



DETAIL FOUNDATION INVESTIGATION AND DESIGN REPORT

for

HOWARD AVENUE / MEMORIAL DRIVE DEEP CUTS

HOWARD AVENUE / CPR GRADE SEPARATION

GWP 3030-06-00

CITY OF WINDSOR, ONTARIO

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PML Ref.: 07TF022A-3
Index No.: 173FIR and 174FDR
GEOCRES No.: 40J6-25
May 13, 2009



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DETAIL FOUNDATION INVESTIGATION REPORT

for

Howard Avenue / Memorial Drive Deep Cuts

Howard Avenue / CPR Grade Separation

GWP 3030-06-00

City of Windsor, Ontario

1. INTRODUCTION

This report summarises the results of a detail foundation investigation carried out for permanent cut slopes along Howard Avenue and realigned Memorial Drive in the City of Windsor, Ontario. This earthwork is part of the proposed road-rail grade separation involving construction of a Canadian Pacific Railway (CPR) overhead at Howard Avenue and the lowering and reconstruction of the Howard Avenue / Memorial Drive intersection. The investigation was conducted for McCormick Rankin Corporation (MRC) on behalf of the Ministry of Transportation of Ontario (MTO).

The current plans call for the Howard Avenue alignment to be lowered with a deep cut section extending some 350 m and being up to 8 m in depth at the overhead to be located at approximate Station 10+298, Howard Avenue chainage. A maximum 4 m deep cut section along the realigned Memorial Drive will extend some 150 m eastward from the intersection with Howard Avenue at Station 10+370, Howard Avenue chainage.

A previous preliminary geotechnical investigation for the new CPR overhead was conducted by Golder Associates Ltd. (Golder) in August 2006, Report No. 06-1140-156, and the data is re-used in this report.

The report provides detail subsurface information pertaining to the deep cut sections along Howard Avenue and the realigned Memorial Drive. Other foundation facets of this project were reported separately to efficiently incorporate changes in the design. The following separate reports were prepared:

PML Ref. No.	Report Title
07TF022A-1	Canadian Pacific Railway Overhead
07TF022A-2	Retaining Walls
07TF022A-3	Road Cuts and Deep Sewers
07TF022A-4	Pumping Station
07TF022A-5	SWM Ponds
07TF022A-6	Watermain Tunnels

The Final Detail Foundation Investigation Report should be listed in SP 109F10.



2. SITE DESCRIPTION AND GEOLOGY

The site is located on the CPR alignment at the crossing of Howard Avenue about 5 km north of the Highway 401 / Howard Avenue interchange in Windsor, Ontario.

Land use in the vicinity of the site includes residential and commercial properties and community facilities. The site is currently the at-grade crossing of the transportation corridors of Howard Avenue and the CPR. A hydro corridor for high voltage power lines runs parallel and to the north of the CPR tracks.

The topography is relatively flat, slightly rising to the east. The unpaved ground beyond the CPR right-of-way, Howard Avenue and Memorial Drive is covered with grass and mature trees.

The project site is situated in the Essex Clay Plain physiography region within the St. Clair Clay Plain. The native soils are mainly represented by cohesive glacial till deposits. The typical rock type in the project area is Middle Devonian limestone of the Paleozoic era. The bedrock is at depths of more than 35 m at the site.

3. INVESTIGATION PROCEDURES

The field work for this study was carried out during the periods of October 8 to 31, 2007 and October 6 to 10, 2008, comprising 21 boreholes advanced to depths of 2.0 to 45.4 m at the locations shown on Drawing DC-1, appended. The boreholes were numbered in the 100-series to distinguish them from borehole 1 that was drilled by Golder during the preliminary investigation of the site. Information from borehole 1 which was included in the RFP has been used to assist in preparation of this report.

The locations of the boreholes were established in the field by Peto MacCallum Ltd. and cleared for the presence of underground services and utilities. Although the hydro corridor running parallel to the CPR and security road right-of-way limited the access for drill rigs during the investigation and lack of permission to enter required that boreholes 103 and 104 be drilled on Howard Avenue instead of their intended locations about 12 m westerly, the results of the subsurface investigation were considered to be adequate for this report. The ground surface elevations at the boreholes



were provided by Callon Dietz Ltd. All elevations in this report are geodetic and expressed in metres.

The boreholes were advanced using continuous flight hollow and solid stem augers and mud rotary drilling methods, powered by a truck-mounted CME-75 drill rig, supplied and operated by a specialist drilling contractor, working under the full-time supervision of a member of our engineering staff.

Representative soil samples were recovered at depth intervals of 0.75 and 1.5 m using a conventional split spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. Penetrometer and in-situ vane shear tests were also performed to assess the shear strength of the cohesive soils. It is noted that the results of penetrometer tests may be lower than the actual values due to sample disturbance.

Groundwater conditions at the borehole locations were assessed during drilling by visual examination of soil, the sampler and drill rods as the samples were retrieved and, when appropriate, by measurement of the water level in the open boreholes. Piezometers were installed in boreholes 107 and 119. The boreholes were backfilled with a bentonite/cement mixture where required in accordance with the MTO guidelines and MOE Reg. 903 for borehole abandonment procedures.

All of the recovered samples were returned to our laboratory for detailed visual examination, classification and routine moisture content determinations. In addition, 37 Atterberg Limits tests and 38 grain size distribution analyses were conducted on selected samples, with the results presented in Figures PC-DC-1 to PC-DC-4, GS-DC-1 to GS-DC-5. Further, unconfined compression tests were performed on three cohesive samples. The laboratory test results are shown on the Record of Borehole sheets.

4. SUMMARISED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including soil classification, inferred stratigraphy, boundary elevations, standard penetration test data, penetrometer and in-situ vane undrained shear strength values and



groundwater observations. The results of laboratory unconfined compressive strength tests, Atterberg limits testing, grain size distribution analyses and moisture content determinations are also shown on the Record of Borehole sheets. The borehole locations are indicated on Drawing DC-1.

The stratigraphic profiles along the toes of slopes are presented on Drawings DC-2 and DC-3. The boundaries between soil strata have been established at the borehole locations only. Between and beyond the boreholes, the boundaries are assumed and may vary.

The subsurface stratigraphy revealed in the boreholes drilled at the site generally comprised surficial fill and/or topsoil underlain by an extensive deposit of clayey silt till mantling bedrock. The soil referred to as silty clay till in the preliminary investigation (borehole 1) is described as clayey silt till in accordance with the MTO standard soil classification. The bedrock surface was contacted at depths of 38.4 to 39.4 m (elevation 148.7 to 150.2). The strata encountered are described below.

4.1 Fill

Pavement structures consisting of 70 to 130 mm thick asphaltic concrete and 100 to 630 mm thick sandy/gravelly fill were present in boreholes 1, 101, 110 and 116 drilled from driveway pavements. Concrete pavements including 250 to 270 mm thick concrete (50 mm of asphaltic concrete over 250 mm of concrete in borehole 106) and 200 to 350 mm thick sand and gravel were present in boreholes 103, 104, 106 and 120 drilled from the Howard Avenue and South Pacific Avenue pavements. The moisture content of the granular fill in borehole 1 was 5%. The pavement structures were penetrated at depths of 0.2 to 0.8 m (elevation 186.9 to 187.9).

Fill composed of heterogeneous materials (gravel, sand and gravel, sand, sandy silt, slag and cinder, clayey silt, silty clay, topsoil) was present surficially in boreholes 102, 105, 109, 112, 113, 118, R6 and encountered below the pavement structure or topsoil at depths of 0.2 to 0.8 m (elevation 186.9 to 188.0) in boreholes 1, 103, 108, 111, 117, 120. The fill was loose to compact/soft to stiff (SPT-'N' values of 7 to 28) and 7 to 37% in moisture content. The fill had a thickness of 0.2 to 1.1 m and was penetrated at depths of 0.2 to 1.5 m (elevation 186.3 to 187.7).



4.2 Topsoil

Surficial topsoil was present in boreholes 107, 108, 111, 114, 115, 117 and 119. A layer of topsoil was also buried under the fill at 0.4 m depth (elevation 187.3) in borehole 101 and a depth of 0.2 m (elevation 187.4) in borehole 102. Identified as low organic clayey/sandy silt, the topsoil was 200 to 400 mm thick and penetrated at depths of 0.2 to 0.8 m (elevation 186.9 to 188.0).

4.3 Silty Clay Till

Directly beneath the fill at depths of 0.2 to 0.7 m (elevation 187.4 to 187.9) in boreholes 109, 112 and 116 was cohesive silty clay till. This deposit was 1.3 to 2.7 m thick and firm to stiff in consistency. The silty clay till was penetrated at depths of 2.0 to 2.9 m (elevation 185.2 to 186.4).

The results of Atterberg limits testing and grain size distribution analyses conducted on 3 samples of this material are presented in Figures PC-DC-1 and GS-DC-1 respectively. The liquid and plastic limits of the silty clay till ranged from 36 to 40 and from 16 to 18 respectively, thus giving the plasticity index of 20 to 22. The moisture content of the deposit varied between 15 and 24%.

4.4 Clayey Silt Till

Underlying the fill, topsoil or silty clay till at depths of 0.2 to 2.9 m (elevation 185.2 to 187.7) in all boreholes was a major cohesive deposit of clayey silt till. Interlayered with silty sand till in borehole 107, this deposit had a total thickness of 36.9 to 39.0 m in boreholes 1, 105, 107 and 108 that were cored into bedrock. The clayey silt till was penetrated at depths of 38.4 to 39.4 m (elevation 148.7 to 150.2) in the four cored boreholes, with boulders detected immediately above the bedrock at 38.8 m depth (elevation 149.3) in borehole 105. The remaining boreholes were terminated in the deposit at depths of 2.0 to 11.6 m (elevation 176.2 to 186.2).

The consistency of the clayey silt till was firm to hard, typically very stiff in the upper 4.5 to 6.5 m thick zone and firm to stiff below elevation 181.5 to 182.5. The results of in-situ vane testing carried out in the lower zone of the deposit yielded undisturbed shear strength values in a typical range of 50 to 100 kPa (soil sensitivity of 2 to 3). Penetrometer tests on samples of the clayey silt till indicated a shear strength varying between 20 and 125 kPa. Unconfined compression testing



on Shelby tube samples of the deposit gave undrained shear strength values of 31 to 145 kPa (strain at failure of 11 to 22%). These results generally confirmed the field vane test results.

The results of Atterberg limits testing and grain size distribution analyses conducted on 34 samples of this material are presented in Figures PC-DC-2 to PC-DC-4 and GS-DC-2 to GS-DC-4 respectively. The liquid limit of the clayey silt till ranged from 16 to 33 and plastic limit from 10 to 18, with a corresponding range in the plasticity index of 6 to 17. The moisture content of the deposit varied between 11 and 24%, locally reaching 35 and 46%. The Atterberg limits and moisture content results are given in Table 1. Within the very stiff to hard desiccated clay crust zone extending to depths of 4.5 to 6.5 m, the natural water values were within a few percentages above and below the plastic limit. The typical liquidity index values ranged from -0.3 to 0.3, which indicated a clayey silt till to be medium to heavy over-consolidated. Below the clay crust, the moisture contents generally increase with depth from 17 to 24% with a corresponding increase in the liquidity index from 0.3 to 0.6.

4.5 Silty Sand Till

A localised layer of cohesionless silty sand till was encountered within the clayey silt till at a depth of 5.4 m (elevation 182.2) in borehole 107. This layer was 1.5 m thick and penetrated at 6.9 m depth (elevation 180.7). The soil was compact in relative density (SPT-'N' value of 21).

The silty sand till had a moisture content of about 16%. The results of one grain size distribution analysis performed on a sample of the non-plastic soil are presented in Figure GS-DC-5.

4.6 Bedrock

Limestone bedrock was contacted below the clayey silt till at depths of 38.4 to 39.4 m (elevation 148.7 to 150.2) in boreholes 1, 105, 107 and 108 put down at the overhead structure location.



4.7 Groundwater

Perched water was detected in the process of augering at 1.1 m depth (elevation 187.5) in borehole 1 (2006) and at a depth of 0.4 m (elevation 187.7) in borehole 105 (2008). Groundwater was not observed in any of the boreholes upon completion of drilling due to the relatively impervious nature of the clayey silt till and limited time available for observation.

Two piezometers were installed in boreholes 107 and 119. Piezometer readings subsequently taken showed water levels to be at the following depths/elevations:

Borehole No.	Mid Screen Position		October 8, 2008		October 10, 2008		October 14, 2008		October 15, 2008		October 16, 2008	
	Depth (m)	Elev.	Depth (m)	Elev.	Depth (m)	Elev.	Depth (m)	Elev.	Depth (m)	Elev.	Depth (m)	Elev.
107	18.3	169.3	19.3	168.3	18.9	168.7	17.7	169.9	17.4	170.2	17.0	170.6
119	6.8	181.0	—	—	—	—	6.2	181.6	4.7	183.1	2.6	185.2

The readings indicated the presence of perched groundwater conditions within the upper desiccated zone of the native soils. Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

5. CLOSURE

The field work was carried out under the supervision of Mr. M. Rapsey, Senior Technician, and direction of Mr. C. M. P. Nascimento, P.Eng. The drilling equipment was supplied by Aardvark Drilling Ltd. The laboratory work was carried out in the PML laboratory in Toronto.



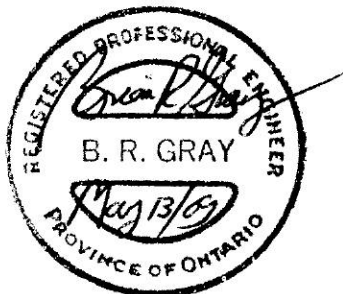
This report was prepared by Mr. G.O. Degil, PhD, P.Eng., Senior Foundation Engineer, and reviewed by Mr. C.M.P. Nascimento, P.Eng. Mr. B.R. Gray, MEng, P.Eng., MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.



C. M. P. Nascimento, P.Eng.
Senior Project Engineer



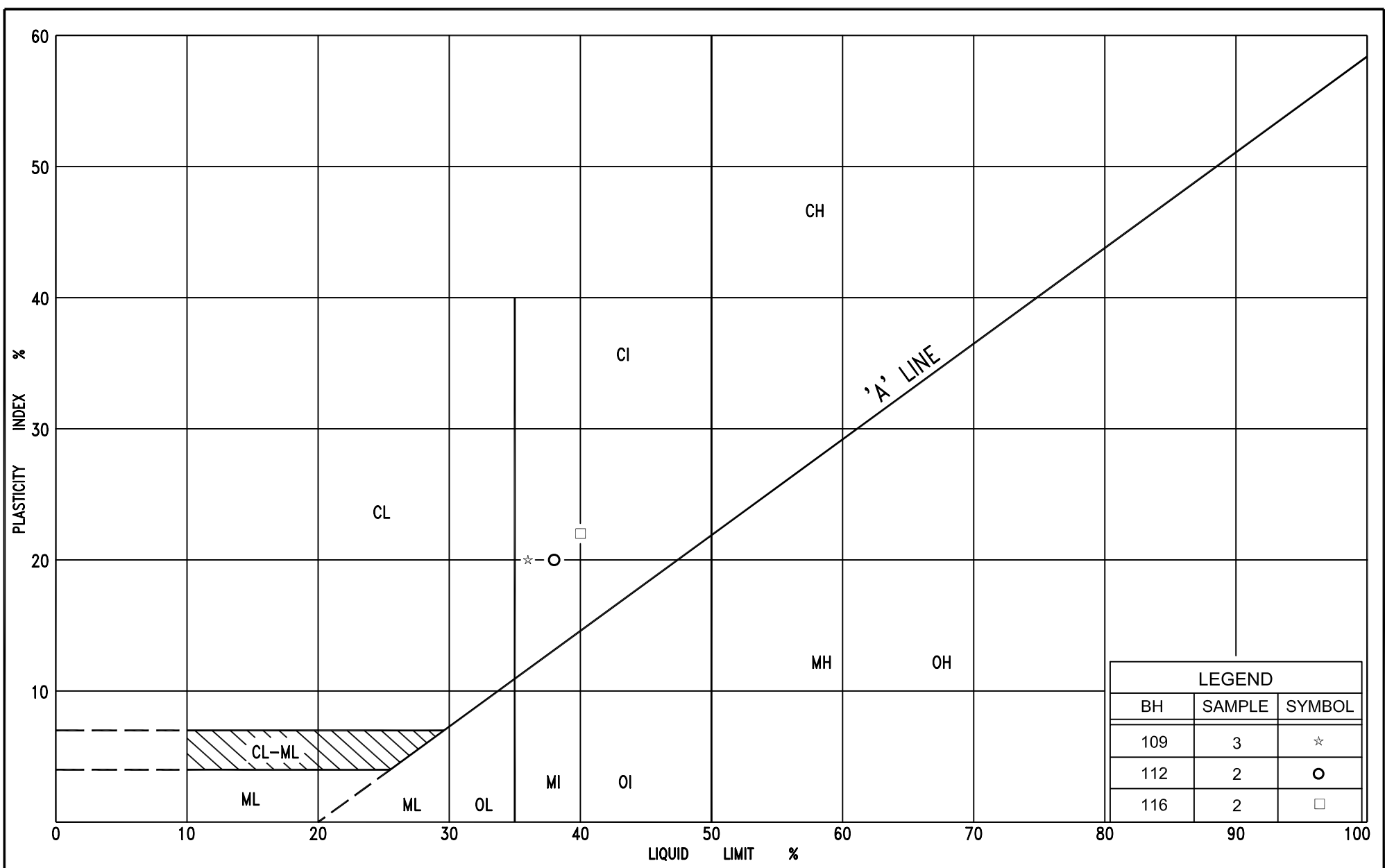
Brian R. Gray, MEng, P.Eng.
MTO Designated Principal Contact

GD/CN/BRG:lnr

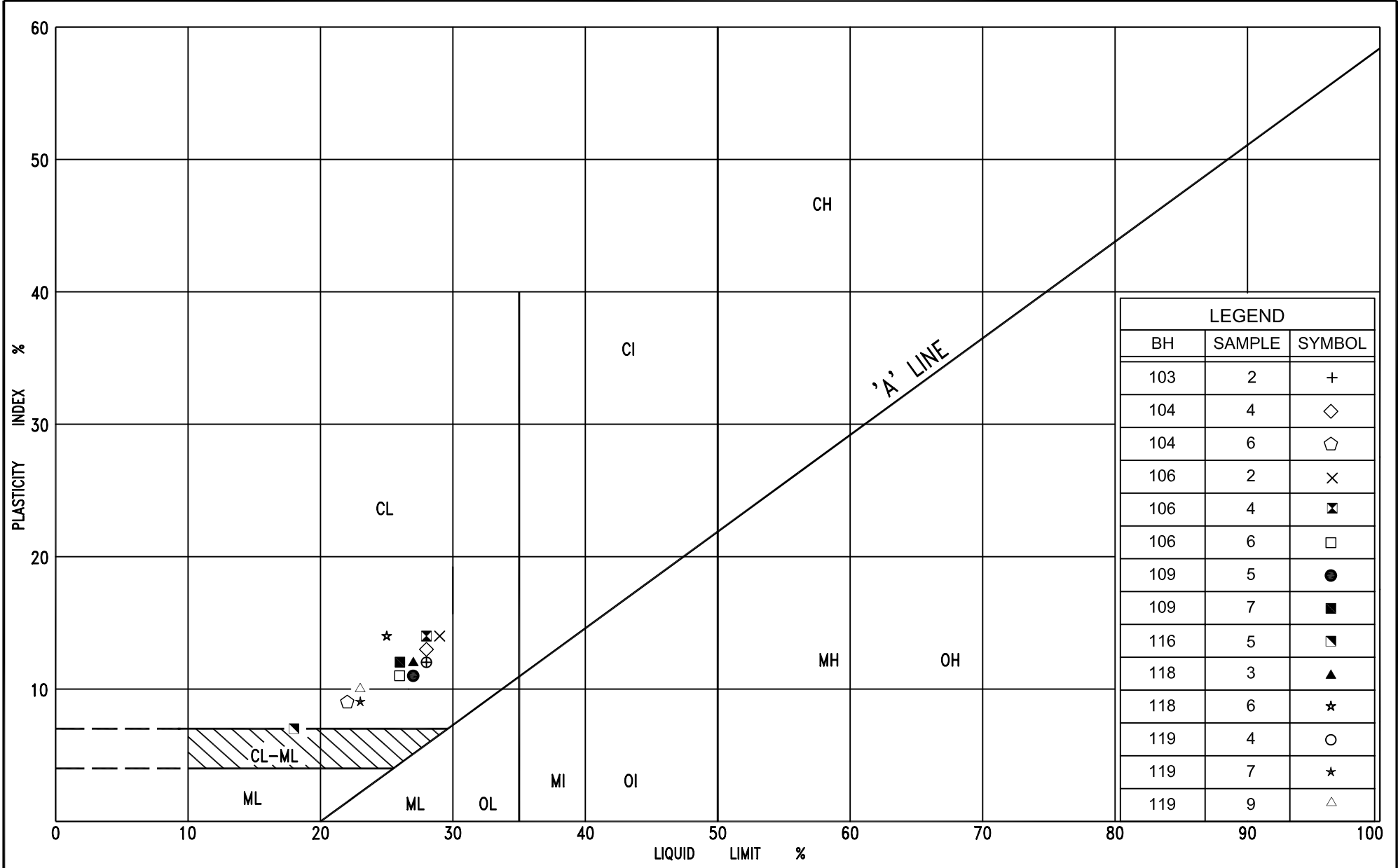


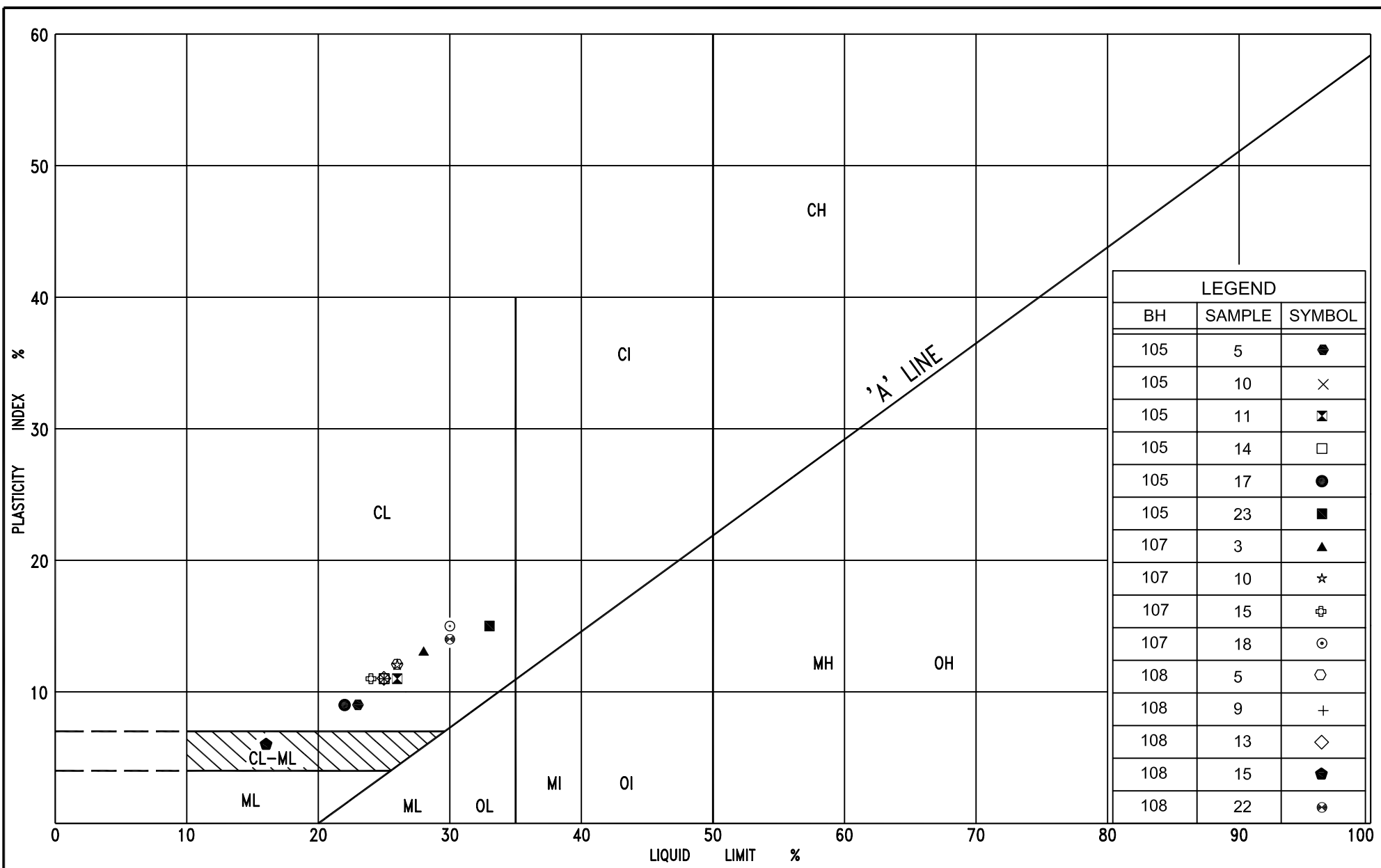
TABLE 1
ATTERBERG LIMITS AND MOISTURE CONTENT RESULTS
CLAYEY SILT TILL / SILTY CLAY TILL

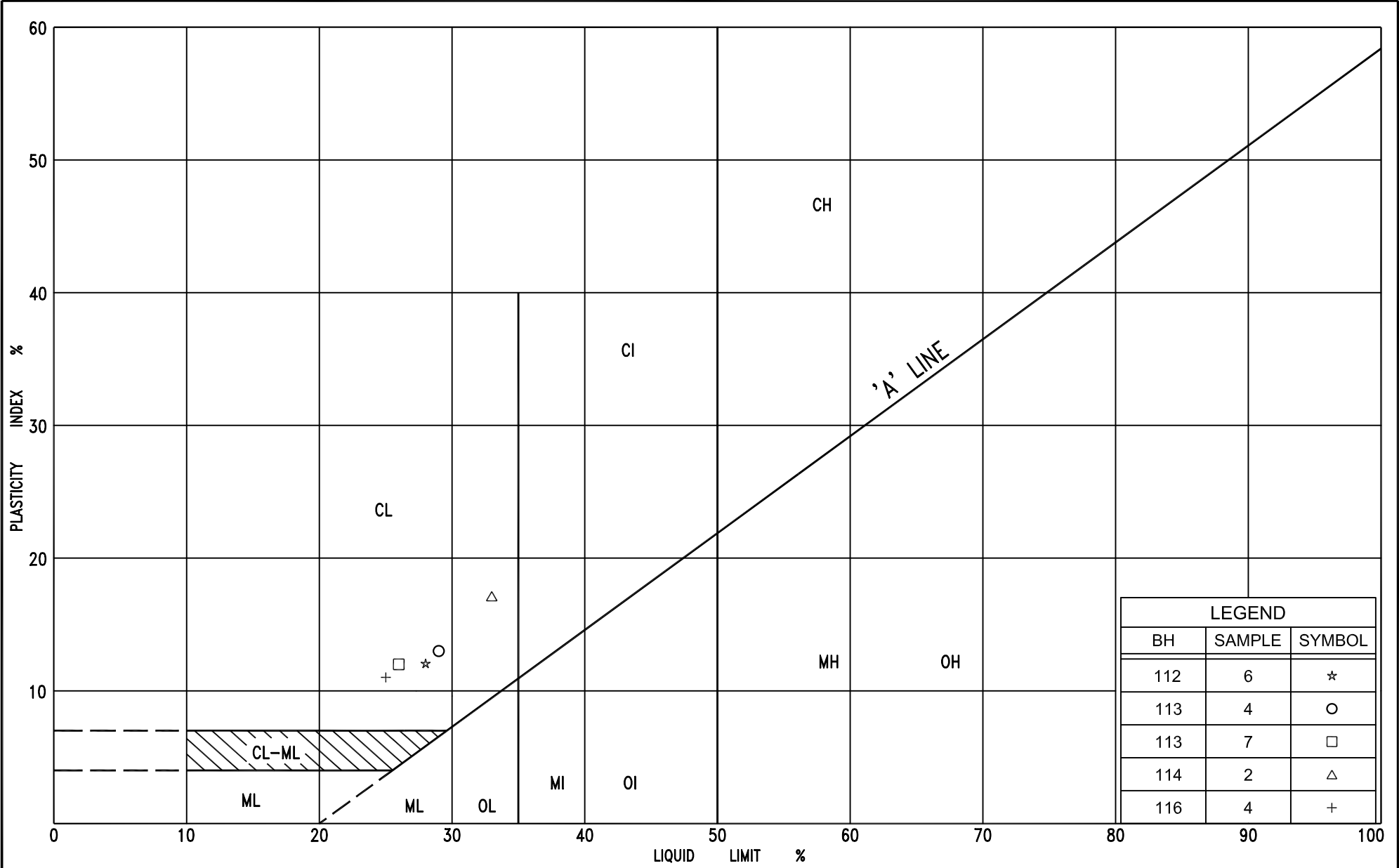
Depth (m)	Borehole No.	Sample No.	Liquid Limit W _L	Plastic Limit W _P	Plasticity Index PI	Moisture Content (%)	Liquidity Index LI
0.7 - 1.2	112	2	38	18	20	23	0.25
	114	2	33	16	17	14	-0.12
1.5 - 2.0	106	2	29	15	14	13	-0.14
	107	3	28	15	13	13	-0.15
	109	3	36	16	20	19	0.15
	116	2	40	18	22	14	-0.18
	118	3	27	15	12	13	-0.17
3.1 - 3.6	103	2	28	16	12	18	0.17
	104	4	28	15	13	12	-0.23
	105	5	23	14	9	13	-0.11
	108	5	26	14	12	14	0.00
	109	5	27	16	11	13	-0.27
	113	4	29	16	13	13	-0.23
	119	4	28	16	12	13	-0.25
3.8 - 4.3	112	6	28	16	12	14	-0.17
4.6 - 5.1	106	4	28	14	14	15	0.07
	116	4	25	14	11	14	0.00
6.1 - 6.6	104	6	22	13	9	15	0.22
	109	7	26	14	12	15	0.08
	113	7	26	14	12	17	0.25
	116	5	18	11	7	11	0.00
	118	6	25	11	14	17	0.43
7.6 - 8.1	105	10	25	14	11	19	0.45
	108	9	25	14	11	19	0.42
	119	7	23	14	9	15	0.11
7.9 - 8.4	106	6	26	15	11	18	0.27
9.1 - 9.6	105	11	26	15	11	19	0.36
	107	10	26	14	12	19	0.42
10.7 - 11.2	119	9	23	13	10	17	0.40
13.7 - 14.2	105	14	25	14	11	18	0.36
	108	13	25	14	11	21	0.64
16.7 - 17.2	107	15	24	13	11	17	0.36
	108	15	16	10	6	16	1.00
18.3 - 18.8	105	17	22	13	9	18	0.56
24.4 - 24.9	107	18	30	15	15	20	0.33
36.6 - 37.1	105	23	33	18	15	24	0.40
	108	22	30	16	14	23	0.50



LEGEND		
BH	SAMPLE	SYMBOL
109	3	☆
112	2	○
116	2	□







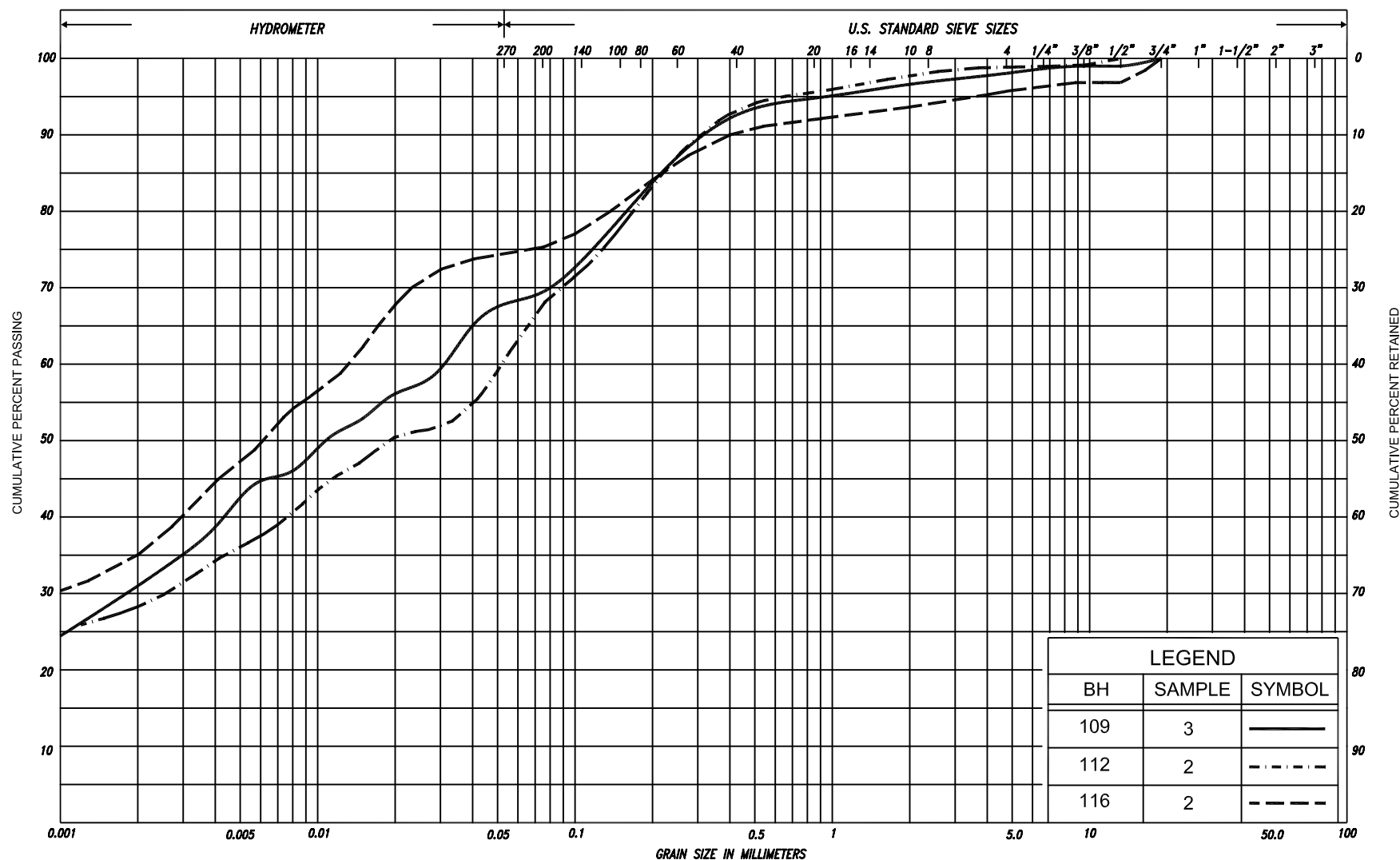
Ministry of
Transportation
Ontario

PLASTICITY CHART
CLAYEY SILT, with sand, trace gravel
(TILL)

