

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 40P9-29

DIST. 3 REGION

W.P. No. 256-88-01

CONT. No. 90-55

W. O. No.

STR. SITE No. 35-468

HWY. No. 6N

LOCATION Hwy 6N & Haulon Culvert
(0.5 km N of Hwy 24 Guelph)

No. of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



Ontario

Ministry of
Transportation and
Communications

FILE No. _____ DATE _____

REMARKS _____

Talked to Don Trpster @ for Bruce Heinbuch 681-1441
July 4, 1989.

Master Soil 749-1062

Dennis Boyd 519-271-3550 Bridge Foreman

Jack Horn 519-824-6261

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 90-55



Ministry of
Transportation and
Communications

INDEX

<u>Page No:</u>	<u>DESCRIPTION</u>
1	Index
2	Abbreviations & Symbols
3 - 15	Foundation Investigation Report for Hanlon Culvert W.P. 256-88-01, Site 35-468 Hwy. 6N, District 3, Stratford

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

EXPLANATION OF TERMS USED IN REPORT

2

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/0.3 m)	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'_{v0}	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	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION INVESTIGATION REPORT

for

Hanlon Culvert
W.P. 256-88-01, Site: 35-468
Hwy. #6N, District #3, (Stratford)

INTRODUCTION

The following is a summary of the soil conditions obtained during a foundation investigation carried out from 89 09 13 to 89 09 21. Eight sampled boreholes and three core tests were carried out. Sampling extended from the surface to the top of the existing culvert and then continued from the bottom of the culvert to a maximum of 3.2 m below. It should be noted that the elevations used at this site are assumed. An assumed elevation of 100 m was assigned to the centreline of the westbound lanes, along the centreline of the existing culvert.

SUBSURFACE CONDITIONSGeneral

Above and to the sides of the existing culvert a gravelly sand fill was found. This fill ranged from very dense at the surface to loose or compact just above and to the sides of the culvert. Below the existing culvert a silty sand, some gravel material was located. This material ranged from compact to very dense with depth. The silty sand was found to be underlain by dolostone bedrock of the Guelph Formation which was proven only in borehole 10, at assumed elevation 93.2 m. In the other boreholes, bedrock was only presumed to be located at a greater depth than assumed elevation 91.9 m.

The groundwater level was approximately 5.2 m below the shoulder level, which was just under the invert level of the existing culvert.

For a more detailed description of the subsurface and groundwater conditions encountered, reference should be made to the attached Record of Borehole Log Sheets. The plan locations of the borings are shown on Figure 1.



P. Payer
P. Payer, P. Eng.
Sr. Foundation Engineer

M. Devata
M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

METRIC

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	W_p	W		
99.8	Shoulder Level											
0.0	Presumed Gravelly Sand											
99.4	Very Dense											
0.4	End of Cone Test						120/13cm					

RECORD OF BOREHOLE No 3

METRIC

W P 256-88-01 LOCATION Sta. 3+253, O/S 16.2m Rt of G Hanlon Expressway ORIGINATED BY PM
DIST 3 HWY 6 BOREHOLE TYPE Continuous Flight Auger (SS & HS) COMPILED BY PM
DATUM Assumed DATE 89 09 13 CHECKED BY *PM*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
99.8	Shoulder Level																
0.0	Gravelly Sand, Trace of Silt	•	1	SS	38		99										
	Dense to Compact	•	2	SS	16												
	(Fill)	•	3	SS	13		98										22 68 (10)
97.4		•	4	SS	6/	15cm											
2.4	Existing Culvert						97										
							96										
							95										
94.7																	
5.1	Silty Sand, Some Gravel Compact (Fill)	•	5	SS	22		94										
94.0		•															
5.8	Silty Sand, With Gravel Compact to Very Dense	•	6	SS	28												
		•	7	SS	12												
		•	8	SS	66		93										37 36 (27)
92.2		•	9	SS	120/	28cm											
7.6	End of Borehole		10	SS	42/	0cm											

