



**FOUNDATION INVESTIGATION REPORT  
BRIDGE REHABILITATION OF KENNEDY ROAD UNDERPASS  
HIGHWAY 401, SITE NO. 24-181  
MISSISSAUGA, ONTARIO  
GWP 2214-14-00**

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PML Ref.: 17TF031  
Index No.: 014FIR  
GEOCRES No.: 30M12-417  
May 14, 2018



**PART A – FOUNDATION INVESTIGATION REPORT  
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**PART A – FOUNDATION INVESTIGATION REPORT**

Bridge Rehabilitation of Kennedy Road Underpass at Highway 401  
GWP 2214-14-00, Site No. 24-181  
Mississauga, Ontario

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**1. INTRODUCTION**

Peto MacCallum Limited (PML) has been retained by D.M. Wills Associates Ltd. on behalf of Ministry of Transportation Ontario (MTO), as a specialist sub-consultant to provide foundation engineering service for the rehabilitation of Highway 401 underpass at Kennedy Road located in the City of Mississauga, Ontario.

This foundation engineering service is part of Assignment No. 2017-E-0011 to provide professional services in the Central Region of MTO. The scope of work, as outlined in the Request For Quotation (RFQ) dated May 2016 under the Terms of Reference, include detail foundation investigation and design recommendations for the installation of a temporary roadway protection system to facilitate the rehabilitation work of Highway 401 Underpass at Kennedy Road. The rehabilitation work will include re-construction and repair of ballast walls, deck ends, substructure and replacement of approach slabs.

This report summarizes the results of the foundation investigation carried out for the proposed rehabilitation of Highway 401 Underpass at Kennedy Road.

**2. PREVIOUS INVESTIGATIONS**

Dominion Soil Investigation Inc. carried out an investigation on behalf of MTO for the design of existing underpass at the crossing of Highway 401 and Kennedy Road, and published a Foundation Investigation Report, dated October 1983 (GEOCREC No. 30M12-185). The fieldwork for this investigation consisted of advancing a total of twelve (12) boreholes between the periods of August 29 to September 7, 1983. Subsequent to this investigation report, the horizontal alignment of the proposed underpass was revised and as a result, MTO carried out additional foundation investigation in March of 1985. The investigation by MTO consisted of advancing five (5) additional boreholes along the new alignment. The records of borehole logs from previous investigations are provided in Appendix B.



### 3. SITE DESCRIPTION

The Kennedy Road underpass is located at the intersection of Highway 401 and Kennedy Road in the City of Mississauga, Ontario. The existing underpass is a 173.5 m long five-span structure with the abutments and piers supported on spread footings.

The topography of the project area is generally flat, with the exception of the highway embankments. The site is moderately vegetated with grass, trees and shrubs and is mainly surrounded by commercial and industrial buildings.

### 4. FIELD INVESTIGATION PROCEDURES

The fieldwork for this investigation was carried out on December 11 and 12, 2017. A total of four (4) boreholes were advanced to depths ranging from 6.6 m to 10.7 m and terminated within highly weathered shale bedrock. The Record of Borehole sheets are provided in Appendix A. The borehole location plan and soil stratigraphic profiles are presented on Drawing KD-1.

The coordinates and elevations of borehole locations and the depth of boreholes are provided in Table 1. The boreholes in the field were laid out by PML engineering staff. The borehole locations were surveyed by J.D. Barnes after completion of drilling. All the elevations (El.) reported in this report are referred to geodetic datum and expressed in meters.

**Table 1- Borehole Information**

BOREHOLE NO.	BOREHOLE LOCATION	MTM NAD 83 COORDINATES		GROUND SURFACE ELEVATION (m)	BOREHOLE DEPTH (m)
		NORTHING (m)	EASTING (m)		
17-1	North Embankment	4 832 967.1	291 120.8	197.5	9.3
17-2		4 832 989.0	291 116.3	197.1	10.7
17-3	South Embankment	4 832 821.2	291 278.9	195.4	7.8
17-4		4 832 798.4	291 284.3	194.6	6.6

PML engineering staff arranged for the clearance of underground services and appropriate permit applications. The respective utility companies cleared the underground services at the borehole locations. Public and MTO utility authorities were informed and all of the utility clearance documents were obtained prior to the commencement of drilling work. Traffic control services were provided by Jackson Trademark Services of Aurora, Ontario, in accordance with



Ontario Traffic Manual, Book 7-Temporary Conditions (2014). Fieldwork was supervised on a full-time basis by PML staff operating under the direction of an engineer.

The boreholes were advanced using continuous flight solid stem augers, powered by truck-mounted B-53 drill rig. The drilling equipment used was 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 starting from the ground surface (or immediately below the asphalt layer) and continued at 0.75 m intervals to a depth of 6.0 m and at 1.5 m intervals to the termination depths of the boreholes, using a conventional 51 mm outer diameter split spoon sampler. The sampler was driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure described in ASTM D1586. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. Attempt to obtain rock core from Borehole 17-3 and 17-4 was not successful and these boreholes were advanced into the highly weathered shale by augering and sampling using split-spoon sampler.

The soil samples were identified in the field in accordance with the MTO Soil Classification procedures and transported to the Toronto PML laboratory for further visual classification and testing. Index tests (water content determination, grain size distribution and Atterberg limits) were carried out on selected representative samples.

The groundwater conditions at the borehole locations were observed during the drilling by visual examination of the soil samples, sampler and drill rods as the samples were retrieved. In addition, water level measurements were taken in the open boreholes upon completion of drilling.

Upon completion of drilling, the boreholes were backfilled in accordance with the MTO and Regulation 903 as amended under the *Ontario Water Resources Act* R.R.O 1990 for borehole abandonment procedures.

## **5. LABORATORY TESTS**

Laboratory tests on representative Standard Penetration Test (SPT) samples recovered during the fieldwork were conducted by the laboratory owned by PML, located in Toronto, Ontario. the laboratory testing program included the following:

- Natural Moisture content determinations (41)



- Grain size distribution analysis (12)
- Atterberg limit tests (12)

All the laboratory tests to determine the index properties were performed in accordance with the MTO test procedures, which follow the American Society for Testing Materials (ASTM) standards, with the exception of hydrometer test (LS-702). The results of the grain size distribution analyses are presented on Figures GS-KD-1 to 3 and the results of Atterberg Limit tests are provided on Figure PC-KD-1 to 3. All the test results are summarised on the attached Record of Borehole Logs provided in Appendix A.

## **6. SITE GEOLOGY AND SUBSURFACE CONDITIONS**

### **6.1. Regional Geology**

The project area is generally located within the physiographic region known as Peel Plain, as outlined in *The Physiography of Southern Ontario* (Chapman and Putnam, 1973). This region covers the central portions of York, Peel, and Halton counties and is characterised by level to undulating cohesive till, containing large amounts of Palaeozoic shale and limestone.

Based on the Bedrock Geology map (MRD126-REV1, 2011) published by the Ontario Ministry of Northern Development and Mines (MNDM), the project site is located within the Queenston formation, and consists mainly of reddish brown Shale with Limestone interbeds. The Quaternary Geology map published by the MNDM, indicates that the subsurface condition in the project area consists of Halton Till (predominantly silt to silty clay matrix, high in matrix carbonate content and clast poor).

### **6.2. Subsurface Conditions**

The subsurface conditions encountered during the course of the investigation conducted by PML, together with the laboratory test results are shown on the attached Record of Borehole Sheets. The borehole locations and stratigraphic profile sections are shown on Drawing KD-1. The boundaries between soil strata have been established at the borehole locations only. The boundaries of the soil strata between and beyond the boreholes are assumed and may vary from location to location.

In general, a 300 mm to 700 mm pavement structure, followed by 3.2 m to 6.0 m of clayey silt to silty clay fill was encountered. The fill layer is immediately underlain by a 0.8 m to 3.8 m thick,



very stiff to hard clayey silt to silty clay till deposit. The till deposit overlies highly weathered reddish brown shale bedrock of Queenston Formation.

For classification purposes, the subsurface conditions encountered at this site can be divided into four (4) distinct zones:

- a) Pavement Structure
- b) Clayey Silt to Silty Clay, with Sand, Trace Gravel (Fill)
- c) Clayey Silt to Silty Clay, Some Sand, Some/Trace Gravel (Till)
- d) Shale Bedrock

#### 6.2.1 Pavement Structure

A pavement structure was encountered immediately below the existing road surface in all of the boreholes advanced during the current investigation. The pavement structure consisted of 150 mm of asphalt over silty sand with gravel. The depth of the total pavement structure, including the asphalt, varied between 300 mm and 700 mm below the road surface. The SPT N-values within the pavement structure ranged from 18 blows to 46 blows/300 mm, indicating compact to dense state of compaction. Moisture content of four (4) samples from the pavement fill material was determined, which varied between 3.1% and 3.6% with an average value of 3.4%.

#### 6.2.2 Clayey Silt to Silty Clay, with Sand, Trace Gravel (Fill)

This clayey silt to silty clay fill layer was encountered immediately below the pavement structure. The thickness of the fill ranges from 3.2 m to 6.0 m. The SPT N-values in this fill layer varied widely from as low as 11 blows/300 mm to 57 blows/280 mm, indicating a stiff to hard consistency. The moisture contents of the samples from the clayey silt to silty clay fill layer ranged from 4.3% to 19.4%, with an average of 13.0%.

The results of laboratory tests conducted on six (6) representative samples from the clayey silt to silty clay fill material are provided in Table 2. The grain size distribution curves of the selected soil samples are provided on Figure GS-KD-1 and the pertinent Atterberg limits are presented on Figure PC-KD-1 in Appendix A.





The results of the grain size distribution analysis indicate that this fill consists of 4% to 21% gravel, 16% to 39% sand, 29% to 44% silt and 17% to 29% clay. Atterberg limits tests performed on the same samples from this fill indicate liquid limit values ranging from 29 to 36, plastic limit values ranging from 15 to 22, and plasticity index values calculated range from 10 to 18. Based on the results of Atterberg limit tests, the fill material may be classified as clay of low to medium plasticity (CL/CI) in the Unified Soil Classification System (USCS).

**Table 2- Laboratory Test Results for Clayey Silt to Silty Clay Fill**

BOREHOLE	SAMPLE	DEPTH (m)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			GRAIN SIZE ANALYSIS (%)			
				W <sub>L</sub>	W <sub>P</sub>	I <sub>P</sub>	GRAVEL	SAND	SILT	CLAY
17-1	3	1.5-2	15.8	35	22	13	10	39	34	17
	6	3.8-4.3	14.0	36	19	17	11	21	43	25
	8	5.3-5.8	16.0	36	18	18	4	25	42	29
17-2	6	3.8-4.3	17.2	25	15	10	20	30	29	21
17-3	2	0.8-1.2	12.1	32	20	12	21	16	42	21
17-4	5	3.0-3.5	13.3	29	16	13	12	18	44	26

W<sub>L</sub>- Liquid limit; W<sub>P</sub> - Plastic Limit; I<sub>P</sub> - Plasticity Index

#### 6.2.3 Clayey Silt to Silty Clay, Some Sand, Some/Trace Gravel (Till)

The fill layer is immediately underlain by a very stiff to hard clayey silt to silty clay till deposit with varying proportions of sand and gravel. The thickness of this till deposit ranges from 0.8 m to 3.8 m, and extends to depths ranging from 4.6 m to 9.1 m below the existing ground surface. The SPT N-values in this deposit varied from 24 blows/300 mm to 84 blows/300 mm, indicating very stiff to hard consistency. The moisture content of this clayey silt to silty clay deposit varied from 12.3% to 20.7%, with an average value of 15.5%.

The results of laboratory tests conducted on three (3) representative samples from the clayey silt to silty clay till deposit are provided in Table 3. The grain size distribution curves of the selected soil samples are provided on Figure GS-KD-2 and the pertinent Atterberg limits are presented on Figure PC-KD-2 in Appendix A.



The results of the grain size distribution analysis indicate that this till deposit consists of 3% to 28% gravel, 19% sand, 30% to 45% silt and 23% to 34% clay. Atterberg limits tests performed on the same samples from this till indicate liquid limit values ranging from 32 to 41, plastic limit values ranging from 17 to 20, and plasticity index values calculated range from 15 to 21. Based on the results of Atterberg limit tests, the till deposit may be classified as clay of low to medium plasticity (CL/CI) in the Unified Soil Classification System (USCS).

**Table 3- Laboratory Test Results for Clayey Silt to Silty Clay Till Samples**

BOREHOLE	SAMPLE	DEPTH (m)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			GRAIN SIZE ANALYSIS (%)			
				W <sub>L</sub>	W <sub>P</sub>	I <sub>P</sub>	GRAVEL	SAND	SILT	CLAY
17-1	10	7.6-8.1	15.5	32	17	15	28	19	30	23
17-2	9	6.1-6.6	18.3	41	20	21	3	19	44	34
17-3	6	3.8-4.3	17.8	38	20	18	4	19	45	32

#### 6.2.4 Shale Bedrock

Attempt to obtain rock core from both boreholes, Borehole 17-3 and 17-4, was not successful due to the highly weathered shale bedrock of Queenston Formation encountered at this site. Both of these boreholes were advanced to a depth of 2.0 m to 2.5 m into the highly weathered shale bedrock by augering and sampling by the use of split-spoon sampler.

Highly weathered shale bedrock was encountered in all boreholes and was penetrated to depths ranging from 0.3 m to 2.5 m by augering and sampling with split spoon. The interpreted weathered shale bedrock surface elevations encountered in the current boreholes are relatively consistent with the bedrock elevations encountered in the previous boreholes reported in GEOCRE Report No. 30M12-185. 'N' values within the highly weathered shale range from 50 blows per 130 mm to 75 blows per 100 mm penetration. Moisture contents of shale samples ranged from 6.8% to 13.7% with an average value of 10.8%.

The laboratory results of tests conducted on three (3) highly weathered shale samples are provided in Table 4. The grain size distribution curves of the samples are provided on Figure GS-KD-3 and the pertinent Atterberg limits are presented on Figure PC-KD-3 in Appendix A.



The results of the grain size distribution analysis indicate that this highly weathered shale consists of particle sizes ranging from 2% to 6% gravel, 13% to 19% sand, 48% to 56% silt and 25% to 31% clay. Atterberg limit tests performed on the same samples from this weathered shale indicate liquid limit values of 36 and 37, plastic limit values of 20, and plasticity index values calculated to be 16 and 17.

**Table 4- Laboratory Test Results for Highly Weathered Shale Samples**

BOREHOLE	SAMPLE	DEPTH (m)	MOISTURE CONTENT (%)	ATTERBERG LIMITS			GRAIN SIZE ANALYSIS (%)			
				W <sub>L</sub>	W <sub>P</sub>	I <sub>P</sub>	GRAVEL	SAND	SILT	CLAY
17-2	11	9.1-9.6	11.1	37	20	17	2	19	48	31
17-3	8	5.3-5.8	12.7	36	20	16	4	18	51	27
17-4	7	4.6-5.0	13.7	36	20	16	6	13	56	25

## **7. GROUNDWATER**

Groundwater was not encountered in any of the boreholes during and upon completion of drilling. Therefore, no piezometer was installed. As a result, stabilized groundwater level was not established during drilling of the boreholes.



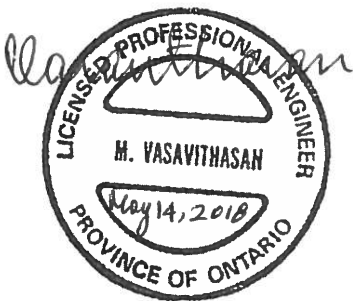
## 8. CLOSURE

The field work was carried out under the supervision of Mr. F. Okunola, Field Technician, and under the direction of Mr. N. Rahman, P.Eng. Drill Tech supplied the drilling equipment for subsurface exploration. Traffic control services were provided by Jackson Trademark Services of Aurora, Ontario. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto, Ontario.

This report was prepared by Mr. M. Kargar, M.Sc., EIT, and reviewed by Mr. M. Vasavithasan, MSc. Eng., P.Eng. and Mr. R. Ng, PhD, MBA, P.Eng. MTO Designated Principal Contact conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.



Mr. Mark Vasavithasan, M.Sc. Eng., P.Eng.  
Project Engineer, Geotechnical Services



Robert Ng, PhD, MBA, P.Eng.  
MTO Designated Principal Contact



## **APPENDIX A**

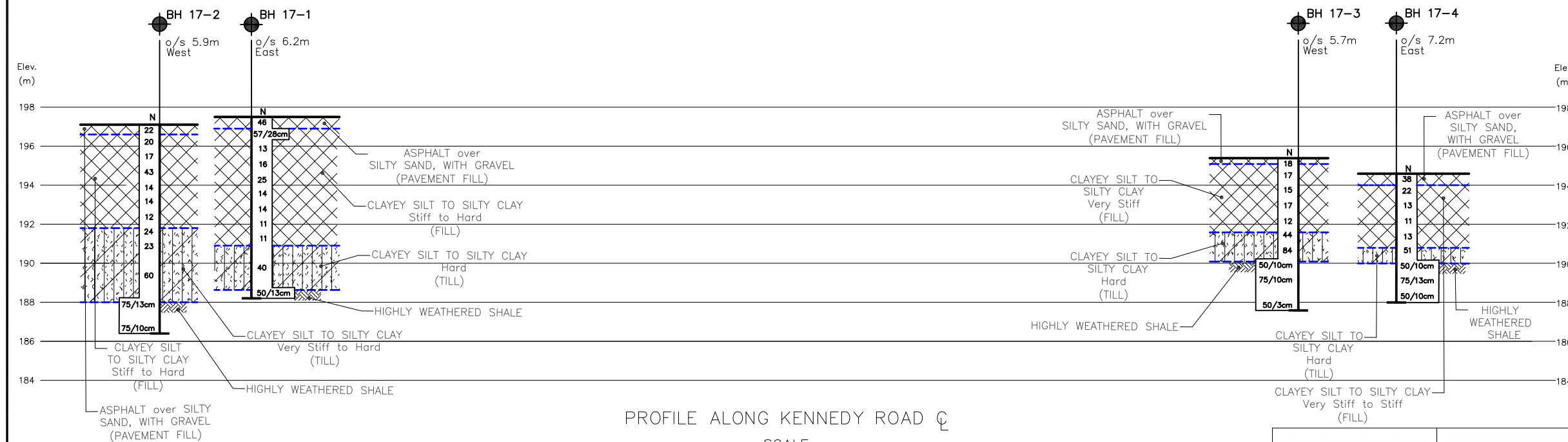
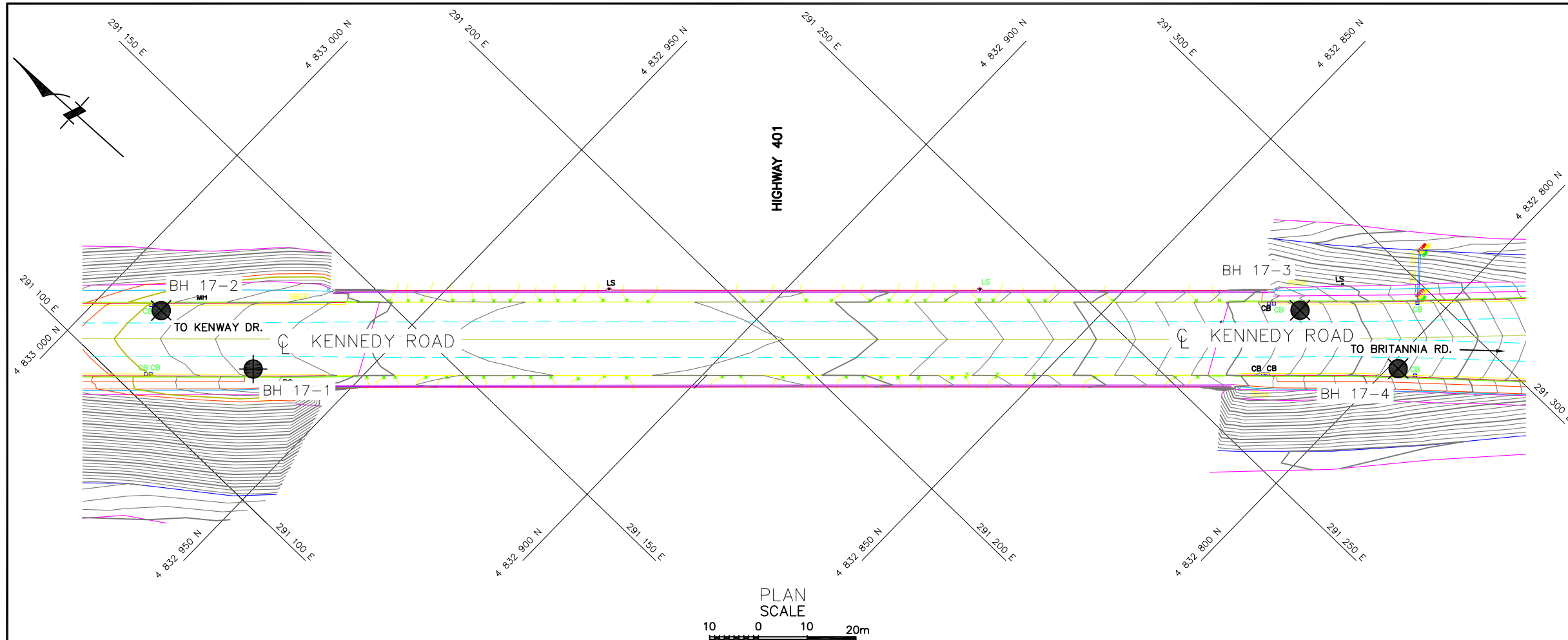
Borehole Locations Plan and Soil Strata - Drawing KD-1