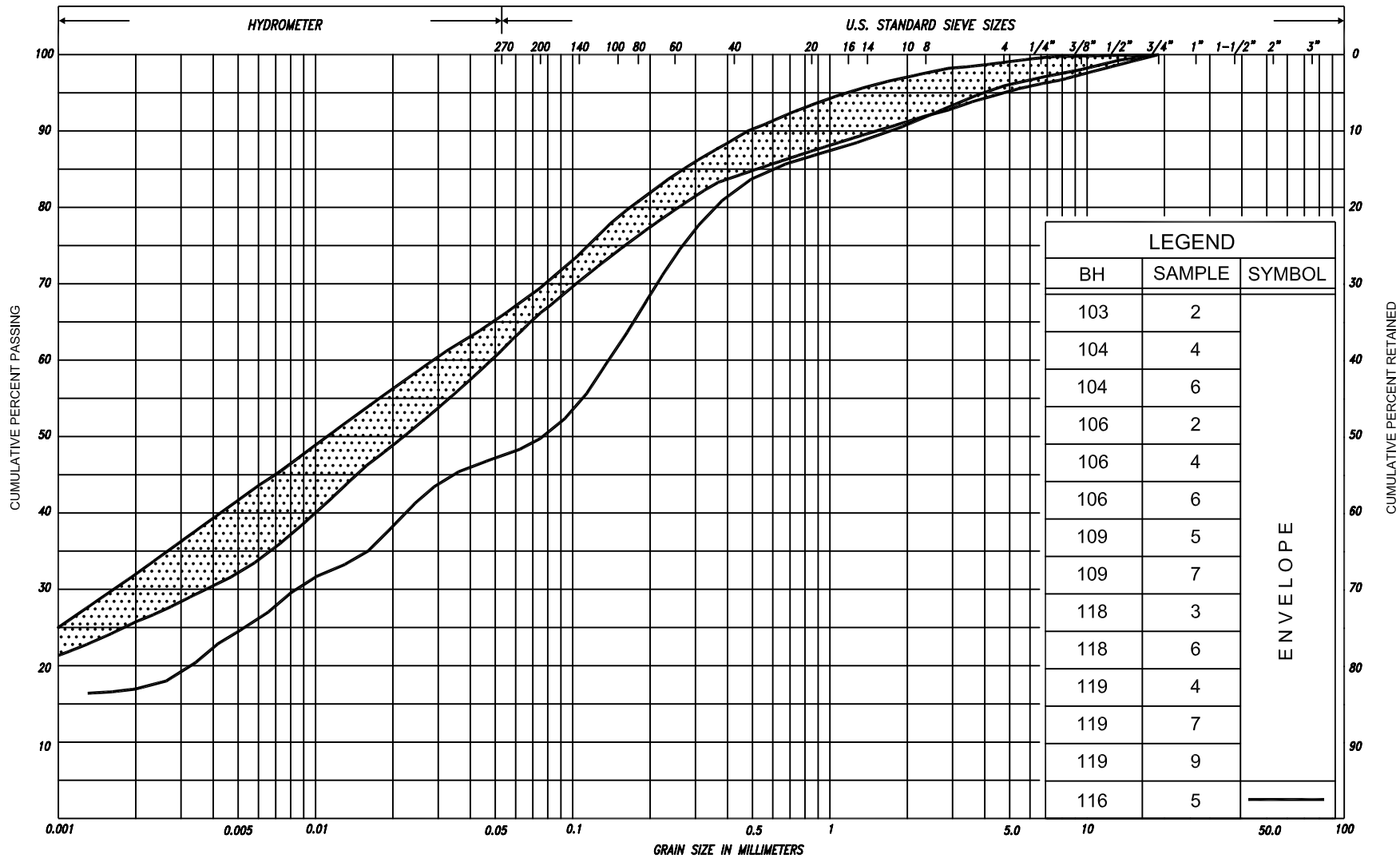
FIG No. PC-DC-4

PROJECT: HOWARD AVENUE

G.W.P. No. 3030-06-00



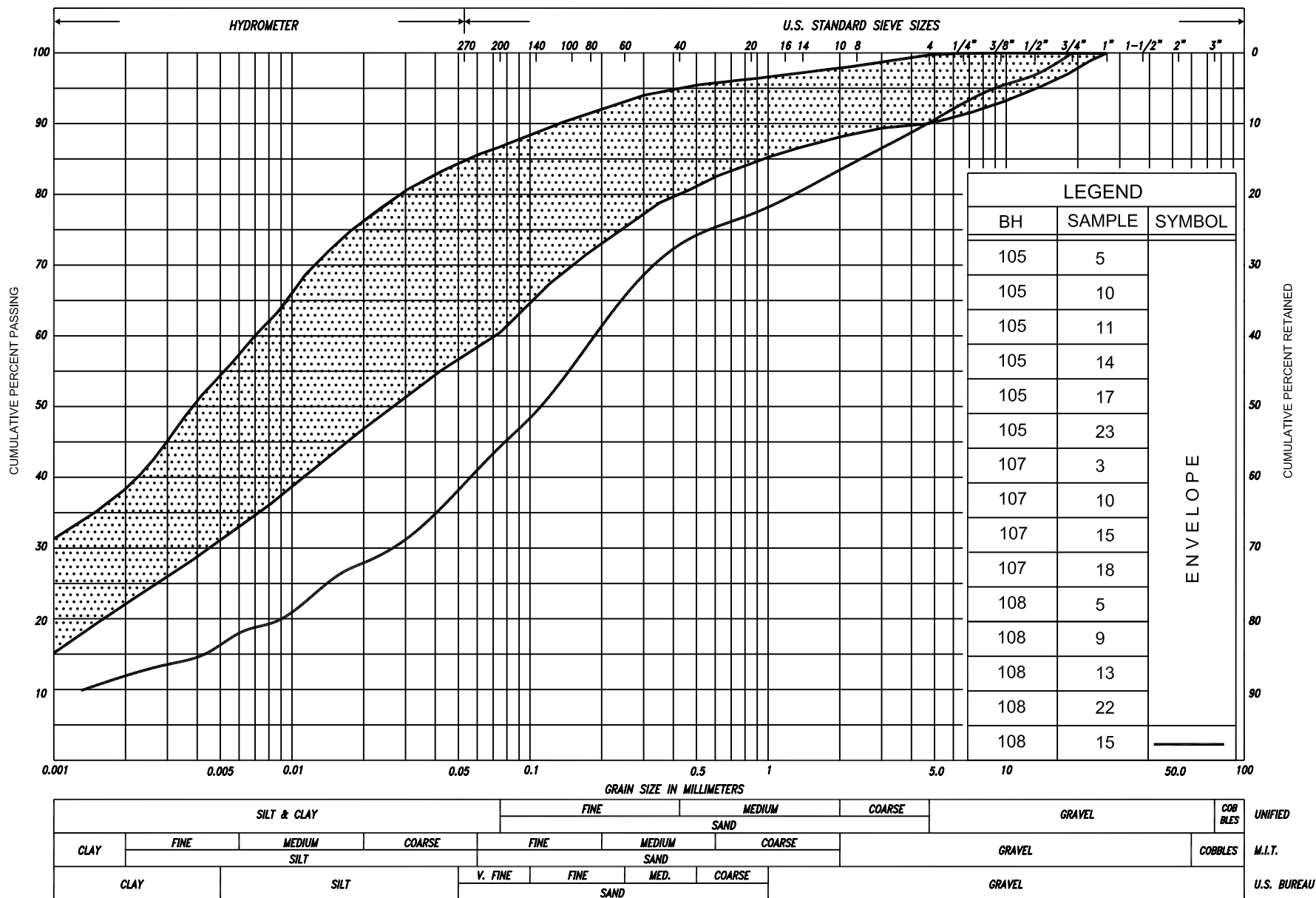
SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL			COBBLES	UNIFIED	
CLAY	FINE		MEDIUM		COARSE	FINE		MEDIUM		COARSE		GRAVEL			COBBLES	M.I.T.
	SILT				SAND		SAND		SAND		GRAVEL			COBBLES	U.S. BUREAU	
CLAY		SILT			V. FINE	FINE	MED.	COARSE	GRAVEL							U.S. BUREAU

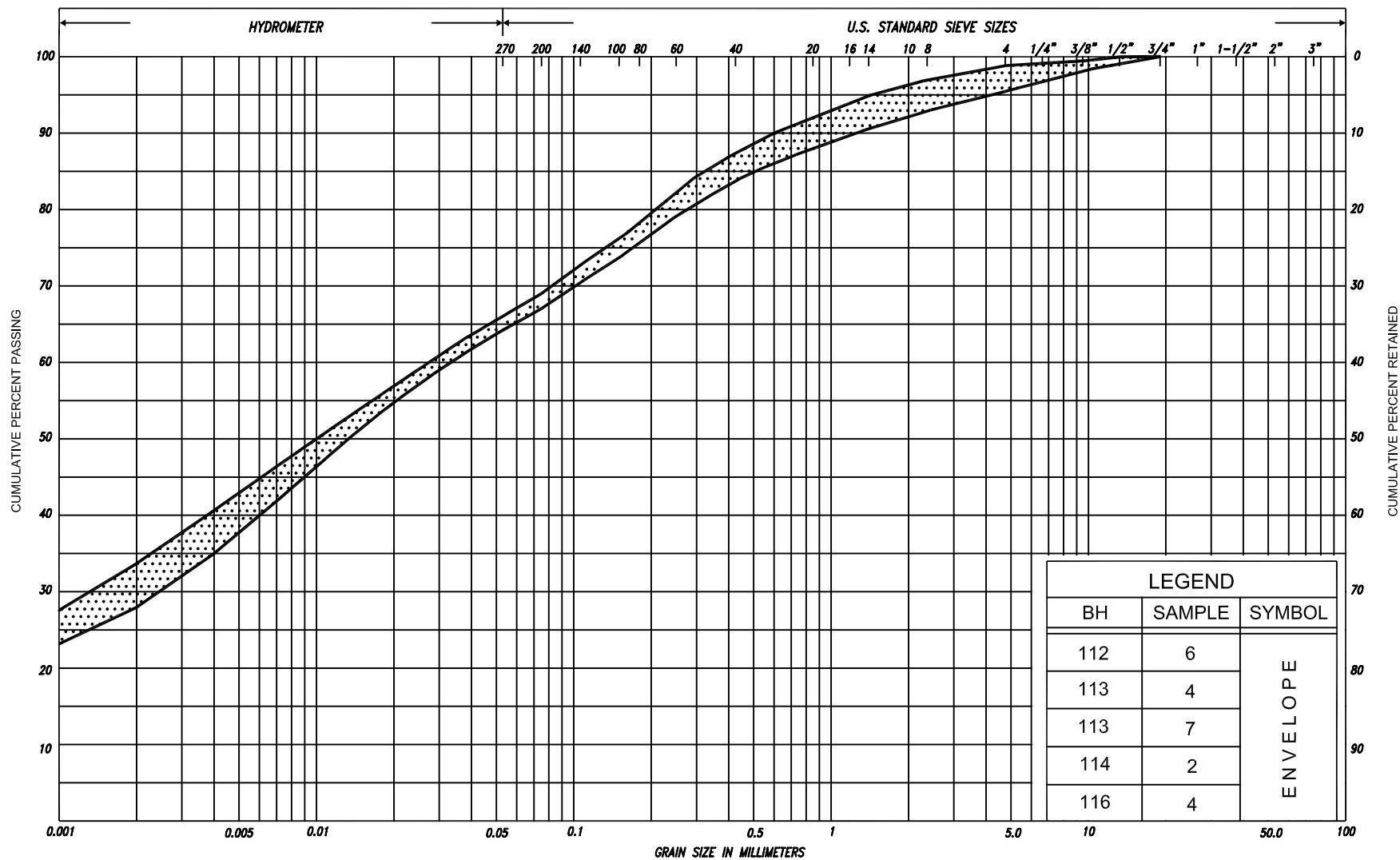


SILT & CLAY				FINE	MEDIUM	COARSE	GRAVEL		COBBLES	UNIFIED
				SAND						
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	GRAVEL		COBBLES	M.I.T.
CLAY		SILT		V. FINE	FINE	MED.	COARSE	GRAVEL		U.S. BUREAU
				SAND						

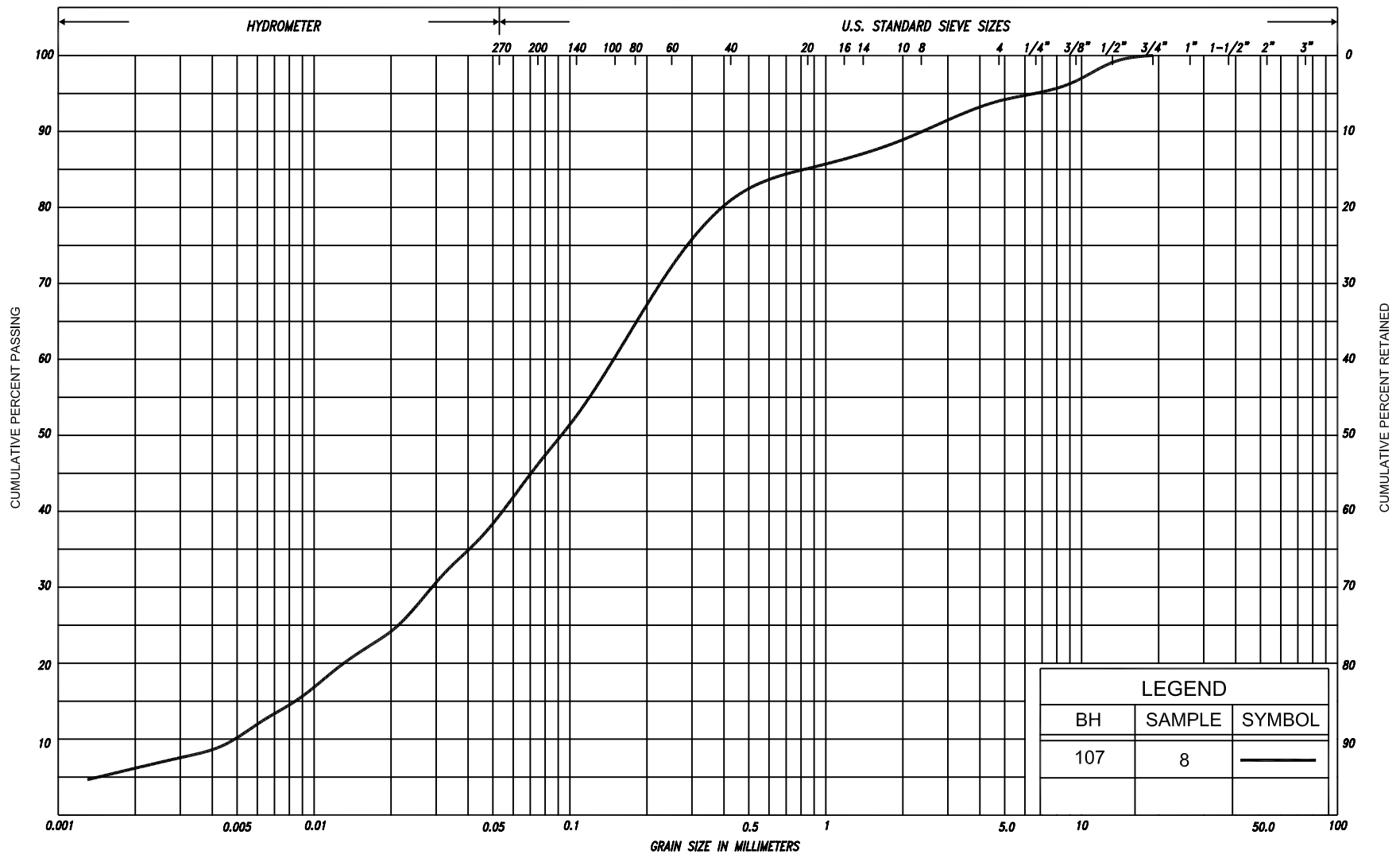
GRAIN SIZE DISTRIBUTION CLAYEY SILT, with sand to sandy, trace gravel (TILL)

FIG No. GS-DC-2
HWY: HOWARD AVENUE
G.W.P. No.3030-06-00





SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL		COBBLES	UNIFIED
CLAY	FINE		MEDIUM	COARSE	FINE	MEDIUM		COARSE	GRAVEL		COBBLES	M.I.T.
	SILT					SAND						U.S. BUREAU
CLAY		SILT			V. FINE	FINE	MED.	COARSE	GRAVEL			
					SAND							



SILT & CLAY			FINE SAND		MEDIUM SAND	COARSE SAND	GRAVEL	COBBLES	UNIFIED
CLAY	FINE	MEDIUM SILT	COARSE	FINE	MEDIUM SAND	COARSE	GRAVEL	COBBLES	M.I.T.
CLAY	SILT		V. FINE	FINE	MED. SAND	COARSE	GRAVEL		U.S. BUREAU

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
F V	FIELD VANE		

STRESS AND STRAIN

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

RECORD OF BOREHOLE No 101

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 683 841 N: 334 054 E ORIGINATED BY M.R.
 DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B.
 DATUM Geodetic DATE October 26, 2007 CHECKED BY G.D.