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

METRIC

W P 256-88-01 LOCATION Sta. 3+252, O/S 6.4m Rt of Hanlon Expressway ORIGINATED BY PM
 DIST 3 HWY 6 BOREHOLE TYPE Continuous Flight Auger (SS & HS) COMPILED BY PM
 DATUM Assumed DATE 89 09 13 - 89 09 14 CHECKED BY PM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
100.0	Shoulder Level							○ UNCONFINED + FIELD VANE						
0.0	Gravelly Sand, Trace of Silt Very Dense to Loose (Fill)													

RECORD OF BOREHOLE No 5

METRIC

W P 256-88-01 LOCATION Sta. 3+257, O/S 6.3m Rt of 4 Manion Expressway ORIGINATED BY PM
DIST 3 HWY 6 BOREHOLE TYPE Continuous Flight Auger (SS) COMPILED BY PM
DATUM Assumed DATE 89 09 14 CHECKED BY *PM*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	Wp	W	Wl	WATER CONTENT (%)					
100.0	Shoulder Level															GR SA SI CL	
0.0	Gravelly Sand,					*											
	Trace of Silt																
	Compact to Loose		1	SS	12												
			2	SS	4												
	(Fill)		3	SS	6												
	Silt Layer																
94.7			4	SS	7												
			5	SS	5												
94.7																	
5.3	End of Borehole																
	* Water Level not Established																

OFFICE REPORT ON SOIL EXPLORATION




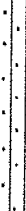
RECORD OF BOREHOLE No 6

METRIC

W P 256-88-01 LOCATION Sta. 3+253, O/S 6.3m Lt of C Hanlon Expressway ORIGINATED BY PM
DIST 3 HWY 6 BOREHOLE TYPE Continuous Flight Auger (SS & HS) COMPILED BY PM
DATUM Assumed DATE 89 09 14 CHECKED BY *LM*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
99.9	Shoulder Level														
0.0															
	Gravelly Sand, Traces of Organics and Clay		1	SS	45		99								
	Trace of Silt		2	SS	23		98								
	Dense to Compact		3	SS	11										
97.3	(Fill)		4	SS	47	12cm									
2.6							97								
	Existing Culvert						96								
							95								
94.7															
5.2	Silty Sand, Trace of Gravel		5	SS	18										
92.2	Compact Gravel (Fill)						94								
5.7	Silty Sand, Trace of Gravel		6	SS	33										
	Compact to Dense		7	SS	18		93								
			8	SS	38										
			9	SS	34		92								
91.8			10	SS	120/	22cm									
8.1	End of Borehole														

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7										METRIC						
W P 256-88-01		LOCATION Sta. 3+252, O/S 14m Lt of E Hanlon Expressway						ORIGINATED BY PM								
DIST 3 HWY 6		BOREHOLE TYPE Continuous Flight Auger (SS & HS)						COMPILED BY PM								
DATUM Assumed		DATE 89 09 14						CHECKED BY PM								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60						80
99.8	Shoulder Level														GR SA SI CL	
0.0	Gravelly Sand Trace of Silt Compact (Fill)		1	SS	21	15cm										
			2	SS	11											
97.5			3	SS	5/											
2.3	Existing Culvert															
94.9																
4.9	Silty Sand and Gravel Dense (Fill)		4	SS	37										65 25 (10)	
91.1	Silty Sand, Some Gravel Compact to Very Dense		5	SS	26	22cm										
5.7			6	SS	23											
			7	SS	25											
			8	SS	31											
			9	SS	120/											
91.7			10	SS	120/	13cm										
8.1	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

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

RECORD OF BOREHOLE No 8

METRIC

W P 256-88-01 LOCATION Sta. 3+249, O/S 14m Lt of C Hanlon Expressway ORIGINATED BY NH
 DIST 3 HWY 6 BOREHOLE TYPE Continuous Flight Auger (SS) COMPILED BY PM
 DATUM Assumed DATE 89 09 20 CHECKED BY *PM*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L			
100.0	Shoulder Level							SHEAR STRENGTH kPa		WATER CONTENT (%)				
								○ UNCONFINED	+ FIELD VANE					
								● QUICK TRIAXIAL	x LAB VANE					
0.0										10	20	30		
	Gravelly Sand and Silt		1	SS	17	*	99							3 54 (43)
			2	SS	7		98							
	Compact to Loose		3	SS	7		97							
			4	SS	10		96							
	(Fill)		5	SS	12		95							
			6	SS	12		94							
95.0			7	SS	11		95							
5.0	Silty Sand, Some Gravel		8	SS	38/	10cm	94							18 44 (38)
	Occasional Cobbles		9	SS	14/	8cm								
93.4	Very Dense		10	SS	28									
6.6	End of Borehole													
	* Water Level not Established													