Explanation of Terms Used in Report

Record of Borehole Sheets

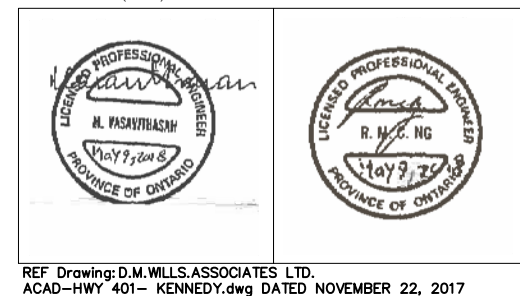
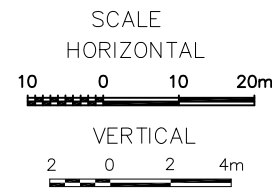
Results of Grain Size Distribution Analyses - Figures GS-KD-1 to GS-KD-3

Results of Atterberg Limit Tests- Figures PC-KD-1 to PC-KD-3



LEGEND			
Borehole			
N Blows/0.3m (Std. Pen Test, 475 J/blow)			
BH No	ELEVATION	NORTHINGS	EASTINGS
BH 17-1	197.5	4 832 967.1	291 120.8
BH 17-2	197.1	4 832 989.0	291 116.3
BH 17-3	195.4	4 832 821.2	291 278.9
BH 17-4	194.6	4 832 798.4	291 284.3

- NOTES:
- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
  - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
  - DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



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. 30M12-417

HWY No	401	DIST	24-181
SUBM'D	TC	CHECKED MK	DATE MAY 9, 2018
DRAWN	TC	CHECKED MK	APPROVED RN
			DWG KD-1

## 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.

**COMPOSITION:** SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0 - 10	10 - 20	20 - 30	30 - 40	> 40
	TRACE	SOME	WITH	ADJECTIVE (SILTY)	AND (AND SILT)

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_i$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL


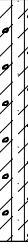

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	n	1, %	POROSITY	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	w	1, %	WATER CONTENT	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$S_r$	%	DEGREE OF SATURATION	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$w_L$	%	LIQUID LIMIT	D	mm	GRAIN DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_p$	%	PLASTIC LIMIT	$D_n$	mm	n PERCENT - DIAMETER
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_s$	%	SHRINKAGE LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	h	m	HYDRAULIC HEAD OR POTENTIAL
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	q	m <sup>3</sup> /s	RATE OF DISCHARGE
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	v	m/s	DISCHARGE VELOCITY
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	i	1	HYDRAULIC GRADIENT
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	k	m/s	HYDRAULIC CONDUCTIVITY
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL	WTP		WETTER THAN PLASTIC LIMIT	j	kN/m <sup>3</sup>	SEEPAGE FORCE
e	1, %	VOID RATIO						

# RECORD OF BOREHOLE No 17-1

1 OF 1

METRIC

G.W.P. 2214-14-00 LOCATION Coords: 4 832 967.1 N; 291 120.8 E ORIGINATED BY F.O.  
 DIST Central HWY 401 BOREHOLE TYPE Continuous Flight Solid Stem Auger COMPILED BY M.Ka.  
 DATUM Geodetic DATE 2017.12.11 LATITUDE 43.636519 LONGITUDE -79.669536 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	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	20	40	60						80	100	20
197.5 0.0	GROUND SURFACE 150 mm ASPHALT over silty sand with gravel						197										10 39 34 17			
196.9 0.6	(PAVEMENT FILL)		1	SS	46															
	CLAYEY SILT TO SILTY CLAY, with sand, trace/some gravel		2	SS	57/28cm															
	Stiff to hard, brown, moist																			
			3	SS	13															
			4	SS	16															
			5	SS	25															
		6	SS	14																
		7	SS	14																
		8	SS	11																
	(FILL)	9	SS	11																
190.9 6.6	CLAYEY SILT TO SILTY CLAY, with sand, some gravel						191										28 19 29 24			
	Hard, brown, moist		10	SS	40															
	(TILL)																			
188.5 9.0	SHALE BEDROCK						190													
188.2 9.3	Highly Weathered		11	SS	50/13cm															
	End of borehole																			
NOTE: Groundwater was not encountered during and upon completion of drilling																				



## METRIC

[illegible]

ONTARIO MTO 17TF031.GPJ ONTARIO MTO.GDT 5/9/18

+ 3, × 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No 17-3

1 OF 1

METRIC

G.W.P. 2214-14-00 LOCATION Coords: 4 832 821.2 N; 291 278.9 E ORIGINATED BY F.O.  
 DIST Central HWY 401 BOREHOLE TYPE Continuous Flight Solid Stem Auger COMPILED BY M.Ka.  
 DATUM Geodetic DATE 2017.12.12 LATITUDE 43.635209 LONGITUDE -79.667573 CHECKED BY M.V.











SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
								○ UNCONFINED	+ FIELD VANE										● QUICK TRIAXIAL		
195.4	GROUND SURFACE						20	40	60	80	100										
0.0	150 mm ASPHALT over silty sand with gravel																				
195.1	(PAVEMENT FILL)		1	SS	18																
0.3	CLAYEY SILT TO SILTY CLAY, with sand, trace gravel		2	SS	17																
	Very stiff, brown, moist																				
	(FILL)		3	SS	15																
			4	SS	17																
			5	SS	12																
191.6	CLAYEY SILT TO SILTY CLAY, some sand, trace gravel		6	SS	44																
3.8	Hard, brown, moist		7	SS	84																
	(TILL)																				
190.1	SHALE BEDROCK		8	SS	50/10cm																
5.3	Highly Weathered		9	SS	75/10cm																
			10	SS	50/3cm																
187.6	End of borehole																				
7.8																					
	NOTE: Groundwater was not encountered during and upon completion of drilling																				

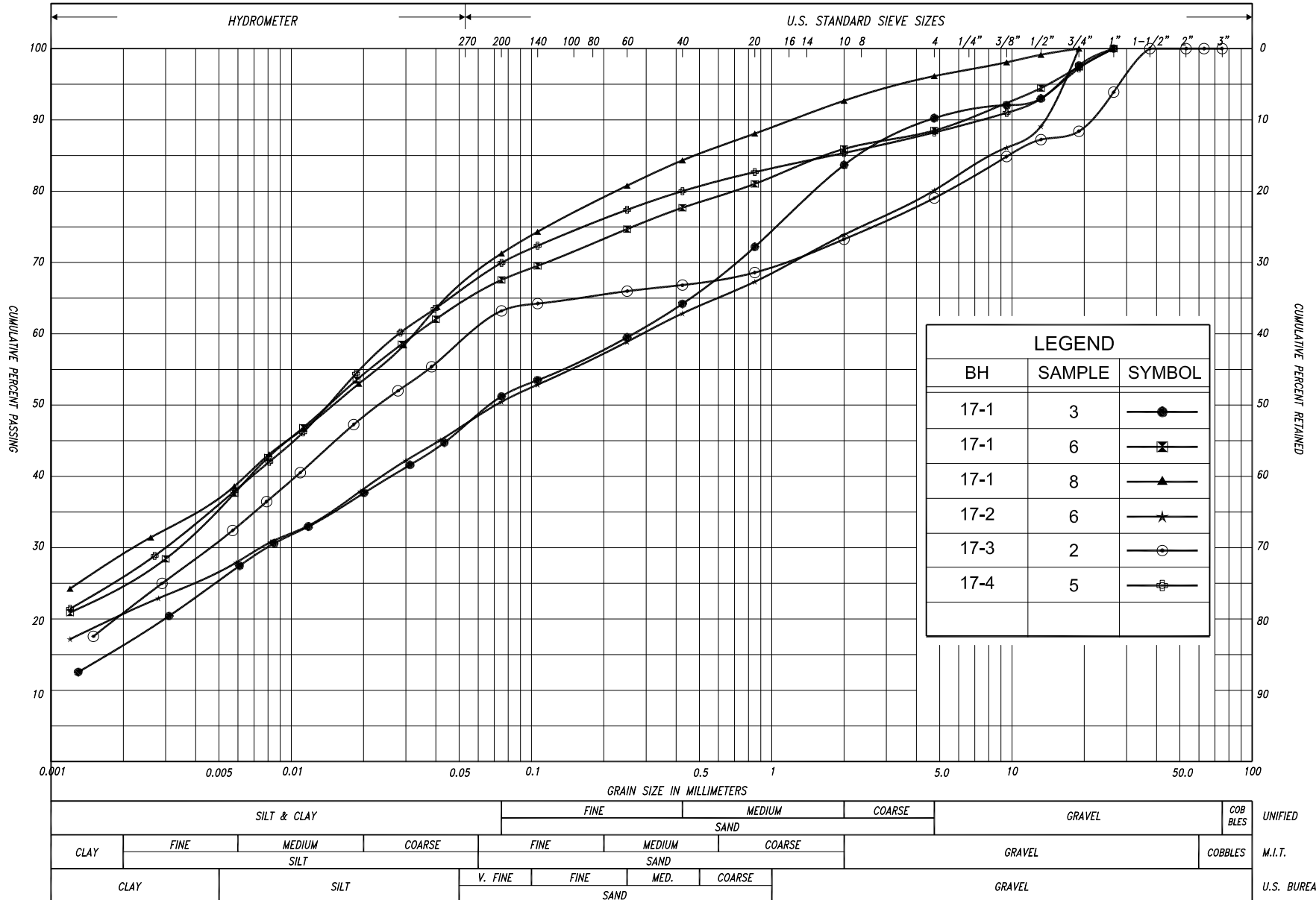
# RECORD OF BOREHOLE No 17-4

1 OF 1

METRIC

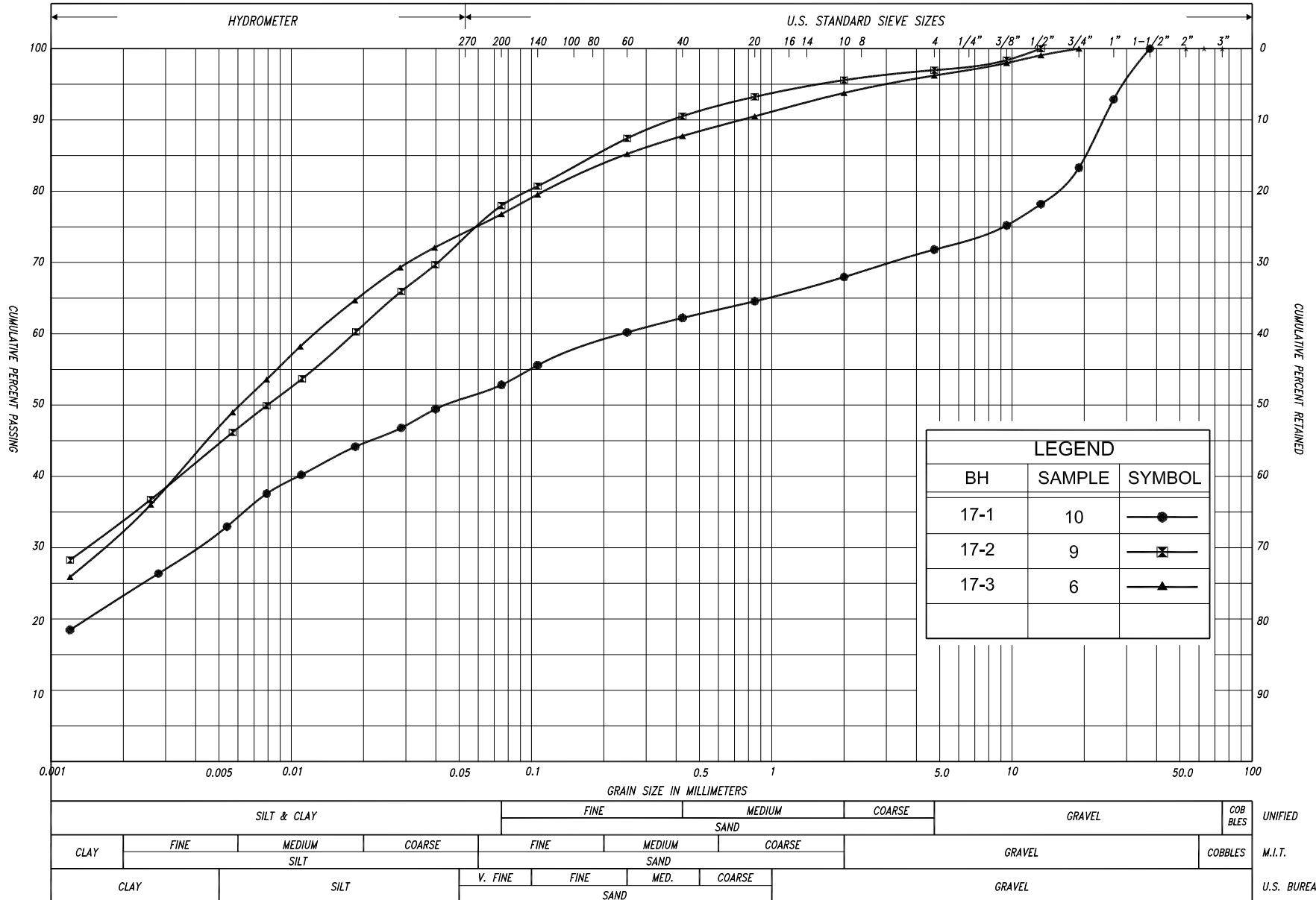
G.W.P. 2214-14-00 LOCATION Coords: 4 832 798.4 N; 291 284.3 E ORIGINATED BY F.O.  
 DIST Central HWY 401 BOREHOLE TYPE Continuous Flight Solid Stem Auger COMPILED BY M.Ka.  
 DATUM Geodetic DATE 2017.12.11 LATITUDE 43.635004 LONGITUDE -79.667506 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	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	20						40	60	80
194.6 0.0	GROUND SURFACE 150 mm ASPHALT over silty sand with gravel																			
194.0 0.6	(PAVEMENT FILL) CLAYEY SILT TO SILTY CLAY, with sand, trace gravel Very stiff to stiff, brown, moist		1	SS	38								○							
			2	SS	22								○							
			3	SS	13								○							
			4	SS	11								○							
			5	SS	13								○	—						
190.8 3.8	(FILL) CLAYEY SILT TO SILTY CLAY, some sand, some gravel Hard, brown, moist		6	SS	51								○							
190.0 4.6	(TILL) SHALE BEDROCK Highly Weathered		7	SS	50/10cm								○	—						
			8	SS	75/13cm								○							
			9	SS	50/10cm								○							
188.0 6.6	End of borehole																			
	NOTE: Groundwater was not encountered during and upon completion of drilling																			



