN SCALE 1:200

Date of Field Investigation 1985 07 03

BH No 1 STA 15+888 ; 13.0 m LT.

BH No 2 STA 15+880 ; 12.5 m RT.

WP 3-80-01

DIST 9

Geocres No 31F-104

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

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

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

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

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

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

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

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 and Communications
Ontario

RECORD OF BOREHOLE No 1 METRIC

W P 3-80-01 LOCATION Sta. 15 + 888, 13.0 m Lt. ORIGINATED BY L.P.

DIST 9 HWY 60 BOREHOLE TYPE Hollow Stem Auger COMPILED BY L.P.

DATUM Geodetic DATE 85-07-03 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
70.7	Ground Surface										
0.0	Silty Sand, trace gravel trace clay and peat		1	SS	1	▼					
70.1	very loose Dk. Brown						70				
0.6	Sand, some gravel, silt trace clay		2	SS	4						
	Sand becoming finer with depth and silt content increasing with depth		3	SS	7		69				
			4	SS	15		68				
	Very Loose to compact		5	SS	14						
67.0	Brown						67				
3.7	Silt, some sand, clay		6	SS	12						
			7	SS	11		66				
64.9	Compact Grey		8	SS	10		65				
5.8	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 2

METRIC

W P 3-80-01 LOCATION Sta. 15 + 880, 12.5 m Rt. ORIGINATED BY L.P.

DIST 9 HWY 60 BOREHOLE TYPE Hollow Stem Auger COMPILED BY L.P.

DATUM Geodetic DATE 85-07-03 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE · PLOT 20 40 60 80 100 / SHEAR STRENGTH ○ 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						
70.5	Ground Surface										
0.0	Sand, trace silt, some gravel						70				
			1	SS	10	▼					
			2	SS	6		69				
	sandy gravel		3	SS	15		68				
	Sand becoming finer with depth and silt content increasing with depth Brown Grey		4	SS	9		67				
			5	SS	14						
			6	SS	6		66				
65.3	Loose to Compact										
5.2	Silt, trace to some sand, clay		7	SS	15		65				
							64				
			8	SS	2		63				
61.9	Compact Grey		9	SS	50/15cm		62				
8.6	End of Borehole Refusal Probable Boulder										

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE