

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M 15-49

DIST. 7 REGION

W.P. No. 59-75-06

CONT. No. 82-03

W. O. No.

STR. SITE No. 21-161

HWY. No. 401

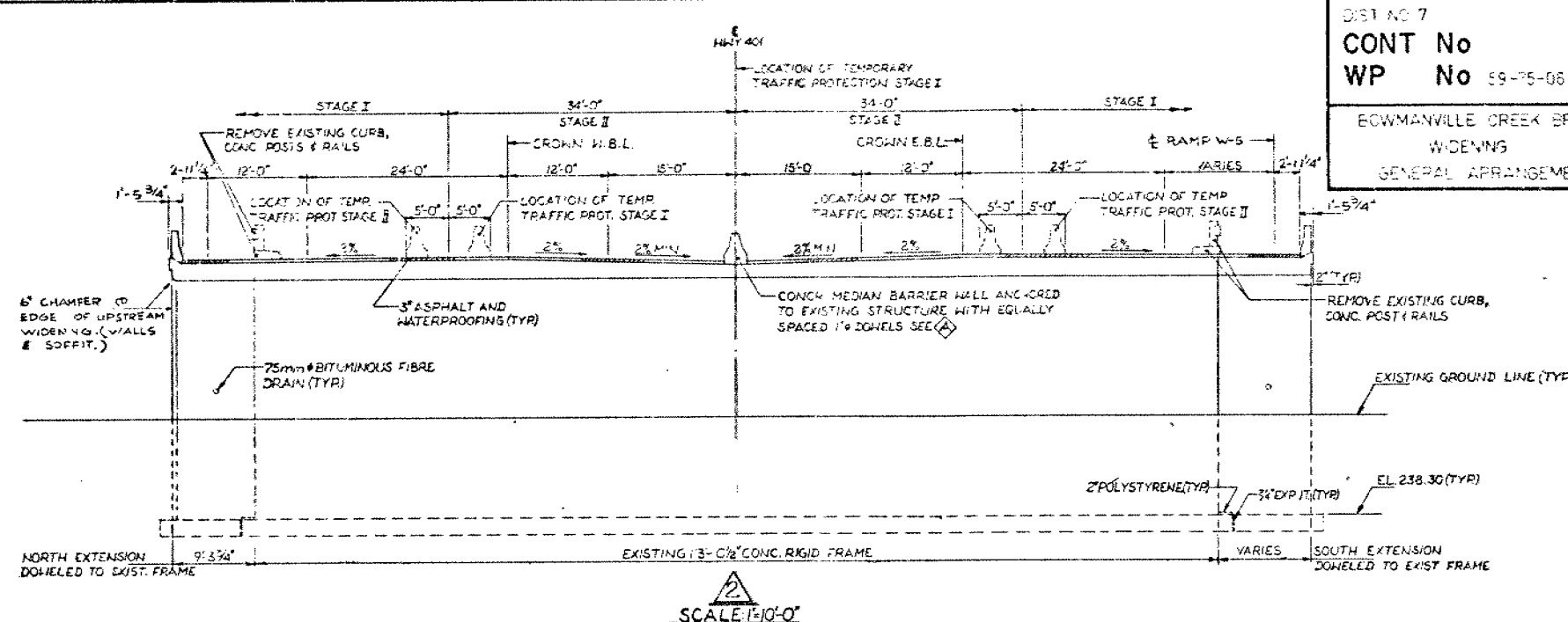
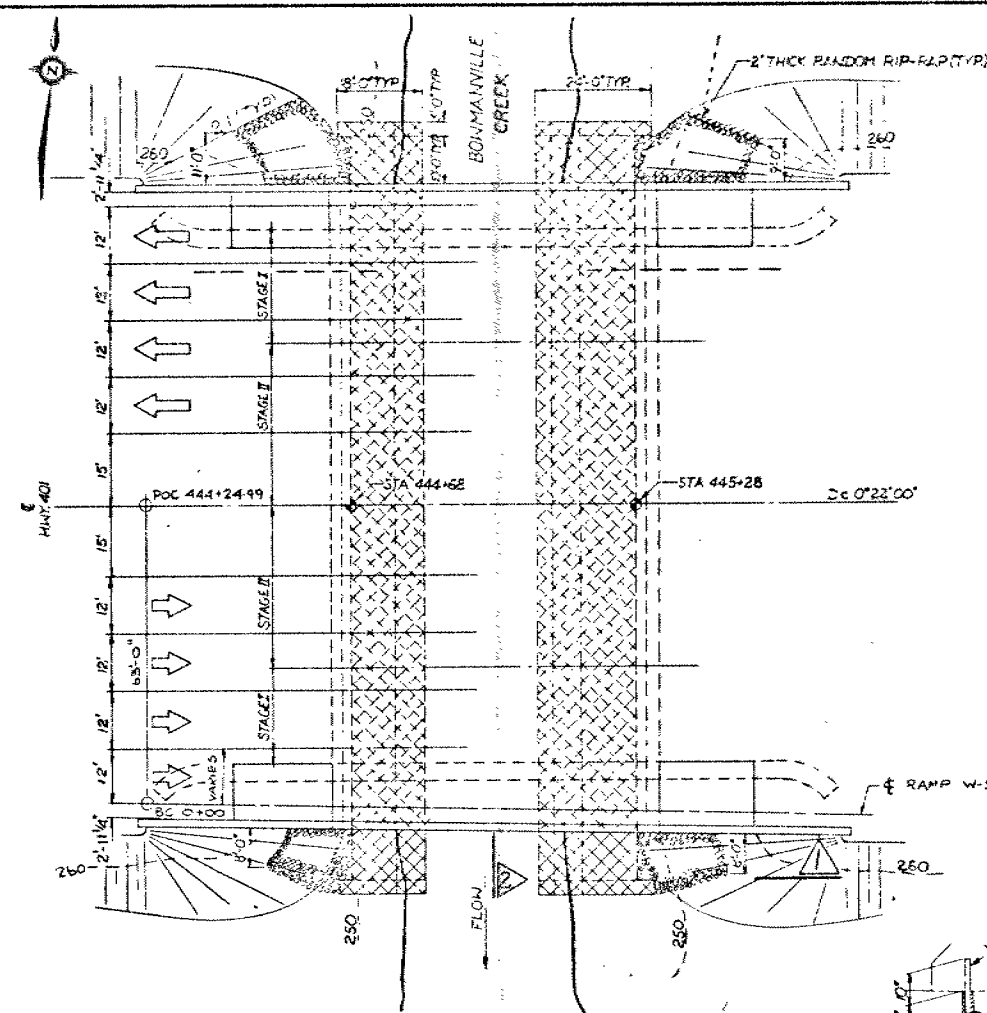
LOCATION Bowmanville Creek Bridge

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



GENERAL NOTES:

CLASS OF CONCRETE

FRAME, RETAINING WALLS & BARRIER WALLS: 30 MPa
FOOTINGS & REMAINDER: 20 MPa

CLEAR COVER TO REINFORCING STEEL:

DECK-TOP: 2", BOTTOM: 1 1/2"
BARRIER WALLS AS NOTED
REMAINDER 3" EXCEPT AS NOTED

GRADE OF REINFORCING STEEL: 400

REINFORCING BARS WITH SUFFIX 'C' SHALL BE COATED BARS.

CONSTRUCTION SEQUENCE:

STAGE I

1. CONSTRUCT DETOUR & ERECT TEMPORARY TRAFFIC PROTECTION @ HWY 401.
2. DIVERT HWY 401 LANES & ERECT TEMPORARY TRAFFIC PROTECTION.
3. REMOVE EXISTING CURBS, CONC POSTS & RAILS, TOP PORTION OF EXISTING WINGWALLS AND ASPHALT FROM OUTER PORTION OF DECK.
4. MAKE REPAIR TO EXISTING CONCRETE DECK AS DIRECTED BY THE ENGINEER.
5. ERECT ROADWAY PROTECTION.
6. EXCAVATE & CONSTRUCT WIDENING & RETAINING WALLS.
7. BACKFILL & WITHDRAW ROADWAY PROTECTION.
8. WATERPROOF AND PAVE WITH 3" ASPHALT.

STAGE II

9. MOVE TEMPORARY TRAFFIC PROTECTION & DIVERT TRAFFIC TO OUTER PORTION OF DECK.
10. REMOVE ASPHALT & REPEAT STEPS 3-8 FOR THE REMAINDER OF DECK.
11. REMOVE TEMPORARY TRAFFIC PROTECTION & DIVERT TRAFFIC TO FINISHED ROADWAY.

LIST OF DRAWINGS:

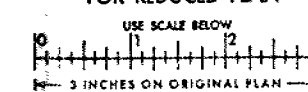
1. GENERAL ARRANGEMENT
2. BORE HOLE LOCATIONS & SOIL STRATA
3. FOOTING LAYOUT
4. FRAME
5. WINGWALLS & RET WALLS DETAILS
6. INTERCONNECTION BETWEEN WINGWALLS
7. BARRIER WALL
8. 20 FT. APPROACH SLAB
9. ROADWAY PROTECTION
10. AS CONSTRUCTED ELEV & DIM.
11. STANDARD DETAILS

CONCRETE QUANTITIES

CONCRETE QUANTITIES ARE LISTED BELOW FOR THE APPROPRIATE CONCRETE LUMP SUM TENDER ITEMS

1. CONCRETE IN BRIDGE AND RETAINING WALLS	411 CU. YD.
2. CONCRETE IN BARRIER WALLS	37 CU. YD.
3. CONCRETE IN APPROACH SLABS	29 CU. YD.
	30 CU. YD.

FOR REDUCED PLAN



REVISIONS	DATE	BY	DESCRIPTION

NOTE:
GABION BASKETS TO BE AS SUPPLIED BY MACCAFERRI STEEL WIRE PRODUCTS OR EQUAL WITH MINIMUM PLAN DIMENSIONS OF 3'.

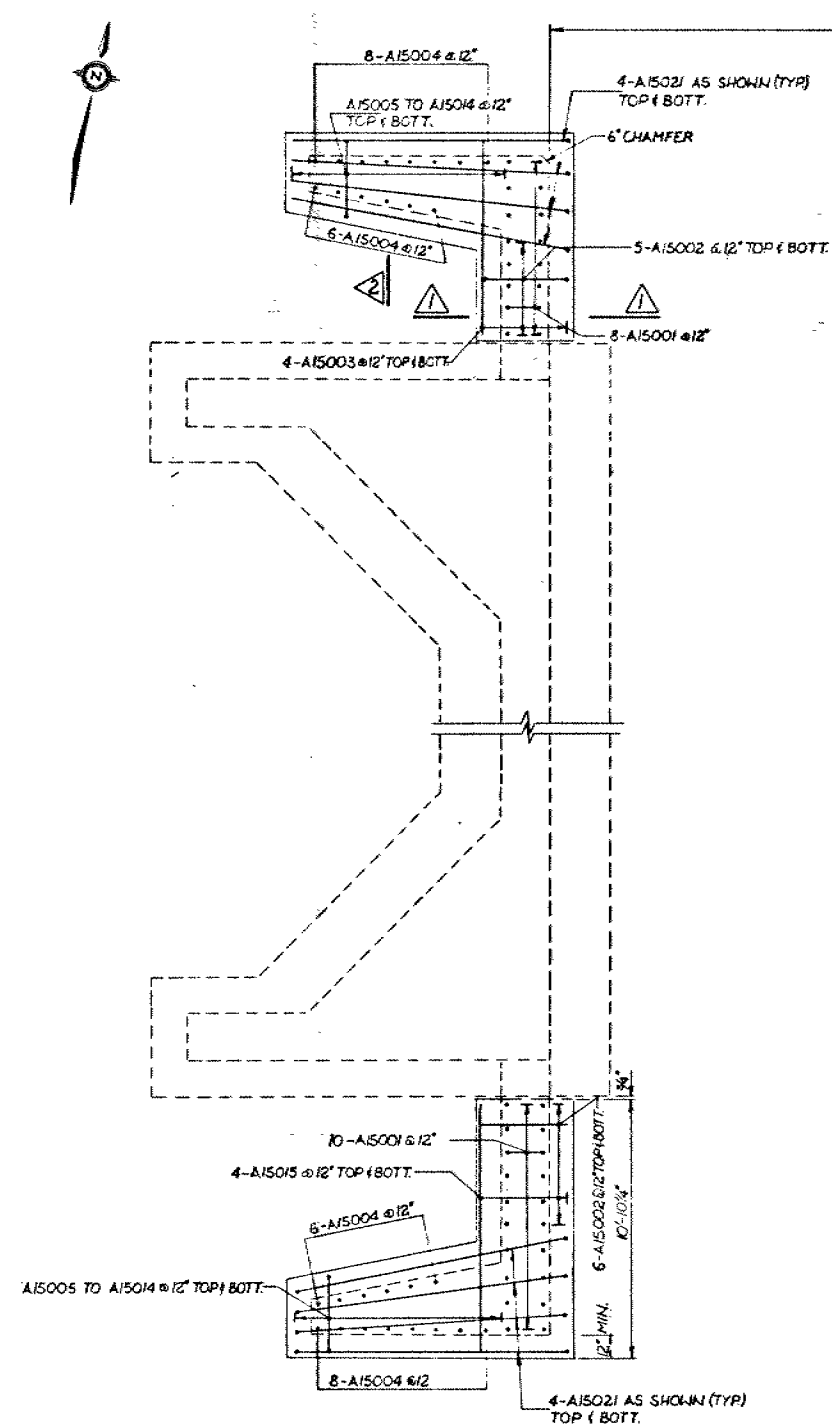
No 7 for Speed Footing

CONT No
WP No 59-75-06

SCAMANVILLE CREEK BRIDGE
WIDENING
FOOTING LAYOUT

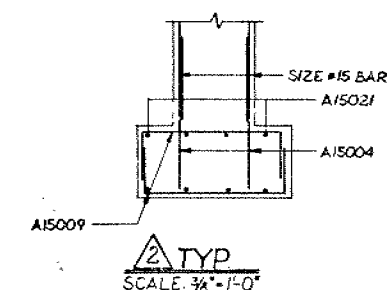
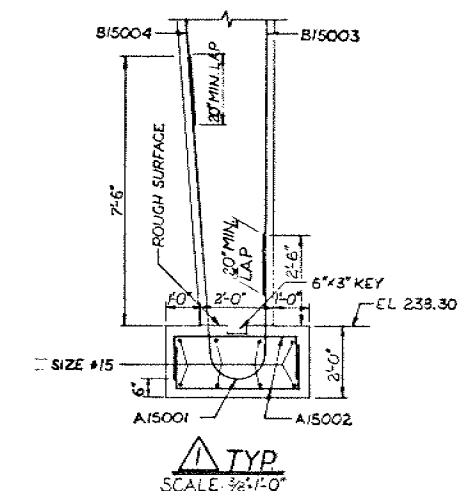
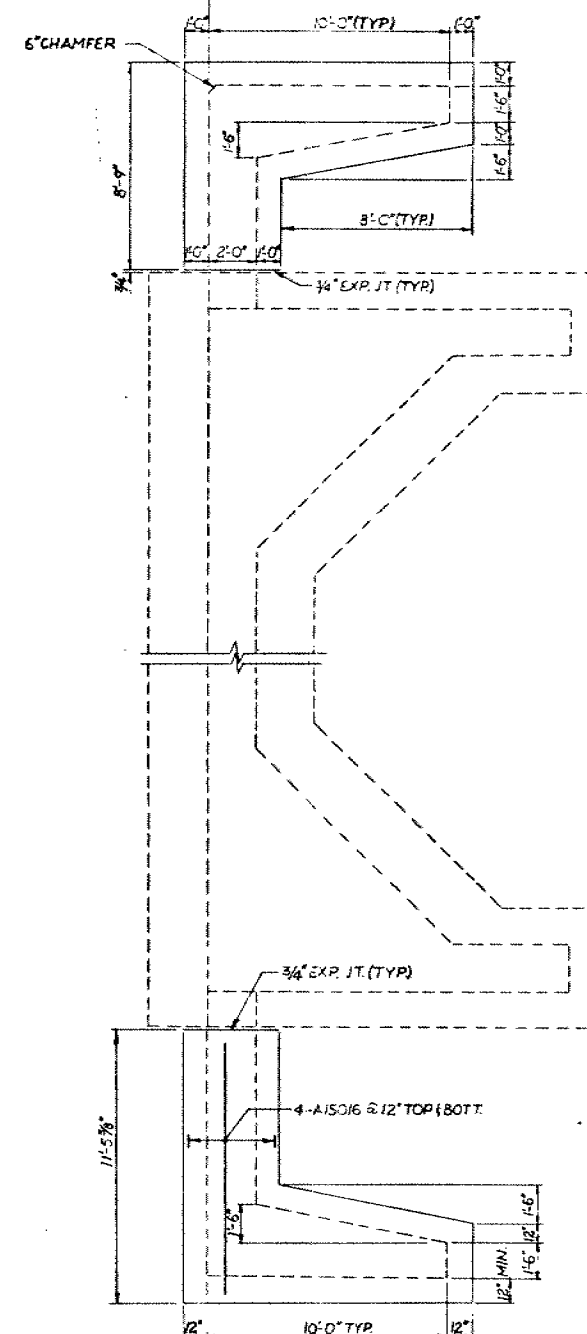
SHEET

NOTE:
DIMENSIONS AND REINFORCING STEEL FOR
N.W. & N.E. CORNERS TYP.

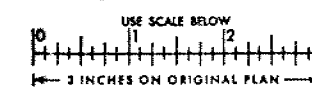


NOTE:
DIMENSIONS & REINFORCING STEEL FOR
S.W. & S.E. CORNERS TYP (EXCEPT AS NOTED)

PLAN
SCALE: 3/8"=1'-0"



FOR REDUCED PLAN



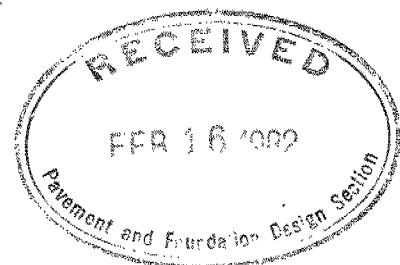
REVISIONS					

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 82-03



Ministry of
Transportation and
Communications



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	W. P. 59-75-06 Widening of Bowmanville Creek Bridge.
	W. P. 59-75-07 Widening of Liberty Street Overpass
	W. P. 59-75-08 Widening Soper Creek - Bowmanville
	W. P. 7-79-03 Wilmot Creek Culvert Extension

NOTE: For purposes of the contract these reports supercede all other foundation reports prepared by or for the Ministry in connection with the above mentioned projects.

'N' VALUE: AN INDICATOR OF SUBSOIL QUALITY. IT IS OBTAINED FROM THE STANDARD PENETRATION TEST (CSA STD. A119.1). SPT 'N' VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 2 INCH O.D. SPLIT-BARREL SAMPLER TO PENETRATE 12 INCHES INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WEIGHING 140 POUNDS, FALLING FREELY A DISTANCE OF 30 INCHES. FOR PENETRATIONS OF LESS THAN 12 INCHES 'N' VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. 'N' VALUES CORRECTED FOR OVERBURDEN PRESSURE ARE DENOTED THUS N_c .

DYNAMIC CONE PENETRATION TEST (CSA STD. A119.3): CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (2" O.D. 60 CONE ANGLE) DRIVEN BY 350 FT-LB IMPACTS ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 12 INCH ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOIL QUALITY: SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSITY.

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

S_u (FSF)	0 - 250	250 - 500	500 - 1000	1000 - 2000	2000 - 4000	> 4000
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

'N' (BLOW/FT)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCK QUALITY: 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 DRILLED IN THAT CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" 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	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS & SYMBOLS

LABORATORY TESTING

TRIAXIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U) ISOTROPICALLY (I) OR NOT (A) AND SHEARED DRAINED (D) OR UNDRAINED (U) WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS) EG. $\bar{C}U$ = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

FIELD SAMPLING

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

EARTH PRESSURE TERMS

μ COEFFICIENT OF FRICTION
 δ ANGLE OF WALL FRICTION
 k_o COEFFICIENT OF EARTH PRESSURE AT REST
 k_A COEFFICIENT OF ACTIVE EARTH PRESSURE
 k_P COEFFICIENT OF PASSIVE EARTH PRESSURE
 i ANGLE OF INCLINATION OF SURCHARGE
 w SLOPE ANGLE-BACKFACE OF WALL
 β ANGLE OF SLOPE
 N_q, N_c BEARING CAPACITY FACTORS
 D_f DEPTH OF FOOTING
 B, L FOOTING DIMENSIONS

INDEX PROPERTIES

γ UNIT WEIGHT OF SOIL (BULK DENSITY)
 γ_w UNIT WEIGHT OF WATER
 γ_d UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
 γ' UNIT WEIGHT OF SUBMERGED SOIL
 G_s SPECIFIC GRAVITY OF SOLIDS
 e VOIDS RATIO
 e_o INITIAL VOIDS RATIO
 e_{max} e IN LOOSEST STATE
 e_{min} e IN DENSEST STATE
 D_r RELATIVE DENSITY = $\frac{e_{max} - e}{e_{max} - e_{min}}$
 n POROSITY
 w WATER CONTENT
 w_L LIQUID LIMIT
 w_p PLASTIC LIMIT
 w_s SHRINKAGE LIMIT
 I_p PLASTICITY INDEX = $w_L - w_p$
 L_L LIQUIDITY INDEX = $\frac{w - w_p}{w_L - w_p}$
 I_c CONSISTENCY INDEX = $\frac{w_L - w}{w_p - w_L}$
 A_c ACTIVITY = $\frac{I_p \text{ of soil}}{I_p \text{ of } 2\mu\text{m soil fraction}}$
 O_m ORGANIC MATTER CONTENT
 S_r DEGREE OF SATURATION
 S SENSITIVITY = $\frac{S_u(\text{undisturbed})}{S_u(\text{remoulded})}$

STRENGTH PARAMETERS

ϕ ANGLE OF SHEARING RESISTANCE
 τ_f PEAK SHEAR STRENGTH
 τ_R RESIDUAL SHEAR STRENGTH
 c COHESION INTERCEPT
 $\sigma_1, \sigma_2, \sigma_3$ NORMAL PRINCIPAL STRESSES
 u PORE WATER PRESSURE
 u_e EXCESS u
 r_u PORE PRESSURE RATIO
 q_u UNCONFINED COMPRESSIVE STRENGTH
 s_u UNDRAINED SHEAR STRENGTH
 ϵ LINEAR STRAIN
 γ SHEAR STRAIN
 ν POISSON'S RATIO
 E MODULUS OF ELASTICITY
 G MODULUS OF SHEAR DEFORMATION
 k_s MODULUS OF SUBGRADE REACTION
 m, n STABILITY COEFFICIENTS
 A, B PORE PRESSURE COEFFICIENTS

NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:
 σ' = EFFECTIVE ANGLE OF SHEARING RESISTANCE;
 σ'_n = EFFECTIVE NORMAL STRESS

HYDRAULIC TERMS

h HYDRAULIC HEAD OR POTENTIAL
 q RATE OF DISCHARGE
 v VELOCITY OF FLOW
 i HYDRAULIC GRADIENT
 j SEEPAGE FORCE PER UNIT VOLUME
 η COEFFICIENT OF VISCOSITY
 k COEFFICIENT OF HYDRAULIC CONDUCTIVITY
 k_h k IN HORIZONTAL DIRECTION
 k_v k IN VERTICAL DIRECTION
 α_v COEFFICIENT OF VOLUME CHANGE
 c_v COEFFICIENT OF CONSOLIDATION
 C_c COMPRESSION INDEX
 C_r RECOMPRESSION INDEX
 d DRAINAGE PATH DISTANCE
 T_v TIME FACTOR
 U DEGREE OF CONSOLIDATION
 O_c OVERCONSOLIDATION RATIO (OCR)

FOUNDATION INVESTIGATION REPORT

For

Proposed Widening of Bowmanville Creek Bridge
King's Highway 401 - Town of Newcastle
W. P. 59-75-06; Site No. 21-161
District No. 7; Port Hope, Ontario

INTRODUCTION

This report describes the results of a geotechnical investigation carried out at the site of the proposed widening of the existing crossing at Bowmanville Creek and Highway 401 in the Town of Newcastle. The services of Dominion Soil Investigation Inc., consulting geotechnical engineers, were retained by the Ministry to carry out the field investigation and prepare the Foundation Investigation and Design Report. The purpose of the investigation was to determine the subsoil and groundwater conditions at the site; to establish the engineering properties of the substrata; and to make recommendations for the foundation design and construction of the proposed bridge structure.

The investigation in the field was completed in May 1978, and consisted of the drilling of four boreholes and the excavation of two test pits. The locations of the boreholes and test pits are shown on Drawing No. 2 and the subsurface conditions encountered are presented on the record of the boreholes and in the Appendix.

DESCRIPTION OF THE SITE

The site is located in the Town of Newcastle at the crossing of Highway 401 and the Bowmanville Creek. The terrain in this area is generally flat and the embankment carrying Highway 401 rises 12 to 18 ft. above the surrounding area. Drainage to the area is provided by the Bowmanville and Soper Creeks.

REGIONAL GEOLOGY

Geologically, the site is situated in the Lake Iroquois plain, which is an area of low relief inundated during the Pleistocene by the water of Lake Iroquois. The old abandoned shoreline of Lake Iroquois lies approximately 4 miles to the north.

The bedrock underlying the basin is of Ordovician age and consists of the Whitby formation, which is a black calcareous shale unit with interbedded limestone layers. The bedrock surface is irregular and regional studies suggest that there are strong similarities between the existing surface topography and that of the bedrock surface.

The surficial deposits consist of sediments of Pleistocene and recent age. Glacio-lacustrine deposits south of the abandoned Lake Iroquois shoreline range from sand and gravel of a near shore and deltaic nature to off-shore sediments such as varved silt and clay. These were deposited on top of a ground moraine of generally coarse sandy texture.

The surface of the till is irregular and drumlinized and the surface of the drumlins are exposed in many places in this area. More recent deposits consisting of organic and alluvial soils are found in the valleys of the creeks.

SUBSOIL CONDITIONS

The four exploratory boreholes drilled at the site indicate in general fill and alluvium to depths ranging between 7.0 and 12.8 ft. below the ground surface, underlain by a basal till extending to the surface of the bedrock. The bedrock, which was encountered $16.0 \pm$ ft. below the ground surface, is a shaley limestone.

Details of the subsurface conditions are shown on the Record of Boreholes and also on the inferred soil profile and sections shown on Drawing No. 2. The relevant index and engineering properties of the principal soil strata are described briefly below.

Fill

Boreholes 1 and 4 encountered fill to depths ranging between 5.0 and 7.5 ft. below the ground surface.

To a depth of 2.5 ft. below the ground surface in Borehole 4, the fill consists of sandy silt followed by sand and gravel with traces of silt to 5.0 ft. Borehole 1 encountered 9-inches of fine sand underlain by

sand and gravel to 4.0 ft., which is in turn underlain by silty sand with some gravel and clay (i.e. till) to a depth of 7.5 ft. below the ground surface.

Based on penetration indices or 'N'-values of 6 to 23 blows per foot, the fill is described as loose to compact.

Sandy Silt

A surficial layer of alluvial sandy silt was encountered at Boreholes 3 and 2 to depths ranging between 2.0 and 2.5 ft. below the ground surface respectively.

Silty Sand

Boreholes 2, 3 and 4 encountered alluvial silty sand to depths ranging between 7.0 and 7.5 ft. below the ground surface.

The thickness of the alluvium ranges between 2.0 and 5.5 ft. and contains various amounts of organic matter. The grain-size distributions of typical samples are shown on Enclosures 6 and 7, indicating 0-10% gravel, 68 to 87% sand (mostly fine), 13 to 32% silt and clay size particles. The 'N'-values range from 2 to 11 blows per foot, indicating very loose to compact relative density. The coefficient of permeability of the alluvium is estimated to range from 10^{-3} cm/sec. to 10^{-5} cm/sec.

Sand and Gravel

Boreholes 1 and 4 encountered sand and gravel and gravelly sand ranging in thickness from 2.0 ft. (Borehole 4) to 5.3 ft. (Borehole 1). The grain size distribution characteristics of this deposit are shown on Enclosure 8, indicating 27% gravel, 55% sand, and 18% silt and clay size particles. The penetration indices range from 8 to 36 blows per foot, indicating loose to dense relative density.

Glacial Till

At depths ranging between 7.0 and 12.8 ft. below the ground surface, the

boreholes encountered a basal till with a thickness ranging from 3.2 ft. in Borehole 1, to 7 to 9 ft. in the remaining boreholes.

The grain size distribution of typical samples shown on Enclosure 5 indicates 18 to 38% gravel, 35 to 49% sand, 21 to 31% silt, and 6 to 11% clay size particles. The till generally exhibits some cementation although layers or zones of little or no cementation were also noted. The penetration resistances within the basal till range from 26 to more than 100 blows per foot, indicating a compact to very dense relative density. Based on the gradation curves and from visual and tactile examination of the samples, the coefficient of permeability of the till is estimated to range between 10^{-4} and 10^{-5} cm/sec. depending on the degree of cementation and density.

Bedrock

The surface of the bedrock was encountered beneath the basal till at a depth of $16.0 \pm$ ft. below the ground surface (i.e. between Elevation 234.6 and 232.2 ft.).

In Borehole 1, from 16.0 to 18.8 ft. below the ground surface, that is from Elevation 234.5 to 231.7 ft., the rock was found to be of very poor quality with some sand seams. The recovery and the R.Q.D. values in this zone are 27%, and the visual examination of the core samples indicates a fractured rock.

Elsewhere, the recovered cores show that the rock formation underlying the site is a grey, shaley limestone. To a depth of 2 ft. below its surface in Borehole 2 (R.Q.D. value = 43%), and 6 to 12-inches in Boreholes 3 and 4, the rock is weathered. Below this zone, the rock is relatively intact with occasional highly weathered thin bands. The high percentage of core recovery (85 to 100%) and R.Q.D. values of 63 to 100%, indicate that the rock is of fair to excellent quality. No major fractures were encountered indicating that the mass permeability of the rock below the weathered zone would be low.

GROUNDWATER CONDITIONS

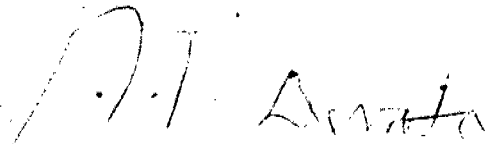
The groundwater conditions in the boreholes were observed during drilling;

water levels were also measured before coring started and after the completion of the coring. A standpipe was installed in Borehole 2 and seepage of surface water was prevented by a bentonite seal about 3 ft. below the ground surface.

Observations made in the boreholes before coring the rock showed water levels ranging between 3.0 and 7.5 ft. below the ground surface. In Boreholes 2 and 3, a slight temporary artesian pressure of 1.0 to 1.5 ft. above the ground surface was noted in the casing after coring. The standpipe installed in Borehole 2, however, later showed a stabilized water level 2.5 ft. below the ground surface. These observations indicate that the average groundwater table at the time of the investigation was at Elevation $248 \pm$ ft.



T. J. Kazmierowski, P. Eng.
Foundations Engineer



M. Devata, P. Eng.
Senior Foundations Engineer

APPENDIX



RECORD OF BOREHOLE No 1

W P 59-75-06 LOCATION Co-ords 15, 951, 619 N; 1, 216, 168 E. ORIGINATED BY N.M.C.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.I.
DATUM GEODETIC DATE MAY 10, 1979 CHECKED BY I.P.I.

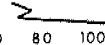
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH					
								○ UNCONFINED ... + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
250.5	GROUND LEVEL													
0.0	9" Fine Sand, Sand & gravel, compact (FILL)		1	SS	23	 5"	250							R.Q.D. = 27%
246.5			2	SS	6									
4.0	Silty Sand, some gravel & Clay (FILL) loose		3	SS	10									
243.0			4	SS	36									
7.5	Sand & Gravel loose with some silt dense layers, wet		5	SS	507		240							
237.7			6	BC	—									
12.8	Silty Sand TILL w. shale & limestone cobbles		7	BC	27%		230							
234.5	some sand seams fractured		8	BC	100%									
16.0	sound, limestone BEDROCK argillaceous, shale bands, grey		9	BC	100%									
225.9													R.Q.D. = 95%	
24.6	END OF BOREHOLE													W.L. E1. 248.5 May 10, 1979

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2

W P 59-75-06 LOCATION Co-ords 15, 951, 648 N; 1, 216, 235 E. ORIGINATED BY N.McC.
 DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.L.
 DATUM GEODETIC DATE MAY 11, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH					WATER CONTENT (%)				
								○ UNCONFINED	+ FIELD VANE				20 40 60				
249.9	GROUND LEVEL						● QUICK TRIAXIAL <th colspan="3">x LAB VANE</th> <td colspan="3"></td> <td></td> <td></td> <td></td>	x LAB VANE									
0.0	Sandy SILT, dark brown															0 68 28 4	
247.4	some organics															0 87 11 2	
2.5	Silty Fine SAND, some org.		1	SS	3											23 35 31 11	
	content&org.layers,very		2	SS	3											18 42 29 11	
242.9	loose, grey, moist		3	SS	31												
7.0	GLACIAL TILL-		4	SS	34												
	heterogeneous mixture of		5	SS	49												
	silty sand with gravel		6	SS	50/ 3"												
233.9	and some clay dense,		7	BC	100%											R.Q.D. = 43%	
16.0	grey, cobble @ 12'		8	BC	100%											R.Q.D. = 100%	
	Limestone																
	BEDROCK weathered																
227.9	argillaceous, shale, sound																
	bands, occ. clayey bands																
22.0	END OF BOREHOLE															DATE W.L. May 11 249.9 Sept. 10 247.4	
																Artesian pressure 1.5 above ground surface ob- served in BW casing.	