**GRAIN SIZE DISTRIBUTION**  
 CLAYEY SILT TO SILTY CLAY, with sand, trace gravel  
 (FILL)

FIG No.	GS-KD-1
HWY	401
G.W.P.	2214-14-00

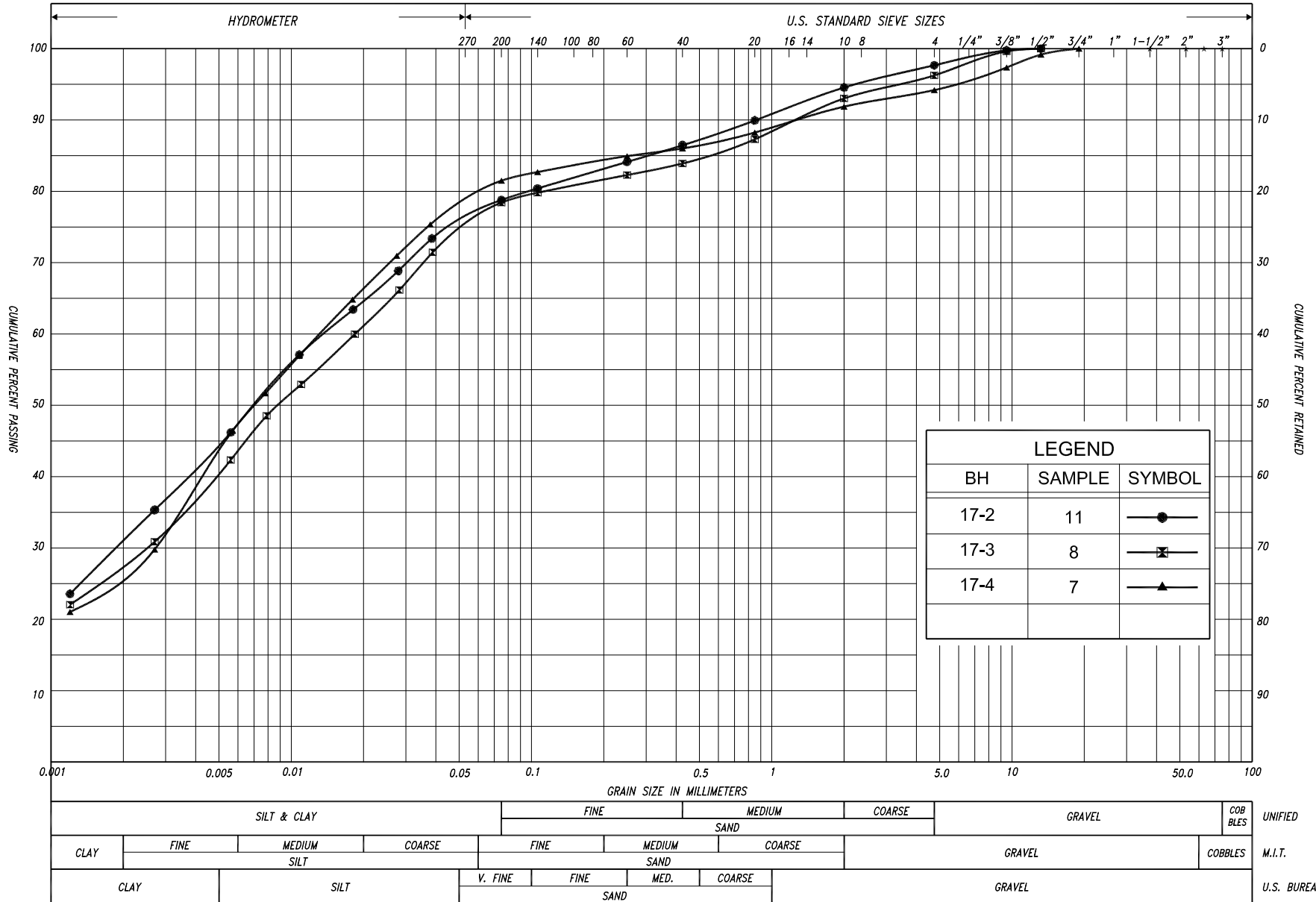


# GRAIN SIZE DISTRIBUTION CLAYEY SILT TO SILTY CLAY, with sand, trace / some gravel (TILL)

FIG No. GS-KD-2

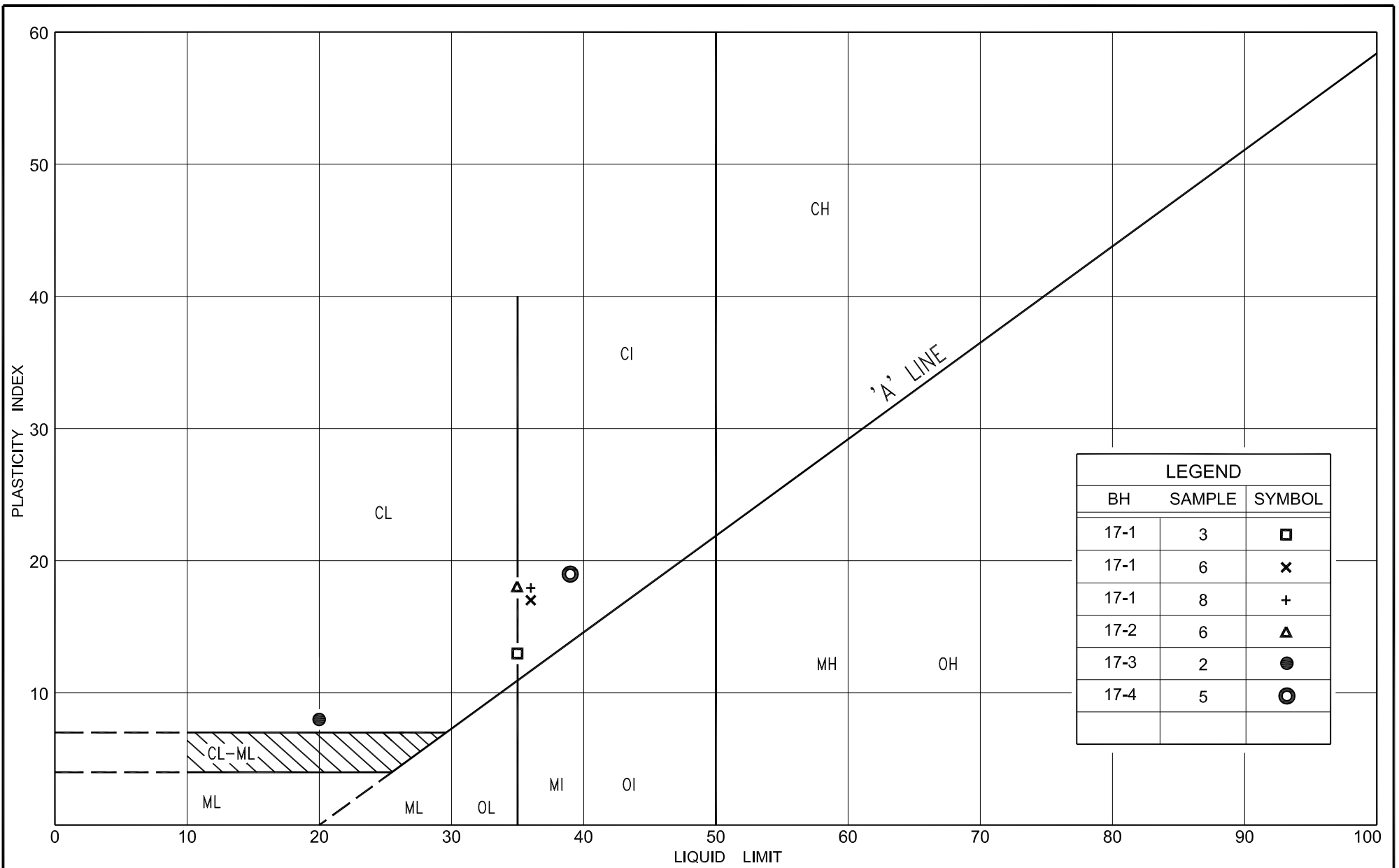
HWY 401

G.W.P. 2214-14-00



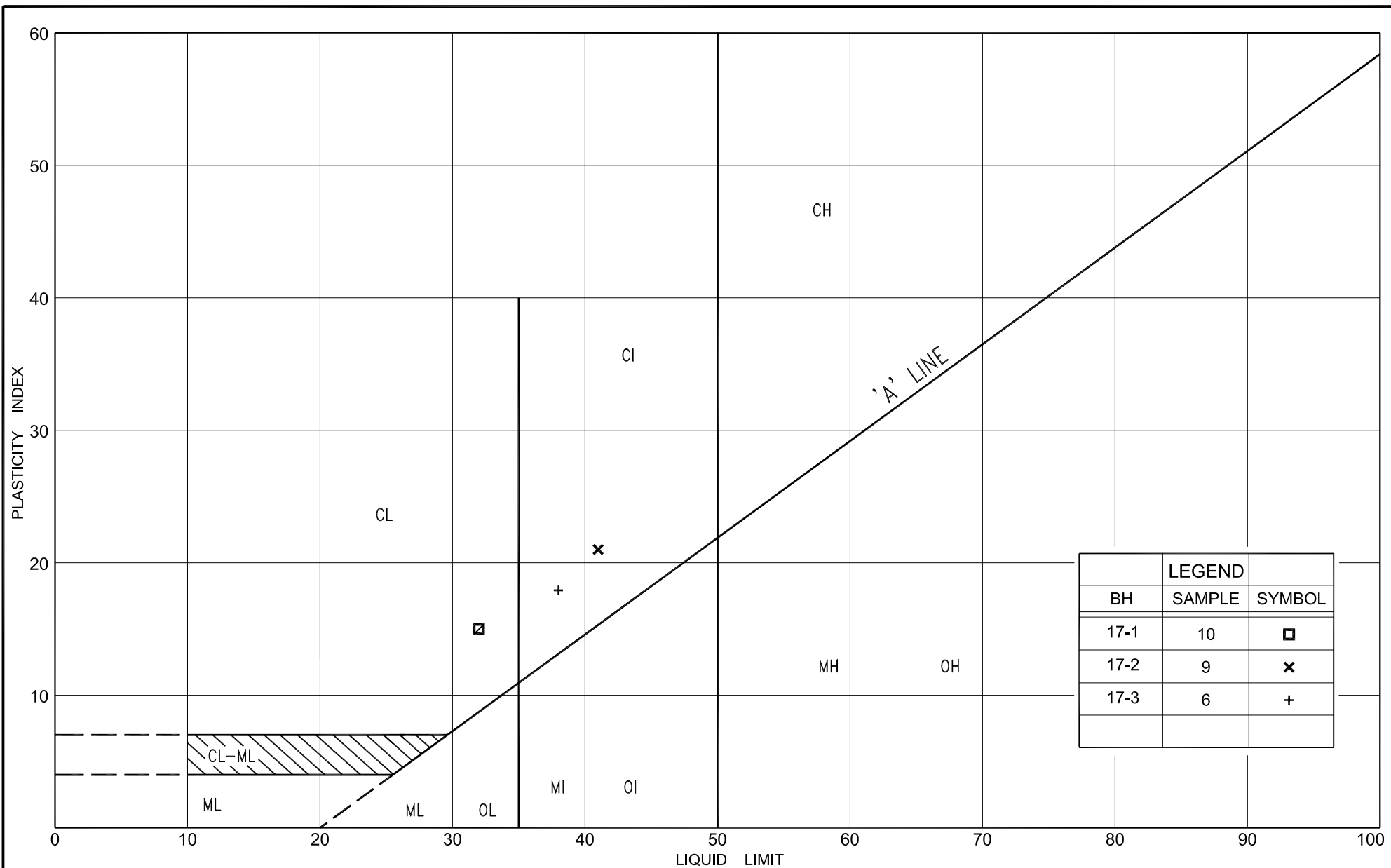
## GRAIN SIZE DISTRIBUTION HIGHLY WEATHERED SHALE

FIG No.	GS-KD-3
HWY	401
G.W.P.	2214-14-00



**PLASTICITY CHART**  
CLAYEY SILT TO SILTY CLAY, with sand, trace gravel  
(FILL)

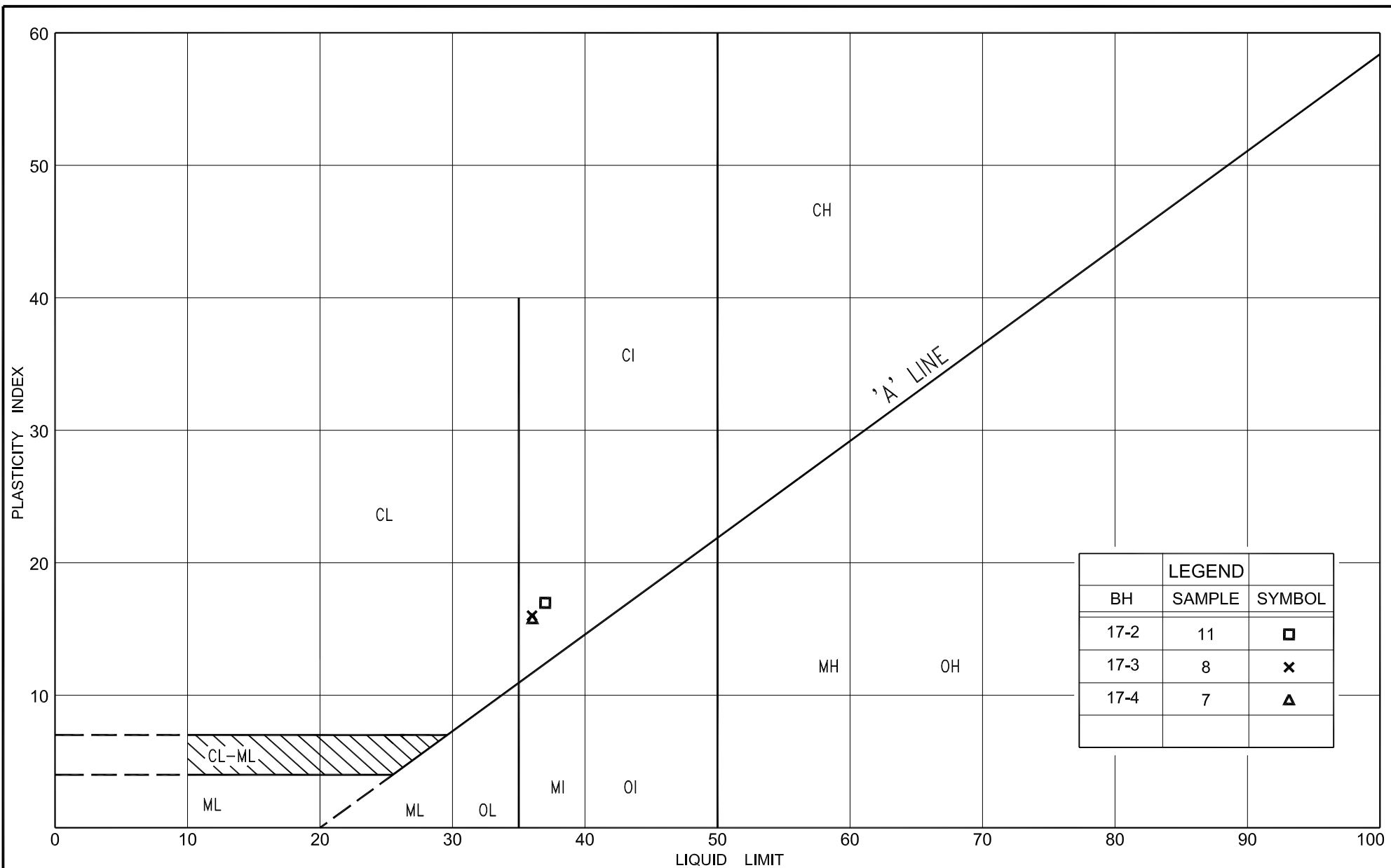
FIG No. PC-KD-1  
HWY 401  
G.W.P. 2214-14-00



**PLASTICITY CHART**  
 CLAYEY SILT TO SILTY CLAY, some sand, trace / some gravel  
 (TILL)

FIG No. PC-KD-2  
 HWY 401  
 G.W.P. 2214-14-00





# PLASTICITY CHART HIGHLY WEATHERED SHALE

FIG No. PC-KD-3

HWY 401

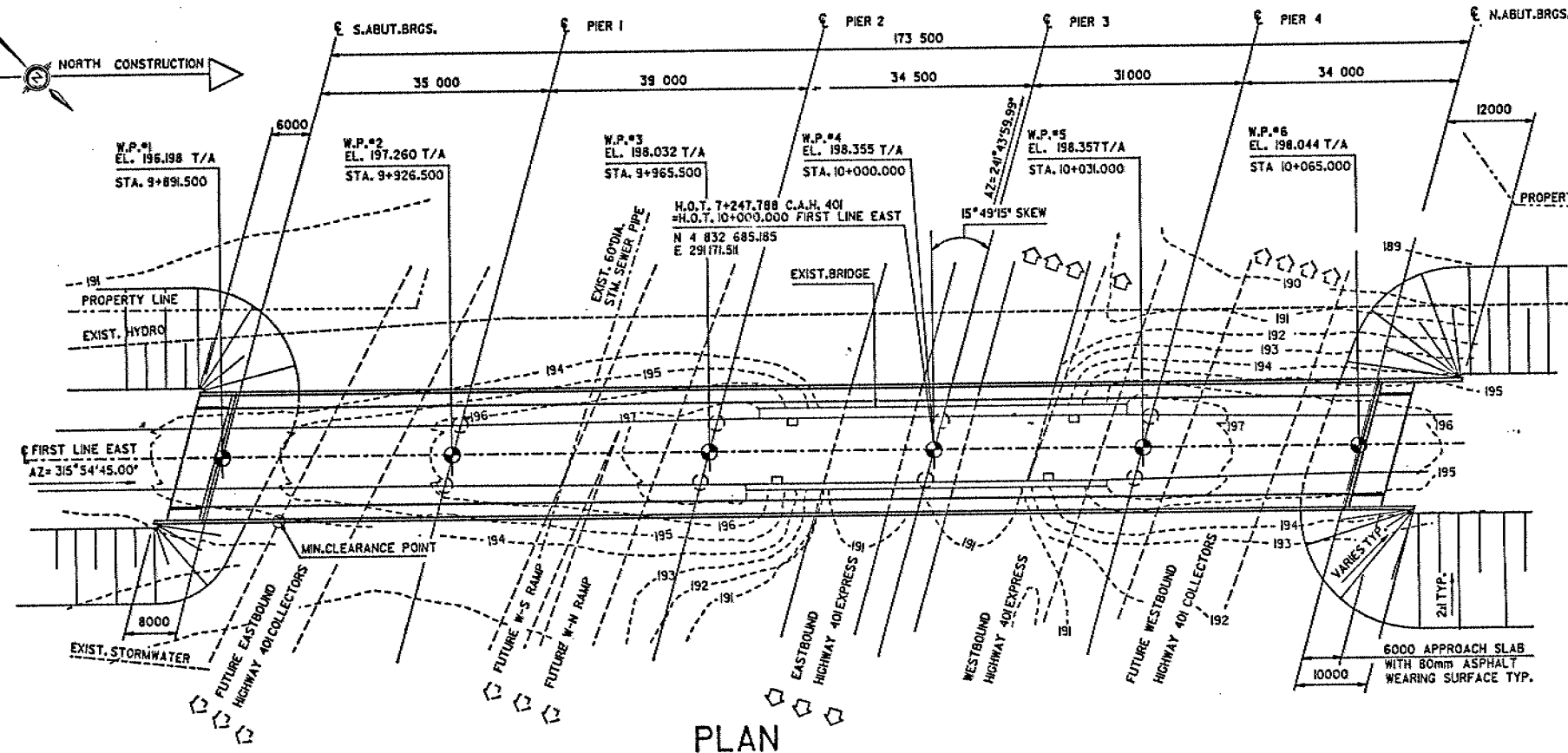
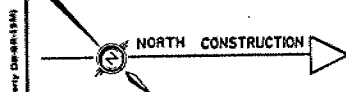
G.W.P. 2214-14-00



## **APPENDIX B**

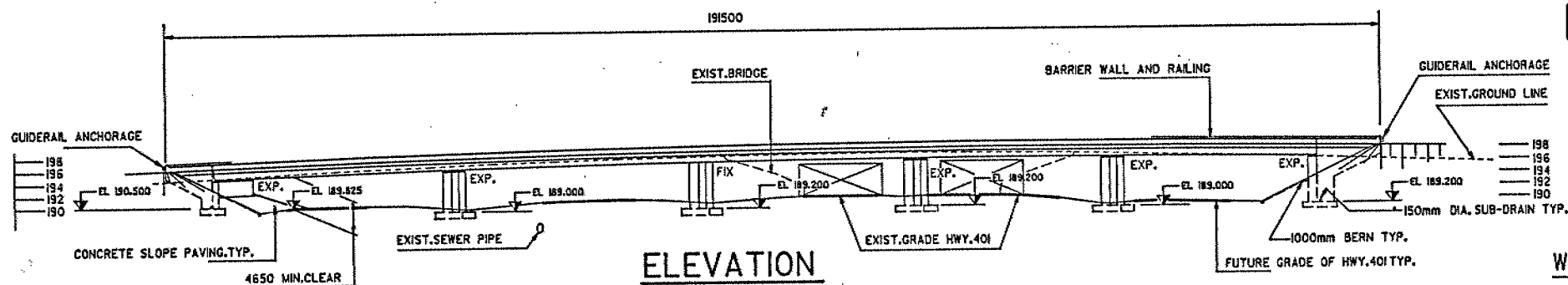
Relevant GEOCREs Data (Report 30M12-185)

GEOCRES No. 30M 12-185DIST. 6 REGION                     W.P. No. 54-82-05CONT. No. 86-67W. O. No.                     STR. SITE No. 24-181HWY. No. 401 / First Line EastLOCATION Hwy 401 / First Line EastNo of PAGES -OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.                     REMARKS:



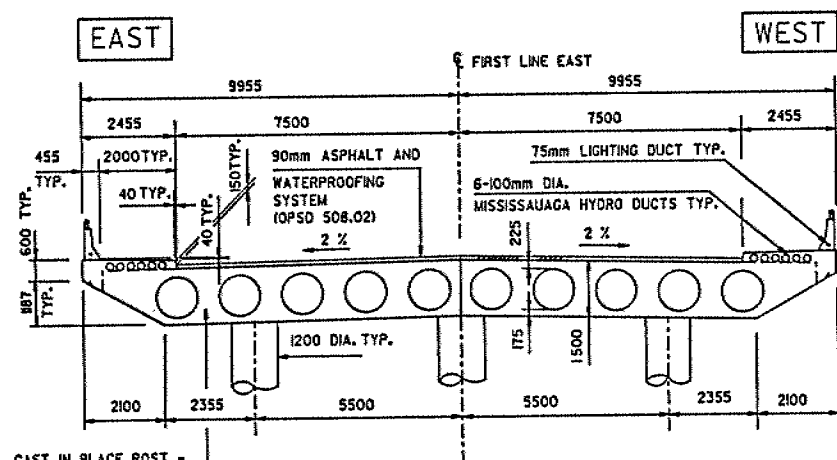
PLAN

SCALE 1/500



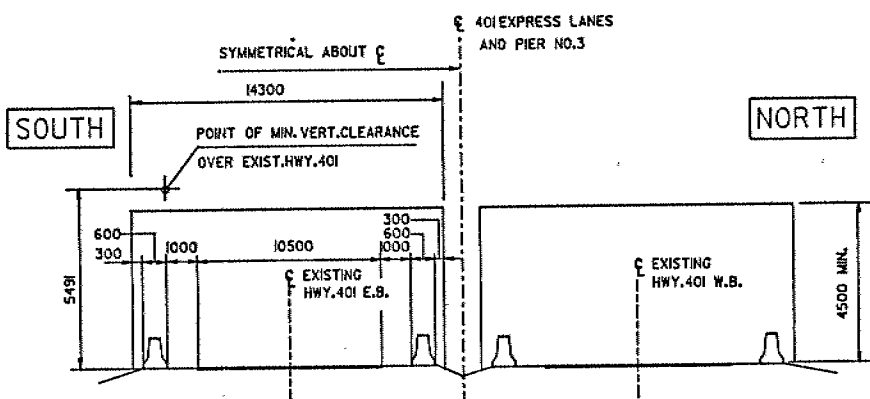
ELEVATION

SCALE 1/500



TYP. DECK SECTION

SCALE 1/100



CONSTRUCTION CLEARANCE DIAGRAM

N.T.S.