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
187.7	Ground Surface						20	40	60	80	100		20	40	60					
0.0	80mm asphaltic concrete over gravelly sand																			
187.3																				
0.4	Brown Moist (FILL)																			
186.9	Topsoil		1	SS	7															
0.8	Clayey silt with sand, trace gravel																			
	Firm to Brown Moist very stiff																			
185.6	(TILL)		2	SS	20															
2.1	End of borehole																			
	* Borehole dry																			

RECORD OF BOREHOLE No 102

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 683 885 N; 334 096 E ORIGINATED BY M.R.
 DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.N.
 DATUM Geodetic DATE October 26, 2007 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED	● QUICK TRIAXIAL	+	×	FIELD VANE	LAB VANE	w _p	w					
187.6 0.0	Ground Surface						20	40	60	80	100									
187.4 0.2	Sand and gravel																			
187.2 0.4	Brown (FILL) Moist																			
	Topsoil																			
	Clayey silt, sandy trace gravel		1	SS	7															
	Firm to hard Brown Moist (TILL)		2	SS	13															
			3	SS	34															
			4	SS	49															
	Grey		5	SS	17															
183.4 4.2	End of borehole																			
	* Borehole dry																			

RECORD OF BOREHOLE No 103

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 683 933 N; 334 070 E ORIGINATED BY M.R.
DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B.
DATUM Geodetic DATE October 25, 2007 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L		
								○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE	× LAB VANE						
188.0	Ground Surface							20	40	60	80	100					
0.0	270mm concrete over sand and gravel																
187.4	Brown Moist Sand, some silt																
0.6	Clayey silt, some sand topsoil inclusions						187										
186.3	Firm Brown Moist (FILL)		1	SS	13												
1.7	Clayey silt with sand, trace gravel						186										
	Stiff to Brown Moist hard (TILL)						185										
			2	SS	32												
							184										
	Grey						183										
			3	SS	12												
							182										
			4	SS	12												
181.4	End of borehole																
6.6																	
	* Borehole dry																
	■ Penetrometer test																

RECORD OF BOREHOLE No 104

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 683 975 N; 334 060 E ORIGINATED BY M.R.
DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.N.
DATUM Geodetic DATE October 09, 2008 CHECKED BY G.D.

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE										w _p w w _L		
								● QUICK TRIAXIAL × LAB VANE												
187.8	Ground Surface						20	40	60	80	100									
0.0	250mm concrete over crushed limestone																			
187.2	Grey Moist (FILL)																			
0.6	Clayey silt with sand, trace gravel		1	SS	9								○							
	Firm to Brown Moist hard		2	SS	5								○							
	(TILL)		3	SS	32								○							
			4	SS	38								○				3 30 37 30			
	Grey		5	SS	14								○	○		21.9				
			6	SS	9								○				3 29 42 26			
			7	SS	8								○							
179.7	End of borehole																			
8.1																				
	* Borehole dry																			
	■ Penetrometer test																			

RECORD OF BOREHOLE No 105

1 of 4


METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 016 N; 334 030 E ORIGINATED BY M.R.
DIST 32 HWY Howard Avenue BOREHOLE TYPE C.F.H.S.A. + Mud Rotary + NQ Coring COMPILED BY N.S.B.
DATUM Geodetic DATE October 29 to 31, 2007 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100					
188.1	Ground Surface															
0.0	Sandy silt, trace clay		1	SS	7								o			Perched water at 0.4m
187.7	Loose Brown Moist (FILL)		2	SS	3								o			
0.4	Slag and cinder Black Wet		3	SS	4								o			
	Clayey silt with sand, trace gravel		4	SS	12								o			
	Firm Brown Moist (TILL)		5	SS	28								o			
	sandy		6	SS	31								o			
	Stiff to hard		7	SS	14								o			
	Mottled grey		8	SS	10								o			
	Grey		9	SS	10								o			
				FV									o			
	Firm to stiff		10	TW	PH								o			
			11	SS	5								o			
				FV									o			
			12	SS	3								o			
				FV									o			
			13	SS	4								o			
				FV									o			
			14	SS	3								o			
				FV									o			
173.1													o			

METRIC

+⁷, ×⁵: Numbers refer to Sensitivity



(%) STRAIN AT FAILURE

METRIC

+⁷, ×⁵: Numbers refer to Sensitivity

20
15 — ○ — 5
10

(%) STRAIN AT FAILURE

METRIC[illegible][illegible]

RECORD OF BOREHOLE No 106

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 683 963 N; 334 099 E ORIGINATED BY M.R.
DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.N.
DATUM Geodetic DATE October 25, 2007 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N VALUES			SHEAR STRENGTH kPa					w _p	w	w _L		GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						WATER CONTENT (%)						
187.5	Ground Surface						20	40	60	80	100									
0.0	50mm asphaltic concrete over 250mm concrete over sand																			
187.0																				
0.5	Brown Moist (FILL)		1	SS	7								○							
	Clayey silt, sandy trace gravel																			
	Firm to Brown Moist very stiff (TILL)		2	SS	25								○							
			3	SS	38								○							
	Grey		4	SS	16								○							
			5	SS	13								○							

RECORD OF BOREHOLE No 107

1 of 4

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 048 N; 334 075 E ORIGINATED BY M.R.
DIST 32 HWY Howard Avenue BOREHOLE TYPE C.F.H.S.A. + Mud Rotary + NQ Coring COMPILED BY M.N.
DATUM Geodetic DATE October 15 to 17, 2007 and October 6 to 8, 2008 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p	w	w _L		GR	SA	SI	CL	
								○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE	× LAB VANE	WATER CONTENT (%)									
187.6	Ground Surface																				
0.0	Topsoil																				
187.4	Clayey silt with sand, trace gravel		1	SS	12																
0.2	Stiff to Brown Moist hard (TILL)		2	SS	13																
			3	SS	24																
			4	SS	25																
			5	SS	37																
	Mottled grey		6	SS	30																
	Grey		7	SS	12																
182.2	Silty sand trace clay, trace gravel																				
5.4	Compact Grey Wet (TILL)		8	SS	21																
180.7	Clayey silt with sand, trace gravel																				
6.9	Firm to Grey Moist stiff (TILL)		9	SS	3																
				FV																	
		10	TW	PH																	
				FV																	
		11	SS	6																	
				FV																	
		12	SS	4																	
				FV																	
		13	SS	3																	
				FV																	
172.6	Cont'd																				

RECORD OF BOREHOLE No 107

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METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 048 N; 334 075 E ORIGINATED BY M.R.
DIST 32 HWY Howard Avenue BOREHOLE TYPE C.F.H.S.A. + Mud Rotary + NQ Coring COMPILED BY M.N.
DATUM Geodetic DATE October 15 to 17, 2007 and October 6 to 8, 2008 CHECKED BY C.N.

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 (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		w _p	w				w _L																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
								○ UNCONFINED	+ FIELD VANE			● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
172.6								20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									</

METRIC








+⁷, ×⁵: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 107

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METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 048 N; 334 075 E ORIGINATED BY M.R.
 DIST 32 HWY Howard Avenue BOREHOLE TYPE C.F.H.S.A. + Mud Rotary + NQ Coring COMPILED BY M.N.
 DATUM Geodetic DATE October 15 to 17, 2007 and October 6 to 8, 2008 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	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																	
142.6 45.0																																
142.2 45.4	End of borehole																															
	* 2008 10 16  Water level measured after drilling  Penetrometer test Piezometer Legends :  Bentonite seal  Filter sand  Screen  Bentonite bed  Native bed Water Level Readings : <table border="1"> <thead> <tr> <th>Date</th> <th>Depth (m)</th> <th>Elev.</th> </tr> </thead> <tbody> <tr> <td>10/08/2008</td> <td>19.3</td> <td>168.3</td> </tr> <tr> <td>10/10/2008</td> <td>18.9</td> <td>168.7</td> </tr> <tr> <td>10/14/2008</td> <td>17.7</td> <td>169.9</td> </tr> <tr> <td>10/15/2008</td> <td>17.4</td> <td>170.2</td> </tr> <tr> <td>10/16/2008</td> <td>17.0</td> <td>170.6</td> </tr> </tbody> </table> C.F.H.S.A: denotes Continuous Flight Hollow Stem Augers	Date	Depth (m)	Elev.	10/08/2008	19.3	168.3	10/10/2008	18.9	168.7	10/14/2008	17.7	169.9	10/15/2008	17.4	170.2	10/16/2008	17.0	170.6													
Date	Depth (m)	Elev.																														
10/08/2008	19.3	168.3																														
10/10/2008	18.9	168.7																														
10/14/2008	17.7	169.9																														
10/15/2008	17.4	170.2																														
10/16/2008	17.0	170.6																														

RECORD OF BOREHOLE No 108

1 of 3

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 049 N; 334 023 E ORIGINATED BY M.R.
DIST 32 HWY Howard Avenue BOREHOLE TYPE C.F.H.S.A. + Mud Rotary + NQ Coring COMPILED BY N.S.B.
DATUM Geodetic DATE October 16 to 19, 2007 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			W _p	W	W _L		
188.1 0.0	Ground Surface						20 40 60 80 100								
187.9 0.2	Topsoil		1	SS	9										
187.4 0.7	Sandy silt, trace clay organics, ashes, coal														
	Loose Mottled Moist black/brown (FILL)		2	SS	13										
	Clayey silt, sandy trace gravel														
	Stiff to Brown Moist hard (TILL)		3	SS	15										
			4	SS	14										
			5	SS	28										
			6	SS	38										
			7	SS	21										
			8	SS	11										
			9	SS	8										
				FV											
			10	SS	8										
				FV											
			11	SS	5										
				FV											
			12	TW	PH										
				FV											
			13	TW	PH										
				FV											
173.1															

METRIC

+⁷, ×⁵: Numbers refer to Sensitivity


20
15 — ○ — 5
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 108

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METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 049 N; 334 023 E ORIGINATED BY M.R.
 DIST 32 HWY Howard Avenue BOREHOLE TYPE C.F.H.S.A. + Mud Rotary + NQ Coring COMPILED BY N.S.B.
 DATUM Geodetic DATE October 16 to 19, 2007 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)								
								○ UNCONFINED		+ FIELD VANE		w _p w w _L								
								● QUICK TRIAXIAL		× LAB VANE										
158.1 30.0	Clayey silt some sand, trace gravel Stiff to Grey Moist very stiff (TILL)																			
			20	SS	11															
					21	SS	14													
			22	SS	13															
										</										

RECORD OF BOREHOLE No 109

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 072 N; 333 998 E ORIGINATED BY M.R.
DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B
DATUM Geodetic DATE October 22, 2007 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p	w	w _L		
188.1	Ground Surface						20	40	60	80	100						
0.0	Sand and gravel		1	SS	28												
187.4	Sandy silt																
0.7	pieces of wood and coal																
	Compact Brown/ Moist		2	SS	9												
	(FILL)																
	Silty clay		3	SS	8												
	with sand, trace gravel																
	Stiff Brown Moist																
	(TILL)																
185.9	Clayey silt		4	SS	35												
2.2	with sand, trace gravel																
	Hard to Brown Moist		5	SS	39												
	very stiff																
	(TILL)																
			6	SS	26												
	sandy																
	Stiff Grey																
181.6			7	SS	14												
6.6	End of borehole																

RECORD OF BOREHOLE No 110

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 138 N; 333 974 E ORIGINATED BY M.R.
 DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B.
 DATUM Geodetic DATE October 23, 2007 CHECKED BY G.D.

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE								● QUICK TRIAXIAL		
188.1 0.0	Ground Surface 70mm asphaltic concrete over sand and gravel						20	40	60	80	100									
187.5 0.6	Brown Moist (FILL) Clayey silt with sand, trace gravel Firm to Brown Moist hard (TILL)		1	SS	5								○							
			2	SS	9								○							
			3	SS	39								○							
			4	SS	41								○							
184.6 3.5	End of borehole * Borehole dry																			

RECORD OF BOREHOLE No 111										1 of 1		METRIC		
G.W.P. 3030-06-00			LOCATION Co-ords: 4 684 184 N; 333 971 E			ORIGINATED BY M.R.								
DIST 32 HWY Howard Avenue			BOREHOLE TYPE Continuous Flight Solid Stem Augers			COMPILED BY N.S.B								
DATUM Geodetic			DATE October 24, 2007			CHECKED BY G.D.								
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					W _p	W
188.2	Ground Surface							20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			WATER CONTENT (%)		
0.0	Topsoil							20 40 60 80 100				20 40 60		
188.0	Gravel, trace sand		1	SS	10		188							
0.2	Compact Brown Moist (FILL)													
187.1	Clayey silt with sand, trace gravel		2	SS	10		187							
1.1	Stiff Brown Moist (TILL)													
186.2	End of borehole		3	SS	14									
2.0														
* Borehole dry														

RECORD OF BOREHOLE No 112

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 160 N; 334 008 E ORIGINATED BY M.R.
DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.N.
DATUM Geodetic DATE October 23, 2007 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N* VALUES			SHEAR STRENGTH kPa					w _p	w	w _L						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE													
188.4	Ground Surface							20	40	60	80	100									
0.0	Clayey silt topsoil inclusions		1	SS	10		188							○							
187.7	Stiff Dark Moist brown (FILL)		2	SS	10									○							
0.7	Silty clay, sandy trace gravel						187							○					1 31 40 28		
	Stiff Brown Moist (TILL)		3	SS	14									○							
186.4	Clayey silt with sand, trace gravel						186							○							
2.0	Hard Brown Moist (TILL)		4	SS	32									○							
														○							
			5	SS	40		185							○							
														○							
184.1			6	SS	37									○					1 30 38 31		
4.3	End of borehole																				
	 <																				

RECORD OF BOREHOLE No 113

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 137 N; 334 021 E ORIGINATED BY M.R.
DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.N.
DATUM Geodetic DATE October 22, 2007 CHECKED BY G.D.

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)				
								○ UNCONFINED		+ FIELD VANE								● QUICK TRIAXIAL		× LAB VANE		
188.1	Ground Surface						20	40	60	80	100						GR	SA	SI	CL		
0.0	Clayey silt, sandy topsoil inclusions and brick fragments		1	SS	13									○								
187.5	Stiff Dark brown Moist (FILL)		2	SS	6									○								
0.6	Clayey silt with sand, trace gravel																					
	Firm to Brown Moist hard (TILL)		3	SS	10									○								
			4	SS	34									○					4	29	39	28
	Grey		5	SS	16									○								
			6	SS	18									○								
181.5			7	SS	10																	
6.6	End of borehole																					
	* Borehole dry																					
	■ Penetrometer test																					

RECORD OF BOREHOLE No 114

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 140 N; 334 031 E ORIGINATED BY M.R.
DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.N.
DATUM Geodetic DATE October 22, 2007 CHECKED BY G.D.

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	● QUICK TRIAXIAL	+	×	FIELD VANE						LAB VANE		
188.1	Ground Surface						20	40	60	80	100									
0.0	Topsoil		1	SS	4															
187.7	Clayey silt with sand, trace gravel Firm to Brown Moist hard (TILL) ____ Grey ____ <																			

RECORD OF BOREHOLE No 115

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 112 N; 334 051 E ORIGINATED BY M.R.
 DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B.
 DATUM Geodetic DATE October 22, 2007 CHECKED BY G.D.

