



**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT
for**

**SYDENHAM RIVER EBL AND WBL BRIDGES
HIGHWAY 402
MTO WEST REGION 59 STRUCTURE REHABILITATIONS
SITES 19-524-1 & 19-524-2, CONTRACT 3
GWP 3075-11-00
TOWNSHIP OF STRATHROY-CARADOC
MIDDLESEX COUNTY, ONTARIO**

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PML Ref.: 13KF006C-SR
Index No.: 163FIR and 164FDR
GEOCRES No.: 40I13-57
January 21, 2015



PRELIMINARY FOUNDATION INVESTIGATION REPORT

for

SYDENHAM RIVER EBL AND WBL BRIDGES

HIGHWAY 402

MTO WEST REGION 59 STRUCTURE REHABILITATIONS

SITES 19-524-1 & 19-524-2, CONTRACT 3

GWP 3075-11-00

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PRELIMINARY FOUNDATION INVESTIGATION REPORT

for
Sydenham River EBL and WBL Bridges
Highway 402
MTO West Region 59 Structure Rehabilitations
Sites 19-524-1 & 19-524-2, Contract 3,
GWP 3075-11-00
Township of Strathroy-Caradoc
Middlesex County, Ontario

1. INTRODUCTION

This report summarizes the results of the foundation investigation carried out for the proposed rehabilitation of the Sydenham River EBL (East Bound Lanes) and WBL (West Bound Lanes) Bridges on Highway 402 in the Township of Strathroy-Caradoc, Middlesex County, Ontario. The proposed rehabilitation is a part of the assignment for the rehabilitation of 59 structures in MTO West Region along Highways 4, 6, 401, 402 and 403. The study was carried out by Peto MacCallum Ltd. (PML) for MMM Group Limited (MMM) on behalf of the Ministry of Transportation of Ontario (MTO).

A Technical Memorandum, dated January 21, 2015, was also prepared as a part of this assignment and is presented in Appendix 1. The purpose of the technical memorandum was to summarize the subsurface and groundwater conditions based on available Geocres reports for the design project terms of reference and to update the foundation design recommendations provided in the available reports to the Limit State design terminology in conformance with the requirements of the Canadian Highway Bridge Design Code (CHBDC).

Based on information gathered from the previous foundation report, the subsoil conditions of the current west abutments of the WBL and EBL bridge structures are not available; therefore, a field investigation comprising of two boreholes was carried out to determine the current subsoil conditions at the west and east abutments.

For subsurface conditions from previous foundation investigations reference should be made to the Technical Memorandum. The present Foundation Investigation and Design Report should be read in conjunction with the Technical Memorandum.

The elevations are expressed in meters in this report.



2. SITE BACKGROUND AND GEOLOGY

The Sydenham River EBL and WBL Bridges on Highway 402 are located in Middlesex County, Ontario. The site is located about 4.7 km northeast of Strathroy, Ontario.

The Sydenham River at this location flows in a general northeast to southwest direction. The river course was diverted to the existing flowing path beneath the Highway 402 structures, approximately 42.6 m west from a previous meandering course. The land surface rises sharply towards the east. The previous river channel was about 7.6 m wide and 3.0 m deep at the time of the previous investigation. The current river channel is about 7.5 m wide.

Physiographically, the site is situated in the region known as the Caradoc Sand Plains. Sand and other light textured water laid deposits are characteristics of this region. The limestone, dolostone or shale bedrock in the area belongs to Hamilton Group of Middle Devonian period.

3. FIELD INVESTIGATION

A total of two boreholes, SR-1 and SR-2, were drilled on July 10 and 11, 2014 at the site location. The boreholes were selected by PML and the survey of the boreholes was conducted by MMM.

The boreholes were drilled in the median between the two structures at the east and west ends. The boreholes locations are shown in Drawing SR-1.

The two boreholes were drilled through the soil cover to 19.8 and 20.4 m. The boreholes were advanced using continuous flight solid augers powered by a track mounted CME 55 drill rig, supplied and operated by a specialist drilling contractor. The drilling crew worked under the full-time supervision of a member of our engineering staff.

Representative samples of the soils encountered in the boreholes were recovered at frequent depth intervals. In the boreholes advanced with conventional drill rigs, soil samples were obtained using a split spoon sampler in conjunction with standard penetration tests. Where standard



penetration tests were not carried out the consistency/compactness of the encountered soils was estimated from manual examination or the rate (ease) of advance of the augers.

The boreholes were backfilled in accordance with the MTO guidelines and MOE regulation 903 for borehole abandonment procedures using a bentonite/cement mixture grout and asphalt patch.

The groundwater conditions at the borehole locations were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and, when appropriate, by measurement of the water level in the open boreholes.

Soils were identified in the field in accordance with the MTO Soil Classification procedures. Recovered soil samples were returned to our laboratory for detailed visual examination and soil classification. The laboratory test program for the current subsurface investigation comprised the following tests:

- Natural moisture content determinations (29)
- Grain size analyses (9)
- Atterberg limits (2)

The results of the laboratory natural moisture content determinations and grain size analyses are shown on the Record of Borehole sheets SR-1 and SR-2. The grain size distribution charts are presented on Figures SR-GS-1 to SR-GS-4 and the plasticity charts are presented in Figures SR-PC-1 and SR-PC-2.

4. SUBSURFACE CONDITIONS

Reference is made to the appended Record of Boreholes SR-1 and SR-2 sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, standard penetration test N values, grain size distribution and groundwater observations. The boundaries between soil strata have been established at the borehole locations only. Between and beyond the boreholes, the boundaries are assumed and may vary.



In summary, the subsurface conditions encountered in the two boreholes included surficial topsoil (in borehole SR-2 only) over 6.3 and 9.1 m thick fill. A 0.5 m thick peat layer was encountered below the fill which overlaid a stiff 1.5 m thick silty clay layer in borehole SR-2. Below the fill in borehole SR-1 and below the silty clay deposit in borehole SR-2, non-cohesive very loose to very dense sandy/silty soils were encountered. Borehole SR-1 was terminated in the silt deposit at 20.4 m, elevation 213.9. In borehole SR-2, hard clayey silt till deposit was encountered below the non-cohesive soils at 19.1 m, elevation 215.3. The borehole was terminated in the clayey silt till deposit at 19.8 m, elevation 214.6. Bedrock was not encountered in the two boreholes.

4.1 Topsoil

A 0.7 m thick surficial topsoil layer was encountered in borehole SR-2 and extended to elevation 233.7. Mixed granular fill was encountered in the topsoil deposit. One N value recorded was 11.

4.2 Fill

Fill was encountered surficially in borehole SR-1 and below topsoil in borehole SR-2. The fill extended to 9.1 and 7.0 m, elevation 225.2 and 227.4, in borehole SR-1 and SR-2, respectively. The fill included layers of gravelly sand, silty sand, clayey silt and silty clay with inclusions of glass and brick pieces, wood debris, organic and rootlets. Cobbles were also included in the fill matrix. N values recorded in the fill units ranged between 7 and 29, with one high N value of 50 blows for 15 cm penetration recorded in borehole SR-2 where cobbles were encountered.

A grain size distribution chart of two fill samples is presented in Figure SR-GS-1. Moisture content determinations of the fill samples ranged between 9 and 30%.



4.3 Peat

A layer of 500 mm thick peat was encountered below the fill layer in borehole SR-2 at 7.0 m, elevation 227.4, which extended to 7.5 m, elevation 226.9.

4.4 Silty Clay

A 1.5 m thick stiff silty clay layer was encountered below the peat layer in borehole SR-2 at 7.5 m, elevation 226.9 and extended to 9.0 m, elevation 225.4. One N value recorded was 15.

A grain size distribution chart is presented in Figure SR-GS-2 and the corresponding plasticity chart is presented in Figure SR-PC-1. The liquid and plastic limits obtained were 41 and 22. The plasticity index value was 19. One moisture content determination was 35%.

4.5 Sand

A 2.7 m thick dense sand layer was encountered in borehole SR-1 below fill at 9.1 m, elevation 225.2. The sand layer extended to 11.8 m, elevation 222.5. Two moisture content determinations were 18 and 24%.

4.6 Silty Sand

A deposit of 1.6 and 1.5 m thick silty sand was encountered in boreholes SR-1 and SR-2 at 11.8 and 9.0 m, elevation 222.5 and 225.4, respectively. The silty sand layer extended to 13.4 and 13.5 m, elevation 220.9 and 223.9. One N value of 54 was recorded in borehole SR-1, indicating very dense compactness. The N value recorded in borehole SR-2, 'WH' (weight of hammer and rods), was disturbed due to hydraulic disturbance during drilling.

A grain size distribution chart is presented in Figure SR-GS-3. Two moisture content determinations were 19 and 21%.



4.7 Silt

A compact to very dense silt deposit was encountered below the silty sand layer in borehole SR-1 at 13.4 m, elevation 220.9 and extended to the borehole termination depth 20.4 m, elevation 213.9. N values recorded ranged from 30 to 92 blows for 28 cm penetration.

Grain size distribution results of selected samples are presented in Figure SR-GS-4. Moisture content determinations ranged between 18 and 26%.

4.8 Sand and Silt / Silt and Sand

A compact 3.0 m thick sand and silt layer was encountered below the silty sand layer in borehole SR -2 at 10.5 m, elevation 223.9 and extended to 13.5 m, elevation 220.9. Two N values 18 and 4 were recorded. The low N value was due to hydraulic disturbance during drilling. A lower 1.1 m thick compact silt and sand layer was encountered below sandy silt at 18.0 m, elevation 216.4 and extended to 19.1 m, elevation 215.3.

Grain size distribution results are presented in Figure SR-GS-5. Two moisture content determinations recorded were 18 to 25%.

4.9 Sandy Silt

A 4.5 m thick compact sandy silt deposit was encountered in borehole SR-2 between the silt and sand layers at 13.5 m, elevation 220.9, extending to 18.0 m, elevation 216.4. N values recorded were between 14 and 26.

A grain size distribution chart of a selected sandy silt sample is presented in Figure SR-GS-6. Moisture content determinations were between 17 and 20%.



4.10 Clayey Silt Till

Hard clayey silt till was encountered in borehole SR-2 below the lower silt and sand deposit at 19.1 m, elevation 215.3. The borehole was terminated in the clayey silt till at 19.8 m, elevation 214.6. One N value recorded was 40.

An Atterberg plasticity chart of the clayey silt till sample is presented in Figure SR-PC-2. The liquid and plastic limits obtained were 26 and 13, respectively, with a plasticity index of 13.

4.11 Groundwater

The Sydenham River water level was at elevation 227.2 in April 2013 (provided by MMM).

Groundwater was encountered in borehole SR-1 at 6.1 m, elevation 228.2 and in borehole SR-2 at 9.1 m, elevation 225.3, during augering. Upon completion of augering, groundwater was encountered in borehole SR-1 at 5.2 m, elevation 229.1 and in borehole SR-2 at 6.4 m, 228.0. The elevation of the river water level was measured at approximate elevation 227.0 in July 11, 2014.

It should be noted that the groundwater level is subjected to seasonal fluctuations of the river water level and rainfall patterns.

5. MISCELLANEOUS

Mr. S. Aziz carried out the field investigation for this study under the supervision of Mr. N. Rahman, P.Eng. Fisher Environmental Ltd. supplied the drilling equipment for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.



6. CLOSURE

This preliminary report was prepared by Mr. N. Rahman, P.Eng and was reviewed by Mr. R. Ng, PhD, P.Eng., Senior Project Engineer. Mr. B. R. Gray, MEng, P.Eng., MTO Designated Principal Contact conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.



Nazibur Rahman, P.Eng.
Project Engineer, Geotechnical Services



Robert Ng, MBA, PhD, P.Eng.
Senior Project Engineer



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

NR/RN/BRG:nr-mi-jk

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
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{v0}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_i	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No. SR-1

1 of 2

METRIC

G.W.P. 3075-11-00 LOCATION Co-ordinates: 4 760 730.6 N; 380 114.5 E ORIGINATED BY S.A.
DIST London HWY 402 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.R.
DATUM Geodetic DATE July 10 and 11, 2014 CHECKED BY B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20 40 60 80 100										20 40 60		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
234.3	Ground Surface																			
0.0	Gravelly sand																			
234.0	Compact Dark brown		1	SS	10		234													
0.3	Silty sand, rootlets organic inclusions																			
	Compact Brown/ Moist grey		2	SS	9							○								
	glass and brick debris wet seams						233													
			3	SS	29							○								
232.1																				
2.2	Clayey silt, cobbles organic inclusions						232													
	Very stiff Brown/ Moist grey		4	SS	16							○								
			5	SS	24		231					○								
			6	SS	16							○								
229.8							230													
4.5	Silty clay, rootlets organic inclusions											○								
	Very stiff Brown/ Moist grey		7	SS	23							○								
229.0							▼*	229												
5.3	Sand, some silt clayey seams organic inclusions											○				0 73 18 9				
	Compact Brown/ Moist dark brown						▼*													
	trace silt wood debris											○								
	Grey Wet											○				0 88 (12)				
	(FILL)																			
			12	SS	16		226						○							
225.2	peat inclusions																			
9.1	Sand some to trace silt																			
	Dense Brown Wet											○								

Cont'd

RECORD OF BOREHOLE No. SR-1

2 of 2

METRIC

G.W.P.	3075-11-00	LOCATION	Co-ordinates: 4 760 730.6 N; 380 114.5 E	ORIGINATED BY	S.A.
DIST	London	HWY	402	BOREHOLE TYPE	Continuous Flight Solid Stem Augers
DATUM	Geodetic	DATE	July 10 and 11, 2014	COMPILED BY	N.R.
				CHECKED BY	B.R.G.

[illegible]

RECORD OF BOREHOLE No. SR-2

1 of 2

METRIC

G.W.P. 3075-11-00 **LOCATION** Co-ordinates: 4 760 681.9 N; 380 158.3 E **ORIGINATED BY** S.A.
DIST London **HWY** 402 **BOREHOLE TYPE** Continuous Flight Solid Stem Augers **COMPILED BY** N.R.
DATUM Geodetic **DATE** July 10, 2014 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
234.4	Ground Surface						20	40	60	80	100						GR	SA	SI	CL
0.0	Topsoil		1	SS	11															
233.7																				
0.7	Sandy silt, rootlets and organic inclusions		2	SS	13															
	Compact Brown/ Moist clay seams dark brown																			
			3	SS	21								○							
232.2																				
2.2	Silty sand, trace clay		4	SS	17								○							
	Compact Grey Moist																			
	cobbles		5	SS	50/15cm															
229.9																				
4.5	Clayey silt, trace gravel rootlets		6	SS	7									○						
	Firm to Brown/ Moist stiff grey																			
	clayey silt to silty clay		7	SS	12									○						
	(FILL)																			
227.4																				
7.0	Peat, amorphous																			
226.9	Dark brown																			
7.5	Silty clay, with sand rootlets, organics wood debris		8	SS	15									○						
	Stiff Grey Moist																			
225.4																				
9.0	Silty sand		9	SS	WH**									○						
	Grey/ Wet brown																			
223.9																				
10.5	Silt and sand, trace clay		10	SS	18									○						
	Compact Grey Wet																			
			11	SS	4***									○						
220.9																				
13.5	Sandy silt, trace clay		12	SS	23									○						
	Compact Grey Wet																			

Cont'd

RECORD OF BOREHOLE No. SR-2

2 of 2

METRIC

G.W.P.	3075-11-00	LOCATION	Co-ordinates: 4 760 681.9 N; 380 158.3 E	ORIGINATED BY	S.A.
DIST	London	HWY	402	BOREHOLE TYPE	Continuous Flight Solid Stem Augers
DATUM	Geodetic	DATE	July 10, 2014	COMPILED BY	N.R.
				CHECKED BY	B.R.G.