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

DIST 6 HWY 401  
CONT No  
WP No 54-82-05



SHEET

HWY 401 UNDERPASS  
AT FIRST LINE EAST  
GENERAL ARRANGEMENT

CS COLE  
SHERMAN

# NOTES

## CLASS OF CONCRETE

- FOOTINGS ..... 20 MPa
- PIERS ..... 35 MPa
- ABUTMENTS AND WINGWALLS ..... 30 MPa
- DECK ..... 35 MPa
- BARRIER WALLS ..... 30 MPa
- AND AS NOTED

## CLEAR COVER TO REINFORCING STEEL

- FOOTINGS ..... 100 ± 25
- ABUTMENTS, WINGWALLS
- FRONT FACE ..... 80 ± 20
- BACK FACE ..... 70 ± 20
- PIERS ..... 80 ± 20
- DECK
- TOP ..... 70 ± 20
- BOTTOM AND SIDES ..... 50 ± 20
- REMAINDER
- UNLESS OTHERWISE SPECIFIED 70 ± 20

## REINFORCING STEEL

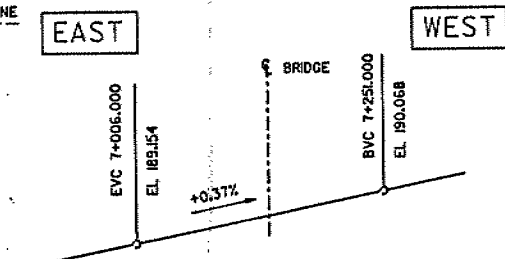
- REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED
- BAR MARKS WITH SUFFIX 'C' DENOTE COATED BARS

## CONSTRUCTION NOTES

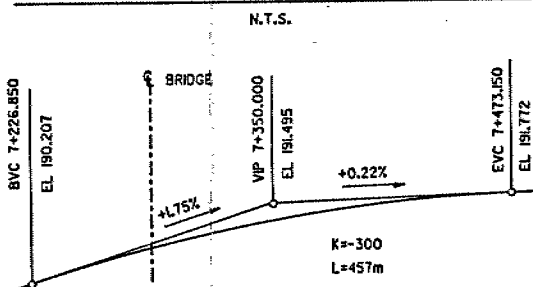
- THE CONTRACTOR SHALL FINISH THE BEARING SEATS LEVEL TO THE SPECIFIED ELEVATIONS TO A TOLERANCE OF ± 3 mm
- W.P. DENOTES WORKING POINT
- T/A DENOTES TOP OF ASPHALT

## LIST OF DRAWINGS

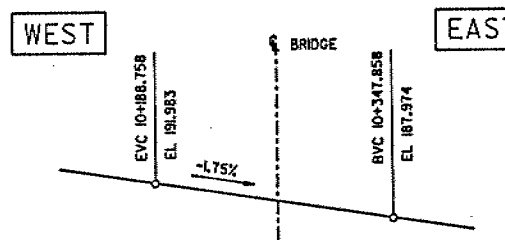
- GENERAL ARRANGEMENT
- BORE HOLE LOCATIONS & SOIL DATA
- FOOTING LAYOUT & DETAILS
- NORTH ABUTMENT
- SOUTH ABUTMENT
- PIER DETAILS
- DECK LAYOUT
- SCREED ELEVATIONS
- LONGITUDINAL CABLE DETAILS
- DECK REINFORCEMENT & TRANSVERSE CABLES SHT.1
- DECK REINFORCEMENT & TRANSVERSE CABLES SHT.2
- DECK REINFORCEMENT & TRANSVERSE CABLES SHT.3
- SECTIONS & DETAILS
- BARRIER WALL ON SIDEWALK
- RAILING FOR BARRIER WALL
- 6000 APPROACH SLAB
- DETAILS OF CONC. SLOPE PAVING
- STANDARD DETAILS I
- EXPANSION JOINT DETAILS
- BRIDGE DATE & SITE NO. DATA
- AS CONSTRUCTED ELEV. & DIM.
- PLAN QUANTITY SHEET NO.1
- PLAN QUANTITY SHEET NO.2



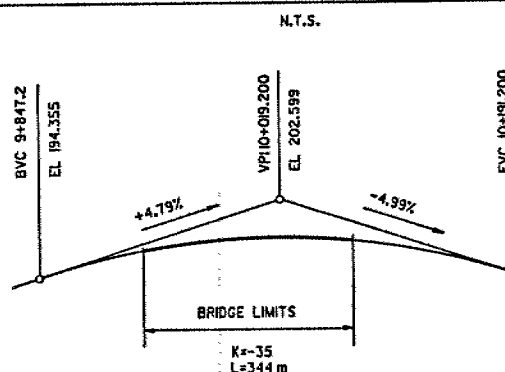
PROFILE - EASTBOUND COLLECTORS



PROFILE - WESTBOUND COLLECTORS



PROFILE  
WEST TO NORTH / WEST TO SOUTH RAMP



PROFILE FIRST LINE EAST

N.T.S.



DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN CS	CHECK G.L.R.	LOADING CHBDC-A-83	DATE NOV. 85
DRAWING SD	CHECK P.R.	SITE No 24-01-101	DWG 1

METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

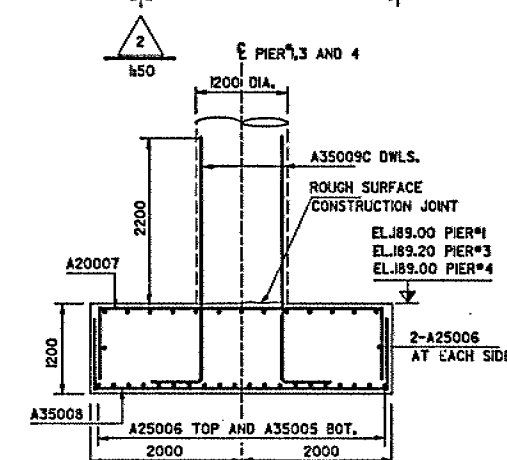
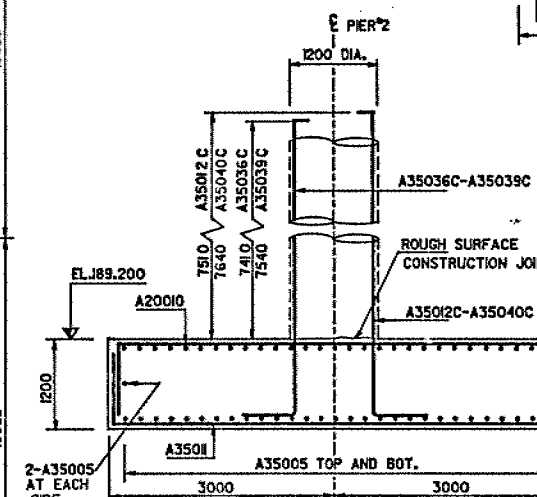
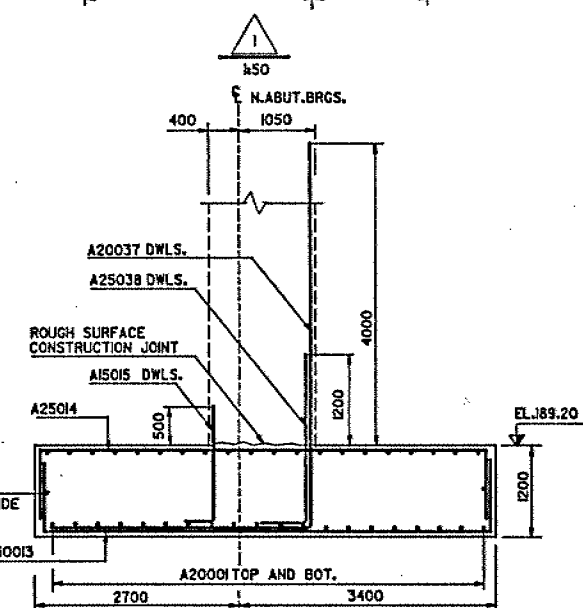
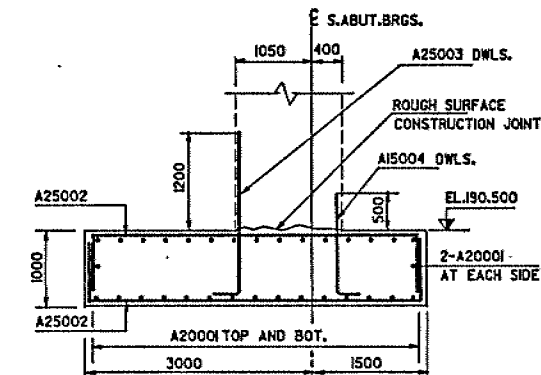
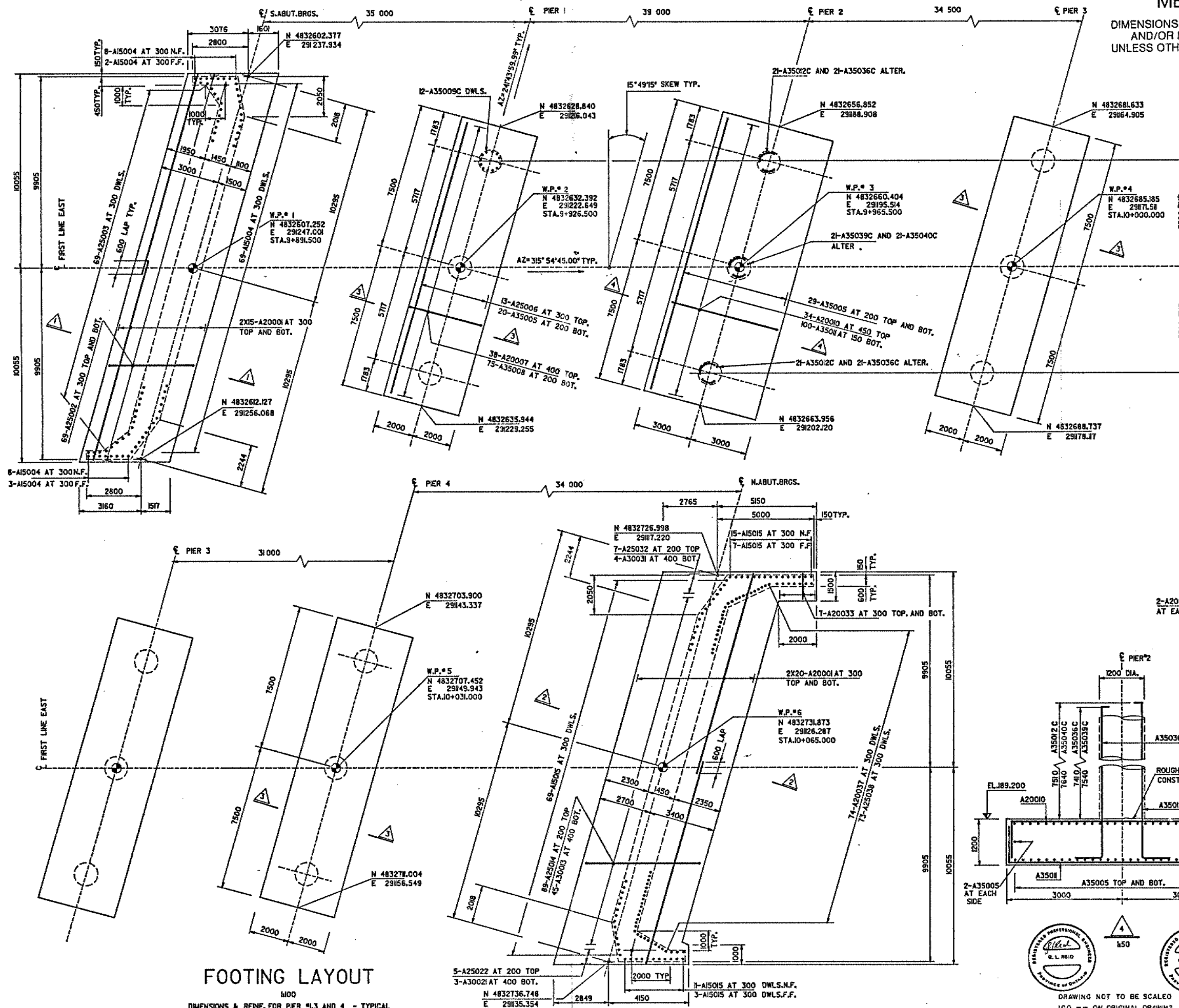
DIST 6 HWY 401  
CONT No  
WP No 54-82-05



SHEET

HWY 401 UNDERPASS  
AT FIRST LINE EAST  
FOOTING LAYOUT & DETAILS

COLE SHERMAN



DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION	DATE
DESIGN SCL	CHECK GLR	LOADING OHBDC-A-83	DATE NOV. 87	
DRAWING JB	CHECK PR	SITE No 24-81-121	DWG 3	

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

WP 54-82-05

DIST 6

HWY 401

STR SITE 24-81-181

Addendum for Hwy. 401 Underpass  
at First Line East

DISTRIBUTION

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R.D. GUNTER

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J.H. PEER

T. YAKUTCHUK

R. FITZGIBBON (Cover Only)

T.J. KOVICH (Cover Only)

FILE

Foundation Investigation Report Addendum  
For  
W.P. 54-82-05, Site 24-81-181  
Hwy. 401 Underpass at First Line East  
Hwy.401, District 6, Toronto

---

INTRODUCTION

This addendum summarizes the results of additional foundation investigations required at this site as a result of a revision in the horizontal alignment of First Line East Road. It is intended to supplement the Foundation Investigation Report prepared for this project by Dominion Soil Investigation Inc.

The fieldwork for the addendum was conducted between 85 03 13 and 85 03 15 utilizing a continuous flight auger machine equipped with 82 mm I.D. hollow-stem augers, N casing and a B core barrel.

This work consisted of 5 sampled boreholes.

SUBSURFACE CONDITIONS

The Record of Borehole Sheets (Appendix B.H. #101 to B.H. #105) illustrate the conditions at the borehole locations. The locations and elevations of the boreholes and stratigraphical profiles based on the borehole data have been added to Drawing No. 548205-A&B

At the locations of the boreholes completed for this addendum, up to 2.9 m of silty clay till overlies the shale bedrock. Refer to the original Foundation Investigation Report for a typical description of the silty clay till. For a description of the rock core samples from the addendum boreholes, refer to Table 1-Addendum (Appendix).

## DISCUSSION AND RECOMMENDATIONS

It is our understanding that the existing bridge which carries First Line East (Kennedy Road) over Hwy. 401 will be replaced by a 5 span structure located near the centreline of the existing structure, and some 20 m west of the alignment originally proposed.

### STRUCTURE FOUNDATIONS

The recommendations in the original Foundation Investigation and Design Report are, in general, applicable to this Addendum.

However, for clarification the following foundation recommendations are applicable.

- 1) The following design values are recommended for spread footings founded at the elevations indicated in Table 2-Addendum.

(O.H.B.D.C. Method)

- Factored Bearing Capacity at U.L.S. = 850 kPa
- Bearing Capacity at S.L.S. Type II = 500 kPa

It is noted that these design values are unchanged from those provided in the original Foundation Investigation and Design Report.

TABLE 2 - ADDENDUM

Footing	Location	Highest Footing	Recommended Elevation
		left	right
South Abutment	Sta. 9 + 891.5	189.5	189.5
Pier 1	Sta. 9 + 926.5	189.0 ✓	190.0
Pier 2	Sta. 9 + 965.5	188.0	190.0
Pier 3	Sta. 10 + 000.0	188.0	189.0
Pier 4	Sta. 10 + 031.0	189.0	189.5
North Abutment	Sta. 10 + 065.0	188.0	189.5

Where required the footings may be stepped or the excavation may be built-up to the designed underside of the footing with mass concrete.

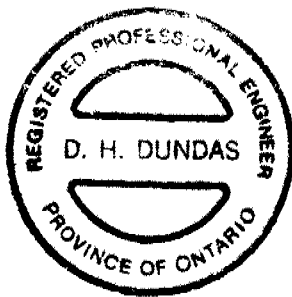


- 2) It is recommended that the bases of all footing excavations should be protected by a minimum of 150 mm of mass concrete within 6 hours of exposure. This can be accomplished by cleaning up the excavation immediately before pouring the mass concrete.

The fieldwork for this addendum was carried out under the supervision of Mr. H. Sturm, Project Foundations Engineer.

The addendum was written by Mr. D. Dundas, Foundations Engineer, and reviewed by Mr. M. Devata, Chief Foundations Engineer (East).

The drilling equipment was owned and operated by Atcost Soil Drilling Inc.