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																
								○ UNCONFINED + FIELD VANE																
								● QUICK TRIAXIAL × LAB VANE																
										WATER CONTENT (%)														
										20 40 60 80 100					20 40 60									
187.8	Ground Surface																							
0.0	Topsoil		1	SS	6		187							○										
187.5	Clayey silt with sand, trace gravel Firm to Brown Moist hard (TILL) Grey		2	SS	11									○										
0.3			3	SS	19		186							○										
			4	SS	33									○										
			5	SS	37		185							○										
							184																	
			6	SS	14		183				■			○										
							182																	
			7	SS	8		181				■			○										
179.7			8	SS	9		180							○										
8.1	End of borehole																							

RECORD OF BOREHOLE No 116

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 117 N; 334 095 E ORIGINATED BY M.R.
 DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.N.
 DATUM Geodetic DATE October 23, 2007 CHECKED BY G.D.

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 (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N* VALUES			SHEAR STRENGTH kPa					W _p W W _L						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
188.1	Ground Surface						20	40	60	80	100								
0.0	100mm asphaltic concrete over gravelly sand																		
187.9	Brown Moist (FILL)		1	SS	9														
0.2	Silty clay some sand, trace gravel																		
	Firm to Brown Moist stiff (TILL)		2	SS	10														5 20 40 35
185.2	Clayey silt with sand, trace gravel lenses of silty sand		3	SS	53														
2.9	Hard Brown Moist (TILL)																		
	Very stiff Grey		4	SS	25														2 30 38 30
	sandy																		
	Stiff		5	SS	15														4 46 33 17
180.0	End of borehole		6	SS	13														
8.1																			
	* Borehole dry																		

RECORD OF BOREHOLE No 117

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 096 N; 334 140 E ORIGINATED BY M.R.
 DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B.
 DATUM Geodetic DATE October 08, 2007 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p	w	w _L		GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)								
188.0 0.0	Ground Surface						20	40	60	80	100									
187.8 0.2	Topsoil		1	SS	12															
187.6 0.4	Sandy silt, some gravel																			
	Compact Dark brown Moist (FILL)		2	SS	11															
	Clayey silt with sand, trace gravel																			
	Stiff to Brown Moist hard (TILL)		3	SS	29															
			4	SS	58															
			5	SS	40															
	Grey		6	SS	13															
			7	SS	14															
			8	SS	10															
179.9 8.1	End of borehole																			
																		</		

RECORD OF BOREHOLE No 118

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 120 N; 334 145 E ORIGINATED BY M.R.
DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.S.B.
DATUM Geodetic DATE October 24, 2007 CHECKED BY G.D.

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
187.9	Ground Surface						20	40	60	80	100						
0.0	Clayey silt, sandy topsoil inclusions		1	SS	14												
187.5	Stiff Dark brown (FILL)		2	SS	22	187											
0.4	Clayey silt with sand, trace gravel																
	Stiff to Brown Moist hard (TILL)		3	SS	42	186										2 29 42 27	
						185											
			4	SS	50	184											
	Grey		5	SS	13	183											
						182											
181.3			6	SS	13											2 30 41 27	
6.6	End of borehole																
	* Borehole dry																
	■ Penetrometer test																

RECORD OF BOREHOLE No 119

1 of 2

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 061 N; 334 057 E ORIGINATED BY M.R.
DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.N.
DATUM Geodetic DATE October 10, 2008 CHECKED BY G.D.





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			SHEAR STRENGTH kPa						
187.8	Ground Surface													
0.0	Topsoil		1	SS	10									
187.5	Clayey silt sandy, trace gravel													
0.3	Very stiff Brown Moist to hard		2	SS	20									
	(TILL)													
			3	SS	23									
			4	SS	38									
	Stiff Grey													
			5	SS	13									
			6	SS	9									
			7	SS	9									
				FV										
			8	SS	6									
				FV										
			9	SS	4									
				FV										
176.2	End of borehole													
11.6														

RECORD OF BOREHOLE No 119

2 of 2

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 061 N; 334 057 E ORIGINATED BY M.R.
 DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.N.
 DATUM Geodetic DATE October 10, 2008 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	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													
172.8	<p><u>Piezometer Legends :</u></p> <p> Bentonite seal</p> <p> Filter sand</p> <p> Screen</p> <p> Bentonite bed</p> <p><u>Water Level Readings :</u></p> <table border="1"> <thead> <tr> <th>Date</th> <th>Depth (m)</th> <th>Elev.</th> </tr> </thead> <tbody> <tr> <td>10/14/2008</td> <td>6.2</td> <td>181.6</td> </tr> <tr> <td>10/15/2008</td> <td>4.7</td> <td>183.1</td> </tr> <tr> <td>10/16/2008</td> <td>2.6</td> <td>185.2</td> </tr> </tbody> </table>	Date	Depth (m)	Elev.	10/14/2008	6.2	181.6	10/15/2008	4.7	183.1	10/16/2008	2.6	185.2															
Date	Depth (m)	Elev.																										
10/14/2008	6.2	181.6																										
10/15/2008	4.7	183.1																										
10/16/2008	2.6	185.2																										

RECORD OF BOREHOLE No 120

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 683 921 N; 334 085 E ORIGINATED BY M.R.
 DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY M.N.
 DATUM Geodetic DATE October 09, 2008 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					w _p w w _L				
187.4	Ground Surface						20	40	60	80	100	20	40	60			
0.0	250mm concrete over sand and gravel																
186.9	Brown Moist																
0.5	Silty clay, organics topsoil inclusions		1	SS	13							○					
186.3	Stiff Dark Moist brown (FILL)		2	SS	19							○					
1.1	Clayey silt, sandy trace gravel oxidized stains																
	Very stiff Brown Moist to hard (TILL)		3	SS	31							○					
	Stiff Grey																
			4	SS	13							○					
			5	SS	9							○					
180.9	End of borehole																
6.5																	
	* Borehole dry																
	■ Penetrometer test																

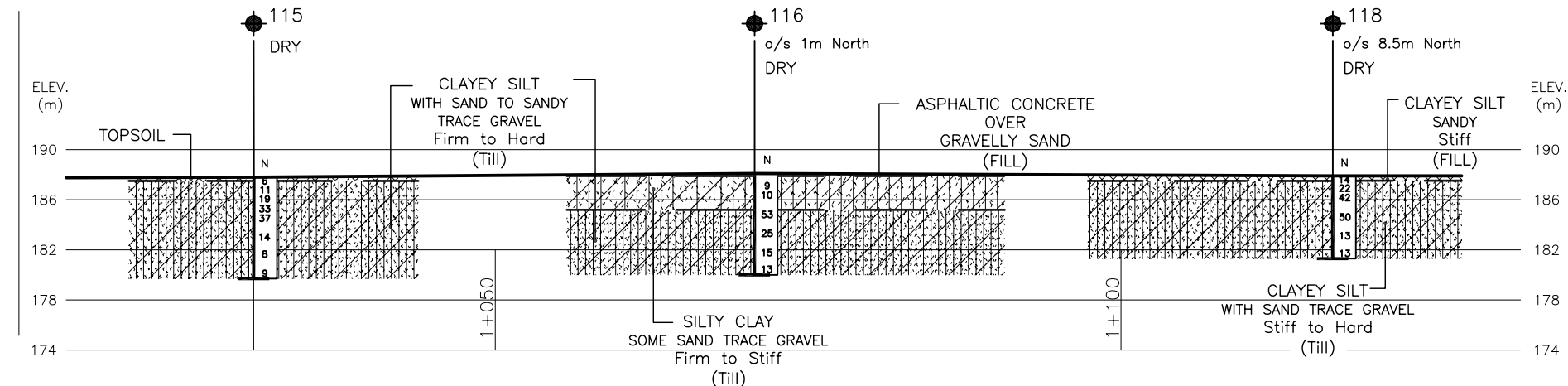
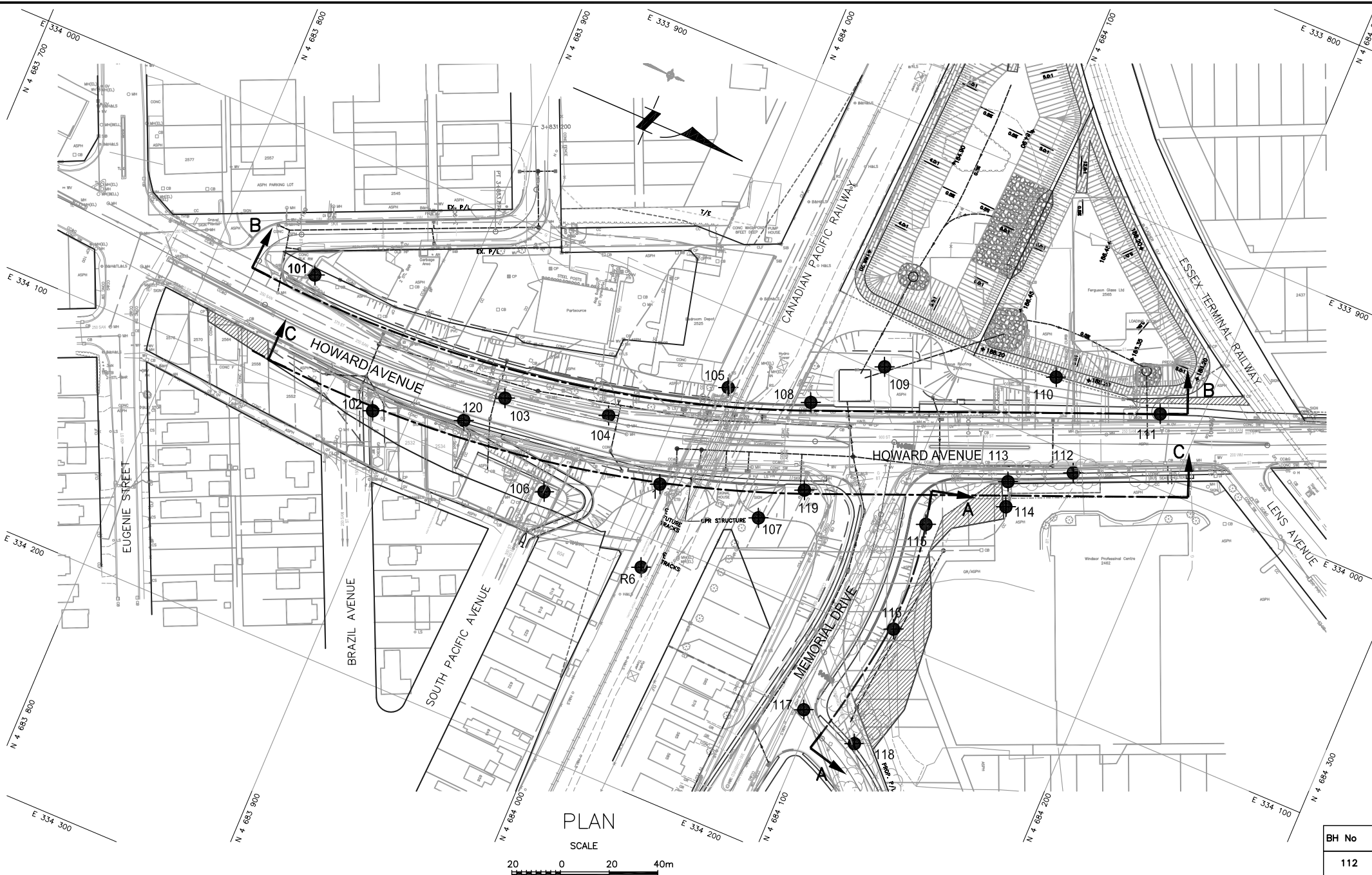
RECORD OF BOREHOLE No R6

1 of 1

METRIC

G.W.P. 3030-06-00 LOCATION Co-ords: 4 684 012 N; 334 112 E ORIGINATED BY M.R.
 DIST 32 HWY Howard Avenue BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY N.S.B.
 DATUM Geodetic DATE October 31, 2007 CHECKED BY G.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
187.8	Ground Surface																
0.0	Sand and gravel, trace silt cobbles		1	SS	13								o				
187.0	Compact Brown Moist (FILL)																
0.8	Clayey silt with sand, trace gravel		2	SS	4		187						o				
	Firm to Brown Moist very stiff		3	SS	9		186						o				
	(TILL)																
			4	SS	27		185						o				
			5	SS	23		184						o				
			6	SS	15		183						o				
	Grey																
			7	SS	6		182						o				
			8	SS	5								o				
			9	SS	12								o				
181.2	End of borehole																
6.6																	
	* Borehole dry																
	■ Penetrometer test																



NOTES:

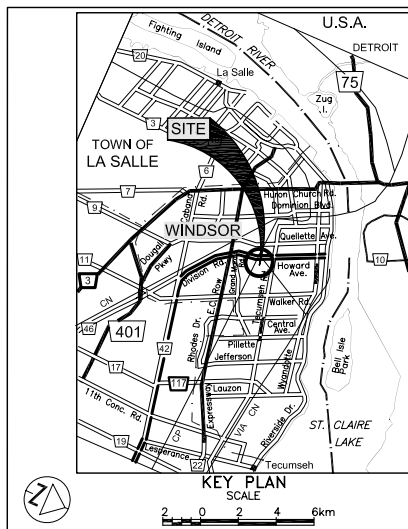
- REFER TO DRAWINGS DC-2, AND DC-3 FOR PROFILES B-B AND C-C.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.

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

CONT No
GWP No 3030-06-00
HOWARD AVENUE DEEP CUTS
CPR / HOWARD AVENUE GRADE SEPARATION
BOREHOLE LOCATIONS



PML Peto MacCallum Ltd.
CONSULTING ENGINEERS



- LEGEND**
- Borehole
 - Dynamic Cone Penetration Test (Cone)
 - Borehole & 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 Oct 2007 and Oct 2008
 - Head
 - ARTESIAN WATER Encountered
 - PIEZOMETER

(Legend Continued)

BH No	ELEVATION	STA DELAMERE TWP	o/s CL MED
112	188.4	4 684 160	334 008
113	188.1	4 684 137	334 021
114	188.1	4 684 140	334 031
115	187.8	4 684 112	334 051
116	188.1	4 684 117	334 095
117	188.0	4 684 096	334 140
118	187.9	4 684 120	334 145
119	187.8	4 684 061	334 057
120	187.4	4 683 921	334 085
R6	187.8	4 684 012	334 112
1	188.6	4 684 005	334 078

BH No	ELEVATION	COORDINATES	
		NORTHINGS	EASTINGS
101	187.7	4 683 841	334 054
102	187.6	4 683 885	334 096
103	188.0	4 683 933	334 070
104	187.8	4 683 975	334 060
105	188.1	4 684 016	334 030
106	187.5	4 683 963	334 099
107	187.6	4 684 048	334 075
108	188.1	4 684 049	334 023
109	188.1	4 684 072	333 998
110	188.1	4 684 138	333 974
111	188.2	4 684 184	333 971

(Legend Continues)

— NOTE —

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

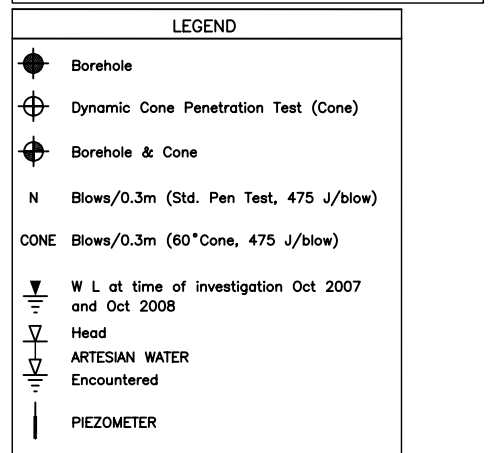
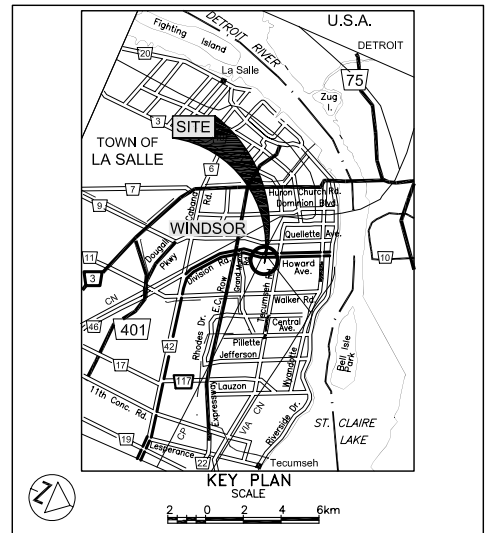
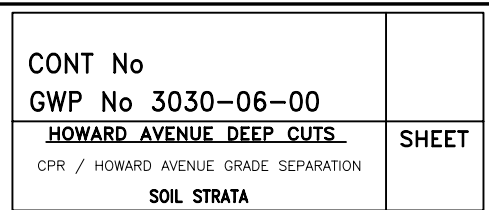


REF No MRC DRAWINGS: H6933XA01.dwg; H6933XB01.dwg;
H6933XN01.dwg; H6933xu01.dwg; H6933XY2.dwg
and H6933Xd2-prop-req.dwg; dated May 13, 2008

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 40J6-25

HWY No	HOWARD AVENUE	DIST	32
SUBM'D	GD	CHECKED	GD
DRAWN	NA	CHECKED	CN
APPROVED	BRG	DWG	DC-1



BH No	ELEVATION	COORDINATES	
		NORTHINGS	EASTINGS
SEE DRAWING DC-1 FOR DETAILS.			