OFFICE REPORT ON SOIL EXPLORATION

METRIC

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 10

METRIC

W P 256-88-01 LOCATION Sta: 3+253; O/S 26.7m Rt of E Hanlon Expressway ORIGINATED BY MH
 DIST 3 HWY 6 BOREHOLE TYPE Continuous Flight Auger COMPILED BY PM
 DATUM Assumed DATE 89 09 20 - 89 09 21 CHECKED BY Am

OFFICE REPORT ON SOIL EXPLORATION

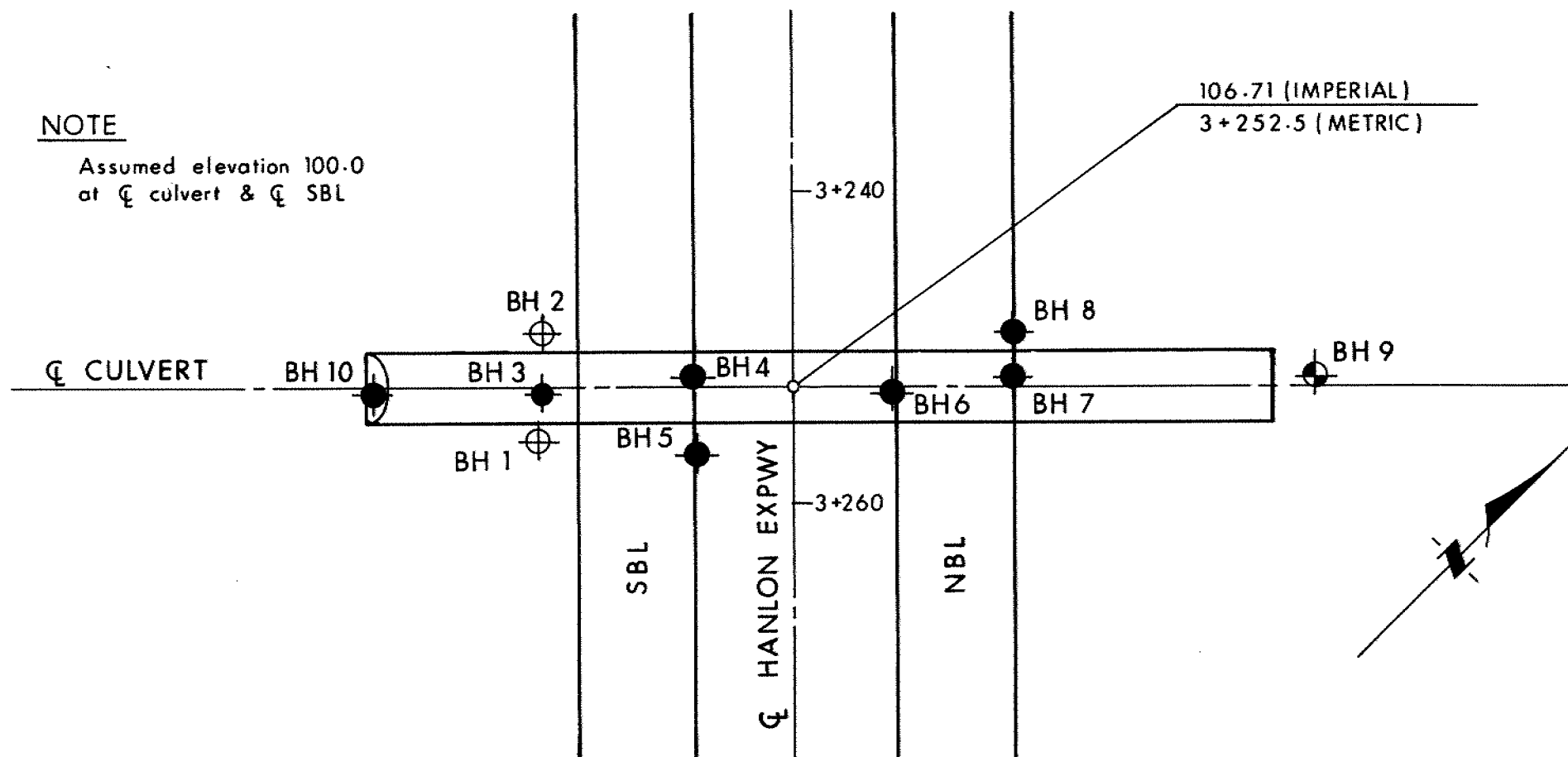
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
94.7	Invert Level																
0.0	Silty Sand, Some Gravel Compact (Fill)		1	SS	17												
0.6	Silty Sand, Topsoil Some Gravel and Boulders Very Dense		2	SS	35/8cm												
93.1																	
1.6	Dolostone		3	RC BXL	REC 87%												
	Sound		4	RC BXL	REC 95%												
91.6	Bedrock																
3.1	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15 \pm 5 (%) STRAIN AT FAILURE
10