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

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

## APPENDIX

TABLE 1 ADDENDUM

## DESCRIPTION OF ROCK CORE - W.P. 54-82-05

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
101	3.58 - 3.78	50	0	3.58 - 4.34	Shale (70%), red, highly weathered, high core loss with limestone (30%), green, moderately weathered
	3.78 - 4.90	82	14	4.34 - 4.90	Shale (95%), red, slightly weathered, closely spaced joints, with siltstone (5%), green, unweathered
102	3.43 - 3.68	80	0	3.43 - 3.68	Shale, highly weathered
	3.68 - 4.98	100	24	3.68 - 4.22	Shale (80%), red, moderately weathered, closely spaced joints, with limestone (20%), green to light grey
				4.22 - 4.98	Shale (100%), red, unweathered, medium spaced joints
103	3.58 - 5.18	90	41	3.58 - 5.54	Shale (60%), red, slightly weathered becoming unweathered, closely spaced joints, with limestone (40%), green and light grey, unweathered, closely spaced joints
	5.18 - 5.54	100	0		
104	2.08 - 2.59	100	0	2.08 - 2.59	Shale (95%), red, highly weathered to clayey with limestone (5%), slightly weathered
	2.59 - 3.89	75	0	2.59 - 3.81	Shale (100%), red, moderately weathered, very closely spaced joints
	3.89 - 4.67	90	32	3.81 - 4.67	Limestone (80%), light grey to green, unweathered, closely spaced joints with shale (20%), slightly weathered
105	1.80 - 2.84	100	15	1.80 - 2.79	Shale (100%), red, highly to moderately weathered, very closely spaced joints
	2.84 - 3.84	77	31	2.79 - 3.84	Limestone (80%), light green, unweathered, closely spaced joints with shale (20%), red, unweathered

\* CR = CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	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
$C_\alpha$	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
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$kg/m^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$kN/m^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	$kg/m^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$kN/m^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$kg/m^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$kN/m^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$kg/m^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$m^3/s$	RATE OF DISCHARGE
$\gamma_d$	$kN/m^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	$kg/m^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	$kN/m^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$kg/m^3$	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$kN/m^3$	SEEPAGE FORCE
$\gamma'$	$kN/m^3$	UNIT WEIGHT OF SUBMERGED SOIL						

# RECORD OF BOREHOLE No 101

METRIC

W P 54-82-05 LOCATION Co-Ords N 4832 601.8; E 291 235.2 ORIGINATED BY IW  
 DIST 6 HWY 401 BOREHOLE TYPE Hollow Stem Auger; B Core COMPILED BY HS  
 DATUM Geodetic DATE 85 03 13 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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					
192.0	Ground Surface																
0.0	Silty Clay (Till) trace sand trace gravel very stiff to hard		1	SS	21		191										
			2	SS	70		190										
			3	SS	114												
189.1																	
2.9	Bedrock Shale		4	SS	129		189										
			5	RC	Rec =50%												
	weathered sound		6	RC	Rec =82%		188										
187.1																	
4.9	End of Borehole																



Ministry of  
Transportation and  
Communications  
Ontario

# RECORD OF BOREHOLE No 102

METRIC

W P 54-82-05 LOCATION Co-Ords: N 4 832 619.0; E 291 213.6 ORIGINATED BY IW  
DIST 6 HWY 401 BOREHOLE TYPE Hollow Stem, B Core COMPILED BY HS  
DATUM Geodetic DATE 85 03 14 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
192.0	Ground Surface																
0.0	Silty Clay (Till) trace Sand trace Gravel very stiff to hard		1	SS	22												
			2	SS	43												
			3	SS	126												
189.1	Bedrock		4	SS	120												
2.9	Shale		5	RC	Rec = 80%												
	weathered sound		6	RC	Rec = 100%												
187.0	End of Borehole																
5.0																	

+3, x5: Numbers refer to  
Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 103

METRIC

W P 54-82-05 LOCATION Co-Ords: N 4 832 662.3; E 291 171.4 ORIGINATED BY IW  
DIST 6 HWY 401 BOREHOLE TYPE Hollow Stem Auger, B Core COMPILED BY HS  
DATUM Geodetic DATE 85 03 14 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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					
190.7	Ground Surface																
0.0	Silty Clay (Till) trace Sand trace Gravel  Very Stiff to Hard		1	SS	15		190										
			2	SS	18		189										
			3	SS	95		188										
187.8			4	SS	77		187										
2.9	Bedrock Shale  weathered sound		5	RC BXL	Rec 90%		186										RQD 41%
185.2	Occasional limestone seams		6	RC BXL	Rec 100%												RQD 0%
5.5	End of Borehole																

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 104

METRIC

W P 54-82-05 LOCATION Co-Ords: N 4 832 697.3; E 291 127.8 ORIGINATED BY IW  
DIST 6 HWY 401 BOREHOLE TYPE Hollow Stem Auger, B Core COMPILED BY HS  
DATUM Geodetic DATE 85 03 15 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	Wp	W	WL	WATER CONTENT (%)					
190.6	Ground Surface																
0.0	Silty Clay (Till) trace Sand trace Gravel  very stiff		1	SS	17												
189.2	Bedrock Shale  Occasional limestone seams  weathered sound  Limestone occasional shale seams		2	SS	65												
1.4			3	RC BXL	Rec 100%										RQD 0%		
			4	RC BXL	Rec 75%										RQD 0%		
			5	RC BXL	Rec 90%										RQD 32%		
185.9	End of Borehole																
4.7																	



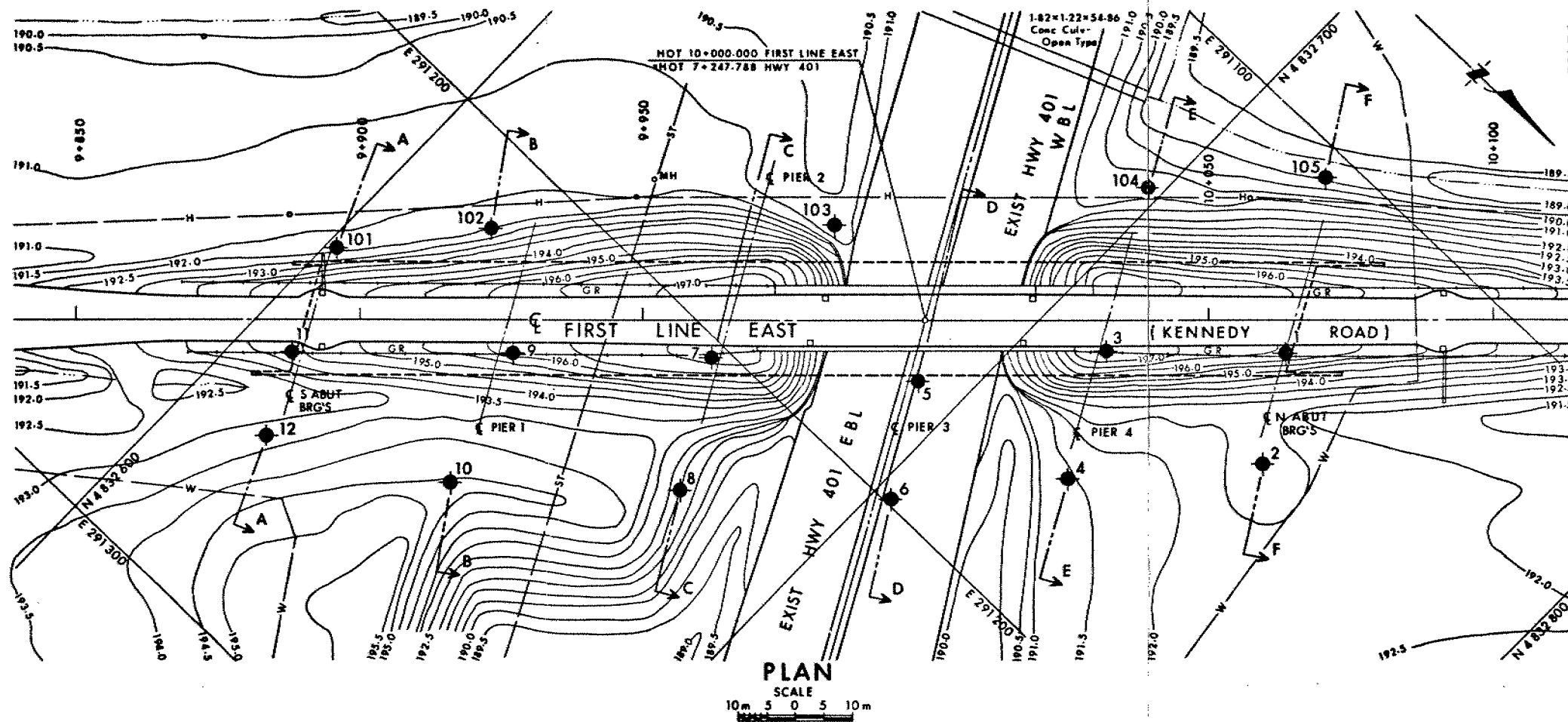


# RECORD OF BOREHOLE No 105

METRIC

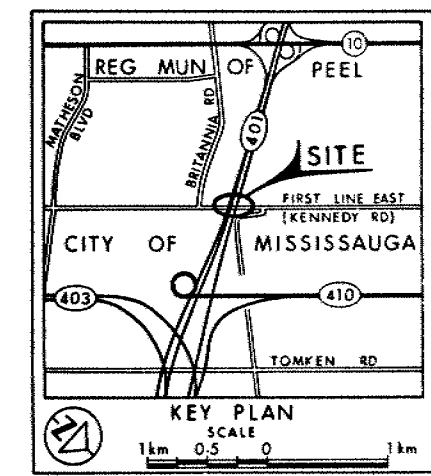
W P 54-82-05 LOCATION Co-Ords: N 4 832 718.4; E 291 104.9 ORIGINATED BY IW  
DIST 6 HWY 401 BOREHOLE TYPE Hollow Stem Auger, B Core COMPILED BY HS  
DATUM Geodetic DATE 85 03 15 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
189.5	Ground Surface																GR SA SI CL
0.0	Silty Clay (Till) trace Sand trace Gravel																
	hard		1	SS	66												
188.1	Bedrock		2	SS	100	0.10m											
1.4			3	RC BXL	Rec 100%												RQD 15%
	shale weathered																
	Limestone sound		4	RC BXL	Rec 77%												RQD 31%
185.6																	
3.9	End of Borehole																



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

CONT No WP No 54-82-05	SHEET
HWY 401 UNDERPASS AT FIRST LINE EAST (KENNEDY RD)	
BORE HOLE LOCATIONS & SOIL STRATA	



**LEGEND**

- ◆ Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ◆ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation  
1983 09 and 1985 03

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	196.6	4 832 735	291 132
2	192.6	4 832 746	291 149
3	197.6	4 832 712	291 154
4	191.5	4 832 723	291 175
5	190.9	4 832 692	291 181
6	190.7	4 832 703	291 199
7	197.5	4 832 663	291 203
8	192.0	4 832 675	291 224
9	196.3	4 832 637	291 227
10	194.7	4 832 645	291 251
11	194.5	4 832 609	291 254
12	193.3	4 832 616	291 268
101	192.0	4 832 601.8	291 235.2
102	192.0	4 832 619.0	291 213.6
103	190.7	4 832 662.3	291 171.4
104	190.6	4 832 697.3	291 127.8
105	189.5	4 832 718.4	291 104.9

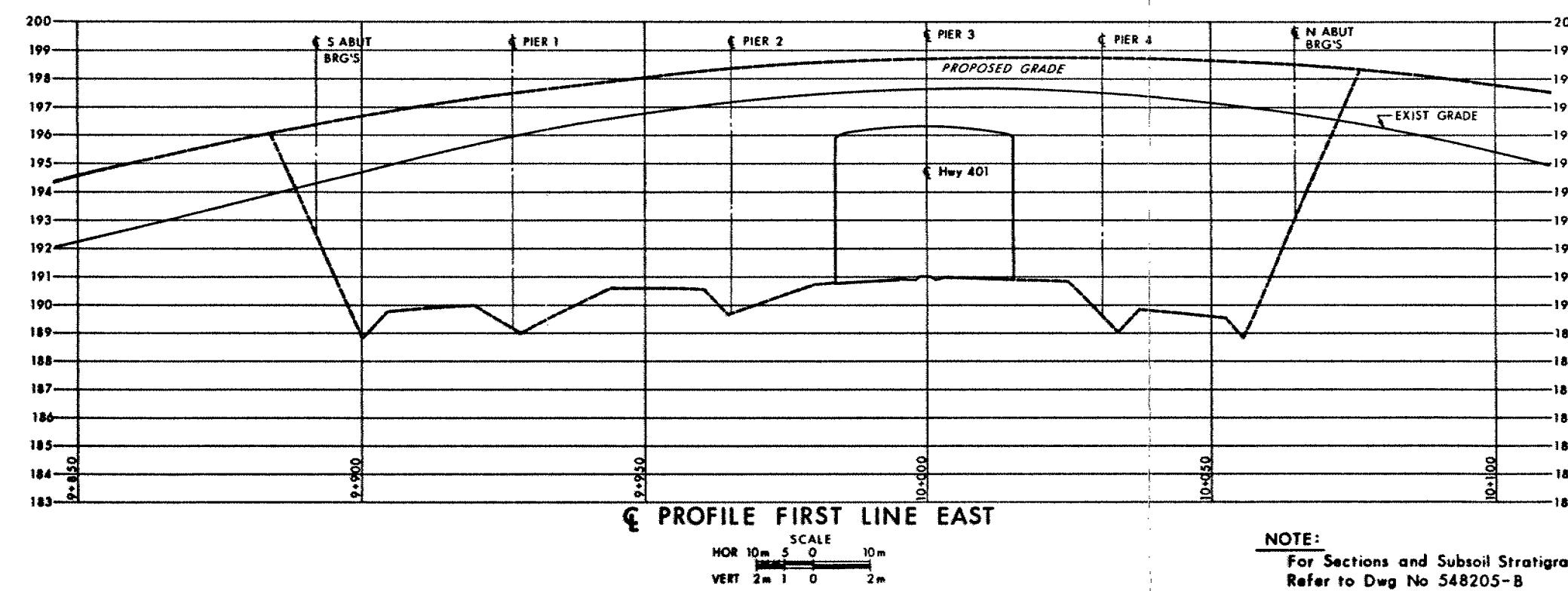
**NOTE**  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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

REV	DATE	BY	DESCRIPTION

Geocres No 30M12-185

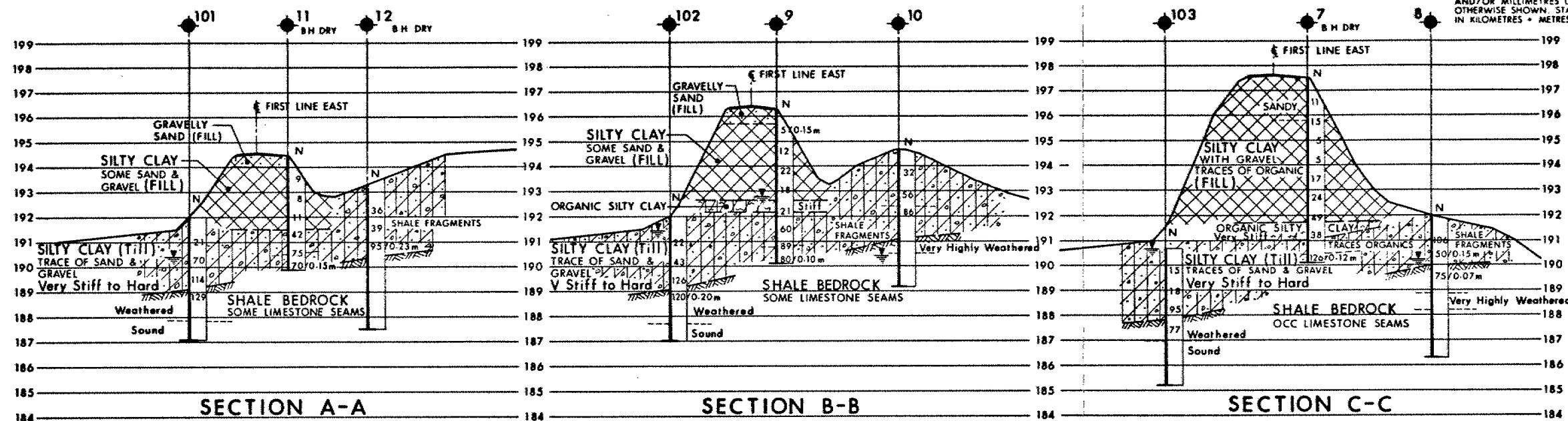
HWY No 401	DIST 6
SUBWD D.D. CHECKED	DATE 1985 11 19
DRAWN CHECKED	SITE 24-181
	DWG 548205-4



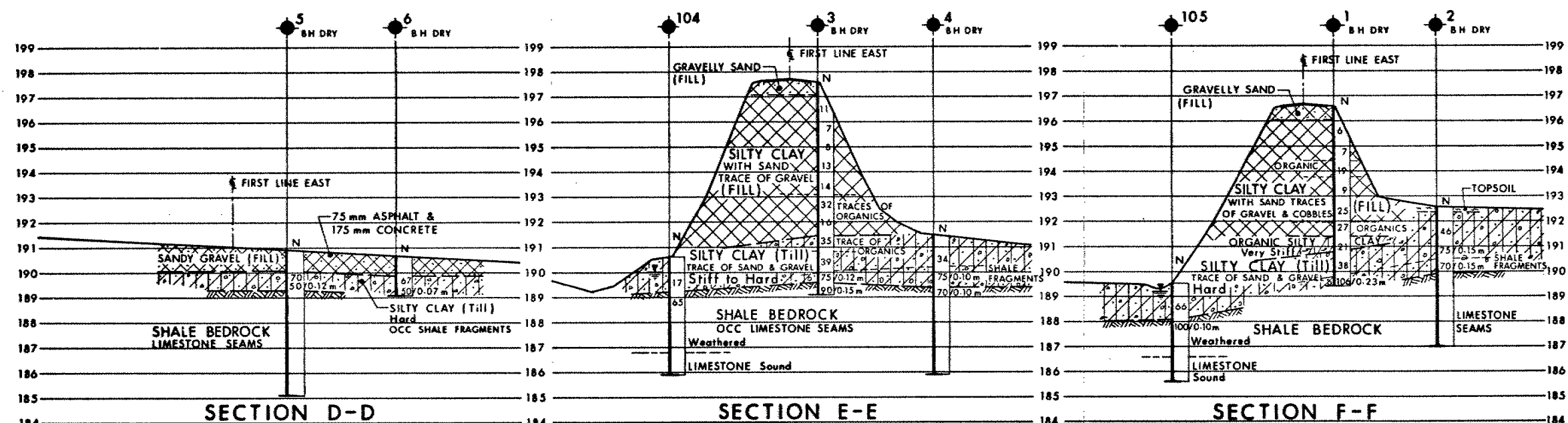
**NOTE**  
For Sections and Subsoil Stratigraphy  
Refer to Dwg No 548205-B

**METRIC**DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES.CONT No  
WP No 54-82-05HWY 401 UNDERPASS  
AT FIRST LINE EAST (KENNEDY RD)  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



SEE DWG No 548205-A

KEY PLAN  
SCALE

SCALE FOR SECTIONS

HOR 10m 5 0 10m  
VERT 2m 1 0 2m

## LEGEND

- ◆ Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CON Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation  
1983 09 and 1985 03

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	196.6		
2	192.6		
3	197.6		
4	191.5		
5	190.9		
6	190.7		
7	197.5		
8	192.0		
9	196.3		
10	194.7		
11	194.5		
12	193.3		
101	192.0		
102	192.0		
103	190.7		
104	190.6		
105	189.5		

SEE DWG No  
548205-A

## NOTE:

For Plan and Profile  
Refer to Dwg No 548205-A

## =NOTE=

The boundaries between soil strata have been established  
only at Bore Hole locations. Between Bore Holes the  
boundaries are assumed from geological evidence.NOTE: The complete foundation investigation and design report for  
this project and other related documents may be examined at the  
Engineering Materials Office, Downsview. Information contained in  
this report and related documents is specifically excluded in  
accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION
Geocres No 30M12-185			
HWY No 401		DIST 6	
SUBM'D D.D. CHECKED		DATE 1985 11 27 SITE 24-181	
DRAWN CHECKED		APPROVED DWG 548205-B	



# DOMINION SOIL INVESTIGATION INC.

CONSULTING SOIL & FOUNDATION ENGINEERS

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FOUNDATION INVESTIGATION  
PROPOSED BRIDGE REPLACEMENT  
HIGHWAY 401, FIRST LINE EAST (KENNEDY ROAD)  
MISSISSAUGA, ONTARIO

DISTRICT #6, CENTRAL REGION  
W.P. 54-82-05 SITE NO. 24-181

Ref. No. 83-8-7  
October 1983

Prepared For:  
Ministry of Transportation and Communications  
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Central Building  
1201 Wilson Avenue  
Downsview, Ontario  
M3M 1J8

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*GEOCARS 30M12-185*

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A P P E N D I C E S

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E N C L O S U R E S

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1.0 INTRODUCTION

Dominion Soil Investigation Inc., Consulting Geotechnical Engineers, were retained by the Ontario Ministry of Transportation and Communications to conduct a foundation investigation at the site of a proposed bridge replacement at Highway 401 and First Line East (Kennedy Road) intersection in Mississauga, Ontario. Authorization to carry out the work was received from Mr. M.S. Devata, Senior Foundations Engineer, Pavement and Foundation Design Section of the Ministry.