[illegible]

CONT No
GWP No 3075-11-00
WP No 3076-08-01
3077-08-01



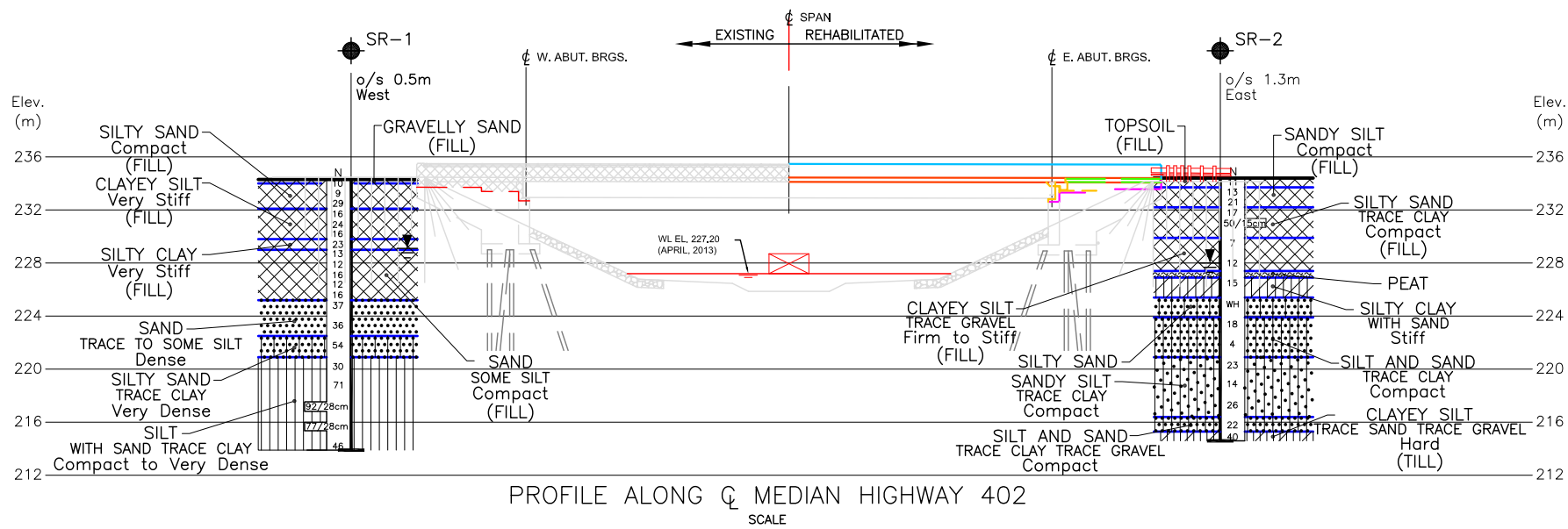
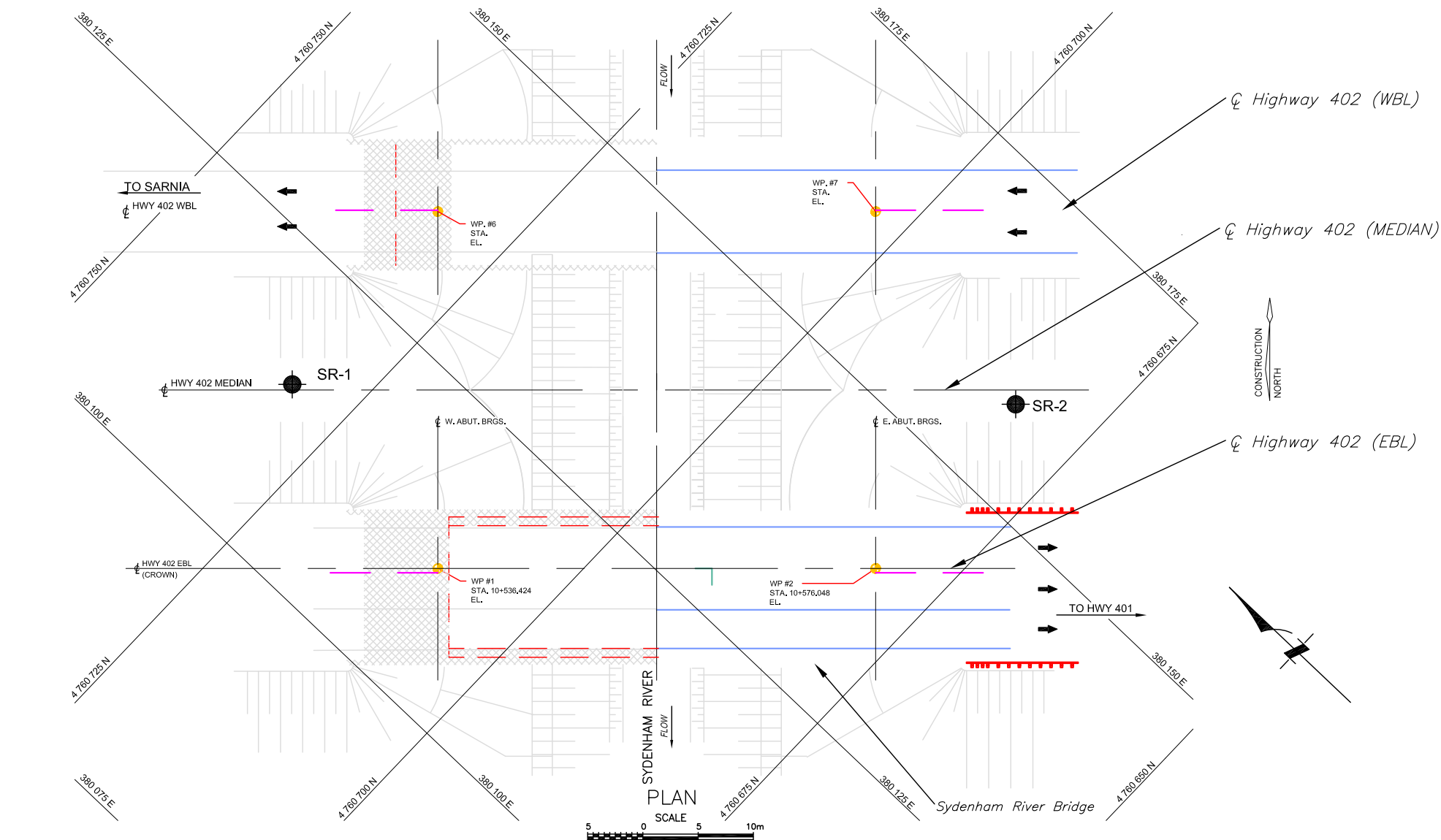
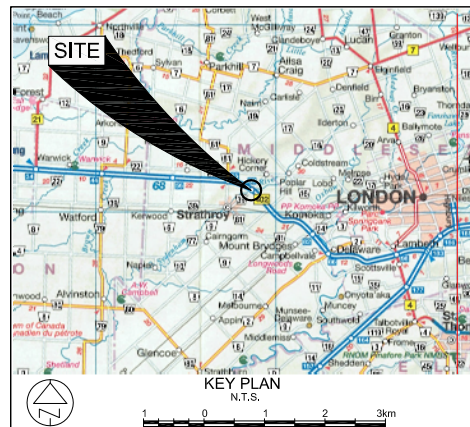
SYDENHAM RIVER BRIDGE

HIGHWAY 402

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

PML Peto MacCallum Ltd.
CONSULTING ENGINEERS



NOTES:

- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH RECORD OF BOREHOLES AND REPORT
- 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.

LEGEND

- Borehole
- Borehole and cone
- Cone penetration test
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WH Penetration due to weight of rods and hammer
- W L at time of investigation July 2014
- Head
- ARTESIAN WATER Encountered
- PIEZOMETER

BH No	ELEVATION	COORDINATES	
		NORTHINGS	EASTINGS
SR-1	234.3	4 760 730.6	380 114.5
SR-2	234.4	4 760 681.9	380 158.3

NOTE

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

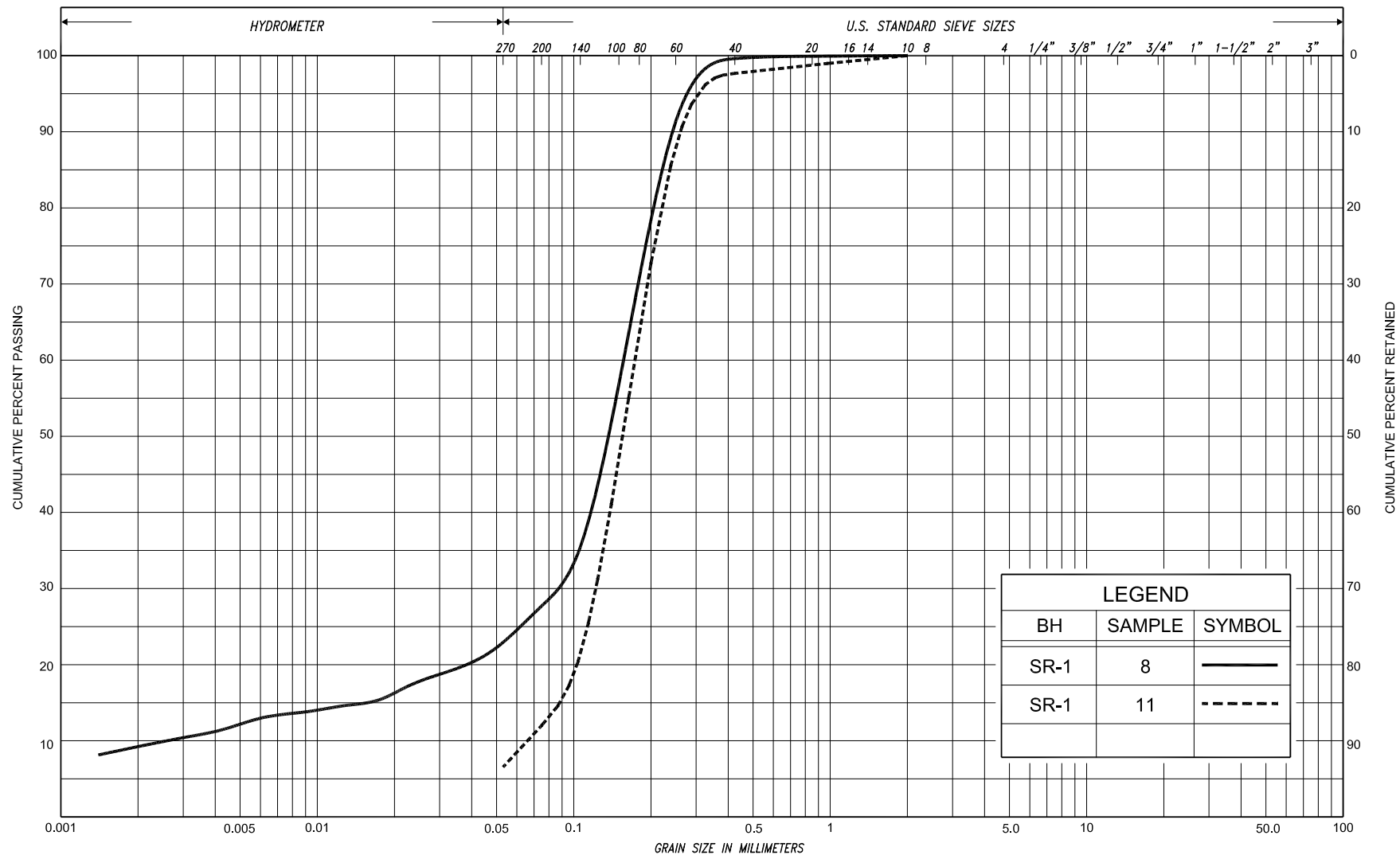


Reference Composite of MMM Drawings:
S381 3001-307-001.GA.dwg; and S381 3001-308-001GA.dwg
dated August 2014

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 40113-57

HWY No	402	CHECKED	NR	DATE	JAN. 21, 2015	DIST	LONDON
SUBMD	NA	CHECKED	NR	DATE	JAN. 21, 2015	SITE	19-524/1 & 2
DRAWN	NA	CHECKED	NR	DATE	JAN. 21, 2015	DWG	SR-1

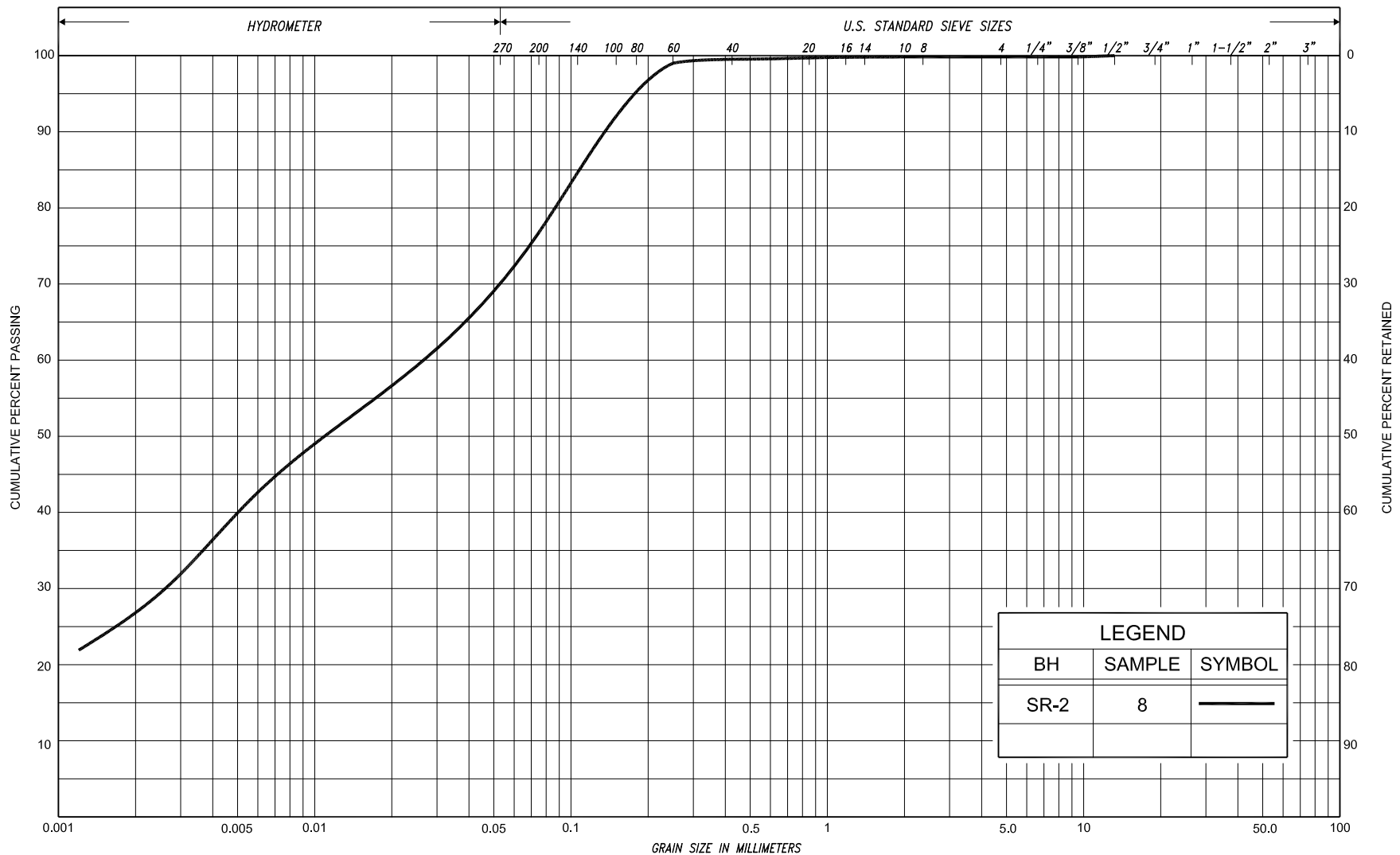


SILT & CLAY					FINE		MEDIUM		COARSE	GRAVEL			COB BLES	UNIFIED		
					SAND											
CLAY	FINE		MEDIUM		COARSE	FINE		MEDIUM		COARSE		GRAVEL			COBBLES	M.I.T.
	SILT					SAND										
CLAY			SILT			V. FINE	FINE	MED.	COARSE		GRAVEL					
					SAND											

GRAIN SIZE DISTRIBUTION SAND, trace to some silt (clayey silt seams) (FILL)

FIG No. SR-GS-1
HWY: 402
G.W.P. No. 3075-11-00





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

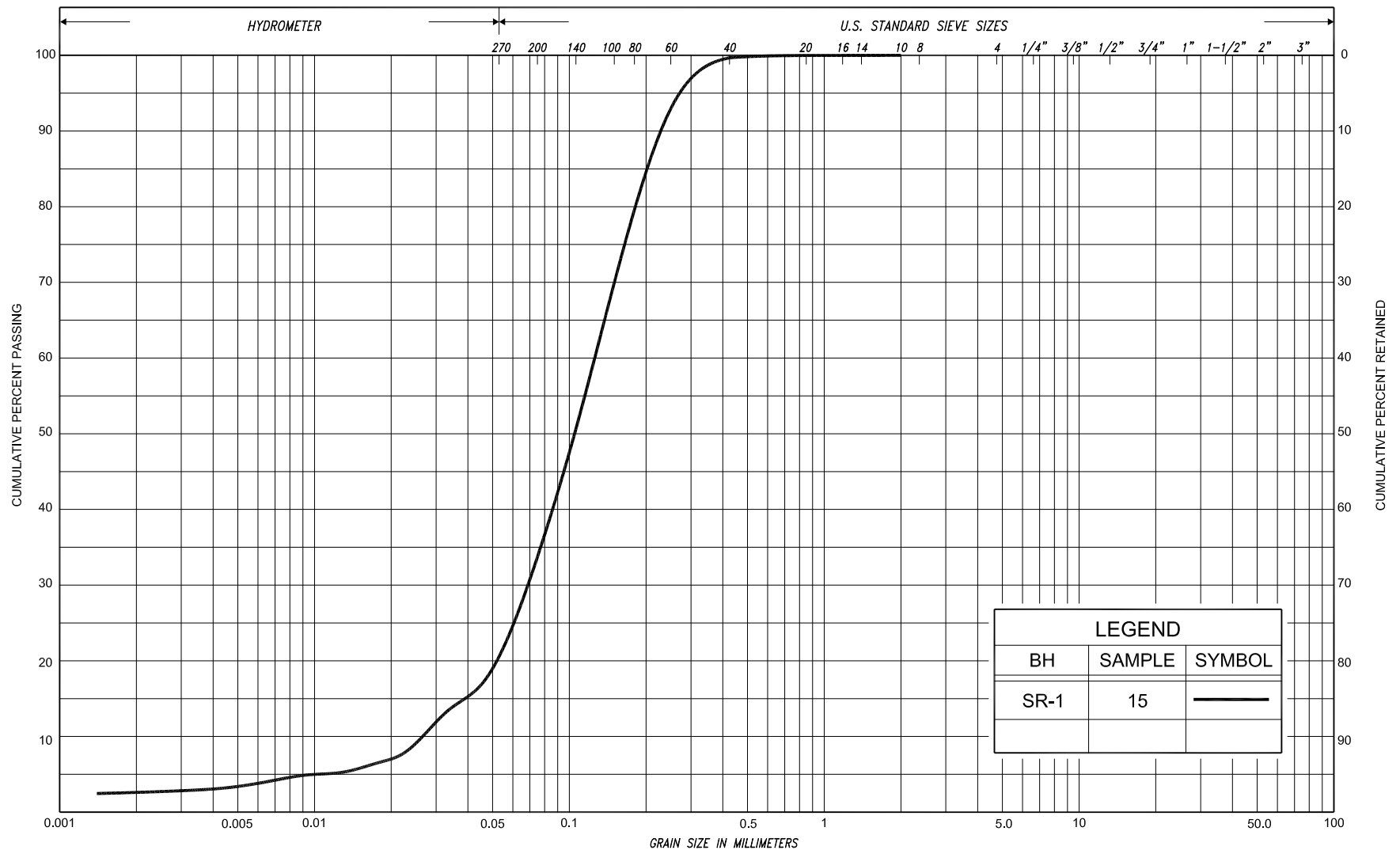


GRAIN SIZE DISTRIBUTION SILTY CLAY, with sand (CI)