NOTE

Assumed elevation 100.0
at \odot culvert & \odot SBL



PLAN
SCALE



Note:

For subsurface details refer
to Record of Borehole sheets

HWY 6N/HANLON CULVERT

Hwy - 6
Dist - 3
Geocres No -
40P9-29
WP 256-88-01
FIG - 1

CONT 90-55
ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 256-88-01

DIST 3

HWY 6N

STR SITE 35-468

Hanlon Culvert

DISTRIBUTION

A. Ho (2)
C.M. Bond
A.E. Irving
D.A. Waller (2)
K.G. Bassi
S.J. Dunham
G. Szekreny
D. Fusee (Cover Only)
M. MacLean (Cover Only)
File ✓

memorandum



To: A. Ho
Head, Structural Section
Southwestern Region

Date: 1989 11 14

Atten: B.A. Heinbuch

From: Foundation Design Section
Room 315, Central Building

RE: Hanlon Culvert
Site 35-468, W.P. 256-88-01
Highway 6N, District 3, Stratford

As requested the following is a summary of the soil conditions obtained during a foundation investigation carried out from 89 09 13 to 89 09 21. Eight sampled boreholes and three core tests were carried out. Sampling extended from the surface to the top of the existing culvert and then continued from the bottom of the culvert to a maximum of 3.2 m below. It should be noted that the elevations used at this site are assumed. An assumed elevation of 100 m was assigned to the centreline of the westbound lanes, along the centreline of the existing culvert.

Subsurface Conditions

General

Above and to the sides of the existing culvert a gravelly sand fill was found. This fill ranged from very dense at the surface to loose or compact just above and to the sides of the culvert. Below the existing culvert a silty sand, some gravel material was located. This material ranged from compact to very dense with depth. The silty sand was found to be underlain by dolostone bedrock of the Guelph Formation which was proven only in borehole 10, at assumed elevation 93.2 m. In the other boreholes, bedrock was only presumed to be located at a greater depth than assumed elevation 91.9 m.

The groundwater level was approximately 5.2 m below the shoulder level, which was just under the invert level of the existing culvert.

For a more detailed description of the subsurface and groundwater conditions encountered, reference should be made to the attached Record of Borehole Log Sheets. Soil parameters for the different soil types are given below. The plan locations of the borings are shown on Figure 1.

Recommendations

General

It has been proposed that a 3730 x 2290 structural plate pipe arch culvert be threaded through the existing 4724x3050 pipe arch, and the void between the two pipe culverts be grouted.

Soil Parameters


The following design values are recommended for the purposes of the O.H.B.D.C. for the bearing capacity of the soil under the existing culvert.

Factored Bearing Capacity at U.L.S.	645 kPa
Capacity at S.L.S. Type II	140 kPa

In addition, the following properties for the soil in the immediate vicinity of the existing culvert may be used for computations:

Assumed Elevation (m)	Unit Weight (kN/m ³)	Cohesion C (kPa)	Friction Angle ϕ (°)
100 - 98.5	21.2	0	32
98.5 - 94.7	19.3	0	28
94.7 - 93.0	19.9	0	31
93.0 - 91	21.2	0	33

Should you require any further information, please do not hesitate to contact this office.