The purpose of the investigation was to determine the subsoil conditions at the site; to define the engineering properties of the substrata; to make recommendations pertaining to the design of the foundations of the proposed structure and to comment on the anticipated construction conditions.

The field work was carried out during the period of August 29 to September 7, 1983, and consisted of drilling twelve boreholes to depths ranging between 1.6 and 8.5 m. The location of the boreholes are shown on Drawing No. 548205-A and the subsurface conditions encountered are presented on the Record of Borehole Sheets.

.../...

## 2.0 SUMMARIZED SUBSOIL CONDITIONS

The boreholes that were drilled through the shoulder of the existing road encountered up to 6 m of fill. Below the fill and/or topsoil the subsoil generally consists of silty clay till changing to 'till-shale' complex and is underlain by a reddish highly weathered bedrock at relatively shallow depths.

Details of the subsurface conditions encountered in the boreholes are given on the individual Record of Boreholes, and inferred subsoil profiles are presented on Drawing No. 548205-A.

The relevant index and engineering properties of the principal strata are briefly discussed in the following paragraphs.

### 2.1 Fill

Boreholes 5 and 6 were drilled from the median of Highway 401 and encountered below an asphalt and concrete layer, granular fill extending to about 0.8 m below the ground surface.

Boreholes 1, 3, 7, 9 and 11 were drilled through the shoulder of the existing Kennedy Road embankment and encountered fill extending 3.0 (B.H. 11) to 6.1 m (B.H. 3) below the ground surface. The composition of the fill generally consists of silty clay with some sand and gravel and is similar in composition to the indigenous till. The grain size distribution of a sample from the fill is presented on Figure 1 indicating 5% gravel, 56% sand, 25% silt and 14% clay size particles.

.../...

The following index properties were measured in the laboratory:

Liquid Limit	25 - 35%
Plastic Limit	11 - 15%
Plasticity Index	14 - 20
Moisture Content	13 - 21%

These values are characteristics of clayey soils of low plasticity.

Pockets or zones of organic material were also found included in the fill.

From 'N'-values ranging between 5 and 32 blows/0.3 m the fill is considered to be firm to hard and unevenly compacted.

## 2.2 Organic Silty Clay

Underlying the embankment fill in Boreholes 1, 7 and 9 a 0.4 to 0.7 m thick organic silty clay layer was encountered. Due to the organic content this material could be expected to be relatively weak and compressible but the recorded Standard Penetration Indices of 21 and 38 and the relatively low moisture contents of 22%, indicate that the material has already been considerably compressed under the weight of the embankment fill.

## 2.3 Silty Clay Till

The natural subsoil below the fill or a thin veneer of topsoil is a reddish brown silty clay till. The till is a well graded mixture of a wide range of particle sizes and as shown on Figure 2, it consists of 6 to 9% gravel, 35 to 38% sand, 38 to 40% silt and 13 to 21% clay size particles.

.../...



An Atterberg Test gave the following values:

Liquid Limit	25%
Plastic Limit	15%
Plasticity Index	10
Moisture Content	13 to 16%

These values indicate clayey soils of low plasticity and the fact that the natural moisture contents are generally at or below the Plastic Limit suggests high strength and low compressibility. From 'N'-values of 32 blows/0.3 m and greater, the till is considered to be hard.

At the borehole locations the till is generally 1 to 2.5 m thick and with increasing depth the frequency of shale content in the till increases. The material at greater depths resembles a highly weathered shale with pockets of till material. This zone can be best described as a 'till-shale complex' and is indicated on the borehole log sheets as zones with "frequent shale fragments". The grain size distribution of a sample from this material is given in Figure 3, indicating 12% gravel, 46% sand, 31% silt and 11% clay size particles. Laboratory tests showed a Liquid Limit of 28 - 34%, Plastic Limit of 15 - 19% with a corresponding plasticity index of 13 - 15 indicating a clayey soil of low plasticity. The measured moisture contents ranged from 8 - 14%.

From 'N'-values of 36 to generally more than 100 blows/0.3 m, the consistency of the 'till-shale complex' is described as hard. Some  
.../...

of the boreholes were terminated within this material after penetrating it a short distance. At the boreholes where this zone was fully penetrated, it was 0.5 to 2 m thick and was underlain by the shale bedrock.

#### 2.4 Shale Bedrock

The site is located close to the interface of reddish Queenston and greyish Dundas shale formations and the depth to the surface of the bedrock in the area is known to be generally shallow.

In the majority of the boreholes shale bedrock was encountered at a depth of 1.5 to 8.0 m below the ground surface between Elevations 191.1 and 189.2 m. In some of the boreholes, the rock was penetrated a short distance by augering and in six of the boreholes NXL size cores were recovered by diamond drilling. In these boreholes the rock was penetrated for a vertical distance of 1.9 to 4.0 m. The core recovery ranged from 86 to 100% and the examination of the recovered samples and cores indicates that the bedrock within the depths explored, is a weathered to highly weathered, closely bedded, reddish shale. The shale, identified as belonging to the Queenston Formation, contains some grey limestone and frequent greyish shale bands. R.Q.D. values ranging from 0 to 85% (generally less than 50%) indicate a rock of generally poor quality.

..../...

3.0 GROUNDWATER CONDITIONS

The groundwater conditions in the boreholes were observed during the drilling. After their completion, where feasible, the boreholes were left open and water levels in the open boreholes were re-checked approximately three weeks thereafter. The recorded values are presented on the individual Record of Borehole Sheets.

Based on these observations, it is our opinion that the groundwater level at the time of the investigation was generally between Elevations 191 and 190 m.

.../...

#### 4.0 DISCUSSION

It is understood that the existing bridge which carries Kennedy Road over Highway 401 will be replaced by two, approximately 11 m wide and 175 m long structures. The new structures will be located to the immediate east of the existing bridge which will be demolished.

This investigation has revealed that in general, underlying some fill or a thin veneer of topsoil, the site is underlain by a hard silty clay till which attains a high shale content with increasing depth. The till-shale complex is underlain by the highly weathered reddish shale bedrock (Queenston shale) at relatively shallow depths. The surface of the bedrock at the borehole locations lies between Elevations 191.1 and 189.2 m. The groundwater level at the time of the investigation was generally between Elevations 190 and 191 m.

#### 4.1 Pier Foundations

The undisturbed hard silty clay till is suitable to support normal spread footing foundations for the piers or possibly closed end abutments and wing walls.

The footings should be extended below the fill, topsoil or organic stratum and the surficially weathered upper zones of the till. The recommended foundation levels and corresponding bearing pressures at each borehole location are given in Table I.

.../...

TABLE I

B.H. No.	Existing Ground Elevation (m)	Highest Recommended Foundation Depth Below the Existing Ground Surface and Elevation (m)	Recommended Bearing Capacity	
			Ultimate Limit States kPa	Serviceability Limit States Type II kPa
1	196.6	6.3 (190.3)	600	380
		6.8 (189.8)	850	500
2	192.6	1.2 (191.4)	600	380
		1.8 (190.8)	850	500
3	197.6	7.2 (190.4)	600	380
		7.8 (189.8)	850	500
4	191.5	1.3 (190.2)	600	380
		1.8 (189.7)	850	500
5	190.9	1.1 (189.8)	600	380
		1.5 (189.4)	850	500
6	190.7	1.1 (189.6)	600	380
		1.5 (189.2)	850	500
7	197.5	6.9 (190.6)	600	380
		7.3 (190.2)	850	500
8	192.0	1.1 (190.9)	600	380
		1.6 (190.4)	850	500
9	196.3	4.9 (191.4)	600	380
		5.5 (190.8)	850	500
10	194.7	1.7 (193.0)	600	380
		2.3 (192.4)	850	500
11	194.5	3.7 (190.8)	600	380
		4.2 (190.3)	850	500
12	193.3	1.8 (191.5)	600	380
		2.5 (190.8)	850	500

.../...

Provided that the subsoil is not unduly disturbed during the construction, the total and differential settlements corresponding to the Serviceability Limit State are expected to be less than 25 and 15 mm, respectively. Under inclined loading conditions, the bearing capacity at Ultimate Limit State should be reduced in accordance with Clause 6.7.3.3.5 of the Ontario Highway Bridge Design Code, 1979 (OHBDC). For the evaluation of the sliding resistance of the foundations, the ultimate angle of friction between the underside of the foundations and the hard silty clay till can be taken as 26 degrees.

The footings should have a permanent earth cover of 1.2 m for frost protection. The foundation excavations should be checked and approved by a geotechnical engineer to ensure that the footings rest on undisturbed subsoil or bedrock capable of sustaining the design pressure.

#### 4.2 Perched Abutments

Perched abutments could be supported either on shallow spread footings established within the compacted approach fills or on pile foundations driven through the fill.

##### 4.2.1 Spread Footings on Fill

In the case that the footings are placed on engineered fill, all topsoil, organic and other unsuitable materials should be removed to the surface of the inorganic hard silty clay till. The material used for embankment construction under the footings should be well graded, .../...

clean granular earth fill (Granular 'A' quality) the width of which at the footing level, should be at least twice the width of the footing and should increase in width below this level at an angle of 1.5 horizontal in 1 vertical or flatter. The fill should be placed in shallow lifts not exceeding 150 mm in thickness and each lift should be uniformly compacted to at least 100% of its Standard Proctor maximum dry density. The horizontal distance measured from the edge of the footing to the face of the embankment slope should not be less than 1.5 times the width of the footing, and the footing should also have a minimum earth cover of 1.2 m.

For footings meeting the above requirements, the Factored Bearing Capacity at Ultimate Limit States ( $q_f$ ) is 600 kPa. The Bearing Capacity at Serviceability Limit States Type II is 250 kPa. With this value, the maximum total settlement should be limited to 25 mm.

#### 4.2.2 Pile Foundations

End bearing steel-H or tube piles could be used to support the perched abutments.

It is estimated that the piles will encounter refusal at or near the surface of the bedrock, i.e. at about 189.5 m. The piles should be reinforced at the tips by welding steel plates to the flanges, as per standard M.T.C. practice, or with hardened rock points to get a good seating on the bedrock and to avoid damage during driving through possible obstructions and the dense zones of the fill or the hard overburden.

.../...

The estimated pile capacities for some common sizes of steel piles driven to a final set of about 1 blow/1 mm penetration with a hammer capable to deliver an energy of 40 to 70 thousand Joules/blow are tabulated below:

ESTIMATED PILE CAPACITY (kN)

<u>Pile Type</u>	<u>Size</u>	<u>Factored Capacity at Ultimate Limit States (<math>Q_f</math>)</u>	<u>Capacity at Serviceability Limit States Type II (<math>Q_s</math>)</u>
Steel H	HP 310 x 110	1400	970
	HP 310 x 79	1000	690
	HP 250 x 62	750	530
	HP 200 x 54	680	445
Steel Pipe	323 x 9.5	900	650
	273 x 9.3	750	530

It is recommended that the driving of the piles in the field be controlled by a recognized pile driving formula such as the Hiley formula. Unbalanced horizontal forces should be resisted by battered piles and for frost protection, the underside of the pile caps should be established at least 1.2 m below finished grade. Because of their superior ability to penetrate through the hard overburden and highly weathered zones of the rock, relatively heavy section steel H-piles are believed to be better suited for this project.

.../...



#### 4.3 Lateral Earth Pressures

Assuming that free-draining granular material and adequate drainage is provided behind the abutments and the wing walls (Figure 6.9.6.1 OHBDC), the lateral earth pressure can be calculated by assuming active earth pressure conditions and using the following equivalent fluid pressures:

- At Ultimate Limit State: 8 kPa/m
- At Serviceability Limit State Type II: 6.5 kPa/m

The rigid walls of the abutments, however, should be designed to withstand the at-rest earth pressures which can be evaluated using the following equivalent fluid pressures:

- At Ultimate Limit State: 10 kPa/m
- At Serviceability Limit States Type II: 8.5 kPa/m

When using the above values, it is assumed that the slope of the backfill behind the retaining structure is approximately level.

Care should be given to avoid the overcompaction of the backfill and the use of heavy compaction equipment behind the retaining walls and abutments. Compaction equipment, for use behind retaining structures, must be restricted in size as per current MTC specifications.

Water accumulation in the backfill behind the retaining structures should be prevented by the use of perforated pipes and weep holes.

.../...

#### 4.4 Approach Fills

The design of the approach fills will not be limited by the strength of the foundation materials underlying the site and there are no stability problems foreseen. All the organic and unsuitable soils must, however, be removed before placing the fill. In the case that the approach fills are constructed from locally available clean earth fills, 2 horizontal in 1 vertical side slopes can be used. The slopes of the embankment should be adequately protected against surface erosion.

In the case of pile supported perched abutments, rockfill or fill containing large gravel or cobble size particles, should not be used in that part of the embankment through which piles are to be driven.

#### 4.5 Construction

There are no soil related construction problems foreseen.

Excavations in the hard till will stand unsupported with nearly vertical faces to a depth of 1.2 m. Where deeper excavations are required, the face of the excavation should be flattened to 45 degrees to comply with the Safety Regulations of the Province. The existing roadway should be adequately protected during the construction by means of shoring, etc.

Water should not be allowed to accumulate in the excavations and surface water should be removed by pumping from temporary sumps. Any material that might be softened by water ponding in the excavation should be removed by hand before pouring the footings, or a skim coat of concrete should be placed.

.../...



5.0 STATEMENT OF LIMITATION

The Statement of Limitation, as quoted in Appendix 'B', is an integral part of this report.

DOMINION SOIL INVESTIGATION INC.

Z.S. Ozden, P.Eng.

ZSO:bh

APPENDICES

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$kPa^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	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
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_f$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$kg/m^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$kN/m^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	$kg/m^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$kN/m^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$kg/m^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$kN/m^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$kg/m^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$m^3/s$	RATE OF DISCHARGE
$\gamma_d$	$kN/m^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	$kg/m^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	$kN/m^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$kg/m^3$	DENSITY OF SUBMERGED SOIL				j	$kN/m^3$	SEEPAGE FORCE

## A P P E N D I X 'B'

### STATEMENT OF LIMITATION

The conclusions and recommendations in this report are based on information determined at the testhole locations. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the site investigations.

We recommend that we be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known, in our analysis certain assumptions had to be made. The actual conditions may, however, vary from those assumed, in which case changes and modifications may be required to our recommendations.

We recommend, therefore, that we be retained during the final design stage to review the design drawings and to verify that they are consistent with our recommendations or the assumptions made in our analysis.

In cases where these recommendations are not followed, the company's responsibility is limited to report accurately the information encountered in the testholes.

The comments given in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of boreholes may not be sufficient to determine all the factors that may affect construction methods and costs. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

ENCLOSURES



# RECORD OF BOREHOLE No 1

METRIC

W P 54-82-05 LOCATION CO-ORDS. 4,832,735N; 291,132E ORIGINATED BY H.C.  
DIST 6 HWY 401 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY F.L.  
DATUM GEODETTIC DATE 1983.09.01 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH									WATER CONTENT (%)	
								20 40 60 80 100										
196.6	Ground Level																	
0.0	Gravelly sand (Road shoulder Fill)																	
196.1																		
0.5	Reddish & brown Silty clay with some sand & traces of gravel & cobbles  (Fill)		1	SS	6													
			2	SS	7													
	black & organic		3	SS	19													
			4	SS	9													
			5	SS	25													
			6	SS	27													
191.4	traces of organics																	
5.2	Dark grey to black v. stiff Organic silty clay traces of decayed roots		7	SS	21													
190.8																		
5.8	Light grey, hard Silty clay till with some sand lenses		8	SS	38													
189.4	Reddish, frequent Shale fragments		9	SS	106	0.23m										Borehole dry on completion.		
7.2	End of Borehole																	

+3, x<sup>5</sup>; Numbers refer to  
Sensitivity

20  
15  
10  
5  
(%) STRAIN AT FAILURE





# RECORD OF BOREHOLE No 2

METRIC

W P 54-82-05 LOCATION CD-ORDS. 4,832,746N; 291,149E ORIGINATED BY H.C.  
DIST 6 HWY 401 BOREHOLE TYPE SOLID STEM AUGER AND NXL ROCK CORE COMPILED BY F.L.  
DATUM GEODETIC DATE 1983.08.29 CHECKED BY I.P.L.