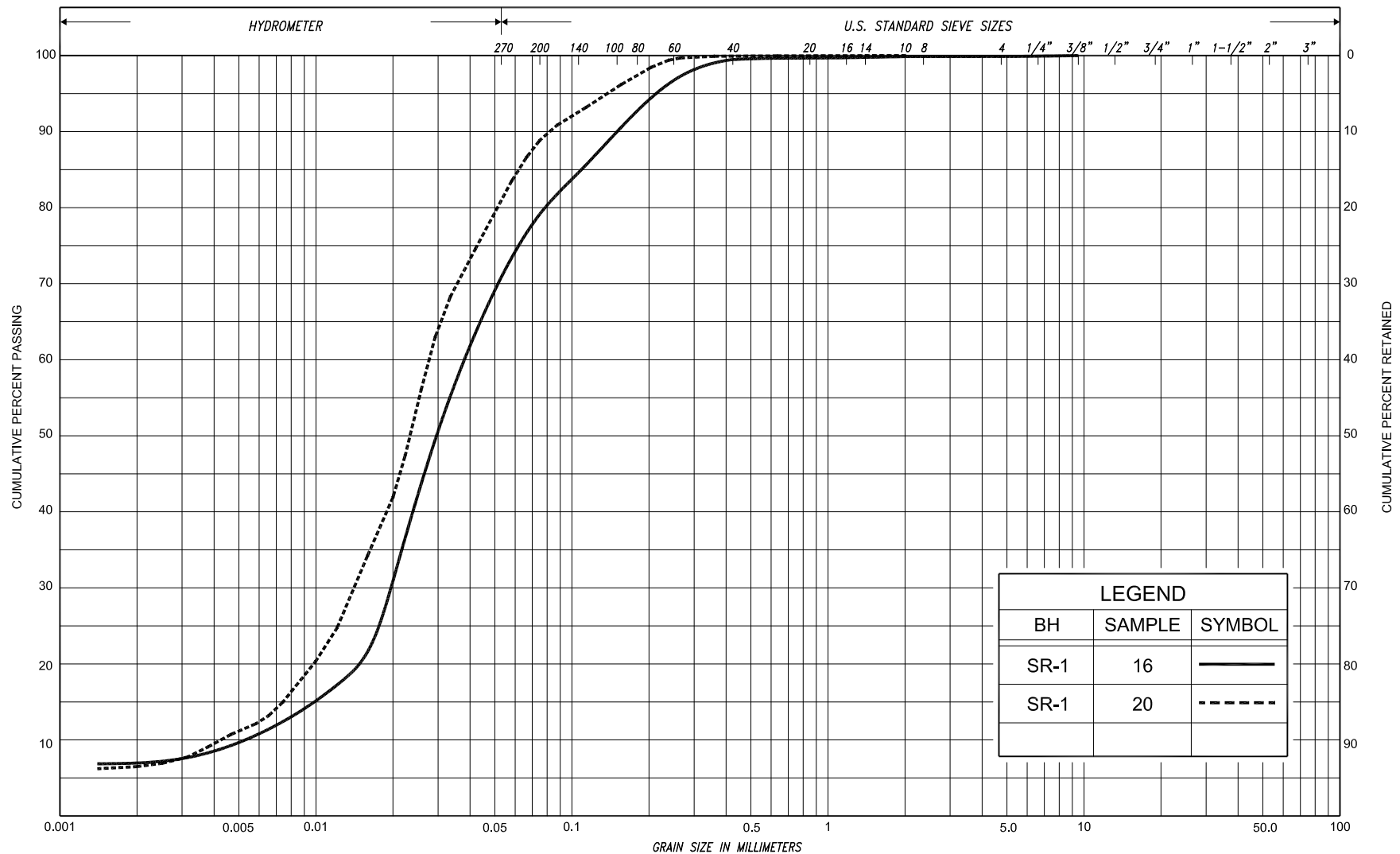
FIG No. SR-GS-2

HWY: 402

G.W.P. No. 3075-11-00



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



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



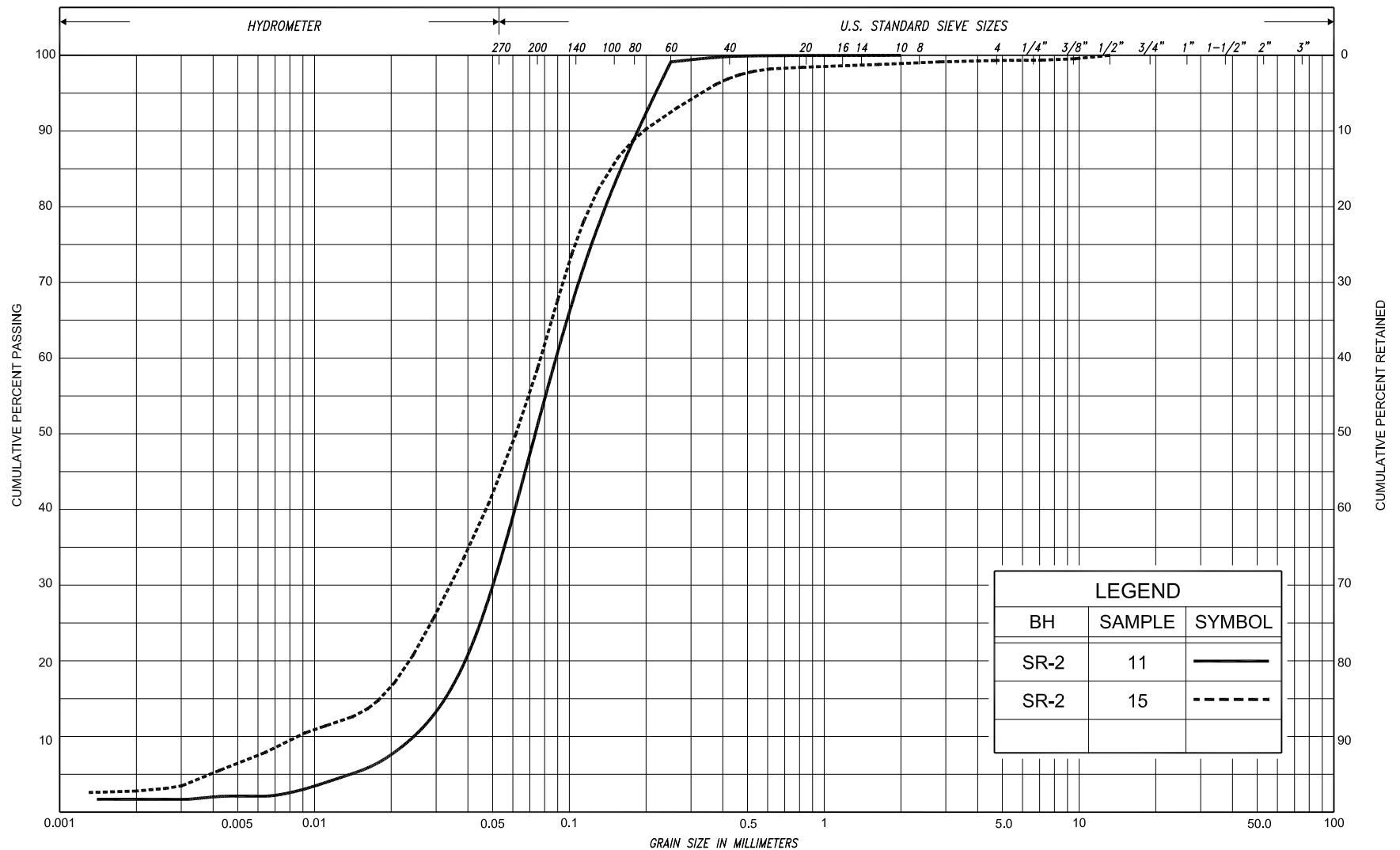
GRAIN SIZE DISTRIBUTION

SILT, some to with sand, trace clay

FIG No. SR-GS-4

HWY: 402

G.W.P. No. 3075-11-00



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



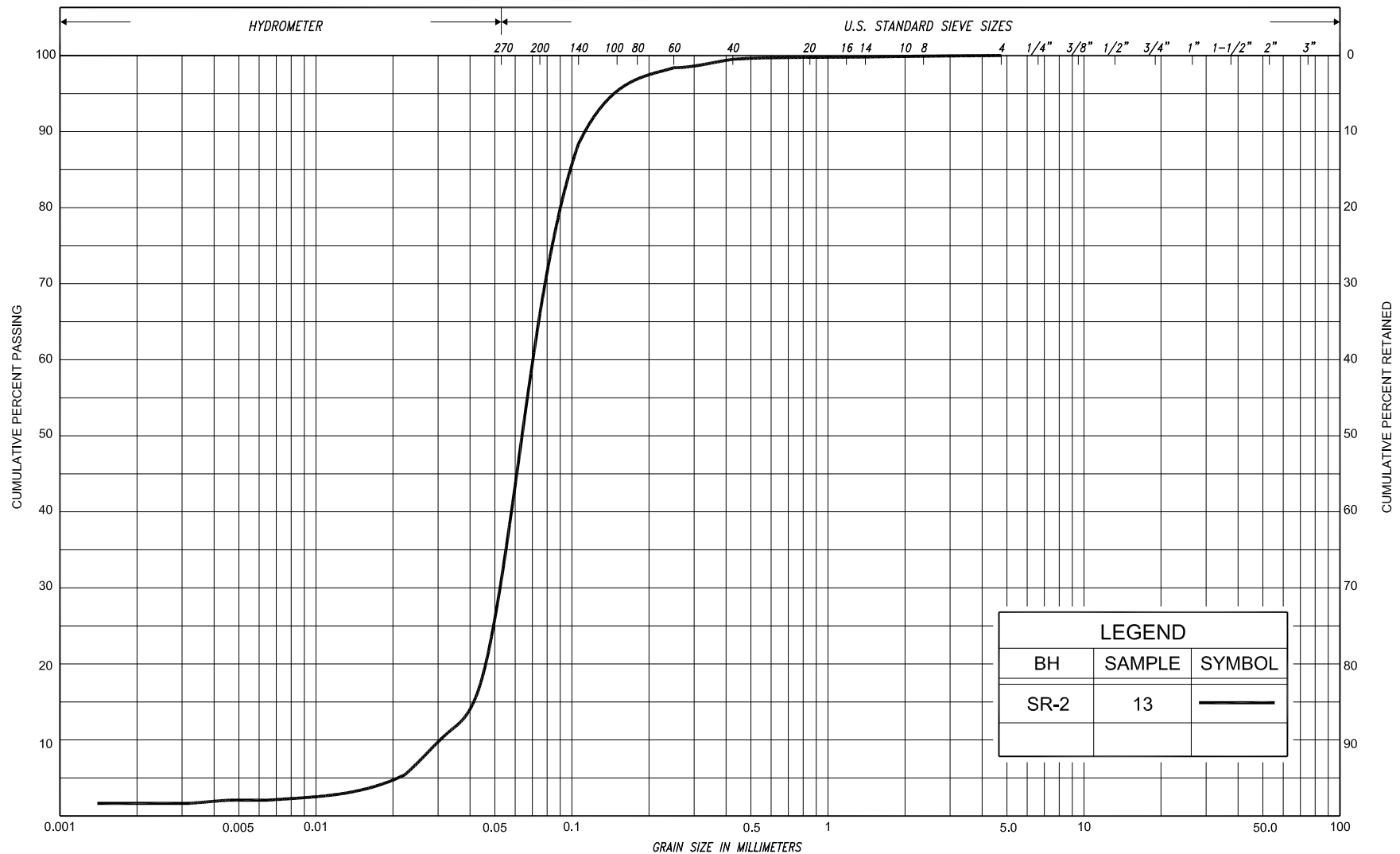
GRAIN SIZE DISTRIBUTION

SILT AND SAND, trace clay, trace gravel

FIG No. SR-GS-5

HWY: 402

G.W.P. No. 3075-11-00



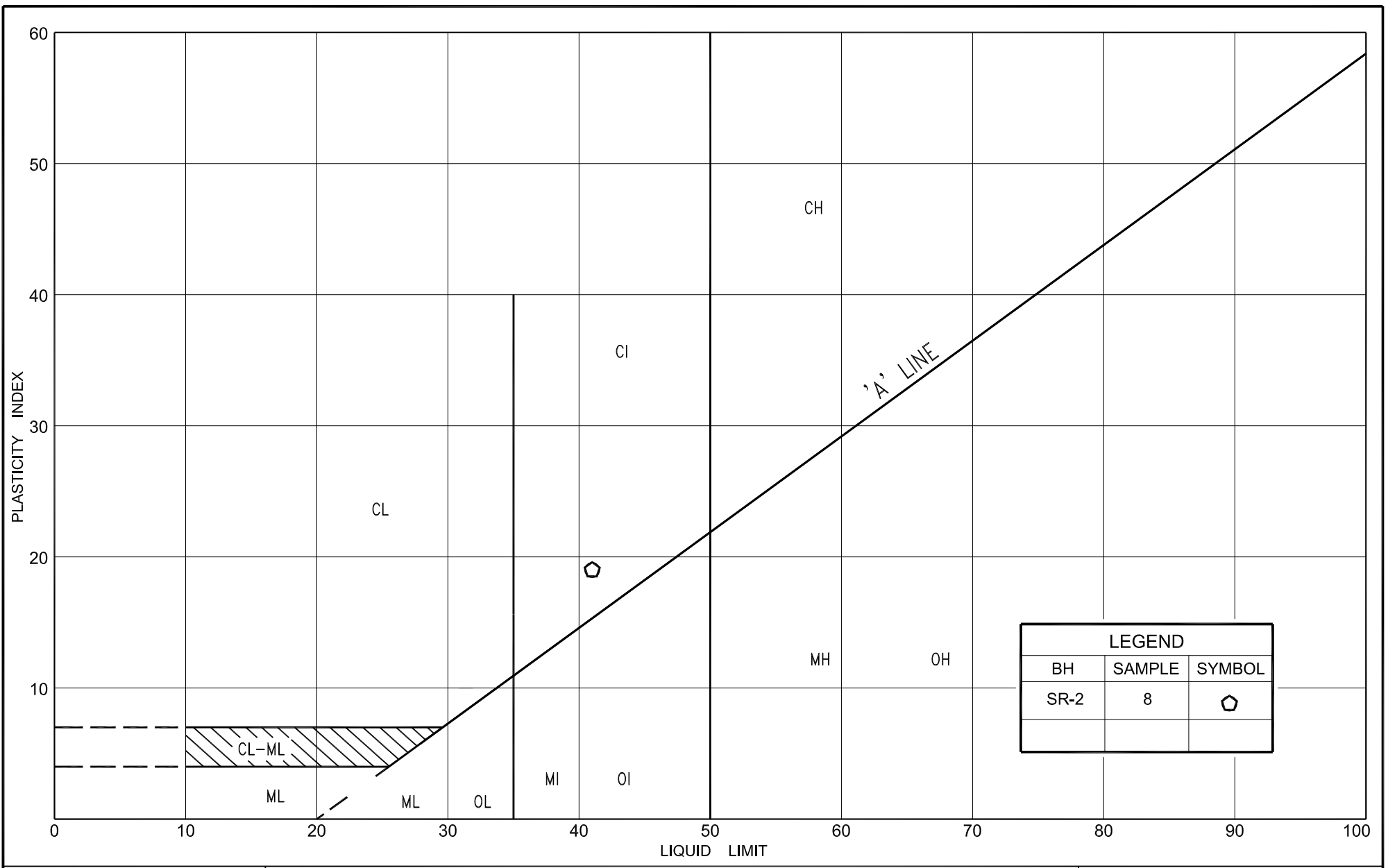
SILT & CLAY				FINE SAND			COARSE SAND	GRAVEL	COBBLES	UNIFIED
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COARSE	GRAVEL	COBBLES	M.I.T.
CLAY	SILT			V. FINE	FINE	MED.	COARSE	GRAVEL		U.S. BUREAU