P. Marks, P. Eng.
Foundation Engineer
for

M. Devata, P. Eng.
Chief Foundation Engineer

PM/MD/mmj

Attachs.

APPENDIX

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

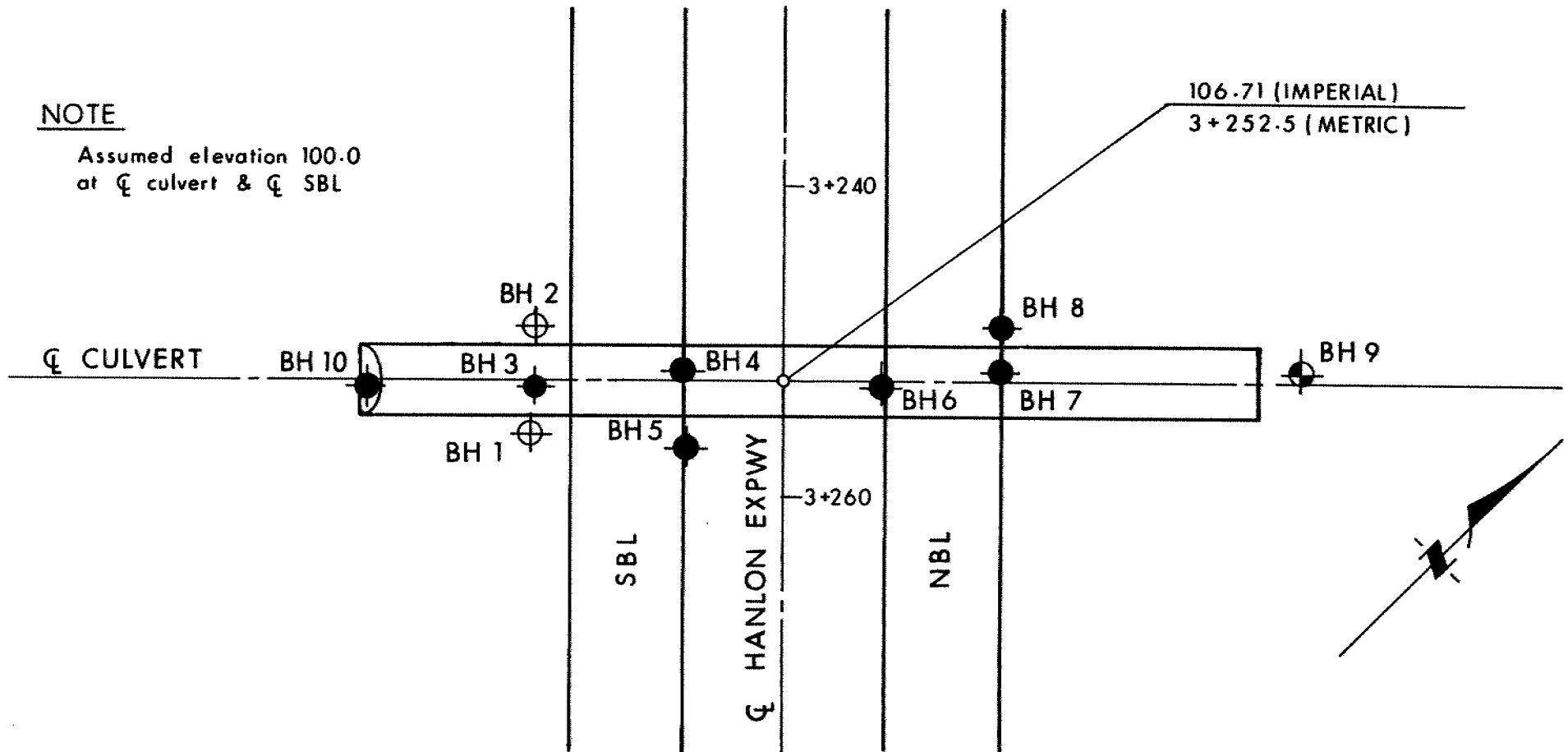
m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
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_f	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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