OFFICE REPORT ON SOIL EXPLORATION

+3, x⁵: Numbers refer to
Sensitivity

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



RECORD OF BOREHOLE No 3

W P 59-75-06 LOCATION Cor-ords, 15, 951, 760 N; 1, 216, 115 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 11, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
248.4	GROUND LEVEL																
248.0	Sandy SILT		1	SS	2												10 70 16 4
240.9	2.0 Silty SAND, w. tr. of gravel, some org. content v. loose, grey to dk. grey		2	SS	4												19 49 24 7
232.2	7.5 GLACIAL TILL: heteroge- neous mixture of silty sand with gravel and traces of clay dense, grey.		3	SS	50	5"	240										34 39 21 6
			4	SS	50	6"											
			5	SS	88	10"											
			6	SS	50	6"											R.Q.D.=94%
16.2	Limestone BEDROCK		7	RC	100%		230										
227.7	argillaceous, sound, grey			BXL													
20.7	END OF BOREHOLE																Artesian pressure 1.0' above ground sur- face ob- served in BW casing after coring

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to
Sensitivity

20
15 → 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 4

W P 59-75-06 LOCATION Co-ords, 15, 951, 800 N; 1, 216, 180 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 11, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
250.4	GROUND LEVEL																
247.9	Sandy Silt FILL brown		1	SS	14		250										
245.4	Sand & Gravel, tr. silt Filly, moist to wet		2	SS	11												0 76 24
243.4	Ord. comp. dk. grey		3	SS	8												27 55 18
241.4	Gravelly Sand, some silt, loose, dk. grey		4	SS	26		240										38 35 21 6
9.0	compact Silty Sand dense TILL		5	SS	50/6												
234.6			6	SS	50/4												
15.8	Limestone BEDROCK argillaceous, sound grey, occasional shale bands and thin sand seams		7	RC BXL	85%		230										R.Q.D. = 63%
224.7			8	RC BXL	98%												R.Q.D. = 96%
25.7	END OF BOREHOLE																DATE W.L. May 11 248.9 Sept. 10 248.8

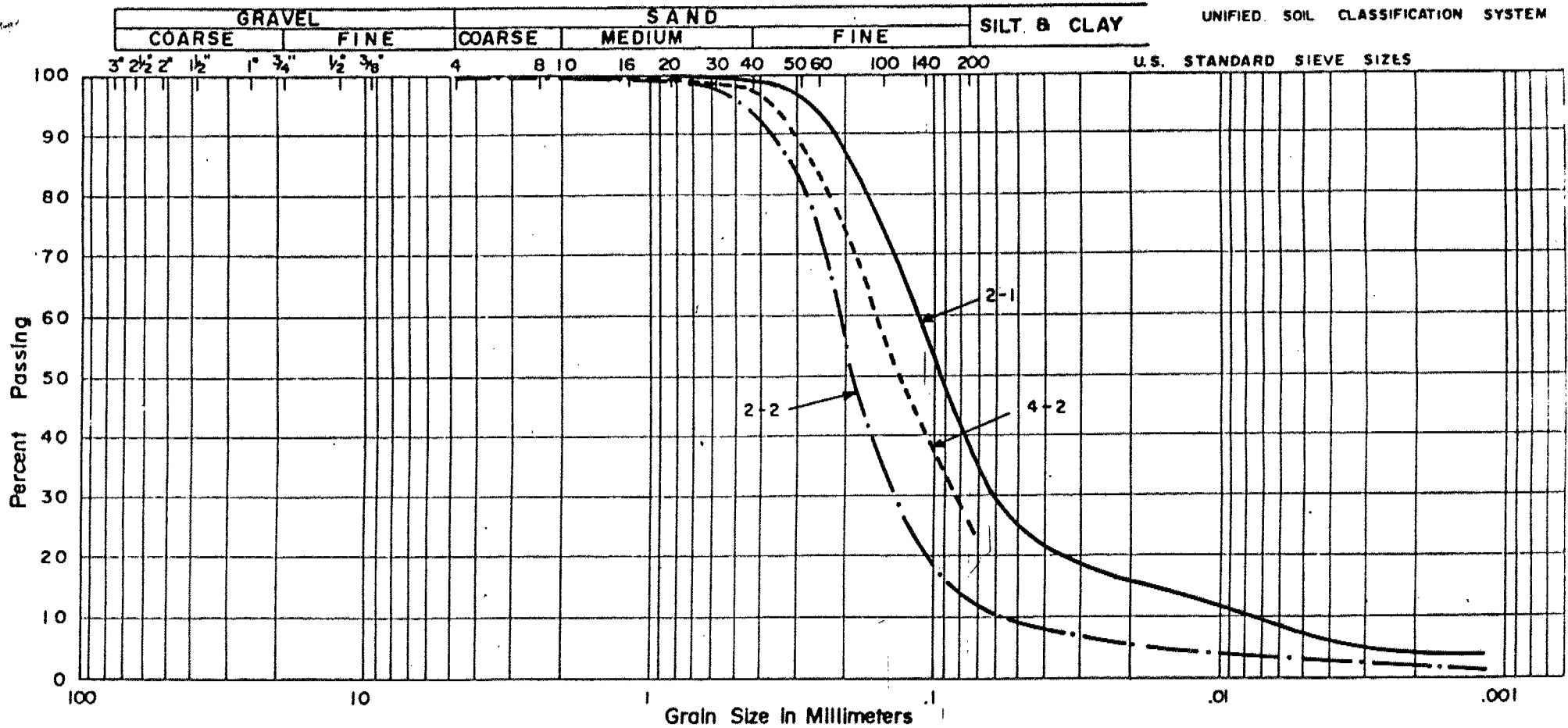
+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

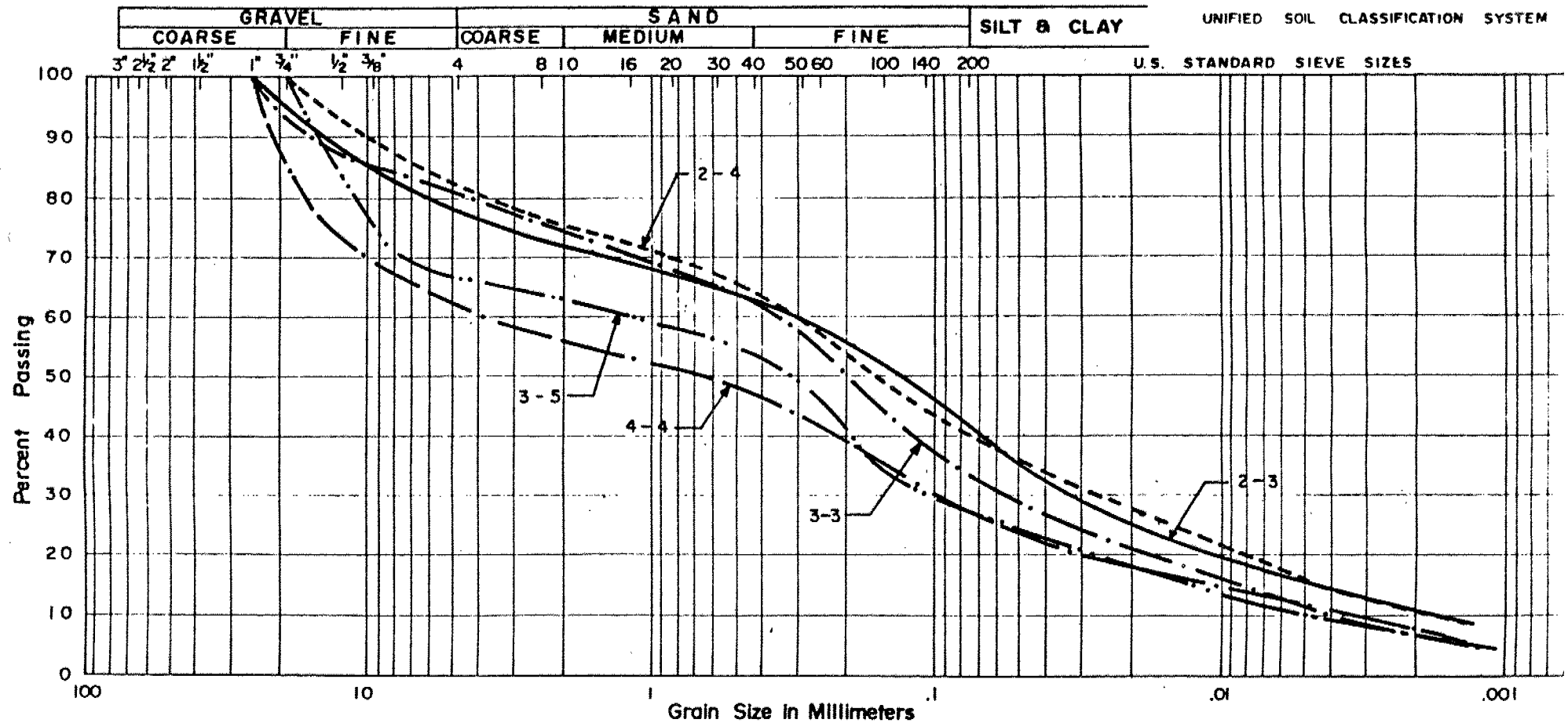
DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION



DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION



PROJECT: BOWMANVILLE CREEK BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE NO: 2 2 3 3 4
 SAMPLE NO: 3 4 3 5 4
 DEPTH:
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SILTY SAND TILL
 with gravel and some clay.

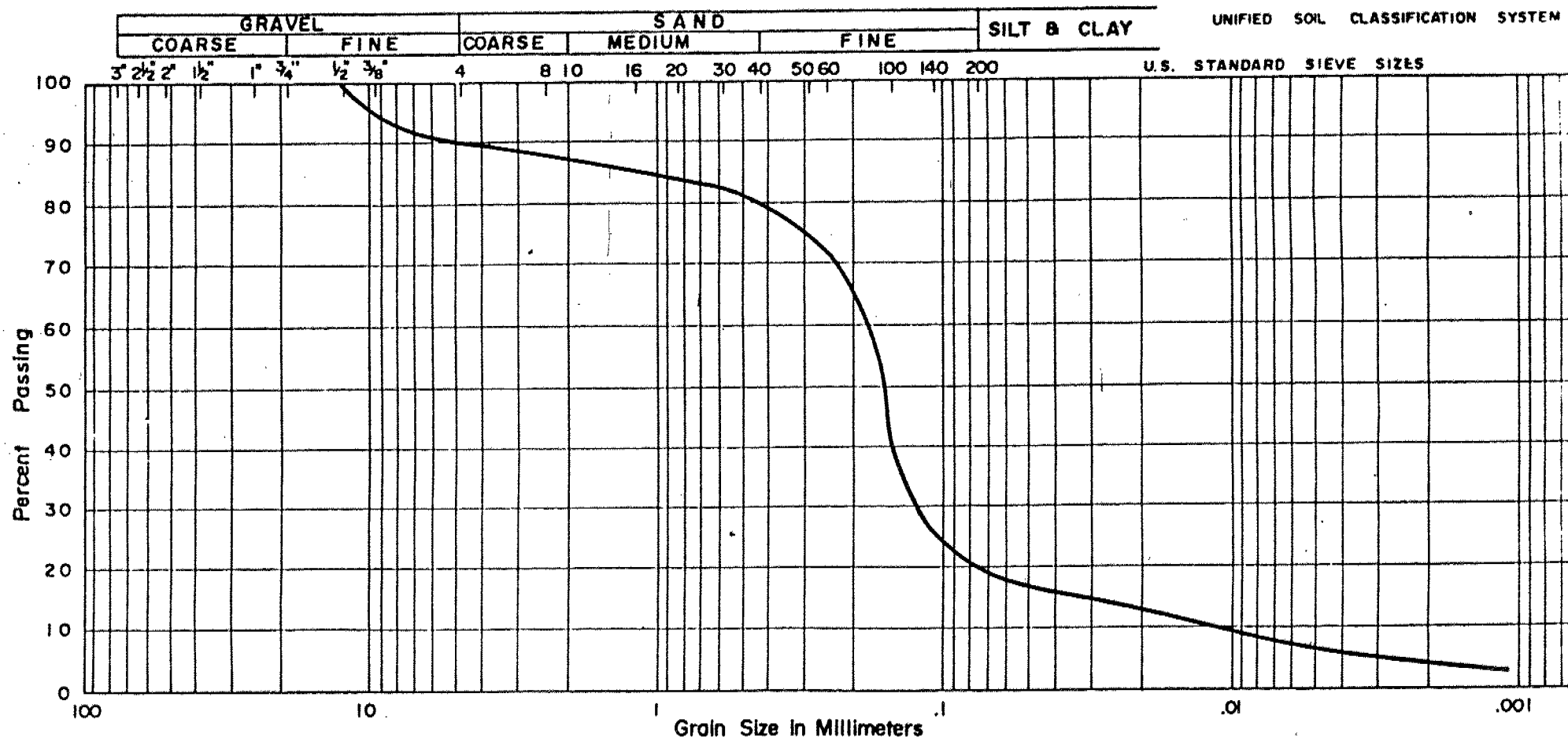
PLASTIC PROPERTIES

LIQUID LIMIT	% =
PLASTIC LIMIT	% =
PLASTICITY INDEX	% =
MOISTURE CONTENT	% = 5.9 - 8.8

ENCLOSURE NO. 1

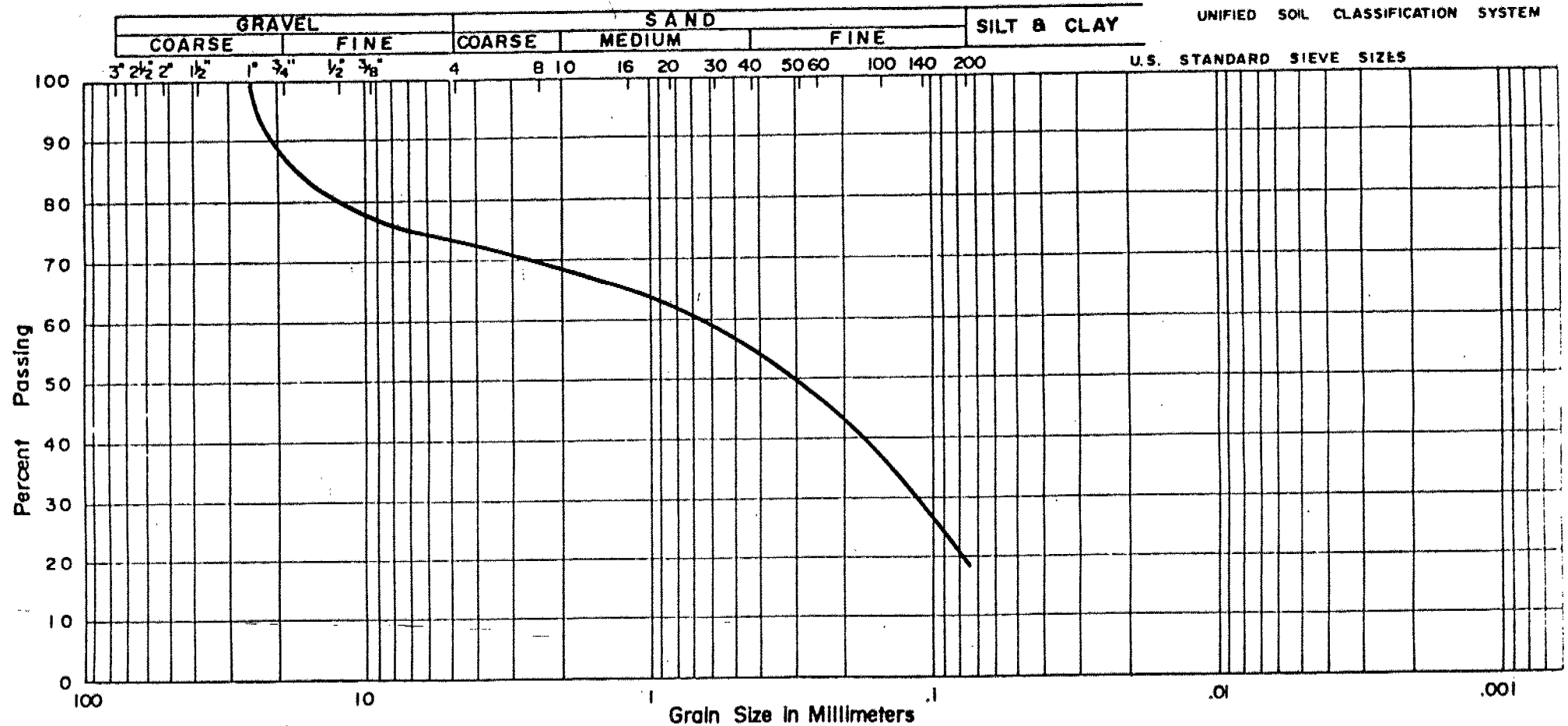
DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION



DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION



PROJECT: BOWMANVILLE CREEK BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE NO: 4
 SAMPLE NO: 3
 DEPTH:
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:
GRAVELLY SAND
 some silt.

PLASTIC PROPERTIES

LIQUID LIMIT	% =
PLASTIC LIMIT	% =
PLASTICITY INDEX	% =
MOISTURE CONTENT	% = 10.1

ENCLOSURE NO. 16

FOUNDATION INVESTIGATION REPORT

For

Proposed Widening of Liberty Street Overpass
King's Highway 401 - Town of Newcastle
W. P. 59-75-07; Site No. 21-162
District No. 7, Port Hope, Ontario

INTRODUCTION

This report describes the results of a geotechnical investigation carried out at the site of the proposed widening of the existing Liberty Street overpass on Highway 401 in the Town of Newcastle. The services of Dominion Soil Investigation Inc., consulting geotechnical engineers, were retained by the Ministry to carry out the field investigation and prepare the Foundation Investigation & Design report. The object of the investigation was to determine the subsoil and groundwater conditions at the site; to establish the engineering properties of the substrata; and to make recommendations for the foundation design and construction of the proposed bridge structure.

- The investigation in the field was completed in May 1978 and consisted of the drilling of eight boreholes and the excavation of a test pit. The locations of the boreholes and the test pit are shown on Drawing 2, and the subsurface conditions found in the boreholes and the test pit are presented on the Record of the Boreholes and in the Appendix.

DESCRIPTION OF THE SITE

The site is located in the Town of Newcastle at the intersection of Highway 401 and Liberty Street. The terrain in this area is generally flat and the embankment carrying Highway 401 rises 15 to 20 ft. above the surrounding area. Drainage to the area is provided by the Bowmanville and Soper Creeks located a short distance to the west and east respectively.

REGIONAL GEOLOGY

Geologically, the site is situated in the Lake Iroquois Plain, which

is an area of low relief inundated during the Pleistocene by the waters of Lake Iroquois. The old abandoned shoreline of Lake Iroquois lies approximately 4 miles to the north.

The bedrock underlying the basin is of Ordovician age and consists of the Whitby formation which is a black calcareous shale unit with interbedded limestone bands. The bedrock surface is irregular and regional studies suggest that there are strong similarities between the existing surface topography and that of the bedrock surface.

The surficial deposits consist of sediments of Pleistocene and recent age. Glacio-lacustrine deposits south of the abandoned Lake Iroquois shoreline range from sand and gravel of a near shore and deltaic nature to off-shore sediments such as varved silt and clay. These were deposited on top of a ground moraine of generally coarse sandy texture.

The surface of the till is irregular and drumlinized and the surface of the drumlins are exposed in many places in this area. More recent deposits consisting of organic and alluvial soils are found in the valleys of the creeks.

SUBSOIL CONDITIONS

The eight exploratory boreholes and one test pit indicate reasonably uniform subsurface conditions. The stratigraphic sequence, as inferred from the borehole logs, is as follows:

- 1) Loose to compact mixed fill;
- 2) Stiff silty clay ;
- 3) Very dense silty sand till;
- 4) Sound shale bedrock.

Details of the subsurface conditions are shown on the Record of Boreholes and also on the inferred soil profile and sections shown on Drawing No. 2. The relevant index and engineering properties of the principal soil strata are described briefly below.

Fill

Fill was encountered in every borehole, ranging in thickness between 3 and 17.5 ft. The composition of the fill varies, but generally sand and silt particles predominate. The penetration indices or 'N'-values range from 2 to 27 blows per foot, with an average value of about 10 blows per foot. Based on this, the relative density of the fill is inferred to be loose to compact and generally in the compact range. The permeability of the fill is expected to be variable and to depend on the composition of the fill, but on the average it is estimated to be in the range of 10^{-3} to 10^{-5} cm/sec.

Silty Clay

A silty clay stratum was encountered in Boreholes 3, 7 and 8. It is believed to be of glacio-lacustrine origin laid down possibly by Lake Iroquois. The thickness of the silty clay ranges from 13 ft. to 4.5 ft. The penetration indices range between 10 and 22 blows per foot, indicating a generally stiff to very stiff consistency. The undrained shear strength of the silty clay is estimated to range between 2000 and 3000 psf. The permeability of this stratum is estimated to be low, generally less than 10^{-6} cm/sec.

Glacial Till

In each borehole, an approximately 10 ft. thick layer of basal till was encountered. The surface of the till lies between Elevations 255.7 ft. (Borehole No. 1) and 249.4 ft. (Borehole No. 6), with an average elevation of about 252 ft. The till has a coarse texture and is a well graded mixture of gravel, sand, silt and clay size particles. Embedded in the till are also frequent cobbles and boulders. Grading curves of representative samples of the till are shown on Enclosures 9, 10 and 11. Reference to these indicates that the till consists of 12 to 42% gravel, 35 to 55% sand, 17 to 25% silt and 5 to 10% clay size particles. The till exhibits some to considerable cohesion due to cementation. The Standard Penetration resistances were generally in excess of 100 blows per foot, indicating a very dense relative density. Due to the well graded and dense nature of the till and the cementation

between the particles, the permeability of the till is estimated to be moderate to generally low in spite of the relatively high sand content. The coefficient of permeability is estimated to be generally less than 10^{-5} cm/sec.

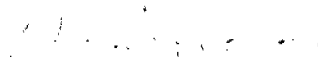
Bedrock

The surface of the bedrock was encountered or inferred from refusal in the boreholes between Elevation 243.5 and 240.6 ft. The rock was cored at four locations and the recovered cores indicate that the rock is a dark grey coloured, highly calcareous shale with many limestone bands. The high percentage of core recovery and high R.Q.D.-values (78 to 100%) indicate a sound rock with good qualities. The rock is intact, showing signs of only insignificant amounts of weathering in the upper few inches of the rock. As the rock is relatively free of fractures, the mass permeability of the rock is estimated to be low.

Groundwater Conditions

The groundwater conditions in the boreholes were observed during drilling and the position of the water level was measured and recorded after the borehole was completed but before the rock was cored. During the drilling, water was noticed only in Borehole No. 2 at a depth of 4 ft. in the fill. The other boreholes bored dry and remained dry for periods up to 7 hours after completing the drilling. These observations confirm the generally low permeability of the substrata. Standpipes were installed in Boreholes 2 and 6 and were protected from the influence of surface water by a bentonite clay seal. Observations carried out in these standpipes in September 1979 indicated water levels at Elevations 249.4 to 254.7 ft. From these results and visual and tactile examination of the soil samples, it is inferred that the permanent groundwater table may be near the surface of the silty sand till. It is expected, however, that a temporary perched water table may develop in the more pervious fill above the nearly impervious silty clay and till strata.


T. J. Kazmierowski, P. Eng.
Foundations Engineer


M. Devata, P. Eng.
Senior Foundations
Engineer

APPENDIX

RECORD OF BOREHOLE No 1

W P 59-75-07 LOCATION Co-ords 15, 592, 177 N; 1, 217, 292 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 14, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
265.2	GROUND SURFACE																
0.0	4" TOPSOIL																
	FILL - Sandy Silt Loose, brown		1	SS	5		260										
			2	SS	5												
255.7	some topsoil		3	SS	14												
9.5	compact v. dense		4	SS	15												
	GLACIAL TILL: heteroge- neous mixture of sand, silt, gravel, boulders		5	SS	78												
	some clay, cemented		6	SS	62		250										
243.5			7	SS	50/6"												
21.7	END OF BOREHOLE Refusal probably on bedrock																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 2

W P 59-75-07 LOCATION Co-ords 15, 592, 185 N.; 1, 217, 163 E. ORIGINATED BY N.McC
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGER, BXL ROCK CORE COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 14, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100					
								SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
								WATER CONTENT (%) 20 40 60					
257.7	GROUND SURFACE												
0.0	FILL, mixture of sand, gravel, wet silt, some cobbles. Compact. Brown		1	SS	12								
250.2			2	SS	14								
7.5	GLACIAL TILL: heterogeneous mixture of sand, silt, gravel, some clay very dense, grey		3	SS	50/100								25,45,20,10
			4	SS	50/100								12,53,25,10
			5	SS	50/100								
			6	SS	50/100								
241.2													
16.5	Sound Shale BEDROCK highly calcareous grey		7	RC BXL	100%								R.Q.D.=100%
236.2													
21.5	END OF BOREHOLE												
													DATE W.L. May 14 253.2 Sept. 10 254.7

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

OFFICE REPORT ON SOIL EXPLORATION

W P 59-75-07 LOCATION Co-ords 15, 951, 996 N.; 1, 217, 348 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 15, 1979 CHECKED BY I.P.L.

+3, x⁵: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 4

W P 59-75-07 LOCATION Co-ords 15, 592, 013 N.; 1, 217, 418 E. ORIGINATED BY N.MCC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING; BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 15, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
255.2	GROUND SURFACE																
0.0	FILL - Sandy Silt																
252.2	brown		1	SS	52		250										42,35,17,6
3.0	GLACIAL TILL: heteroge- neous mixture of sand, silt, gravel, some clay very dense, grey, cemented		2	SS	72												25,45,25,5
			3	SS	507	5" DRY											25,45,25,5
			4	SS	507	6"											
242.5			5	SS	507	4"											
12.7	Shale BED- weathered ROCK, highly calcareous w. limestone bands, grey		6	R.C. BXL	78%		240										R.Q.D.=78%
236.8																	
18.4	END OF BOREHOLE																

*3, *5 : Numbers refer to
Sensitivity

20
15 + 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 5

W P 59-75-07 LOCATION Co-ords 15, 952, 166 N.; 1, 217, 323 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 16, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT Σ					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
257.3	GROUND SURFACE																
0.0	5" Topsoil		1	SS	3												
251.8	FILL - mixture of clay, silt,sand,loose,brown		2	SS	15												
5.5	GLACIAL TILL: heteroge- neous mixture of boulder sand,silt,gravel, some clay,very dense, grey limestone fragments		3	SS	507	2"	250										
			4	SS	507	6"											
			5	SS	51												
240.8			6	SS	44												
16.5	Shale BEDROCK fractured calcareous,with sound		7	RC	100%		240										
235.5	limestone bands, grey		8	BXL	100%												R.Q.D.=100%
21.8	END OF BOREHOLE																

+³, x⁵: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6

W P 59-75-07 LOCATION Co-ords 15, 952, 016 N.; 1, 217, 372 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGER, BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 23, 1979 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES		20	40	60	80	100		
254.4	GROUND SURFACE												
0.0	FILL - sand and gravel compact, brown		1	SS	27								
249.4			2	SS	50/5								
5.0	GLACIAL TILL; heteroge- neous mixture of sand, silt, gravel, some clay v. dense, grey		3	SS	50/5								
			4	SS	50/5								
240.9	limestone boulders		5	RC	-								
13.5	Shale BEDROCK, calcareous w. limestone bands, grey, sound		6	RC	-								
236.1			7	BXL	98%								
18.3	END OF BOREHOLE												

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

DATE W.L.
May 23 NIL
Sept.
10 249.4

R.Q.D.=100%

15,55,25,5
40,35,20,5

Bentonite
Seal



RECORD OF BOREHOLE No 7

W P 59-75-07 LOCATION Co-ords 15, 952, 163 N.; 1, 217, 405 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGER/ERING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 17, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH										WATER CONTENT (%)
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										
274.0	GROUND SURFACE																	
0.0	FILL - mixture of sand, gravel, clayey silt, limestone fragments v. loose to compact brown		1	SS	5	DRY	270											
			2	SS	2													
			3	SS	14													
			4	SS	20													
			5	SS	12													
			6	SS	22													
256.5			7	SS	22				260									
17.5	Clayey SILT, some sand v. stiff, grey		8	SS	15													
252.0			9	SS	50/6"				250									
22.0	GLACIAL TILL: heterogeneous mixture of sand, silt, gravel, some clay																	
241.7	boulders																	
32.3	END OF BOREHOLE Refusal probably on bedrock																	

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 8

W P 59-75-07 LOCATION Co-ords 15, 952, 049 N.; 1, 217, 442 E. ORIGINATED BY N. McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 17, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
273.7	GROUND SURFACE													
0.0	FILL - mixture of sand, gravel, clayey silt, v. loose to compact, brown		1	SS	4									
			2	SS	4									
			3	SS	22									
			4	SS	9									
			5	SS	13									
256.7		wet	6	SS	9									
17.0	Clayey Silt, some gravel, stiff, grey-brown		7	SS	12									
251.7			8	SS	15									
22.0	GLACIAL TILL: heterogeneous mixture of sand, silt, gravel, some clay v. dense, cemented, grey boulders		9	SS	50/ 5"									
			10	SS	51									
240.6														
33.1	END OF BOREHOLE Refusal probably on bedrock													

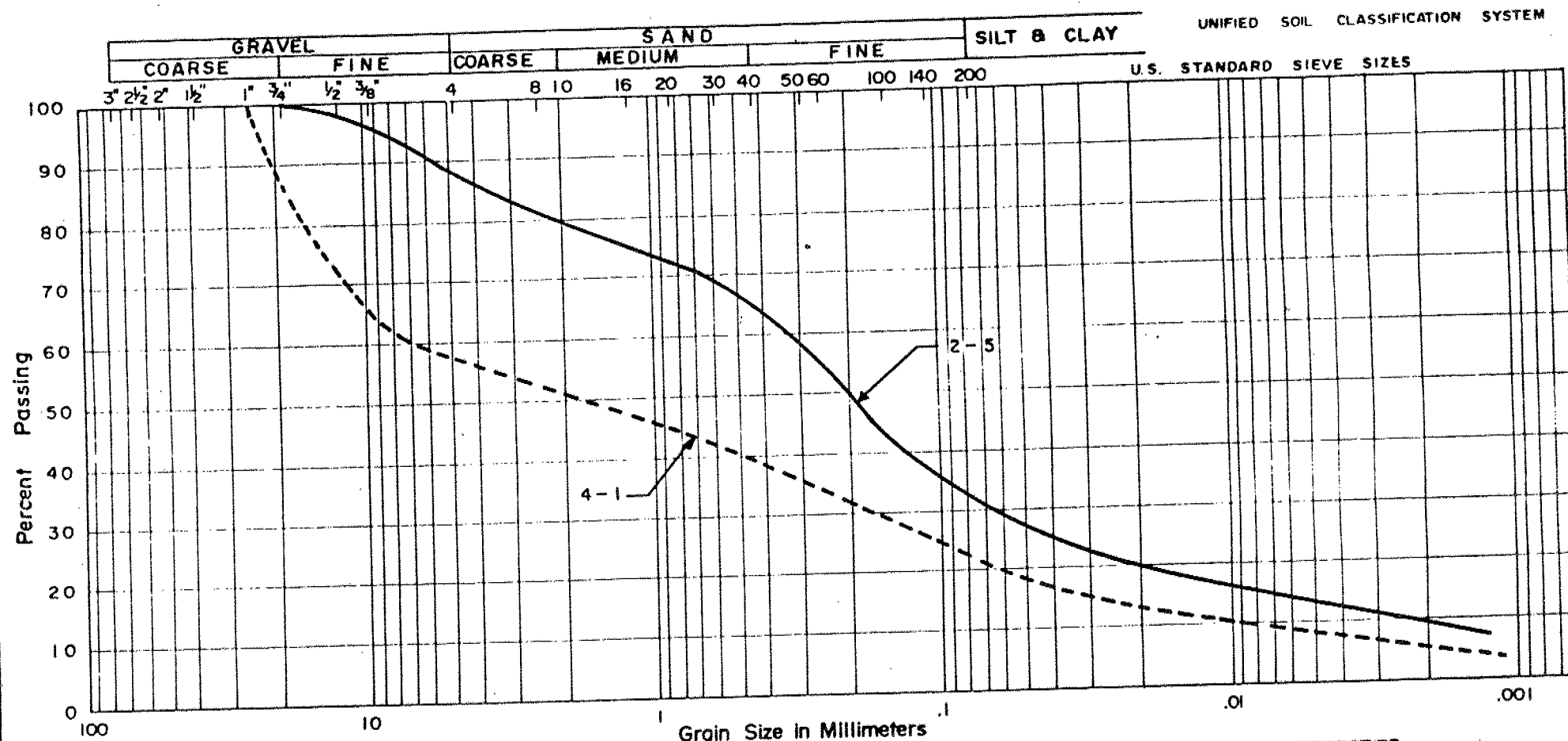
+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION

OUR REFERENCE № 79-5-6



PROJECT: LIBERTY BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE №: 2 4
 SAMPLE №: 5 1
 DEPTH: 13.0 3.5
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SILTY SAND
 with gravel, tr. clay.

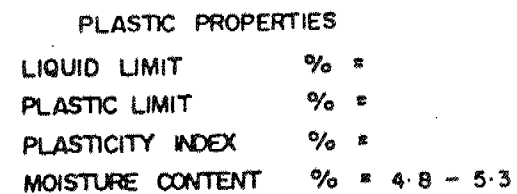
PLASTIC PROPERTIES

LIQUID LIMIT	% =
PLASTIC LIMIT	% =
PLASTICITY INDEX	% =
MOISTURE CONTENT	% = 5.4 - 5.5

ENCLOSURE № 9

30

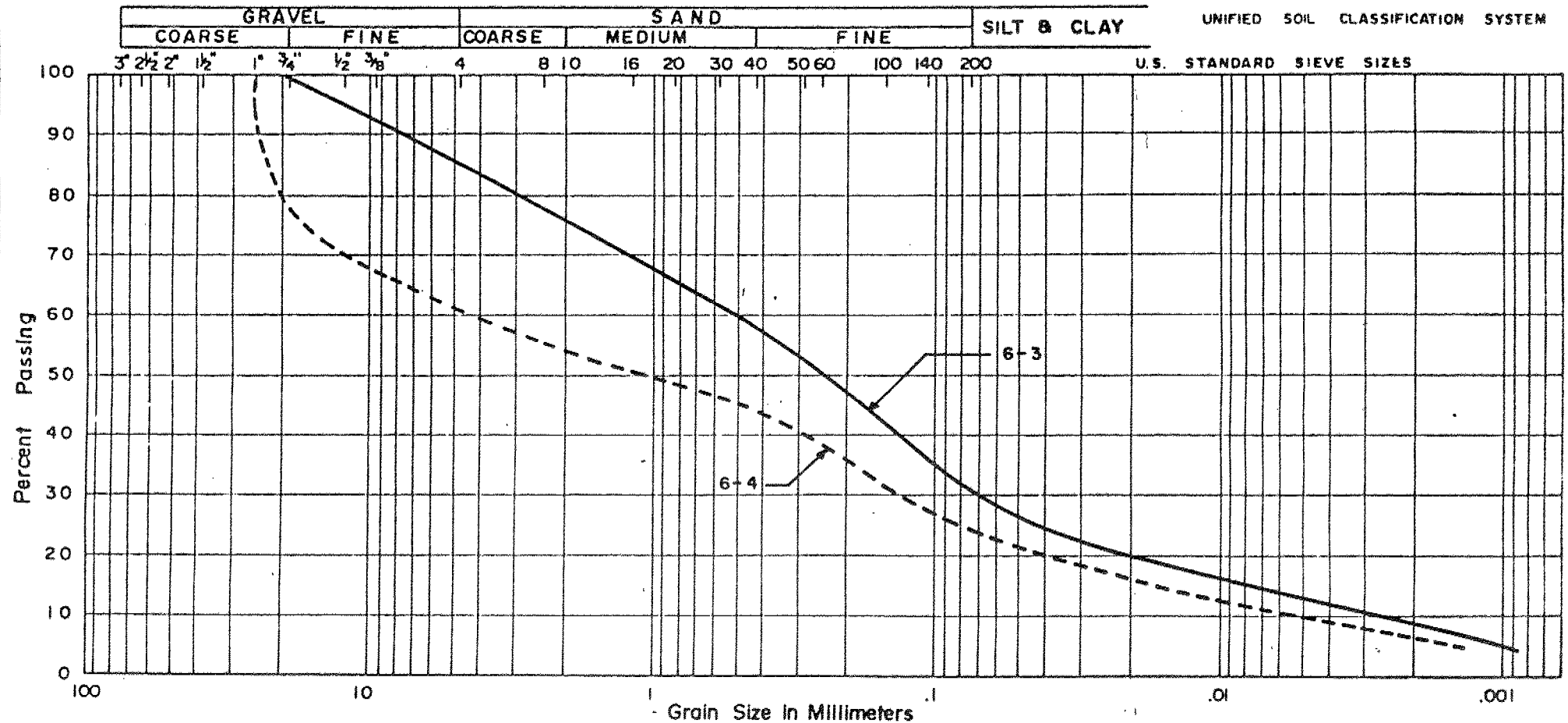
OUR REFERENCE N^o 79-5-6



DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO. 79-5-6.



PROJECT: LIBERTY BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE NO: 6 6
 SAMPLE NO: 3 4
 DEPTH: 4' 10'
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:
SILTY SAND TILL
 with some gravel.

PLASTIC PROPERTIES

LIQUID LIMIT	% =
PLASTIC LIMIT	% =
PLASTICITY INDEX	% =
MOISTURE CONTENT	% = 5.1 - 4.5

ENCLOSURE NO. 11

FOUNDATION INVESTIGATION REPORT

For

Proposed Widening
Soper Creek - Bowmanville
W.P. 59-75-08

INTRODUCTION

This report describes the results of a geotechnical investigation carried out at the site of the proposed widening of the existing crossing at Soper Creek and Highway 401 in the Town of Newcastle. The services of Dominion Soil Investigation Inc., consulting geotechnical engineers, were retained by the Ministry to carry out the field investigation and prepare the Foundation Investigation and Design Report. The purpose of the investigation was to determine the subsoil and groundwater conditions at the site; to establish the engineering properties of the substrata; and to make recommendations for the foundation design and construction of the proposed bridge structure.