GRAIN SIZE DISTRIBUTION

SANDY SILT, trace clay

FIG No. SR-GS-6
 HWY: 402
 G.W.P. No. 3075-11-00

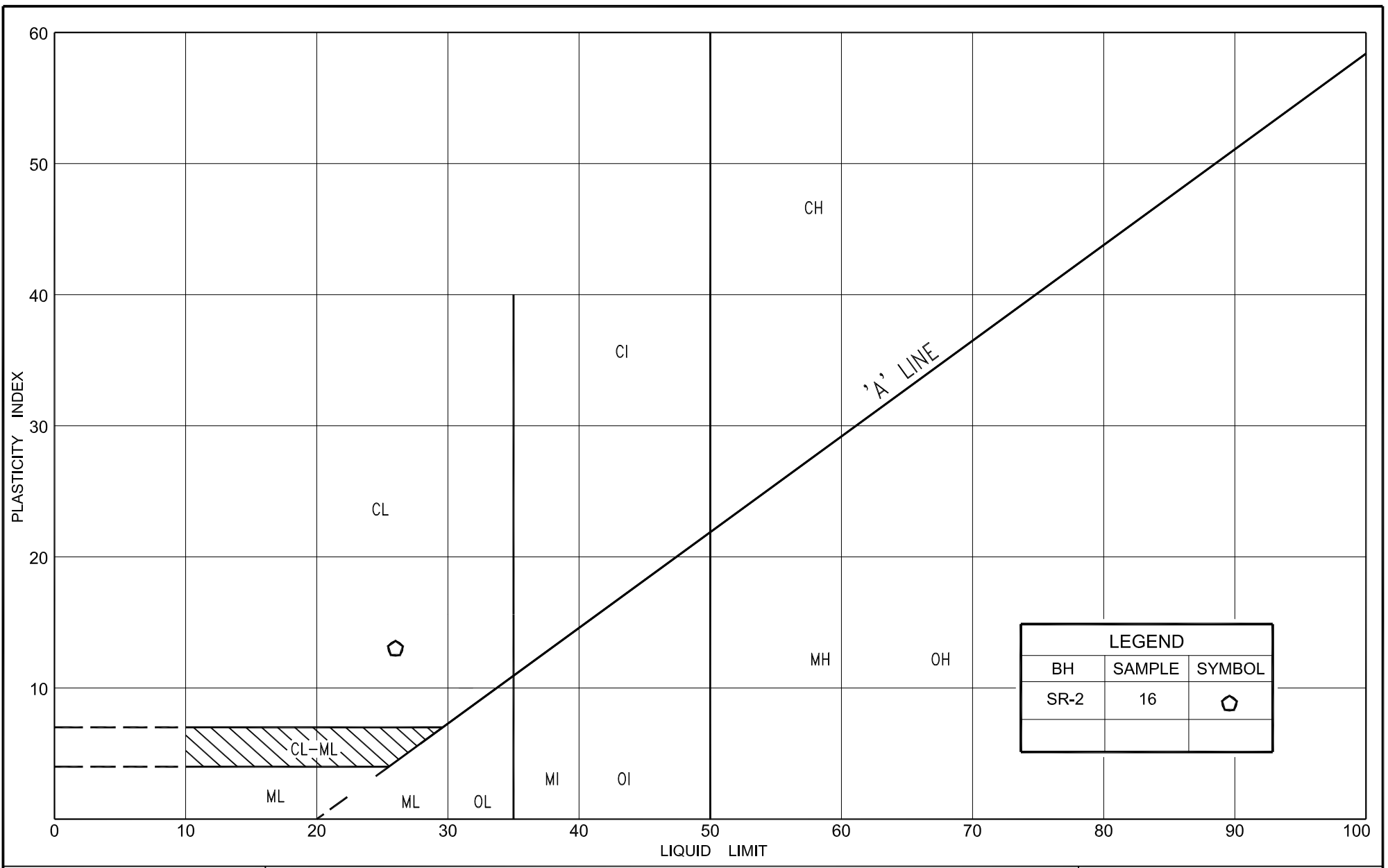


PLASTICITY CHART SILTY CLAY, with sand (CI)

FIG No. SR-PC-1

HWY: 402

G.W.P. No. 3075-11-00



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

FIG No.	SR-PC-2
HWY:	402
G.W.P. No.	3075-11-00



APPENDIX 1

TECHNICAL MEMORANDUM



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Table 1 – List of Standard Specifications

Figure 1 – Key Plan

Appendix A – Previous Foundation Investigation Report (GEOCRES 40I13-45)

- General Layout, Sydenham River Bridge
- Footing Layout and Reinforcing Drawing

Appendix B – Site Photographs

FOUNDATION TECHNICAL MEMORANDUM

For

Sydenham River EBL and WBL Bridges
Highway 402
MTO West Region 59 Structure Rehabilitations
Sites 19-524-1 & 19-524-2
Contract 3, GWP 3075-11-00
Township of Strathroy-Caradoc
Middlesex County, Ontario

1. INTRODUCTION

The Foundation Engineering Services for the present project involve the detail foundation investigation and design for the rehabilitation of 59 structures in MTO West Region along Highways 4, 6, 401, 402 and 403. Ten (10) Group Work Projects (GWPs) are contemplated to be completed between 2014 and 2020.

This technical memorandum summarizes the factual results of geotechnical data based on review and compilation of existing subsurface information from relevant reports in MTO GEOCRES Library for the Highway 402 Sydenham River EBL (Eastbound Lanes) and WBL (Westbound Lanes) Bridges. The Foundation Engineering recommendations from the original bridge foundation reports are summarized with reference to the "Canadian Highway Bridge Design Code" (CHBDC) and follow in general the "Guidelines for Professional Engineers providing Geotechnical Engineering Services".

From the Minutes of Meeting Report, dated May 5, 2014, it is understood that the rehabilitation of the structures will include replacement of the existing concrete barrier walls and conversion to semi-integral abutments. In addition, traffic staging will be required to complete the rehabilitation work of the Sydenham River EBL and WBL Bridge structures in two stages and will be coordinated with the traffic staging for Hickory Drive EBL and WBL Overpass structures.

The purpose of this technical memorandum is to summarize the subsurface and groundwater conditions and foundation recommendations based on available reports for the design project team's reference.

The elevations in this report are expressed in meters, unless otherwise noted.



2. PROJECT SITE BACKGROUND AND GEOLOGY

The Sydenham River EBL and WBL Bridges on Highway 402 are located in the Township of Strathroy-Caradoc, Middlesex County, Ontario. The site is located about 4.7 km northeast of Strathroy, Ontario. A key plan is shown in Figure 1.

The Sydenham River at this location flows in a general northeast to southwest direction. The river course was diverted to the existing flowing path beneath the Highway 402 structures, approximately 42.6 m west from a previous meandering course. The land surface rises sharply towards the east. The previous river channel was about 7.6 m wide and 3.0 m deep at the time of investigation. The current river channel is about 7.5 m wide.

Physiographically, the site is situated in the region known as the Caradoc Sand Plains. Sand and other light textured water laid deposits are characteristic of this region. The limestone, dolostone or shale bedrock in the area belongs to Hamilton Group of Middle Devonian period.

3. SOURCE OF INFORMATION

The following reports and drawings were available for review and information for the Sydenham River Bridge EBL and WBL structures, which are appended in Appendix A. Reference 1 listed below represents the foundation investigation report for the final bridge alignment.

1. Foundation Investigation Report, for W.P. 40-66-17/18 Highway 402, District 2, London, Sydenham River Bridges EBL/WBL 9.8 Miles West of Highway 2. Soil Mechanics Section Geotechnical Office, Ministry of Transportation and Communication Ontario, dated February 20, 1976. GEOCREs No. 40I13-45. (Reference 1)
2. General Layout, Sydenham River Bridge, 9.8 Miles West of Highway 2, Drawing No. 1, Site No. 19-524-B, Dist. 2, W.P No. 40-66-18, dated July 1977. (Reference 2)



3. Footing Layout and Reinforcing, Sydenham River Bridge, 9.4 Miles west of Highway 2, Drawing No. 5, Site No. 19-524-B, Dist. 2, W.P. 40-66-18, dated July 1977. (Reference 3)

4. SITE RECONNAISSANCE

As part of the current foundation engineering assessment study, a site reconnaissance of the Sydenham River EBL and WBL Bridge structures was carried out on February 19, 2014. A photographic record of the site visit is attached in Appendix B.

The site photographs present current conditions of abutments and wingwalls of the WBL and EBL structures including appearance of structure, visual slope stability, soil erosion and slope vegetation conditions.

The adjacent slopes of the west and east abutments of the EBL and WBL structures were covered with snow and ice locally with withered grass. Erosion or scouring on the adjacent slopes and edges of the abutment structures was not observed due to the snow covering of the ground. The front slopes of the abutments were covered with rock protection. The front face of abutments was sloped approximately 2H:1V.

No obvious major cracks, except for surficial cracks, were observed on the east and west abutment walls and wingwalls (Photographs 1 to 5) of the WBL structure. Slight spalling was observed on the north wingwall of the east abutment of the WBL structure (Photograph 1). At the east abutment and wingwalls of the EBL structure, only minor surficial cracks and slight spalling was observed on the walls (Photographs 6 to 8). However, cracks and spalling were observed on the west abutment wall and associated wingwalls of the EBL structure. Horizontal cracks were observed on the north and south wingwalls of the west abutment of the EBL structure (Photographs 9 and 12). Localized concrete spalling, pop-outs and cracks were observed on the west abutment wall (Photographs 10 and 11). Further, major spalling and concrete deterioration was observed on the southwest corner of the west abutment/wingwall of the EBL structure (Photograph 13).



Based on the General Arrangement Drawing (Reference 2), a 150 mm diameter perforated CSP was placed behind the east and west abutment walls of the EBL and WBL structures; however, the CSPs were not visible during the site reconnaissance. Open weep drains or outlet holes were observed on abutment walls. It is inferred that the drainage system is performing satisfactorily.

5. PREVIOUS FIELD INVESTIGATION AND SUMMARIZED SUBSURFACE CONDITIONS

The site is located on Highway 402, about 4.7 km northeast of Strathroy in Middlesex County, Ontario. The general subsurface conditions presented in this section are based on the Foundation Report, GEOCRE 40I13-45 dated February 20, 1976. The elevations reported were converted from imperial (ft) to metric (m).

5.1 Field Investigation

The field work for this site included six boreholes with accompanied six dynamic cone penetration tests (DCPTs) and was carried out in the period of November 7 to 20, 1975. Three boreholes, 1, 2 and 3, were investigated at the east side and the other three boreholes 4, 5 and 6, were investigated at west side of the previous Sydenham River course. The boreholes were drilled to the depths of 15.7 to 37.0 m (elevation 191.3 to 212.8). The DCPTs were penetrated to 5.7 to 7.9 m from ground surface, where refusal was met. The subsurface investigation procedure utilized hollow stem augering in conjunction with washboring (NX & BX casing) methods. According to a memorandum dated May 12, 1976, it was recommended that the proposed structure and stream be diverted to 42.6 m (140 ft) to the west from the site investigated. Therefore, the subsurface investigation program did not include the current west abutment locations.

Originally, it was considered to construct the Sydenham EBL and WBL bridges over the previous river course. Thus, boreholes 1, 2 and 3 were investigated to the east of the previous river course and boreholes 4, 5 and 6 were investigated to the west of the river course (References 1 and 2). However, the locations of the bridges and the river course were later relocated to about 42.6 m west from the previous location to the current location (Reference 2). Thus, the boreholes investigated west of the previous river course correspond to the east abutments of the current bridges. No subsurface information is currently available for the present west abutments of the bridges.



5.1.1 West Abutments of WBL and EBL Structures

The field investigation did not include boreholes at the current west abutments of the WBL and EBL structures. Based on the relocation of the bridges and diversion of the Sydenham River course, no information was available for subsoil conditions under the current west abutments of the WBL and EBL structures.

5.1.2 East Abutments of WBL and EBL Structures

Boreholes 4, 5 and 6 were investigated under the originally proposed location for west abutments, which currently represent the subsurface condition of the east abutments of the WBL and EBL structures. The depth of the boreholes ranged from 15.7 to 37.0 m.

Silty Sand to Sandy Silt

Surficially, a 15.5 to 15.7 m thick very loose to dense silty sand to sandy silt deposit was contacted in the three boreholes and extended to elevation 212.4 to 212.8. Borehole 5 was terminated in the cohesionless soil deposit at 15.7 m, elevation 212.8. N values recorded in the silty sand to sandy silt deposit ranged from 3 to 107 with low N values of 1 blow for 15 to 46 cm penetration. The low N values were encountered within the upper very loose zone in the silty sand to sandy silt stratum.

Grain size distribution charts of silty sand to sandy silt samples were presented in Fig. No.1 of the original report (Reference 1). The corresponding moisture content determinations approximately ranged from 17.0 to 25.0%.

Clayey Silt

Below the silty sand to sandy silt layer, a very stiff to hard clayey silt layer was contacted in boreholes 4 and 6 at 15.5 m, elevation 212.5 and 212.4, respectively. The clayey silt layer extended to termination depths of the boreholes 4 and 6 at 17.2 and 37.0 m, elevation 210.8 and 191.3, respectively. N values recorded ranged between 18 and 116.



Grain size distribution charts of clayey silt samples were presented in Fig. No. 2. Moisture content determinations ranged from 18 to 22%. The Atterberg liquid limit ranged between 20 and 31 and the plastic limit from 13 to 15. The plasticity index value ranged from 7 to 16.

5.1.3 Groundwater

Groundwater was observed at 1.0 to 4.9 m, elevation 227.1 to 231.2, in boreholes 1 to 5 during the field investigation. In borehole 6, groundwater was not established during the field investigation.

6. FOUNDATION

6.1 Previous Foundation Discussions and Recommendations

Based on the site reconnaissance, the current EBL and WBL bridges are single span structures. Because the structure was relocated west of the original location, recommendations relevant to the previous west abutments (current east abutments) of the structures are discussed. No subsurface information is available at the current west abutment locations of the EBL and WBL structures.

The foundation report recommended three-span (18.6-18.6-18.6 m or 61 ft) twin (EBL/WBL) structures at the proposed site. The proposed grade of Highway 402 was to be approximately 9.1 m (30 ft) above the previous riverbed.

Both pile and spread footings were recommended for the structures at this site location. Topsoil and any surficial organic material was recommended to be removed within the construction area in accordance with the MTC standards.

6.1.1 Piles

The report recommended footings (abutments and piers) for both structures may be supported on one of the following types of piles.



A) Franki type displacement caissons may be used for footing support. The base of the pile can be formed at elevation 225.5 for west abutments (the current east abutments) and at elevation 224.9 for west piers. The following design loads were recommended for different size of piles:

Dimension (Φ)	355 mm (14 in)	457 mm (18 in)	560 mm (22 in)
Safe Design Load	686 kN (70 tons)	1225 kN (125 tons)	1471 kN (150 tons)

B) Alternatively, the report recommended the footing may be supported on steel tube piles driven to approximately elevation 220.6, for the west abutments (current east abutments) of the EBL and WBL bridge structures. A safe design load of 355 kN (40 tons) per pile was recommended for the 324 mm (12¾ in) outer diameter (O.D.) and 6 mm (1/4 in) thick wall steel tube piles. Further, it was recommended to employ the Hiley Dynamic Pile Driving Formula (MTC Standard SS3-10 and 11) to control pile driving.

6.1.2 Spread Footings on Compacted Fill

The report also recommended that spread footings could alternatively be utilized at the abutments of the EBL and WBL structures on well compact suitable Granular A material within the approach fills. A safe design load of 190 kPa (2 tsf) was recommended. It noted that the Granular A material was to be compacted according to the previous MTC standards.

6.1.3 Frost Protection

The report recommended to prepare adequate protect against frost for base of the footing and the pile cap with a minimum of 1.2 m earth cover.

6.1.4 Hydrology Considerations

The report indicated that the recommendations pertaining to the magnitude of scour protection at the previous structure site were to be provided by the Hydrology Section concerning the suitability of the use of spread footings for the structures.



6.1.5 Approach Embankments

A maximum height of 9.1 m proposed approaches were anticipated at the site location. The upper portion of the subsoil encountered (minimum 15.8 m) in the boreholes contained granular type material followed by a deep deposit of very stiff to hard clayey silt. Therefore, no stability problem was anticipated. The topsoil and any organic material was recommended to be removed from the construction area in accordance with MTC standards.

The report recommended that compacted acceptable material should be used for the fill and that the grain sizes of this fill should not be larger than 75 mm, since piles may be driven through the compacted fill material. No 'bouldery' fill was to be placed within the approaches. Further, it was recommended that the slopes of the approaches should be constructed at 2H: 1V.

The report anticipated that the elastic settlement of the granular portion of the subsoil would have taken place during or immediately after the completion of the embankment construction. Further, it was estimated that the settlement of cohesive portion of the subsoil would occur over a long term period and would not exceed 76 mm (3 inches).

6.1.6 River Diversion

At the time of the preparation of the previous report (Reference 1), the details of the new river bed were not available; however, the report indicated that the river was to be realigned at Sta. 119+65±. Several local slumping of the existing banks were visible at the time of the investigation. Thus, the report recommended slopes to be constructed at 2H:1V to ensure the stability of new river bank, and that the slopes be protected with at least 610 mm of rip-rap material above the recorded high water level in the vicinity of the structures.

6.1.7 Groundwater Control

Based on groundwater level, which was observed at or slightly above (maximum 300 mm) the footing level (elevation 227.4) at the time of previous investigation, there were no major dewatering issues anticipated. Conventional sump pumping was recommended to control seepage into the excavations.