NOTE

Assumed elevation 100.0
at \odot culvert & \odot SBL



Note:

For subsurface details refer
to Record of Borehole sheets

HWY 6N/HANLON CULVERT

Hwy - 6
Dist - 3
Geocres No -
40P9-29
WP 256-88-01
FIG -1



METRIC

W P 256-88-01 LOCATION Sta. 3+256, 0/S 16.4m Rt of C Hanlon Expressway ORIGINATED BY PM
DIST 3 HWY 6 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY PM
DATUM Assumed DATE 89 09 13 CHECKED BY th

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
99.8	Shoulder Level												
0.0	Presumed												
99.3	Gravelly Sand Very Dense												
0.5	End of Cone Test												
										</			

+3, x5: Numbers refer to Sensitivity

15- ϕ 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 256-88-01 LOCATION Sta. 3+249, O/S 16.2m Rt of Hanlon Expressway ORIGINATED BY PM
DIST 3 HWY 6 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY PM
DATUM Assumed DATE 89 09 13 CHECKED BY PM

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 3

METRIC

W P 256-88-01 LOCATION Sta. 3+253, O/S 16.2m Rt of E Hanlon Expressway ORIGINATED BY PM
DIST 3 HWY 6 BOREHOLE TYPE Continuous Flight Auger (SS & HS) COMPILED BY PM
DATUM Assumed DATE 89 09 13 CHECKED BY PM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
99.8	Shoulder Level																
0.0	Gravelly Sand, Trace of Silt																
			1	SS	38												
	Dense to Compact		2	SS	16												
	(Fill)		3	SS	13												
97.4			4	SS	6/	15cm										22 68 (10)	
2.4	Existing Culvert																
94.7																	
5.1	Silty Sand, Some Gravel Compact (Fill)		5	SS	22												
94.0																	
5.8	Silty Sand, With Gravel Compact to Very Dense		6	SS	28												
			7	SS	12												
			8	SS	66												
92.2			9	SS	120/	28cm											
7.6	End of Borehole		10	SS	42/	0cm											

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 4

METRIC

W P 256-88-01 LOCATION Sta. 3+252, O/S 6.4m Rt of E Hanlon Expressway ORIGINATED BY PM
DIST 3 HWY 6 BOREHOLE TYPE Continuous Flight Auger (SS & HS) COMPILED BY PM
DATUM Assumed DATE 89 09 13 - 89 09 14 CHECKED BY PM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
100.0	Shoulder Level							○ UNCONFINED + FIELD VANE						
0.0								● QUICK TRIAXIAL x LAB VANE						
	Gravelly Sand, Trace of Silt		1	SS	69		99							
	Very Dense to Loose		2	SS	55									
	(Fill)		3	SS	12		98							
97.4			4	SS	6									
2.6							97							
	Existing Culvert						96							
							95							
94.7														
5.3	Silty Sand, Some Gravel Loose (Fill)		5	SS	9		94							
94.2														
5.8	Topsoil		6	SS	40									
	Silty Sand, Some Gravel		7	SS	16		93							
	Very Dense/Compact		8	SS	11									
			9	SS	61									
91.9			10	SS	100	0cm	92							
8.2	End of Borehole													
	* Presumed Dolostone Weathered Bedrock													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 5

METRIC

W P 256-88-01 LOCATION Sta. 3+257, O/S 6.3m Rt of Q Hanlon Expressway ORIGINATED BY PM
DIST 3 HWY 6 BOREHOLE TYPE Continuous Flight Auger (SS) COMPILED BY PM
DATUM Assumed DATE 89 09 14 CHECKED BY PM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80					
100.0	Shoulder Level															
0.0	Gravelly Sand,					*										
	Trace of Silt															
	Compact to Loose		1	SS	12											
			2	SS	4											
	(Fill)		3	SS	6											
			4	SS	7											
	Silt Layer															
94.7			5	SS	5											
5.3	End of Borehole															
	* Water Level not Established															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