The investigation in the field was completed in May 1978, and consisted of the drilling of six boreholes and the excavation of two test pits. The locations of the boreholes and the test pits are shown on Drawing 2, and the subsurface conditions found in the boreholes and the test pits are presented on the Record of the Boreholes and in the Appendix.

DESCRIPTION OF THE SITE

The site is located in the Town of Newcastle at the crossing of Highway 401 and the Soper Creek. The terrain in this area is generally flat and the embankment carrying Highway 401 rises 12 to 18 ft. above the surrounding area. Drainage to the area is provided by the Bowmanville and Soper Creeks.

REGIONAL GEOLOGY

Geologically, the site is situated in the Lake Iroquois Plain, which is an area of low relief inundated during the Pleistocene by the waters of Lake Iroquois. The old abandoned shoreline of Lake Iroquois lies approximately 4 miles to the north.

The bedrock underlying the basin is of Ordovician age and consists of the Whitby formation which is a black calcareous shale unit with interbedded

limestone bands. The bedrock surface is irregular and regional studies suggest that there are strong similarities between the existing surface topography and that of the bedrock surface.

The surficial deposits consist of sediments of Pleistocene and recent age. Glacio-lacustrine deposits south of the abandoned Lake Iroquois shoreline range from sand and gravel of a near shore and deltaic nature to off-shore sediments such as varved silt and clay. These were deposited on top of a ground moraine of generally coarse sandy texture.

The surface of the till is irregular and drumlinized and the surface of the drumlins are exposed in many places in this area. More recent deposits consisting of organic and alluvial soils are found in the valleys of the creeks.

SUBSOIL CONDITIONS

The six exploratory boreholes and two test pits indicate reasonably uniform subsurface conditions. The stratigraphic sequence, as inferred from the borehole and the test pit logs, is as follows:

- 1) Loose to compact mixed fill;
- 2) Loose silty fine sand;
- 3) Compact to dense glacial till;
- 4) Sound shale bedrock.

Details of the subsurface conditions are shown on the Record of Boreholes and also on the inferred soil profile and sections shown on Drawing No. 2. The relevant index and engineering properties of the principal soil strata are described briefly below.

Fill

Fill was encountered in boreholes 1, 5 and 6 ranging in thickness between 6.5 and 17.5 ft. The composition of the fill varies, but generally sand and silt particles predominate. The penetration indices or 'N'-values range from 1 to 27 blows per foot, with an average value of about 7 blows

per foot. Based on this, the relative density of the fill is inferred to be loose to compact and generally in the loose range. The permeability of the fill is expected to be variable and to depend on the composition of the fill, but on the average it is estimated to be medium.

Silty Fine Sand

A silty fine sand stratum was encountered in all Boreholes except Borehole 1. It is believed to be of recent alluvial origin laid down possibly by the creek. The thickness of the stratum ranges from 5.5 ft. to 8.2 ft. The grain size distribution of the deposit is shown on Enclosure 7, indicating 48 to 55% fine sand, 31 to 43% silt; and 6 to 10% clay. The clay size particles impart some plasticity to the soil and an Atterberg test performed on a sample of a more clayey zone indicated a liquid limit of 28% and a plasticity index of 8.0. The deposit also contains some organic matter. The penetration indices range between 2 and 15 blows per foot, with an average value of 8, indicating a generally loose to very loose relative density. The permeability of this stratum is estimated to be medium to low, generally less than 10^{-5} cm/sec.

Glacial Till

In Boreholes 3 and 5 an approximately 3.5 ft. thick layer of basal till was encountered below the alluvium. The till has a fine to coarse texture and is a well graded mixture of gravel, sand, silt and clay size particles. Grading curves of representative samples of the till are shown on Enclosure 8. Reference to these indicates that the till consists of 9 to 25% gravel, 33 to 54% sand, 27% silt and 10 to 15% clay size particles. The till exhibits some cementation. The Standard Penetration resistances range between 13 and 33 blows per foot, indicating a compact to dense relative density. Due to the well graded nature of the till and the light cementation between the particles, the permeability of the till is estimated to be moderate to generally low in spite of the relatively high sand content. The coefficient of permeability is estimated to be generally less than 10^{-5} cm/sec.

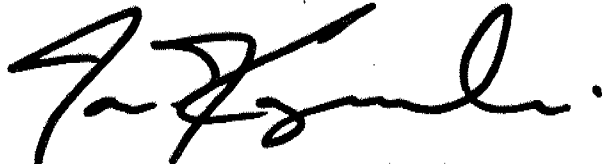
Bedrock

The surface of the bedrock was encountered or inferred from refusal in the boreholes between Elevation 241.6 and 243.4 ft. The rock was cored

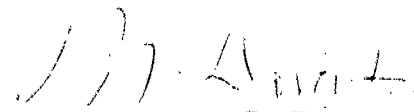
at four locations and the recovered cores indicate that the rock is a dark grey coloured, highly calcareous shale with many limestone bands. The high percentage of core recovery and the relatively high R.Q.D.-values (70 to 84%) indicate a sound rock with good qualities. The rock is intact, showing signs of only some weathering in the upper few inches of the rock. As the rock is relatively free of fractures, the mass permeability of the rock is estimated to be low.

Groundwater Conditions

The groundwater conditions in the boreholes were observed during drilling and the position of the water level was measured and recorded after the borehole was completed but before the rock was cored. Standpipes were installed in Boreholes 2 and 3 and were protected from the influence of surface water by a bentonite clay seal. Observations carried out in these standpipes in September 1979 indicated water levels at about Elevation 245.5 ft. corresponding to the water level in the creek. From these results and the visual and tactile examination of the soil samples, it is inferred that the groundwater table will generally correspond to the water level in the creek, which at the time of the investigation was at El.245.5 ft.



T. J. Kazmierowski, P. Eng.
Foundations Engineer



M. Devata, P. Eng.
Senior Foundations Engineer

APPENDIX



RECORD OF BOREHOLE No 1

W P 59-75-08 LOCATION Co-ords. 15, 952, 265 N.; 1, 217, 730 E. ORIGINATED BY N. McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 14, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
249.1	GROUND SURFACE																
0.0	5" Topsoil		1	SS	4												
	FILL - mixture of		2	SS	4												
242.6	clayey silt, gravel,		3	RC	100%												
	topsoil, loose																
6.5	Shale BEDROCK, calcareous			BXL													
	w. limestone bands, sound		4	RC	98%												
238.0	dark grey			BXL													
11.1	END OF BOREHOLE																

+³, x⁵: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No. 2

W P 59-75-08 LOCATION Co-ords. 15, 952, 300 N.; 1, 217, 900 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING; BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 14, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
251.6	GROUND SURFACE												
0.0	4" Topsoil		1	SS	10		250						0.48, 43.9
	Silty Fine SAND, some		2	SS	8								11, 49, 31, 9
	gravel, loose, dark		3	SS	50/2								
243.4	grey wet												
8.2	Shale BEDROCK,		4	RC	100%		240						R.Q.D. = 73%
	calcareous, limestone			BXL									
237.9	bands, sound, grey												
13.7	END OF BOREHOLE												DATE W.L. May 14 244.1 Sept. 10 245.6

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No. 3

W P 59-75-08 LOCATION Co-ords, 15, 952, 105 N.; 1, 217, 745 E. ORIGINATED BY N.M.C.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING; BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 15, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100										SHEAR STRENGTH			WATER CONTENT (%)		
																		○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE			20 40 60		
252.8	GROUND SURFACE																						
0.0	Silty Fine SAND					STANDPIPE	250									0,51,39,10 25,33,27,15 9,54,27,10 R.Q.D.=70%							
	tr. of clay,		1	SS	9																		
	gravel,org.matter		2	SS	15																		
	loose to compact		3	SS	13																		
245.3	Brown Grey	4	SS	33																			
7.5	GLACIAL TILL, heteroge-						240																
241.7	neous mix of sand, silt,																						
	gravel, some clay, comp. to																						
11.1	Shale BEDROCK,																						
	calcareous, limestone																						
236.7	bands, sound, grey		5	RC	100%																		
				BXL																			
16.1	END OF BOREHOLE																						

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No. 4

W P 59-75-08 LOCATION Co-ords, 15, 952, 129 N.; 1, 217, 835 E. ORIGINATED BY N.M.C.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING; BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 16, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE		WATER CONTENT (%) 20 40 60					
247.1	GROUND SURFACE														
0.0	18" Topsoil, Silty fine						240							0,55,39,6	
241.6	SAND, tr. of gravel, org. matter, v. loose, wood		1	SS	2										
			2	SS	2/4										
5.5	Shale BEDROCK, calcareous, sound, grey		3	RC BXL	100%									R.Q.D.=75%	
236.3															
10.8	END OF BOREHOLE													M.L.EI. 246.6 May 16, 1979	

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No. 5

W P 59-75-08 LOCATION Co-ords. 15, 952, 225 N.; 1, 217, 695 E. ORIGINATED BY N. McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING COMPILED BY I. P. L.
DATUM GEODETIC DATE MAY 17, 1979 CHECKED BY I. P. L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
269.2	GROUND SURFACE																
0.0	6" Asphalt																
266.2	FILL - sand and gravel		1	SS	13												
3.0	FILL - mixture of sand, silt, clay, v. loose to compact, brown		2	SS	11												
			3	SS	3												
			4	SS	27												
			5	SS	11												
252.7			6	SS	7												
16.5	Silty Fine SAND, some gravel, organics, occasional clayey zones		7	SS	7												
	loose, dark grey		8	SS	10												
245.7	GLACIAL FILL: heteroge- neous mixt. of sand, silt, gravel, some clay, compact		9	SS	30												
23.5			10	SS	24												
242.4																	
26.8	END OF BOREHOLE Refusal possibly on bedrock																W.L. E1. 247.2 May 17, 1979

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No. 6

W P 59-75-08 LOCATION Co-ords, 15, 952, 175 N.; 1, 217, 865 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 17, 1979 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT Wl	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					WATER CONTENT (%) 			
266.7	GROUND SURFACE															
264.9	FILL - sand & gravel		1	SS	7											
264.2	FILL - mixture of Silt, Clay, Sand, some gravel. V. loose to loose, brown to grey		2	SS	7											
264.2			3	SS	9											
264.2			4	SS	1											
264.2			5	SS	2											
264.2			6	SS	2											
249.2	Silty Fine SAND, trace of clay, loose, dark grey		7	SS	8											0.53, 40, 7
17.5			8	SS	5											
242.0																
24.7	END OF BOREHOLE Refusal possibly on bedrock															W.L.EI.248.7 May 17, 1979

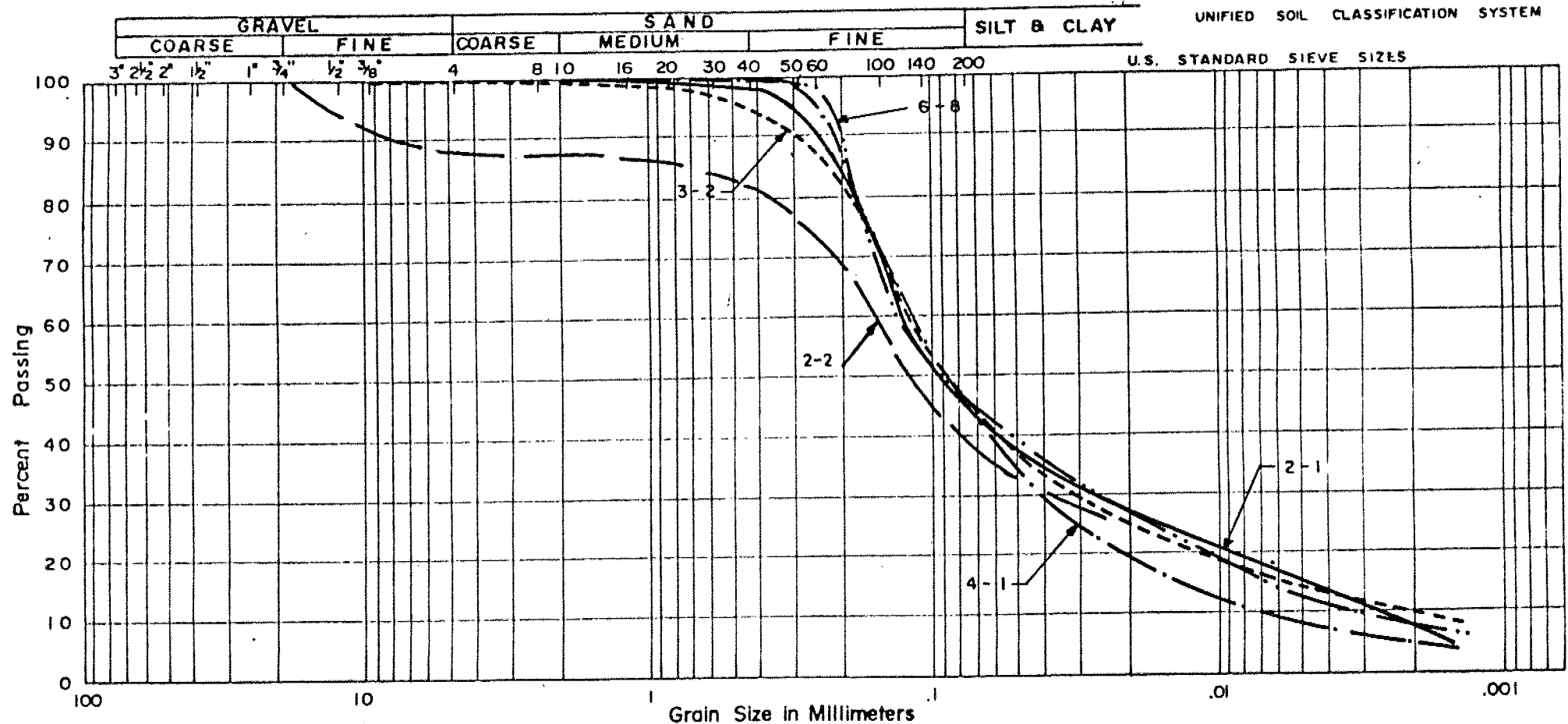
+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO 79-5-7



PROJECT: SOPER CREEK BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE NO: 2 3 4 6 2
 SAMPLE NO: 1 2 1 8 2
 DEPTH:
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SILTY FINE SAND

PLASTIC PROPERTIES

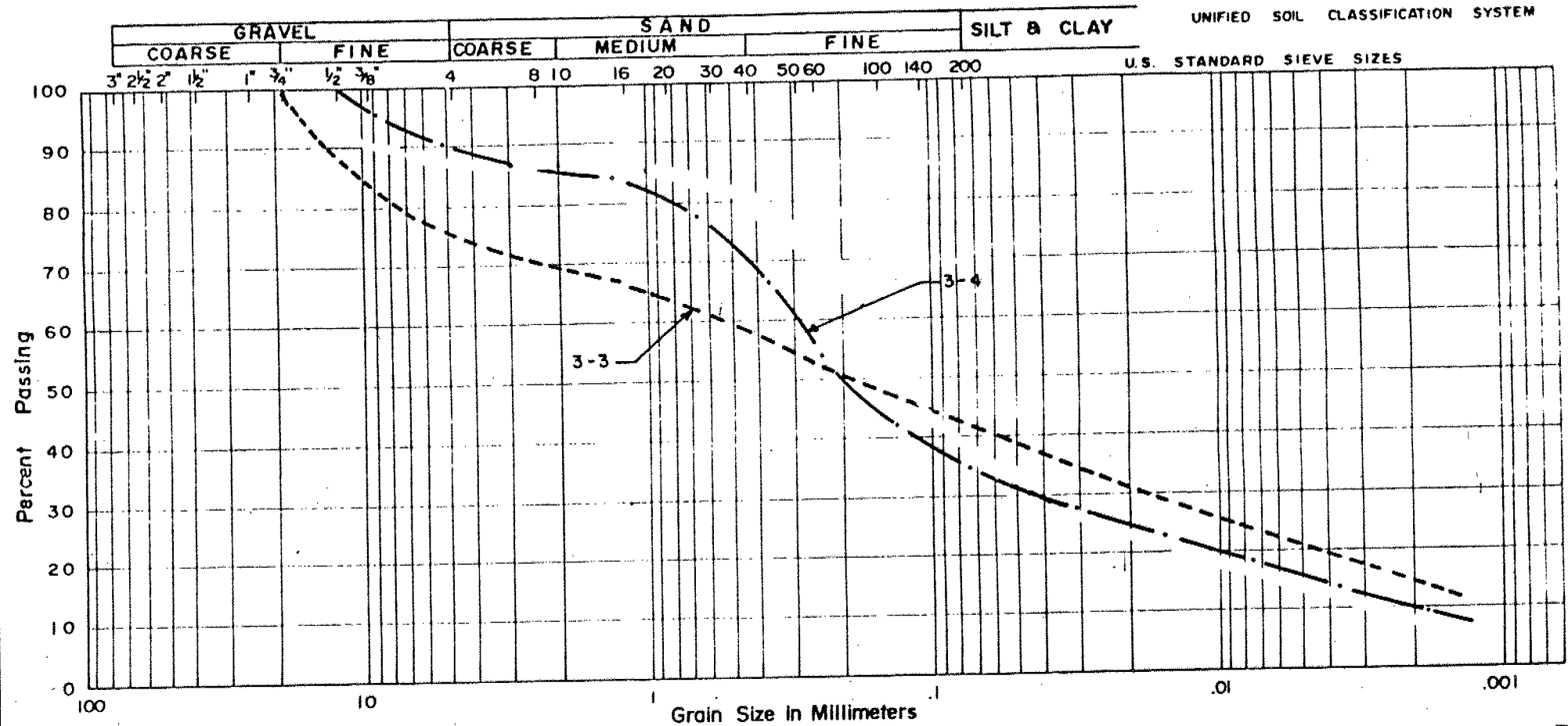
LIQUID LIMIT	% = 28.4
PLASTIC LIMIT	% = 20.4
PLASTICITY INDEX	% =
MOISTURE CONTENT	% = 17.6 - 56.6

ENCLOSURE NO 7

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO 79-5-7



PROJECT: SOPER CREEK BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE NO: 3 3
 SAMPLE NO: 3 4
 DEPTH:
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SILTY SAND TILL

PLASTIC PROPERTIES

LIQUID LIMIT	% =
PLASTIC LIMIT	% =
PLASTICITY INDEX	% =
MOISTURE CONTENT	% = 6.4 - 20.3

ENCLOSURE NO 8

FOUNDATION INVESTIGATION REPORT

For

Wilmot Creek Culvert Extension
W. P. 7-79-03, Site 21-173
Hwy. 35/115, District 7, Port Hope

INTRODUCTION

This report contains the results of a foundation investigation carried out at the above site. Four sampled boreholes, each accompanied by a dynamic cone penetration test were carried out on March 19 to March 22, 1968 using a skid mounted diamond drill for wash boring with NX casing. In addition two sampled borings were also carried out on September 13, 1979 using hollow stem augers to advance the borings. These boreholes were advanced to depths of 10 to 26 feet below ground surface and bedrock was proven by obtaining up to 5 feet of rock core in three of the sampled boreholes.

SITE DESCRIPTION AND GEOLOGY

The site is located at the present crossing of Hwy. 35/115 over Wilmot Creek, situated about 1.5 miles north of Hwy. 401; within the Town of Newcastle, Regional Municipality of Durham.

The site topography is hilly. Wilmot Creek has cut a channel some 60 to 80 feet wide and up to 10 feet deep below the average ground surface with near vertical banks. To the north-east of the creek the ground rises rapidly at slopes as steep as 1.5:1 to a generally rolling plane some 45 feet above creek level. To the southwest, the ground rises very gradually. Wilmot Creek itself flows southeasterly over a cobble and boulder bed with a depth of water varying from 2 to 24 inches.

The highway crosses the creek at a skew of about 106 degrees. The crossing is facilitated by an existing 38 foot x 20.5 foot concrete arch culvert, some 170 feet long. Associated with this structure are existing fill embankments in the order of

28 feet high which show no signs of instability. Immediately downstream of the Hwy. 35/115 crossing is an abandoned single lane, single span (38') steel beam structure with timber deck. The structure foundations are in good condition.

Physiographically the site is located in the Iroquois Plain. This region is characterized by a clay plain which has been smoothed by wave action. Bordering this plain is Lake Ontario to the south and the old shoreline of glacial Lake Iroquois to the north. The old shoreline is distinguished by cliffs bars and beaches with an undulating till plain above.

SUBSURFACE CONDITIONS

General

Uniform soil conditions prevail across the site, consisting of 12 to 18 feet of stiff to hard glacial till overlying limestone bedrock. In some areas fill material composed of clayey silt, sand and gravel with organics was found overlying the glacial till.

The boundaries between the various soil and rock types are shown on the attached Record of Borehole Sheets. The locations and elevations of the boreholes are shown on Drawing No. 2, together with two stratigraphical sections inferred from the boreholes.

Following is a brief description of the various soil and rock types encountered.

Fill Material (Clayey Silt, Sand and Gravel Trace of Organics)

On two borings put down northwest of the highway, fill material was encountered. This surficial stratum is composed of a mixture of brown clayey silt, sand and gravel with organic inclusions and was found to extend to a total depth of about 3 feet in these areas. Dynamic cone penetration tests indicate that the fill material is in a loose state of compaction.

Creek Bed Deposits (Cobbles and Boulders and Medium Sand, Trace Gravel)

These granular deposits were encountered in the two borings put down southeast of the highway and extends from the creek bed down to the glacial till. These recent alluvial deposits are composed of a zone, up to two feet thick, of cobbles, generally 3 to 5 inches in size, and boulders up to 2 feet in size. In the boring put down southwest of the creek, the creek bed deposit is some 4 feet thick, the lower 2 feet being composed of medium sand with a trace of gravel. Based on the nature of the augering operation, the creek bed deposits are inferred to be in a compact state of relative density.

Glacial Till

This is the predominate deposit across the site extending from the parent ground surface some 12 to 18 feet down to the limestone bedrock. The texture of material clearly shows the deposit to be of glacial origin, being composed of a heterogeneous mixture of clayey silt, sand and gravel with plasticity generally decreasing with depth. In one borehole, B.H.#5, occasional cobbles up to 6 inches in size were encountered within this deposit below elevation 264.0. The upper 2 to 8 foot zone of this cohesive glacial deposit is in a reworked state and contains occasional sand and gravel seams up to 6 inches thick.

The results of grain size distribution testing on representative samples from this deposit are shown in envelope form on Figure 1 in the Appendix of this report. The results of Atterberg Limit tests are plotted on the Plasticity Chart, Figure 2. These results are summarized below.

		<u>Range</u>	<u>Average</u>
Natural Moisture Content	w%	8 - 15	9
Liquid Limit	w _p %	9 - 15	12
Plastic Limit	w _L %	12 - 32	20
Plasticity Index	I _p %	6 - 16	8

Based on the Atterberg Limit testing, the glacial matrix can be described as an inorganic clay of low plasticity.

Standard Penetration Testing carried out within this deposit gave 'N' values ranging from 4 to 31 blows per foot in the upper reworked zone

and from 56 to over 100 blows per foot in the lower zone. The consistency as inferred from this data is stiff in the upper zone and hard in the lower portion.

Limestone Bedrock

Bedrock was proven in three of the borings by obtaining up to 5 feet of AXT or BXL size rock core. Elsewhere the bedrock surface was taken to be at the point of refusal to augering. The bedrock surface was found to be at a depth of 14.5 to 18.5 feet below existing ground surface, corresponding to elevation 257 to 260. The bedrock may be described as limestone, fine to medium texture. The upper 2.5 feet of bedrock in Borehole #5 was found to be in a fractured or jointed condition, elsewhere the bedrock is sound.

Groundwater Conditions

Groundwater condition level observations were carried out during the course of the investigation by measuring in the boreholes. These observations are shown on the Record of Borehole Sheets as well as on Drawing No. 2. During the March, 1968 investigation, the water level was found to be 1.5 to 4.0 feet below ground surface which corresponds to elevation 274 to 277. At this time, the creek water level was measured to be at elevation 273.0 (March, 1968). These observations indicates a steep hydraulic gradient towards the creek. In the recent investigation, the creek water level was found to be at elevation 272.6 (September, 1979).



T. J. Kazmierowski, P. Eng.
Foundations Engineer



M. Devata, P. Eng.
Senior Foundations Engineer

APPENDIX



RECORD OF BOREHOLE No 1

W P 7-79-03 LOCATION Co-ords. N 15,958,321; E 1,234,014 ORIGINATED BY RR
DIST 7 HWY 35/115 BOREHOLE TYPE Hollow Stem Augers COMPILED BY RR
DATUM Geodetic DATE September 13, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
272.6	Water Level																
0.5	Cobbles some boulders compact						270										
2.5	Medium sand, trace gravel, compact		1	SS	29												
4.5	Heterogeneous mixture. Clayey silt - Stiff		2	SS	10												
	Sand, trace of gravel - Hard		3	SS	31												
			4	SS	102												
			5	SS	100 1/4"		260										
			6	SS	100 1/2"												
257.4	Glacial Till																
15.2	Refusal to augering. Probable bedrock																
	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20'
15' 5' (%) STRAIN AT FAILURE
10'



RECORD OF BOREHOLE No 2

W P 7-79-03 LOCATION Co-ords. N 15,958,335; E 1,234,040 ORIGINATED BY RR
DIST 7 HWY 35/115 BOREHOLE TYPE Hollow Stem Augers and BXL Rock Core COMPILED BY RR
DATUM Geodetic DATE September 13, 1979 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
272.6	Water Level																
0.5	Cobbles & Boulders						270										20 38 31 11
2.0	Heterogeneous mixture Clayey silt, Stiff sand Trace of gravel Glacial Till		1	SS	25												
			2	SS	8												
			3	SS	17												
			4	SS	80												
258.1	Limestone bedrock		5	SS	100		260										15 29 32 24
14.5	Sound		6	SS	100												
255.6			7	SS	100												
17.0	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

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



RECORD OF BOREHOLE No 3 (Formerly B.H.#3 - W.P.301-66-0)

W P 7-79-03 LOCATION Co-ords. N 15,958,469, E 1,233,889 ORIGINATED BY VK
DIST 7 HWY 35/115 BOREHOLE TYPE Diamond Drill-NX Casing and Cone Test COMPILED BY WH
DATUM Geodetic DATE March 21, 1968 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
281.0	Ground Level												
0.0	Fill mat'l. clayey silt												
278.0	sand & gr. with some org		1	SS	20								
3.0	Heterogeneous mixture of clayey silt, sand and gravel		2	SS	59								
	Stiff Hard		3	SS	144								
	Glacial Till		4	SS	100	5"							
260.0			5	SS	155								
21.0	(Sound)		6	AXT	100%								
255.0	Limestone Bedrock			RC	REC								
26.0	End of Borehole												

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 4

(Formerly B.H.#4 - W.P.301-66-0)

W P 7-79-03 LOCATION Co-ords. 15,958,518; E 1,233,837 ORIGINATED BY VK
DIST 7 HWY 35/115 BOREHOLE TYPE Diamond Drill - NX Casing and Cone Test COMPILED BY WH
DATUM Geodetic DATE March 22, 1968 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
279.3	Ground Level															
0.0	Fill mat'l. (Clayey silt sand & gr. with organics)															
276.3																
3.0	Heterogeneous mixture of clayey silt, Stiff Hard		1	SS	4											6 25 39 30
			2	SS	50											
268.8	sa. & gr. Glacial Till		3	SS	95		270									
10.5	End of Borehole															

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 5 (Formerly B.H.#1 - W.P.301-66-0)

W P 7-79-03 LOCATION Co-ords. N 15,958,556; E 1,233,900 ORIGINATED BY VK
DIST 7 HWY 35/115 BOREHOLE TYPE Diamond Drill - NX Casing and Cone Test COMPILED BY WH
DATUM Geodetic DATE March 19-20, 1968 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
276.5	Ground Level											
0.0	Heterogeneous mixture of clayey silt, sand and gravel.		1	SS	56							5 32 42 21
			2	SS	100	2"						14 30 38 18
	Hard. Glacial Till (with boulders up to 6" diameter - below elevation 264).		3	SS	100	6"						
			4	SS	138							
			5	BXL RC	14%							
258.0				SS	100	6"						
18.5	(Fractured & Weathered)		7	SS	100	1"						
255.5			8	BXL RC								
21.0	(Sound)		9	AXT	100							
251.5	Limestone Bedrock			RC	REC							
25.0	End of Borehole											

+3, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 6

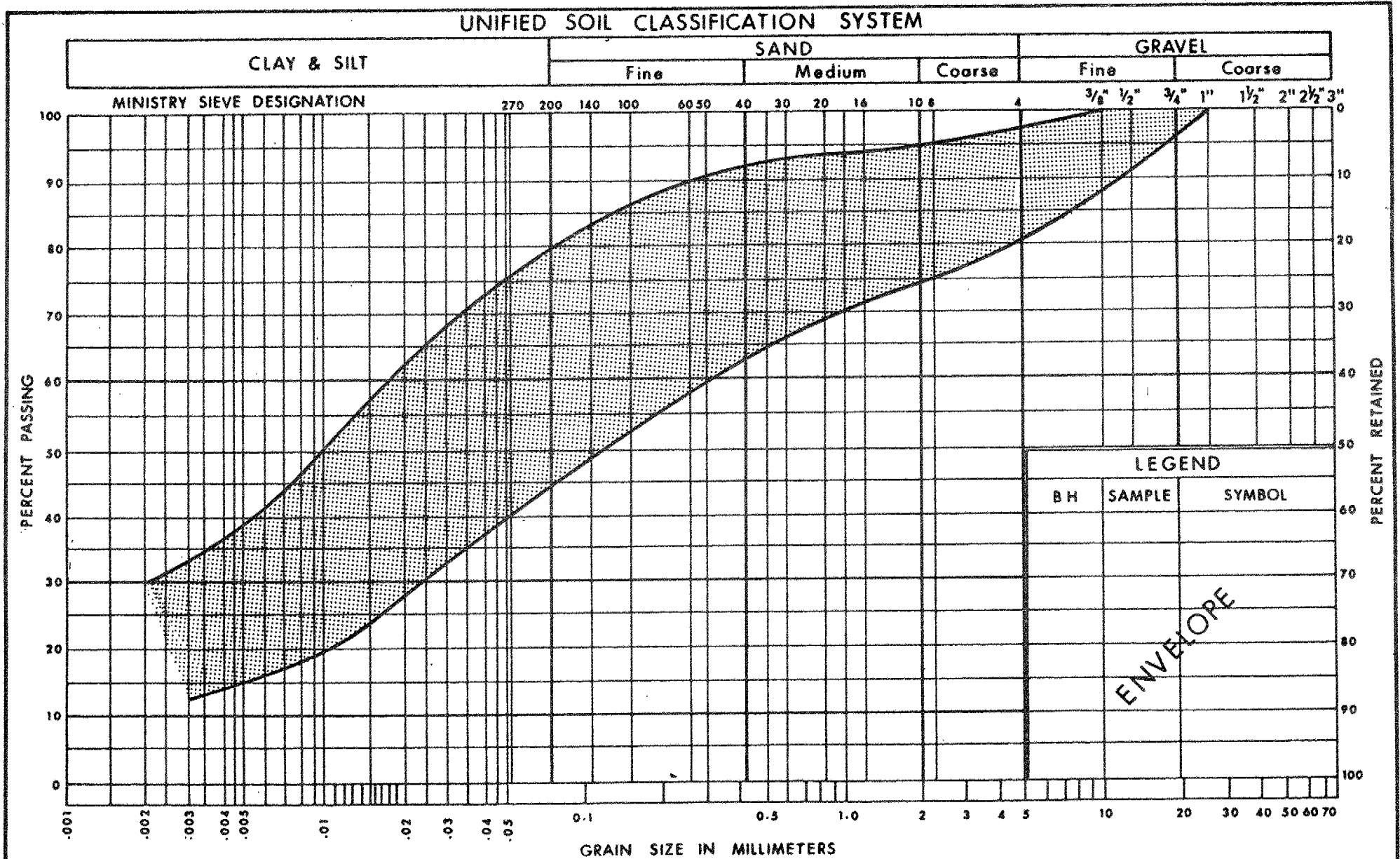
(Formerly B.H.#2 - W.P.301-66-0)

W P 7-79-03 LOCATION Co-ords. N 15,958,517; E 1,233,919 ORIGINATED BY VK
DIST 7 HWY 35/115 BOREHOLE TYPE Diamond Drill - NX Casing and Cone Test COMPILED BY WH
DATUM Geodetic DATE March 20, 1968 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES					
275.0	Ground Level											
0.0	Heterogeneous mixture of clayey silt, sand and gravel. Hard.		1	SS	179							0 1 55 44
264.5	Glacial Till		2	SS	100/4"							
			3	SS	100/6"							
10.5	End of Borehole											

+3, x5: Numbers refer to
Sensitivity

20
15 ± 5 (%) STRAIN AT FAILURE
10

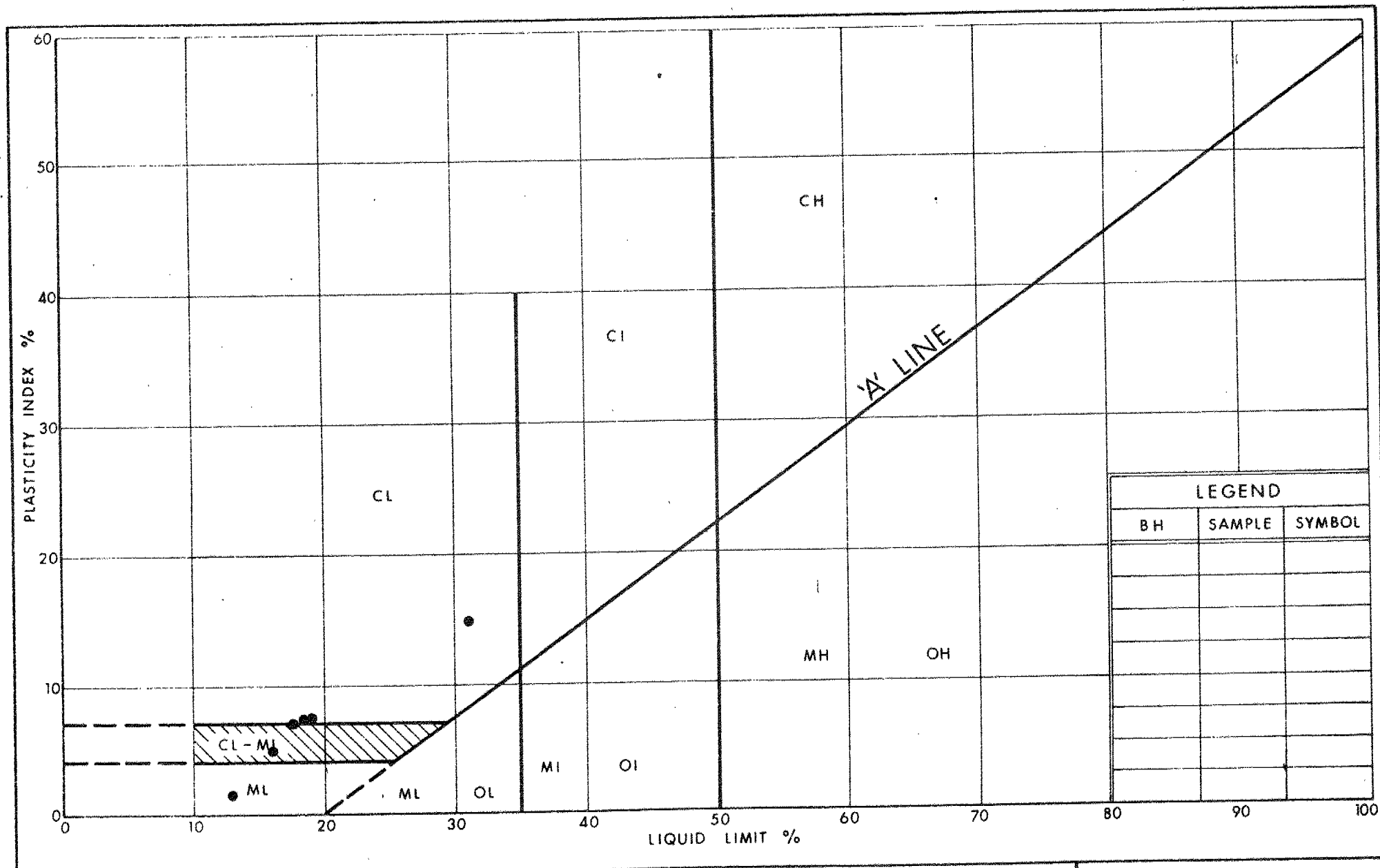


**Ministry of
Transportation and
Communications**

GRAIN SIZE DISTRIBUTION
GLACIAL TILL
HET MIX OF CLAYEY SILT, SAND & GRAVEL

FIG No 1

WP 7 - 79 - 03



Ministry of
Transportation and
Communications

PLASTICITY CHART

GLACIAL TOLL

HET MIX OF CLAYEY SILT, SAND & GRAVEL

FIG No 2

W P 7-79-03

30MI5-49

GEOCRES No.