Based on the General Layout (Reference 2), the structure was relocated west of the original location and the river was to be diverted west as well. The proposed EBL and WBL structures were to be constructed as single span structures (39.6 m or 130 ft in length from the west abutment to the east abutment). The 324 mm O.D. steel tube piles with 6 mm thick wall were to be driven under the abutments footings with design load of 355 kN (40 tons) per pile. The pile cap was to be placed approximately at elevation 228.6. The river bed was to be diverted from station 119+65 to 118+25.

Based on Footing Layout and Reinforcing drawing (Reference 3), the following information was tabulated.

PILES DATA				
Location	No. Required	Batter	Length m (ft)	Pile type
West abutment	10	1:3	10.0 (33)	Steel Tube Pile 324 mm O.D. and 6 mm Thick
	4	1:10	9.75 (32)	
	5	1:3	10.0 (33)	
	4	1:8	9.75 (32)	
	2	vertical	9.75 (32)	
	2	vertical	9.75 (32)	
East abutment	10	1:3	10.0 (33)	
	4	1:10	9.75 (32)	
	5	1:3	10.0 (33)	
	4	1:8	9.75 (32)	
	2	vertical	9.75 (32)	
	2	vertical	9.75 (32)	



6.2 Assessment of Foundation Parameters

Based on the Borehole Location and Soil Strata drawing and memorandum dated May 19, 1976, the bridge was to be relocated to the west about 42.6 m from the previous location and the Sydenham River was also to be diverted. The previous west abutments of the EBL and WBL structures are currently the east abutments of the structures. No subsoil information is available for the current west abutments of the structures.

Piles were driven through well compacted Granular A pads at the abutment locations for the EBL and WBL bridge structures and the pile toes were placed at approximately, elevation 219.6 ±. Based on the subsurface encountered, the following geotechnical SLS and ULS are provided:

Factored Geotechnical axial Resistance at ULS	= 800 kN
Geotechnical axial Reaction at SLS	= 400 kN

The seismic site coefficient for the conditions at this site is 1.0 (soil profile Type 1, Canadian Highway Bridge Design Code (CHBDC) 2006 Edition, clause 4.4.6).

The bearing resistance for inclined loads should be reduced in accordance with the requirements of clause 6.7.4 of the CHBDC.

The foundation frost penetration depth at the site is 1.2 m according to OPSD 3090.101.

7. DISCUSSION

It is understood that the Sydenham River EBL and WBL Bridge structures rehabilitation project includes modification of the bridge abutments to semi-integral abutments and replacement of the existing concrete barrier walls. Traffic staging will be required to complete the rehabilitation work in two stages and will be coordinated with the two stage traffic staging for the Hickory Drive EBL and WBL Overpass structures rehabilitation work. In the first stage traffic will be shifted to the outside lanes and all ramps at the Hickory Drive will remain open. In the second stage, traffic will be shifted to the inside lane and all the ramps at the Hickory Drive will be closed.



It will be necessary to implement temporary support systems to provide roadway protection and to permit excavation and backfilling of trenches or excavations for the conversion to semi-integral deck ends. The construction for temporary support system should conform to OPSS 404 and 539. A performance level of 2 for the protection system, according to OPSS 539, should be adopted to prevent excessive lateral and/or vertical movement of the existing embankment during construction. The contractor is responsible for the selection, detailed design and performance of the roadway protection scheme. The contractor should monitor the movement of the roadway protection system.

Based on information gathered from the previous foundation report, the subsoil conditions of the current west abutments of the WBL and EBL structures are not available; therefore it is suggested to carry out a minimum field investigation to determine the current subsoil condition at the west abutment locations.

Further, based on the site reconnaissance, rehabilitation and maintenance should be carried out at the abutment locations, especially at the west abutment of the EBL structure.

8. CLOSURE

Based on the review of the previous investigation report, it is considered that sufficient subsurface information is not present at the west abutment locations. PML has carried out a foundation investigation at the Sydenham River EBL and WBL Bridge structures to determine the existing subsoil and groundwater conditions prior to the commencement of the rehabilitation work. The preliminary foundation investigation and design report is presented under a separate cover.

This technical memorandum was prepared by Mr. N. Rahman, P.Eng with the assistance of Mr. M. Khorsand, EIT and was reviewed by Mr. R. Ng, PhD, P.Eng. Mr. B. R. Gray, MEng, P.Eng., MTO Designated Principal Contact conducted an independent review of the report.



We trust this memo is sufficient for your immediate needs. Please, do not hesitate to contact us if you have any inquiries and/or comments.

Yours very truly,

Peto MacCallum Ltd.



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Senior Project Engineer



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

NR/RN/BRG:nr-mi

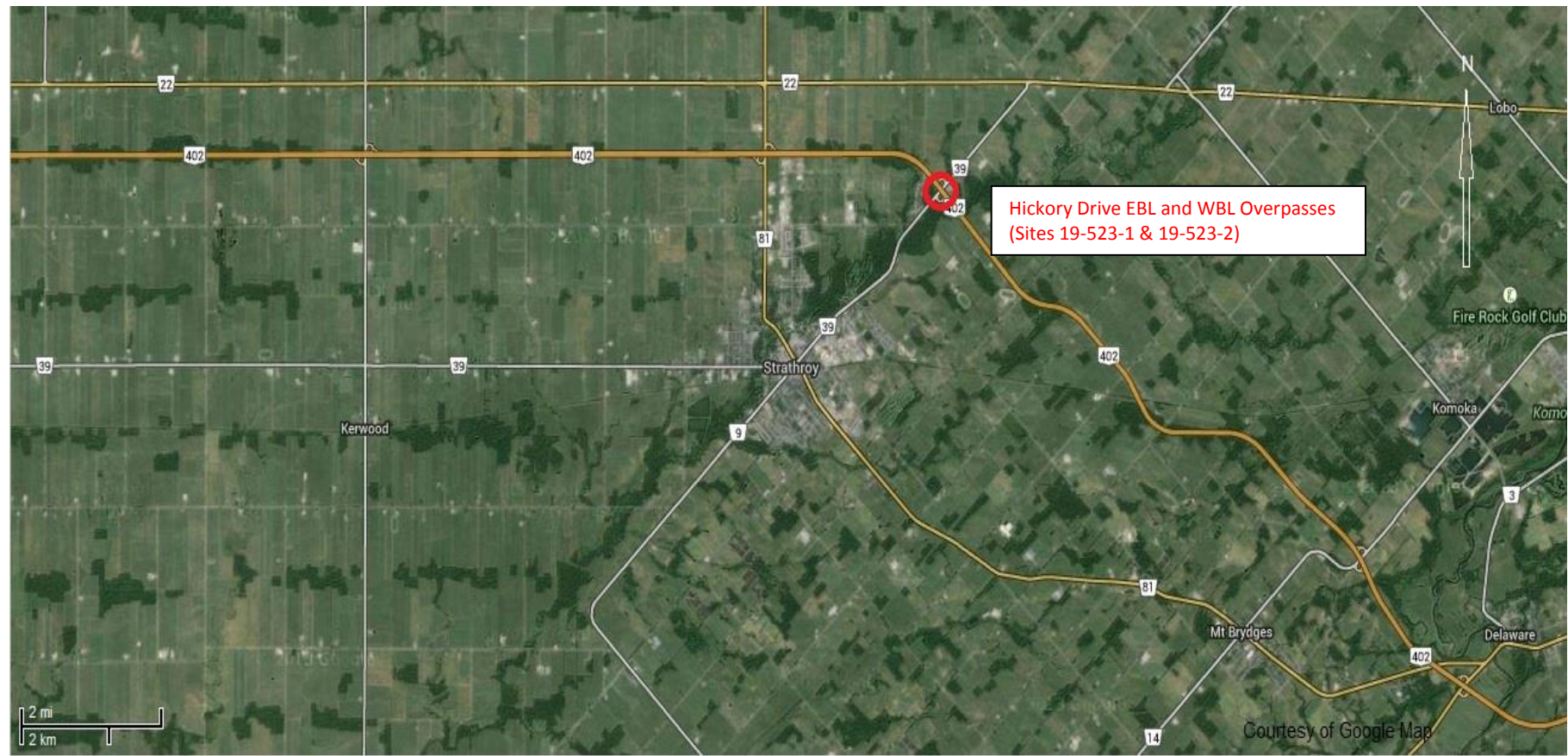


TABLE 1

LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

DOCUMENT	TITLE
OPSS 404	Construction Specification for Support Systems
OPSS 539	Construction Specification for Temporary Protection Systems
OPSD 3090.101	Foundation Frost Depth for Southern Ontario

Figure 1 – Key Plan





APPENDIX A

Previous Foundation Investigation Report (GEOCRES 40I13-45)
General Layout, Sydenham River Bridge

G.I.-30 SEPT. 1976

GEOCRES No. 40I13-45DIST. 2 REGION W.P. No. 40-66-17 & 18CONT. No. 79-51W. O. No. STR. SITE No. HWY. No. 402LOCATION Sydenham River Bridges
E.B.L / W.B.LNo. of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: Mr. A.P. Watt (2)
Regional Structural Planning Engineer
Southwestern Region, London

FROM: Soil Mechanics Section
Geotechnical Office
West Bldg.

ATTENTION:

DATE: February 20, 1976

OUR FILE REF.

IN REPLY TO

FEB 26 1976

SUBJECT:

40 I 13-45
GEOCREs No.

FOUNDATION INVESTIGATION REPORT

For

W.P. 40-66-17/18
Hwy. 402 District 2, London
Sydenham River Bridges
E.B.L./W.B.L. 9.4 Miles West of Hwy. 2

Attached we are forwarding to you our detailed Foundation Investigation Report on the subsoil conditions existing at the above mentioned site.

We believe that the factual data and recommendations contained therein will prove adequate for your requirements. Should additional information be required, please do not hesitate to contact our Office.

K.G. Selby

K.G. Selby
Supervising Engineer

KGS/bp

cc: R.S. Pillar
C.S. Grebski
B.J. Giroux
G.A. Wrong
A. Wittenberg
J.R. Roy
D.P. Collins
R. Hore
A. Anderson)
A. Crowley) Memo only
G. Sloan)
Files

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4. GROUNDWATER CONDITIONS
5. DISCUSSION AND RECOMMENDATIONS
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 - (5.2) Foundations
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 - (5.4) Stream Diversion

FOUNDATION INVESTIGATION REPORT

For

W.P. 40-66-17/18
Hwy. 402 District 2, London
Sydenham River Bridges
E.B.L./W.B.L. 9.4 Miles West of Hwy. 2

1. INTRODUCTION

This report contains the results of a foundation investigation carried out at the above described location. The field work consisted of six boreholes.

The factual and interpreted soil data, together with recommendations for the design and construction of the proposed structures and approaches are presented in the report.

2. SITE DESCRIPTION

The site of the proposed twin structures is located at the crossing of the proposed Hwy. #402 and Sydenham River, Lot 20, Con. X, Twp. of Caradoc, Co. of Middlesex.

Sydenham River at this location flows in a general northeast to southwest direction. The river follows a somewhat meandering course through a self-eroded valley which is about 0.5 mi. wide. The existing river channel is about 25 ft. wide and 10 ft. deep.

The land surface rises sharply towards east. Physiographically the site is located in the region referred to as the Caradoc Sand Plains. Sands and other light textured waterlaid deposits are characteristics for this region.

3. SUBSURFACE CONDITIONS

(3.1) General

Generally, a zone of silty sand to sandy silt, traces of clay occurs in the upper stratum of all boreholes. Below the granular there is a

very stiff to hard clayey silt with traces to some sand. The cohesive deposit is followed by a very dense deposit of sand and gravel with trace of silt and clay. The boundaries of the various deposits are shown on the accompanying Record of Borehole Sheets. The stratigraphical sections plotted on Drawing No. 406617 & 18-A have been inferred from this data. From ground level downward the various soil types encountered are described in some detail as follows:

(3.2) Silty Sand to Sandy Silt, Traces of Clay

This deposit was intersected at every boring location immediately below ground surface but was not penetrated to its full extent in each borehole. The thickness was found to range from 52 to 81 ft. in Borehole #4 and 2 respectively.

The material in the stratum consists of sands and silts with varying proportions. The chief constituent is sand in the upper segment, while the lower part of the deposit contains a larger percentage of silt. Traces of clay were also found within this zone. Grain size distribution testing was carried out on selected samples from the deposit. The results are plotted in envelope form on Figure 1.

Standard penetration testing was carried out within this granular deposit and the results are plotted on the Record of Borehole Sheets. The obtained 'N' values ranged from 1 blow/18" to 196 blows/11 inches. Based on these results, it is estimated that the relative density of this deposit varies from very loose to very dense. The natural moisture content ranges from 5% to 23%.

(3.3) Clayey Silt, Some to Trace of Sand

The granular deposit is underlain by a cohesive stratum in Boreholes #1,2,4 and 6 at approx. elev. 697. At the other borehole locations, the borings were terminated in the silty sand to sandy silt deposit. The stratum also contains some to traces of clay.

A limited number of laboratory tests carried out on selected samples indicate the following physical properties:

	<u>RANGE</u>
Liquid Limit (%)	17-32
Plastic Limit (%)	11-16
Natural Moisture Content (%)	16-22

The results of grain size distribution tests are plotted on Figure 2 of the Appendix.

The consistency of the stratum varies from very stiff to hard.

(3.4) Sand and Gravel, Traces of Silt and Clay

In Borehole #2 a very dense deposit of sand and gravel with traces of silt and clay was encountered below the cohesive deposit. The lower boundary was not determined.

4. GROUNDWATER CONDITIONS

The following groundwater levels were observed during the field investigation:

Borehole #1	Elevation	758.5
#2		748.5
#3		746.0
#4		745.0
#5		745.0
#6		Not Established

5. DISCUSSION AND RECOMMENDATIONS

(5.1) General

It is proposed to build three-span (61'-61'-61') twin structures at the crossing of the realigned Sydenham River and future Hwy. #402. The centre line of the proposed river diversion will be at Sta: 119 + 65+.

The proposed profile grade of Hwy. #402 will be approx. 30 ft. above the riverbed. In the vicinity of the E.B.L.'s east abutment up to 5 ft. of cut will be required.

(5.2) Foundations(5.2.1) Pile Support

All the footings (Abutments and Piers) for both structures may be supported on one of the following pile types:

(a) Franki Piles

Franki type displacement caissons may be used for footing support. The base of the pile, can be formed at the following elevations:

West Abutments (N & S Structures)	Elevation	740 ±
West Piers (N & S Structures)	Elevation	738 ±
East Piers (N & S Structures)	Elevation	740 ±
East Abutment (N Structure)	Elevation	740 ±
East Abutment (S Structure)	Elevation	755 ±

For different sizes of piles the following safe design loads are recommended:

14 in.	-	70 tons
18 in.	-	125 tons
22 in.	-	150 tons

(b) Steel Tube Piles

The footings may be supported on steel tube piles driven to approx. elev. 750 for the east abutment (E.B.L.) and elsewhere to elev. 724. In the case of 12 3/4" O.D. and 1/4" thick wall steel tube piles, a safe design load of 40 tons per pile may be used. Pile driving should be controlled by employing the Hiley Dynamic Pile Driving Formula (MTC Standards SS3-10 & 11).

(5.2.2) Spread Footings on Compacted Fill

The abutments with the exception of south structure's (E.B.L.) east abutment, may be supported on spread footings placed on well compacted suitable granular material within the approach fills. A safe design load of 2.0 t.s.f. may be assumed.

The granular material should consist of granular 'A' and should be fully compacted according to the current MTC standards. A construction scheme is outlined on Figure 3 of the Appendix.

The east abutment of the north structure (W.B.L.) will be situated on a sidehill. To avoid the condition, where part of the footing is located on original ground and partially on compacted fill, it is recommended that the subsoil be excavated for a minimum of 4 ft. below the base of footing and backfilled with Granular 'A'.

(5.2.3) Spread Footing in Original Ground

The east abutment of the south structure may be supported on spread footing placed within the dense to very dense zone of the subsoil, below elev. 766 \pm . A safe net pressure of 3.0 t.s.f. may be assumed for design purposes.

(5.2.4) Hydrology Considerations

The suitability of spread footings at the proposed structure site depends on the magnitude of scour protection. This aspect will be investigated by the Hydrology Section and recommendations will be given.

(5.2.5) Frost Protection

The pile caps and the base of spread footings should be protected with a minimum of 4 ft. of earth cover.

(5.2.6) Dewatering

The observed groundwater level is located at or slightly above (Max. 12") the footing levels. (Elev. 746 \pm). Therefore, no major dewatering problems are anticipated. Any seepage into the excavations could be handled by pumping from sumps.

(5.3) Approach Embankments

(5.3.1) Stability

The maximum height of the proposed approaches is in the order of 30 ft. (Measured from the existing river bottom). Cuts, up to 5 ft. deep will be required in the vicinity of the east abutment (E.B.L. only). The upper (Min 52 ft.) portion of the encountered subsoil is basically granular type material, followed by a deep deposit of very stiff to hard clayey silt. No stability problems are expected. The slopes of the approaches (cuts and fills) should be constructed with 2 horizontal and 1 vertical.

(5.3.2) Embankment Material

The fill should consist of well compacted acceptable material. Care should be taken to ensure that no bouldery fill is placed within the approaches through which piles have to be driven and it is recommended that this portion of the fill contain grain sizes not larger than 3 in.