- NOTE -

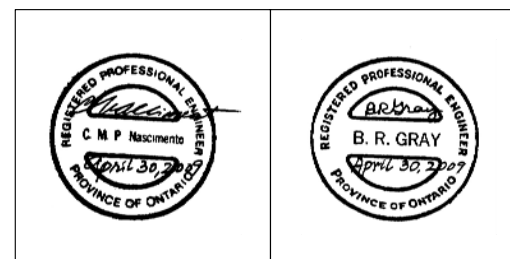
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS			
	DATE	BY	DESCRIPTION

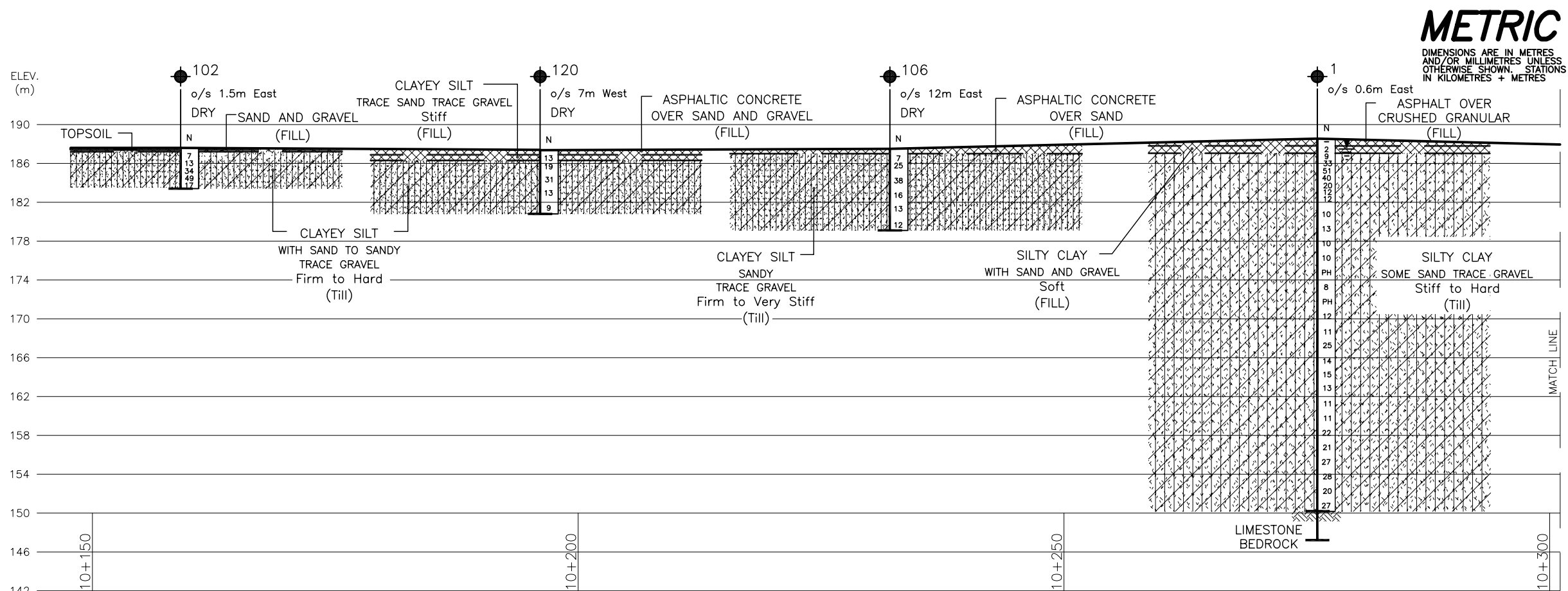
HWY No				HOWARD AVENUE				DIST		LONDON		
SUBM'D		GD	CHECKED	GD	DATE			APRIL 30, 2009		SITE		--
DRAWN		NA	CHECKED	CN	APPROVED			BRG		DWG		DC-2

SCALE

5 0 5 10m



REF No MRC DRAWINGS: H6933XA01.dwg; H6933XB01.dwg;
H6933XN01.dwg; H6933xu01.dwg; H6933XY2.dwg
and H6933Xd2-prop-req.dwg; dated May 13, 2008

***METRIC***

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

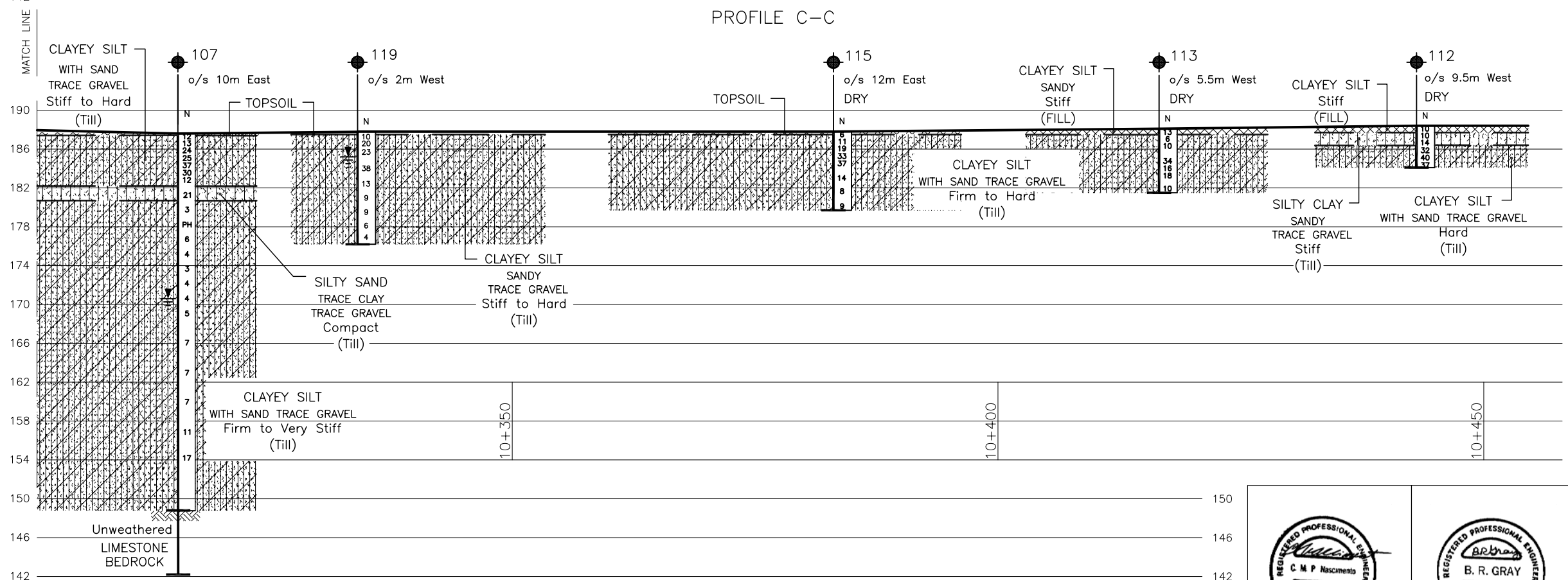
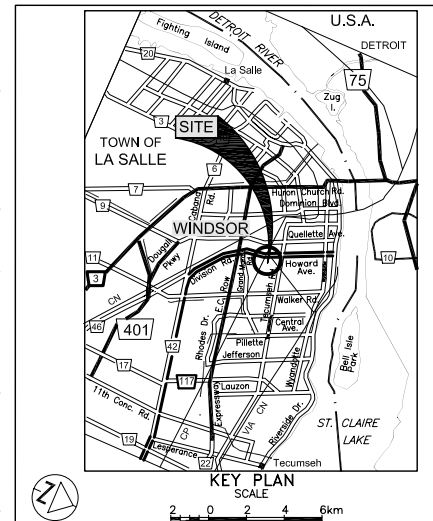
CONT No
GWP No 3030-06-00

HOWARD AVENUE DEEP CUTS

CPR / HOWARD AVENUE GRADE SEPARATION

SOIL STRATA

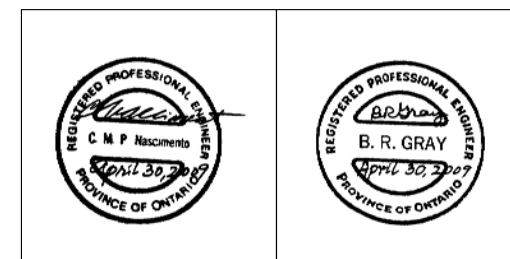
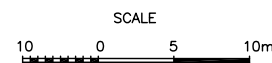
SHEET



NOTES:

1. REFER TO DRAWING DC-1 FOR BOREHOLE LOCATIONS PLAN AND DRAWINGS DC-2 AND DC-4 FOR PROFILES A-A AND C-C.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.

PROFILE C-C (Continued)



REF No MRC DRAWINGS: H6933XA01.dwg; H6933XB01.dwg;
H6933XN01.dwg; H6933xu01.dwg; H6933XY2.dwg
and H6933Xd2-prop-req.dwg; dated May 13, 2008

(Legend Continues)

- NOTE -

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS			
DATE	BY	DESCRIPTION	

Geocres No. 40J6-25

HWY No	HOWARD AVENUE			DIST	LONDON
SUBM'D	GD	CHECKED	GD	DATE	APRIL 30, 2009
				SITE	--
DRAWN	NA	CHECKED	CN	APPROVED	BRG
				DWG	DC-3



APPENDIX A

Data from Golder Associates Ltd. Preliminary Foundation Investigation Report

PROJECT: 06-1140-156

RECORD OF BOREHOLE 1

SHEET 1 OF 5

LOCATION: SEE LOCATION PLAN

BORING DATE: AUGUST 15/ 16, 2006

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE		SHEAR STRENGTH Cu, kPa				WATER CONTENT PERCENT					
							20	40	60	80	10 ⁻⁴	10 ⁻³	10 ⁻²	10 ⁻¹		
0		PAVEMENT SURFACE	188.55													
		ASPHALT	0.00													
			0.13													
		Grey, crushed granular base (FILL)		1	AS	188										
			187.79													
			0.76													
		Soft, grey, silty clay, mixed with sand and gravel (FILL)		2	SS	2										
			187.03													
			1.52													
		Stiff, mottled brown and grey, SILTY CLAY, some sand, trace gravel, fissured with silt pockets (TILL)		3	SS	3										
			186.42													
			2.13													
				4	SS	33										
		Hard, brown, SILTY CLAY, some sand, trace gravel, occ. silt pockets and fissures (TILL)		5	SS	51										
			184.28													
			4.27													
				7	SS	20										
				8	SS	12										
				9	SS	12										
		Very stiff to stiff, grey, SILTY CLAY, some sand, trace gravel (TILL)														
				10	SS	10										
				11	SS	13										

--- CONTINUED NEXT PAGE ---

August 15,
2006Minor water seepage
into borehole
encountered at about
elevation 187.48m
during drilling on August
16, 2006

MH

DEPTH SCALE

1 : 50

LOGGED: CC
CHECKED: G

LDN BHS 06-1140-156.GPJ GLDR CAN GDT 10/10/06 DATA INPUT: Tony Mastrolia

PROJECT: 06-1140-156

LOCATION: SEE LOCATION PLAN

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE 1

BORING DATE: AUGUST 15/ 16, 2006

SHEET 2 OF 5

DATUM: GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER		TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT PERCENT	
									Cu, kPa	nat V. + rem V. ⊕			U - ⊙	Wp
-- CONTINUED FROM PREVIOUS PAGE --														
10	BUD ROTARY NO CASING	Very stiff to stiff, grey, SILTY CLAY, some sand, trace gravel (TILL)		12	SS	10	179	⊕	+					
11														
12														
13														
14														
15														
16														
17														
18														
19														

-- CONTINUED NEXT PAGE --

DEPTH SCALE

1:50


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LON_BHS 06-1140-156.GPJ GLDR CAN.GDT 10/10/08 DATA INPUT: Tony Macdonald

PROJECT: 06-1140-156

LOCATION: SEE LOCATION PLAN

SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE 1

BORING DATE: AUGUST 15/ 16, 2006

SHEET 3 OF 5

DATUM GEODETIC

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES			ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		WATER CONTENT PERCENT Wp — W — Wi	ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS		
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m		SHEAR STRENGTH								
								Cu, kPa	nat V. rem V. + ⊕ ⊖ ⊙ ⊘	10 ⁻⁴ 10 ⁻³ 10 ⁻² 10 ⁻¹	10 ⁻⁴ 10 ⁻³ 10 ⁻² 10 ⁻¹				10 20 30 40	
— CONTINUED FROM PREVIOUS PAGE —																
20	MUD ROTARY HQ CASING	Very stiff to stiff, grey, SILTY CLAY, some sand, trace gravel (TILL)		18	SS	11	169									
21					167.67 20.86	19	SS	25	168							
22									167							
23				Stiff to very stiff, grey, SILTY CLAY, numerous silt pockets, some sand, trace gravel (TILL)		20	SS	14	166							
24			162.11 26.44	22	SS	13	163									

DEPTH SCALE

1:50

LOGGED: C.C.
CHECKED: [Signature]

LDN BHS 06-1140-156.GPJ GOLDER CAN.GDT 10/10/06 DATA INPUT: Terry Macdonald

LOCATION. SEE LOCATION PLAN

BORING DATE. AUGUST 15/ 16, 2006

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES		BORING METHOD	SOIL PROFILE			SAMPLES		ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
			DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE		BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT PERCENT						
										Cu, kPa	nat V. rem V. $\oplus \ominus$	wp	w					
														20 40 60 80	10 ⁻⁴ 10 ⁻³ 10 ⁻² 10 ⁻¹			
— CONTINUED FROM PREVIOUS PAGE —																		
30					159.05 20.50													
						25	SS	22										
31																		
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LDN BHS 08-1140-156.GPJ GLDR_CAN.GDT 10/7/08 DATA INPUT: Tony Macintosh

DEPTH SCALE
1:50

LOGGED: C.C.

CHECKED: 1

PROJECT: 06-1140-156

RECORD OF BOREHOLE 1

SHEET 5 OF 5

LOCATION: SEE LOCATION PLAN

BORING DATE: AUGUST 15/ 16, 2006

DATUM: GEODETIC

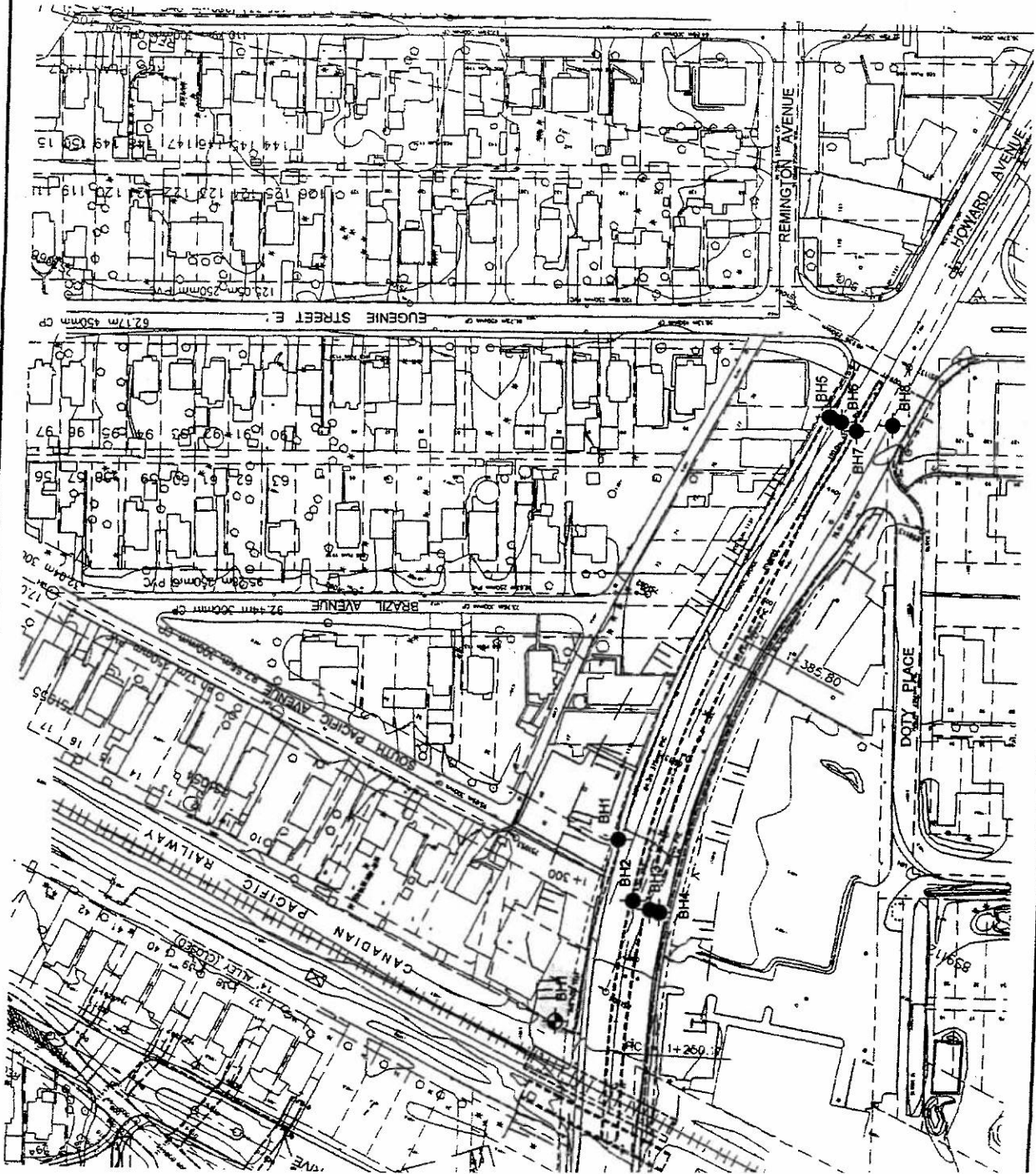
SAMPLER HAMMER, 63.5kg, DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg, DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	ELEVATION	SHEAR STRENGTH Cu, kPa				WATER CONTENT PERCENT	
									nat V. + rem V. @	Q - U -			Wp	W
— CONTINUED FROM PREVIOUS PAGE —														
40	MUD ROTARY HQ CASING	Limestone BEDROCK		31	RC		149	82		35				
				32	RC			100		0				
41				33	RC									
		END OF BOREHOLE				147.20 41.35								

DEPTH SCALE
1:50LOGGED: C.C.
CHECKED: *g*

LDN BHS 06-1140-156.GPJ GLDR CAN GDT 10/1008 DATA INPUT: Terry Macdonald



LEGEND

- BOREHOLE LOCATION (Current Investigation)
- BOREHOLE LOCATION (Previous Investigation)
Report Number 901-4047

NOTES

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH
ACCOMPANYING REPORT.