DOMINION SOIL INVESTIGATION INC.

CONSULTING ENGINEERS

TORONTO KITCHENER LONDON WINDSOR THUNDER BAY SARNIA



DOMINION SOIL INVESTIGATION INC.

CONSULTING SOIL & FOUNDATION ENGINEERS

104 CROCKFORD BLVD., SCARBOROUGH, ONTARIO, CANADA, M1R 3C6

(416) 751-6565

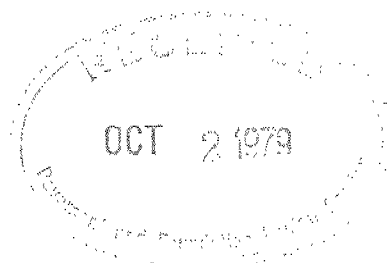
30M15-49

GEOCRES No.

FOUNDATION INVESTIGATION
PROPOSED WIDENING OF BOWMANVILLE CREEK BRIDGE
KING'S HIGHWAY 401 - TOWN OF NEWCASTLE
W.P. 59-75-06; SITE NO. 21-161
DISTRICT NO. 7; PORT HOPE, ONTARIO

Ref. No. 79-5-5
September 1979

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



DISTRIBUTION:

15 copies - Ministry of Transportation and Communications
2 copies - Dominion Soil Investigation Inc.

C O N T E N T S

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2.0 DESCRIPTION OF THE SITE	2
3.0 REGIONAL GEOLOGY	3
4.0 SUBSOIL CONDITIONS	4
4.1 Fill	4
4.2 Sandy Silt	5
4.3 Silty Sand	5
4.4 Sand and Gravel	5
4.5 Glacial Till	6
4.6 Bedrock	6
5.0 GROUNDWATER CONDITIONS	8
6.0 DISCUSSION OF THE RESULTS	9
6.1 Foundation Design	9
6.2 Horizontal Earth Pressures	10
6.3 Approach Fill	11
6.4 Construction	12
7.0 STATEMENT OF LIMITATION	12

A P P E N D I C E S

APPENDIX 'A', RECORD OF TEST PITS 1 & 2.....
APPENDIX 'B', FIELD WORK & LABORATORY TESTING
APPENDIX 'C', ABBREVIATIONS & SYMBOLS USED IN THIS REPORT
APPENDIX 'D', STATEMENT OF LIMITATION

E N C L O S U R E S

PLAN, PROFILE CENTRE LINE HIGHWAY 401, SECTIONS A-A and B-B	Drawing 1
BOREHOLE LOGS	Enclosures 1 - 4 inclusive
GRAIN SIZE DISTRIBUTION CURVES	Enclosures 5 - 8 inclusive

Ref. No. 79-5-5
W.P. 59-75-06

- 1 -

Si

1.0 INTRODUCTION

This report describes the results of a geotechnical investigation carried out at the site of the proposed widening of the existing crossing at Bowmanville Creek and Highway 401 in the Town of Newcastle. The investigation was requested by the Ministry of Transportation and Communications, and authorization to carry out the work was received from the Pavement and Foundation Design Section of the Ministry.

The purpose of the investigation was to determine the subsoil and groundwater conditions at the site; to establish the engineering properties of the substrata; and to make recommendations for the foundation design and construction of the proposed bridge structure.

The investigation in the field was completed in May 1978, and consisted of the drilling of four boreholes and the excavation of two test pits. The locations of the boreholes and test pits are shown on Drawing No. 597506-A and the subsurface conditions encountered are presented on the record of the boreholes and in the Appendix.

.../...



2.0 DESCRIPTION OF THE SITE

The site is located in the Town of Newcastle at the crossing of Highway 401 and the Bowmanville Creek. The terrain in this area is generally flat and the embankment carrying Highway 401 rises 12 to 18 ft. above the surrounding area. Drainage to the area is provided by the Bowmanville and Soper Creeks.

.../...

3.0 REGIONAL GEOLOGY

Geologically, the site is situated in the Lake Iroquois plain, which is an area of low relief inundated during the Pleistocene by the waters of Lake Iroquois. The old abandoned shoreline of Lake Iroquois lies approximately 4 miles to the north.

The bedrock underlying the basin is of Ordovician age and consists of the Whitby formation, which is a black calcareous shale unit with interbedded limestone layers. The bedrock surface is irregular and regional studies suggest that there are strong similarities between the existing surface topography and that of the bedrock surface.

The surficial deposits consist of sediments of Pleistocene and recent age. Glacio-lacustrine deposits south of the abandoned Lake Iroquois shoreline range from sand and gravel of a near shore and deltaic nature to off-shore sediments such as varved silt and clay. These were deposited on top of a ground moraine of generally coarse sandy texture.

The surface of the till is irregular and drumlinized and the surface of the drumlins are exposed in many places in this area. More recent deposits consisting of organic and alluvial soils are found in the valleys of the creeks.

.../...

4.0 SUBSOIL CONDITIONS

The four exploratory boreholes drilled at the site indicate in general fill and alluvium to depths ranging between 7.0 and 12.8 ft. below the ground surface, underlain by a basal till extending to the surface of the bedrock. The bedrock, which was encountered $16.0 \pm$ ft. below the ground surface, is a shaley limestone. The stratigraphic sequence, as inferred from the borehole logs, is as follows:

- 1.) Loose to compact fill (Boreholes 1 and 4).
- 2.) Sandy Silt (Boreholes 2 and 3)
- 3.) Loose to compact silty sand (except Borehole 1).
- 4.) Loose to dense sand and gravel (Boreholes 1 and 4).
- 5.) Compact to very dense glacial till.
- 6.) Shaley limestone bedrock.

Details of the subsurface conditions are shown on the Record of Boreholes (Enclosures 1 to 4 inclusive) and also on the inferred soil profile and sections shown on Drawing No. 597506-A. The relevant index and engineering properties of the principal soil strata are described briefly below.

4.1 Fill

Boreholes 1 and 4 encountered fill to depths ranging between 5.0 and 7.5 ft. below the ground surface.

To a depth of 2.5 ft. below the ground surface in Borehole 4, the fill consists of sandy silt followed by sand and gravel with traces of silt to 5.0 ft. Borehole 1 encountered 9-inches of fine sand underlain by .../...

sand and gravel to 4.0 ft., which is in turn underlain by silty sand with some gravel and clay (i.e. till) to a depth of 7.5 ft. below the ground surface.

Based on penetration indices or 'N'-values of 6 to 23 blows per foot, the fill is described as loose to compact.

4.2 Sandy Silt

A surficial layer of alluvial sandy silt was encountered at Boreholes 3 and 2 to depths ranging between 2.0 and 2.5 ft. below the ground surface respectively.

4.3 Silty Sand

Boreholes 2, 3 and 4 encountered alluvial silty sand to depths ranging between 7.0 and 7.5 ft. below the ground surface.

The thickness of the alluvium ranges between 2.0 and 5.5 ft. and contains various amounts of organic matter. The grain-size distribution of typical samples is shown on Enclosures 6 and 7, indicating 0-10% gravel, 68 to 87% sand (mostly fine), 13 to 32% silt and clay size particles. The 'N'-values range from 2 to 11 blows per foot, indicating very loose to compact relative density. The coefficient of permeability of the alluvium is estimated to range from 10^{-3} cm/sec. to 10^{-5} cm/sec.

4.4 Sand and Gravel

Boreholes 1 and 4 encountered sand and gravel and gravelly sand ranging in thickness from 2.0 ft. (Borehole 4) to 5.3 ft. (Borehole 1). The grain size distribution characteristics of this deposit are shown on Enclosure 8, indicating 27% gravel, 55% sand, and 18% silt and clay size particles.

.../...

The penetration indices range from 8 to 36 blows per foot, indicating loose to dense relative density.

4.5 Glacial Till

At depths ranging between 7.0 and 12.8 ft. below the ground surface, the boreholes encountered a basal till with a thickness ranging from 3.2 ft. in Borehole 1, to 7 to 9 ft. in the remaining boreholes.

The grain size distribution of typical samples shown on Enclosure 5 indicates 18 to 38% gravel, 35 to 49% sand, 21 to 31% silt, and 6 to 11% clay size particles. The till generally exhibits some cementation although layers or zones of little or no cementation were also noted. The penetration resistances within the basal till range from 26 to more than 100 blows per foot, indicating a compact to very dense relative density. Based on the gradation curves and from visual and tactile examination of the samples, the coefficient of permeability of the till is estimated to range between 10^{-4} and 10^{-5} cm/sec., depending on the degree of cementation and density.

4.6 Bedrock

The surface of the bedrock was encountered beneath the basal till at a depth of $16.0 \pm$ ft. below the ground surface (i.e. between Elevation 234.6 and 232.2 ft.).

In Borehole 1, from 16.0 to 18.8 ft. below the ground surface, that is from Elevation 234.5 to 231.7 ft., the rock was found to be of very .../...

poor quality with some sand seams. The recovery and the R.Q.D. values in this zone are 27%, and the visual examination of the core samples indicates a fractured rock.

Elsewhere, the recovered cores show that the rock formation underlying the site is a grey, shaley limestone. To a depth of 2 ft. below its surface in Borehole 2 (R.Q.D. value = 43%), and 6 to 12-inches in Boreholes 3 and 4, the rock is weathered. Below this zone, the rock is relatively intact with occasional highly weathered thin bands. The high percentage of core recovery (85 to 100%) and R.Q.D. values of 63 to 100%, indicate that the rock is of fair to excellent quality. No major fractures were encountered indicating that the mass permeability of the rock below the weathered zone would be low.

5.0 GROUNDWATER CONDITIONS

The groundwater conditions in the boreholes were observed during drilling; water levels were also measured before coring started and after the completion of the coring. A standpipe was installed in Borehole 2 and seepage of surface water was prevented by a bentonite seal about 3 ft. below the ground surface.

Observations made in the boreholes before coring the rock showed water levels ranging between 3.0 and 7.5 ft. below the ground surface. In Boreholes 2 and 3, a slight temporary artesian pressure of 1.0 to 1.5 ft. above the ground surface was noted in the casing after coring. The standpipe installed in Borehole 2, however, later showed a stabilized water level 2.5 ft. below the ground surface. These observations indicate that the average groundwater table at the time of the investigation was at Elevation 248 \pm ft.

6.0 DISCUSSION OF THE RESULTS

The existing bridge, which was built around 1950, is a single span rigid frame reinforced concrete structure. It has a clear span of about 60 ft., and the available design drawing (D.H.O. Dwg. No. D-3126-2, June 1950) shows that the existing foundation level is at about Elevation 236 ft.

It is proposed to widen this structure both to the north and south to provide an additional width of about 10 ft. on each side. The widened structure will be similar in design to the existing bridge.

To verify whether the existing structure was founded as shown on the design drawing, two test pits were dug near the north and south-east corners of the existing abutment approximately 10 to 15 ft. from the creek.

The conditions found in the test pits are described in Appendix 'A'. Due to the heavy flow of water, however, the sides of the test pits collapsed before the foundation depths could be reached.

6.1 Foundation Design

Drawing D-3126-2 shows the top of the footings of the existing bridge at Elevation 238.3 ft. The probable founding depth is, therefore, 236 \pm ft., but confirmation of this by means of a test pit has not been possible. The boreholes show that at this elevation the subsoil consists of dense to very dense till underlain by bedrock at elevations .../...

ranging between 234.6 and 232.2 ft. Borehole 1 showed a poor quality, fractured rock to about Elevation 231.7 ft., below which rock is sound. It can, therefore, be concluded that the existing structure is either founded on dense to very dense till or on bedrock if the foundations were extended several feet below the level shown on the design drawing.

The widened structure should be founded at the same level as the existing structure. The allowable bearing pressure on the dense to very dense till is 10 k.s.f. The maximum total settlement should be less than 0.6-inch. Should, however, the till be disturbed due to the excavation and groundwater flow, then greater settlements can be expected. It may, therefore, be more prudent to extend the footings to the surface of the bedrock provided that this does not result in the undermining of the existing footings.

For footings placed on top of the weathered rock at or below Elevation 234 ft. (Borehole 4), 233 ft. (Boreholes 1 and 2), and 232 ft. (Borehole 3), a safe bearing value of 16 k.s.f. can be used. This value can be increased to 40 k.s.f. if the footings are extended into the sound rock (i.e. 6 to 18-inches below these layers).

6.2 Horizontal Earth Pressures

The abutments and wing walls should be designed to resist the horizontal earth pressure exerted by the approach embankments behind them. The earth pressure on the abutments can be assumed to be distributed in accordance with the following formula:
.../...

$$p = K (\gamma \cdot d + q)$$

where p = unit horizontal earth pressure at depth
"d" (p.s.f.)

K = coefficient of horizontal earth pressure
= 0.40 for granular backfill

γ = unit weight of soil = 135 p.c.f.

d = distance from top of wall to point of
application of pressure (ft.)

q = unit surcharge load applied at ground
surface (p.s.f.)

The backfill behind the abutment should be well drained or else the water pressure behind the abutment should be included in the calculation of the horizontal forces acting on the abutment.

The coefficient of friction (μ) between the foundation and the smooth rock surface or the till can be taken to be 0.45. The design should incorporate a safety factor against horizontal sliding of not less than 1.75. Additional resistance could be obtained by keying in the footings into the rock. The passive resistance of the rock against the vertical face of the footing or key can be taken to be 10 k.s.f.

6.3 Approach Fill

There are no stability problems foreseen for the proposed widening of the approach fills. The approach embankment could be constructed in accordance with the current M.T.C. Specifications and Standards, using 2 horizontal in 1 vertical side slopes and keying the new fills into the existing fills.

.../...



6.4 Construction

High water levels recorded in the boreholes and visual observations made in the test pits indicate that problems due to the groundwater can be expected during the construction. It is believed that to provide support to the sides of the excavation and to prevent excessive water seepage, the use of tight interlocking sheet piling will be necessary. To enable to penetrate into the dense till, a heavy section will be necessary. It is also expected that where the base is on the fractured rock, the seepage through the bottom of the excavation could be heavy.

7.0 STATEMENT OF LIMITATION

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

DOMINION SOIL INVESTIGATION INC.

[Signature]
for Z.S. Ozden, P.Eng.



[Signature]
I.P. Lieszkowszky, P.Eng.
ZS/IPL:esp



A P P E N D I C E S

Prep. By F.L.

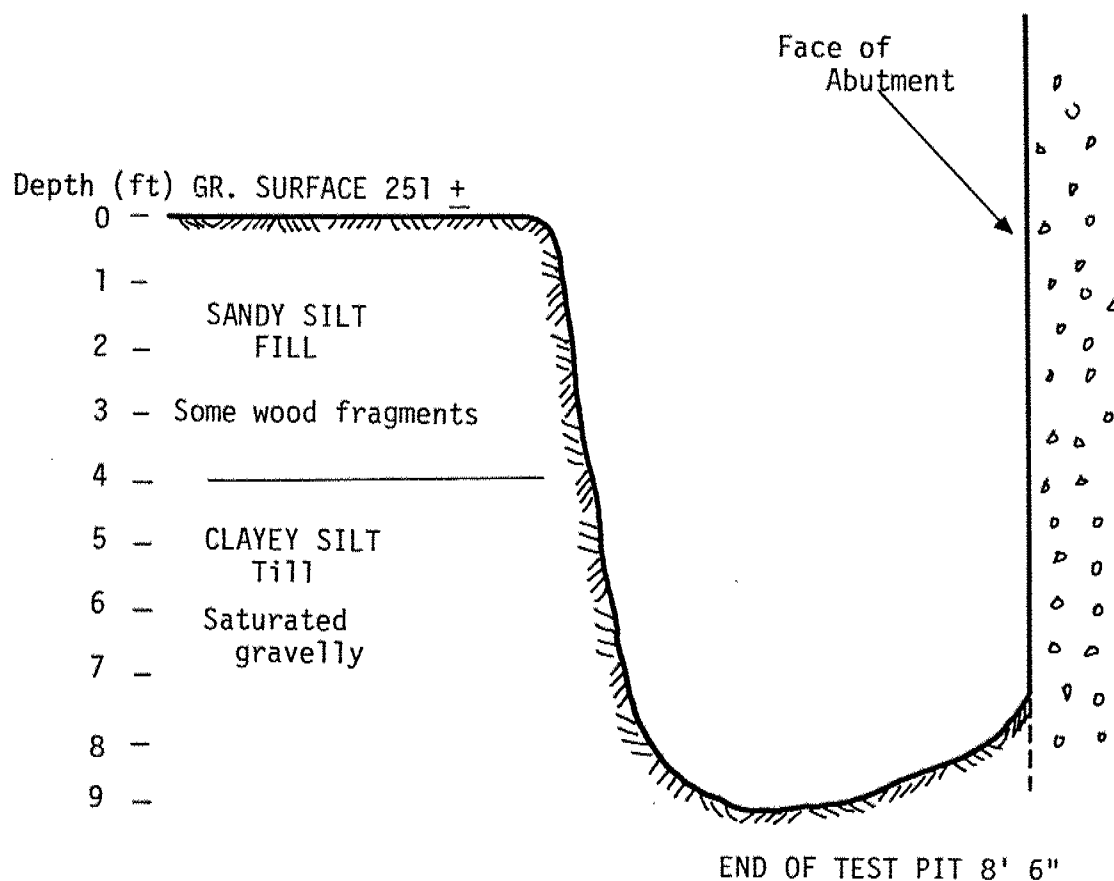
RECORD OF TEST PIT #1
(South-east corner)

W.P. 59-75-06

BOWMANVILLE CREEK CROSSING AND HWY 401

DISTRICT 7, NEWCASTLE

TEST PIT LOCATION: SOUTH CORNER OF EAST ABUTMENT

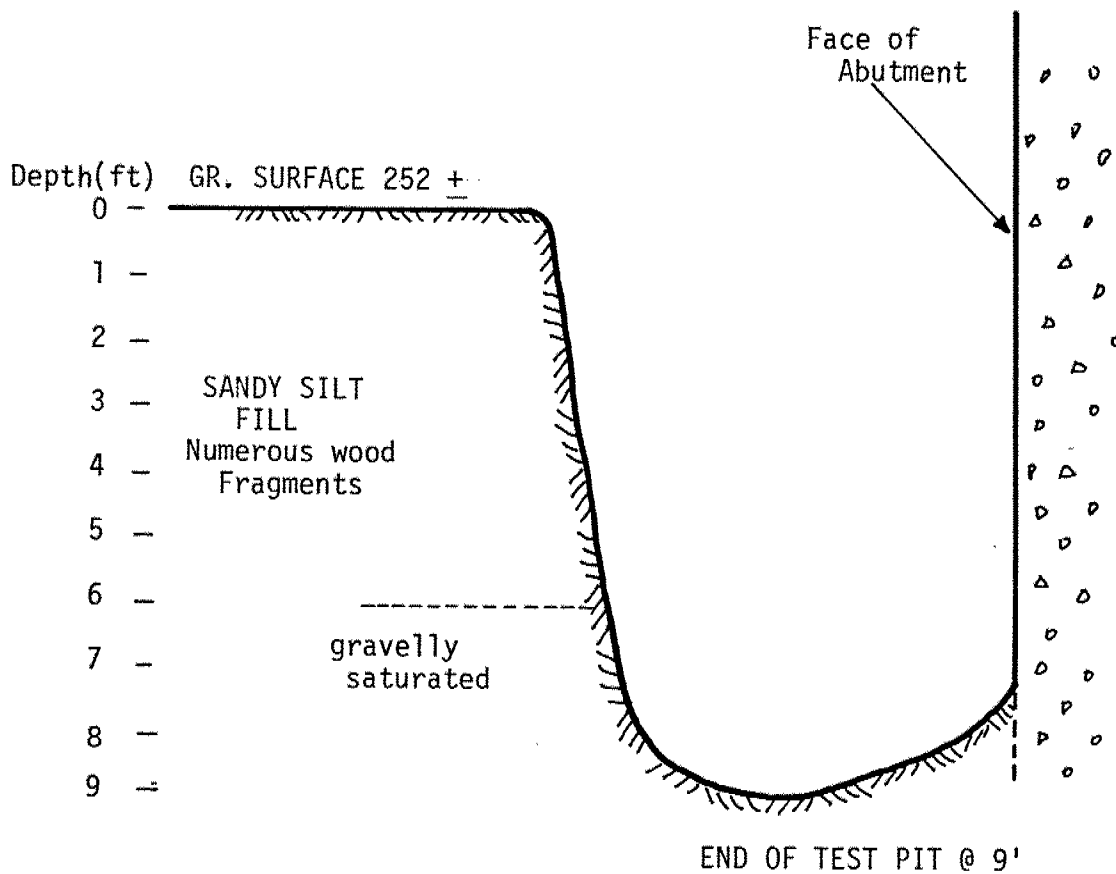


Note: Water coming in
very rapidly at 4 ft.

Prep. By F.L.

RECORD OF TEST PIT #2
(north-east corner)

W.P. 59-75-06
BOWMANVILLE CREEK CROSSING AND HWY 401
DISTRICT 7, NEWCASTLE
TEST PIT LOCATION: NORTH CORNER OF EAST ABUTMENT



Note: Water bubbling up from below at 4.5 ft.

APPENDIX 'B'

Field Work

The field work was carried out on May 10 and 11, 1979, and consisted of four boreholes to depths ranging between 20.7 and 25.7 ft. The locations of the boreholes are shown on Drawing No. 597506-A. The boreholes were drilled with a BOA-8M machine mounted on an all terrain vehicle.

The sampling of the overburden was carried out at 2.5 and 5 ft. intervals. Samples were taken by the Standard Penetration test method. This method, which consists of driving a 2-inch outside diameter split spoon sampler into the undisturbed ground with 350 ft./lb. energy, provides representative soil samples from any level below the ground surface. The number of blows required to advance the sampler into the undisturbed ground are recorded as the Standard Penetration resistance or 'N'-values from which the relative density of the soil can be inferred. The relationship between penetration resistance and relative density is given in Appendix 'C'. The results of the borings and penetration tests are shown on the Record of Boreholes, presented as Enclosures 1 to 4 inclusive.

The boreholes wer extended by augering to a depth where refusal was met and were further extended below this level by diamond drilling technique, using BXL size (2-3/8-inch diameter) coring equipment.

.../...

The field work was supervised by a soil technician who also determined the ground surface elevations at the borehole locations. The elevations of the boreholes were referred to geodetic datum, using as a benchmark the top of the pavement at centre line of the existing bridge on the south side. The elevation of this benchmark is shown as 269.15 ft. on Plan E-5456-1, dated April 1979.

Laboratory Testing

All soil samples were shipped in air-tight jars to the laboratory of Dominion Soil Investigation Inc. for examination and testing. Representative soil samples were selected for sieve and hydrometer analyses and the natural moisture content was also determined. The laboratory test results are presented on the Record of Boreholes, and the Grain Size Distribution Curves are plotted on Enclosures 5 to 8 inclusive.

APPENDIX 'C'

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION 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
CU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

Si

APPENDIX 'D'

STATEMENT OF LIMITATION

The conclusions and recommendations in this report are based on information determined at the borehole locations and on geological data of a general nature which may be available for the area investigated. Soil and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations and conditions may become apparent during construction which could not be detected or anticipated at the time of the soil investigation.

We recommend that we be retained to ensure that all necessary stripping, subgrade preparation and compaction requirements are met, and to confirm that the soil conditions do not deviate materially from those encountered in the boreholes. In cases where this recommendation is not followed, the company's responsibility is limited to interpreting accurately the information encountered at the boreholes.

This report is applicable only to the project described in the introduction, constructed substantially in accordance with details of alignment and elevations quoted in the text.

ENCLOSURES

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M 15-49

DIST. 7 REGION

W.P. No. 59-75-06

CONT. No. 82-03

W. O. No.

STR. SITE No. 21-161

HWY. No. 401

LOCATION Bowmanville Creek Bridge

No of PAGES -

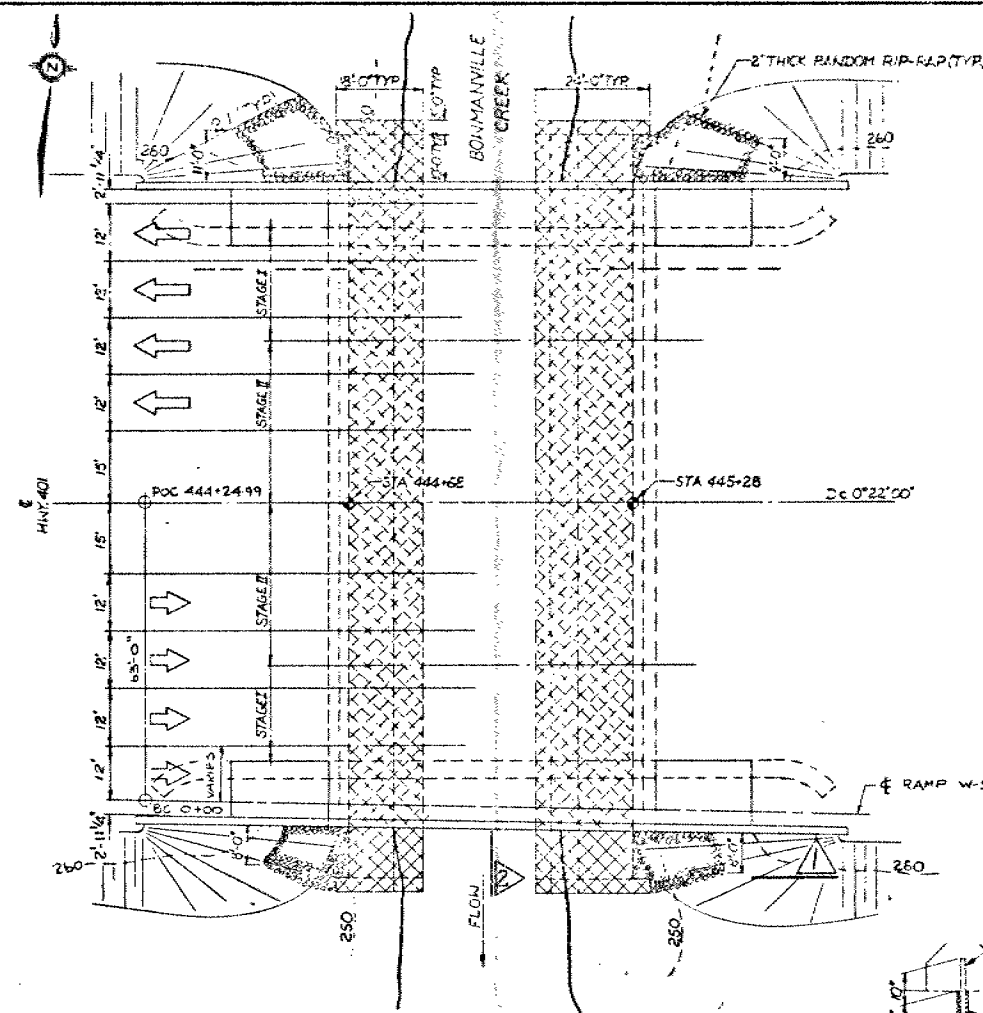
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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

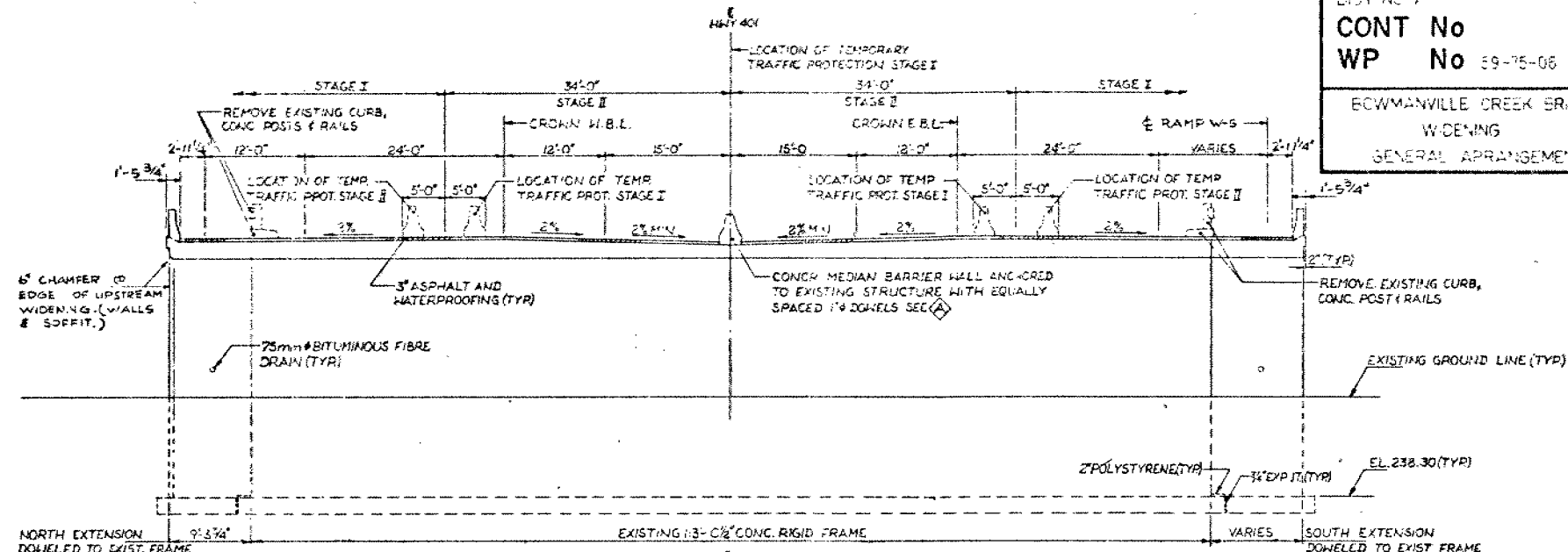
DIST NO 7
CONT No
WP No 59-75-06

BOWMANVILLE CREEK BRIDGE
WIDENING
GENERAL ARRANGEMENT

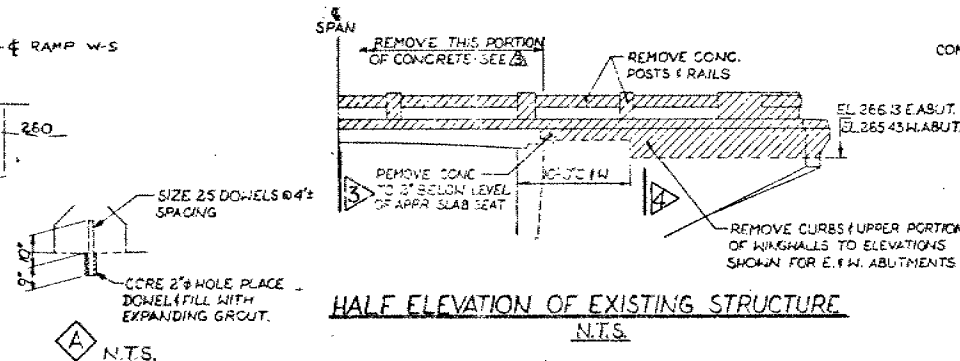
SHEET



PLAN
SCALE: 1"=20'-0"



SCALE: 1"=10'-0"



HALF ELEVATION OF EXISTING STRUCTURE
N.T.S.

GENERAL NOTES:

CLASS OF CONCRETE

FRAME, RETAINING WALLS & BARRIER WALLS: 30 MPa
FOOTINGS & REMAINDER: 20 MPa

CLEAR COVER TO REINFORCING STEEL:

DECK-TOP: 3", BOTTOM: 1 1/2"
BARRIER WALLS: AS NOTED
REMAINDER: 3" EXCEPT AS NOTED

GRADE OF REINFORCING STEEL: 400

REINFORCING BARS WITH SUFFIX 'C' SHALL BE COATED BARS.

CONSTRUCTION SEQUENCE:

STAGE I

1. CONSTRUCT DETOUR & ERECT TEMPORARY TRAFFIC PROTECTION @ HWY 401.
2. DIVERT HWY 401 LANES & ERECT TEMPORARY TRAFFIC PROTECTION.
3. REMOVE EXISTING CURBS, CONC POSTS & RAILS, TOP PORTION OF EXISTING WINGWALLS AND ASPHALT FROM OUTER PORTION OF DECK.
4. MAKE REPAIR TO EXISTING CONCRETE DECK AS DIRECTED BY THE ENGINEER.
5. ERECT ROADWAY PROTECTION.
6. EXCAVATE & CONSTRUCT WIDENING & RETAINING WALLS.
7. BACKFILL & WITHDRAW ROADWAY PROTECTION.
8. WATERPROOF AND PAVE WITH 3" ASPHALT.

STAGE II

9. MOVE TEMPORARY TRAFFIC PROTECTION & DIVERT TRAFFIC TO OUTER PORTION OF DECK.
10. REMOVE ASPHALT & REPEAT STEPS 3-8 FOR THE REMAINDER OF DECK.
11. REMOVE TEMPORARY TRAFFIC PROTECTION & DIVERT TRAFFIC TO FINISHED ROADWAY.

LIST OF DRAWINGS:

1. GENERAL ARRANGEMENT
2. BORE HOLE LOCATIONS & SOIL STRATA
3. FOOTING LAYOUT
4. FRAME
5. WINGWALLS & RET WALLS DETAILS
6. INTERCONNECTION BETWEEN WINGWALLS
7. BARRIER WALL
8. 20 FT. APPROACH SLAB
9. ROADWAY PROTECTION
10. AS CONSTRUCTED ELEV & DIM.
11. STANDARD DETAILS

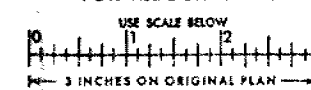
CONCRETE QUANTITIES

CONCRETE QUANTITIES ARE LISTED BELOW FOR THE APPROPRIATE CONCRETE LUMP SUM TENDER ITEMS

1. CONCRETE IN BRIDGE AND RETAINING WALLS	411 CU. YD.
2. CONCRETE IN BARRIER WALLS	37 CU. YD.
3. CONCRETE IN APPROACH SLABS	29 CU. YD.

NOTE:
GABION BASKETS TO BE AS SUPPLIED BY MACCAFERRI STEEL WIRE PRODUCTS OR EQUAL WITH MINIMUM PLAN DIMENSIONS OF 3'.