METRIC

W P 256-88-01 LOCATION Sta. 3+253, O/S 6.3m Lt of G. Hanlon Expressway ORIGINATED BY PM
DIST 3 HWY 6 BOREHOLE TYPE Continuous Flight Auger (SS & HS) COMPILED BY PM
DATUM Assumed DATE 89 09 14 CHECKED BY LHM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
99.9	Shoulder Level								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%)			
0.0	Gravelly Sand, Traces of Organics and Clay		1	SS	45		99						
	Trace of Silt		2	SS	23		98						
	Dense to Compact		3	SS	11								
97.3	(Fill)		4	SS	4	12cm							
2.6	Existing Culvert						97						
							96						
							95						
94.7	Silty Sand, Trace of Gravel		5	SS	18		94						
92.2	Compact Gravel (Fill)		6	SS	33								
5.7	Silty Sand, Trace of Gravel		7	SS	18		93						
	Compact to Dense		8	SS	38								
			9	SS	34								
91.8			10	SS	120/	22cm	92						
8.1	End of Borehole												



RECORD OF BOREHOLE No 7

METRIC

W P 256-88-01 LOCATION Sta. 3+252, O/S 14m Lt of E Hanlon Expressway ORIGINATED BY PM
DIST 3 HWY 6 BOREHOLE TYPE Continuous Flight Auger (SS & HS) COMPILED BY PM
DATUM Assumed DATE 89 09 14 CHECKED BY PM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
99.8 0.0	Shoulder Level										
	Gravelly Sand						99				
	Trace of Silt										
	Compact		1	SS	21		98				
97.5	(Fill)		2	SS	11						
			3	SS	5	15cm					
2.3	Existing						97				
	Culvert										
							96				
94.9											
4.9	Silty Sand and Gravel		4	SS	37		95				
	Dense										
91.1	(Fill)										
			5	SS	26		94				
5.7	Silty Sand,		6	SS	23						
	Some Gravel		7	SS	25		93				
	Compact to		8	SS	31						
	Very Dense		9	SS	120/	22cm	92				
91.7			10	SS	120/	13cm					
8.1	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 8

METRIC

W P 256-88-01 LOCATION Sta. 3+249, O/S 14m Lt of Q Hanlon Expressway ORIGINATED BY NH
 DIST 3 HWY 6 BOREHOLE TYPE Continuous Flight Auger (SS) COMPILED BY PM
 DATUM Assumed DATE 89 09 20 CHECKED BY Am

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
								SHEAR STRENGTH kPa						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L			WATER CONTENT (%) 10 20 30				
100.0	Shoulder Level													
0.0	Gravelly Sand and Silt Compact to Loose (Fill)					*	99						3 54 (43)	
			1	SS	17									
			2	SS	7									
			3	SS	7									
			4	SS	10									
			5	SS	12									
			6	SS	12		96							
95.0			7	SS	11		95							
5.0	Silty Sand, Some Gravel		8	SS	38	10cm							18 44 (38)	
	Occasional Cobbles		9	SS	14	8cm								
93.4	Very Dense		10	SS	28		94							
6.6	End of Borehole													
	* Water Level not Established													

RECORD OF BOREHOLE No 9

METRIC

W P 256-88-01

LOCATION Sta: 3+252, U/S 33.2m Lt of C Hanlon Expressway

ORIGINATED BY NH

DIST 3 HWY 6

BOREHOLE TYPE Continuous Flight Auger (HS)

COMPILED BY _____ PM

DATUM Assumed

DATE 89 09 20

CHECKED BY Flm

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 10

METRIC

W P 256-88-01 LOCATION Sta: 3+253; O/S 26.7m Rt of E Hanlon Expressway ORIGINATED BY MH
 DIST 3 HWY 6 BOREHOLE TYPE Continuous Flight Auger COMPILED BY PM
 DATUM Assumed DATE 89 09 20 - 89 09 21 CHECKED BY *Am*

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
94.7	Invert Level												
0.0	Silty Sand, Some Gravel Compact (Fill)		1	SS	17								
94.1													
0.6	Silty Sand, Topsoil Some Gravel and Boulders Very Dense		2	SS	35/	8cm							
93.1													
1.6	Dolostone		3	RC BXL	REC 87%								
	Sound		4	RC BXL	REC 95%								
91.6	Bedrock												
3.1	End of Borehole												

+3, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10