ALL LOCATIONS APPROXIMATE.

REFERENCES

CAD PLAN SUPPLIED BY: DILLON CONSULTING LIMITED
RECEIVED: September 18, 2008



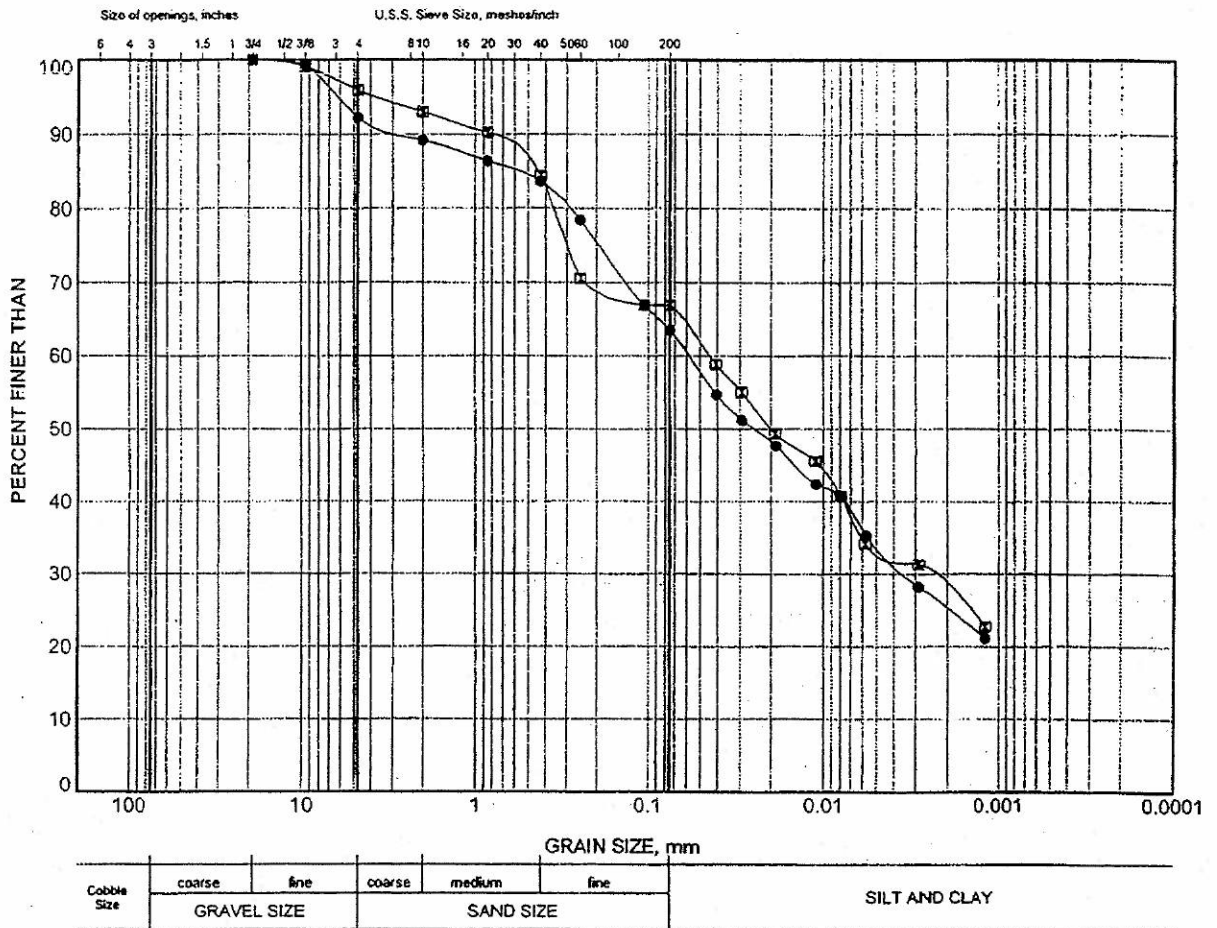
PROJECT: DILLON CONSULTING LIMITED
HOWARD AVENUE GRADE SEPARATION AT
CANADIAN PACIFIC RAILWAY, WINDSOR, ONTARIO

PROJECT No. 08-1140-156
FILE No. 0811401560001-01
SCALE: AS SHOWN
REV: 0

DESIGN: T.L.
CHECK: C.T.
DATE: OCT/09/08

LOCATION PLAN

FIGURE 2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	1	10	180.7
□	1	15	173.5

PROJECT				DILLON CONSULTING LIMITED HOWARD AVENUE GRADE SEPARATION AT CANADIAN PACIFIC RAILWAY, WINDSOR, ONTARIO			
FILE				GRAIN SIZE DISTRIBUTION UPPER GREY SILTY CLAY (TILL)			
PROJECT No.		06-1140-156		FILE No.		06-1140-156.GPJ	
DRAWN		T.M.		SCALE		N/A	
CHECK		C		REV		FIGURE 3	



LDN_GSD_NEW GLDR LDN.GOT



DETAIL FOUNDATION DESIGN REPORT

for

HOWARD AVENUE / MEMORIAL DRIVE DEEP CUTS

HOWARD AVENUE / CPR GRADE SEPARATION

GWP 3030-06-00

CITY OF WINDSOR, ONTARIO

PETO MacCALLUM LTD.
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TORONTO, ONTARIO
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Distribution:

- 5 cc: McCormick Rankin Corporation (MRC) for distribution to MTO, Project Manager – WBIIG (London) + 1 digital copy (pdf)
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PML Ref.: 07TF022A-3
Index No.: 174FDR
GEOCRES No.: 40J6-25
May 13, 2009



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2. SLOPE STABILITY ANALYSES2

3. SEISMIC DESIGN CONSIDERATIONS3

4. CONSTRUCTION CONSIDERATIONS4

 4.1 Excavation4

 4.2 Groundwater Control6

5. CLOSURE7

Table 1 – List of Standard Specifications Referenced in Report

Appendix A – Slope Stability Results

DETAIL FOUNDATION DESIGN REPORT

for

Howard Avenue / Memorial Drive Deep Cuts

Howard Avenue / CPR Grade Separation

GWP 3030-06-00

City of Windsor, Ontario

1. INTRODUCTION

This report provides foundation engineering comments and recommendations regarding permanent cut slopes along Howard Avenue and realigned Memorial Drive in the City of Windsor, Ontario. This earthwork is part of the proposed road-rail grade separation involving construction of a Canadian Pacific Railway (CPR) overhead at Howard Avenue and the lowering and reconstruction of the Howard Avenue/Memorial Drive intersection. The report was prepared for McCormick Rankin Corporation (MRC) on behalf of the Ministry of Transportation of Ontario (MTO).

The current plans call for the Howard Avenue alignment to be lowered with the cut section extending some 350 m and being up to 8 m deep at the overhead. The lowest point of the cut is to be located at approximate Station 10+298, Howard Avenue chainage. A maximum 4 m deep cut section along the realigned Memorial Drive will extend some 150 m eastward from the intersection with Howard Avenue. Recommendations for the other components of the project are provided separately.

In summary, the subsurface stratigraphy revealed in the boreholes drilled at the site generally comprised surficial fill and/or topsoil underlain by an extensive deposit of clayey silt till mantling bedrock. The consistency of the clayey silt till in the upper desiccated zone extending to depths of 4.5 to 6.5 m (elevation 181.5 to 182.5) was typically very stiff and firm to stiff below this zone. The bedrock surface was contacted at depths of 38.4 to 39.4 m.

The earth cuts shallower than 4 to 6 m will be dug within the upper desiccated zone of the cohesive till soils. The deeper cuts will be extended to the top of the typically stiff clayey silt till deposit. The right-of-way of the lowered section of Memorial Drive will be cut into the desiccated zone while the section of Howard Avenue deeper than about 6 m will extend into the non-desiccated zone.



The deep grades will be established within retaining walls which will support the lower 5.2 to 6.6 m sections with the upper zone of the cuts sloped back. It is considered feasible to establish the temporary and final conditions for the earth cuts as noted in the following sections of this report.

2. SLOPE STABILITY ANALYSES

Slope stability analyses were carried out for permanent cut slopes required for this project. The stability of cut slopes for both short-term (undrained) and long-term (drained) conditions was analysed using the limit equilibrium methods and the SLOPE/W software developed by Geo-Slope International Ltd. Aided by user input, the software analyses numerous potential failure surfaces and establishes the minimum safety factor.

The following configuration was adopted in the slope stability analyses: an 8 m high slope, the firm to stiff clayey silt till with an upper very stiff crust 4.5 m in thickness, the groundwater level 2.0 m below the crest of slope gradually decreasing to the base of excavation.

The soil parameters used in the stability analyses were obtained from field and laboratory tests and adjusted by engineering judgement in case of layered soil deposits. The effective shear strength parameters were estimated based on the data obtained during this investigation. A summary of the engineering properties assumed for the calculations is given below:

Soil Type	Unit Weight (kN/m ³)	Total Shear Strength Parameters		Effective Shear Strength Parameters	
		Cohesion (kPa)	Internal Friction (degrees)	Cohesion (kPa)	Internal Friction (degrees)
Very Stiff Clayey Silt Till	21.5	60	0	5	26
Firm to Stiff Clayey Silt Till	21.5	60	0	10	24



The total stress parameters are used in the short-term analyses (during construction) and effective stress parameters in the long-term analyses of the stable slope angle. The results of the slope stability analyses are provided in Appendix A and listed below:

Condition	Slope Inclination	Factor of Safety	Figure No.
Short Term	1H:1V	2.0	A-1
Long Term	2H:1V	1.2	A-2
	2.5H:1V	1.4	A-3
	3H:1V	1.6	A-4
	2.8H:1V	1.5	A-5

These results show that the stability of an 8 m high slope cut in the clayey silt till present at the site is more critical in the long term than during construction. The results of the stability analyses indicate that 8 m high slopes would be stable in the long term if cut at an inclination of 2.8 horizontal to 1 vertical (2.8H:1V). The safety factor of 1.5 obtained was the minimum factor of safety recommended in design of permanent slopes.

Permanent earth slopes 8 m high (or higher) should be provided with a minimum 2 m wide mid-height bench according to OPSD-202.010. This project includes retaining walls in the final configuration of the slopes, consequently it is not anticipated that the mid-height benches will be required for this project.

3. SEISMIC DESIGN CONSIDERATIONS

The site is located in Seismic Performance Zone 1. The liquefaction potential of the clayey soils was evaluated by consideration of the grain size distribution (percentage of particles < 0.005 mm in size), liquid limit values and the ratio of the water content to the liquid limit. Based on the research by Marcuson et al (1990), we believe that liquefaction of the fine grained soils (more than 35% of the soil particles passing the No. 200 sieve) is unlikely. The liquefaction potential of



the granular soils assessed using the procedure suggested by Seed and Idriss (1971) is considered unlikely as well (clause 4.6.2 of CHBDC).

4. CONSTRUCTION CONSIDERATIONS

4.1 Excavation

Excavation for the lowering of Howard Avenue and Memorial Drive and construction of the overhead structure and associated retaining walls is expected to extend through the fill and into the clayey silt till to a depth of up to 8.0 m.

All work should be carried out in accordance with the Occupational Health and Safety Act (OHSA) (Ontario Regulation 213/91) and with local/MTO regulations. The fill and firm to stiff clayey silt till are classified as Type 3 soils according to the OHSA criteria. Temporary cut slopes (to be exposed less than 3 months and protected from the weather) inclined at 45° to the horizontal should generally be stable as confirmed by the results of slope stability analyses (Figure A-1). Flatter side slopes may be required if excessively soft/wet materials or concentrated seepage zones are encountered locally.

The excavations for cut slope construction should be carried-out in accordance with OPSS 206 as amended by SP 206S03.

The retaining walls at the overhead are envisaged to employ retained soil system (RSS) walls and be constructed in a series of steps to the founding level to meet the proposed site grading and construction requirements. It is noted that construction of the RSS walls south of the CPR will require shoring along the railway diversion to facilitate excavation to the lower level of the RSS wall anchors and fill.

The slope stability analyses carried out for 8 m high slopes indicate that an adequate factor of 1.5 is achieved in case of permanent slopes cut at an inclination of 2.8H:1V or flatter. Since retaining walls are to be used in the deepest portion of the cut section along Howard Avenue, it is



recommended that permanent slopes or slopes remaining exposed longer than 3 months be inclined at 2.8H:1V or flatter for cut sections in excess of 6 m.

Shallow cuts within the upper zone of the very stiff clayey silt till are expected to be stable at steeper slopes. Thus, a 4 m high slope could be cut at an inclination of 2H:1V with a safety factor of 1.5.

It is anticipated that installation of the deep sewers in the Howard Avenue sag section will commence after or during the construction of the overhead and retaining walls. Therefore, excavation for the sewers will likely require local temporary shoring to ensure stability of the subgrade against basal heave.

The invert level of the sewer at the pumping station is planned to be at elevation 178.5 and the road grade on Howard Avenue across the station at elevation 184.2, hence the depth of excavation for installation of the sewers will be less than 6 m below the road grade. At the location of the overhead structure, the depth of excavation for the sewer is expected to be about 3.5 m below the road grade.

The sewers should be installed utilising either open cut procedures or temporary shoring. If excavation with back slopes inclined at 45° to the horizontal cannot be employed, shoring will be needed to support the vertical walls of the excavation. Alternatives for temporary shoring of the vertical walls cut for the sewer installations include sheet piles and soldier piles and lagging. The factor of safety with respect to bottom instability is calculated to be in excess of 2, therefore, the sheet piles, if required, need not extend below the base of excavation deeper than a nominal penetration of 1 m. The detail design of the temporary shoring systems should be provided by the contractor.



4.2 Groundwater Control

Perched water was detected during the augering at 1.1 m depth (elevation 187.5) in borehole 1 and at a depth of 0.4 m (elevation 187.7) in borehole 105. The water levels in deep and shallow piezometers installed in boreholes 107 and 119 were at respective depths of 17.0 and 2.6 m (elevation 170.6 and 185.2). The groundwater levels are subject to seasonal fluctuations and precipitation patterns.

Considering the relatively impervious soils revealed in the boreholes, groundwater seepage from fissures in the desiccated upper zone of the soil cover or surface water that enters the excavations for construction of the overhead and temporary cut slopes should be readily handled by conventional sump pumping techniques.

The permanent drainage of the earth slopes will be controlled by the RSS walls planned along the lower zones of the slopes. In view of the typically relatively impervious nature of the native soils, the seepage flow is expected to be low. Localized relatively more pervious zones, such as the silty sand found in borehole 107, will yield higher seepage volumes.

In general, permanent slopes should be protected against surface erosion by sodding (OPSS 571) and suitable vegetation. Refer to OPSS 572 for time constraints and type of seed and mulch required. Where more pervious strata are encountered during construction, rip-rap or granular sheeting should be provided in accordance with OPSS 511.