(5.3.3) Settlement

Settlements of the granular portion of the subsoil will be elastic in nature and should take place during or immediately after the completion of the embankment construction.

It is estimated that the settlement of the cohesive portion of the subsoil would not exceed 3 inches and would occur over a long term period.

(5.3.4) Topsoil Removal

The topsoil and any surficial organic material should be removed within the construction area in accordance with current MTC standards.

(5.4) Stream Diversion

It is intended to realign the meandering Sydenham River at this location. As indicated on Plan E-5386-1 the centre line of the diversion will intersect the proposed Hwy. #402, Line 'A' at Sta: 119 + 65+.

At the time of the report writing details concerning the depth and

width of the new riverbed are not available.

Indications are, that the silty sand deposit encountered immediately below the ground surface may be subjected to scour and erosion. Several local slumping of the existing banks are visible.

In order to ensure the stability of the new river banks it is recommended that 2:1 slopes be constructed and protected with rip-rap cover to a level at least 2 ft. above the recorded high water level in the vicinity of the structure.

P. Payer
P. Payer, P. Eng.
Senior Engineer



K. G. Selby
K.G. Selby, P. Eng.
Supervising Engineer

APPENDIX

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 1

WP 40-66-17/18 LOCATION Co-ords. 15,618,163 N; 1,247,288 E. ORIGINATED BY PP
DIST 2 HWY 402 BORING DATE November 7, 1975 COMPILED BY OJ
DATUM Geodetic BOREHOLE TYPE Washbore-NX & BX Casing CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT —WL PLASTIC LIMIT —WP WATER CONTENT —W			UNIT WEIGHT Y	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		25	50	75	100	125	WP	W	WL		
774.7	Ground Level															GR SA SI CL
0.0	Silty sand to sandy silt, traces of clay Compact to Very Dense		1	SS	12	770										0 47 (53)
			2	SS	18											0 5 92
			3	SS	37											
			4	SS	43											
			5	SS	64											
			6	SS	100	4"										0 87 (13)
			7	SS	100	5"										
			8	SS	100	5"										
			9	SS	61											0 90 (10)
			10	SS	39											
			11	SS	44											
			12	SS	53											0 87 (13)
			13	SS	56											
			14	SS	137											
			15	SS	85											
696.7						700										
78.0	Clayey silt		17	SS	52											
693.2	Hard															
81.5	End of Borehole															

RECORD OF BOREHOLE NO 2

WP 40-66-17/18

LOCATION Co-ords. 15,618,265 N; 1,247,352 E.

ORIGINATED BY PP

DIST 2 HWY 402

BORING DATE November 12-17, 1975

COMPILED BY OJ

DATUM Geodetic

BOREHOLE TYPE Washbore - NX & BX Casing

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		25 50 75 100 125					w_p w w_L				
							SHEAR STRENGTH					WATER CONTENT %				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					10 20 30				% GR SA SI CL
751.8	Ground Level															
0.0	Silty sand to sandy silt, traces of clay Loose to Very Dense		1	SS	10	750									0 60 (40)	
			2	SS	8											
			3	SS	20											
			4	SS	52		740									
			5	SS	27											
			6	SS	69											
			7	SS	32		730									
			8	SS	196		11"				150/5"					
			9	SS	78											
			10	SS	88											
							720									
					11	SS	60									
					12	SS	23									
					13	SS	52									
			14	SS	18											
						700										
696.8	Clayey silt, some sand. Very Stiff to Hard		15	SS	19	690								0 0 75 2		
55.0				16	SS	66										
							680									
					17	SS	29									
							670									
					18	SS	16									
					660											
			19	SS	25									0 15 67 1		
					650											
							cont.									

RECORD OF BOREHOLE No 2 cont.

WP 40-66-17/18 LOCATION Co-ords. 15,618,256 N; 1,247,352 E. ORIGINATED BY PP
 DIST 2 HWY 402 BORING DATE November 12-17, 1975 COMPILED BY OJ
 DATUM Geodetic BOREHOLE TYPE Washbore-NX & BX Casing CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		25	50	75	100	125	w_p	w	w_L		
	continued															
			20	SS	35	640										
634.8																
117.0	Sand & gravel, traces															
631.3	of silt & clay		21	SS	59											40 48 (12)
120.5	End of Borehole															

ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

LOCATION Co-ords. 15,618,298 N; 1,247,316 E.

BORING DATE Nov. 18, 1975

BOREHOLE TYPE Washbore-NX Casing

ORIGINATED BY MK
COMPILED BY OJ
CHECKED BY _____

[illegible]

15 ϕ 5 % STRAIN AT FAILURE

RECORD OF BOREHOLE NO 4

WP 40-66-17/18 LOCATION Co-ords. 15,618,390 N; 1,247,223 E. ORIGINATED BY MK
 DIST 2 HWY 402 BORING DATE November 17-18, 1975 COMPILED BY OJ
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		25	50	75	100	125	w_p	w	w_L		
748.2	Ground Level															GR SA SI CL
0.0	Silty sand to sandy silt. Very Loose to Very Dense	.	1	SS	4											0 7 91
			2	SS	1/18											
			3	SS	3											
			4	SS	1/6											
			5	SS	38											
			6	SS	36											
			7	SS	9											
			8	SS	8											
			9	SS	18											
			10	SS	56											
			11	SS	13											
			12	SS	17											
			13	SS	22											
			14	SS	11											
			15	SS	17											
697.2			16	SS	40											0 5 80 1
51.0	Clayey silt, trace of sand.		17	SS	52											
691.7	Very Stiff to Hard		18	SS	18											
56.5	End of Borehole															

RECORD OF BOREHOLE NO 5

WP 40-66-17/18 LOCATION Co-ords. 15,618,271 N; 1,247,184 E. ORIGINATED BY MK
 DIST 2 HWY 402 BORING DATE November 18 - 19, 1975 COMPILED BY OJ
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT 25 50 75 100 125 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W W_P — W — W_L WATER CONTENT % 10 20 30	UNIT WEIGHT γ	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES					
749.6	Ground Level									
0.0	Silty sand to sandy silt, traces of clay Very Loose to Very Dense		1	SS	5					
			2	SS	1/12"					
			3	SS	1/18"					
			4	SS	1/12"					
			5	SS	1/18"					
			6	SS	46					0 91 (9
			7	SS	22					
			8	SS	16					
			9	SS	11					
			10	SS	76					
			11	SS	107					
			12	SS	10					
			13	SS	21					
			14	SS	15					0 9 90 1
698.1				15	SS	24				
			16	SS	19					
51.5	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 6

WP 40-66-17/18 LOCATION Co-ords. 15,618,315 N; 1,247,143 E. ORIGINATED BY MK
DIST 2 HWY 402 BORING DATE November 19-20, 1975 COMPILED BY OJ
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w $w_p \rightarrow w \rightarrow w_L$ WATER CONTENT % 10 20 30	UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N VALUES		25	50	75	100	125			
748.0	Ground Level													
0.0	Silty sand to sandy silt, traces of clay Very Loose to Very Dense		1	SS	4									
			2	SS	1/12"									
			3	SS	3									
			4	SS	62									
			5	SS	15									
			6	SS	15									
			7	SS	14									
			8	SS	33									
			9	SS	10									
			10	SS	66									
			11	SS	17									
			12	SS	25									
			13	SS	22									
			14	SS	18									
			15	SS	25									
697.0	Clayey silt, traces of sand. Very Stiff to Hard		16	SS	61									0 7 92 1
51.0														
			17	SS	22									0 1 92 7
			18	SS	20									0 16 78 6 0 1 77 22
			19	SS	20									0 0 71 29
			20	SS	64									0 5 69 26
			21	SS	26									0 0 79 21

cont.

20
15 ϕ 5 % STRAIN AT FAILURE
10

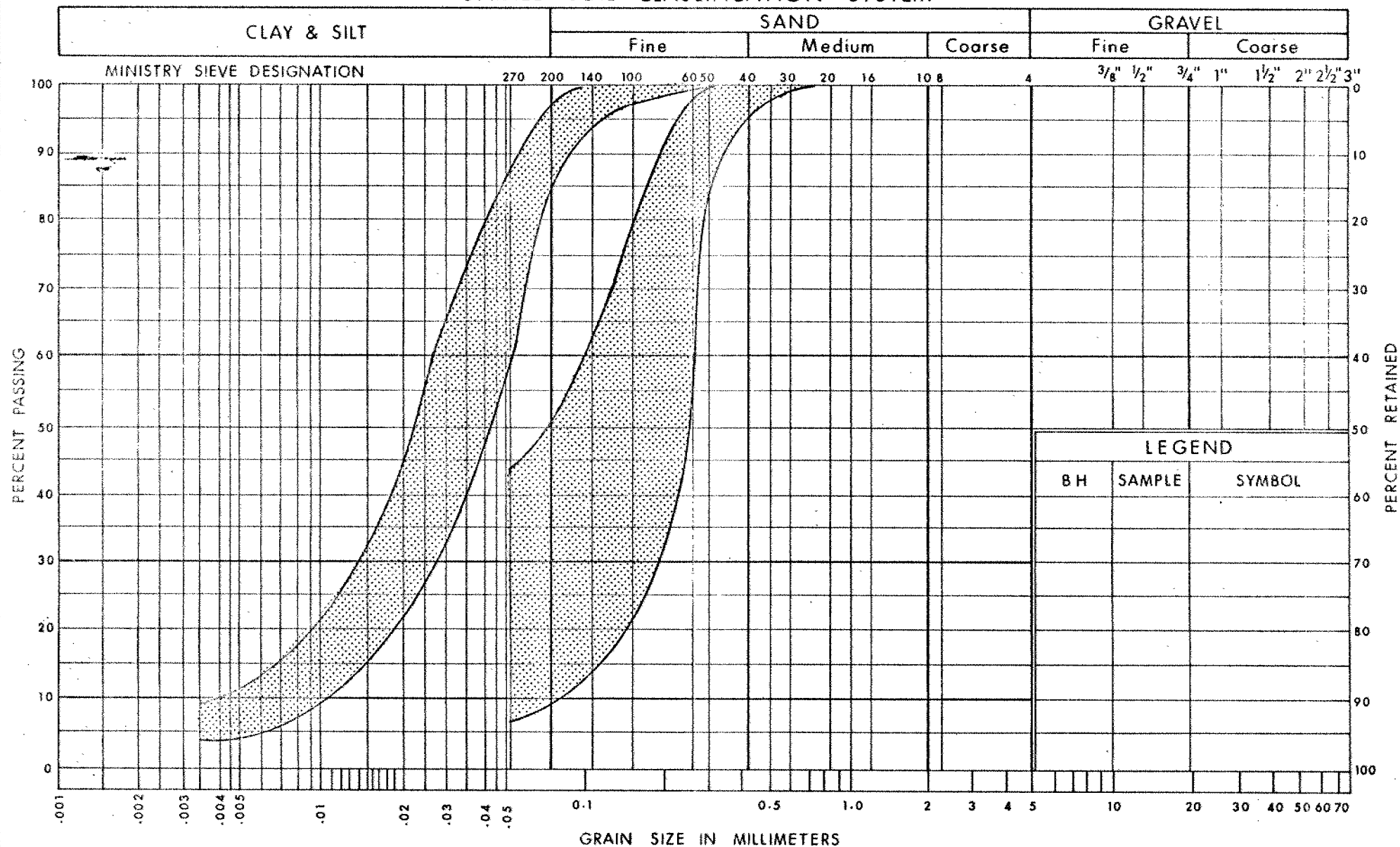
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 6 cont.

WP 40-66-17/18 LOCATION Co-ords. 15,618,315 N; 1,247,143 E. ORIGINATED BY MK
DIST 2 HWY 402 BORING DATE November 19-20, 1975 COMPILED BY OJ
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		25	50	75	100	125	w_p	w	w_L		
	continued						SHEAR STRENGTH					WATER CONTENT %				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					10 20 30				
			22	SS	90	640										
627.5			23	SS	116	630										0 8 53 39
121.5	End of Borehole															

UNIFIED SOIL CLASSIFICATION SYSTEM

Ministry of
Transportation and
Communications

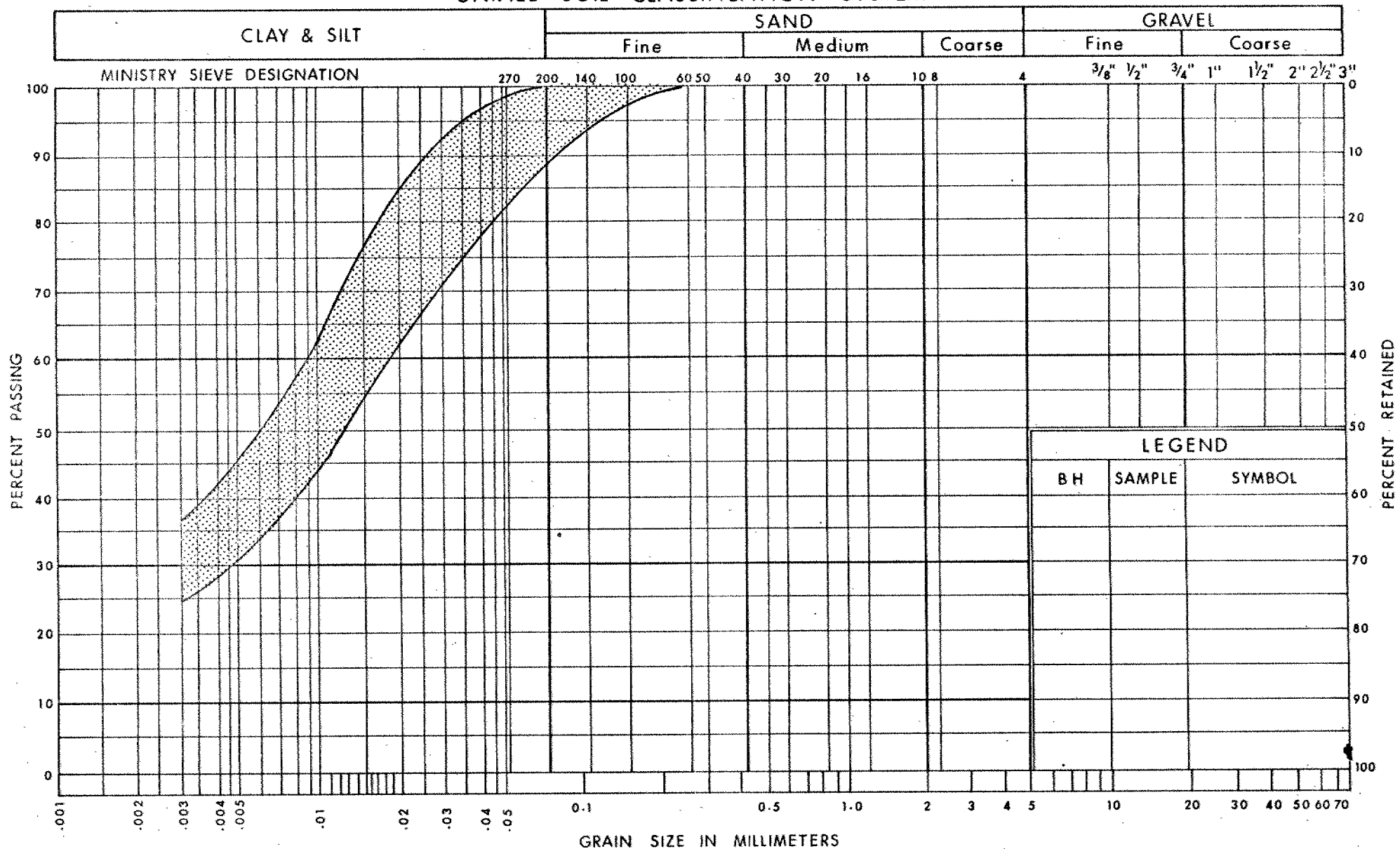
ENGINEERING SERVICES BRANCH

GRAIN SIZE DISTRIBUTION SILTY SAND TO SANDY SILT

FIG No 1

W P 40-66-17 & 18

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation and
Communications

Ontario

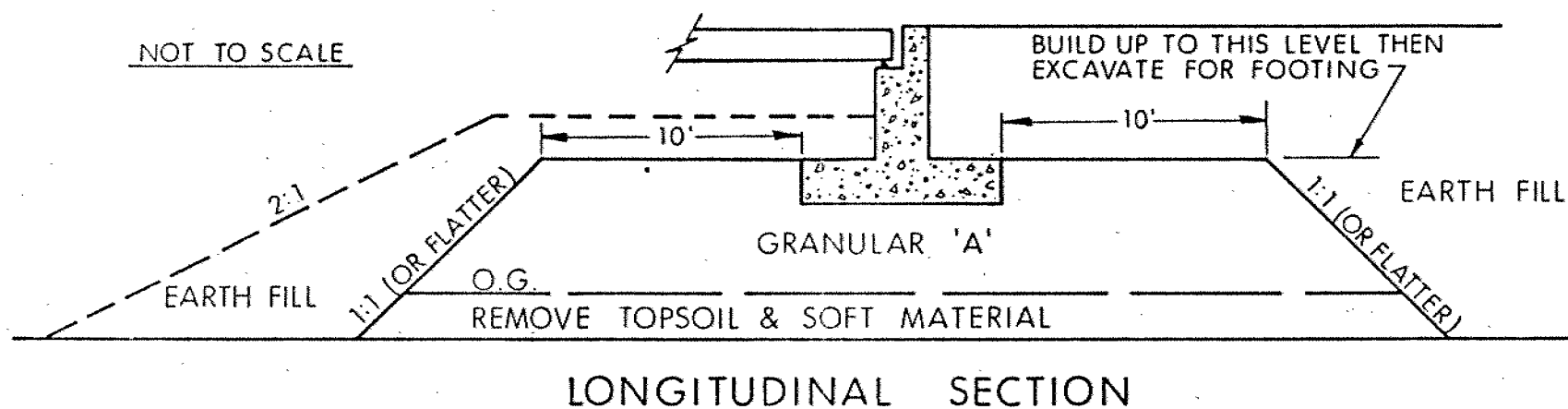
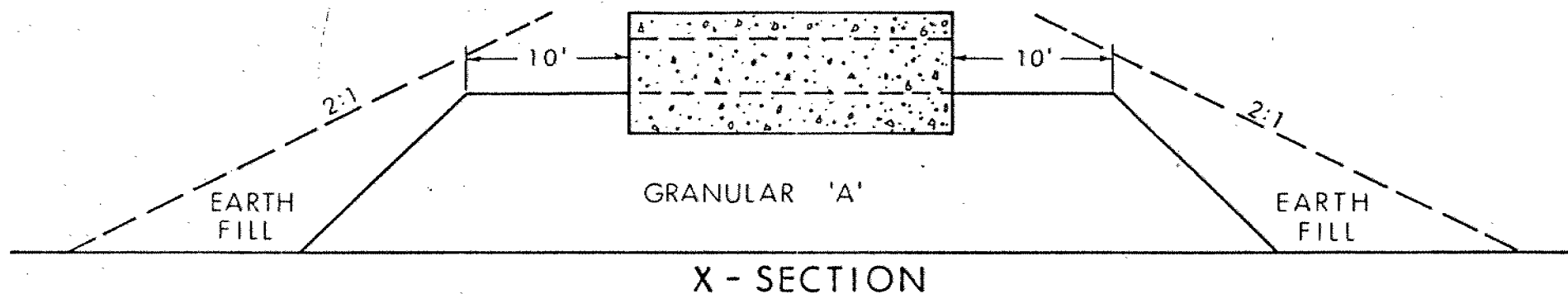
ENGINEERING SERVICES BRANCH