FOR REDUCED PLAN



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CHECK	LOADING	DATE
DRAWING	CHECK	SITE No	DWG

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 82-03



Ministry of
Transportation and
Communications



INDEX

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2	Abbreviations and Symbols
3 - 58	Foundation Investigation Reports For
	W. P. 59-75-06 Widening of Bowmanville Creek Bridge.
	W. P. 59-75-07 Widening of Liberty Street Overpass
	W. P. 59-75-08 Widening Soper Creek - Bowmanville
	W. P. 7-79-03 Wilmot Creek Culvert Extension

NOTE: For purposes of the contract these reports supercede all other foundation reports prepared by or for the Ministry in connection with the above mentioned projects.

'N' VALUE: AN INDICATOR OF SUBSOIL QUALITY. IT IS OBTAINED FROM THE STANDARD PENETRATION TEST (CSA STD. A119.1). SPT 'N' VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 2 INCH O.D. SPLIT-BARREL SAMPLER TO PENETRATE 12 INCHES INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WEIGHING 140 POUNDS, FALLING FREELY A DISTANCE OF 30 INCHES. FOR PENETRATIONS OF LESS THAN 12 INCHES 'N' VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. 'N' VALUES CORRECTED FOR OVERBURDEN PRESSURE ARE DENOTED THUS N_c .

DYNAMIC CONE PENETRATION TEST (CSA STD. A119.3): CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (2" O.D. 60 CONE ANGLE) DRIVEN BY 350 FT-LB IMPACTS ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 12 INCH ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOIL QUALITY: SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSITY.

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

S_u (PSF)	0 - 250	250 - 500	500 - 1000	1000 - 2000	2000 - 4000	> 4000
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

'N' (BLOW/FT)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCK QUALITY: 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 DRILLED IN THAT CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" 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	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS & SYMBOLS

LABORATORY TESTING

TRIAXIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U) ISOTROPICALLY (I) OR NOT (A) AND SHEARED DRAINED (D) OR UNDRAINED (U) WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS) EG. CUU = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

FIELD SAMPLING

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

EARTH PRESSURE TERMS

μ COEFFICIENT OF FRICTION
 δ ANGLE OF WALL FRICTION
 k_o COEFFICIENT OF EARTH PRESSURE AT REST
 k_A COEFFICIENT OF ACTIVE EARTH PRESSURE
 k_P COEFFICIENT OF PASSIVE EARTH PRESSURE
 i ANGLE OF INCLINATION OF SURCHARGE
 w SLOPE ANGLE-BACKFACE OF WALL
 β ANGLE OF SLOPE
 N_q, N_c BEARING CAPACITY FACTORS
 D_f DEPTH OF FOOTING
 B, L FOOTING DIMENSIONS

INDEX PROPERTIES

γ UNIT WEIGHT OF SOIL (BULK DENSITY)
 γ_w UNIT WEIGHT OF WATER
 γ_d UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
 γ' UNIT WEIGHT OF SUBMERGED SOIL
 G_s SPECIFIC GRAVITY OF SOLIDS
 e VOIDS RATIO
 e_o INITIAL VOIDS RATIO
 e_{max} e IN LOOSEST STATE
 e_{min} e IN DENSEST STATE
 D_r RELATIVE DENSITY = $\frac{e_{max} - e}{e_{max} - e_{min}}$
 n POROSITY
 w WATER CONTENT
 w_L LIQUID LIMIT
 w_P PLASTIC LIMIT
 w_S SHRINKAGE LIMIT
 I_P PLASTICITY INDEX = $w_L - w_P$
 I_L LIQUIDITY INDEX = $\frac{w - w_P}{w_L - w_P}$
 I_c CONSISTENCY INDEX = $\frac{w_L - w}{w_L - w_P}$
 A_c ACTIVITY = $\frac{I_P}{w_L - w_P}$
 O_m ORGANIC MATTER CONTENT
 S_r DEGREE OF SATURATION
 S SENSITIVITY = $\frac{S_u(\text{undisturbed})}{S_u(\text{remoulded})}$

STRENGTH PARAMETERS

ϕ ANGLE OF SHEARING RESISTANCE
 τ_f PEAK SHEAR STRENGTH
 τ_R RESIDUAL SHEAR STRENGTH
 c COHESION INTERCEPT
 $\sigma_1, \sigma_2, \sigma_3$ NORMAL PRINCIPAL STRESSES
 u PORE WATER PRESSURE
 u_e EXCESS u
 r_u PORE PRESSURE RATIO
 q_u UNCONFINED COMPRESSIVE STRENGTH
 s_u UNDRAINED SHEAR STRENGTH
 ϵ LINEAR STRAIN
 γ SHEAR STRAIN
 ν POISSON'S RATIO
 E MODULUS OF ELASTICITY
 G MODULUS OF SHEAR DEFORMATION
 k_s MODULUS OF SUBGRADE REACTION
 m, n STABILITY COEFFICIENTS
 A, B PORE PRESSURE COEFFICIENTS

NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:
 ϕ' = EFFECTIVE ANGLE OF SHEARING RESISTANCE;
 σ' = EFFECTIVE NORMAL STRESS

HYDRAULIC TERMS

h HYDRAULIC HEAD OR POTENTIAL
 q RATE OF DISCHARGE
 v VELOCITY OF FLOW
 i HYDRAULIC GRADIENT
 j SEEPAGE FORCE PER UNIT VOLUME
 η COEFFICIENT OF VISCOSITY
 k COEFFICIENT OF HYDRAULIC CONDUCTIVITY
 k_h k IN HORIZONTAL DIRECTION
 k_v k IN VERTICAL DIRECTION
 α_v COEFFICIENT OF VOLUME CHANGE
 c_v COEFFICIENT OF CONSOLIDATION
 C_c COMPRESSION INDEX
 C_r RECOMPRESSION INDEX
 d DRAINAGE PATH DISTANCE
 T_v TIME FACTOR
 U DEGREE OF CONSOLIDATION
 O_c OVERCONSOLIDATION RATIO (OCR)

FOUNDATION INVESTIGATION REPORT

For

Proposed Widening of Bowmanville Creek Bridge
King's Highway 401 - Town of Newcastle
W. P. 59-75-06; Site No. 21-161
District No. 7; Port Hope, Ontario

INTRODUCTION

This report describes the results of a geotechnical investigation carried out at the site of the proposed widening of the existing crossing at Bowmanville Creek and Highway 401 in the Town of Newcastle. The services of Dominion Soil Investigation Inc., consulting geotechnical engineers, were retained by the Ministry to carry out the field investigation and prepare the Foundation Investigation and Design Report. The purpose of the investigation was to determine the subsoil and groundwater conditions at the site; to establish the engineering properties of the substrata; and to make recommendations for the foundation design and construction of the proposed bridge structure.

The investigation in the field was completed in May 1978, and consisted of the drilling of four boreholes and the excavation of two test pits. The locations of the boreholes and test pits are shown on Drawing No. 2 and the subsurface conditions encountered are presented on the record of the boreholes and in the Appendix.

DESCRIPTION OF THE SITE

The site is located in the Town of Newcastle at the crossing of Highway 401 and the Bowmanville Creek. The terrain in this area is generally flat and the embankment carrying Highway 401 rises 12 to 18 ft. above the surrounding area. Drainage to the area is provided by the Bowmanville and Soper Creeks.

REGIONAL GEOLOGY

Geologically, the site is situated in the Lake Iroquois plain, which is an area of low relief inundated during the Pleistocene by the water of Lake Iroquois. The old abandoned shoreline of Lake Iroquois lies approximately 4 miles to the north.

The bedrock underlying the basin is of Ordovician age and consists of the Whitby formation, which is a black calcareous shale unit with interbedded limestone layers. The bedrock surface is irregular and regional studies suggest that there are strong similarities between the existing surface topography and that of the bedrock surface.

The surficial deposits consist of sediments of Pleistocene and recent age. Glacio-lacustrine deposits south of the abandoned Lake Iroquois shoreline range from sand and gravel of a near shore and deltaic nature to off-shore sediments such as varved silt and clay. These were deposited on top of a ground moraine of generally coarse sandy texture.

The surface of the till is irregular and drumlinized and the surface of the drumlins are exposed in many places in this area. More recent deposits consisting of organic and alluvial soils are found in the valleys of the creeks.

SUBSOIL CONDITIONS

The four exploratory boreholes drilled at the site indicate in general fill and alluvium to depths ranging between 7.0 and 12.8 ft. below the ground surface, underlain by a basal till extending to the surface of the bedrock. The bedrock, which was encountered $16.0 \pm$ ft. below the ground surface, is a shaley limestone.

Details of the subsurface conditions are shown on the Record of Boreholes and also on the inferred soil profile and sections shown on Drawing No. 2. The relevant index and engineering properties of the principal soil strata are described briefly below.

Fill

Boreholes 1 and 4 encountered fill to depths ranging between 5.0 and 7.5 ft. below the ground surface.

To a depth of 2.5 ft. below the ground surface in Borehole 4, the fill consists of sandy silt followed by sand and gravel with traces of silt to 5.0 ft. Borehole 1 encountered 9-inches of fine sand underlain by

sand and gravel to 4.0 ft., which is in turn underlain by silty sand with some gravel and clay (i.e. till) to a depth of 7.5 ft. below the ground surface.

Based on penetration indices or 'N'-values of 6 to 23 blows per foot, the fill is described as loose to compact.

Sandy Silt

A surficial layer of alluvial sandy silt was encountered at Boreholes 3 and 2 to depths ranging between 2.0 and 2.5 ft. below the ground surface respectively.

Silty Sand

Boreholes 2, 3 and 4 encountered alluvial silty sand to depths ranging between 7.0 and 7.5 ft. below the ground surface.

The thickness of the alluvium ranges between 2.0 and 5.5 ft. and contains various amounts of organic matter. The grain-size distributions of typical samples are shown on Enclosures 6 and 7, indicating 0-10% gravel, 68 to 87% sand (mostly fine), 13 to 32% silt and clay size particles. The 'N'-values range from 2 to 11 blows per foot, indicating very loose to compact relative density. The coefficient of permeability of the alluvium is estimated to range from 10^{-3} cm/sec. to 10^{-5} cm/sec.

Sand and Gravel

Boreholes 1 and 4 encountered sand and gravel and gravelly sand ranging in thickness from 2.0 ft. (Borehole 4) to 5.3 ft. (Borehole 1). The grain size distribution characteristics of this deposit are shown on Enclosure 8, indicating 27% gravel, 55% sand, and 18% silt and clay size particles. The penetration indices range from 8 to 36 blows per foot, indicating loose to dense relative density.

Glacial Till

At depths ranging between 7.0 and 12.8 ft. below the ground surface, the

boreholes encountered a basal till with a thickness ranging from 3.2 ft. in Borehole 1, to 7 to 9 ft. in the remaining boreholes.

The grain size distribution of typical samples shown on Enclosure 5 indicates 18 to 38% gravel, 35 to 49% sand, 21 to 31% silt, and 6 to 11% clay size particles. The till generally exhibits some cementation although layers or zones of little or no cementation were also noted. The penetration resistances within the basal till range from 26 to more than 100 blows per foot, indicating a compact to very dense relative density. Based on the gradation curves and from visual and tactile examination of the samples, the coefficient of permeability of the till is estimated to range between 10^{-4} and 10^{-5} cm/sec. depending on the degree of cementation and density.

Bedrock

The surface of the bedrock was encountered beneath the basal till at a depth of 16.0 \pm ft. below the ground surface (i.e. between Elevation 234.6 and 232.2 ft.).

In Borehole 1, from 16.0 to 18.8 ft. below the ground surface, that is from Elevation 234.5 to 231.7 ft., the rock was found to be of very poor quality with some sand seams. The recovery and the R.Q.D. values in this zone are 27%, and the visual examination of the core samples indicates a fractured rock.

Elsewhere, the recovered cores show that the rock formation underlying the site is a grey, shaley limestone. To a depth of 2 ft. below its surface in Borehole 2 (R.Q.D. value = 43%), and 6 to 12-inches in Boreholes 3 and 4, the rock is weathered. Below this zone, the rock is relatively intact with occasional highly weathered thin bands. The high percentage of core recovery (85 to 100%) and R.Q.D. values of 63 to 100%, indicate that the rock is of fair to excellent quality. No major fractures were encountered indicating that the mass permeability of the rock below the weathered zone would be low.

GROUNDWATER CONDITIONS

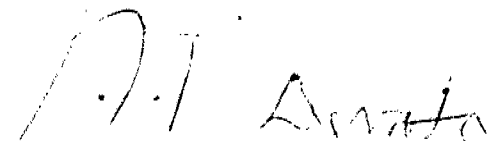
The groundwater conditions in the boreholes were observed during drilling;

water levels were also measured before coring started and after the completion of the coring. A standpipe was installed in Borehole 2 and seepage of surface water was prevented by a bentonite seal about 3 ft. below the ground surface.

Observations made in the boreholes before coring the rock showed water levels ranging between 3.0 and 7.5 ft. below the ground surface. In Boreholes 2 and 3, a slight temporary artesian pressure of 1.0 to 1.5 ft. above the ground surface was noted in the casing after coring. The standpipe installed in Borehole 2, however, later showed a stabilized water level 2.5 ft. below the ground surface. These observations indicate that the average groundwater table at the time of the investigation was at Elevation $248 \pm$ ft.



T. J. Kazmierowski, P. Eng.
Foundations Engineer



M. Devata, P. Eng.
Senior Foundations Engineer

APPENDIX



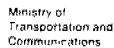
RECORD OF BOREHOLE No 1

W P 59-75-06 LOCATION Co-ords 15, 951, 619 N; 1, 216, 168 E. ORIGINATED BY N.M.C.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.I.
DATUM GEODETIC DATE MAY 10, 1979 CHECKED BY I.P.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100					W _p	W	W _L		
								SHEAR STRENGTH									
						○ UNCONFINED ... + FIELD VANE					WATER CONTENT (%)						
						● QUICK TRIAXIAL x LAB VANE											
250.5	GROUND LEVEL																
0.0	9" Fine Sand. Sand & gravel, compact (FILL)		1	SS	23												
246.5			2	SS	6												
4.0	Silty Sand, some gravel & Clay (FILL) loose		3	SS	10												
243.0			4	SS	36												
7.5	Sand & Gravel loose with some silt dense layers, wet		5	SS	507	5"											
237.7			6	RC	—												
12.8	Silty Sand TILL w. shale & limestone cobbles		7	RC	27%										R.Q.D. = 27%		
234.5	some sand seams fractured		8	RC	100%										R.Q.D. = 95%		
16.0	sound, limestone BEDROCK argillaceous, shale bands, grey		9	BXL	100%												
225.9																	
24.6	END OF BOREHOLE														W.L.E. 248.5 May 10, 1979		

+3, x5: Numbers refer to
Sensitivity

20
15
10
5
0
5
10
15
20
(%) STRAIN AT FAILURE



W P 59-75-06 LOCATION Co-ords 15, 951, 648 N; 1, 216, 235 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 11, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH							WATER CONTENT (%) 20 40 60			
								○ UNCONFINED								+ FIELD VANE		
								20 40 60 80 100										
								● QUICK TRIAXIAL	x LAB VANE									
249.9	GROUND LEVEL																	
247.4	Sandy SILT, dark brown some organics		1	SS	3		Seal							0 68 28 4				
242.9	Silty Fine SAND, some org. content & org. layers, very loose, grey, moist		2	SS	3									0 87 11 2				
242.9	GLACIAL TILL -		3	SS	31									23 35 31 11				
233.9	heterogeneous mixture of silty sand with gravel and some clay dense, grey, cobble @ 12'		4	SS	34									18 42 29 11				
233.9			5	SS	49													
16.0	Limestone weathered BEDROCK argillaceous, shale, sand bands, occ. clayey bands		6	SS	50/4"													
227.9			7	BC	100%									R.Q.D. = 43%				
22.0	END OF BOREHOLE		8	BC	100%									R.Q.D. = 100%				
														DATE W.L. May 11 249.9 Sept. 10 247.4 Artesian pressure 1.5 above ground surface ob- served in BW casing.				

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3

W P 59-75-06 LOCATION Cor-ords, 15, 951, 760 N; 1, 216, 115 E. ORIGINATED BY N.MCC.
 DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.L.
 DATUM GEODETIC DATE MAY 11, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
248.4	GROUND LEVEL																
246.4	Sandy SILT		1	SS	2												10 70 16 4
240.9	Silty SAND, w. tr. of gravel, some org. content v. loose, grey to dk. grey		2	SS	4												19 49 24 7
7.5	GLACIAL TILL: heteroge- neous mixture of silty sand with gravel and traces of clay dense, grey.		3	SS	50/	5"	240										34 39 21 6
			4	SS	50/	6"											
			5	SS	88/	10"											
232.2			6	SS	50/	6"											R.Q.D.=94%
16.2	Limestone BEDROCK		7	RC	100%		230										
227.7	argillaceous, sound, grey			BXL													
20.7	END OF BOREHOLE																Artesian pressure 1.0' above ground sur- face ob- served in BW casing after coring.

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 4

W P 59-75-06 LOCATION Co-ords, 15, 951, 800 N; 1, 216, 180 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 11, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
250.4	GROUND LEVEL																
247.9	Sandy Silt FILL brown		1	SS	14		250										
245.4	Sand & Gravel, tr. silt		2	SS	11												0 76 24
243.4	Filly moist to wet dry, some dk grey		3	SS	8												27 55 18
241.4	Gravelly Sand, some silt, loose, dk. grey		4	SS	26		240										38 35 21 6
9.0	compact Silty Sand dense TILL		5	SS	50/6												
234.6			6	SS	50/6												
15.8	Limestone BEDROCK argillaceous, sound grey, occasional shale bands and thin sand seams		7	RC BXL	85%		230										R.Q.D. = 63%
224.7			8	RC BXL	98%												R.Q.D. = 96%
25.7	END OF BOREHOLE																DATE W.L. May 11 248.9 Sept. 10 248.8

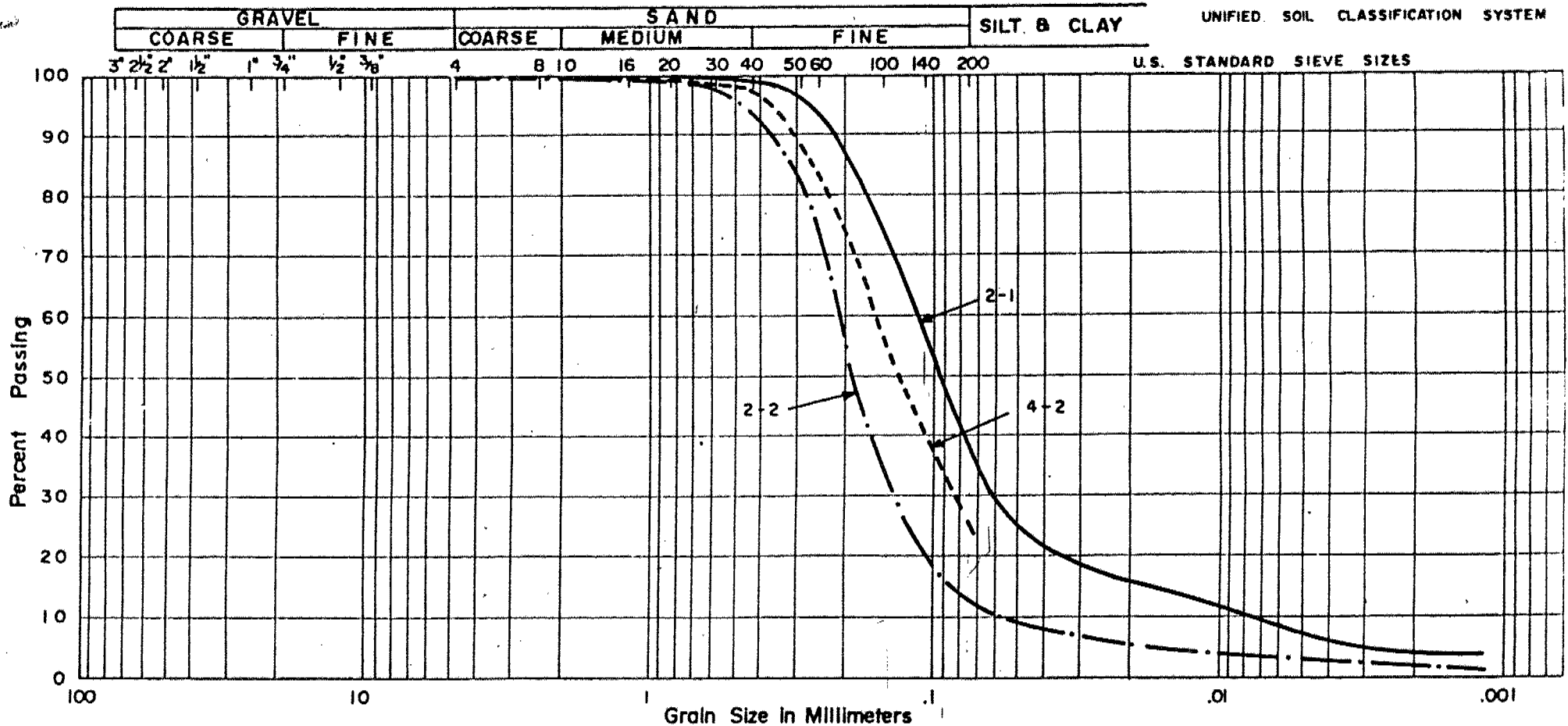
+3, x5: Numbers refer to
Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION



PROJECT: BOWMANVILLE CREEK BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE N^o: 2 2 4
 SAMPLE N^o: 1 2 2
 DEPTH:
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

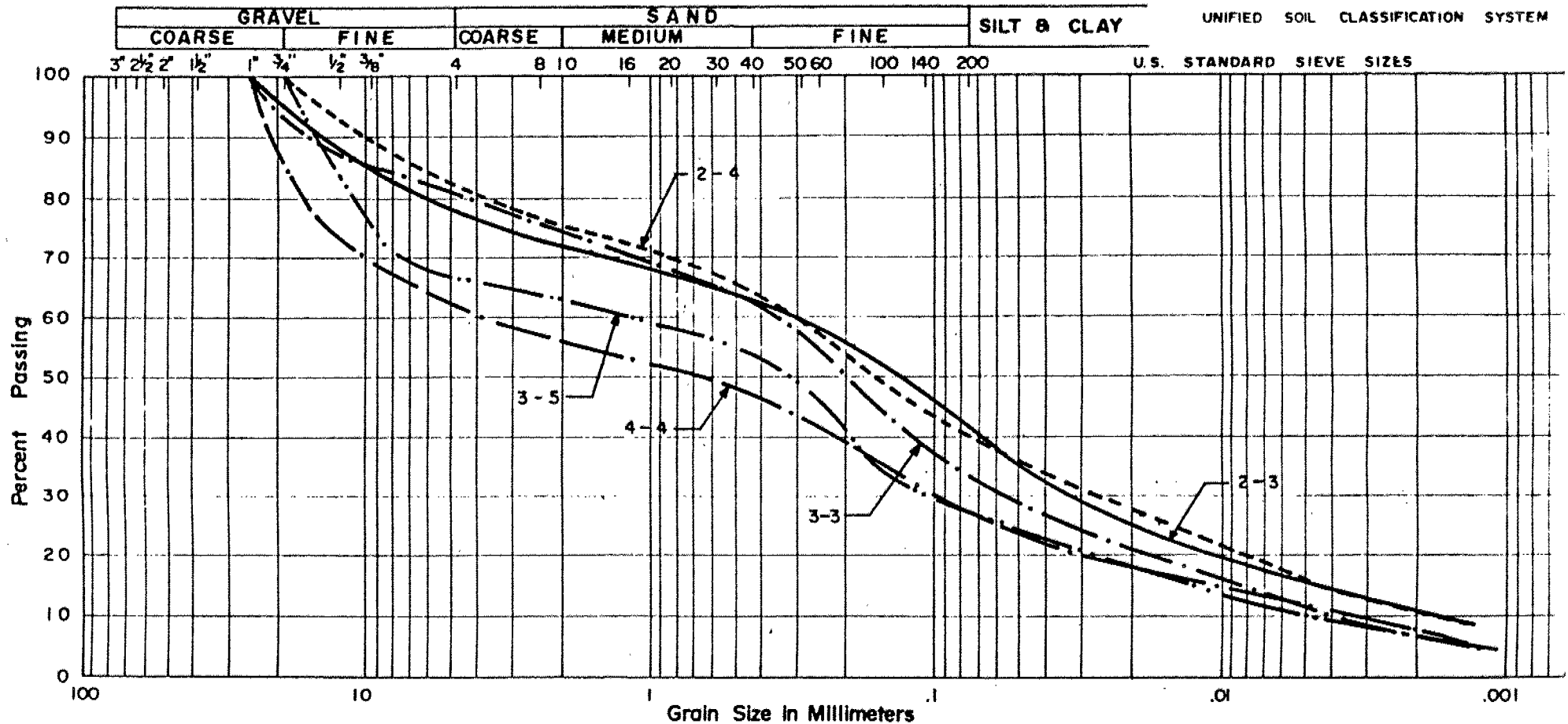
Classification of Sample and Group Symbol:
SILTY FINE SAND

PLASTIC PROPERTIES

LIQUID LIMIT % =
 PLASTIC LIMIT % =
 PLASTICITY INDEX % =
 MOISTURE CONTENT % = 23.0 - 26.7

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION



PROJECT: BOWMANVILLE CREEK BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE NO: 2 2 3 3 4
 SAMPLE NO: 3 4 3 5 4
 DEPTH:
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

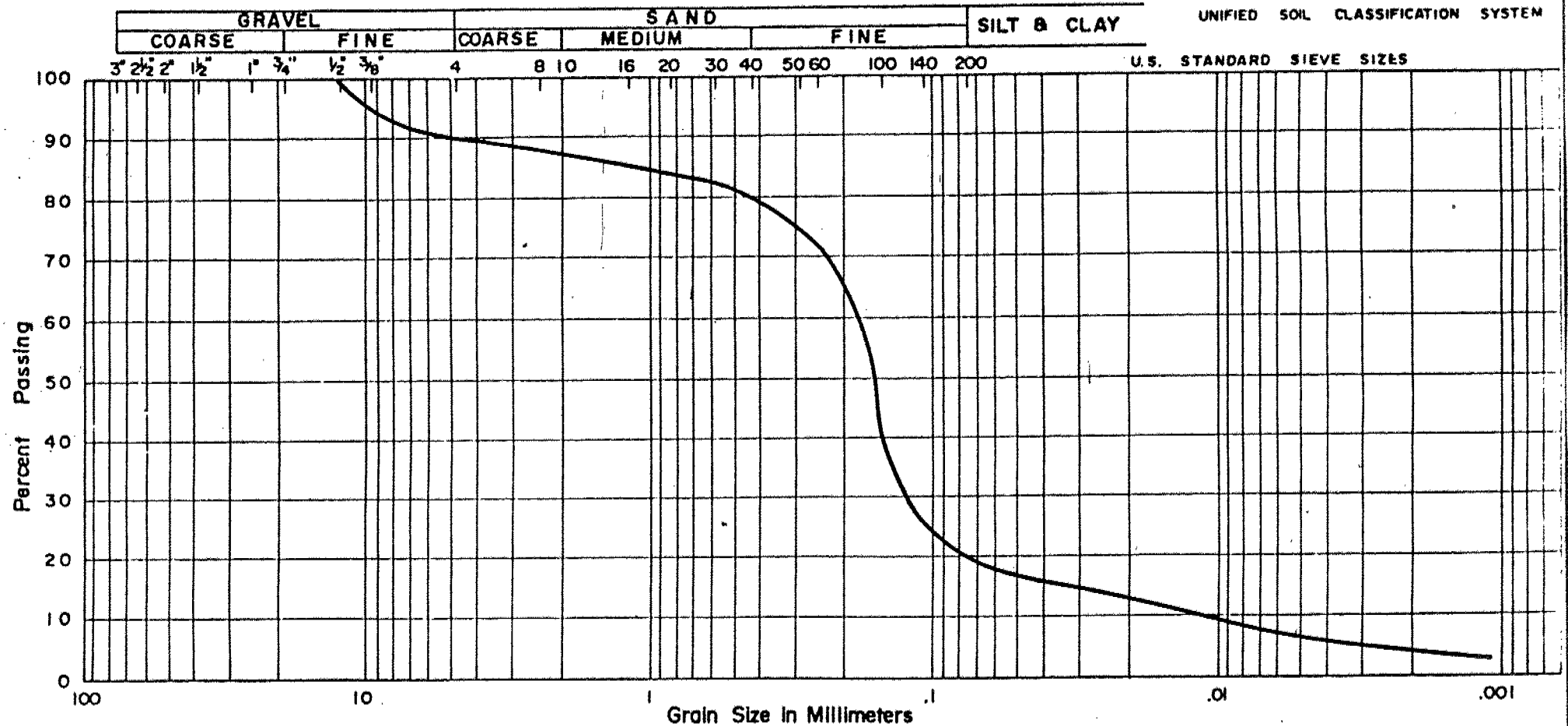
SILTY SAND TILL
 with gravel and some clay.

PLASTIC PROPERTIES

LIQUID LIMIT % =
 PLASTIC LIMIT % =
 PLASTICITY INDEX % =
 MOISTURE CONTENT % = 5.9 - 8.8

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION



PROJECT: BOWMANVILLE CREEK BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE NO: 3
 SAMPLE NO: 1
 DEPTH:
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

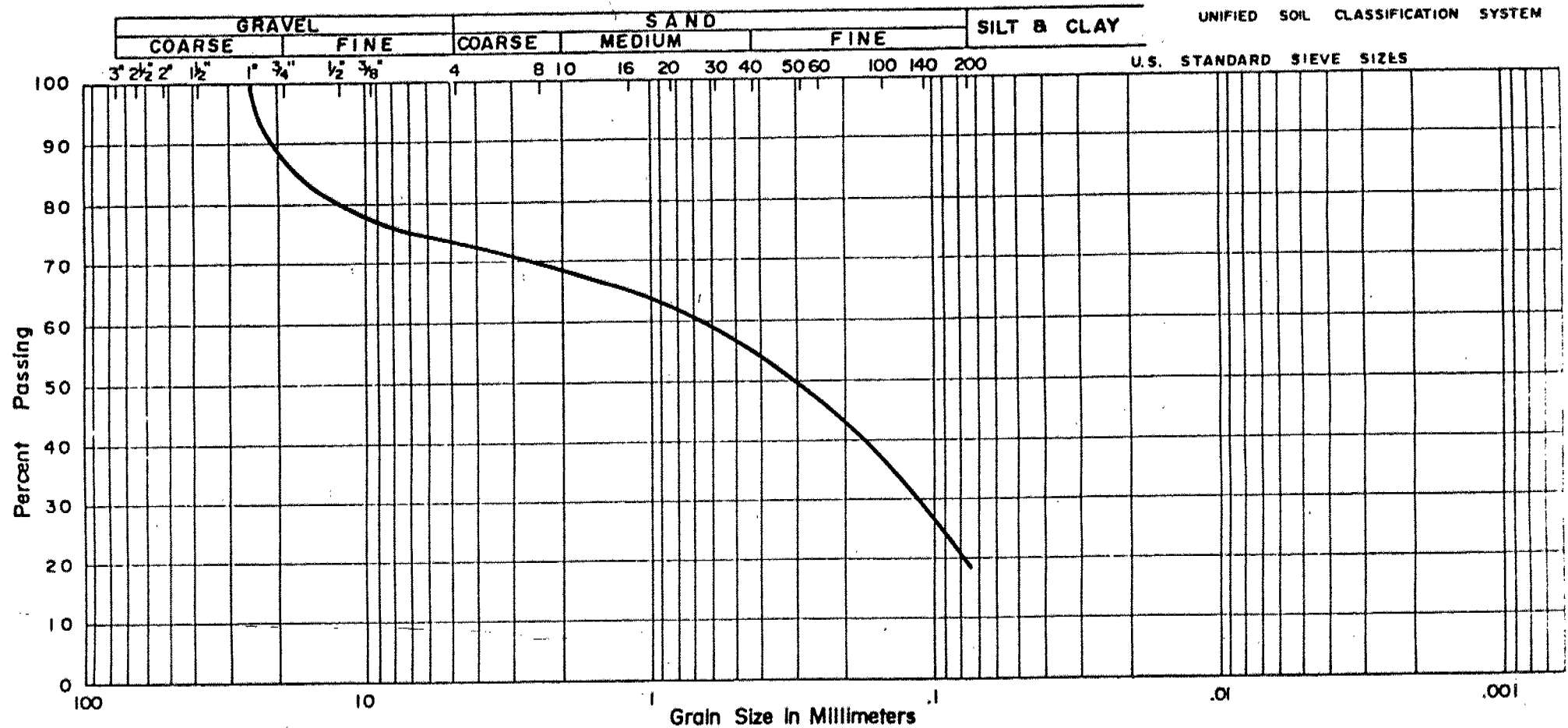
SILTY SAND
 trace gravel.

PLASTIC PROPERTIES

LIQUID LIMIT % =
 PLASTIC LIMIT % =
 PLASTICITY INDEX % =
 MOISTURE CONTENT % = 21.4

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION



PROJECT: BOWMANVILLE CREEK BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE NO: 4
 SAMPLE NO: 3
 DEPTH:
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:
GRAVELLY SAND
 some silt.

PLASTIC PROPERTIES

LIQUID LIMIT	% =
PLASTIC LIMIT	% =
PLASTICITY INDEX	% =
MOISTURE CONTENT	% = 10:1

FOUNDATION INVESTIGATION REPORT

For

Proposed Widening of Liberty Street Overpass
King's Highway 401 - Town of Newcastle
W. P. 59-75-07; Site No. 21-162
District No. 7, Port Hope, Ontario

INTRODUCTION

This report describes the results of a geotechnical investigation carried out at the site of the proposed widening of the existing Liberty Street overpass on Highway 401 in the Town of Newcastle. The services of Dominion Soil Investigation Inc., consulting geotechnical engineers, were retained by the Ministry to carry out the field investigation and prepare the Foundation Investigation & Design report. The object of the investigation was to determine the subsoil and groundwater conditions at the site; to establish the engineering properties of the substrata; and to make recommendations for the foundation design and construction of the proposed bridge structure.

- The investigation in the field was completed in May 1978 and consisted of the drilling of eight boreholes and the excavation of a test pit. The locations of the boreholes and the test pit are shown on Drawing 2, and the subsurface conditions found in the boreholes and the test pit are presented on the Record of the Boreholes and in the Appendix.

DESCRIPTION OF THE SITE

The site is located in the Town of Newcastle at the intersection of Highway 401 and Liberty Street. The terrain in this area is generally flat and the embankment carrying Highway 401 rises 15 to 20 ft. above the surrounding area. Drainage to the area is provided by the Bowmanville and Soper Creeks located a short distance to the west and east respectively.

REGIONAL GEOLOGY

Geologically, the site is situated in the Lake Iroquois Plain, which

is an area of low relief inundated during the Pleistocene by the waters of Lake Iroquois. The old abandoned shoreline of Lake Iroquois lies approximately 4 miles to the north.

The bedrock underlying the basin is of Ordovician age and consists of the Whitby formation which is a black calcareous shale unit with interbedded limestone bands. The bedrock surface is irregular and regional studies suggest that there are strong similarities between the existing surface topography and that of the bedrock surface.

The surficial deposits consist of sediments of Pleistocene and recent age. Glacio-lacustrine deposits south of the abandoned Lake Iroquois shoreline range from sand and gravel of a near shore and deltaic nature to off-shore sediments such as varved silt and clay. These were deposited on top of a ground moraine of generally coarse sandy texture.

The surface of the till is irregular and drumlinized and the surface of the drumlins are exposed in many places in this area. More recent deposits consisting of organic and alluvial soils are found in the valleys of the creeks.

SUBSOIL CONDITIONS

The eight exploratory boreholes and one test pit indicate reasonably uniform subsurface conditions. The stratigraphic sequence, as inferred from the borehole logs, is as follows:

- 1) Loose to compact mixed fill;
- 2) Stiff silty clay ;
- 3) Very dense silty sand till;
- 4) Sound shale bedrock.