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	SHEAR STRENGTH					WATER CONTENT (%)				
								20 40 60 80 100					W <sub>p</sub>	W			W <sub>L</sub>
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										
192.6	Ground Level																
0.0	0.23 m Topsoil														Augering ↓ Diamond Drilling		
	Brown, hard Silty clay till		1	SS	46												
			2	SS	75/ 0.15 m												
	----- Frequent shale fragments Reddish		3	SS	70/ 0.15m												
189.9																	
2.7	Reddish Shale, some greyish shale and limestone seams		4	RC NXL	100%										Borehole dr on complet- ion of augering. Wet cave @ 1.6 m Sept. 20/83.		
			5	RC NXL	100%												
187.0																	
5.6	End of Borehole																

+3, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 3

METRIC

W P 54-82-05 LOCATION CO-ORDS. 4,832,712N; 291,154E ORIGINATED BY H.C.  
DIST 6 HWY 401 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY F.I.  
DATUM GEODETIC DATE 1983.09.01 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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										WATER CONTENT (%)		
								SHEAR STRENGTH ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    x LAB VANE												
197.6	Ground Level																			
0.0	Gravelly sand						197													
197.1	(Road Shoulder Fill)																			
0.5	Brown/reddish/grey Silty clay with some sand & traces of gravel (Fill)		1	SS	11															
			2	SS	7		196													
			3	SS	8		195													
			4	SS	13															
			5	SS	14		194													
	traces of organics		6	SS	32		193													
			7	SS	16		192													
191.5	Traces of organics some sand lenses		8	SS	35		191													
6.1	Brownish hard Silty clay till		9	SS	39															
	Frequent shale frag- ments		10	SS	75/	0.12m	190													
189.6	Reddish																			
8.0	Reddish Shale																			
189.1	Weathered		11	SS	90/	0.15m														
8.5	End of Borehole																			

+3, x5: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 4

METRIC

W P 54-82-05 LOCATION CO-ORDS. 4,832,723N; 291,175E ORIGINATED BY H.C.  
DIST 6 HWY 401 BOREHOLE TYPE SOLID STEM AUGER AND NXL ROCK CORE COMPILED BY F.L.  
DATUM GEODETIC DATE 1983.08.29 and 1983.09.01 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
191.5	Ground Level															GR 5A SI CL
0.0	0.12 m Topsoil					191										
	Reddish Silty clay till		1	SS	34											
	Stiff to Hard															
	Hard		2	SS	75/	190										
	Frequent Shale fragments					0.10m										
189.4			3	SS	70/	189										
2.1	Reddish Shale some greyish shale and limestone seams		4	RC NXL	90%											
			5	RC NXL	100%	188										
						187										
						186										
185.9																
5.6	End of Borehole															

Augering  
↑  
Diamond  
Drilling

Borehole dry  
on complet-  
ion of  
augering.

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15 + 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 5

METRIC

W P 54-82-05 LOCATION CO-ORDS. 4,832,692N; 291,181E ORIGINATED BY H.C.  
DIST 6 HWY 401 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY F.L.  
DATUM GEODETIC DATE 1983.09.07 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR 5A S1 CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
190.9	Ground Level																
0.0	75 mm Asphalt 175 mm Concrete Sandy gravel (Fill)																
190.1																	
0.8	Reddish, hard Silty clay till, with shale fragments		1	SS	70		190										
189.3			2	SS	50/	0.12m											
1.8	Reddish Shale some greyish shale and limestone seams						189										
			3	RC NXL	93%		188										
			4	RC NXL	86%		187										
			5	RC NXL	100%		186										
185.1																	
5.8	End of Borehole																

Augering  
↓  
Diamond  
Drilling

Borehole dry  
on complet-  
ion of  
augering.

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6												METRIC		
W P 54-82-05		LOCATION CO-ORDS. 4,832,703N; 291,199E				ORIGINATED BY H.C.								
DIST 6 HWY 401		BOREHOLE TYPE SOLID STEM AUGER				COMPILED BY F.L.								
DATUM GEODETIC		DATE 1983.09.07				CHECKED BY I.P.L.								
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40					
190.7	Ground Level													
0.0	75 mm Asphalt 175 mm Concrete Sandy Gravel fill													
189.9														
0.8	Reddish, hard Silty clay till, with shale fragments		1	SS	67									
189.1	Reddish weathered shale		2	SS	50/	0.07m								
1.6	End of Borehole													

+3, x5 : Numbers refer to  
Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 7

METRIC

W P 54-82-05 LOCATION CO-ORDS. 4,832,663N: 291,203E ORIGINATED BY H.C.  
DIST 6 HWY 401 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY F.L.  
DATUM GEODETIC DATE 1983.08.30 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
197.5	Ground Level															
0.0	0.1 m Topsoil															
			1	SS	11											
	Sandy		2	SS	15											
	Grey/brown/dk. grey Silty clay, with some gravel, traces of organic pockets (Fill)		3	SS	5											
			4	SS	5											
			5	SS	17											
			6	SS	24											
			7	SS	49											
191.7																
5.8	Dark grey/black Organic silty clay		8	SS	38											
191.0	V. stiff															
6.5	Reddish, hard Silty clay till with traces of organics															
	Frequent shale frag- ments		9	SS	126/0.12m											
190.1																
7.4	End of Borehole															

Borehole dy  
on complet-  
ion

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 8

METRIC

W P 54-82-05 LOCATION CO-ORDS. 4,832,675N; 291,224E ORIGINATED BY H.C.  
DIST 6 HWY 401 BOREHOLE TYPE SOLID STEM AUGER AND NXL ROCK CORE COMPILED BY F.L.  
DATUM GEODETIC DATE 1893.08.29 and 1983.08.31 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH									WATER CONTENT (%)	
								20 40 60 80 100										
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE											
192.0	Ground Level															GR SA SI CL		
0.0	0.05 m Topsoil																	
	Reddish, hard Silty clay till, with shale fragments		1	SS	106	191												
			2	SS	50/	0.15m												
190.0																		
2.0	Reddish Shale, some greyish shale and limestone seams		3	SS	75/	0.07m												
	Very highly weathered zone		4	RC NXL	93%	189												
			5	RC NXL	90%	188												
						187												
186.3																		
5.7	End of Borehole																	

Augering  
↑  
Diamond  
Drilling

Borehole dry  
on completion  
of augering.  
W.L. @ 1.8m  
& hole caved  
in @ 2.7m  
Sept.20/83

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 9

METRIC

W P 54-B2-05 LOCATION CO.ORDS. 4,832,637N; 291,227E ORIGINATED BY H.C.  
DIST 6 HWY 401 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY F.L.  
DATUM GEODETIC DATE 1983.08.30 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH									WATER CONTENT (%)	
								20 40 60 80 100										
196.3	Ground Level																	
0.0	Gravelly sand (Fill)					0.15m										Encountered boulder at 1.1 m. Borehole re-located 1.5m north and re-drilled		
195.7																		
0.6	Sandy		1	SS	5/													
	Red/brown/dk. brown Silty clay, with some sand and gravel (Fill)		2	SS	12													
			3	SS	22													
			4	SS	18													
192.6																		
3.7	Dark grey/black Stiff Organic silty clay		5	SS	21													
192.2																		
4.1	Some organics																	
	Greyish, hard Silty clay till	6	SS	60												6 36 38 20		
	Frequent shale fragments Reddish	7	SS	89												Borehole dry on completion. Water level @ 3.5m & B.H. caved in @ 3.8 m Sept. 20/83		
190.1			8	SS	80/	0.10m												
6.2	End of Borehole																	

Encountered boulder at 1.1 m. Borehole re-located 1.5m north and re-drilled

6 36 38 20

Borehole dry on completion. Water level @ 3.5m & B.H. caved in @ 3.8 m Sept. 20/83

+3, x<sup>5</sup>: Numbers refer to Sensitivity

20  
15  
10  
5  
0  
(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 10

METRIC

W P 54-82-05 LOCATION CO-ORDS. 4,832,645N; 291,251E ORIGINATED BY H.C.  
DIST 6 HWY 401 BOREHOLE TYPE SOLID STEM AUGER AND NXL ROCK CORE COMPILED BY F.L.  
DATUM GEODETIC DATE 1983.08.29 and 1983.08.31 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
194.7	Ground Level															
0.0	0.15 m Topsoil															
	V.stiff Hard		1	SS	32											
	Reddish Silty clay till		2	SS	56											
			3	SS	86											
	Frequent shale frag- ments		4	RC NXL	59%											
191.1			5	RC NXL	92%											
3.6	Very highly weathered		6	RC NXL	100%											
	Reddish shale, some greyish shale & limestone seams															
189.2	End of Borehole															
5.5																

Augering  
+  
Diamond  
Drilling

Borehole dry  
on complet-  
ion of  
augering.  
W.L. @ 4.3m  
& borehole  
caved-in @  
4.9 m  
Sept.20/83

+3, x5: Numbers refer to  
Sensitivity

20  
15 ÷ 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 11

METRIC

W P 54-82-05 LOCATION CO-ORDS. 4,832,609N; 291,254E ORIGINATED BY H.C.  
DIST 6 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGER COMPILED BY F.L.  
DATUM GEODETIC DATE 1983.08.30 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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									WATER CONTENT (%)			
								SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE												
194.5	Ground Level																			
0.0	0.05m Topsoil						194													
194.0	Gravelly sand (Fill)																			
0.5	Reddish/brown/dry Silty clay, with some sand and gravel (Fill)		1	SS	9															
		2	SS	8		193														
		3	SS	11																
191.5							192													
3.0	Layered Silty clay V. stiff Hard		4	SS	42		191													
	Greyish Silty clay till																			
	Frequent shale fragments		5	SS	75															
189.9	Reddish		6	SS	70/	0.15m	190									Borehole dry on completion.				
4.6	End of Borehole																			

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 12

METRIC

W P 54-82-05 LOCATION CO-ORDS. 4,832,616N; 291,268E ORIGINATED BY H.C.  
DIST 6 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGER AND NXL ROCK CORE COMPILED BY F.L.  
DATUM GEODETIC DATE 1983.08.29 and 1983.08.31 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
193.3	Ground Level															
0.0	0.15 m Topsoil															
	Reddish, hard Silty clay till, with shale fragments		1	SS	36											
			2	SS	39											
			3	SS	95/	0.23m										
190.4																
2.9	Reddish Shale, some greyish shale and limestone seams		4	RC NXL	100%											
			5	RC NXL	100%											
187.5																
5.8	End of Borehole															

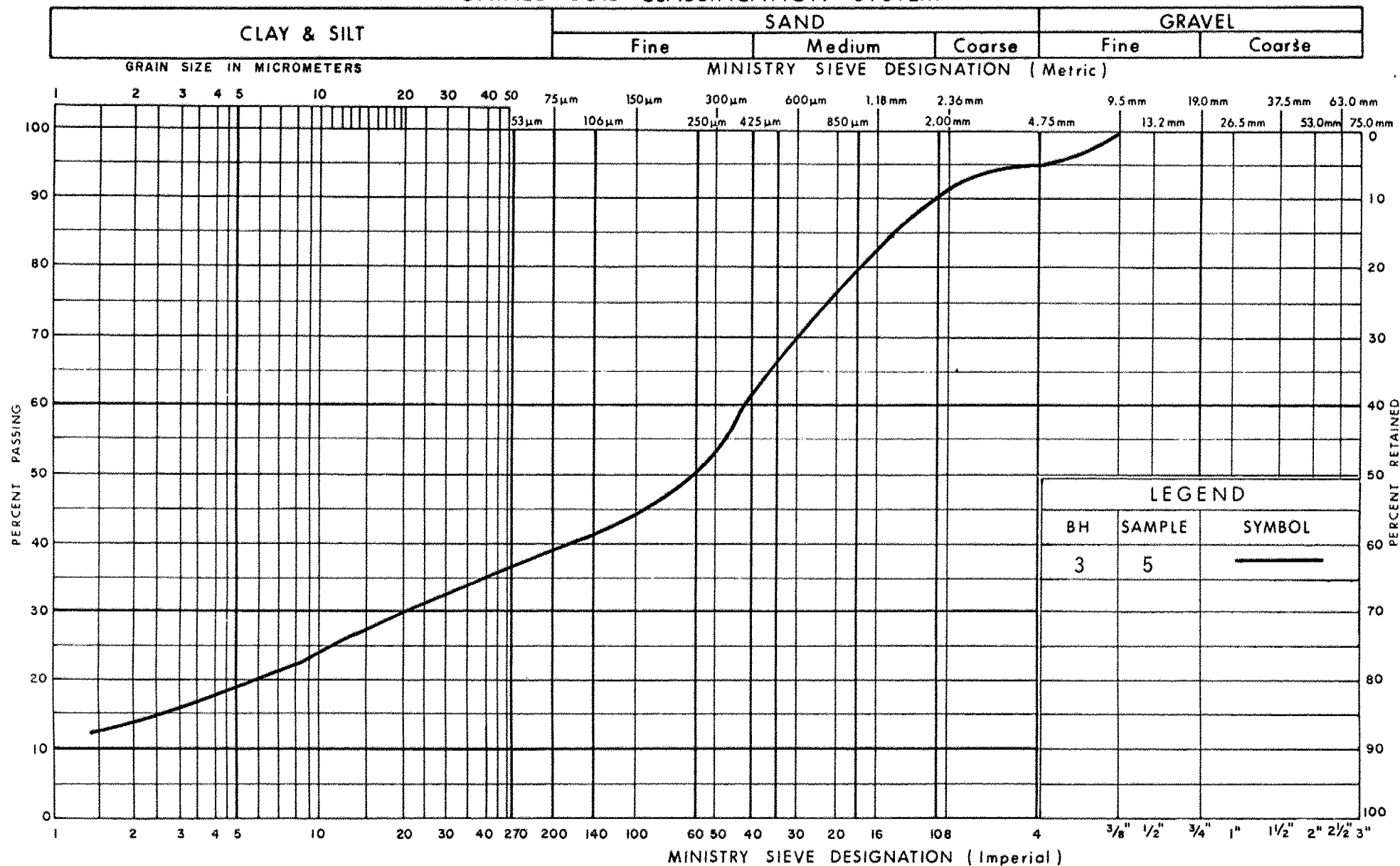
Augering  
↓  
Diamond  
Drilling

Borehole dry  
on completion  
of  
augering.

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

## UNIFIED SOIL CLASSIFICATION SYSTEM



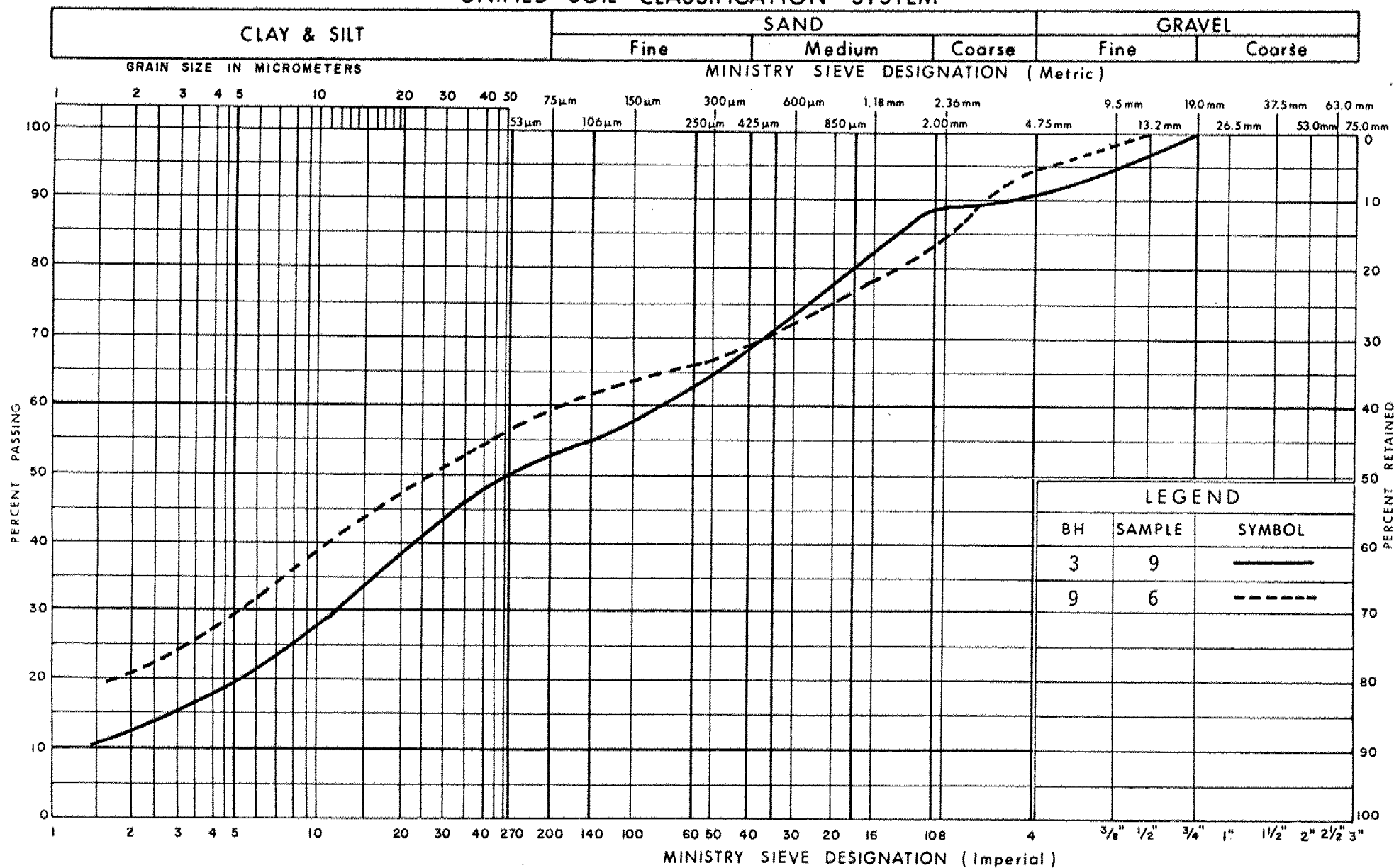
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Transportation and  
Communications