GRAIN SIZE DISTRIBUTION
CLAYEY SILT
SOME SAND

FIG No. 2

W P 40-66-17 & 18

ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE



NOTES

- 1 - REMOVE TOPSOIL & /OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A'.
- 2 - PLACE GRANULAR 'A' TO TOP OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M.T.C. STANDARDS.
- 3 - EXCAVATE COMPACTED GRANULAR 'A' MATERIAL FOR FOOTING.

ABBREVIATIONS & SYMBOLS USED IN THIS REPORTPENETRATION RESISTANCE

'N' = STANDARD PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>c LB./SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 250	VERY LOOSE	0 - 4
SOFT	250 - 500	LOOSE	4 - 10
FIRM	500 - 1000	COMPACT	10 - 30
STIFF	1000 - 2000	DENSE	30 - 50
VERY STIFF	2000 - 4000	VERY DENSE	> 50
HARD	> 4000		

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
I_p	PLASTICITY INDEX
w_s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_C	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

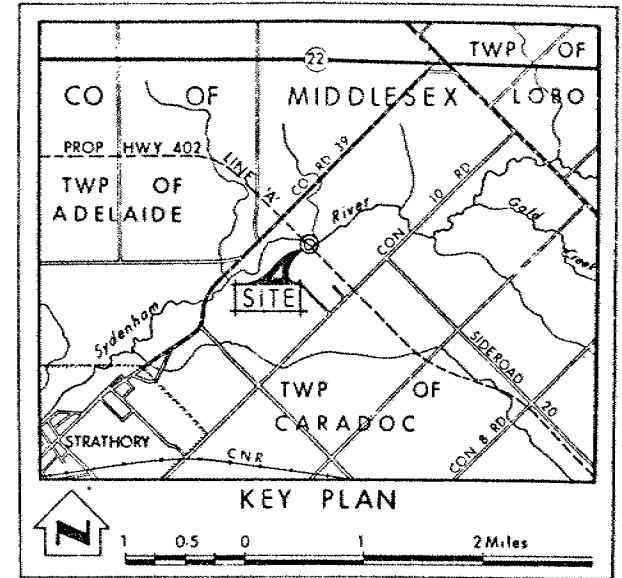
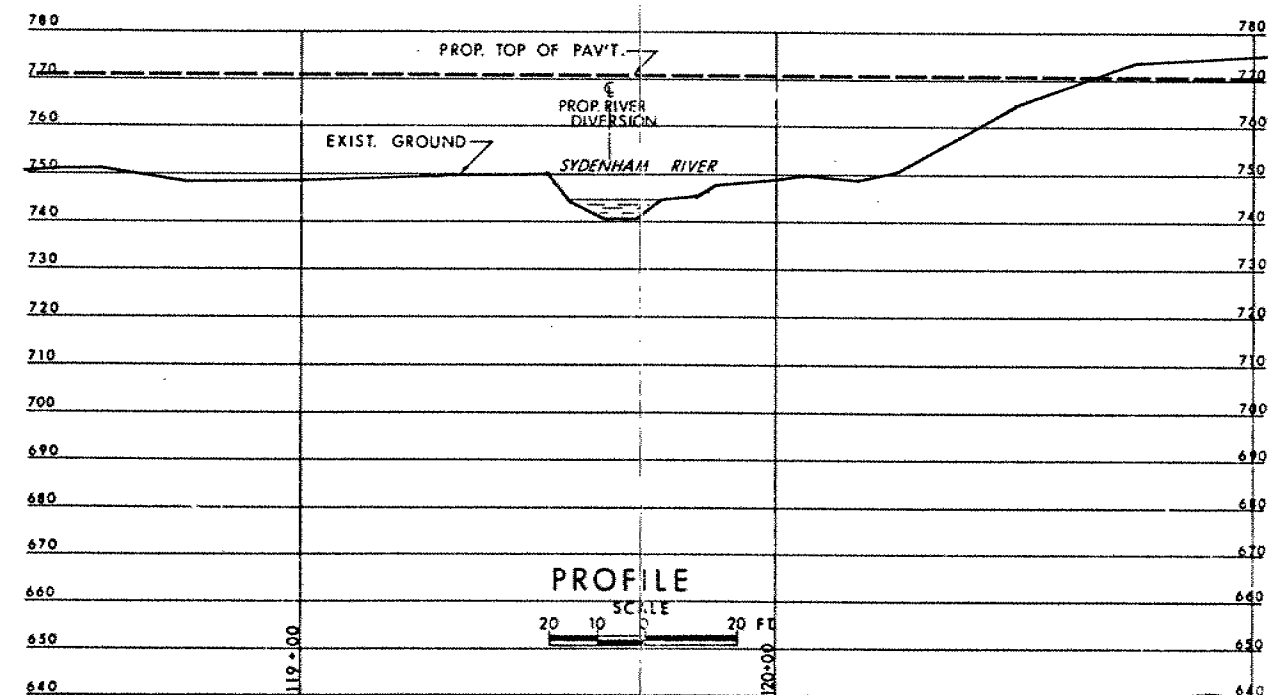
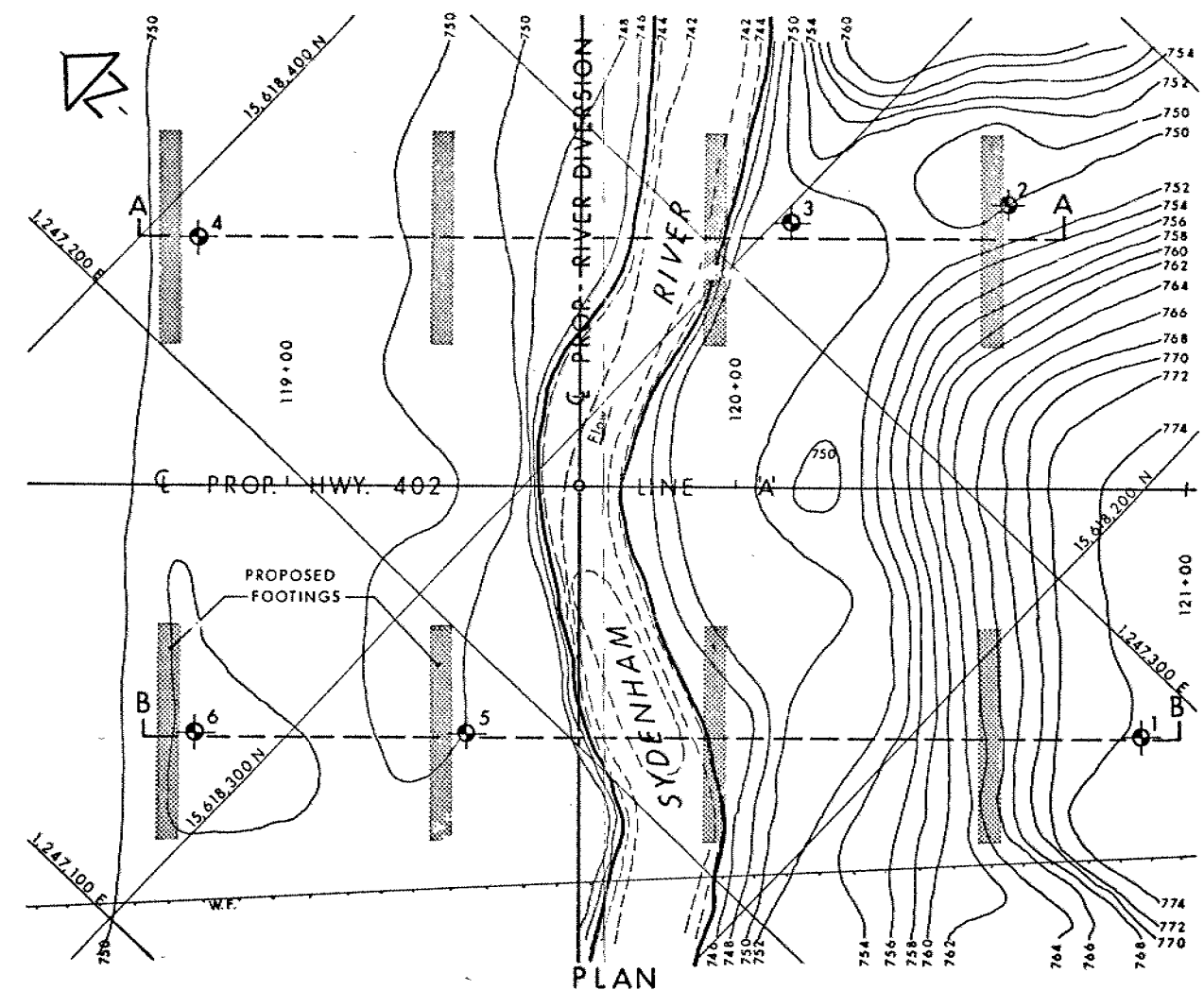
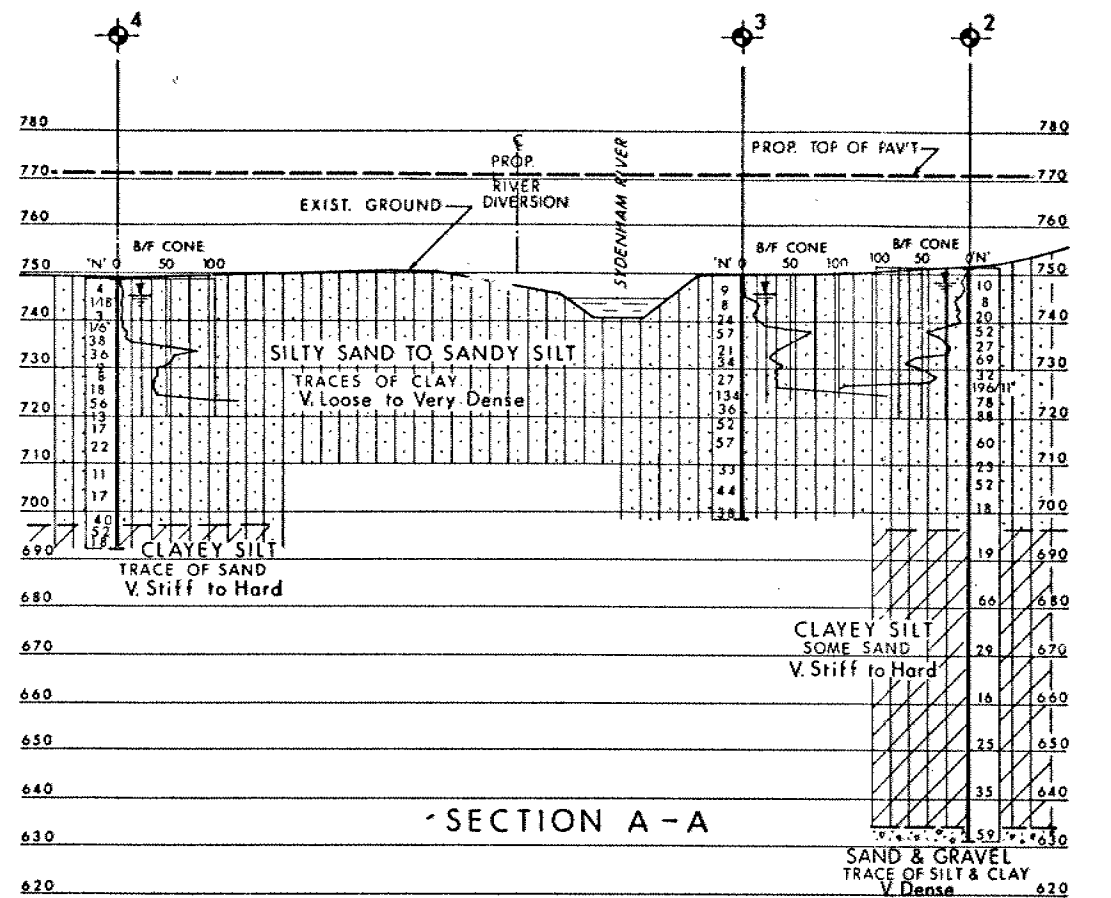
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL



LEGEND

- Bore Hole
- Dynamic Cone Penetration Resistance Test (B/F CONE - Blows/Ft. Cone Test (350 ft. lbs. energy/blow))
- Bore Hole & Cone Test
- Water Levels established at time of field investigation, NOV. 1975
- NO Water Levels established in Bore Hole No. 6

NO.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	774.7	15,618,163	1,247,288
2	751.8	15,618,265	1,247,352
3	749.8	15,618,298	1,247,316
4	748.2	15,618,390	1,247,223
5	749.6	15,618,271	1,247,184
6	748.0	15,618,315	1,247,143

NOTE: FOR CONTRACT DOCUMENTS

The complete foundation investigation report for this structure may be examined at the Structural Office and Foundations Office, Downsview, and at the LONDON District Office.