Details of the subsurface conditions are shown on the Record of Boreholes and also on the inferred soil profile and sections shown on Drawing No. 2. The relevant index and engineering properties of the principal soil strata are described briefly below.

Fill

Fill was encountered in every borehole, ranging in thickness between 3 and 17.5 ft. The composition of the fill varies, but generally sand and silt particles predominate. The penetration indices or 'N'-values range from 2 to 27 blows per foot, with an average value of about 10 blows per foot. Based on this, the relative density of the fill is inferred to be loose to compact and generally in the compact range. The permeability of the fill is expected to be variable and to depend on the composition of the fill, but on the average it is estimated to be in the range of 10^{-3} to 10^{-5} cm/sec.

Silty Clay

A silty clay stratum was encountered in Boreholes 3, 7 and 8. It is believed to be of glacio-lacustrine origin laid down possibly by Lake Iroquois. The thickness of the silty clay ranges from 13 ft. to 4.5 ft. The penetration indices range between 10 and 22 blows per foot, indicating a generally stiff to very stiff consistency. The undrained shear strength of the silty clay is estimated to range between 2000 and 3000 psf. The permeability of this stratum is estimated to be low, generally less than 10^{-6} cm/sec.

Glacial Till

In each borehole, an approximately 10 ft. thick layer of basal till was encountered. The surface of the till lies between Elevations 255.7 ft. (Borehole No. 1) and 249.4 ft. (Borehole No. 6), with an average elevation of about 252 ft. The till has a coarse texture and is a well graded mixture of gravel, sand, silt and clay size particles. Embedded in the till are also frequent cobbles and boulders. Grading curves of representative samples of the till are shown on Enclosures 9, 10 and 11. Reference to these indicates that the till consists of 12 to 42% gravel, 35 to 55% sand, 17 to 25% silt and 5 to 10% clay size particles. The till exhibits some to considerable cohesion due to cementation. The Standard Penetration resistances were generally in excess of 100 blows per foot, indicating a very dense relative density. Due to the well graded and dense nature of the till and the cementation

between the particles, the permeability of the till is estimated to be moderate to generally low in spite of the relatively high sand content. The coefficient of permeability is estimated to be generally less than 10^{-5} cm/sec.

Bedrock

The surface of the bedrock was encountered or inferred from refusal in the boreholes between Elevation 243.5 and 240.6 ft. The rock was cored at four locations and the recovered cores indicate that the rock is a dark grey coloured, highly calcareous shale with many limestone bands. The high percentage of core recovery and high R.Q.D.-values (78 to 100%) indicate a sound rock with good qualities. The rock is intact, showing signs of only insignificant amounts of weathering in the upper few inches of the rock. As the rock is relatively free of fractures, the mass permeability of the rock is estimated to be low.

Groundwater Conditions

The groundwater conditions in the boreholes were observed during drilling and the position of the water level was measured and recorded after the borehole was completed but before the rock was cored. During the drilling, water was noticed only in Borehole No. 2 at a depth of 4 ft. in the fill. The other boreholes bored dry and remained dry for periods up to 7 hours after completing the drilling. These observations confirm the generally low permeability of the substrata. Standpipes were installed in Boreholes 2 and 6 and were protected from the influence of surface water by a bentonite clay seal. Observations carried out in these standpipes in September 1979 indicated water levels at Elevations 249.4 to 254.7 ft. From these results and visual and tactile examination of the soil samples, it is inferred that the permanent groundwater table may be near the surface of the silty sand till. It is expected, however, that a temporary perched water table may develop in the more pervious fill above the nearly impervious silty clay and till strata.



T. J. Kazmierowski, P. Eng.
Foundations Engineer

M. Devata, P. Eng.
Senior Foundations
Engineer

APPENDIX

RECORD OF BOREHOLE No 1

W P 59-75-07 LOCATION Co-ords 15, 592, 177 N; 1, 217, 292 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 14, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100									
								SHEAR STRENGTH									
265.2	GROUND SURFACE																
0.0	4" TOPSOIL		1	SS	5		260									TIME W.L. 9:30am Dry 5:00pm Dry	
	FILL - Sandy Silt Loose, brown		2	SS	5												
255.7	some topsoil		3	SS	14												
9.5	compact		4	SS	15												
	v. dense		5	SS	78												
	GLACIAL TILL: heteroge- neous mixture of sand, silt, gravel, boulders		6	SS	62		250										
243.5	some clay, cemented		7	SS	50/6"												
21.7	END OF BOREHOLE Refusal probably on bedrock																

TIME W.L.
9:30am Dry
5:00pm Dry

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 2

W P 59-75-07 LOCATION Co-ords 15, 592, 185 N.; 1, 217, 163 E. ORIGINATED BY N.McC
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGER, BXL ROCK CORE COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 14, 1979 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES		20	40	60	80	100					
257.7	GROUND SURFACE															
0.0	FILL, mixture of sand, gravel, wet silt, some cobbles. Compact. Brown		1	SS	12											
250.2			2	SS	14											
7.5	GLACIAL TILL: heterogeneous mixture of sand, silt, gravel, some clay very dense, grey		3	SS	50/											25,45,20,10
			4	SS	50/											12,53,25,10
			5	SS	50/											
			6	SS	50/											
241.2																
16.5	Sound Shale BEDROCK highly calcareous grey		7	RC	100%											R.Q.D.=100%
236.2																
21.5	END OF BOREHOLE															
																DATE W.L. May 14 253.2 Sept. 10 254.7

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

RECORD OF BOREHOLE No 3

W P 59-75-07 LOCATION Co-ords 15, 951, 996 N.; 1, 217, 348 E. ORIGINATED BY N.McC.
 DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING COMPILED BY I.P.L.
 DATUM GEODETIC DATE MAY 15, 1979 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100						
269.3	GROUND SURFACE												
0.0	3" Topsoil, FILL-sand silt,peat,loose,brown		1	SS	3								
265.3			2	SS	14								
4.0	Silty CLAY stiff to very stiff brown, trace of gravel		3	SS	18								
			4	SS	19								
			5	SS	10								
			6	SS	20								
252.3													
17.0	GLACIAL TILL:heteroge- neous mixture of sand, silt,gravel,some clay		7	SS	50/6								
247.5													
21.8	END OF BOREHOLE Refusal, probably on boulder												

DATE W.L.
May 15
9:15am Dry
10:00am 249.3
May 16 260.2

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 4

W P 59-75-07 LOCATION Co-ords 15, 592, 013 N.; 1, 217, 418 E. ORIGINATED BY N.MCC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING; BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 15, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
255.2	GROUND SURFACE																
0.0	FILL - Sandy Silt																
252.2	brown		1	SS	52		250										42,35,17,6
3.0	GLACIAL TILL: heteroge- neous mixture of sand, silt, gravel, some clay very dense, grey, cemented		2	SS	72												25,45,25,5
			3	SS	50/	5"											25,45,25,5
			4	SS	50/	6"											
242.5			5	SS	50/	4"											
12.7	Shale BED- weathered ROCK, highly sound calcareous w. limestone bands, grey		6	R.C. BXL	78%		240										R.Q.D.=78%
236.8																	
18.4	END OF BOREHOLE																






+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 5

W P 59-75-07 LOCATION Co-ords 15, 952, 166 N.; 1, 217, 323 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 16, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) 20 40 60				
257.3	GROUND SURFACE																
0.0	5" Topsoil		1	SS	3	2" 6" DRY	250									R.Q.D.=100%	
251.8	FILL - mixture of clay, silt,sand,loose,brown		2	SS	15												
5.5	GLACIAL TILL: heteroge- neous mixture of boulder sand,silt,gravel, some clay,very dense, grey limestone fragments		3	SS	507												
			4	SS	507												
240.8			5	SS	51												
			6	SS	44												
16.5	Shale BEDROCK fractured calcareous,with sound		7	RC	100%	240											
235.5	limestone bands, grey		8	BXL	100%												
21.8	END OF BOREHOLE																

+³, x⁵: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



W P 59-75-07 LOCATION Co-ords 15, 952, 016 N.; 1, 217, 372 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGER, BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 23, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						SHEAR STRENGTH	WATER CONTENT (%) 20 40 60
								○ UNCONFINED ● QUICK TRIAXIAL						+ FIELD VANE x LAB VANE	
254.4	GROUND SURFACE														
0.0	FILL - sand and gravel compact, brown		1	SS	27		250								
249.4			2	SS	507.6	"		Bentonite Seal							
5.0	GLACIAL TILL: heterogeneous mixture of sand, silt, gravel, some clay v. dense, grey		3	SS	507.6	"			○						
			4	SS	507.6	"			○						
240.9	limestone boulders		5	RC	-	"			○						
13.5	Shale BEDROCK, calcareous w. limestone bands, grey, sound		7	RC BXL	98%		240								
236.1															
18.3	END OF BOREHOLE														

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 7

W P 59-75-07 LOCATION Co-ords 15, 952, 163 N.; 1, 217, 405 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERER COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 17, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
274.0	GROUND SURFACE																
0.0	FILL - mixture of sand, gravel, clayey silt, limestone fragments v. loose to compact brown		1	SS	5		270										
			2	SS	2												
			3	SS	14												
			4	SS	20												
			5	SS	12		260										
			6	SS	22												
256.5			7	SS	22												
17.5	Clayey SILT, some sand v. stiff, grey		8	SS	15												
252.0																	
22.0	GLACIAL TILL: heteroge- neous mixture of sand, silt, gravel, some clay		9	SS	50/ 6"		250										
241.7	boulders																
32.3	END OF BOREHOLE Refusal probably on bedrock																

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 8

W P 59-75-07 LOCATION Co-ords 15, 952, 049 N.; 1, 217, 442 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 17, 1979 CHECKED BY I.P.L.

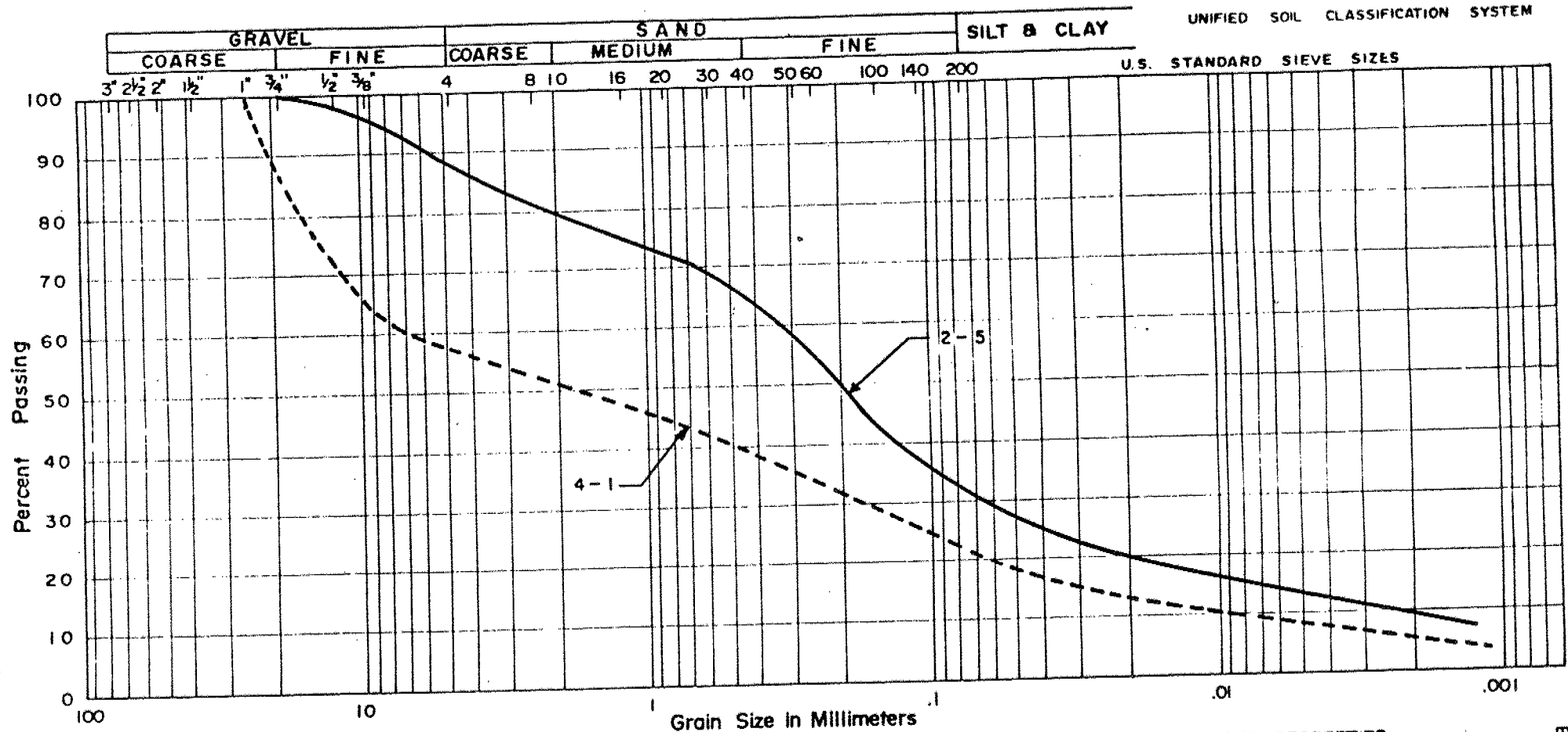
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
273.7	GROUND SURFACE																
0.0	FILL - mixture of sand, gravel, clayey silt, v. loose to compact, brown		1	SS	4		270										
			2	SS	4												
			3	SS	22												
			4	SS	9												
			5	SS	13		260										
256.7			6	SS	9												
17.0	Clayey Silt, some gravel, stiff, grey-brown		7	SS	12												
251.7			8	SS	15												
22.0	GLACIAL TILL: heterogeneous mixture of sand, silt, gravel, some clay v. dense, cemented, grey boulders		9	SS	50/ 5"		250										
			10	SS	51												
240.6																	
33.1	END OF BOREHOLE Refusal probably on bedrock																

OFFICE REPORT ON SOIL EXPLORATION

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO 79-5-6



PROJECT: LIBERTY BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE NO: 2 4
 SAMPLE NO: 5 1
 DEPTH: 13.0 3.5
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SILTY SAND
 with gravel, tr. clay.

PLASTIC PROPERTIES

LIQUID LIMIT	% =
PLASTIC LIMIT	% =
PLASTICITY INDEX	% =
MOISTURE CONTENT	% = 5.4 - 5.5

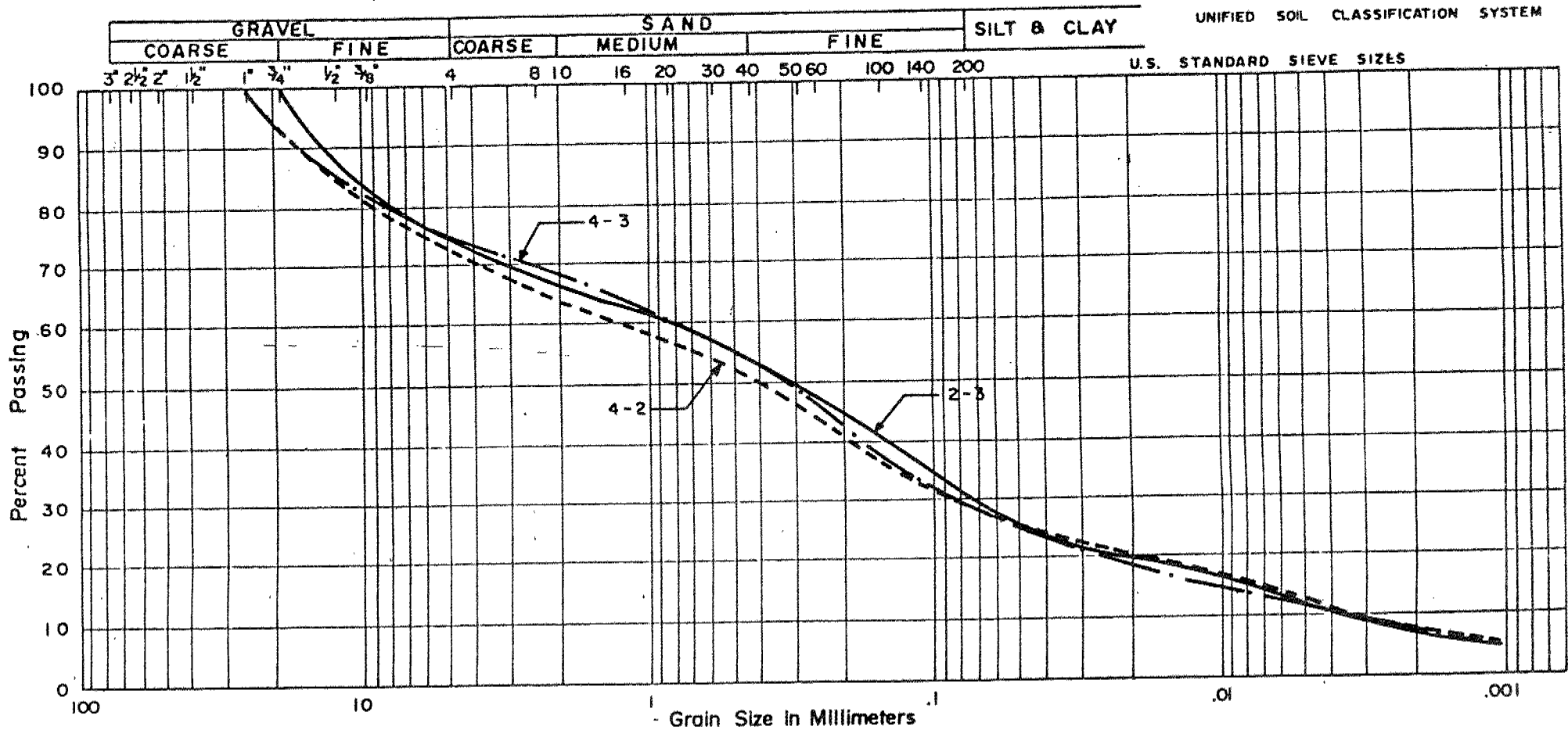
ENCLOSURE NO 9

30

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO 79-5-6



PROJECT: LIBERTY BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE NO: 2 4 4
 SAMPLE NO: 3 2 3
 DEPTH: 8 6 8
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SILTY SAND TILL
 some gravel, tr. clay.

PLASTIC PROPERTIES

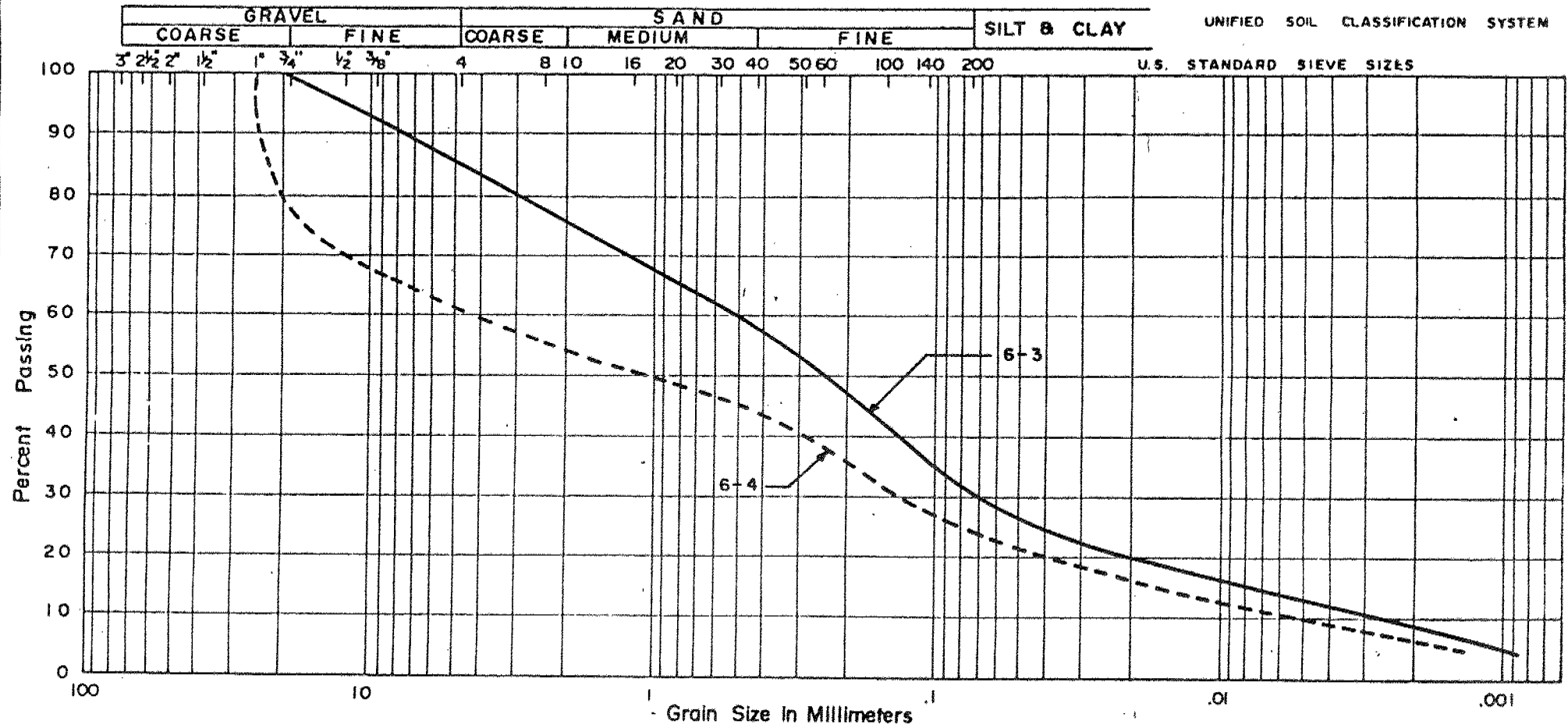
LIQUID LIMIT % =
 PLASTIC LIMIT % =
 PLASTICITY INDEX % =
 MOISTURE CONTENT % = 4.8 - 5.3

ENCLOSURE NO 10

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No 79-5-6



PROJECT: LIBERTY BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE No: 6 6
 SAMPLE No: 3 4
 DEPTH: 4' 10'
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:
SILTY SAND TILL
 with some gravel

PLASTIC PROPERTIES

LIQUID LIMIT	% =
PLASTIC LIMIT	% =
PLASTICITY INDEX	% =
MOISTURE CONTENT	% = 5.1 - 4.5

FOUNDATION INVESTIGATION REPORT

For

Proposed Widening
Soper Creek - Bowmanville
W.P. 59-75-08

INTRODUCTION

This report describes the results of a geotechnical investigation carried out at the site of the proposed widening of the existing crossing at Soper Creek and Highway 401 in the Town of Newcastle. The services of Dominion Soil Investigation Inc., consulting geotechnical engineers, were retained by the Ministry to carry out the field investigation and prepare the Foundation Investigation and Design Report. The purpose of the investigation was to determine the subsoil and groundwater conditions at the site; to establish the engineering properties of the substrata; and to make recommendations for the foundation design and construction of the proposed bridge structure.

The investigation in the field was completed in May 1978, and consisted of the drilling of six boreholes and the excavation of two test pits. The locations of the boreholes and the test pits are shown on Drawing 2, and the subsurface conditions found in the boreholes and the test pits are presented on the Record of the Boreholes and in the Appendix.

DESCRIPTION OF THE SITE

The site is located in the Town of Newcastle at the crossing of Highway 401 and the Soper Creek. The terrain in this area is generally flat and the embankment carrying Highway 401 rises 12 to 18 ft. above the surrounding area. Drainage to the area is provided by the Bowmanville and Soper Creeks.

REGIONAL GEOLOGY

Geologically, the site is situated in the Lake Iroquois Plain, which is an area of low relief inundated during the Pleistocene by the waters of Lake Iroquois. The old abandoned shoreline of Lake Iroquois lies approximately 4 miles to the north.

The bedrock underlying the basin is of Ordovician age and consists of the Whitby formation which is a black calcareous shale unit with interbedded

limestone bands. The bedrock surface is irregular and regional studies suggest that there are strong similarities between the existing surface topography and that of the bedrock surface.

The surficial deposits consist of sediments of Pleistocene and recent age. Glacio-lacustrine deposits south of the abandoned Lake Iroquois shoreline range from sand and gravel of a near shore and deltaic nature to off-shore sediments such as varved silt and clay. These were deposited on top of a ground moraine of generally coarse sandy texture.

The surface of the till is irregular and drumlinized and the surface of the drumlins are exposed in many places in this area. More recent deposits consisting of organic and alluvial soils are found in the valleys of the creeks.

SUBSOIL CONDITIONS

The six exploratory boreholes and two test pits indicate reasonably uniform subsurface conditions. The stratigraphic sequence, as inferred from the borehole and the test pit logs, is as follows:

- 1) Loose to compact mixed fill;
- 2) Loose silty fine sand;
- 3) Compact to dense glacial till;
- 4) Sound shale bedrock.

Details of the subsurface conditions are shown on the Record of Boreholes and also on the inferred soil profile and sections shown on Drawing No. 2. The relevant index and engineering properties of the principal soil strata are described briefly below.

Fill

Fill was encountered in boreholes 1, 5 and 6 ranging in thickness between 6.5 and 17.5 ft. The composition of the fill varies, but generally sand and silt particles predominate. The penetration indices or 'N'-values range from 1 to 27 blows per foot, with an average value of about 7 blows

per foot. Based on this, the relative density of the fill is inferred to be loose to compact and generally in the loose range. The permeability of the fill is expected to be variable and to depend on the composition of the fill, but on the average it is estimated to be medium.

Silty Fine Sand

A silty fine sand stratum was encountered in all Boreholes except Borehole 1. It is believed to be of recent alluvial origin laid down possibly by the creek. The thickness of the stratum ranges from 5.5 ft. to 8.2 ft. The grain size distribution of the deposit is shown on Enclosure 7, indicating 48 to 55% fine sand, 31 to 43% silt; and 6 to 10% clay. The clay size particles impart some plasticity to the soil and an Atterberg test performed on a sample of a more clayey zone indicated a liquid limit of 28% and a plasticity index of 8.0. The deposit also contains some organic matter. The penetration indices range between 2 and 15 blows per foot, with an average value of 8, indicating a generally loose to very loose relative density. The permeability of this stratum is estimated to be medium to low, generally less than 10^{-5} cm/sec.

Glacial Till

In Boreholes 3 and 5 an approximately 3.5 ft. thick layer of basal till was encountered below the alluvium. The till has a fine to coarse texture and is a well graded mixture of gravel, sand, silt and clay size particles. Grading curves of representative samples of the till are shown on Enclosure 8. Reference to these indicates that the till consists of 9 to 25% gravel, 33 to 54% sand, 27% silt and 10 to 15% clay size particles. The till exhibits some cementation. The Standard Penetration resistances range between 13 and 33 blows per foot, indicating a compact to dense relative density. Due to the well graded nature of the till and the light cementation between the particles, the permeability of the till is estimated to be moderate to generally low in spite of the relatively high sand content. The coefficient of permeability is estimated to be generally less than 10^{-5} cm/sec.

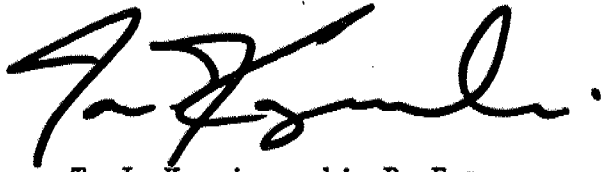
Bedrock

The surface of the bedrock was encountered or inferred from refusal in the boreholes between Elevation 241.6 and 243.4 ft. The rock was cored

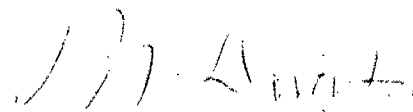
at four locations and the recovered cores indicate that the rock is a dark grey coloured, highly calcareous shale with many limestone bands. The high percentage of core recovery and the relatively high R.Q.D.-values (70 to 84%) indicate a sound rock with good qualities. The rock is intact, showing signs of only some weathering in the upper few inches of the rock. As the rock is relatively free of fractures, the mass permeability of the rock is estimated to be low.

Groundwater Conditions

The groundwater conditions in the boreholes were observed during drilling and the position of the water level was measured and recorded after the borehole was completed but before the rock was cored. Standpipes were installed in Boreholes 2 and 3 and were protected from the influence of surface water by a bentonite clay seal. Observations carried out in these standpipes in September 1979 indicated water levels at about Elevation 245.5 ft. corresponding to the water level in the creek. From these results and the visual and tactile examination of the soil samples, it is inferred that the groundwater table will generally correspond to the water level in the creek, which at the time of the investigation was at El.245.5 ft.



T. J. Kazmierowski, P. Eng.
Foundations Engineer



M. Devata, P. Eng.
Senior Foundations Engineer

APPENDIX



RECORD OF BOREHOLE No 1

W P 59-75-08 LOCATION Co-ords. 15, 952, 265 N.; 1, 217, 730 E. ORIGINATED BY N.M.C.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 14, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
249.1	GROUND SURFACE																
0.0	5" Topsoil		1	SS	4												
	FILL - mixture of		2	SS	4												
	clayey silt, gravel,		3	RC	100%												
242.6	topsoil, loose		4	BXL													
6.5	Shale BEDROCK, calcareous						240										R.Q.D.=84%
238.0	w. limestone bands, sound																
	dark grey																
11.1	END OF BOREHOLE																M.L.E1.244.1 May 14, 1979

+3, x⁵: Numbers refer to
Sensitivity

20
15 $\frac{1}{5}$ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No. 2

W P 59-75-08 LOCATION Co-ords. 15, 952, 300 N.; 1, 217, 900 E. ORIGINATED BY N.M.C.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING; BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 14, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	20 40 60					
251.6	GROUND SURFACE													
0.0	4" Topsoil		1	SS	10		250							0.48, 43.9
	Silty Fine SAND, some		2	SS	8									11.49, 31.9
	gravel, loose, dark		3	SS	50/2									
243.4	grey													
8.2	Shale BEDROCK,		4	RC	100%		240							R.Q.D.=73%
	calcareous, limestone													
237.9	bands, sound, grey													
13.7	END OF BOREHOLE													DATE W.L. May 14 244.1 Sept. 10 245.6

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No. 3

W P 59-75-08 LOCATION Co-ords, 15, 952, 105 N.; 1, 217, 745 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING; BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 15, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
252.8	GROUND SURFACE																
0.0	Silty Fine SAND tr. of clay, Brown Grey		1	SS	9		250										0,51,39,10
245.3	Gravel, org. matter loose to compact		2	SS	15												25,33,27,15
7.5	GLACIAL TILL: heteroge- neous mix of sand, silt, grav. & some clay, comp. dense		3	SS	13												9,54,27,10
241.7			4	SS	33												
11.1	Shale BEDROCK, calcareous, limestone bands, sound, grey		5	RC BXL	100%		240										R.Q.D.=70%
236.7																	
16.1	END OF BOREHOLE																DATE W.L. May 15 NIL Sept. 10 245.5'

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No. 4

W P 59-75-08 LOCATION Co-ords, 15, 952, 129 N.; 1, 217, 835 E. ORIGINATED BY N. McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING; BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 16, 1979 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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					W _p	W	W _L		
247.1	GROUND SURFACE																
0.0	18" Topsoil, Silty fine		1	SS	2	4	240								0,55,39,6		
241.6	SAND, tr. of gravel, org. matter, v. loose, wood		2	SS	2/4												
5.5	Shale BEDROCK, calcareous, sound, grey		3	RC BXL	100%												
236.3																	
10.8	END OF BOREHOLE														W.L.E1.246.6 May 16, 1979		

OFFICE REPORT ON SOIL EXPLORATION

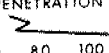


+3, x5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No. 5

W P 59-75-08 LOCATION Co-ords. 15, 952, 225 N.; 1, 217, 695 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 17, 1979 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80						100
269.2	GROUND SURFACE																
0.0	6" Asphalt		1	SS	13												
266.2	FILL - sand and gravel		2	SS	11												
3.0	FILL - mixture of sand silt, clay, v. loose to compact, brown		3	SS	3												
			4	SS	27												
			5	SS	11												
252.7		6	SS	7													
16.5	Silty Fine SAND, some gravel, organics, occasional clayey zones	7	SS	7													
	loose, dark grey	8	SS	10													
245.7	GLACIAL FILL: heteroge- neous mixt. of sand, silt, gravel & some clay, compact	9	SS	30													
23.5		10	SS	24													
242.4																	
26.8	END OF BOREHOLE Refusal possibly on bedrock																

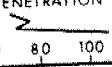







OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No. 6

W P 59-75-08 LOCATION Co-ords, 15, 952, 175 N.; 1, 217, 865 E. ORIGINATED BY N.MCC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 17, 1979 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	20	40	60	80	100	W _p		
266.7	GROUND SURFACE														
264.2	FILL - sand & gravel		1	SS	7										
25	FILL - mixture of Silt, Clay, Sand, some gravel. V. loose to loose, brown to grey		2	SS	7										
			3	SS	9										
			4	SS	1										
			5	SS	2										
			6	SS	2										
249.2			7	SS	8										
17.5	Silty Fine SAND, trace of clay, loose, dark grey		8	SS	5										0,53,40,7
242.0															
24.7	END OF BOREHOLE Refusal possibly on bedrock														W.L.E1.248.7 May 17,1979

OFFICE REPORT ON SOIL EXPLORATION

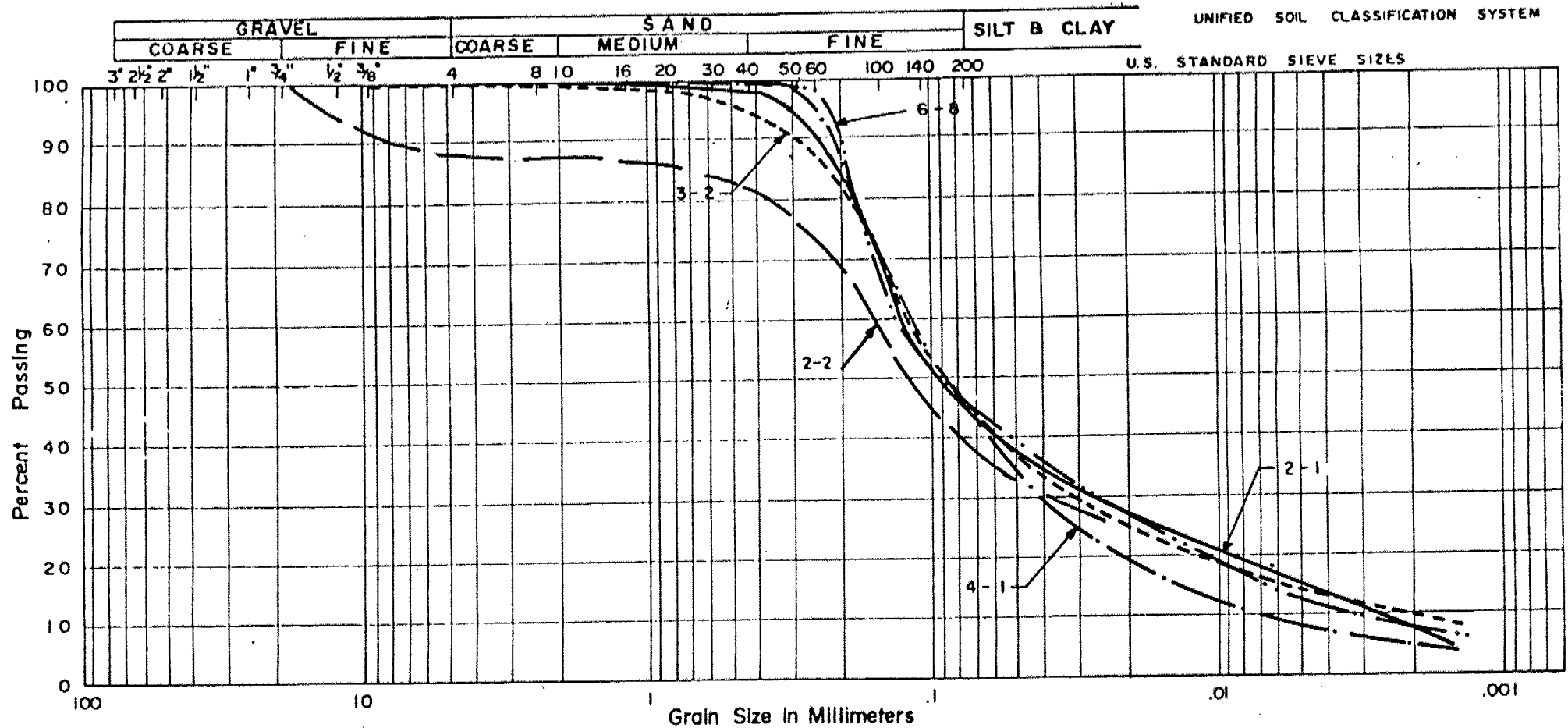
+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO 79-5-7