5. CLOSURE

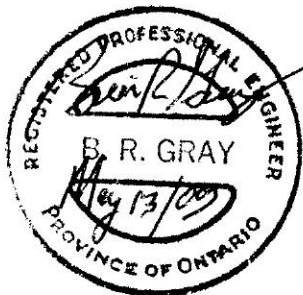
This report was prepared by Mr. G.O. Degil, PhD, P.Eng., Senior Foundation Engineer, and reviewed by Mr. C.M.P. Nascimento, P.Eng., Senior Project Engineer. Mr. B.R. Gray, MEng, P.Eng., MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.



C. M. P. Nascimento, P.Eng.
Senior Project Engineer



Brian R. Gray, MEng, P.Eng.
MTO Designated Principal Contact

GD/CN/BRG:lnr



TABLE 1
LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

DOCUMENT	TITLE
OPSS 206	Construction Specification for Grading
OPSS 511	Construction Specification for Rip-rap, Rock Protection and Granular Sheeting
OPSS 571	Construction Specification for Sodding
OPSS 572	Construction Specification for Seed and Cover
OPSD-202.010	Slope Flattening Using Excess Material on Earth or Rock Embankment
SP 109F10	Structural Reference Plans and Reports
SP 206S03	Construction Specification for Grading



APPENDIX A

Slope Stability Results

SLOPE STABILITY RESULTS

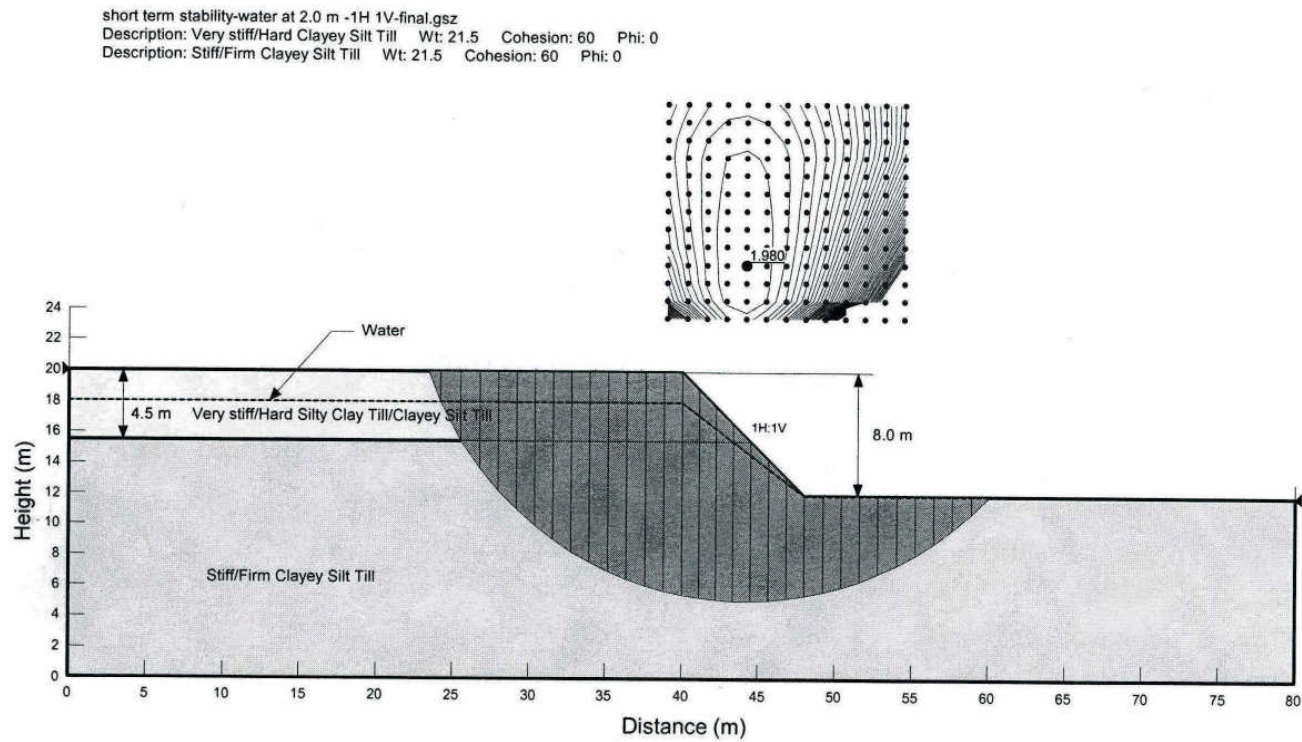


Figure A-1

SLOPE STABILITY RESULTS

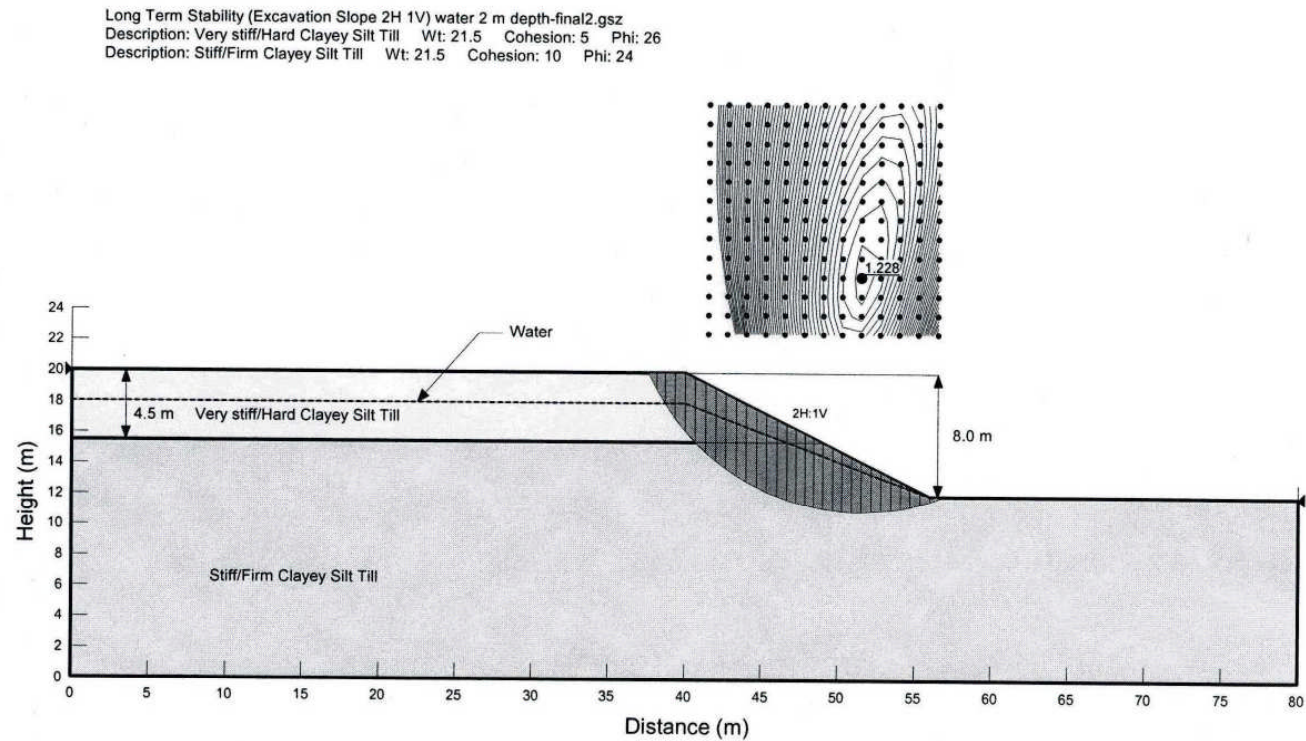


Figure A-2

SLOPE STABILITY RESULTS

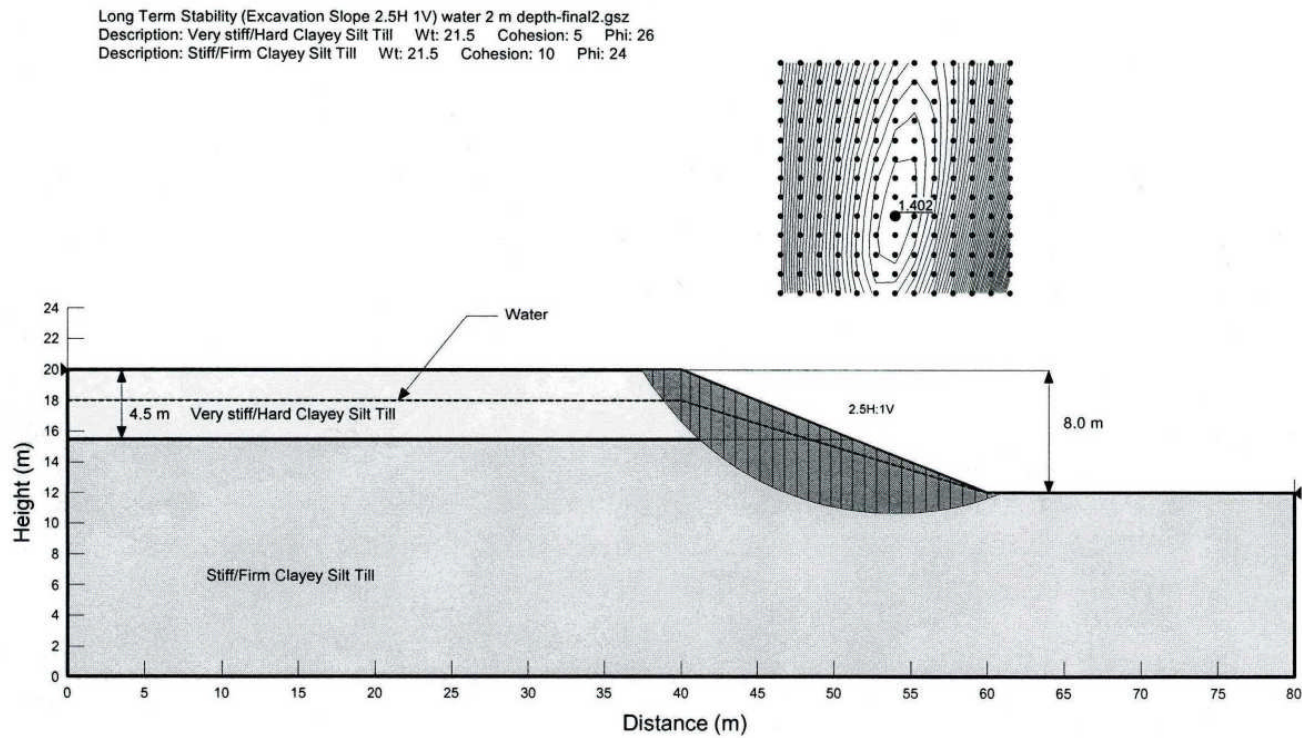


Figure A-3

SLOPE STABILITY RESULTS

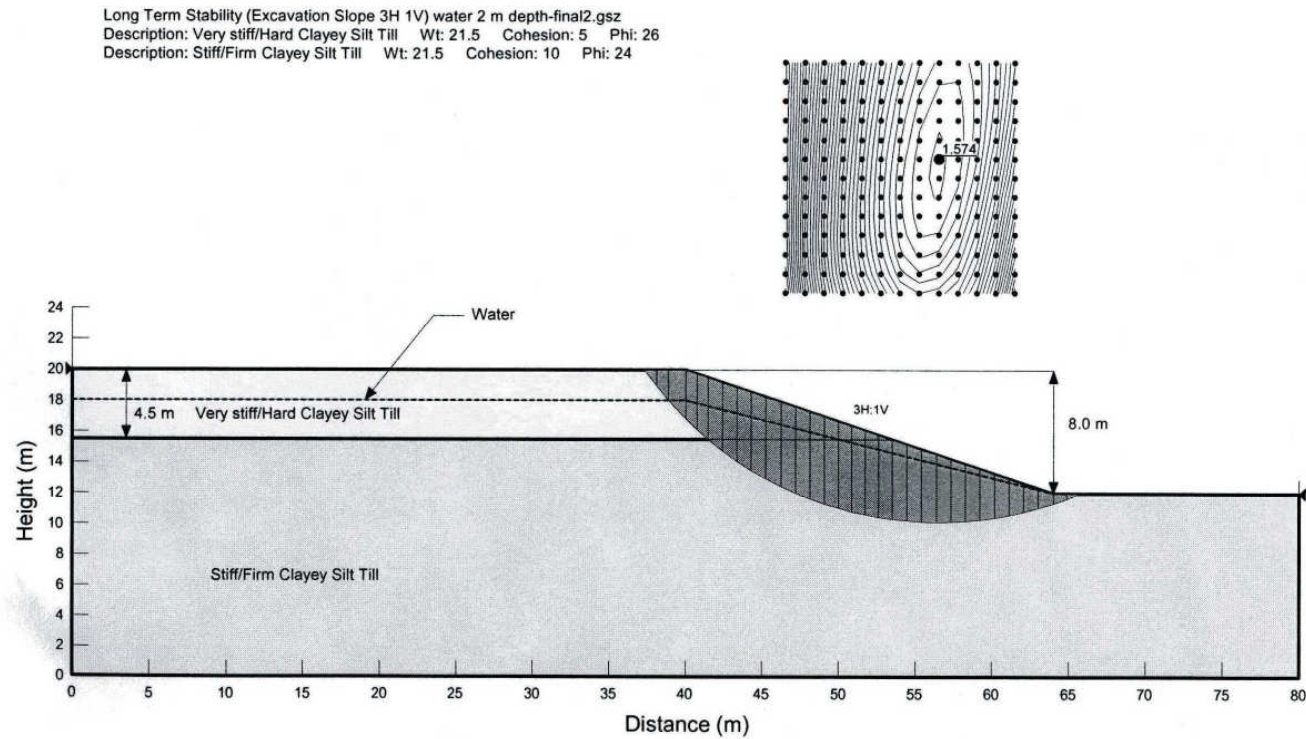


Figure A-4

SLOPE STABILITY RESULTS

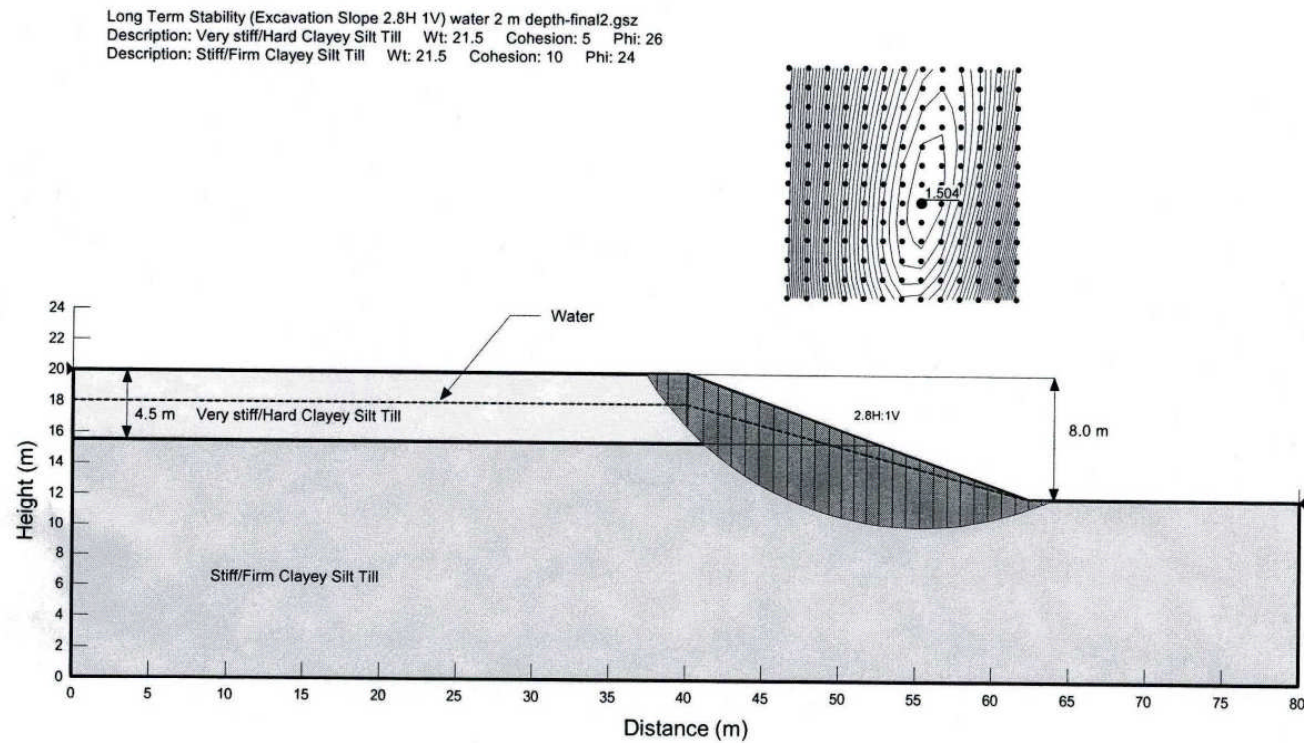


Figure A-5