NOTE

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

REVISION	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

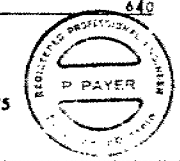
SYDENHAM RIVER

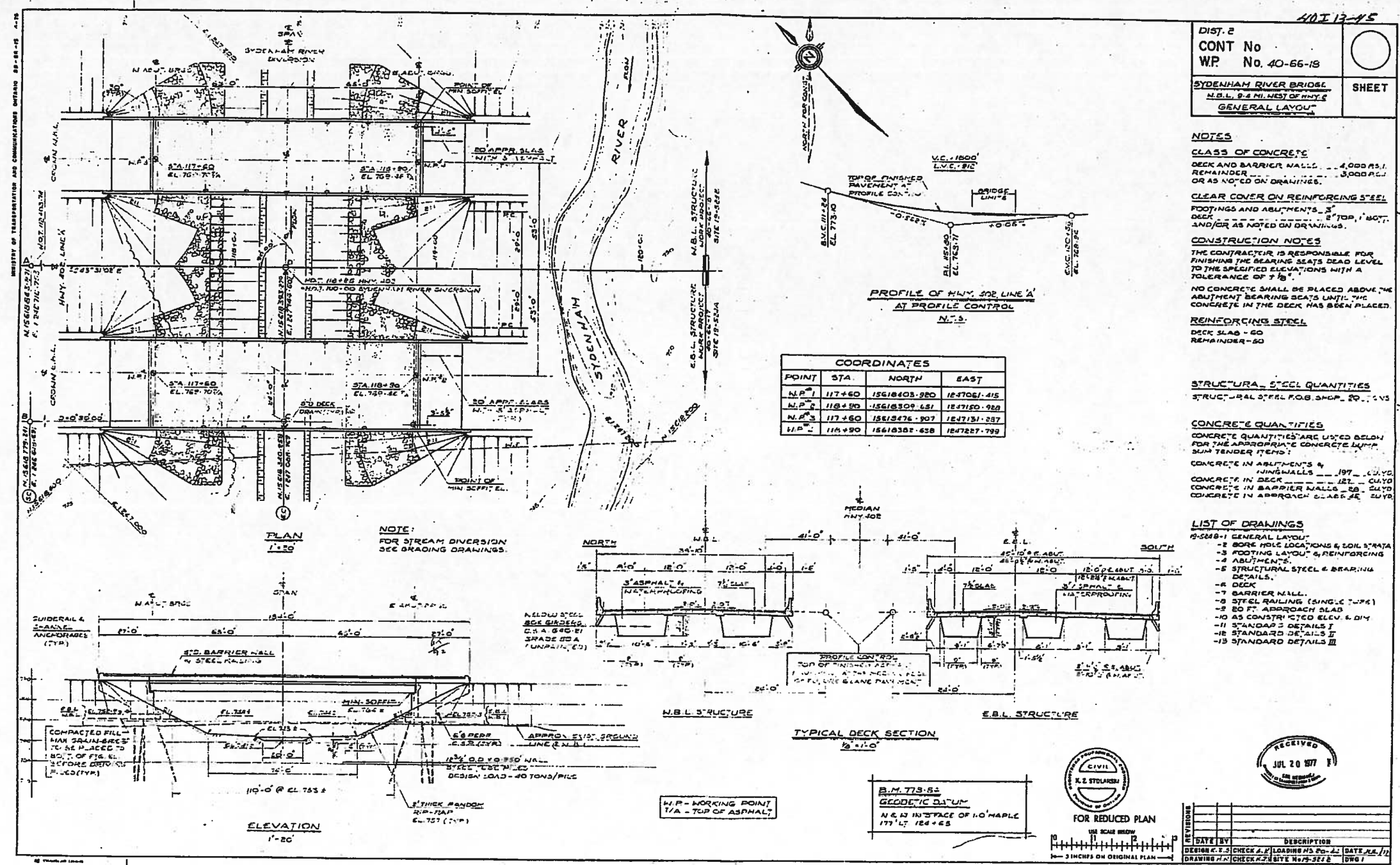
HIGHWAY NO Proposed 402 LINE 'A' DIST NO 2
CO MIDDLESEX
TWP CARADOC LOT 20 CON 10

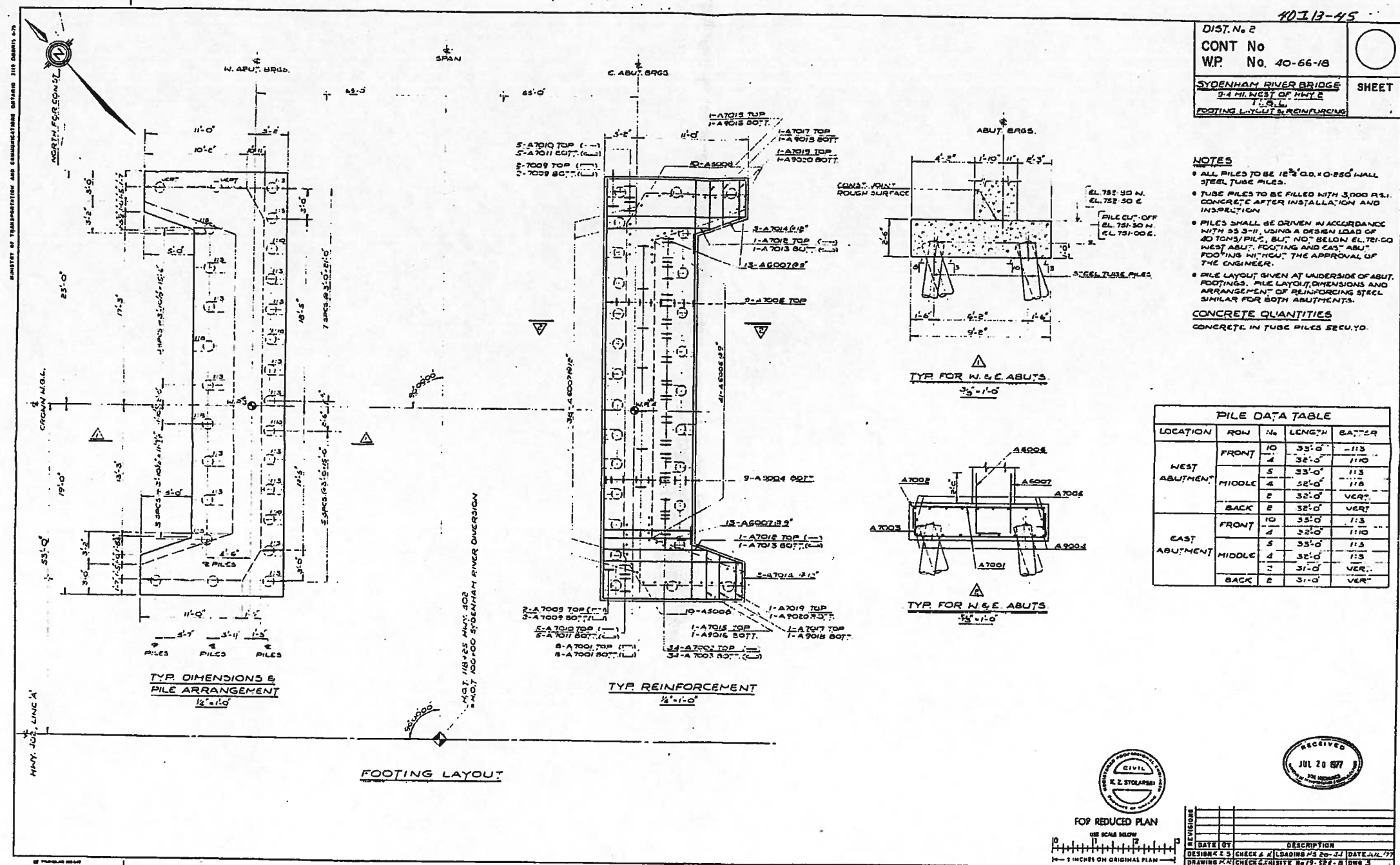
BORE HOLE LOCATIONS & SOIL STRATA

SUBMIT P.P.	CHECKED	W.P. NO 40-66-17 & 18	DRAWING NO
DRAWN O.L.J.	CHECKED	W.D. NO	406617 & 18-A
DATE 10 FEB. 1976	SITE NO 19-524	BRIDGE DRAWING NO	
APPROVED	CONT NO		

REF. E-5386-1 JULY 1975







1013-45
DIST. No. 2
CONT No
WP. No. 40-66-18
SYDENHAM RIVER BRIDGE
3.4 MI. WEST OF HWY 1
FOOTING LAYOUT & REINFORCING

NOTES
• ALL PILES TO BE 12" O.D. x 0.250 WALL STEEL TUBE PILES.
• TUBE PILES TO BE FILLED WITH 3,000 P.S.I. CONCRETE AFTER INSTALLATION AND INSPECTION.
• PILES SHALL BE DRIVEN IN ACCORDANCE WITH 35 3"-11" USING A DESIGN LOAD OF 40 TONS/PILE, BUT NOT BELOW EL. 781.00 WEST ABUT. FOOTING AND EAST ABUT. FOOTING WITHOUT THE APPROVAL OF THE ENGINEER.
• PILE LAYOUT GIVEN AT UNDERSIDE OF ABUT. FOOTINGS. PILE LAYOUT, DIMENSIONS AND ARRANGEMENT OF REINFORCING STEEL SIMILAR FOR BOTH ABUTMENTS.
CONCRETE QUANTITIES
CONCRETE IN TUBE PILES SEC. YD.

PILE DATA TABLE				
LOCATION	ROW	No.	LENGTH	BATTER
WEST ABUTMENT	FRONT	10	33'-0"	1:13
		4	32'-0"	1:10
	MIDDLE	5	33'-0"	1:13
		4	32'-0"	1:10
EAST ABUTMENT	FRONT	10	33'-0"	1:13
		4	32'-0"	1:10
	MIDDLE	5	33'-0"	1:13
		4	32'-0"	1:10



FOR REDUCED PLAN
USE SCALE BELOW
1" = 1' ON ORIGINAL PLAN
REVISIONS
DATE BY DESCRIPTION
DESIGNER: K. Z. STOJARSKI
CHECKER: K. Z. STOJARSKI
DATE: JUL 28 1977
DRAWING NO. 1013-45-1



APPENDIX B

Site Photographs



Photograph 1: Viewing south at the north wingwall of the east abutment of the WBL structure. Slope covered with snow and thus, no erosion or scour was observed on slope. No obvious major cracks were observed on the wall. (February 19, 2014)



Photograph 2: Looking at the east abutment wall of the WBL structure. The front slope of the abutment wall was covered with rock protection in non-uniform distribution. Surficial cracks observed on abutment wall. Weeping holes observed in the abutment wall. (February 19, 2014)



Photograph 3: Viewing north at the south wingwall of east abutment of WBL structure. Slope covered with snow and thus, no erosion was observed on the slope. Surficial cracks were observed on the wall. (February 19, 2014)



Photograph 4: Looking northwest at the south wingwall of the west abutment of the WBL structure. Slope covered with ice and snow. Surficial cracks were observed on the wall. (February 19, 2014)



Photograph 5: Looking at the west abutment wall of the WBL structure. The front slope of the abutment wall was covered with rock protection in non-uniform distribution. Surficial cracks were observed on the abutment wall. Weeping holes were observed in the abutment wall. (February 19, 2014)



Photograph 6: Viewing south at the north wingwall of east abutment of EBL structure. Minor concrete scaling was observed on wingwall. No erosion was observed on slope. No obvious major cracks were observed, except for map cracks. Minor spalling was observed on the wall. (February 19, 2014)



Photograph 7: Looking at the east abutment wall of the EBL structure. The front slope of the abutment wall was covered with stones in non-uniform distribution. Surficial cracks observed on abutment wall. Weeping hole observed in abutment wall. (February 19, 2014)



Photograph 8: Viewing north at the south wingwall of the east abutment of the EBL structure. Minor concrete scaling was observed on the wingwall. No erosion was observed on slope due to snow covering. Surficial cracks and slight spalling were observed on the wall. (February 19, 2014)



Photograph 9: Viewing south at the north wingwall of the west abutment of the EBL structure. A major horizontal crack with concrete spalling was observed on the wingwall. The slope was covered with snow and thus, no erosion was observed of the slope. (February 19, 2014)



Photograph 10: Viewing south at the west abutment wall of the EBL structure. Concrete spalling was observed on the wall with minor cracks. The front slope of the abutment wall was covered with rock protection in non-uniform distribution. (February 19, 2014)



Photograph 11: Viewing the south end of the west abutment wall of the EBL structure. Concrete spalling with associated pop outs were observed on the abutment wall. (February 19, 2014)



Photograph 12: Viewing northwest at the south wingwall of the west abutment of the EBL structure. A major horizontal crack was observed on the wingwall with concrete spalling. (February 19, 2014)



Photograph 13: Looking at the southwest corner of the west abutment of the EBL structure. Major concrete spalling with concrete deterioration was observed. (February 19, 2014)



PRELIMINARY FOUNDATION DESIGN REPORT
for
SYDENHAM RIVER EBL AND WBL BRIDGES
HIGHWAY 402
MTO WEST REGION 59 STRUCTURE REHABILITATIONS
SITES 19-524-1 & 19-524-2, CONTRACT 3
GWP 3075-11-00
TOWNSHIP OF STRATHROY-CARADOC
MIDDLESEX COUNTY, ONTARIO

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M6A 1V5
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PML Ref.: 13KF006C-SR
Index No.: 164FDR
GEOCRES No.: 40I13-57
January 21, 2015



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Table 1 – List of Standard Specifications

PRELIMINARY FOUNDATION DESIGN REPORT

for
Sydenham River EBL and WBL Bridges
Highway 402
MTO West Region 59 Structure Rehabilitations
Sites 19-524-1 & 19-524-1, Contract 3
GWP 3075-11-00
Township of Strathroy-Caradoc
Middlesex County, Ontario

1. INTRODUCTION

This part of the report provides preliminary foundation engineering analysis and recommendations for preliminary design and construction of temporary roadway protection to be used in the rehabilitation of the Sydenham River EBL and WBL Bridges on Highway 402 in the Township of Strathroy-Caradoc, Middlesex County, Ontario. The study was carried out by Peto MacCallum Ltd. (PML) for MMM Group Limited (MMM) on behalf of the Ministry of Transportation of Ontario (MTO).

It is understood that the Sydenham River EBL and WBL Bridge structures rehabilitation project includes modification of the bridge abutments to semi-integral abutments and replacement of the existing concrete barrier walls. Traffic staging will be required to complete the rehabilitation work in two stages and will be coordinated with the two stage traffic staging for Hickory Drive EBL and WBL Overpass structures. In the first stage traffic will be shifted to the outside lanes and all ramps at the Hickory Drive will remain open. In the second stage, traffic will be shifted to the inside lane and all the ramps at the Hickory Drive Overpasses will be closed.

It is anticipated that the installation of temporary roadway protection will be required along the centreline of the eastbound and westbound lanes at both ends of the EBL and WBL bridges.

In summary, the subsurface conditions encountered in the two boreholes included surficial topsoil (in borehole SR-2 only) over 6.3 and 9.1 m thick fill. A 0.5 m thick peat layer was encountered below the fill, which overlaid a stiff 1.5 m thick silty clay layer in borehole SR-2. Below the fill in borehole SR-1 and below the silty clay deposit in borehole SR-2, non-cohesive very loose to very dense sandy/silty soils were encountered. Borehole SR-1 was terminated in the silt deposit at 20.4 m. In borehole SR-2, hard clayey silt till deposit was encountered below the non-cohesive soils. The borehole was terminated in the clayey silt till deposit at 19.8 m. Bedrock was not encountered in the two boreholes.



The Foundation Design Report (FDR) was prepared to provide preliminary geotechnical foundation parameters for the west abutments of the EBL and WBL bridge structures, temporary roadway protection and to address groundwater control measures. The FDR document was intended for the design project terms of reference to supplement existing foundation information. Reference should be made to the Technical Memorandum, dated August 29, 2014, for additional foundation recommendations, which were based on the original report.

A list of the Ontario Provincial Standard documents referenced in this report is enclosed in Table 1. The elevations referred in this report are expressed in meters.

2. PRELIMINARY ENGINEERING DISCUSSION AND RECOMMENDATIONS

2.1 Foundation (West Abutments of the EBL and WBL Bridge Structures)

The subsurface and groundwater conditions encountered in borehole SR-1 (borehole investigated in the median of the west abutments of the EBL and WBL structures) were similar to the subsurface and groundwater conditions encountered in the east abutment locations of the bridge structures.

Piles were driven through well compacted Granular A pads at the abutment locations for WBL bridge structures and the pile toes were placed at approximately, elevation 219.6 ±, Based on the subsurface encountered, the following geotechnical SLS and ULS are provided:

Factored Geotechnical axial Resistance at ULS	= 800 kN
Geotechnical axial Reaction at SLS	= 400 kN

The seismic site coefficient for the conditions at this site is 1.0 (soil profile Type 1, Canadian Highway Bridge Design Code (CHBDC) 2006 Edition, clause 4.4.6).

The bearing resistance for inclined loads should be reduced in accordance with the requirements of clause 6.7.4 of the CHBDC.

The foundation frost penetration depth at the site is 1.2 m according to OPSD 3090.101.



2.2 Temporary Roadway Protection

It is understood that temporary roadway protection will be used during the rehabilitation of the Sydenham River EBL and WBL Bridges on Highway 402. The temporary roadway protection is expected to extend to a sufficient depth to allow for anticipated excavations up to 4 m deep at the abutments. Temporary protection is feasible and should be constructed in accordance with OPSS 539. A minimum performance level of 2, according to OPSS 539 is recommended. The contractor is responsible for selection, preparation of a detailed design and performance for the roadway protection system. The presence of cobbles and boulders within the fill material and the possibility of the granular fill migrating through the temporary protection should be considered during detailed design.

Provided adequate groundwater control is achieved, site soils are classified as Type 3 soils according to Occupational Health and Safety Act, 1990 and Regulation 213/1991 for Construction Projects. Excavations in Type 3 soil should be cut back at an inclination of 1H:1V from the base of the excavation.

2.3 Groundwater Control

Groundwater was encountered in borehole SR-1 at 6.1 m, elevation 228.2 and in borehole SR-2 at 9.1 m, elevation 225.3, during augering. Upon completion of augering, groundwater was encountered in borehole SR-1 at 5.2 m, elevation 229.1 and in borehole SR-2 at 6.4 m, 228.0. The Sydenham River water level was at elevation 227.2 in April 2013 and was at about elevation 227.0 in July 11, 2014.

The prevailing groundwater level based on the original investigation, it is anticipated that higher water level may be encountered during excavation for the bridge rehabilitation work.

Because it is anticipated that up to 4.0 m of cut will be made at the abutment locations, it is expected that conventional filtered sump pumping techniques will be sufficient to control seepage of water into the excavation. Groundwater control of excavations is the Contractor's responsibility.

It should be noted that the groundwater levels are subject to seasonal fluctuations of the river water level and precipitation patterns.



3. CLOSURE

This preliminary report was prepared by Mr. N. Rahman, P.Eng and was reviewed by Mr. R. Ng, PhD, P.Eng., Senior Project Engineer. Mr. B. R. Gray, MEng, P.Eng., MTO Designated Principal Contact conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.



Nazibur Rahman, P.Eng.
Project Engineer, Geotechnical Services



Robert Ng, MBA, PhD, P.Eng.
Senior Project Engineer



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

NR/RN/BRG:nr-mi-jk



TABLE 1
LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

DOCUMENT	TITLE
OPSS 539	Construction Specification for Temporary Protection Systems
OPSD 3090.101	Foundation Frost Penetration Depths for Southern Ontario