PROJECT: SOPER CREEK BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE NO: 2 3 4 6 2
 SAMPLE NO: 1 2 1 8 2
 DEPTH:
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SILTY FINE SAND

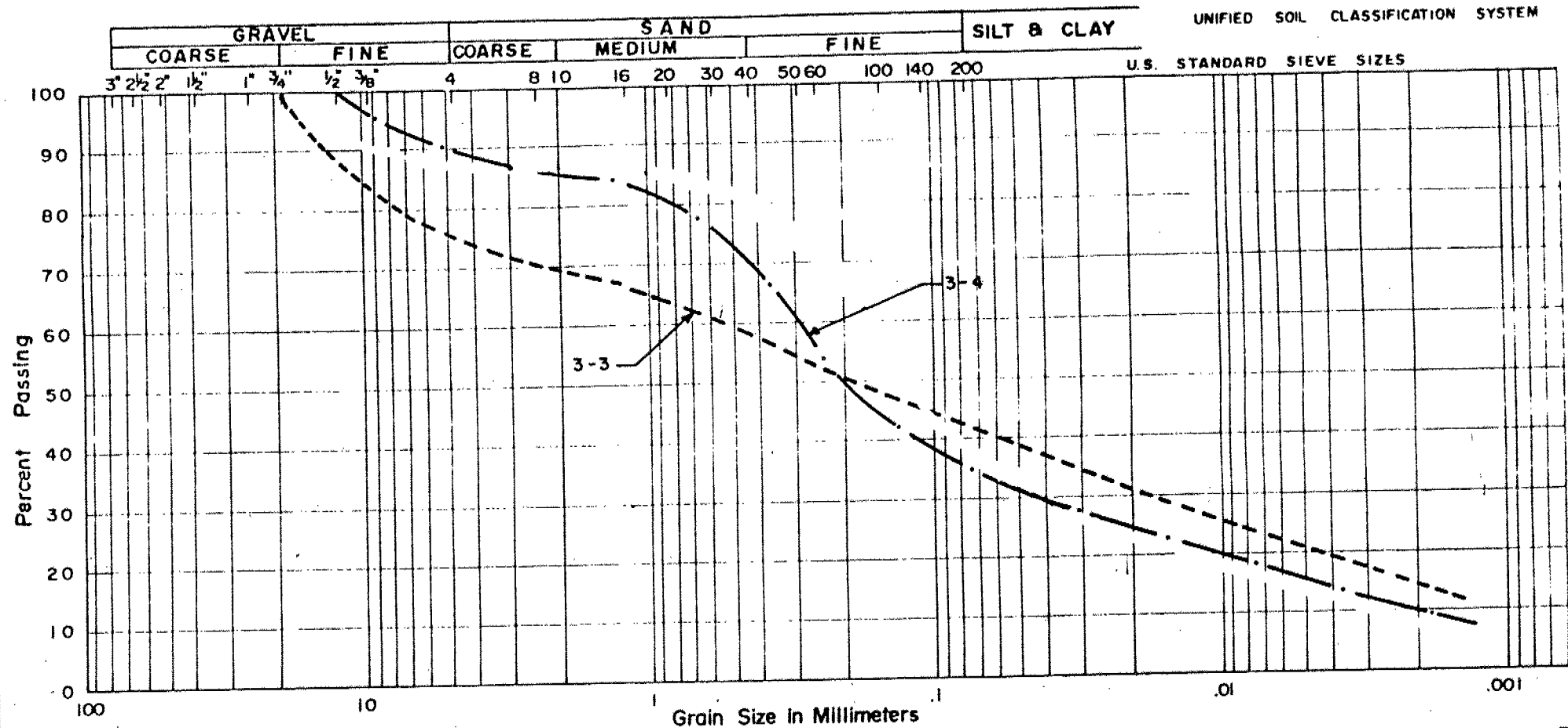
PLASTIC PROPERTIES
 LIQUID LIMIT % = 28.4
 PLASTIC LIMIT % = 20.4
 PLASTICITY INDEX % =
 MOISTURE CONTENT % = 17.6 - 56.6

ENCLOSURE NO 7

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO 79-5-7



PROJECT: SOPER CREEK BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE NO: 3 3
 SAMPLE NO: 3 4
 DEPTH:
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SILTY SAND TILL

PLASTIC PROPERTIES

LIQUID LIMIT % =
 PLASTIC LIMIT % =
 PLASTICITY INDEX % =
 MOISTURE CONTENT % = 6.4 - 20.3

45

ENCLOSURE NO 8

FOUNDATION INVESTIGATION REPORT

For

Wilmot Creek Culvert Extension
W. P. 7-79-03, Site 21-173
Hwy. 35/115, District 7, Port Hope

INTRODUCTION

This report contains the results of a foundation investigation carried out at the above site. Four sampled boreholes, each accompanied by a dynamic cone penetration test were carried out on March 19 to March 22, 1968 using a skid mounted diamond drill for wash boring with NX casing. In addition two sampled borings were also carried out on September 13, 1979 using hollow stem augers to advance the borings. These boreholes were advanced to depths of 10 to 26 feet below ground surface and bedrock was proven by obtaining up to 5 feet of rock core in three of the sampled boreholes.

SITE DESCRIPTION AND GEOLOGY

The site is located at the present crossing of Hwy. 35/115 over Wilmot Creek, situated about 1.5 miles north of Hwy. 401; within the Town of Newcastle, Regional Municipality of Durham.

The site topography is hilly. Wilmot Creek has cut a channel some 60 to 80 feet wide and up to 10 feet deep below the average ground surface with near vertical banks. To the north-east of the creek the ground rises rapidly at slopes as steep as 1.5:1 to a generally rolling plane some 45 feet above creek level. To the southwest, the ground rises very gradually. Wilmot Creek itself flows southeasterly over a cobble and boulder bed with a depth of water varying from 2 to 24 inches.

The highway crosses the creek at a skew of about 106 degrees. The crossing is facilitated by an existing 38 foot x 20.5 foot concrete arch culvert, some 170 feet long. Associated with this structure are existing fill embankments in the order of

28 feet high which show no signs of instability. Immediately downstream of the Hwy. 35/115 crossing is an abandoned single lane, single span (38') steel beam structure with timber deck. The structure foundations are in good condition.

Physiographically the site is located in the Iroquois Plain. This region is characterized by a clay plain which has been smoothed by wave action. Bordering this plain is Lake Ontario to the south and the old shoreline of glacial Lake Iroquois to the north. The old shoreline is distinguished by cliffs bars and beaches with an undulating till plain above.

SUBSURFACE CONDITIONS

General

Uniform soil conditions prevail across the site, consisting of 12 to 18 feet of stiff to hard glacial till overlying limestone bedrock. In some areas fill material composed of clayey silt, sand and gravel with organics was found overlying the glacial till.

The boundaries between the various soil and rock types are shown on the attached Record of Borehole Sheets. The locations and elevations of the boreholes are shown on Drawing No. 2, together with two stratigraphical sections inferred from the boreholes.

Following is a brief description of the various soil and rock types encountered.

Fill Material (Clayey Silt, Sand and Gravel Trace of Organics)

On two borings put down northwest of the highway, fill material was encountered. This surficial stratum is composed of a mixture of brown clayey silt, sand and gravel with organic inclusions and was found to extend to a total depth of about 3 feet in these areas. Dynamic cone penetration tests indicate that the fill material is in a loose state of compaction.

Creek Bed Deposits (Cobbles and Boulders and Medium Sand, Trace Gravel)

These granular deposits were encountered in the two borings put down southeast of the highway and extends from the creek bed down to the glacial till. These recent alluvial deposits are composed of a zone, up to two feet thick, of cobbles, generally 3 to 5 inches in size, and boulders up to 2 feet in size. In the boring put down southwest of the creek, the creek bed deposit is some 4 feet thick, the lower 2 feet being composed of medium sand with a trace of gravel. Based on the nature of the augering operation, the creek bed deposits are inferred to be in a compact state of relative density.

Glacial Till

This is the predominate deposit across the site extending from the parent ground surface some 12 to 18 feet down to the limestone bedrock. The texture of material clearly shows the deposit to be of glacial origin, being composed of a heterogeneous mixture of clayey silt, sand and gravel with plasticity generally decreasing with depth. In one borehole, B.H.#5, occasional cobbles up to 6 inches in size were encountered within this deposit below elevation 264.0. The upper 2 to 8 foot zone of this cohesive glacial deposit is in a reworked state and contains occasional sand and gravel seams up to 6 inches thick.

The results of grain size distribution testing on representative samples from this deposit are shown in envelope form on Figure 1 in the Appendix of this report. The results of Atterberg Limit tests are plotted on the Plasticity Chart, Figure 2. These results are summarized below.

		<u>Range</u>	<u>Average</u>
Natural Moisture Content	w%	8 - 15	9
Liquid Limit	w _p %	9 - 15	12
Plastic Limit	w _L %	12 - 32	20
Plasticity Index	I _p %	6 - 16	8

Based on the Atterberg Limit testing, the glacial matrix can be described as an inorganic clay of low plasticity.

Standard Penetration Testing carried out within this deposit gave 'N' values ranging from 4 to 31 blows per foot in the upper reworked zone

and from 56 to over 100 blows per foot in the lower zone. The consistency as inferred from this data is stiff in the upper zone and hard in the lower portion.

Limestone Bedrock

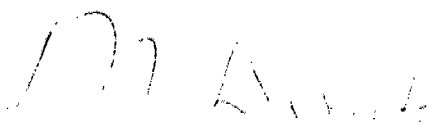
Bedrock was proven in three of the borings by obtaining up to 5 feet of AXT or BXL size rock core. Elsewhere the bedrock surface was taken to be at the point of refusal to augering. The bedrock surface was found to be at a depth of 14.5 to 18.5 feet below existing ground surface, corresponding to elevation 257 to 260. The bedrock may be described as limestone, fine to medium texture. The upper 2.5 feet of bedrock in Borehole #5 was found to be in a fractured or jointed condition, elsewhere the bedrock is sound.

Groundwater Conditions

Groundwater condition level observations were carried out during the course of the investigation by measuring in the boreholes. These observations are shown on the Record of Borehole Sheets as well as on Drawing No. 2. During the March, 1968 investigation, the water level was found to be 1.5 to 4.0 feet below ground surface which corresponds to elevation 274 to 277. At this time, the creek water level was measured to be at elevation 273.0 (March, 1968). These observations indicates a steep hydraulic gradient towards the creek. In the recent investigation, the creek water level was found to be at elevation 272.6 (September, 1979).



T. J. Kazmierowski, P. Eng.
Foundations Engineer



M. Devata, P. Eng.
Senior Foundations Engineer

APPENDIX



RECORD OF BOREHOLE No 1

W P 7-79-03 LOCATION Co-ords. N 15,958,321; E 1,234,014 ORIGINATED BY RR
DIST 7 HWY 35/115 BOREHOLE TYPE Hollow Stem Augers COMPILED BY RR
DATUM Geodetic DATE September 13, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
272.6	Water Level													
0.5	Cobbles, some boulders compact						270							
2.5	Medium sand, trace gravel, compact		1	SS	29									
4.5	Heterogeneous mixture. Clayey silt - Stiff		2	SS	10									
	Sand, trace of gravel - Hard		3	SS	31									
			4	SS	102									
257.4	Glacial Till		5	SS	100/4"		260							3 16 51 30
			6	SS	100/5"									
15.2	Refusal to augering. Probable bedrock													
	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20'
15-20' 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2

W P 7-79-03 LOCATION Co-ords. N 15,958,335; E 1,234,040 ORIGINATED BY RR
DIST 7 HWY 35/115 BOREHOLE TYPE Hollow Stem Augers and BXL Rock Core COMPILED BY RR
DATUM Geodetic DATE September 13, 1979 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
272.6	Water Level																
0.5	Cobbles & Boulders						270										20 38 31 11
2.0	Heterogeneous mixture Clayey silt, Stiff sand		1	SS	25												
	Trace of Hard		2	SS	8												
	Gravel		3	SS	17												
	Glacial Till		4	SS	80		260										15 29 32 24
258.1	Limestone bedrock		5	SS	100												
14.5	Sound		6	SS	100												
255.6	End of Borehole		7	SS	100												

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



RECORD OF BOREHOLE No 3 (Formerly B.H.#3 - W.P.301-66-0)

W P 7-79-03 LOCATION Co-ords. N 15,958,469, E 1,233,889 ORIGINATED BY VK
DIST 7 HWY 35/115 BOREHOLE TYPE Diamond Drill-NX Casing and Cone Test COMPILED BY WH
DATUM Geodetic DATE March 21, 1968 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
281.0	Ground Level										
0.0	Fill mat'l. clayey silts										
278.0	sand & gr. with some org		1	SS	20						
3.0	Heterogeneous mixture of clayey silt, sand and gravel		2	SS	59						
	Glacial Till		3	SS	144						
			4	SS	100	5"					
260.0			5	SS	155						
21.0	(Sound)		6	AXT RC	100% REC						
255.0	Limestone Bedrock										
26.0	End of Borehole										

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 4

(Formerly B.H.#4 - W.P.301-66-0)

W P 7-79-03 LOCATION Co-ords. 15,958,518; E 1,233,837 ORIGINATED BY VK
DIST 7 HWY 35/115 BOREHOLE TYPE Diamond Drill - NX Casing and Cone Test COMPILED BY WH
DATUM Geodetic DATE March 22, 1968 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
279.3	Ground Level																
0.0	Fill mat'l. (Clayey silt sand & gr. with organics)																
276.3																	
3.0	Heterogeneous mixture of clayey silt, <u>Stiff</u> <u>Hard</u>		1	SS	4												6 25 39 30
			2	SS	50												
268.8	sa. & gr. Glacial Till		3	SS	95		270										
10.5	End of Borehole																

+3, x5 : Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 5 (Formerly B.H.#1 - W.P.301-66-0)

W P 7-79-03 LOCATION Co-ords. N 15,958,556; E 1,233,900 ORIGINATED BY VK
DIST 7 HWY 35/115 BOREHOLE TYPE Diamond Drill - NX Casing and Cone Test COMPILED BY WH
DATUM Geodetic DATE March 19-20, 1968 CHECKED BY

Geodetic		DATE		March 19 - 20, 1966										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N ^o VALUES			20 40 60 80 100	SHEAR STRENGTH					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	10 20 30					
276.5	Ground Level													
0.0	Heterogeneous mixture of clayey silt, sand and gravel. Hard. Glacial Till (with boulders up to 6" diameter - below elevation 264).		1	SS	56									5 32 42 21
			2	SS	100	2"								14 30 38 18
			3	SS	100	6"								
			4	SS	138									
			5	BXL RC	142									
			6	SS	100	6"								
258.0														
18.5	(Fractured & Weathered)		7	SS	100	1"								
255.5			8	BXL RC										
21.0	(Sound)		9	AXT	100									
251.5	Limestone Bedrock			RC	REC									
25.0	End of Borehole													

+3, x⁵: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 6

(Formerly B.H.#2 - W.P.301-66-0)

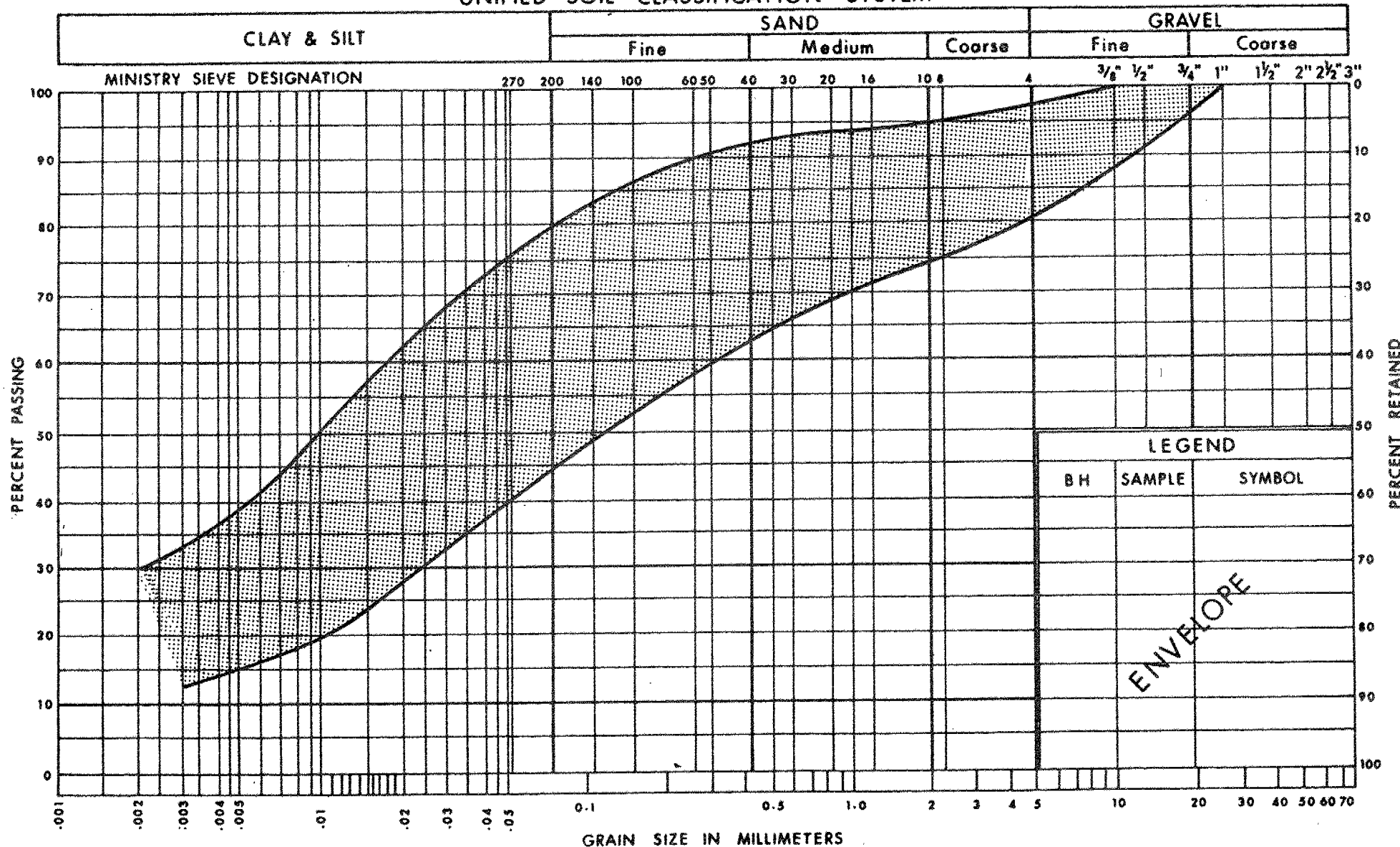
W P 7-79-03 LOCATION Co-ords. N 15,958,517; E 1,233,919 ORIGINATED BY VK
DIST 7 HWY 35/115 BOREHOLE TYPE Diamond Drill - NX Casing and Cone Test COMPILED BY WH
DATUM Geodetic DATE March 20, 1968 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
275.0	Ground Level											
0.0	Heterogeneous mixture of clayey silt, sand and gravel. Hard.		1	SS	179							0 1 55 44
264.5	Glacial Till		2	SS	100/4"							
			3	SS	100/6"							
10.5	End of Borehole											

+3, x5: Numbers refer to
Sensitivity

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

UNIFIED SOIL CLASSIFICATION SYSTEM

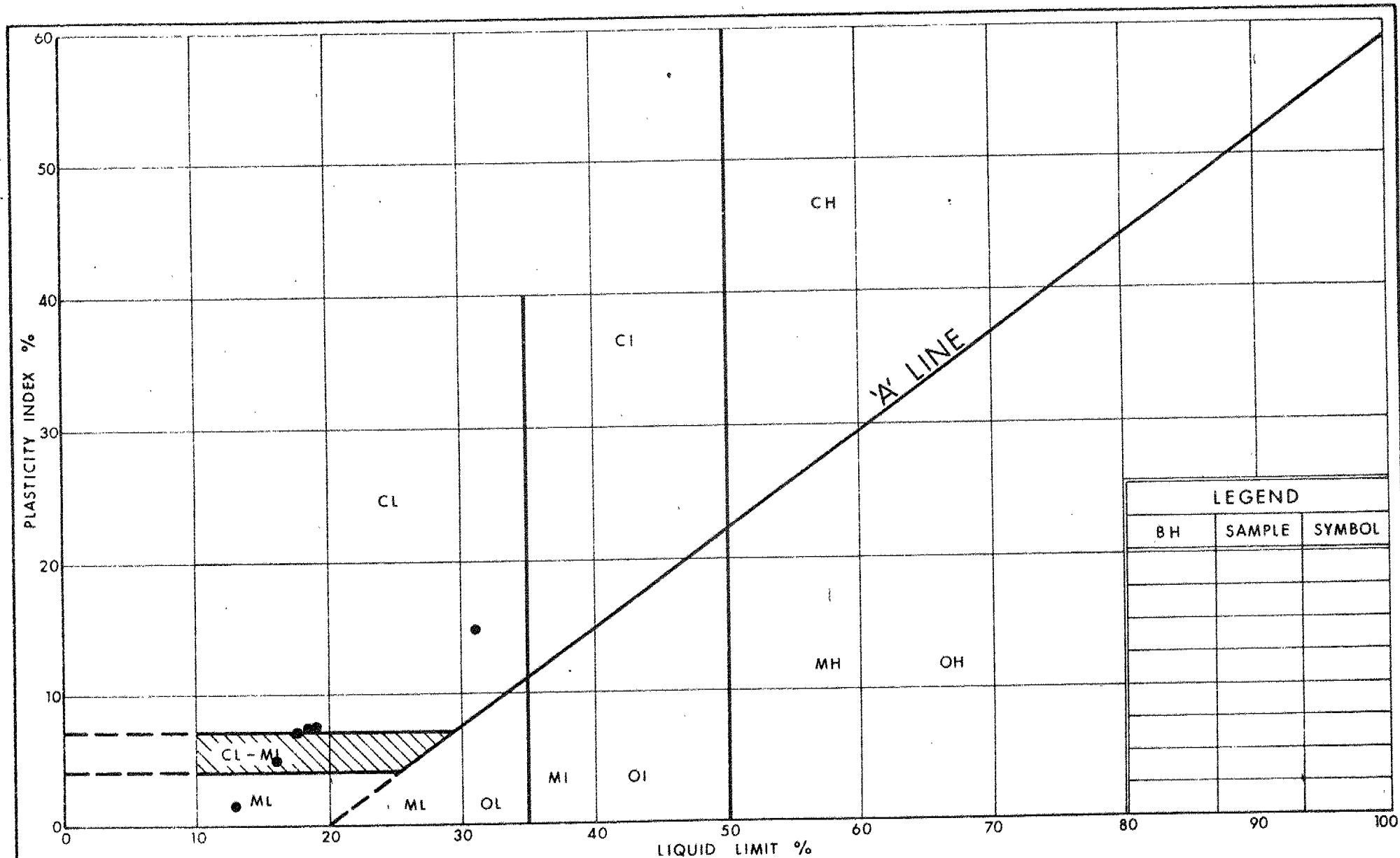


Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
GLACIAL TILL
HET MIX OF CLAYEY SILT, SAND & GRAVEL

FIG No 1

WP 7 - 79 - 03



Ministry of
Transportation and
Communications

PLASTICITY CHART
GLACIAL TILL
HET MIX OF CLAYEY SILT, SAND & GRAVEL

FIG No 2

W P 7-79-03

30MI5-49

GEOCRES No.

DOMINION SOIL INVESTIGATION INC.

CONSULTING ENGINEERS

TORONTO KITCHENER LONDON WINDSOR THUNDER BAY SARNIA



DOMINION SOIL INVESTIGATION INC.

CONSULTING SOIL & FOUNDATION ENGINEERS

104 CROCKFORD BLVD., SCARBOROUGH, ONTARIO, CANADA, M1R 3C6

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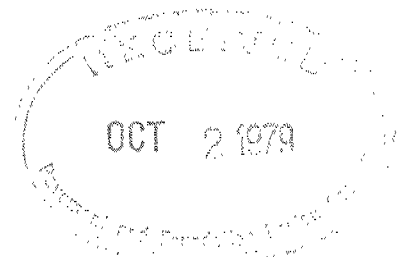
30M15-49

GEOCRES No.

FOUNDATION INVESTIGATION
PROPOSED WIDENING OF BOWMANVILLE CREEK BRIDGE
KING'S HIGHWAY 401 - TOWN OF NEWCASTLE
W.P. 59-75-06; SITE NO. 21-161
DISTRICT NO. 7; PORT HOPE, ONTARIO

Ref. No. 79-5-5
September 1979

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



DISTRIBUTION:

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A P P E N D I C E S

APPENDIX 'A', RECORD OF TEST PITS 1 & 2.....
APPENDIX 'B', FIELD WORK & LABORATORY TESTING
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E N C L O S U R E S

PLAN, PROFILE CENTRE LINE HIGHWAY 401, SECTIONS A-A and B-B	Drawing 1
BOREHOLE LOGS	Enclosures 1 - 4 inclusive
GRAIN SIZE DISTRIBUTION CURVES	Enclosures 5 - 8 inclusive

Ref. No. 79-5-5
W.P. 59-75-06

- 1 -

Si

1.0 INTRODUCTION

This report describes the results of a geotechnical investigation carried out at the site of the proposed widening of the existing crossing at Bowmanville Creek and Highway 401 in the Town of Newcastle. The investigation was requested by the Ministry of Transportation and Communications, and authorization to carry out the work was received from the Pavement and Foundation Design Section of the Ministry.

The purpose of the investigation was to determine the subsoil and groundwater conditions at the site; to establish the engineering properties of the substrata; and to make recommendations for the foundation design and construction of the proposed bridge structure.

The investigation in the field was completed in May 1978, and consisted of the drilling of four boreholes and the excavation of two test pits. The locations of the boreholes and test pits are shown on Drawing No. 597506-A and the subsurface conditions encountered are presented on the record of the boreholes and in the Appendix.

.../...



2.0 DESCRIPTION OF THE SITE

The site is located in the Town of Newcastle at the crossing of Highway 401 and the Bowmanville Creek. The terrain in this area is generally flat and the embankment carrying Highway 401 rises 12 to 18 ft. above the surrounding area. Drainage to the area is provided by the Bowmanville and Soper Creeks.

.../...

3.0 REGIONAL GEOLOGY

Geologically, the site is situated in the Lake Iroquois plain, which is an area of low relief inundated during the Pleistocene by the waters of Lake Iroquois. The old abandoned shoreline of Lake Iroquois lies approximately 4 miles to the north.

The bedrock underlying the basin is of Ordovician age and consists of the Whitby formation, which is a black calcareous shale unit with interbedded limestone layers. The bedrock surface is irregular and regional studies suggest that there are strong similarities between the existing surface topography and that of the bedrock surface.

The surficial deposits consist of sediments of Pleistocene and recent age. Glacio-lacustrine deposits south of the abandoned Lake Iroquois shoreline range from sand and gravel of a near shore and deltaic nature to off-shore sediments such as varved silt and clay. These were deposited on top of a ground moraine of generally coarse sandy texture.

The surface of the till is irregular and drumlinized and the surface of the drumlins are exposed in many places in this area. More recent deposits consisting of organic and alluvial soils are found in the valleys of the creeks.

.../...



4.0 SUBSOIL CONDITIONS

The four exploratory boreholes drilled at the site indicate in general fill and alluvium to depths ranging between 7.0 and 12.8 ft. below the ground surface, underlain by a basal till extending to the surface of the bedrock. The bedrock, which was encountered $16.0 \pm$ ft. below the ground surface, is a shaley limestone. The stratigraphic sequence, as inferred from the borehole logs, is as follows:

- 1.) Loose to compact fill (Boreholes 1 and 4).
- 2.) Sandy Silt (Boreholes 2 and 3)
- 3.) Loose to compact silty sand (except Borehole 1).
- 4.) Loose to dense sand and gravel (Boreholes 1 and 4).
- 5.) Compact to very dense glacial till.
- 6.) Shaley limestone bedrock.

Details of the subsurface conditions are shown on the Record of Boreholes (Enclosures 1 to 4 inclusive) and also on the inferred soil profile and sections shown on Drawing No. 597506-A. The relevant index and engineering properties of the principal soil strata are described briefly below.

4.1 Fill

Boreholes 1 and 4 encountered fill to depths ranging between 5.0 and 7.5 ft. below the ground surface.

To a depth of 2.5 ft. below the ground surface in Borehole 4, the fill consists of sandy silt followed by sand and gravel with traces of silt to 5.0 ft. Borehole 1 encountered 9-inches of fine sand underlain by .../...

sand and gravel to 4.0 ft., which is in turn underlain by silty sand with some gravel and clay (i.e. till) to a depth of 7.5 ft. below the ground surface.

Based on penetration indices or 'N'-values of 6 to 23 blows per foot, the fill is described as loose to compact.

4.2 Sandy Silt

A surficial layer of alluvial sandy silt was encountered at Boreholes 3 and 2 to depths ranging between 2.0 and 2.5 ft. below the ground surface respectively.

4.3 Silty Sand

Boreholes 2, 3 and 4 encountered alluvial silty sand to depths ranging between 7.0 and 7.5 ft. below the ground surface.

The thickness of the alluvium ranges between 2.0 and 5.5 ft. and contains various amounts of organic matter. The grain-size distribution of typical samples is shown on Enclosures 6 and 7, indicating 0-10% gravel, 68 to 87% sand (mostly fine), 13 to 32% silt and clay size particles. The 'N'-values range from 2 to 11 blows per foot, indicating very loose to compact relative density. The coefficient of permeability of the alluvium is estimated to range from 10^{-3} cm/sec. to 10^{-5} cm/sec.

4.4 Sand and Gravel

Boreholes 1 and 4 encountered sand and gravel and gravelly sand ranging in thickness from 2.0 ft. (Borehole 4) to 5.3 ft. (Borehole 1). The grain size distribution characteristics of this deposit are shown on Enclosure 8, indicating 27% gravel, 55% sand, and 18% silt and clay size particles.

.../...

The penetration indices range from 8 to 36 blows per foot, indicating loose to dense relative density.

4.5 Glacial Till

At depths ranging between 7.0 and 12.8 ft. below the ground surface, the boreholes encountered a basal till with a thickness ranging from 3.2 ft. in Borehole 1, to 7 to 9 ft. in the remaining boreholes.

The grain size distribution of typical samples shown on Enclosure 5 indicates 18 to 38% gravel, 35 to 49% sand, 21 to 31% silt, and 6 to 11% clay size particles. The till generally exhibits some cementation although layers or zones of little or no cementation were also noted. The penetration resistances within the basal till range from 26 to more than 100 blows per foot, indicating a compact to very dense relative density. Based on the gradation curves and from visual and tactile examination of the samples, the coefficient of permeability of the till is estimated to range between 10^{-4} and 10^{-5} cm/sec., depending on the degree of cementation and density.

4.6 Bedrock

The surface of the bedrock was encountered beneath the basal till at a depth of $16.0 \pm$ ft. below the ground surface (i.e. between Elevation 234.6 and 232.2 ft.).

In Borehole 1, from 16.0 to 18.8 ft. below the ground surface, that is from Elevation 234.5 to 231.7 ft., the rock was found to be of very .../...

poor quality with some sand seams. The recovery and the R.Q.D. values in this zone are 27%, and the visual examination of the core samples indicates a fractured rock.

Elsewhere, the recovered cores show that the rock formation underlying the site is a grey, shaley limestone. To a depth of 2 ft. below its surface in Borehole 2 (R.Q.D. value = 43%), and 6 to 12-inches in Boreholes 3 and 4, the rock is weathered. Below this zone, the rock is relatively intact with occasional highly weathered thin bands. The high percentage of core recovery (85 to 100%) and R.Q.D. values of 63 to 100%, indicate that the rock is of fair to excellent quality. No major fractures were encountered indicating that the mass permeability of the rock below the weathered zone would be low.

5.0 GROUNDWATER CONDITIONS

The groundwater conditions in the boreholes were observed during drilling; water levels were also measured before coring started and after the completion of the coring. A standpipe was installed in Borehole 2 and seepage of surface water was prevented by a bentonite seal about 3 ft. below the ground surface.

Observations made in the boreholes before coring the rock showed water levels ranging between 3.0 and 7.5 ft. below the ground surface. In Boreholes 2 and 3, a slight temporary artesian pressure of 1.0 to 1.5 ft. above the ground surface was noted in the casing after coring. The standpipe installed in Borehole 2, however, later showed a stabilized water level 2.5 ft. below the ground surface. These observations indicate that the average groundwater table at the time of the investigation was at Elevation 248 \pm ft.

6.0 DISCUSSION OF THE RESULTS

The existing bridge, which was built around 1950, is a single span rigid frame reinforced concrete structure. It has a clear span of about 60 ft., and the available design drawing (D.H.O. Dwg. No. D-3126-2, June 1950) shows that the existing foundation level is at about Elevation 236 ft.

It is proposed to widen this structure both to the north and south to provide an additional width of about 10 ft. on each side. The widened structure will be similar in design to the existing bridge.

To verify whether the existing structure was founded as shown on the design drawing, two test pits were dug near the north and south-east corners of the existing abutment approximately 10 to 15 ft. from the creek.

The conditions found in the test pits are described in Appendix 'A'. Due to the heavy flow of water, however, the sides of the test pits collapsed before the foundation depths could be reached.

6.1 Foundation Design

Drawing D-3126-2 shows the top of the footings of the existing bridge at Elevation 238.3 ft. The probable founding depth is, therefore, $236 \pm$ ft., but confirmation of this by means of a test pit has not been possible. The boreholes show that at this elevation the subsoil consists of dense to very dense till underlain by bedrock at elevations .../...

ranging between 234.6 and 232.2 ft. Borehole 1 showed a poor quality, fractured rock to about Elevation 231.7 ft., below which rock is sound. It can, therefore, be concluded that the existing structure is either founded on dense to very dense till or on bedrock if the foundations were extended several feet below the level shown on the design drawing.

The widened structure should be founded at the same level as the existing structure. The allowable bearing pressure on the dense to very dense till is 10 k.s.f. The maximum total settlement should be less than 0.6-inch. Should, however, the till be disturbed due to the excavation and groundwater flow, then greater settlements can be expected. It may, therefore, be more prudent to extend the footings to the surface of the bedrock provided that this does not result in the undermining of the existing footings.

For footings placed on top of the weathered rock at or below Elevation 234 ft. (Borehole 4), 233 ft. (Boreholes 1 and 2), and 232 ft. (Borehole 3), a safe bearing value of 16 k.s.f. can be used. This value can be increased to 40 k.s.f. if the footings are extended into the sound rock (i.e. 6 to 18-inches below these layers).

6.2 Horizontal Earth Pressures

The abutments and wing walls should be designed to resist the horizontal earth pressure exerted by the approach embankments behind them. The earth pressure on the abutments can be assumed to be distributed in accordance with the following formula:
.../...

$$p = K (\gamma \cdot d + q)$$

where p = unit horizontal earth pressure at depth
"d" (p.s.f.)