**GRAIN SIZE DISTRIBUTION**  
SILTY CLAY with some Sand & traces of gravel (FILL)

FIG No 1

W P 54-82-05

## UNIFIED SOIL CLASSIFICATION SYSTEM



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Communications

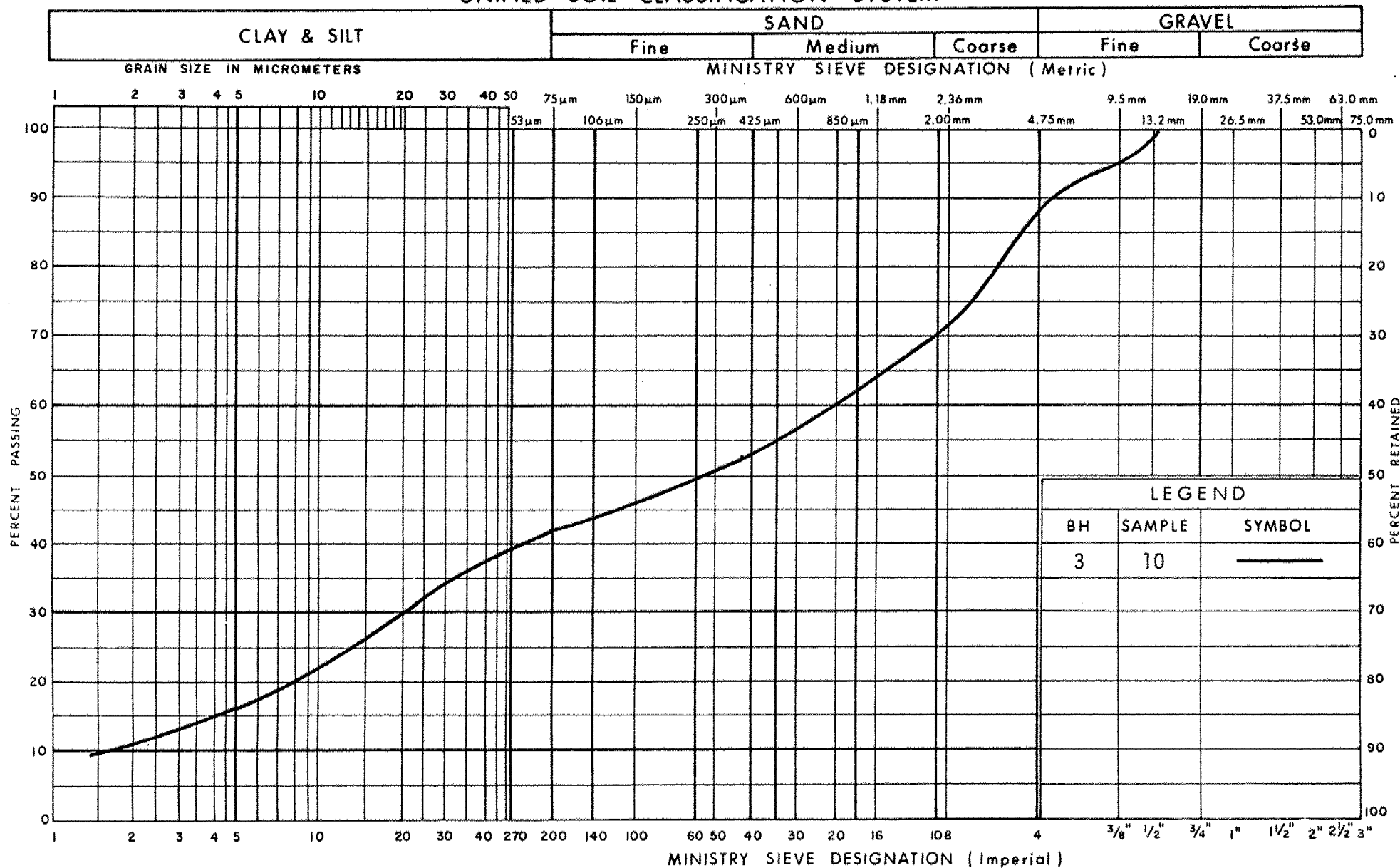
## GRAIN SIZE DISTRIBUTION

SILTY CLAY TILL

FIG No 2

W P 54-82-05

## UNIFIED SOIL CLASSIFICATION SYSTEM

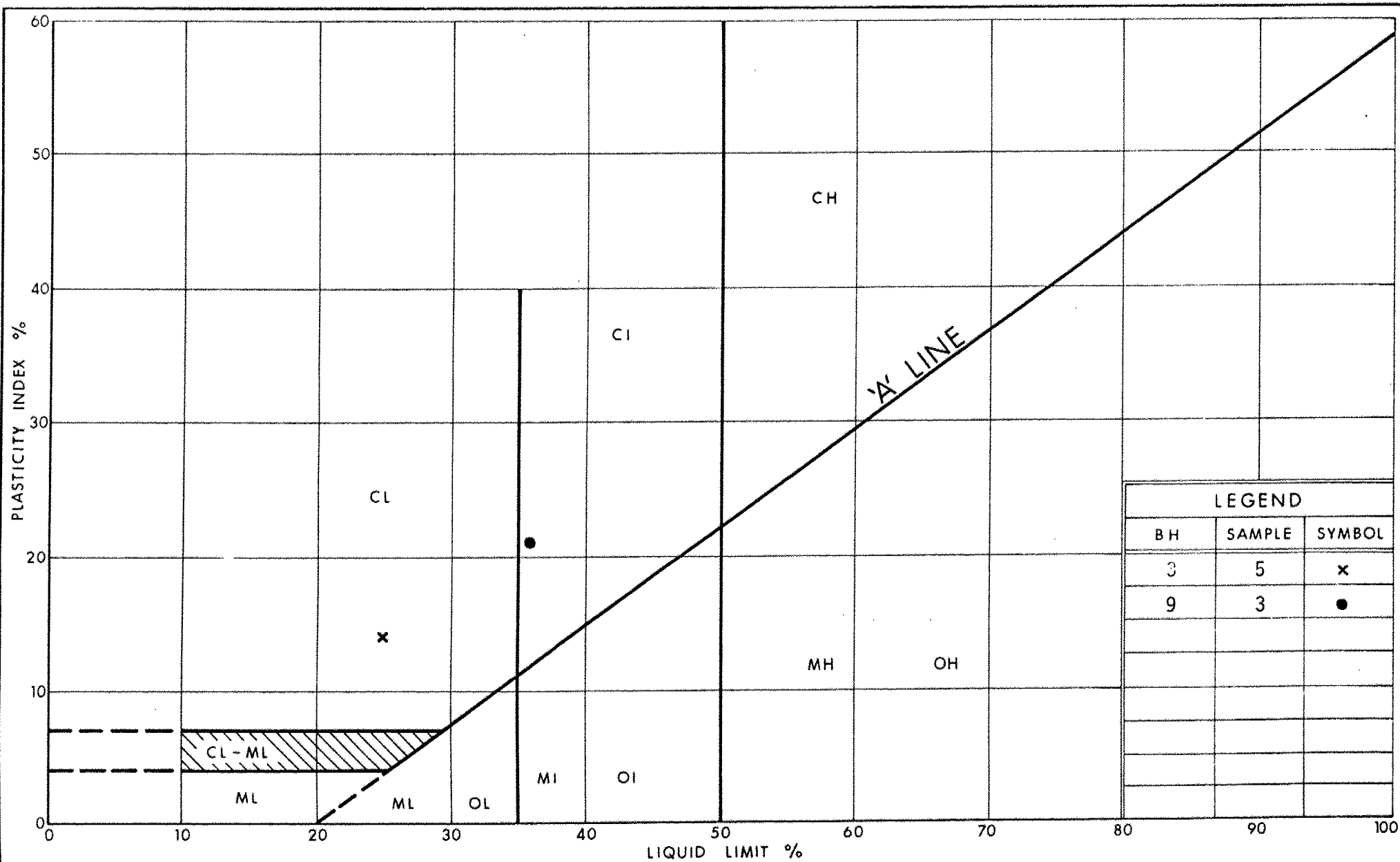


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Communications

**GRAIN SIZE DISTRIBUTION**  
SILTY CLAY TILL with shale fragments

FIG No 3

W P 54-82-05



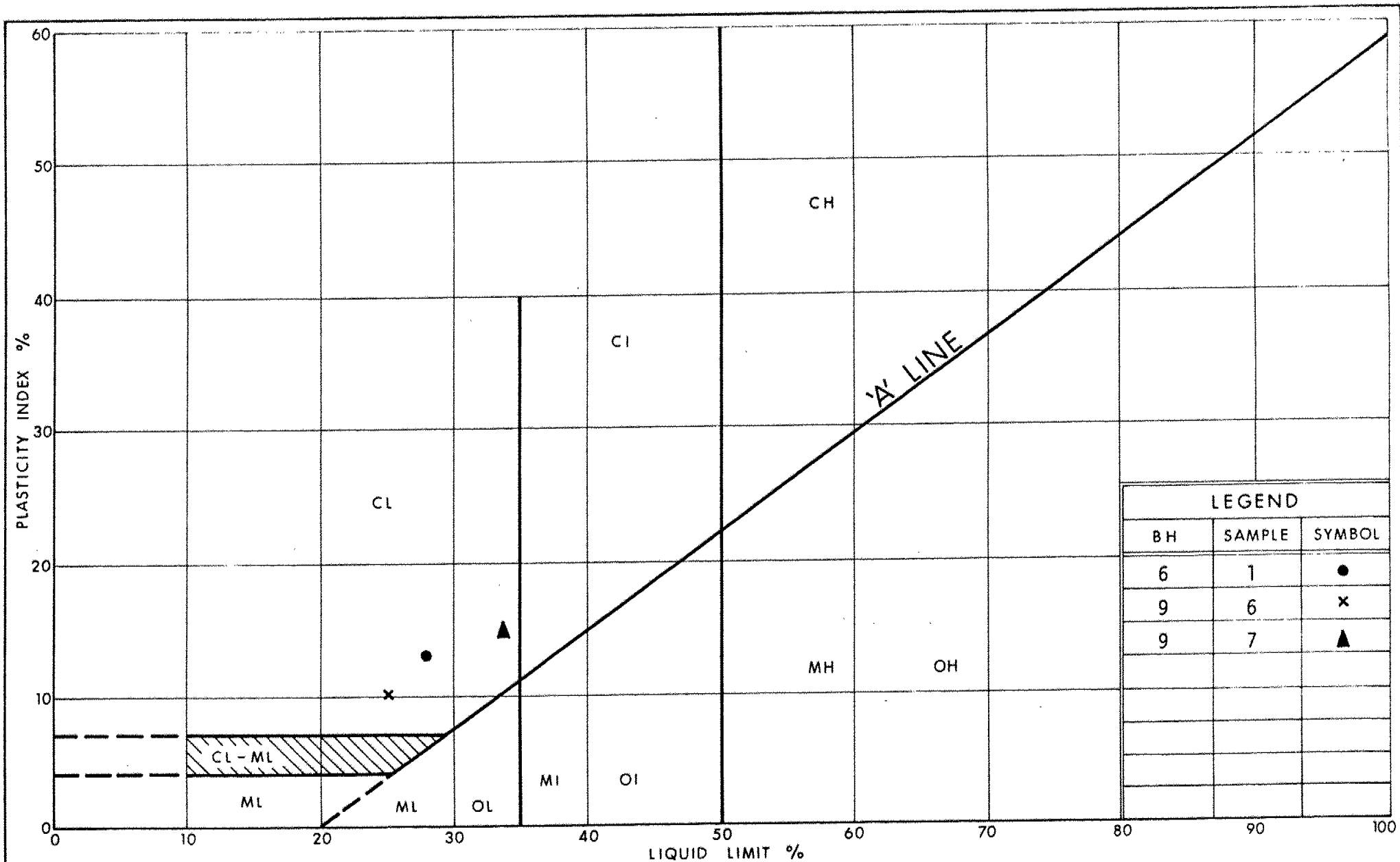
Ministry of  
Transportation and  
Communications  
Ontario

## PLASTICITY CHART

SILTY CLAY with some Sand & Gravel (Fill)

FIG No 4

W P 54-82-05



Ontario

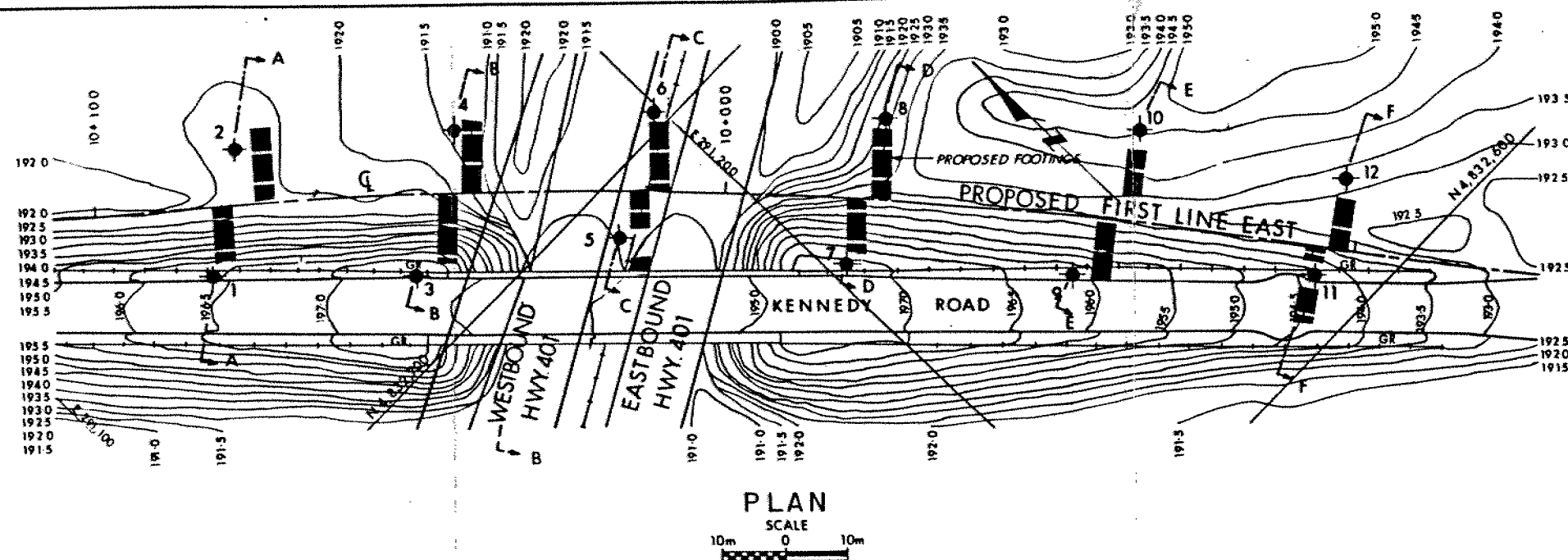
Ministry of  
Transportation and  
Communications

# PLASTICITY CHART SILTY CLAY TILL

FIG No 5

W P 54-82-25





**METRIC**

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

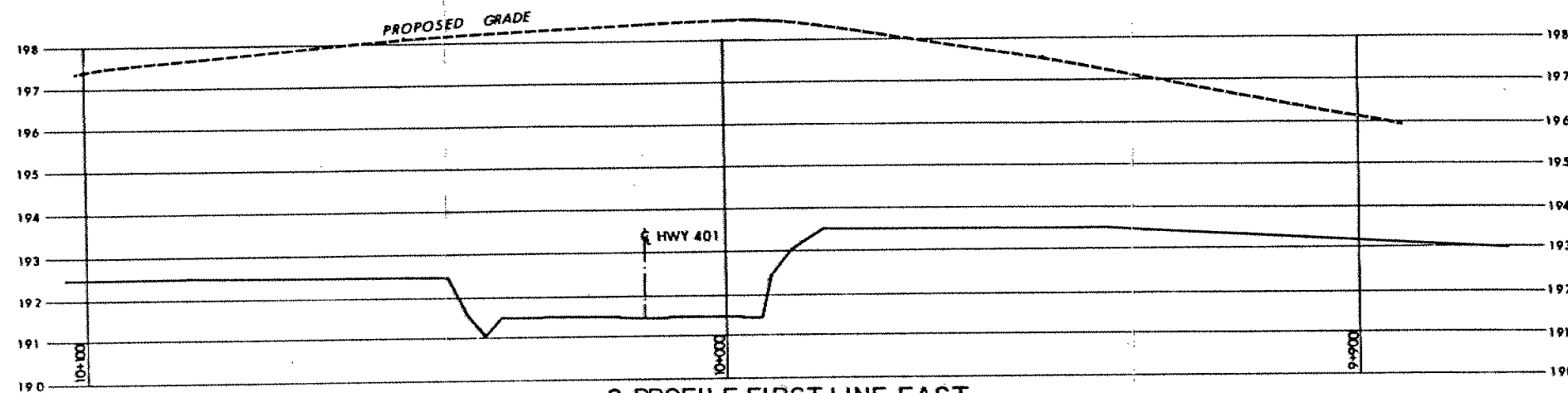
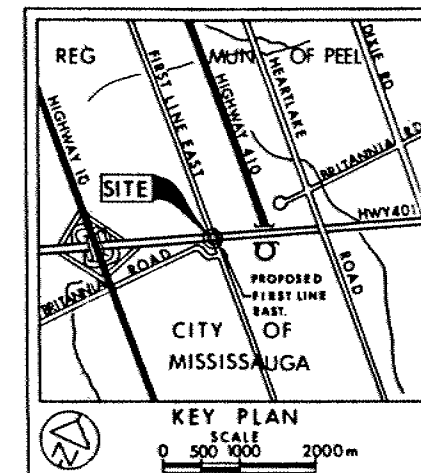
CONT No  
WP No 54-82-05

HWY 401 - HWY 410/403 TO HWY 10  
FIRST LINE EAST (KENNEDY RD)  
BORE HOLE LOCATIONS & SOIL STRATA

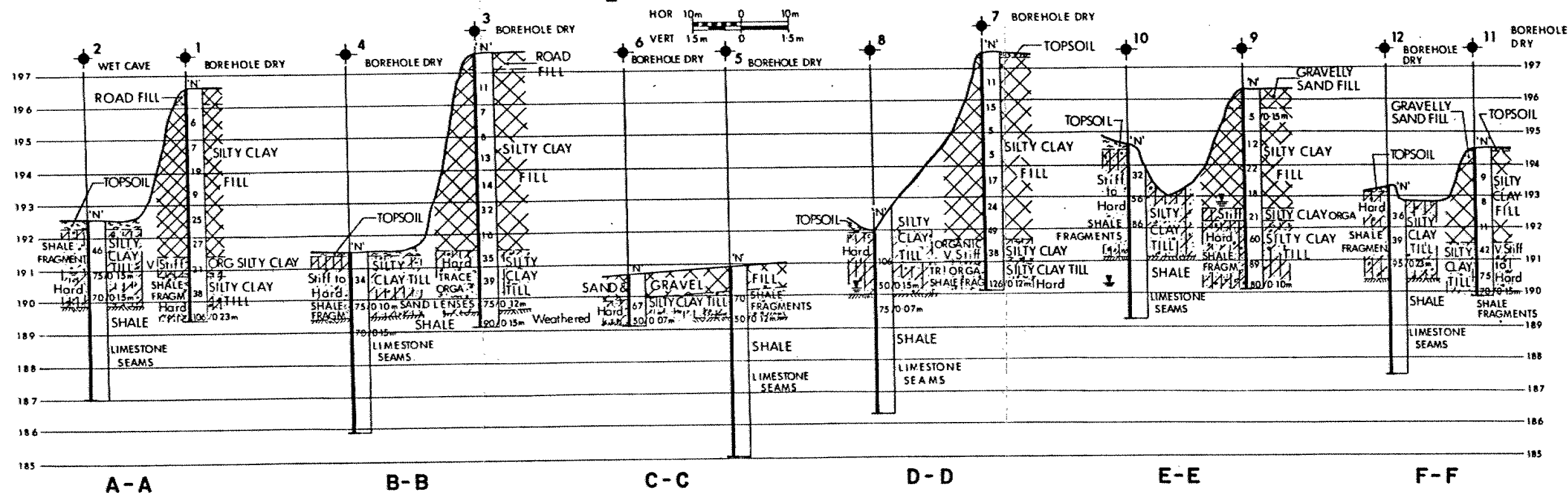
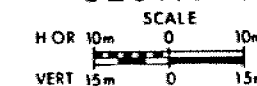


SHEET

DOMINION SOIL INVESTIGATION INC.



SECTIONS



LEGEND

- ◆ Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- ↓ WL at time of investigation 1983 09

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	196.6	4,832,735	291,132
2	192.6	4,832,746	291,149
3	197.6	4,832,712	291,154
4	191.5	4,832,723	291,175
5	190.9	4,832,692	291,181
6	190.7	4,832,703	291,199
7	197.5	4,832,663	291,203
8	192.0	4,832,675	291,224
9	196.3	4,832,637	291,227
10	194.7	4,832,645	291,251
11	194.5	4,832,609	291,254
12	193.3	4,832,616	291,268

NOTE

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

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

DATE	BY	DESCRIPTION
Geocres No 30412-185		
HWY No 401	CHECKED ZSO	DATE 1983 11 02
SUBMITTAL	CHECKED ZSO	SITE 24-181
DRAWN FL	CHECKED ZSO	DWG 548205-A