K = coefficient of horizontal earth pressure
= 0.40 for granular backfill

γ = unit weight of soil = 135 p.c.f.

d = distance from top of wall to point of
application of pressure (ft.)

q = unit surcharge load applied at ground
surface (p.s.f.)

The backfill behind the abutment should be well drained or else the water pressure behind the abutment should be included in the calculation of the horizontal forces acting on the abutment.

The coefficient of friction (μ) between the foundation and the smooth rock surface or the till can be taken to be 0.45. The design should incorporate a safety factor against horizontal sliding of not less than 1.75. Additional resistance could be obtained by keying in the footings into the rock. The passive resistance of the rock against the vertical face of the footing or key can be taken to be 10 k.s.f.

6.3 Approach Fill

There are no stability problems foreseen for the proposed widening of the approach fills. The approach embankment could be constructed in accordance with the current M.T.C. Specifications and Standards, using 2 horizontal in 1 vertical side slopes and keying the new fills into the existing fills.

.../...

Si

6.4 Construction

High water levels recorded in the boreholes and visual observations made in the test pits indicate that problems due to the groundwater can be expected during the construction. It is believed that to provide support to the sides of the excavation and to prevent excessive water seepage, the use of tight interlocking sheet piling will be necessary. To enable to penetrate into the dense till, a heavy section will be necessary. It is also expected that where the base is on the fractured rock, the seepage through the bottom of the excavation could be heavy.

7.0 STATEMENT OF LIMITATION

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

DOMINION SOIL INVESTIGATION INC.

Z. S. Ozden
for Z.S. Ozden, P.Eng.



I. P. Lieszkowsky
I.P. Lieszkowsky, P.Eng.
ZS/IPL:esp



A P P E N D I C E S

Prep. By F.L.

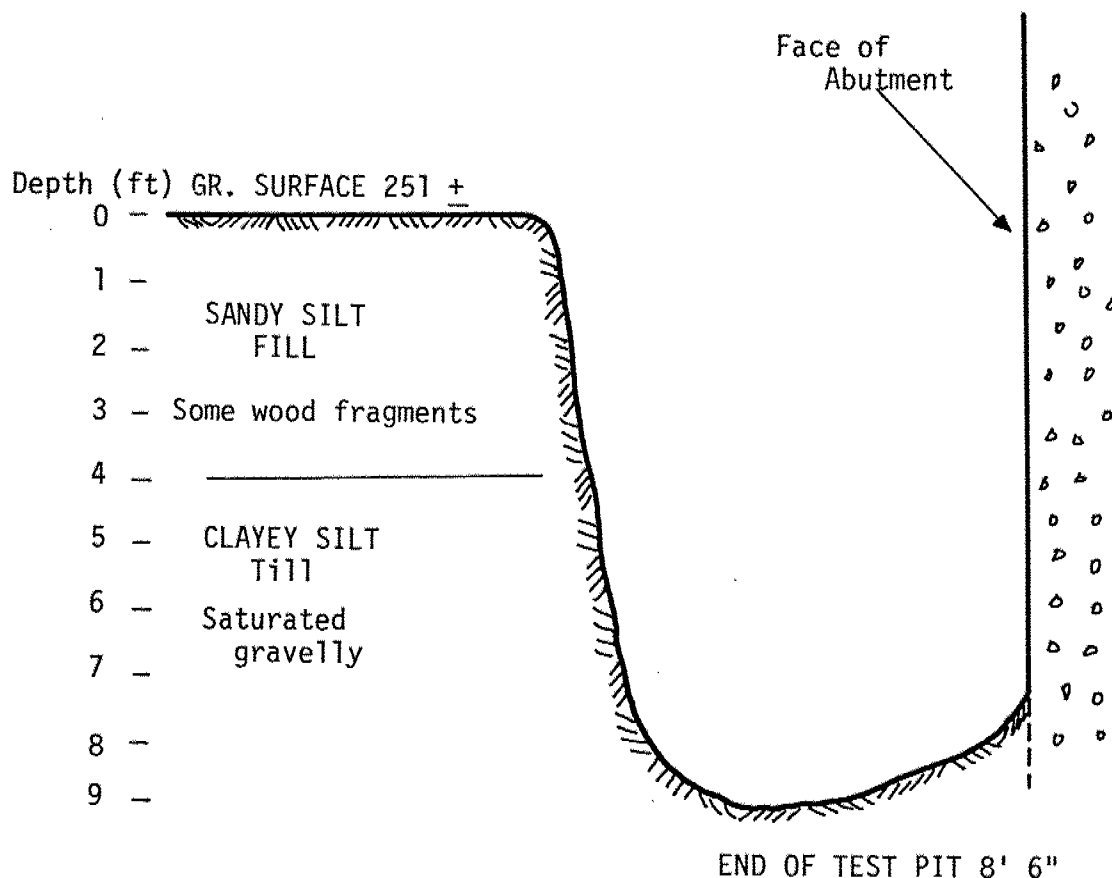
RECORD OF TEST PIT #1
(South-east corner)

W.P. 59-75-06

BOWMANVILLE CREEK CROSSING AND HWY 401

DISTRICT 7, NEWCASTLE

TEST PIT LOCATION: SOUTH CORNER OF EAST ABUTMENT

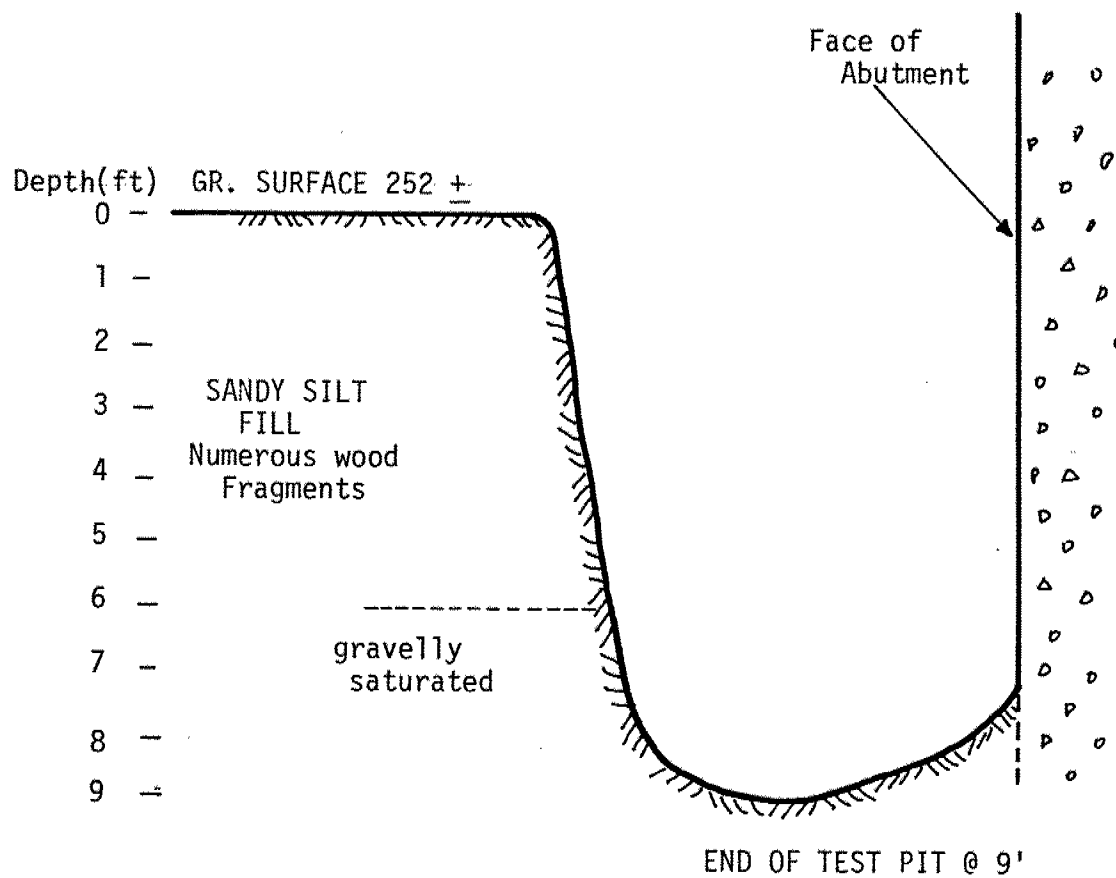


Note: Water coming in
very rapidly at 4 ft.

Prep. By F.L.

RECORD OF TEST PIT #2
(north-east corner)

W.P. 59-75-06
BOWMANVILLE CREEK CROSSING AND HWY 401
DISTRICT 7, NEWCASTLE
TEST PIT LOCATION: NORTH CORNER OF EAST ABUTMENT



Note: Water bubbling up from below at 4.5 ft.

APPENDIX 'B'

Field Work

The field work was carried out on May 10 and 11, 1979, and consisted of four boreholes to depths ranging between 20.7 and 25.7 ft. The locations of the boreholes are shown on Drawing No. 597506-A. The boreholes were drilled with a BOA-8M machine mounted on an all terrain vehicle.

The sampling of the overburden was carried out at 2.5 and 5 ft. intervals. Samples were taken by the Standard Penetration test method. This method, which consists of driving a 2-inch outside diameter split spoon sampler into the undisturbed ground with 350 ft./lb. energy, provides representative soil samples from any level below the ground surface. The number of blows required to advance the sampler into the undisturbed ground are recorded as the Standard Penetration resistance or 'N'-values from which the relative density of the soil can be inferred. The relationship between penetration resistance and relative density is given in Appendix 'C'. The results of the borings and penetration tests are shown on the Record of Boreholes, presented as Enclosures 1 to 4 inclusive.

The boreholes wer extended by augering to a depth where refusal was met and were further extended below this level by diamond drilling technique, using BXL size (2-3/8-inch diameter) coring equipment.

.../...



The field work was supervised by a soil technician who also determined the ground surface elevations at the borehole locations. The elevations of the boreholes were referred to geodetic datum, using as a benchmark the top of the pavement at centre line of the existing bridge on the south side. The elevation of this benchmark is shown as 269.15 ft. on Plan E-5456-1, dated April 1979.

Laboratory Testing

All soil samples were shipped in air-tight jars to the laboratory of Dominion Soil Investigation Inc. for examination and testing. Representative soil samples were selected for sieve and hydrometer analyses and the natural moisture content was also determined. The laboratory test results are presented on the Record of Boreholes, and the Grain Size Distribution Curves are plotted on Enclosures 5 to 8 inclusive.

APPENDIX 'C'

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION 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 "		

APPENDIX 'D'STATEMENT OF LIMITATION

The conclusions and recommendations in this report are based on information determined at the borehole locations and on geological data of a general nature which may be available for the area investigated. Soil and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations and conditions may become apparent during construction which could not be detected or anticipated at the time of the soil investigation.

We recommend that we be retained to ensure that all necessary stripping, subgrade preparation and compaction requirements are met, and to confirm that the soil conditions do not deviate materially from those encountered in the boreholes.

In cases where this recommendation is not followed, the company's responsibility is limited to interpreting accurately the information encountered at the boreholes.

This report is applicable only to the project described in the introduction, constructed substantially in accordance with details of alignment and elevations quoted in the text.

ENCLOSURES



RECORD OF BOREHOLE No 1

W P 59-75-06 LOCATION Co-ords 15, 951, 619 N; 1, 216, 168 E. ORIGINATED BY H.M.C.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.I.
DATUM GEODETIC DATE MAY 10, 1979 CHECKED BY I.P.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT Wl	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH										WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	x LAB VANE							
250.5	GROUND LEVEL																	
0.0	9" Fine Sand. Sand & gravel, compact (FILL)		1	SS	23	5"	250									R.Q.D. = 27%		
246.5	4.0 Silty Sand, some gravel & Clay (FILL) loose		2	SS	6													
243.0	7.5 Sand & Gravel loose with some silt dense layers, wet		3	SS	10		240											
237.7	12.8 Silty Sand TILL w. shale & limestone cobbles		4	SS	36													
234.5	16.0 some sand seams fractured sound, limestone BEDROCK argillaceous, shale bands, grey		5	SS	50/7		230											
			6	RC														
			7	NXL	27%													
			8	RC	100%													
			9	BXL	100%													
225.9																R.Q.D. = 95%		
24.6	END OF BOREHOLE															W.L.E1.248.5 May 10, 1979		

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

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



RECORD OF BOREHOLE No 2

W P 59-75-06 LOCATION Co-ords 15, 951, 648 N; 1, 216, 235 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 11, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
249.9	GROUND LEVEL																
0.0	Sandy SILT, dark brown		1	SS	3												0 68 28 4
247.4	some organics		2	SS	3												0 87 11 2
2.5	Silty Fine SAND, some org.		3	SS	31												23 35 31 11
242.9	content & org. layers, very		4	SS	34												18 42 29 11
7.0	loose, grey, moist		5	SS	49												
	GLACIAL TILL -		6	SS	50/8"												
	heterogeneous mixture of		7	BC	100%												R.Q.D. = 43%
233.9	silty sand with gravel		8	BC	100%												R.Q.D. = 100%
	and some clay dense,																
	grey, cobble @ 12'																
16.0	Limestone																
	BEDROCK weathered																
227.9	argillaceous, shale, sound																
	bands, occ. clayey bands																
22.0	END OF BOREHOLE																DATE W.L. May 11 249.9' Sept. 10 247.4'
																	Artesian pressure 1.5' above ground surface ob- served in BW casing.

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

W P 59-75-06 LOCATION Cor-ords, 15, 951, 760 N; 1, 216, 115 E. ORIGINATED BY N.M.C.
 DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.L.
 DATUM GEODETIC DATE MAY 11, 1979 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	Wp	W	Wl		
248.4	GROUND LEVEL															GR SA SI CL
248.4	Sandy SILT															
2.0	Silty SAND, w. tr. of gravel, some org. content, v. loose, grey to dk. grey.		1	SS	2											10 70 16 4
240.9			2	SS	4											
7.5	GLACIAL TILL: heteroge- neous mixture of silty sand with gravel and traces of clay dense, grey.		3	SS	50/2	5"										19 49 24 7
			4	SS	50/2	6"										
			5	SS	88/10	10"										34 39 21 6
232.2			6	SS	50/2	6"										
16.2	Limestone BEDROCK		7	RC	100%											R.Q.D.=94%
227.7	argillaceous, sound, grey			BXL												
20.7	END OF BOREHOLE															Artesian pressure 1.0' above ground sur- face ob- served in BW casing after coring

+3, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

W P 59-75-06 LOCATION Co-ords, 15, 951, 800 N; 1, 216, 180 E. ORIGINATED BY N.McC.
DIST 7 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGERING, BXL ROCK CORING COMPILED BY I.P.L.
DATUM GEODETIC DATE MAY 11, 1979 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
250.4	GROUND LEVEL																
247.9	Sandy Silt FILL Brown						250										
245.5	Sand & Gravel, tr. silt		1	SS	14												
245.0	Silt, moist to wet		2	SS	11												
243.4	Org. comp. dk. grey		3	SS	8												
241.8	Gravelly Sand, some silt		4	SS	26												
9.0	compact Silty Sand dense TILL		5	SS	5076		240										
234.6			6	SS	5074												
15.8	Limestone BEDROCK argillaceous, sound grey, occasional shale bands and thin sand seams		7	RC BXL	85%		230										R.Q.D. = 63%
224.7			8	RC BXL	98%												R.Q.D. = 96%
25.7	END OF BOREHOLE																DATE W.L. May 11 248.9 Sept. 10 248.8

+3, x5: Numbers refer to
Sensitivity

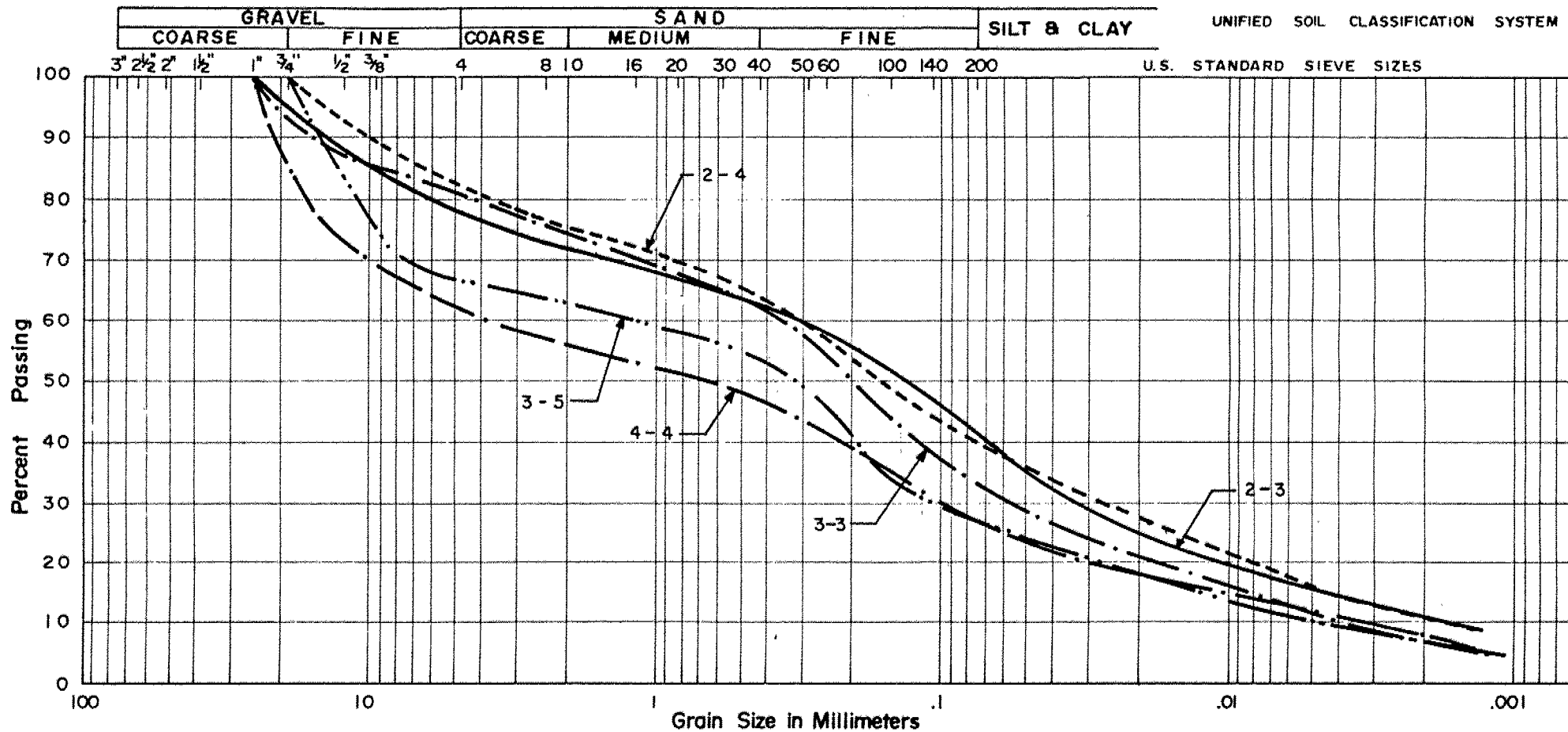
20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION

OUR REFERENCE № 79-5-5



PROJECT: BOWMANVILLE CREEK BRIDGE

LOCATION: BOWMANVILLE, ONT.

BOREHOLE №: 2 2 3 3 4

SAMPLE №: 3 4 3 5 4

DEPTH:

ELEVATION:

COEFFICIENT OF UNIFORMITY:

COEFFICIENT OF CURVATURE:

PLASTIC PROPERTIES

LIQUID LIMIT % =

PLASTIC LIMIT % =

PLASTICITY INDEX % =

MOISTURE CONTENT % = 5.9 - 8.8

Classification of Sample and Group Symbol:

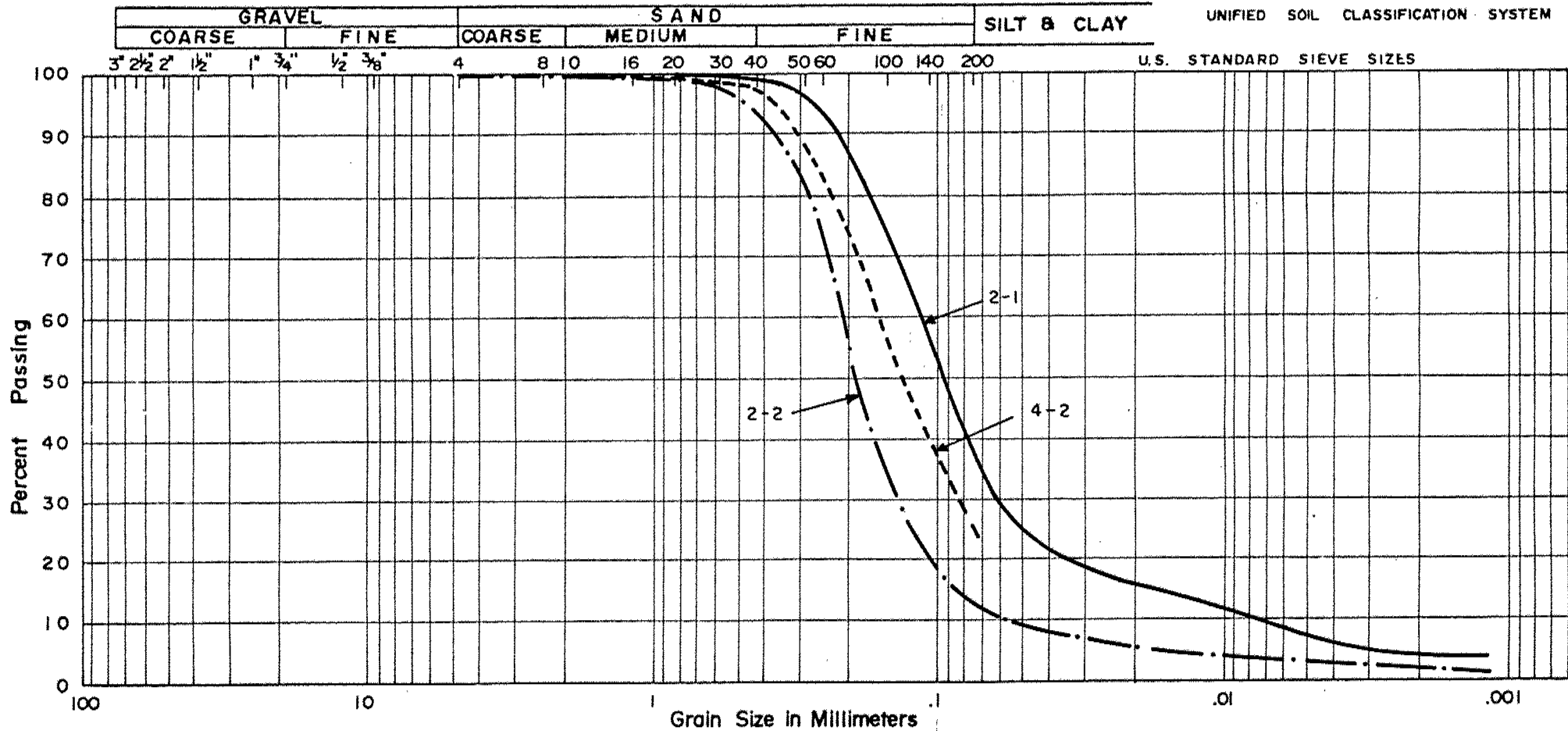
SILTY SAND TILL
with gravel and some clay.

ENCLOSURE № 5

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION

OUR REFERENCE No 79-5-5



PROJECT: BOWMANVILLE CREEK BRIDGE

LOCATION: BOWMANVILLE, ONT.

BOREHOLE No: 2 2 4

SAMPLE No: 1 2 2

DEPTH:

ELEVATION:

COEFFICIENT OF UNIFORMITY:

COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SILTY FINE SAND

PLASTIC PROPERTIES

LIQUID LIMIT % =

PLASTIC LIMIT % =

PLASTICITY INDEX % =

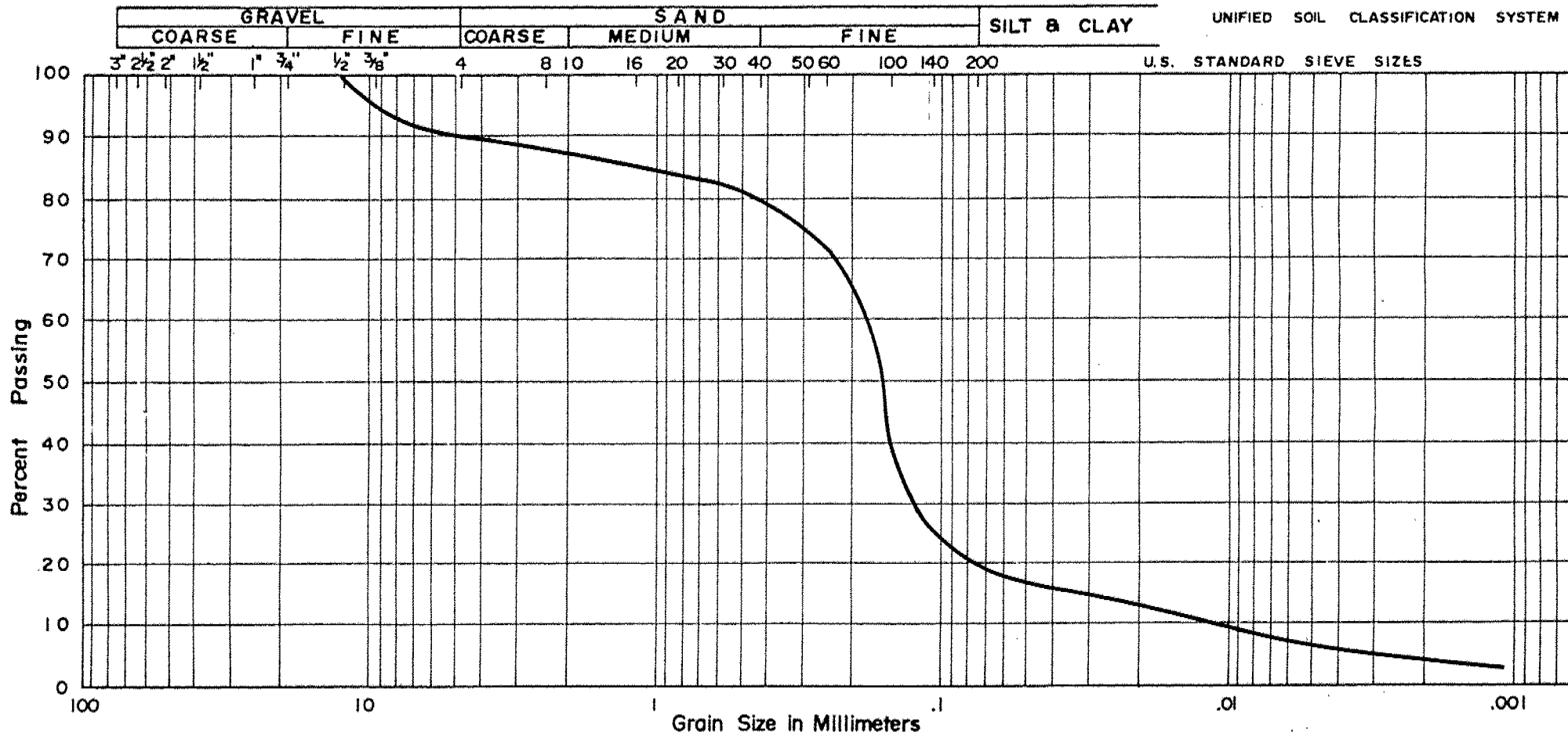
MOISTURE CONTENT % = 23.0 - 26.7

ENCLOSURE No 6

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION

OUR REFERENCE № 79-5-5



PROJECT: BOWMANVILLE CREEK BRIDGE
 LOCATION: BOWMANVILLE, ONT.
 BOREHOLE №: 3
 SAMPLE №: 1
 DEPTH:
 ELEVATION:

COEFFICIENT OF UNIFORMITY:
 COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SILTY SAND
 trace gravel.

PLASTIC PROPERTIES

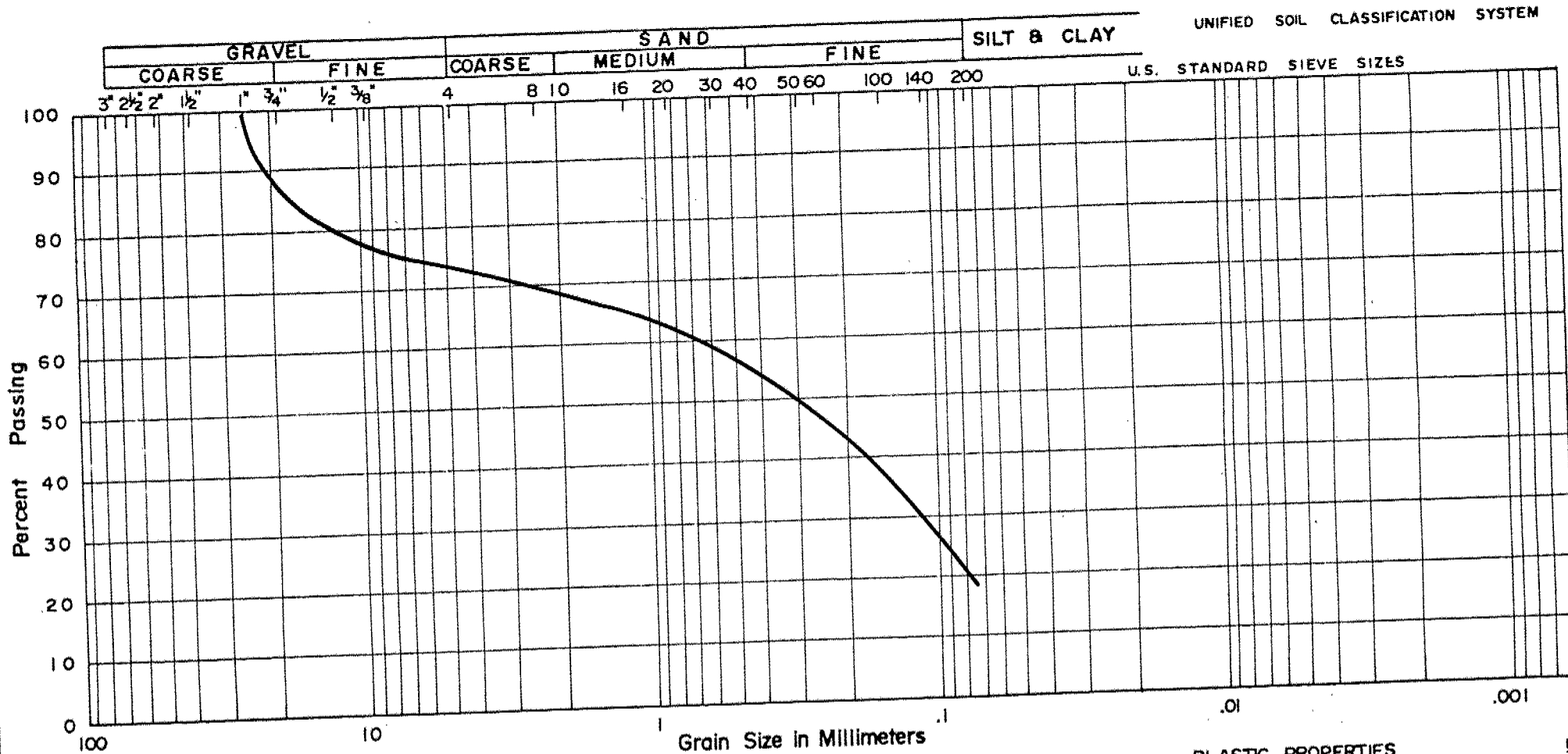
LIQUID LIMIT	% =
PLASTIC LIMIT	% =
PLASTICITY INDEX	% =
MOISTURE CONTENT	% = 21.4

ENCLOSURE № 7

DOMINION SOIL INVESTIGATION INC.

GRAIN SIZE DISTRIBUTION

OUR REFERENCE N^o 79-5-5



Mr. G. C. E. Burkhardt,
Head,
Structural Section,
Central Region.

Pay't. & Foundation Design Section
Engineering Materials Office
Room 315, Central Building
Downsview.
79 10 02

Re: Foundation Investigation
Proposed Widening of Bowmanville Creek Bridge
King's Highway 401 - Town of Newcastle
W.P. 59-75-06; Site No. 21-161
District No. 7; Port Hope, Ontario

The foundation investigation for the above mentioned project was carried out by a Geotechnical Consultant, Dominion Soil Investigation Inc. A detailed report has been submitted by the consultant on 79 10 02 and a copy of which is enclosed for your requirements. Our comments related to this project are as follows.

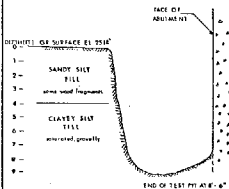
- 1) The widened portion of the footing should be designed as an independent unit and founded at the same elevation as the existing one.
- 2) Care should be exercised during construction to ensure the integrity of the existing foundations. The new footing base must be inspected by this section prior to placement of concrete. The purpose of this is to avoid placing the widening on any loosened subsoil left over by the previous construction operation. If any sub-excavation is required, this should be brought up to the required grade with mass concrete.
- 3) In computing the sliding resistance between the concrete footing base and the glacial till, a coefficient of friction equal to 0.65 should be used for design purposes.

MD/cy
Encl:

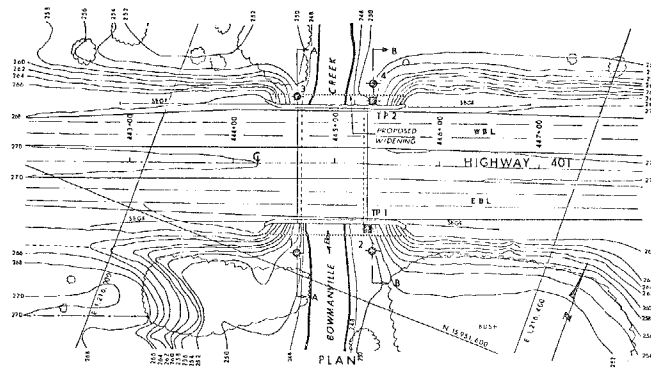
M. Devata,
Senior Foundation Engineer.

c.c. G. C. E. Burkhardt (3)
R. D. Gunter
I. V. Oliver
D. E. Thrasher (2)
C. Grebski
R. Hore
R. Fitzgibbon)
J. Anderson) cover only
T. J. Kovich)
Files ✓
G. J. Giroux

TEST PIT No. 1



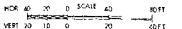
SECTION



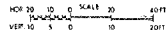
PLAN



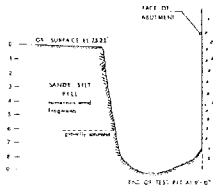
PROFILE OF HIGHWAY 401



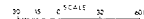
SECTIONS



TEST PIT No. 2



SECTION



CONT No
WP No 59-75-06

BOWMANVILLE CREEK
BORE HOLE LOCATIONS & SOIL STRATA



DOMINION SOIL INVESTIGATION INC.



LEGEND

- Bore hole
- Dynamic Cone Penetration Test (Cone)
- Bore hole A-Cone
- Bore hole (50' test 300' No. 100)
- Cone (50' test 300' No. 100)
- W.L. at time of investigation
- WATER May 1976
- WATER May 1976
- WATER May 1976

No.	ELEVATION	COORDINATES	
		EAST	NORTH
1	250.5	13 931 416	1216 108
2	249.8	13 931 448	1216 235
3	213.4	13 931 420	1216 195
4	210.4	13 931 400	1216 180

NOTE:

The boundary between soil strata has been determined by the bore hole locations. Between bore holes the boundaries are assumed from geological evidence.

30M15-49
GEOCREP No.